MORAY WEST
OFFSHORE WINDFARM

Draft Environmental Management Plan

Moray Offshore Windfarm (West) Limited

Technical Appendix 4.1

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Acronyms	
Acronym	**Expanded Term**
ADD	Acoustic Deterrent Devices
AFS	Anti-fouling system
ALARP	As low as reasonably practical
BWM	Ballast water management (also refers to ballast sediment where appropriate)
CDM	Construction (Design and Management) Regulations
COSHH	Control of Substances Hazardous to Health
DPR	Daily Progress Report
ECoW	Ecological/Environmental Clerk of Works
EDPR UK	EDP Renewables UK
EIA	Environmental Impact Assessment
EIA Report	The Environmental Impact Assessment Report
EMP	Environmental Management Plan
EMS	Environmental Management System
EU	European Union
FLO	Fisheries Liaison Officer
HR	Human Resources
HSE	Health and Safety Executive or Health Safety and Environment
HSSE	Health, Safety, Security & Environment
IMO	International Maritime Organisation
ISO	International Organisation for Standardisation
JNCC	Joint Nature Conservation Committee
Licensee	Moray Offshore Windfarm (West) Limited
MGN	Marine Guidance Note
MARPOL 73/78	International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978
MFRAG	Moray Firth Regional Advisory Group
MHWS	Mean High Water Springs
MCA	Maritime and Coastguard Agency
MCC	Marine Coordination Centre
MINNS	Marine invasive non-native species
MMO	Marine Mammal Observer
MORL	Moray Offshore Renewables Limited
MPCP	Marine Pollution Contingency Plan
MS-LOT	Marine Scotland Licensing Operations Team

Acronyms	
Acronym	**Expanded Term**
O&M	Operations and Maintenance
OfTI	The Offshore Transmission Infrastructure. The OfTI includes the transmission cable required to connect the Wind Farm to the OnTI. This covers the OSPs and the cable route from the OSPs to the MHWS at the landfall site
OSP	Offshore Substation Platform
PAM	Passive Acoustic Monitoring
PON	Petroleum Operations Notices
PC	Principal Contractor
PM	Project Manager
QHSSE	Quality, Health, Security, Safety and Environment
RA	Risk Assessment
RAMS	Risk Assessments Method Statement
ROV	Remotely operated vehicle
TAS	Transportation Audit Sheet
UXO	Unexploded Ordnance
WFD	Water Framework Directive
WTG	Wind Turbine Generator

Glossary of Terms	
Term	**Expanded Term**
Consent Conditions	The terms that will be imposed on Moray West under any future S36 Consent and Marine Licence Consents granted for the Development, that must be fulfilled throughout the period that the Consent is valid
Contractor	Contractor to the Principal Contractor or Moray West
Corrective action	Action to eliminate the cause of a detected non-conformity
Development	The Wind Farm and the OfTI
EIA Report	The Environmental Impact Assessment Report submitted to the Scottish Ministers by Moray West in support of the the Development
Environment	Surroundings in which a development operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelation
Environmental impact	Any change to the environment, whether adverse or beneficial, wholly or partially resulting from a development's environmental aspects
Environmental incident	An undesired event with possible significant environmental impact(s) as a result
Inter-array cables	The electrical cables that connect the WTGs to the OSPs

Glossary of Terms	
Term	**Expanded Term**
Induction	Formal introduction to the Moray West Project and associated safety, health and environmental requirements
JNCC	Joint Nature Conservation Committee
Landfall site	The point above MHWS between Findlater Castle and Redhythe Point on the Moray Coast, where the OfTI export cable connects to the OnTI
Licensee	Moray Offshore Windfarm (West) Limited
Marine Coordination	The management and surveillance of people, vessels and offshore structures to ensure the safe preparation and execution of offshore activities, in order to minimise the probability of an incident, and to provide effective response if an incident does occur
Marine Licences	Written consents granted by the Scottish Ministers under Part 4 of the Marine (Scotland) Act 2010 and under Part 4 of the Marine and Coastal Access Act 2009
Moray West	Moray Offshore Wind Farm (West) Limited
Moray West Site	Area of wind farm boundary
On-site	On-site means within the boundaries of the Wind Farm and OfTI as defined within the Section 36 Consent and the Marine Licences
Principal Contractor (PC)	The organisation appointed for the management of the construction phase under the CDM Regulations
Project	The Development (Moray West Offshore Wind Farm and Moray West OfTI) and the Moray West OnTI.
Toolbox talk	A short presentation given to Project team members on an aspect of environmental management
Training records	Records to demonstrate that required training has been provided
Wind Farm	The offshore wind farm as assessed in the EIA Report including wind turbines, their foundations, inter-array cabling and meteorological mast

1 Introduction

1.1 Background

Moray Offshore Windfarm (West) Limited (known as 'Moray West') is promoting the development of the Moray West Offshore Wind Farm and associated Moray West Offshore Transmission Infrastructure (OfTI) (hereafter referred to jointly as 'the Development').

This document has been produced to support the Offshore Environmental Impact Assessment (EIA) Report (Offshore EIA Report) which has been prepared on behalf of Moray West in support of the following consent applications to construct and operate the Development:

- Section 36 Consent under the Electricity Act 1989; and
- Marine Licences as required under the Marine and Coastal Access Act 2009 and the Marine (Scotland) Act 2010.

It is assumed that the Licensing Authority, in this case Marine Scotland Licensing Operations Team (MS-LOT) on behalf of the Scottish Ministers, will attach to any future consents granted for the project a condition requiring that an Environmental Management Plan (EMP) be submitted, for approval, prior to the commencement of construction. The overall aim of this draft EMP is to provide the overarching framework for environmental management during the construction of the Development that would be sufficient to satisfy the anticipated requirements set out in any future Section 36 Consent and Marine Licence conditions.

1.2 Objectives of this Document

The purpose of this Draft EMP is to provide the overarching framework for on-site environmental management during construction and operation of the Development. The Draft EMP will set out Moray West's approach to managing and mitigating environmental risk associated with the construction and operation of the Development.

The EIA Report sets out the potential environmental sensitivities associated with the Development that will need to be considered prior to the commencement of construction. The potential effects are presented in the Offshore EIA Report, alongside embedded mitigation and further mitigation as required. Good industry practice will be implemented by all contractors and personnel engaged on the Development as a minimum standard.

This Draft EMP will set out the Development specific environmental management framework and procedures that will be followed by Moray West personnel, the Principal Contractor(s) (and their Subcontractors) and Moray West's Environmental Clerk of Works (ECoW) during the construction of the Development, in accordance with the commitments set out in the EIA Report. It also details the principles that will be applied by the Principal Contractor in formulating their own plans and requiring their Subcontractors to comply with these plans, and by which the commitments made by Moray West in respect of environmental management and mitigation will be practically implemented by Moray West personnel, Principal Contractors and Contractors during construction.

The over-arching environmental management measures detailed within this Draft EMP will also extend into the operational phase of the Development. The EMP will be amended and revised to take into account any specific environmental management measures associated with Operations and Maintenance (O&M) activities as detailed under Section 1.5.

The final EMP will make reference to any relevant Section 36 and Marine Licence conditions attached to Consents granted for the Development to demonstrate compliance with the requirements of the conditions. The Draft EMP will be submitted to MS-LOT in advance of construction works commencing so that the relevant consent conditions can be formally discharged.

The Development will be constructed and operated at all times in accordance with the environmental management framework set out in the approved EMP.

1.3 Linkages with Other Consent Plans

It is anticipated that any future consents granted for the Development will require a number of consent plans to be submitted to the Scottish Ministers (Marine Scotland Licensing Operations Team, MS-LOT) for approval prior to the commencement of construction. This Draft EMP will therefore form part of a suite of documents that will be submitted to MS-LOT. The Final EMP will aim to avoid duplication of information where presented in other consent plans. Information presented herein may therefore be removed and appropriate cross-referencing inserted as required. Details presented in the Final EMP will be consistent with information presented across the suite of consent plans as far as is practicable.

1.4 Structure of this EMP

Table 1.4.1 below sets out the structure of this Draft EMP.

Table 1.4.1: Draft EMP Structure

Section		Summary of Contents
1	Introduction	Background to consent requirements and overview of the EMP scope and structure; Identifies those other Consent Plans relevant to the environmental management process and the linkage between those plans and the EMP; and Sets out broad Moray West approach to updating this EMP and statements of compliance.
2	Scope of the EMP	Summary of the scope of environmental management and mitigation measures addressed by this EMP.
3	Project Description	Provides an overview of the Development and an overview of the construction program key milestone dates.
4	Environmental Management Framework	Describes the environmental management framework associated with construction of the Development. It provides information on the implementation of the EMP.
5	EMP Roles and Responsibilities	Sets out the roles and responsibilities of key personnel and the reporting procedures associated with the implementation of the EMP.
6	Environmental Management and Mitigation Measures	Sets out the specific environmental management and mitigation measures that will be implemented by Moray West personnel and their Principal Contractor and Subcontractors.

1.5 Updates and Amendments

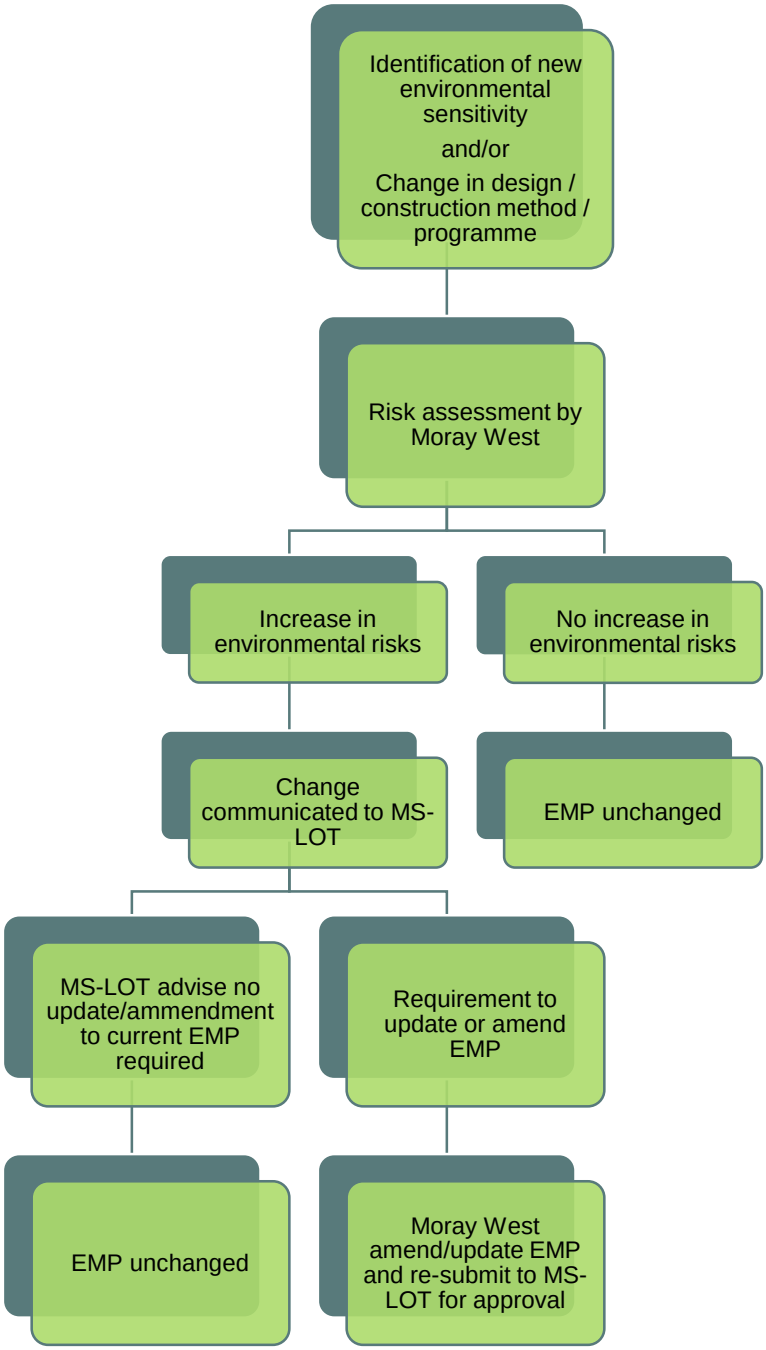
Updates to this EMP may be required due to changes to the proposed construction methodology (that require additional management or mitigation measures or changes to measures already proposed), new environmental sensitivities identified by monitoring prior to construction or following construction, emerging guidance or new legislative requirements.

Where it is necessary to update this EMP, Moray West propose to use the change management process set out in Figure 1.1 in identifying such information, communicating such change to MS-LOT, re-drafting the EMP, seeking approval for the necessary amendments or updates and disseminating the approved changes/amendments to responsible parties.

In addition, the approved EMP will be updated and amended three months prior to final commissioning of the Development setting out the environment management framework that will be applied throughout the operational lifecycle of the Development (but excluding decommissioning).

The operational EMP will reflect the working practices and potential environmental management issues relating to Operations and Maintenance (O&M). The updated EMP will focus on the activities associated with O&M of the Development and incorporate any findings or lessons learned during the construction phase.

Figure 1.1: Proposed Change Management Procedure



1.6 Statement of Compliance

Moray West, in undertaking the construction of the Development will ensure compliance with this EMP as approved by MS-LOT (and as updated or amended from time to time following the procedure set out in Section 6 of this EMP).

Where updates or amendments are required to this EMP, Moray West will ensure the MS-LOT are informed as soon as reasonably practicable and where necessary the EMP will be updated or amended (see Section 1.5 above).

Moray West, in undertaking the construction of the Development will ensure compliance with the environmental mitigation and management set out in the original application and the EIA Report. An EIA Report Commitments Register will be amended to this EMP prior to implementation (see Section 6.2).

Moray West will ensure compliance with overarching Moray West company, EDP Renewables UK Ltd systems and standards, the relevant EDP Renewables UK Ltd legislation and such other relevant legislation and guidance designed to ensure the safety of construction personnel and other third parties (see also Section 4 of this EMP).

Moray West will ensure that compliance with the approved EMP (and all other relevant, approved Consent Plans) is made a requirement for the Principal Contractor and Contractors through conditions of contract and will monitor compliance through appropriate processes (see also Section 5 of this EMP).

1.6.1 Legislative Requirements

Moray West will, in undertaking the construction of the Development, ensure compliance with all relevant legislation and that all necessary licences and permissions are obtained by the Principal Contractor and Contractors, through conditions of contract.

Moray West will, in undertaking the construction and operation of the Development, ensure compliance with all relevant legislation and that all necessary licences and permissions are obtained by the Principal Contractors and Subcontractors prior to the commencement of works, through conditions of contract and by an appropriate auditing process. Moray West will comply, and require that its Principal Contractor and Contractors comply, with the requirements of relevant environmental and maritime legislation as standard.

A range of environmental related legislation applies to the project covering:

- General consenting;
- Environmental assessment;
- Waste and discharges;
- Decommissioning;
- Physical Presence; and
- Pollution Control.

A register of legislation relevant to on-site environmental management and this EMP is presented in Annex 4.1A.

2 Scope of the Plan

This EMP is for use by those parties involved in the pre-construction and construction activities associated with the Development. The EMP covers, in line with industry standards and good practice, the following:

- The roles and responsibilities of key project personnel with respect to environmental management;
- Mechanisms for reporting to the MS-LOT and stakeholders on environmental issues and compliance with the EMP;
- Mitigation measures to prevent adverse impacts to environmental interests in accordance with the application;
- Pollution prevention measures;
- Chemical usage measures;
- Measures to prevent the introduction of marine non-native invasive species;
- Waste management measures;
- Measures to minimise the risk to marine animals;
- Measures to minimise the risk to marine archaeology;
- Management measures pertaining to transporting and supply of equipment and materials;
- Measures to minimise the environmental risk associated with Unexploded Ordnance (UXO); and
- Notifications of dropped objects.

The following aspects are not covered by this EMP:

- Other offshore surveys or works;
- Other onshore surveys or works;
- Any post-construction related activities (excluding environmental monitoring);
- Any operation and maintenance related activities;
- Any decommissioning related activities; and
- Any activity requiring a permit to work (e.g. permit to work in enclosed space).

3 Project Description

3.1 Overview

The Development boundary is shown in Figure 3.1. The boundary encompasses:

- The Moray West Offshore Wind Farm Site. This is where the offshore wind farm will be located, which will include the Wind Turbine Generators (WTGs), WTG foundations and substructures, inter-array cables, up to two Offshore Substation Platform(s) (OSP(s)), OSP interconnector cables and to the extent located within the Moray West Offshore Wind Farm Site, the offshore export cables.
- The Moray West Offshore Export Cable Corridor. This is where the offshore export cables will be located.

The Development is located on the Smith Bank in the Outer Moray Firth, approximately 22.5 km from the Caithness coastline. The Wind Farm Site covers an area of approximately 225 km^2 and the Offshore Export Cable Corridor covers an area of approximately 185 km^2.

The Development will comprise of WTGs and all infrastructure required to transmit the power generated by the WTGs to shore, where the Moray West OnTI will then transmit it to the national grid network electricity transmission system (NETS) via the Project's ultimate grid connection location at Blackhillock in Moray.

The key components of the Development will be as follows:

- Up to 85 offshore WTGs;
- Up to two OSPs;
- Substructures and associated seabed foundations (for WTGs and OSPs);
- Subsea inter-array cables linking individual WTGs within each other and linking strings of WTGs with the OSPs;
- Subsea interconnector cables linking OSPs (two OSPs are installed);
- Subsea export cables running from the OSPs to shoreline landfall;
- Scour protection around substructures and cable protection (if required); and
- Monitoring equipment, such as metocean buoys (if required).

It is currently planned that construction of the Development would commence in 2022 and end in 2024, spanning 36 months. Site investigation and seabed preparation would take place prior to 2022. Timescales are subject to Moray West securing a route to market through the Contract for Difference (CfD) process.

Figure 3.1 provides an indicative layout of the WTGs and the OfTI corridor.

Figure 3.1: Location of the Development

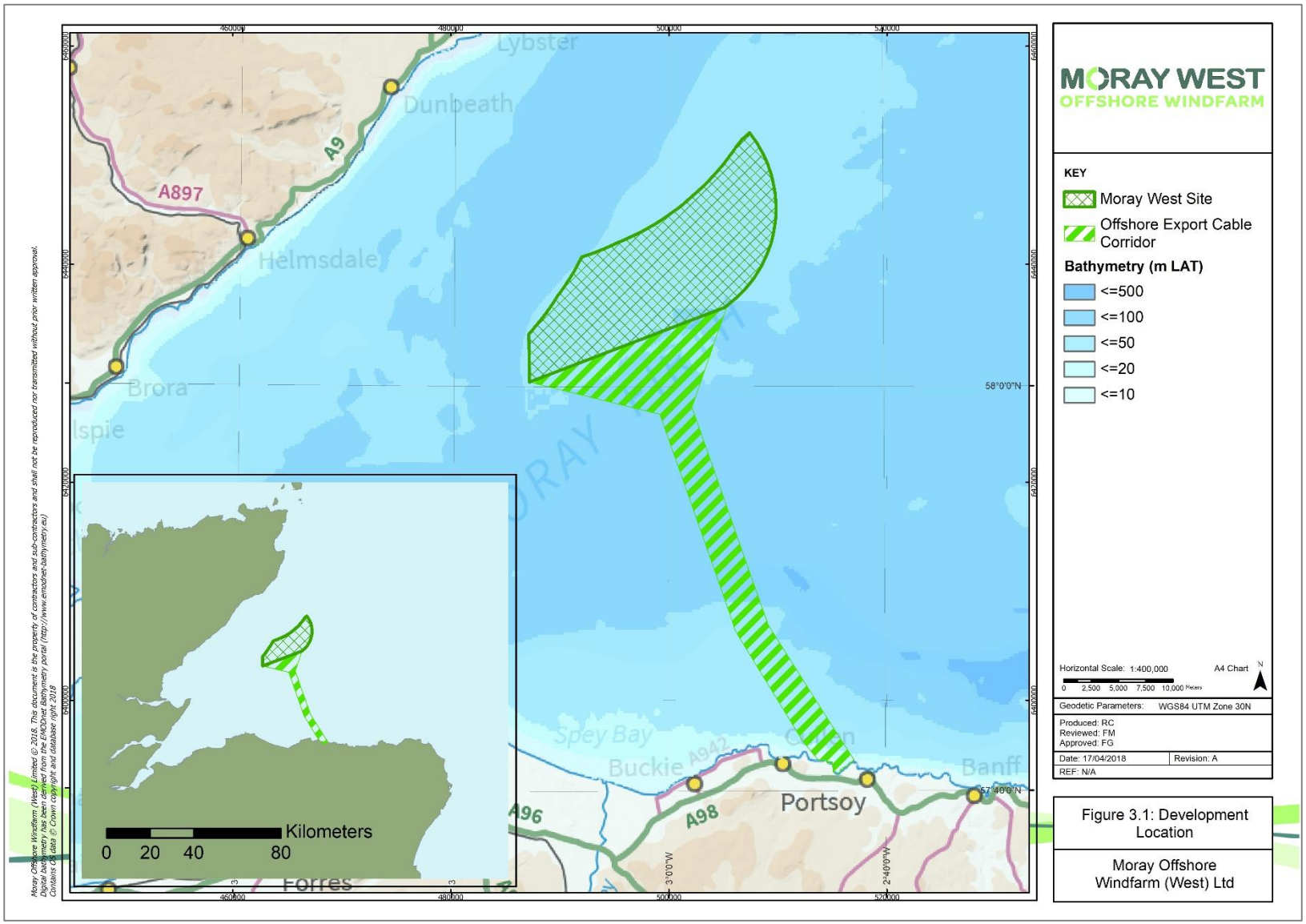
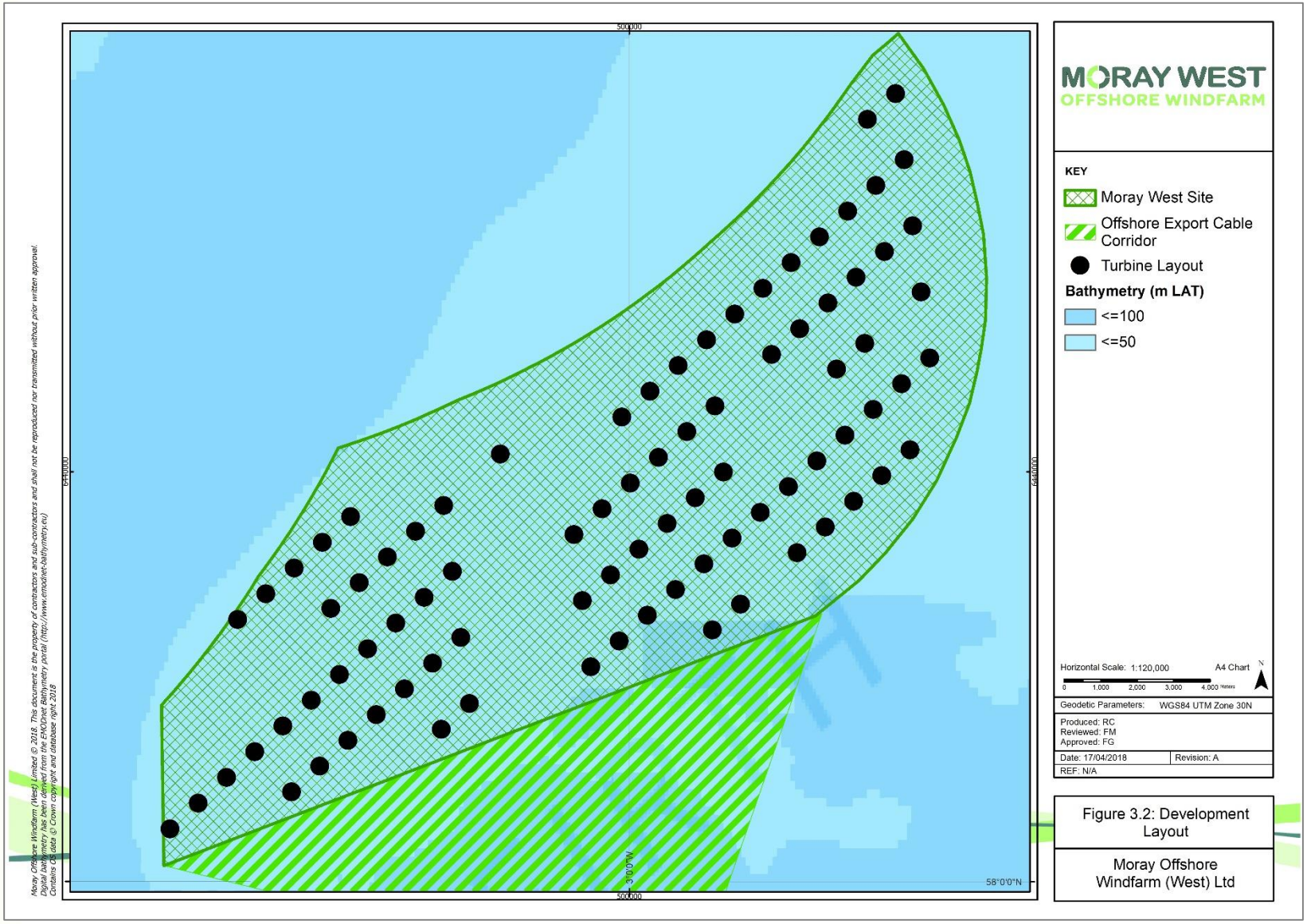


Figure 3.2: Indicative Layout of the WTGs and OfTI Corridor



3.2 Construction Programme

An indicative construction schedule for the Development is shown in Figure 3.3. The order in which the sites will be constructed has not yet been determined.

Figure 3.3: Indicative Construction Programme

	2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Offshore Construction Commencement												
Piling (only applicable to piled foundation solution)												
Substructure Installation												
Inter Array Cable Installation												
OSP Installation												
Export Cable Installation												
WTG Installation												
1st Generation												

4 Environmental Management Framework

4.1 Introduction

This section sets out the overarching company environmental management framework for the Moray West Offshore Wind Farm and OfTI, under the following areas:

- Moray West Health, Safety and Environment (HSE) Charter;
- EMP personnel competency;
- EMP training;
- EMP document circulation and management; and
- EMP monitoring and review of performance.

4.2 Moray West Health, Safety and Environment (HSE) Charter

Moray West has a Project HSE Charter which summarises the core HSE values and behaviours to which all personnel must adhere. The Principal Contractor and Contractors shall be required to be aware of the Moray West project HSE commitments and sign an acknowledgement of compliance with the Moray West Project HSE Charter.

In line with the policy, the HSE Charter and industry practice, all working on the project (staff and contractor) are empowered to 'stop the job', if they believe there is an immediate risk of harm to people or the environment.

As another demonstration of leadership, Moray West promotes the use of HSE observation cards on all project sites and activities. This is to encourage a culture of openness and proactivity, ensuring that conditions and acts which could cause harm to people or the environment are understood and rectified, and that positive behaviours are recognised.

In accordance with the Moray West HSE Charter, the Draft EMP will assist in meeting the following Project environmental objectives:

- Zero spills to sea;
- Zero High Potential Incidents;
- All personnel working on the project shall have a Risk Assessment for every task, which addresses environmental risk; and
- Compliance with all applicable legislation, licences and conditions.

4.3 EMP Personnel Competency and Training

4.3.1 Moray West Project Staff Environmental Competence

Moray West is committed to ensuring environmentally competent staff are employed to support the delivery of this EMP. This is achieved through the implementation of the Moray West Competency Management Procedure.

All Moray West roles are required to satisfy a series of minimum competency requirements (skills knowledge and experience), people are matched to those roles based on the extent to which they meet those requirements. On an annual basis, the Moray West QHSSE Manager and HR Manager will take the results of ongoing performance and potential appraisal processes and conduct a gap analysis. This gap analysis forms the basis of ongoing training and incorporates element of environmental competency.

4.3.2 Moray West Contractor Environmental Competence

Moray West will assess overall competence and suitability of all contracted individuals and organisations prior to the award of Contracts.

As part of the selection process, Moray West will select consultants and contractors that exhibit a good understanding of environmental management and risk within their tenders. Potential contractors will be required to complete a prequalification QHSSE Questionnaire and are subject to ongoing performance review and periodic reassessment depending on the duration of their scope of work. Contractors will be required to demonstrate that they operate an Environmental Management System (EMS) appropriate to their scope of work. ISO 14001 is used as a benchmark, but if a contractor can justify an alternative, but equivalent, standard, then this is accepted. They must also maintain the status of their EMS for the duration of the works. It is required that consultants or contractors ensure that sub-contractors have a good understanding of environmental management and risk.

Where key personnel of the Principal Contractor(s) who perform a significant environmental role (e.g. construction manager) are changed or replaced, Moray West will request evidence that the Principal Contractor has undertaken a review of their environmental competence for that role.

4.4 Training

4.4.1 Induction Requirements

Moray West shall ensure that the EMP's contents are included in the inductions of all Moray West personnel and Principal Contractor(s) prior to them undertaking works on site.

The Principal Contractor and their Contractors shall ensure that all employees, sub-contractors, suppliers, and other visitors to the site are made aware of the content of the EMP where it relates to their scope of works. This may be delivered as part of a larger site induction. The induction process shall include an assessment to verify that key information has been successfully conveyed to inductees.

Regular updates on site or task specific environmental commitments shall be undertaken through the use of toolbox talks (as set out in Section 4.4.2 of this document).

Inductions to the site shall include (as a minimum):

- Identification of specific environmental risks associated with the work to be undertaken on site by the inductee;
- Identification of specific environmental risks which relate to specific areas of the Development site;
- Any site, time or task specific mitigation that is required in order to comply with commitments made in the EIA Report or consent documents;
- Summary of the main environmental risks at the site as identified during the pre-construction surveys;
- Role of the ECoW and contact details;
- Environmental Incident and Emergency Response Procedures; and
- Any other relevant information.

The induction contents shall be shared with Moray West and the ECoW prior to the commencement of works for review and input. The ECoW may request to be involved in the delivery of the site induction.

4.4.2 Toolbox Talks

The Principal Contractor and Contractors will be required to deliver toolbox talks on environmental matters on a regular basis. A record of all toolbox talks, their content and the attendees will be maintained and recorded.

The ECoW shall support the delivery of Toolbox talks and provide specialist input as required/requested.

Where there has been a problem or deterioration in environmental performance, the Principal Contractor and their Contractors shall increase the frequency of toolbox talks.

4.5 EMP Document Management

The approved EMP will be a controlled document and will be formally issued to the Principal Contractor and Contractors.

A current copy of the EMP will be held at the locations stated in Section 1.4: Plan Locations. Moray West will ensure that MS-LOT are provided with the most up to date copy of the EMP.

A register of document versions and issue dates will be maintained by Moray West.

4.5.1 Plan Locations

Copies of this EMP will be held in the following locations:

- Moray West Head Office;
- At the premises of any agent, Principal Contractor and Contractors acting on behalf of Moray West;
- All site offices dealing with marine operations;
- The Moray West Marine Coordination Centre; and
- With Moray West's ECoW.

4.6 Continual Improvement and Monitoring of the EMP Performance

As part of the Moray West EMS, there is a commitment to continual improvement of the EMP and its implementation. Moray West will prepare and implement an audit plan to assess the effectiveness of and compliance with the EMP. The program will cover the company's own and contractors' implementation of the EMP. Corrective and preventive actions raised during audits (to address non-conformances, non-conformities or other issues) will be tracked and the management will approve action close out. Audits will be organised by the QHSSE Manager with support from the project ECoW with regards to the MPCP and EMP (See Section 5: Roles and Responsibilities).

Further monitoring and review arrangements will ensure the compliance of activities with applicable laws and authorisations. The objectives of audits are to ensure:

- Periodic assessments are undertaken to confirm that the EMP processes are being implemented as planned and are effective. This will involve both internal assessments and, where appropriate, external assessments;
- All contractors and sub-contractors are complying with the EMP and with any relevant statutory provisions;
- The EMP standards are appropriate and are being used as intended;
- Line management can identify EMP shortcomings, identify remedies and improvements through effective follow-up procedures;

- An annual management review of the EMP is carried out to identify and implement necessary improvements; and
- The findings and corrective actions from these audits and reviews are prioritized, tracked and used to systematically improve the performance and processes of Moray West.

Contractors should ensure that a copy of calibration tests and certificates are presented to Moray West where relevant and records of survey results and environmental performance are freely available when requested.

The timing of environmental audits will be agreed between the Package Manager and the Principal Contractor. The Principal Contractor will be responsible for discussing and agreeing the results of the audits with the QHSSE Manager and ECoW as relevant, prior to any debrief with the Package Manager. The contractor will be provided with a written record of the findings of any audit carried out**.** A duplicate will be maintained within the Moray West database.

The Principal Contractor is required to contact the Package Manager as soon as practicable and within 24 hours should any environmental incident occur.

5 EMP Roles & Responsibilities

This section sets out the roles and responsibilities of all relevant Development personnel during the construction phase, in relation to the delivery of this EMP.

It is anticipated that future consents would require the appointment of certain specialist environmental roles to oversee the construction of the Development, including an ECoW and a Fisheries Liaison Officer (FLO). The ECoW role is central to the implementation of the EMP and is further described below.

Moray West shall always ensure that the Principal Contractor and Contractors have sufficient resources of the required competence to meet the contractual and environmental requirements.

Table 4.6.1 sets out the roles and responsibilities of key personnel that will be involved in the delivery of the EMP.

Table 4.6.1: Anticipated Key Moray West Roles and Responsibilities

Moray West Role	Summary of Responsibilities
Moray West Project Director	Overall responsibility for environmental performance of the maintenance works; and Overall responsibility for legal and consenting compliance.
Moray West Offshore Consents Manager	Primary contact for MS-LOT, Moray Firth Regional Advisory Group (MFRAG) (This document assumes that MFRAG will remain in existence as a forum for sharing / agreement of post-consent environmental management and monitoring), statutory bodies and stakeholders (excluding the responsibilities undertaken by Moray West ECoW); Managing Moray West's ECoW reporting on compliance with consent conditions to MS-LOT; Where necessary, managing the process of obtaining new Project consents (if a result of Moray West originated activities) or monitoring consent applications made by Key Contractors (if a result of Key Contractors (or their Subcontractors) originated activities); Attendance at meetings, providing environmental input; Reviewing Key Contractor documentation (e.g. method statements and risk assessments, EMPs) to ensure compliance with the Moray West EMP and associated Annexes; Managing the Moray West FLO and Archaeological Consultant; and Reporting to MS-LOT and MFRAG in respect to the PEMP.
Moray West Environmental Clerk of Works (ECoW)	Quality assurance of final draft version of the EMP; Provide advice to Moray West on compliance with consent conditions; Monitor and report on compliance; and Help induct site personnel on site / works environmental policy and procedures.
Moray West QHSSE Manager	Writing and maintenance of the EMP; Review and assessment of all method statements; Ensure environmental risks from installation works are reduced to as low as reasonably practicable (ALARP); Legal compliance reviews; Ongoing project environmental performance monitoring; Reporting of incidents; Complete a Pollution Incident Report for all spillages; Onshore Emergency Response Coordination; and Improvement Management.

Table 4.6.2: Anticipated Key Moray West Roles and Responsibilities	
Moray West Role	**Summary of Responsibilities**
Moray West Project HSE Manager	Day-to-day contact with Principal Contractor and Contractors; Collation of performance data; Inspection and Audit; Incident Investigation; Client Focal point for deposits, chemicals, transport, waste, and equipment; Emergency Response; and Liaison with marine coordination centre.
Moray West HSE Design Manager	Support with any ongoing design process and ensuring environmental risks are addressed.
Package Managers	Responsible for ensuring that sufficient resources and processes are in place across their work package to deliver/comply with the EMP and to manage potential environmental impacts; Ensuring that provision is made for environmental management issues to form part of construction progress meetings and Project inductions; Ensuring that all construction personnel and contractors assist and support the ECoW where required, for example during on-site monitoring and audits; Ensuring that any corrective actions arising from environmental audits are addressed; Establishing contractual obligations for Principal Contractors and subcontractors in relation to EMP; and Addressing Principal Contractor and Subcontractor non-compliance.
Vessel Auditors	Assessment of vessel biosecurity arrangements
Fisheries Liaison Officer (FLO)	Establishing and maintaining effective communications between Moray West, any contractors or sub-contractors, fishermen and other users of the sea concerning the overall project and any amendments to the CMS and site environmental procedures; Provision of information relating to the safe operation of fishing activity on the site of the Development when possible; and Ensuring that relevant project information is made available and circulated in a timely manner to minimise interference with fishing operations and other users of the sea
Offshore Fisheries Liaison Officer	Duties similar to above but based offshore on a project vessel
Marine Coordinator	Responsible for the management and surveillance of people, vessels and offshore structures to ensure the safe preparation and execution of offshore construction activities and monitor the Construction Design Management (CDM) area.

5.1 Principal Contractor Responsibilities

The Principal Contractor and contractors will be required to adhere to all aspects of environmental management as set out within this Draft EMP. As a minimum the Principal Contractor's responsibilities will include the following:

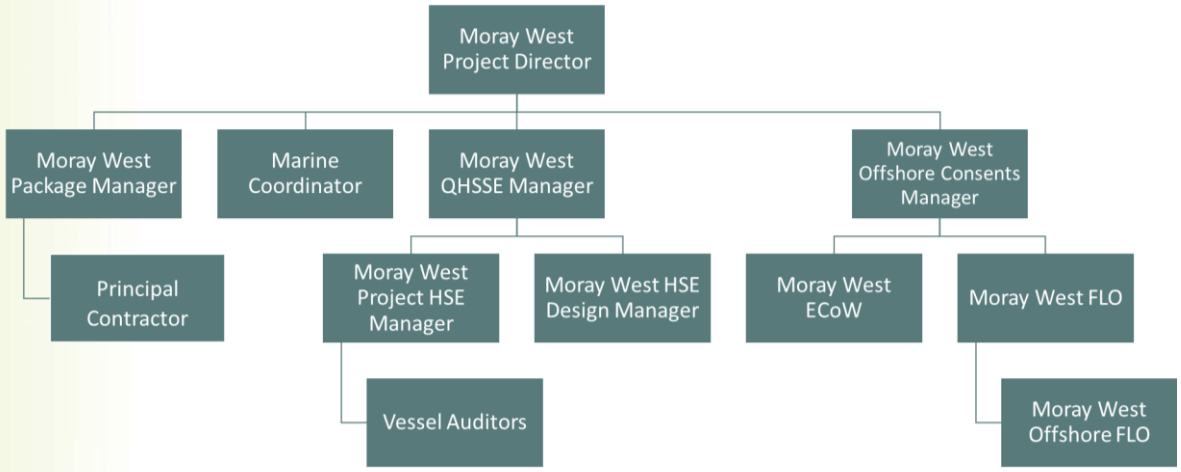
- To ensure that their own procedures, and those of any subcontractors, encompass and fully discharge the mitigation and management measures and commitments presented in this EMP;

- To ensure environmental risks from works are reduced to ALARP (as low as reasonably practicable);
- To ensure that sufficient resources and processes are in place to deliver/comply with the EMP and manage potential environmental impacts;
- To ensure that they regular report on HSE to the Moray West management team;
- To be responsible for implementing and discharging the required mitigation (control) measures on site on behalf of Moray West;
- To develop a contractor-specific EMP, using this overarching EMP and associated Annexes as guidance, for Moray West review and comment;
- To comply with the requirements of the Moray West overarching EMP as a minimum standard and look to include additional mitigation measures where appropriate;
- To ensure that the Moray West EMP is implemented by reviewing task specific Method Statements and Risk Assessments to ensure consistency and compliance;
- To ensure that Subcontractors adhere to the requirements of the overarching Moray West EMP and the Principal Contractor EMP and Method Statements;
- To be responsible for the dissemination of information from the Moray West management team or ECoW to anyone working on or visiting site.
- To produce and maintain records of activity on site and communicate those to the ECoW to enable reporting of compliance to MS-LOT; and
- Liaison with the Moray West ECoW and facilitating the ECoW in the fulfillment of their responsibilities.

5.2 EMP Lines of Communication

Figure 5.1 provides an indicative organisational structure and the anticipated lines of communications between key personnel.

Figure 5.1: Indicative EMP Lines of Communications



5.3 EMP Communications and Reporting

5.3.1 Moray West Internal Communications

There is a range of opportunities for the exchange and sharing of project environmental information. These include:

- Project and company inductions;
- Moray West Team Meetings – HSE is a fixed agenda item;
- Moray West Project Meetings – HSE is a fixed agenda item;
- Moray West HSE Meetings – Moray West holds regular HSE-specific meetings with staff to ensure that people are able to raise concerns and get feedback on ongoing matters;
- Site Meetings – HSSE is a fixed agenda item;
- Monthly HSE Promotions – every month there is a fresh HSE theme for promotion and discussion;
- Monthly HSE Reports – every month a full report of all project HSE leading and lagging indicators is prepared and shared with the team; and
- Task/area specific HSE tool-box talks – these will be held before tasks with specific HSE and/or mitigation are undertaken.

5.3.2 Moray West ECoW and Communications

The ECoW plays a key role in the delivery of the EMP. In fulfilling this role, the ECoW shall:

- Establish direct contact with Contractors, Subcontractors, the Archaeological Consultant and FLO when required;
- Provide support to the West QHSSE Department and Development Team;
- Report directly to MS-LOT on compliance with the EMP;
- Provide input to inductions which will include communicating key messages of the EMP;
- Work with contractors and Moray West QHSSE to establish practical environmental communication and reporting protocols that ensure sufficient information for compliance reporting is acquired; and
- Work with the Moray West Development Team to liaise with MS-LOT and other stakeholders on environmental management matters.

In practice, the ECoW will spend time at site (only offshore as required) and will be available to all personnel involved when needed. They will be in regular contact with the Moray West Client Representatives offshore.

The ECoW will establish communication channels with key personnel, including Moray West QHHSE team, Marine Coordination team, onboard Client Representatives and Contractors (as appropriate). The ECoW will be available to support these teams as required.

5.3.3 Moray West, Principal Contractor and Subcontractor Communications

During the construction of the Development, HSE shall be a standing item in all project meetings and shall be part of established daily reporting when offshore. The offshore client representative and Principal

Contractor will be responsible for providing Daily Progress Reports (DPR) to the Moray West HSE team and ECoW (who would then ensure that MS-LOT received details as appropriate).

The Principal Contractor and their Contractors shall define their arrangements (schedule, frequency etc.) for progress reporting in their respective EMPs.

5.3.4 External Communications

Table 5.3.1 sets out the reporting arrangement that will be used to provide the MS-LOT and relevant stakeholders with regular reporting on construction activity, including any environmental reporting data and any issues that have been encountered, and how these have been addressed.

Table 5.3.1: Anticipated External Communications

Report	Proposed frequency	Relevant stakeholder
ECoW Compliance reporting, including construction progress and agreed environmental reporting criteria.	Monthly summary with Quarterly Reporting	MS-LOT
Moray West and ECoW Meetings with MS-LOT	As Required	MS-LOT
Moray West Consenting updates	As Required	MFRAG and other key stakeholders
Incident Reporting (including accidental discharge of pollutants)	As Required	MS-LOT
Substance Deposits	As required	MS-LOT
Planned discharge of chemicals (if required).	As required (in advance of discharge)	MS-LOT
Force Majeure	As required	MS-LOT
Materials Transportation and Material Alterations	Monthly	MS-LOT
Moray Firth Offshore Wind Developers Group – Commercial Fisheries Working Group (MFOWDG-CFWG) (or similar as may be required by condition attached to any future consents)	As required	MS-LOT/SFF/Offshore Wind Developers
Notice to Mariners	Fortnightly	Kingfisher Bulletins

5.4 Incident Reporting

Moray West is committed, through its Environmental Policy, to quick action and a proactive approach to learning in response to environmental incidents. In order to achieve this, prompt reporting of all environmental incidents is expected from all individuals and organisations. This is in addition to any legal or statutory reporting requirements or other recognised industry best-practice. Depending on the level of potential and/or actual impact, rapid escalation of the incident through the Moray West and partner organisations may be required. Formal reporting criteria and guidance will be developed as roles are defined.

6 Environmental Management and Mitigation Measures

6.1 Introduction

This section of the EMP represents the management and mitigation measures and has been prepared to satisfy compliance with the anticipated consent conditions for the Development.

6.2 EIA Report Commitments Register

A commitments register will be compiled detailing all the environmental management and mitigation measures relevant to the construction phase of the Development detailed within the Moray West Offshore EIA Report. The commitments register will be cross-checked against the EMP and, where relevant, the suite of other consent plans to ensure that all environmental management measures are implemented as detailed within the application documents. The final EIA Report Commitments Register will be submitted as an Annex to this EMP and will signpost to where each commitment is addressed within the relevant consent plan.

6.3 Marine Pollution and Contingency Planning

A project Marine Pollution Contingency Plan (MPCP) will be produced setting out provisions in respect of spills and collision incidents that have the potential to occur during the construction the Moray West Offshore Wind Farm and OfTI. The contents of the MPCP include:

- Sources of Potential Pollution;
- Roles and Responsibilities;
- Agencies and Organisations;
- Incident Reporting including statutory and Development-specific notifications; and
- Spill Response procedures.

The MPCP will take into account existing plans for all operations, including offshore installations that may have an influence on the implementation of Moray West.

The Principal Contractor and Contractors shall comply with the requirements of the MPCP and ensure their own arrangements are aligned.

In accordance with Maritime and Coastguard Agency (MCA) guidelines, during construction the focus will be on prevention and avoidance of contingency situations through risk identification and management, and through stringent controls being put into place (e.g. where refuelling at sea has to take place, this shall be done according to industry standards).

However, if an incident occurs the emphasis will shift to marine pollution control to minimise the discharge and to mitigate its effects. There will be products, systems or services for controlling, cleaning up and minimising marine pollution, e.g. oil absorbents and booms, pollution prevention training, monitoring and clean up services.

The primary aim of this response strategy is to:

- Ensure personnel safety and integrity of the vessels;
- Minimise potential environmental and socio-economic impact and ensure a fast recovery to affected resources;
- Where practicable, utilise the prevailing environmental conditions to complement the response; and

- Utilise pre-planned actions to previously identified incident situations.

The following sections outline management measures that will routinely be implemented, where appropriate to manage and mitigate the risk of accidental release of oil or chemicals.

6.3.1 Bunding and Storage

The Principal Contractors and Contractors shall ensure suitable bunding and storage facilities are employed to prevent the release of fuel oils, lubricating fluids associated with the plant and equipment into the marine environment.

Requirements for bunding and storage shall be written into risk assessment method statements, and the Principal Contractor's and Contractors' own EMPs.

6.3.2 Chemical Usage

The Principal Contractor and Contractors shall provide to the Moray West HSE Manager a comprehensive list of all chemicals to be used in the works (prior to each phase of the works), and notifications of any potential changes to that list. Moray West shall seek agreement from MS-LOT to use the proposed chemicals. Any additional chemicals / amendments to the list will be sent to MS-LOT for approval prior to them being used.

In addition, Moray West will require that all Principal Contractors (and subcontractors) have in place appropriate procedures for the use, transport and storage of chemicals during the construction phase of the Development (as appropriate).

6.4 Management Measures to Prevent the Introduction of Marine Invasive Non-Native Species

Moray West shall ensure that the risk of transferring marine invasive non-native species (MINNS) to and from the Moray Site is minimised by ensuring appropriate bio-fouling management practices are implemented during all construction activities.

The Principal Contractor and Contractors shall ensure that their vessels comply with the requirements set out in the following sections and provide all the suitable documentary evidence, in the form of a Biosecurity Plan, to the Moray West HSE Manager and ECoW one month prior to the vessels entering the site.

Management of biosecurity focuses on three areas:

- Ballast Water;
- Antifouling; and,
- Equipment.

6.4.1 Ballast Water

Vessels contracted to work on the project are required to follow current UK guidance on ballast water management. These include:

- Maritime and Coastguard Agency MGN 363 (M+F): The Control and Management of Ships' Ballast Water and Sediments; and
- Maritime and Coastguard Agency MGN 81 (M+F): Guidelines for the Control and Management of Ships' Ballast Water to Minimise the Transfer of Harmful Aquatic Organisms and Pathogens.

Vessels will also be required to comply with the IMO 1997 guidelines "Guidelines for the Control and Management of Ships' Ballast Water to Minimise the Transfer of Harmful Aquatic Organisms and

Pathogens". In particular, when loading, discharging or exchanging ballast, the vessel will be required to comply with Section 9 of the "Guidelines for the control and management of ships' ballast water to minimise the transfer of harmful aquatic organisms and pathogens" (IMO, 1997).

To demonstrate compliance, Moray West will require the Principal Contractor and Contractors to submit a biosecurity plan that provides evidence of:

- A ballast water and sediment management plan which assists in the minimisation of non-native species through safe and effective procedures for ballast water management (to be provided in UK English);
- Details of any approval by a UK recognised Classification Society of the ballast water and sediment management plan; and
- For vessels with Ballast Water Management (BWM) plan, the relevant certification or declaration.

In addition, the Vessel Masters/Operators will be required to make the Ballast Water Record Book available to the Project HSE Manager and MCC.

6.4.2 Hull Anti-fouling Management

Vessels contracted to work on the project for any purpose will be required to follow current UK guidance on the use of hull anti-fouling systems (AFS). These include:

- The Merchant Shipping (Anti-Fouling Systems) Regulations 2009;
- Maritime and Coastguard Agency MGN 398 (M+F): Merchant Shipping (Anti-Fouling Systems) Regulations 2009; and
- The International Convention on the Control of Harmful Anti-Fouling Systems on Ships 2001.

All certificates, declarations and other relevant documentation should be valid for the contract period. Where the AFS will be renewed during the contracted period of works, details of where and how the system will be renewed (as part of the Biosecurity Plan) should be provided to the Project HSE Manager and ECoW by the Principal Contractor and Contractors. This should include details of how any macro-fouling material and waste-water will be disposed of in accordance with relevant authority biosecurity plans.

6.4.3 Equipment Management Practices

All vessels working on the project shall ensure:

- All equipment for use in the sea at site, is washed with fresh water and cleaned prior to arriving on site but after previous contract has been completed; and
- Where it is not possible to undertake such measures, justification should be provided within their biosecurity arrangements and operating procedures. In all cases, time in air between different water bodies must be allowed to ensure equipment is dry before use on site. Details of the required time periods to ensure equipment is dried must be provided.
- The process for cleaning and disposing of waste water should also be specified

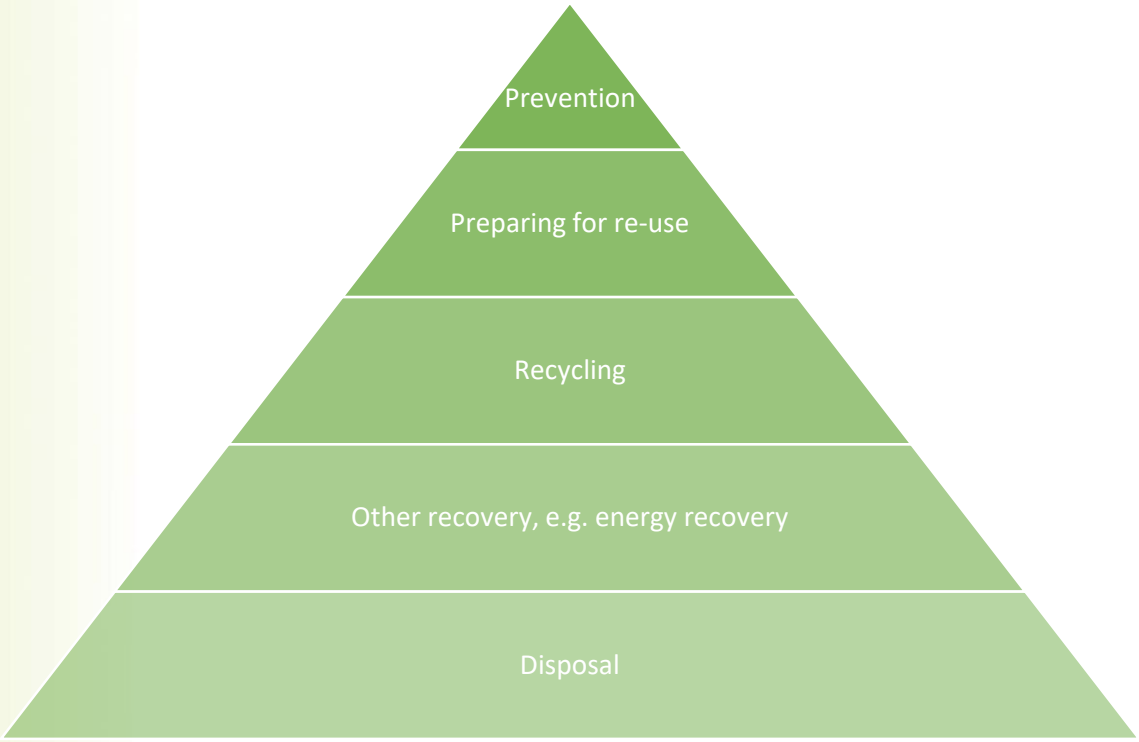
The Principal Contractor and Contractor shall provide information in support of the above to the Project HSE Manager and ECoW.

6.5 Waste Management

6.5.1 Waste Hierarchy

Construction waste generated from the Moray West Offshore Wind Farm and OfTI will be managed according to the principles of the waste hierarchy (Figure 6.1). The waste hierarchy ranks waste management options according to what is best for the environment, giving priority to waste prevention. When waste has been generated, priority is given to preparing it for re-use, then recycling, then recovery, and last of all disposal (for example, landfill).

Figure 6.1: Waste Hierarchy (Source: Scottish Government, 2009)



The waste hierarchy is a key element of sustainable waste management and is a legal requirement of the revised EU WFD and is central to the Waste (Scotland) Regulations 2012.

6.5.2 Waste Prevention

All reasonably practicable measures shall be taken to minimise the amount of waste produced in general and of hazardous waste in particular.

Opportunities to reduce packaging or implement take-back schemes for packaging and unused materials will be discussed with the suppliers. Where possible, hazardous materials will be substituted for less hazardous alternatives.

Waste minimisation measures will be set out in waste management plans and implemented by the Principal Contractors (and their Subcontractors) during construction and operation in order to achieve the waste allowance targets. These measures may include:

- Ordering and using only enough materials required to complete the task;
- Handling and storing materials so as to maximise product life; and
- Ensuring that materials that can be reused are handled to prevent damage.

6.5.3 Re-Use

Opportunities to re-use materials will be investigated as the detailed design progresses.

6.5.4 Recycling

Wastes generated during the construction process will be segregated into waste types to facilitate off-site recycling (for example, metals, wood, and plastic). Sufficient space will be allocated for storage of separate containers of key waste materials. These containers will be clearly labelled and construction staff will be given training on waste segregation.

The Principal Contractors (and their Subcontractors) will consider the use of recycled materials where possible, subject to Moray West approval, cost and availability.

6.5.5 Disposal

All waste that cannot be reused, recycled or recovered will be collected by the licensed waste management contractor and disposed of at a permitted site suitable for the type of waste. Waste generated from offshore activities will be brought onshore for recycling or disposal. Ground food waste will be disposed of at sea in accordance with the Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008.

6.6 Management and Mitigation Measures to Minimise any Effects on Marine Animals

As detailed in Section 1.3, it is anticipated that this EMP will be part of a wider suite of consent plans. It is anticipated that the Consent Plans detailed in Table 6.6.1 will also be a requirement of any future consents for the Development. The Principal Contractor and Contractor will be required to adhere to the provisions set out in the consent Plans in respect of environmental management and mitigation where it is relevant to their scope of works.

Table 6.6.1: Summary of Mitigation Measures to Manage the Risk to Marine Animals Contained within Anticipated Consent Plans

Consent Plan	Summary of Mitigation
Piling Strategy	The Piling Strategy will set out Development-specific mitigation measures to minimise the risk to marine mammals and fish species from underwater noise impacts. The Piling Strategy will be informed by site specific survey environmental and geotechnical survey data.
Vessel Management Plan	The Vessel Management Plan will set out the measures taken to manage and coordinate vessel traffic during construction of the Development. Additional measures to minimise disturbance to marine mammals and birds will be detailed within the consent plan.
Cable Plan	The Cable Plan will set out the arrangements of subsea cabling detailing the environmental constraints and setting out any mitigation measures to minimise effects on habitats and species.

6.7 Management and Mitigation Measures to Minimise Effects on Marine Archaeology

Pre-construction geotechnical and geophysical surveys will be undertaken within the Moray West Site and Offshore Export Cable Corridor following submission of the Application and EIA Report. Data analysis will be completed to identify any anomalies that could be archaeological artefacts with further investigations undertaken as necessary. The findings of this analysis will form the basis of mitigation for marine archaeology. The mitigation may include archaeological exclusion zones, if appropriate, and will detail the protocol for reporting on any archaeological discoveries.

It is anticipated that in the event of discovering an object, the Principal Contractor and Contractors shall inform the project HSE Manager and ECoW within 24 hours. Final reporting procedures will be refined prior to construction. A project specific Protocol for Archaeological Discovery (PAD) or Marine Archaeology Reporting Protocol (MARP) will set out any statutory notifications that will be required. The PAD or MARP will be submitted to MS-LOT for approval prior to the commencement of construction.

6.8 Management and Mitigation Measures to Minimise Marine Unexploded Ordnance (UXO) Risks

Prior to the construction phase there will be a UXO survey and clearance programme, to minimise the risk of encountering UXO during construction.

Nonetheless, in the event of a UXO discovery, the Principal Contractor and Contractors shall inform the Moray West HSE Manager and MCC immediately.

In the unlikely event of needing to detonate a UXO, MS-LOT will be consulted and JNCC guidelines followed and relevant permissions will be sought. This will involve, as a minimum:

- Visual Monitoring by Marine Mammal Observers (MMOs);
- Passive Acoustic Monitoring (PAM);
- Pre-detonation search for marine mammals;
- Delay if marine mammals detected within the Mitigation Zone;
- Sequencing of the explosive charges;
- Acoustic Deterrent Devices (ADDs);
- Post-detonation search; and
- Communication.

The Principal Contractor shall have a contract with a recognised, competent UXO disposal company.

6.9 Environmental Management of Transportation and Supply of Materials

The Principal Contractor and Contractors will be required to complete a Transportation Audit Sheet (TAS) on the first working day of the month, for every month during the Construction period. The TAS will be submitted to the Moray West HSE Manager and will cover all aspects of construction activity.

The TAS will include, as a minimum, the following information:

- Loading facility;
- Vessels;
- Equipment;
- Shipment routes; and
- Schedules of all substances or objects listed in the licence to be deposited.

If the Principal Contractor or Contractors become aware of any substances or objects on the audit sheet that are missing, or an accidental deposit occurs, they will make the necessary notification within 24 hours. It is anticipated that notifications will be made to the Moray West HSE Manager and MCC in the first instance.

Moray West shall contact MS-LOT as soon as practicable after becoming aware, for advice on the appropriate remedial action.

6.10 Notification of Dropped Objects

Notification of dropped objects during the construction or operational phase will be completed using MS-LOT's Offshore Wind & Marine Renewables Dropped Object Form subject to confirmation by MS-LOT.

The equivalent Oil and Gas PON2 (Loss or Dumping of Materials at Sea from offshore Oil and Gas Installations) guidance for dropped objects identifies dropped objects as materials lost or discarded at sea, including any materials deposited under conditions of force majeure, but excluding any materials legally deposited in accordance with the requirements of relevant legislation (Oil & Gas UK, 2014; DECC, 2014). Although small objects dropped into the sea are unlikely to affect the environment and other sea users, it is not possible to set a threshold under which reporting is unnecessary. Instead, operators are advised to apply some common sense as to the lower level of object that is reportable and to report any lost/dropped object if they are unsure of the hazard it might cause.

An example procedure to be followed in the event of any construction or operational staff becoming aware that any object has been accidentally (or by need of Force Majeure) dropped or otherwise deposited is set out below in Table 6.10.1.

A copy of this dropped object procedure and the Dropped Object Notification Pro-forma will be available on all construction and operational vessels; relevant staff will be inducted on the dropped object procedures.

Note that separate provisions apply for the accidental loss of pollutants; these procedures will be set out in a Development MPCP and must be referred to in place of the following (see also Section 6.3 of this EMP).

Table 6.10.1: Dropped Objects Notification and Remediation Process
Introduction
This Dropped Objects Procedure identifies an example of likely measures to be put in place to manage dropped objects during the construction phase of the Development, including recovery where possible, and the recording of losses. This also includes procedures for communicating deposits made under circumstances of Force Majeure. Dropped objects can present a significant hazard to other sea users and the marine environment. Submission of a Dropped Object Notification form enables MS-LOT, in consultation with other relevant stakeholders, to decide what action should be taken and to allow notification of other sea users of any navigational hazards.
Prevention
Consideration should be given to minimising wherever possible the potential for objects to be dropped or otherwise accidentally deposited. The Principal Contractor and Contractors should have its own process for ensuring equipment and materials are adequately stored and controlled and that staff are adequately trained and briefed on avoiding dropped objects or accidental deposits, and in the event that they do occur on this notification procedure. The Principal Contractor and Contractors will be required to complete the TAS to record all materials, equipment and components being loaded and transported and deposited under any licensable activities permitted by future Marine Licences granted to Moray West.
Identification
If the Principal Contractor or a Contractor becomes aware of any substance or objects on the TAS that are missing, or an accidental deposit occurs (for example by personnel observing or reporting that an object has been lost) the responsible Contractor will log the loss as soon as becoming aware of the incident and notify the Marine Coordinator of the incident.

Note that every reasonable measure will be taken to immediately retrieve dropped objects where this is considered reasonably practicable (a Marine Licence is not required for such recovery under The Marine Licensing (Exempted Activities) (Scottish Inshore and Offshore Regions) Amendment Order 2012).
Notification
If the object is not retrieved within 24 hours the Principal Contractor or Contractor will complete a Dropped Object Proforma and submit it to the relevant Moray West personnel, anticipated to be the Project HSE Manager and ECoW. The ECoW will notify MS-LOT by submitting the completed Dropped Object Notification Pro-forma. The completed Pro-forma will, at the same time, be provided to the Scottish Fishermen's Federation, the Maritime & Coastguard Agency, and Kingfisher at Seafish. MS-LOT must also be notified of any activities to recover dropped objects that have been conducted but not been successful (or are considered unlikely to be successful) or that are planned (but may take some time) at the time of notification.
Recovery
MS-LOT will provide advice to Moray West on appropriate remedial action in relation to each incident reported. MS-LOT may deem it necessary to carry out a side scan survey to locate the substances or objects and may require the deposits to be removed by Moray West. The results of any such surveys will be analysed as soon as reasonably possible and the proposed remedial action and proposals for recovery of the Dropped Object will be provided to MS-LOT.
Exemptions from Notifications
The Notification can be delayed in the event that a vessel makes immediate attempts to retrieve the object, and if recovery is successful then notification is not required.

Annex 4.1A: EMP Legislation Register

EMP Legislation Register			
Legislation	**Relevance to Moray West**	**Summary**	Regulatory Body
Consenting			
Electricity Act 1989	Section 36 Consent to generate electricity	To operate generating station within UK territorial waters adjacent to Scotland as defined in The Scottish Adjacent Waters Boundaries Order 1999.	Scottish Ministers, acting through MS-LOT.
Marine (Scotland) Act 2010	Marine Licence to place structures on the seabed Conservation and biodiversity	A framework for the development of a new planning system for the marine area and to ensure greater protection for the marine environment and biodiversity. Applies to a number of activities e.g. removal of materials from the seabed (including structures), deposit of materials during decommissioning, disturbance of the seabed, use of explosives and installation of certain types of cables. For depositing substances or objects and for the construction, alteration or improvement of any works in or over the sea or on or under the seabed (below Mean High Water Springs (MHWS)) including the temporary placement of construction materials and/or disposal of dredged material etc. in Scottish Territorial Waters.	
Marine and Coastal Access Act 2009	Marine Licence to place structures on the seabed Conservation and biodiversity	A framework for the development of a new planning system for the marine area and to ensure greater protection for the marine environment and biodiversity. Applies to a number of activities e.g. removal of materials from the seabed (including structures), deposit of materials during decommissioning, disturbance of the seabed, use of explosives and installation of certain types of cables. For depositing substances or objects and for the construction, alteration or improvement of any works in or over the sea or on or under the seabed (below Mean High Water Springs (MHWS)) including the temporary placement of construction materials and/or disposal of dredged material etc. in Scottish Waters beyond the Territorial Sea (Scottish Offshore Waters).	
Environmental Assessment			
The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017	Requirements for EIA	Transposes portions of the EIA Directive into Scottish law. For any development that comes under sections 36 or 37, application for consent has to be made to the Scottish Ministers. In addition, pursuant to the Regulations, development that is also considered likely to have significant effect on the environment must also be subject to EIA and an	

EMP Legislation Register			
Legislation	**Relevance to Moray West**	**Summary**	Regulatory Body
		Environmental Statement submitted with the application.	
The Marine Works (Environmental Impact Assessment) Regulations 2017	Requirements for EIA	Transposes portions of the EIA Directive into Scottish law.	
Conservation of Habitats and Species Regulations 2010	EC Habitats and Birds Directive	Transpose the requirements of the EC Habitats Directive and EC Birds Directive into national law within Scottish Territorial Waters (up to the 12 nautical mile (NM) territorial waters limit). Provide for the designation and protection of European sites (Special Protection Areas (SPAs) and Special Areas of Conservation (SACs)), the protection of European protected species, and the adaptation of planning and other controls for the protection of European Sites. Consolidation of various amendments to the 1994 Regulations and apply in Scotland to Section 36 applications. Specifies the requirements for a European Protected Species (EPS) Licence.	
Conservation (Natural Habitats, &c.) Regulations 1994	EC Habitats and Birds Directive	Transpose the requirements of the EC Habitats Directive and EC Birds Directive into national law within Scottish Territorial Waters (up to the 12 nautical mile (NM) territorial waters limit). Specifies the requirements for a European Protected Species (EPS) Licence.	
Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007	EC Habitats and Birds Directive	Transpose the requirements of the EC Habitats Directive and EC Birds Directive into national law within Scottish Offshore Waters (beyond the 12 nautical mile (NM) territorial waters limit).	
The Marine Strategy Framework Directive	Management of human activities in the marine environment	Outlines a transparent, legislative framework for an ecosystem-based approach to the management of human activities which supports the sustainable use of marine goods and services. The overarching goal of the Directive is to achieve 'Good Environmental Status' (GES) by 2020 across Europe's marine environment.	
Convention for the Protection of the Marine Environment of the North-East Atlantic (The OSPAR Convention)	Environmental protection	Regulates international cooperation on environmental protection in the North-East Atlantic, including pollution and assessment of marine environmental quality.	Defra
Statutory nature conservation agency protocol for minimising the risk of injury to	Protection of marine mammals form piling noise	Outlines a protocol for the mitigation of potential underwater noise impacts arising from pile driving during offshore wind farm construction. Recommends all operations that include pile driving	JNCC / SNH

EMP Legislation Register			
Legislation	**Relevance to Moray West**	**Summary**	Regulatory Body
marine mammals from piling noise (2010)		should consider producing an Environmental Management Plan (EMP).	
Wildlife and Countryside Act 1981 (as amended)	Nature conservation legislation	Protection of wild bird and other animals, prevention of the introduction of non-native species.	SNH, SEPA
Wildlife and Natural Environment (Scotland) Act 2011	Nature conservation legislation	Prevention of the introduction of non-native species, amendments to the Wildlife and Countryside Act 1981. Sets a strong context for preparing and implementing Marine Biosecurity Plans.	
Waste and Discharges			
Environmental Protection Act 1990	Pollution control	This Act, and associated regulations, introduces a "Duty of Care" for all controlled wastes. Waste producers are required to ensure that wastes are identified, described and labelled accurately, kept securely and safely during storage, transferred only to authorised persons and that records of transfers (waste transfer notes) are maintained for a minimum of two years. Carriers and waste handling sites require licensing. This Act and associated Regulations brought into effect a system of regulation for "controlled waste". Although the Act does not apply to offshore activities, it requires operators to ensure that offshore waste is handled and disposed of onshore in accordance with the "Duty of Care" introduced by the Act.	SEPA
Environmental Protection Act 1990 (Amendment) (Scotland) Regulations 2001	Pollution control	Transfer of functions of the Environmental Protection Act 1990 from Ministers of the Crown to Scottish Ministers for Scottish matters.	
Environment Act 1995	Pollution control, environmental management.	Establishment of environmental protection agencies in England and Scotland. Provisions for the control of pollution and dealing with contamination. Setting of standards for environmental management.	
Controlled Waste (Scotland) Regulations 1992 (as amended)	Controlled waste	Define "Controlled Waste" for the purposes of Environmental Protection Act 1990. Three categories of controlled waste are defined i.e. household, industrial and commercial.	
Special Waste (Scotland) Regulations 1996 (as amended)	Hazardous waste	Control of the movements of the most hazardous types of waste. Introduces a new consignment note, a new system of fees is in operation and the mixing of special wastes is expressly prohibited.	
Landfill Directive (1999/31/EC)	Waste management	Supplements the requirements of the Waste Framework Directive (2008/98/EC). Prevention and reduction the negative effects of landfilling on the environment as well as any resultant risk to human	

EMP Legislation Register			
Legislation	**Relevance to Moray West**	**Summary**	Regulatory Body
		health. Sets out requirements for the location, management, engineering, closure and monitoring for landfills and requirements relating to the characteristics of the waste to be landfilled.	
Waste (Scotland) Regulations 2012	Waste management and recycling	The regulations introduce a number of important new requirements including the segregation of materials such as glass, metal, plastics, paper and card for recycling. It also introduces the requirement for food businesses to present food waste for collection and a ban on sending segregated materials for incineration or to landfill. Waste contractors must provide services that enable high quality recycling. The drawing up of waste management plans is an obligation of EU Member States and is required by Article 28 of the Waste Framework Directive (WFD) which the Waste (Scotland) Regulations 2012 implement.	
The Waste (Meaning of Hazardous Waste and European Waste Catalogue) (Miscellaneous Amendments) (Scotland) Regulations 2015	Hazardous waste	These regulations include an amendment to the definition of "Waste Directive" / "Waste Framework Directive" to mean Directive 2008/98/EC as amended by Commission Regulation (EU) No 1357/2014 replacing Annex III to Directive 2008/98/EC for the following legislation (amongst others): Environmental Protection Act 1990; Special Waste Regulations 1996; Landfill (Scotland) Regulations 2003.	
Waste Management Licensing (Scotland) Regulations 2011	Waste Management	The regulations dictate the licensing of persons or businesses involved in the management of waste and relate directly to the licensing of a site or activity to carry out the management, processing and disposal of wastes.	
The Environmental Protection (Duty of Care) (Scotland) Regulations 2014	Waste Management	Under these Regulations any person who imports, produces, carries, keeps, treats or disposes of Controlled Waste has a duty to take all reasonable steps to ensure that their waste is handled lawfully and safely. Special/Hazardous Waste is a sub-category of Controlled Waste (see also Special Waste Regulations).	
The Waste (Recyclate Quality) (Scotland) Regulations 2015	Recycling	Requires the holder of a Waste Management Licence to comply with the Materials Recovery Code. Also a Pollution Prevention and Control (PPC) permit for the running of a waste recovery facility must contain a requirement to comply with the Materials Recovery Code.	
Merchant Shipping (Prevention of Pollution by Sewage	Sewage and Garbage treatment,	Implement both the revised Annex IV of MARPOL 73/78 – Regulations for the Prevention of Pollution by Sewage from Ships, and the Annex V of MARPOL	MCA

EMP Legislation Register			
Legislation	**Relevance to Moray West**	**Summary**	Regulatory Body
and Garbage from Ships) Regulations 2008	storage and disposal	73/78 (including amendments) – Regulations for the Prevention of Pollution by Garbage from Ships. Implements into UK law international regulations on treatment and disposal of garbage and food waste from vessels operating in UK water. All ships of 400 gross tonnage or above and every ship which is certified to carry 15 or more persons must carry a Garbage Management Plan and a Garbage Record Book. The regulations also provide powers for the MCA to issue an International Sewage Pollution Prevention Certificate to ships in the same categories.	
International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM) – adopted 2004 and enters into force on the 8th of September 2017	Ballast water management	Objective to prevent, minimise and ultimately eliminate the transfer of harmful aquatic organisms and pathogens though control and management of ships' ballast water and sediments. Under this regulation, all tankers > 150 GRT and all ships (including submersibles, floating craft & floating platforms) > 400 GRT (unless not engaged in international voyages or as exempted under the regulations) in the UK are required to have a Ballast Water Exchange Management Plan and a Ballast Water Record Book and to be surveyed and issued with an International Ballast Water Management Certificate.	MCA
The Merchant Shipping (Anti-Fouling Systems) Regulations 2009	Anti-fouling Pollution prevention	Prohibits the use of harmful organotin compounds in anti-fouling paints used on ships and will establish a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems and places into UK law Regulation (EC) 782/2003 on the prohibition of organotin compounds on ships. Provides powers for the MCA to issue an International Anti-fouling System Certificate to ships of 400 gross tonnage or above and every ship which is certified to carry 15 or more persons.	MCA
Offshore Chemical Regulations 2002 (as amended)	Control of Chemical Usage	Provides a mandatory control system for the use and discharge of chemicals by the offshore oil and gas industry. Under the terms of the Wind Farm Marine Licence and the OfTW Marine Licence (condition 3.1.7) the Offshore Chemical Regulations should be followed during construction works with utilised chemicals selected from the List of Notified Chemicals.	BEIS, Marine Scotland
Food & Environmental Protection Act (FEPA) 1985 (with amendments) Deposits in the Sea	Discharges	Used to cover the discharge or placement of substances or articles in the sea or on the seabed where the deposits could not be covered by other legislation (e.g. Marine (Scotland) Act, 2010). A licence is required under FEPA for any waste disposal in the sea or under the seabed. The Deposits in the	BEIS

EMP Legislation Register			
Legislation	**Relevance to Moray West**	**Summary**	Regulatory Body
(Exemptions) Order 1985		Sea (Exemptions) Order 1985 exempts from FEPA licensing the deposit on site or under the seabed of any chemicals and drill cuttings.	
Control of Substances Hazardous to Health Regulations 1994 COSHH	Control of substances hazardous to health	Assessment, prevention or control of exposure and monitoring of substances hazardous to health.	HSE
The REACH Enforcement Regulations 2008	Chemical usage	These enforce Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) which require chemical users to demonstrate the safe manufacture of chemicals and their safe use throughout the supply chain. Under REACH, the users of chemicals as well as their manufacturers and importers have a responsibility to ensure that the risks to both human health and the environment are adequately assessed.	BEIS, Marine Scotland
Decommissioning			
Energy Act 2004	Decommissioning requirements	Introduced a decommissioning scheme for offshore wind and marine energy installations. Under the terms of the Act, the Secretary of State may require a person who is responsible for one of these installations or lines to submit (and eventually carry out) a decommissioning programme for them.	BEIS
Physical Presence			
Energy Act 2004	Safety zones	Section 95 of and Schedule 16 to the Energy Act 2004 set out the basic requirements for applying to the Secretary of State for a safety zone to be placed around or adjacent to an offshore renewable energy installation. Following public consultation the Electricity (Offshore Generating Stations) (Safety Zones) (Applications Procedures and Control of Access) Regulations 2007, which set out the process to be followed in more detail, were introduced in August 2007.	BEIS
Marine (Scotland) Act 2010	Obstruction to navigation	This Act provides that where an obstruction or danger to navigation is caused, or is likely to result, the prior written consent of Scottish Ministers is required for the siting of the offshore installation - whether mobile or permanent – in Scottish Territorial Waters.	Scottish Ministers, acting through MS-LOT.
Marine and Coastal Access Act 2009	Obstruction to navigation	This Act provides that where an obstruction or danger to navigation is caused, or is likely to result, the prior written consent of Scottish Ministers is required for the siting of the offshore installation – whether mobile or permanent – in Scottish Offshore Waters.	

EMP Legislation Register			
Legislation	**Relevance to Moray West**	**Summary**	Regulatory Body
Pollution Control			
The Merchant Shipping (Prevention of Oil Pollution) Regulations 1996	Prevention of oil pollution	These Regulations give effect to Annex I of MARPOL 73/78 (prevention of oil pollution) in UK waters. They address oily drainage from machinery spaces on vessels and installations and sets limits for the levels of oil in discharged water from these sources. Vessels and installations are required to hold a valid Oil Pollution Prevention Certificate. Vessels are also required to hold a current, approved Shipboard Oil Pollution Emergency Plan (SOPEP) in accordance with guidelines issued by the International Maritime Organisation (IMO). Oil tankers of 150 gross tonnage and above and all ships of 400 gross tonnage and above are required carry an Oil Record Book to record when specific operations take place on board which have the potential to lead to oil pollution from vessels and an approved Shipboard Oil Pollution Emergency Plan (SOPEP).	BEIS, Marine Scotland
Bonn Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances (2004)	Prevention of oil pollution Pollution protection	An agreement to combat oil pollution and to stimulate active cooperation and mutual assistance among states bordering the North Sea in case of casualties or other incidents at sea that are of great concern for the protection of the coasts and related interests.	BEIS, Marine Scotland
The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2007	Carriage of dangerous goods	Implements the requirements of the European agreement concerning the carriage of dangerous goods (ADR), including safe storage and transport by road rail and sea.	DfT
Marine Management Organisation (MMO) (2016) Approved oil spill treatment products	Oil spill response	Quick reference list of products approved for use on the UK Continental Shelf	MMO, Marine Scotland
Marine Safety Agency (MSA) (1996) Merchant Shipping Notice No. M.1663, Vessels Engaged in Oil Recovery	Oil spill response	Provides guidelines for the design, construction, ship's equipment and operation of offshore support vessels, which may be required to have the capability of handling, storing and transporting oil recovered from a spill in emergency situations.	MSA
The Merchant Shipping (Ship-To-Ship Transfers) Regulations 2010 (as amended)	Refuelling operations Cargo transfers	Bring in controls on ship-to-ship transfers in UK waters, including prohibiting ship-to-ship transfers and bunkering operations outside harbour authority waters and put in place a legislative regime for assessing and licensing harbour authorities which	MCA

EMP Legislation Register			
Legislation	**Relevance to Moray West**	**Summary**	Regulatory Body
		propose to allow ship-to-ship transfers in their waters. Merchant Shipping Notice (MSN) 1829 "Ship to Ship Transfer Regulations 2010/2012" sets out detailed requirements regarding Ship to Ship Transfers of a cargo consisting wholly or mainly of oil. The Notice is given statutory force by the Merchant Shipping (Ship to Ship Transfers) Regulations 2010 (as amended). An exemption is provided in MSN 1829 for vessels to refuel, or be refuelled by daughter-craft, so as not to impair operationally necessary refuelling.	
The Merchant Shipping (Oil Pollution Preparedness, Response and Cooperation Convention) Regulations 1998 (OPRC Regulations)	Oil spill	The Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998 introduce into UK law the oil spill planning requirements and legal oil spill reporting requirements of the OPRC Convention.	BEIS, Marine Scotland
The Merchant Shipping (ISM Code) Regulations 2014	Pollution prevention	Provides for the application of the ISM Code on all vessels to which the SOLAS Convention applies and to other vessels to which EC regulations apply. The ISM Code provides an international standard for the safe management and operation of ships and for pollution prevention.	MCA
Merchant Shipping (Reporting Requirements for Ships Carrying Dangerous or Polluting Goods) Regulations 1995/2498 (as amended, 2204/SI 2110 and 2005/SI1092)	Pollution response	These regulations contain requirements in connection with reporting requirements for discharges, during the operation of a ship, of oil or noxious liquid	MCA
Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997/2367	Pollution prevention	Regulations apply to ships carrying dangerous goods in bulk or packaged form or marine pollutants in packaged form.	MCA
Merchant Shipping (Prevention of Pollution: Substances Other than Oil) (Intervention) Order 1997/1869	Pollution prevention	These regulations list the substances other than oil to which the restrictions contained in the Merchant Shipping Act 1995 apply. Also see MGN 37 (M) for guidance on the application of this legislation.	MCA

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MORAY WEST
OFFSHORE WINDFARM

Draft Decommissioning Programme

Moray Offshore Windfarm (West) Limited

Technical Appendix 4.2

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Acronyms	
Acronym	**Expanded Term**
AC	Alternating Current
BOWL	Beatrice Offshore Windfarm Limited
CD	Chart Datum
CfD	Contract for Difference
DECC	Department of Energy and Climate Change
DP	Decommissioning Programme
EDPR	EDP Renewables
EIA	Environmental Impact Assessment
MW	megawatts
NCMPA	Nature Conservation Marine Protected Area
OfTI	Offshore Transmission Infrastructure
OnTI	Onshore Transmission Infrastructure
OSP	Offshore Substation Platform
PMF	Priority Marine Features
RIAA	Report to Inform an Appropriate Assessment
SAC	Special Area of Conservation
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
WTG	Wind Turbine Generator
UNCLOS	United Nations Convention on the Law of the Sea

Glossary of Terms	
Term	**Description**
Development	The Moray West Offshore Windfarm and associated Offshore Transmission Infrastructure (OfTI).
Project	The Moray West Offshore Windfarm, OfTI and OnTI
Moray West Offshore Export Cable Corridor	The area within which the Moray West Offshore Export Cable is to be located as presented in Moray West EIA Report.
Moray West Site	Area within which the Moray West Offshore Wind Farm will be located
“The Plan”	Draft Decommissioning Programme for the Moray West Offshore Wind Farm and associated offshore transmission infrastructure
Moray Offshore	Moray Offshore Renewable Power Limited
Moray West	Moray Offshore Windfarm (West) Limited
S36 Consent	The written consent granted by the Scottish Ministers under Section 36 of the Electricity Act 1989, on 19 March 2014

Executive Summary

In early 2018 Moray West will submit applications for Section 36 consents for the Moray West Offshore Wind Farm located within the outer Moray Firth, Scotland, together with Marine Licence applications for the offshore wind farm and the Offshore Transmission Infrastructure (OfTI) (the Development). Moray West is owned by EDP Renewables (EDPR).

The Energy Act 2004 requires that Moray West prepares for approval, by the Scottish Ministers, and ultimately carries out, a Decommissioning Programme (DP) for the Development.

This document constitutes the preliminary DP for the Development. Moray West has included it in the various consent applications to give regulatory authorities and key stakeholders an opportunity to comment on draft proposals for how the structures comprising the Moray West Offshore Windfarm and OfTI will be decommissioned.

The onshore aspects of the overall Project (Development plus the Onshore Transmission Infrastructure (OnTI)) and their associated decommissioning requirements fall under the Town and Country Planning (Scotland) Act 1997 and so are not considered within this Programme.

The Programme is informed and supported by the Environmental Impact Assessment (EIA) carried out for the Development.

The resulting Environmental Impact Assessment (EIA) Report has been submitted as part of the Development's application for consent. The EIA Report provides detailed analysis of the baseline physical, biological and human environment. The assessment of the impact of the Development on receptors takes into account decommissioning provisions that are consistent with those presented in this document.

In considering appropriate decommissioning provisions, Moray West have sought to adhere to the following key principles:

- Safety for all at all times;
- Consideration of the rights and needs of legitimate users of the sea;
- Minimise environmental impact;
- Adherence to 'polluter pays' principle;
- Promote sustainable development;
- Maximise the reuse of materials;
- Commercial viability; and
- Practical integrity.

The following key documents have also informed the Decommissioning Programme:

- Decommissioning of Offshore Renewable Energy Installations under the Energy Act 2004: Guidance notes for Industry, DECC, January 2011 (revised);
- Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone, International Maritime Organisation (IMO), 19th October 1989;
- Guidance Notes for Industry: Decommissioning of Offshore Installations and Pipelines under the Petroleum Act 1998, DECC, March 2011;
- OSPAR Guidance on Environmental Considerations for Offshore Wind Farm Development, 2008;
- Guidelines for Environmental Risk Assessment and Management – Green Leaves III, Defra, November 2011; and
- United Nations Convention on the Law of the Sea (UNCLOS), 1982

1 Introduction

Moray Offshore Windfarm (West) Limited (known as 'Moray West') is promoting the development of the Moray West Offshore Wind Farm and associated Moray West Offshore Transmission Infrastructure (OfTI) (referred to as 'the Development').

The Moray West Site covers an area of approximately 225 km^2 on the Smith Bank in the Outer Moray Firth (Figure 1.1), approximately 22 km from the Caithness coastline.

The Moray West Offshore Wind Farm will comprise up to 85 Wind Turbine Generators (WTGs), associated substructures and seabed foundations, inter-array cables and any scour protection around substructures or cable protection. The OfTI comprises up to two Offshore Substation Platforms (OSPs) which will be located within the Moray West Site, OSP interconnector cables and two offshore export cable circuits which will be located within the Offshore Export Cable Corridor and will be used to transmit the electricity generated by the offshore wind farm to shore.

The offshore export cable circuits come ashore in the Landfall Area which is located on the Aberdeenshire Coast between Findlater Castle and Redhythe Point, approximately 65 km south of the Moray West Site.

It is expected the offshore wind farm will be operational for at least 35 years. Moray West is therefore seeking consent a duration of 50 years. Under the Energy Act 2004, wind farms and associated OfTI must be decommissioned at the end of their lifetime. A decision as to whether the sites will be re-powered will be taken by Moray West approximately 40-45 years after energy generation has commenced.

Upon issue of the Section 36 consent for the Moray West Offshore Wind Farm, it is anticipated that the Scottish Ministers will issue a notice under Section 105(2) of the Energy Act 2004 regarding the requirement to prepare a Decommissioning Programme (DP) for the Development prior to the commencement of construction.

In anticipation of this requirement, Moray West has drafted a preliminary DP for the Development. This preliminary DP is being submitted for approval in accordance with the requirements of the Energy Act 2004. The document is structured in accordance with the format recommended in the 'Decommissioning of offshore renewable energy installations under the Energy Act 2004; Guidance notes for industry. DECC, January 2011 (revised).'

The DP outlines the methods for decommissioning, paying particular attention to:

- Comparing the methods of partial and complete removal of foundations;
- Considering integration and cooperation with other companies during decommissioning;
- The expected timeframes and costs of removal;
- Environmental impacts; and
- Monitoring.

This Plan is to be reviewed and revised as necessary throughout the lifecycle of the Project to reflect changing circumstances and regulatory requirements, and to incorporate improvements in knowledge and understanding of the marine environment and advancements in technology and working practices. As a minimum, this document is expected to be reviewed and updated at the following points in time:

- A review and update will be undertaken prior to construction of the Moray West Offshore Wind Farm and OfTI, and the final draft programme will be formally submitted for approval to the Scottish Ministers in accordance with the Energy Act 2004 (or relevant legislation in force at that time).
- A review and update for formal submission will be made, if required, after 2 years of operation;

- A review and update will take place when key information changes, e.g. change in ownership of the site. Following the update, a formal submission for acceptance of amendments will be made;
- A review, update and formal submission for acceptance of amendments will be made if the sites undergo repowering;
- A review and update, if required, two years prior to the provision of financial security;
- Halfway through the period during which financial security is provided; and
- A review and Final Plan will be prepared prior to decommissioning of the sites and the programme will be formally submitted for approval to the Scottish Ministers in accordance with the Energy Act 2004 (or relevant legislation in force at that time).

1.1 Structure of this Draft DP

This document is divided into the sections summarised in Table 1.1.1 below, and follows the structure set out in the DECC guidance (DECC, 2011).

Table 1.1.1: Decommissioning Programme Structure

Section Number	Section Title	Summary of Content
1	Introduction	Background to the Development including the companies that are party to the programme and their ownership status, and consent requirements relevant to this DP.
2	Background Information	Relevant background information including the layout of the Development and confirmation of items to be decommissioned; and, a summary of environmental conditions across the site.
3	Description of Items to be Decommissioned	A full description of all items associated with the Moray West Offshore Windfarm to be decommissioned.
4	Description of Proposed Decommissioning Measures	An overview of the proposed approach to decommissioning the Development, including: an overview of the process; details of items to be left in situ; and, waste management.
5	Environmental Impact Assessment	Details of the EIA that was prepared for the Development and its consideration of decommissioning activities.
6	Consultations with Interested Parties	The consultation process undertaken to support development and finalisation of the DP.
7	Schedule	Details of the proposed decommissioning time-scale.
8	Project Management and Verification	Information on how Moray West will manage the implementation of the DP.
9	Costs	An overall cost estimate of the proposed decommissioning measures.
10	Financial Security	Details of the financial security which the companies that are party to the programme propose to provide.
11	Seabed Clearance	Information relating to Moray West's proposals confirming that, following decommissioning, the site has been cleared, including information on site surveys and schedules.
13	Restoration of Sites	Description of how Moray West intends to restore the site as far as reasonably practicable, to the condition that it was in prior to construction of the installation.

Table 1.1.1: Decommissioning Programme Structure		
Section Number	**Section Title**	**Summary of Content**
14	Post-Decommissioning Monitoring, Maintenance and Management of the Site	Details of the post decommissioning monitoring/activities that will be required, given that Moray West is not proposing to fully remove all infrastructure.
15	Supporting Studies	Details of supporting studies that have been used to inform the DP.
16	References	A list of references used in the production of this DP.

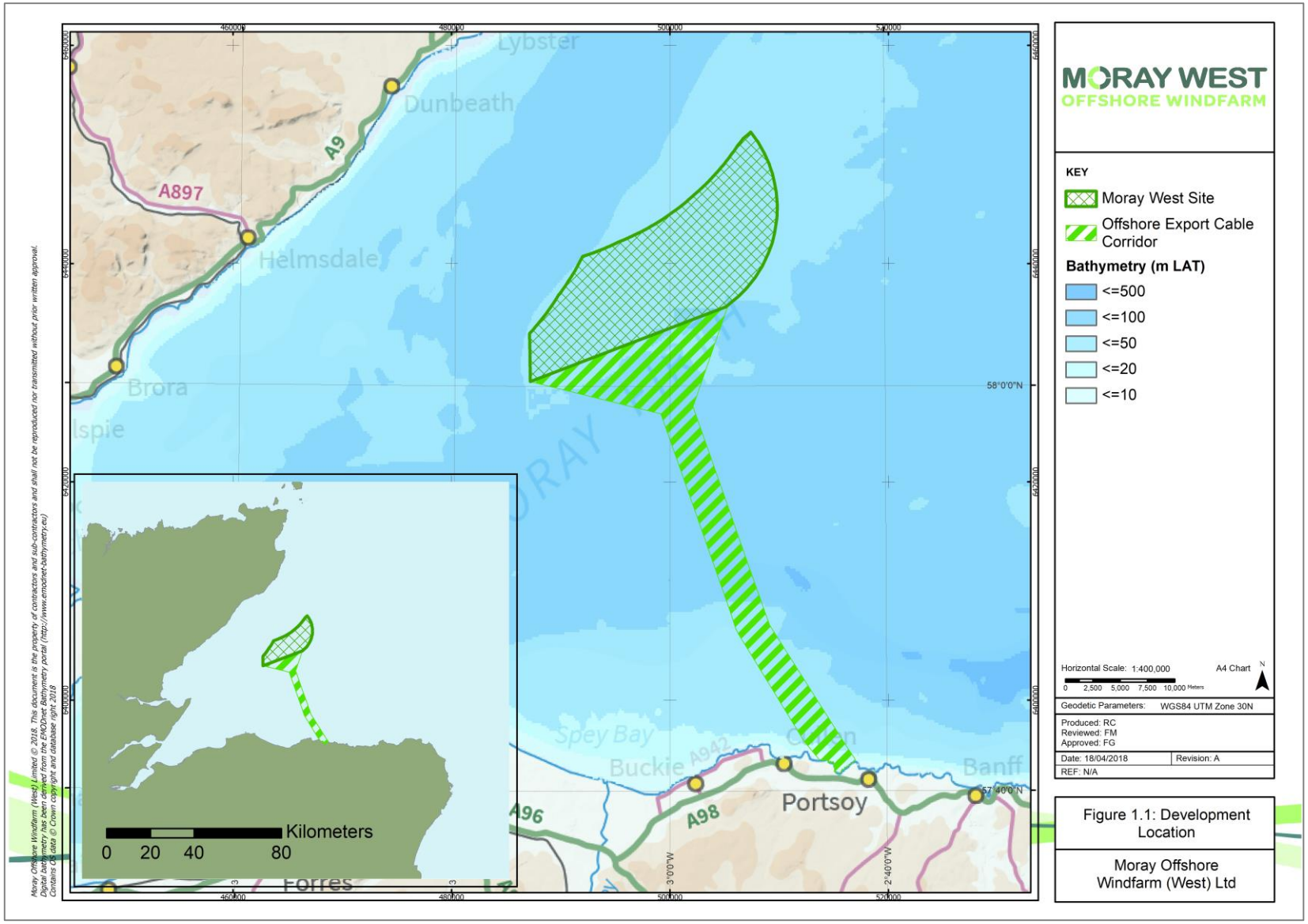

Figure 1.1: Development location

2 Background Information

2.1 Description of the Development

The Development boundary is shown in

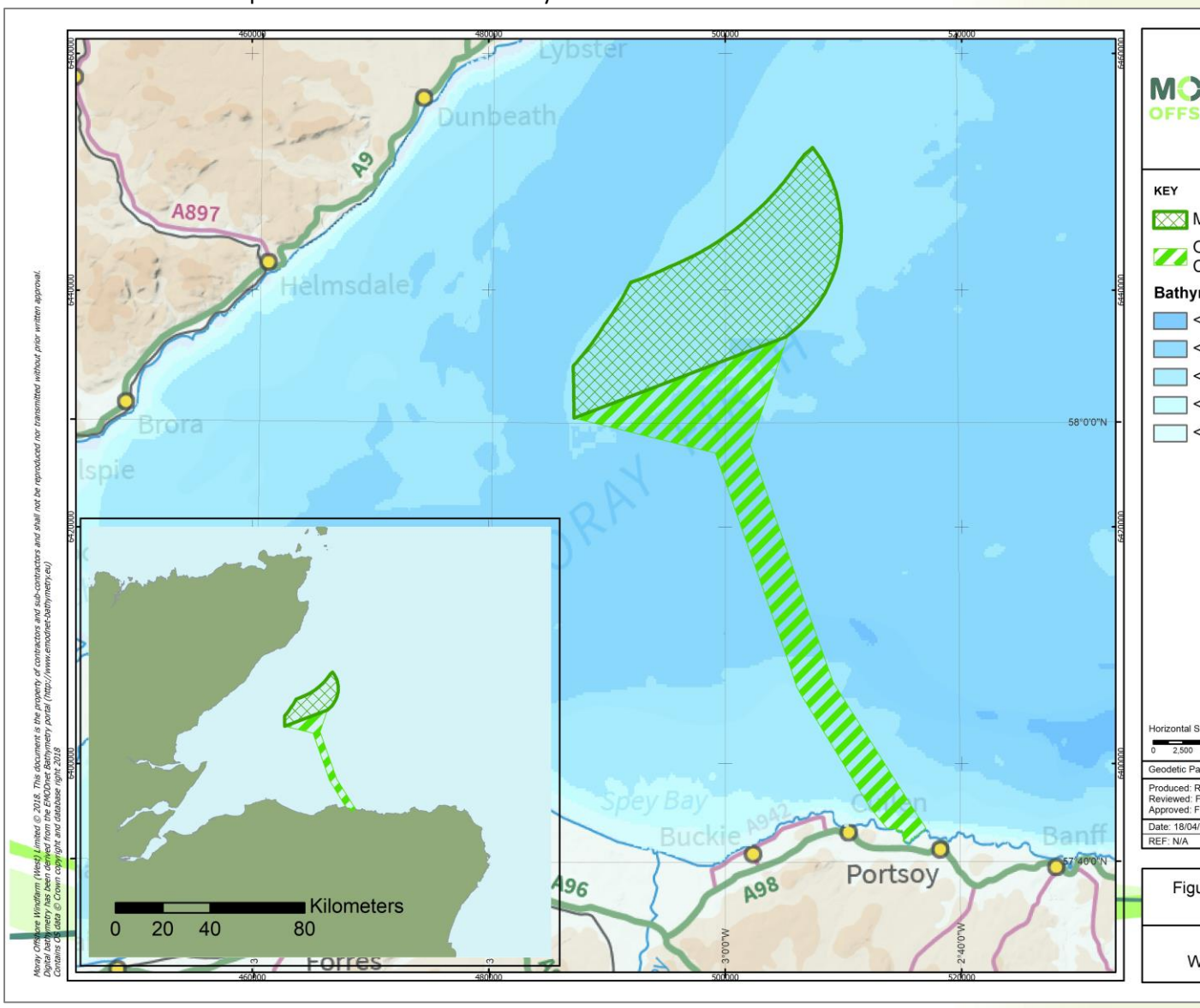

Figure 1.1. The boundary encompasses:

- The Moray West Offshore Wind Farm Site. This is where the offshore wind farm will be located, which will include the WTGs, WTG foundations and substructures, inter-array cables, an OSP(s), and interconnector cables; and
- The Moray West Offshore Export Cable Corridor. This is where the offshore export cable circuits will be located.

The Development is located on the Smith Bank in the Outer Moray Firth, approximately 22 km from the Caithness coastline. The Wind Farm Site covers an area of approximately 225 km^2 and the Offshore Export Cable Corridor covers an area of approximately 185 km^2.

The Development will comprise of WTGs and all infrastructure required to transmit the power generated by the WTGs to the national grid network via the grid connection location at Blackhillock in Moray.

The key components of the Development will be as follows:

- Up to 85 offshore WTGs;
- Up to two OSPs;
- Substructures and associated seabed foundations (for WTGs and OSPs);
- Subsea inter-array cables linking individual WTGs to the OSPs;
- Subsea interconnector cables linking OSPs (if two OSPs are installed);
- Subsea export cable circuits running from the OSPs to shoreline landfall;
- Scour protection around substructures and cable protection (if required); and
- Monitoring equipment, such as metocean buoys (if required).

2.2 Project Status and Programme

It is currently planned that construction of the Development would commence in 2022 and end in 2024, spanning 32 months. Site investigation and seabed preparation would take place prior to 2022. Timescales are subject to Moray West securing a route to market through the Contract for Difference (CfD) process.

The sequence of activities associated with the installation of the Development are likely to be as follows:

- Detailed pre-construction site investigations – some of these may be subject to separate licence applications;
- Onshore manufacture of components;
- Seabed preparation works;
- Transport to Site and installation of foundations;
- Transport to Site and installation of inter-array cables;
- Transport to Site and installation of OSPs;
- Transport to Site and installation of export cables;
- Transport to Site and installation of wind turbine generators;
- System testing and commissioning; and
- Installation of ancillary equipment.

2.3 Site Characteristics

A range of surveys and desk studies have been completed by Moray West to establish the physical characteristics of the Development site. These studies have informed the EIA for the Development, are reported as part of the EIA Report and Scoping Reports for the Development, and form the basis for this section of the Plan. The following sections provide a brief summary of information to inform consideration of the decommissioning provisions.

2.3.1 Physical Environment

2.3.1.1 Wind Climate

The prevailing wind direction is from the west (247.5 to 292.5˚N), accounting for almost 20% of the record, and from the south (157.5 to 202.5˚N) and south-east (112.5 to 157.5˚N), together accounting for around 35% of the total record. Wind speeds are in the range 2 to 8m/s over 70% of the time and only infrequently

(less than 1% of the time) exceed 16m/s. During extreme events (return period of 1 in 10-years or more), wind speeds can peak as high as 25 or 30m/s.

2.3.1.2 Bathymetry

The Moray West Site spans the crest and western flank of the Smith Bank and is characterised by water depths in the range 35 to 54 m below LAT. The shallowest depths are found in the north of the Moray West Site and the greatest depths are found in the south. From the Moray West Site the depth increases to 95 m along the Offshore Export Cable Corridor before decreasing again in inshore waters. These deeper areas are encountered where the Offshore Export Cable Corridor crosses the western margin of the Southern Trench, a long deep east to west orientated channel located in the southern part of the outer Moray Firth. The Southern Trench reaches depths of approximately 220 m off the Aberdeenshire coast to the east of the Offshore Export Cable Corridor.

2.3.1.3 Water Levels

The Moray West Site and Offshore Export Cable Corridor are subject to semi-diurnal tidal variations in water level. The mean spring range is approximately 3 m throughout the length of the Offshore Export Cable Corridor and within the Moray West Site.

It is possible that relative sea levels could rise in this region during the course of the 21st Century and by 2050 (i.e. approximately the end of the project lifecycle) are likely to be around 0.22-0.35 m higher than 1990 levels (Lowe *et al.,* 2009).

2.3.1.4 Waves

The wave regime in the outer Moray Firth includes both swell waves generated elsewhere in the North Sea and locally generated wind waves. The wave regime in the outer Moray Firth is typically characterised by fetch limited wave conditions (from the west and south-west). The longer period swell waves tend to come from offshore sectors only.

The largest waves come from the more exposed offshore sectors (from north through south-east) although the southern end of the Offshore Export Cable Corridor is sheltered from south-easterly waves. Offshore wave heights during extreme events from these directional sectors may be 6 to 7 m during relatively frequent (annual) events. However, waves coming from other directions within the outer Moray Firth are generally smaller during extreme events (4 to 5 m or up to 7 m, respectively) due to the relatively shorter distances available for wave growth.

2.3.1.5 Currents

Depth-averaged peak spring current speeds range between approximately 0.2 to 0.4 m/s in the Moray West Site and Offshore Export Cable Corridor. The faster speeds are found at the boundary between the Offshore Export Cable Corridor and the Moray West Site. In this area, peak flood current speeds are approximately 10% faster than adjacent peak ebb current speeds due to the influence of the Pentland Firth. Currents are relatively weaker elsewhere in the Offshore Export Cable Corridor.

Peak flood currents (directed approximately south or south-south-west into the Moray Firth) occur approximately 1.5 to 2 hours before high water at Wick; peak ebb currents (directed approximately north or north-north-east out of the Moray Firth) occur approximately 4 to 4.5 hours after high water at Wick.

2.3.1.6 Wind Climate

The prevailing wind direction is from the west (247.5 to 292.5˚N), accounting for almost 20% of the record, and from the south (157.5 to 202.5˚N) and south-east (112.5 to 157.5˚N), together accounting for around 35% of the total record. Wind speeds are in the range 2 to 8m/s over 70% of the time and only infrequently 43 (less than 1% of the time) exceed 16m/s. During extreme events (return period of 1 in 10-years or more), wind speeds can peak as high as 25 or 30m/s.

2.3.1.7 Sediments

Seabed sediments across the Moray West Site generally consist of Holocene gravelly sand and sand with a minor proportion of fines (<5 to 10% silt and clay sized). A modal peak grain size between 150 to 215 µm (fine sand) was found in the majority of the grab samples collected from the Moray West Site. Other modal peak grain sizes were also variably observed, ranging from 24,000 µm (pebble gravel) to 350 µm (medium sand). The proportion of shell in sediment samples from and nearby to the Moray West Site are frequently in excess of 50% (Partrac, 2010; British Geological Survey (BGS), 1987).

Near to the Moray West Site, in intermediate water depths, the Moray West Offshore Export Cable Corridor transits areas of mixed sands and gravels, with a small proportion of fines (<5 to 10%) present. Seabed sediments become progressively finer in deeper water along the route, becoming relatively muddy (30 to 65% fines) in the deepest parts. The sediment character and distribution in these offshore sections is the result of the relatively benign tidal regime and the spatially variable effect of wave action at the seabed, depending upon the local water depth.

2.3.2 Biological Environment

2.3.2.1 Designated Sites

Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora, also known as "The Habitats Directive", provides for the conservation of natural habitats and of wild flora and fauna including in offshore areas. The EC Directive 2009/147/EC on the conservation of wild birds, also known as "the Birds Directive" applies to the conservation of all species of naturally occurring wild birds including in offshore areas. In the UK, sites designated as Special Areas of Conservation (SACs) and Special Protection Areas (SPAs), under the Habitats Directive and Birds Directive respectively, form part of the Natura 2000 network. These sites aim to deliver the requirements of the Directives through the establishment of a European network of important high-quality conservation sites that will make a significant contribution to conserving the qualifying features.

Table 2.3.1 below details the SACs that have qualifying features that are considered within the Report to Inform the Appropriate Assessment (RIAA) submitted in support of the Application, as having the potential to interact with the Development.

Table 2.3.1: Designated SACs and Relevant Qualifying Features that have the Potential to Interact with the Moray West Wind Farm Site and OfTI

Site	Qualifying Features
Moray Firth SAC	Bottlenose dolphin Sandbanks which are slightly covered by sea water all the time
Dornoch Firth and Morrich More SAC	Harbour seal Sandbanks which are slightly covered by sea water all the time Reefs
Faray and Holm of Faray SAC	Grey seal
Sanday SAC	Harbour seal
Isle of May SAC	Grey seal
Monach Islands SAC	Grey seal
Berriedale and Langwell Waters SAC	Atlantic salmon
River Borgie SAC	Atlantic salmon Freshwater pearl mussel (*Margaritifera margaritifera*)

Table 2.3.1: Designated SACs and Relevant Qualifying Features that have the Potential to Interact with the Moray West Wind Farm Site and OfTI	
Site	**Qualifying Features**
River Dee SAC	Atlantic salmon Freshwater pearl mussel
River Naver SAC	Atlantic salmon Freshwater pearl mussel
River Thurso SAC	Atlantic salmon
River Oykel SAC	Atlantic salmon Freshwater pearl mussel
River Moriston SAC	Atlantic salmon Freshwater pearl mussel
River Spey SAC	Atlantic salmon Freshwater pearl mussel Sea lamprey
Culbin Bar SAC	Atlantic salt meadows (Glauco-Puccinellietalia maritimae) Embryonic shifting dunes

Table 2.3.2 details SPAs with possible connectivity to the Moray West Wind Farm and OfTI, and the listed species within foraging range.

Table 2.3.2: Qualifying SPA Species with Foraging Ranges that Interact with Moray West Offshore Wind Farm from Relevant Breeding Colonies		
(p)SPA	**Distance to Moray West Site (km) / Offshore Export Cable Corridor from the Closest Points**	**Qualifying Feature (Mean Maximum Foraging Range)**
Breeding		
Auskerry	92.4 / 108.4	Storm petrel (91.7 ± 27.5 km)
Buchan Ness to Collieston Coast	92.7 / 59.6	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km) Herring gull (61.1 ± 44.0 km) Kittiwake (60 ± 23 km)
Calf of Eday	111.7 / 127.7	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km)
Cape Wrath	110.3 / 112.9	Fulmar (400 ± 245.8 km) Puffin (105.4 ± 46 km) Guillemot (84 ± 50.1 km)
Copinsay	74.3 / 90.3	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km) Kittiwake (60 ± 23 km)
East Caithness Cliffs	19.9 / 23.1	Fulmar (400 ± 245.8 km) Cormorant (25 ± 10 km) Shag (35 km)

Table 2.3.2: Qualifying SPA Species with Foraging Ranges that Interact with Moray West Offshore Wind Farm from Relevant Breeding Colonies		
(p)SPA	**Distance to Moray West Site (km) / Offshore Export Cable Corridor from the Closest Points**	**Qualifying Feature (Mean Maximum Foraging Range)**
		Puffin (105.4 ± 46 km) Guillemot (84 ± 50.1 km) Razorbill (48.5 ± 35 km) Herring gull (61.1 ± 44.0 km) Great black-backed gull (20km) Kittiwake (60 ± 23 km)
Fair Isle	157.8 / 173.2	Fulmar (400 ± 245.8 km) Gannet (229.4 ± 124.3 km)
Fetlar	281.2 / 296.8	Fulmar (400 ± 245.8 km)
Flannan Isles	254.6 / 255.4	Fulmar (400 ± 245.8 km)
Forth Islands	202.9 / 163.8	Fulmar (400 ± 245.8 km) Gannet (229.4 ± 124.3 km)
Foula	213.5 / 229.5	Fulmar (400 ± 245.8 km)
Fowlsheugh	132 / 88.4	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km)
Handa	118.9 / 120.5	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km)
Hermaness, Saxa Vord and Valla Field	300.2 / 315.8	Fulmar (400 ± 245.8 km) Gannet (229.4 ± 124.3 km)
Hoy	64.9 / 79.5	Fulmar (400 ± 245.8 km) Puffin (105.4 ± 46 km) Guillemot (84 ± 50.1 km) Arctic skua (62.5 ± 17.7 km) Kittiwake (60 ± 23 km)
Marwick Head	101.9 / 116.8	Guillemot (84 ± 50.1 km)
North Caithness Cliffs	41.6 / 57	Fulmar (400 ± 245.8 km) Puffin (105.4 ± 46 km) Guillemot (84 ± 50.1 km) Razorbill (48.5 ± 35 km) Kittiwake (60 ± 23 km)
North Rona and Sula Sgeir	188.7 / 192.2	Fulmar (400 ± 245.8 km) Gannet (229.4 ± 124.3 km)
Noss	235.8 / 251.1	Fulmar (400 ± 245.8 km) Gannet (229.4 ± 124.3 km)
Outer Firth of Forth and St Andrews Bay Complex	165.2 / 124.7	Gannet (229.4 ± 124.3 km)
Pentland Firth	38.2 / 54.1	Arctic skua (62.5 ± 17.7 km) Guillemot (84 ± 50.1 km)
Rousay	104.2 / 119.8	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km)

Table 2.3.2: Qualifying SPA Species with Foraging Ranges that Interact with Moray West Offshore Wind Farm from Relevant Breeding Colonies		
(p)SPA	**Distance to Moray West Site (km) / Offshore Export Cable Corridor from the Closest Points**	**Qualifying Feature (Mean Maximum Foraging Range)**
Seas off Foula	187.5 / 203.6	Fulmar (400 ± 245.8 km)
Shiant Isles	182 / 182.1	Fulmar (400 ± 245.8 km)
Sule Skerry and Sule Stack	126.6 / 133.3	Gannet (229.4 ± 124.3 km)
Sumburgh Head	201.8 / 217.1	Fulmar (400 ± 245.8 km)
Troup, Pennan and Lion's Heads	52.5 / 21	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km) Razorbill (48.5 ± 35 km) Herring gull (61.1 ± 44.0 km) Kittiwake (60 ± 23 km)
West Westray	116.7 / 132.4	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km)
Non-Breeding		
Moray Firth	10.8 / 0.0	Scaup Eider Long-tailed duck Common scoter Velvet scoter Goldeneye Red-breasted merganser Red-throated diver Great northern diver Cormorant Shag Slavonian grebe

The Southern Trench is currently proposed as a Nature Conservation Marine Protected Area (NCMPA). The area included in the proposed NCMPA extends along Aberdeenshire coast between Buckie and Fraserburgh following the coastline round and extending out to approximately the 12 nm limit. The Southern Trench NCMPA proposal has been submitted to the Scottish Government for consideration but is currently delayed, with no timescale for designation available. Key interest features of the Southern Trench proposed NCMPA, and basis for its proposed designation include minke whale, benthic habitats including burrowed mud habitat and stratification fronts.

With the exception of parts of Cullen Bay and Sandend Bay, much of the south coast of the Moray Firth (Moray and Aberdeenshire coastline) is nationally designated with qualifying features of geology and habitats (saltmarsh, shingle, springs and lowland dry heath). Of relevance to the Development the EIA Report identified the Cullen to Stake Ness Coast SSSI which is designated for the underlying geology and coincides with part of the landfall area on the Moray Firth coast.

2.3.2.2 Benthic Ecology

Within the Moray West Site sediments tended to be homogeneous with much of the area characterised by sands or slightly gravelly sands. Similar sediments were recorded along the Offshore Export Cable Corridor. A range of biotopes were recorded comprising SS.SCS.ICS.MoeVen (Moerella spp. with venerid bivalves in infralittoral gravelly sand) and SS.SSa.CFiSa.EpusOborApri (*Echinocyamus pusillus, Ophelia borealis* and *Abra prismatica* in circalittoral fine sand), SS.SCS.ICS.MoeVen biotope.

The deeper sections of the Offshore Export Cable Corridor comprised of more fine mud sediments with the biotopes SS.SMu.CFiMu.SpnMeg (Seapens and burrowing megafauna in circalittoral fine mud in areas of deeper muddy sediment) and SS.SMx.CMx.OphMx (*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment).

On the inshore areas of the Offshore Export Cable Corridor stony habitats were more widely recorded with a varied epibiota which ranged from sparsely populated pebbles/stones to more consolidated cobble with a richer hydroid/bryozoan turf.

A number of habitats/species of conservation interest were also noted during the survey including the biotope SS.SCS.ICS.MoeVen which is a Priority Marine Feature (PMF). Other PMFs recorded during the survey include the Arctic quahog (*Arctica Islandica*) and flameshell beds (*Limaria hians*) although these were only recorded at single stations and in very low numbers. In addition, the deeper muddy habitats along the Offshore Export Cable Corridor were classified as SS.SMu.CFiMu.SpnMeg which is also a PMF.

2.3.2.3 Fish and Shellfish Ecology

A review of fish sensitivity maps (Coull *et. al.,* 1998) indicates that the Moray West Site is within reported spawning grounds by cod (*Gadus morhua*), plaice (*Pleuronectes platessa*), lemon sole (*Microstomus kitt*), sprat (*Sprattus sprattus*) and Norway lobster (*Nephrops norvegicus*). Herring (*Clupea harengus*) spawn to the north of the Moray West Site, while whiting (Merlangius merlangus) spawn further to the east. Sandeel (*Ammodytes marinus* and *Ammodytes tobianus*) are mapped as spawning within the inner Moray Firth, including along the Offshore Export Cable Corridor. The Moray West Site is also close to a nursery area for herring, haddock (*Melanogrammus aeglefinus*), whiting, saithe (*Pollachius virens*), plaice (landfall coastal area only), lemon sole, sprat and Norway lobster.

Survey work completed within the Moray Firth as part of pre-construction monitoring surveys for the Moray Easy and Beatrice Offshore Wind Farm Ltd. (BOWL) projects has focused on sandeel and cod. Three species of sandeels (Ammodytidae spp.) were caught during surveys with abundance data indicating that the area around the Moray West Site and Offshore Wind Farm Area do not support particularly important sandeel populations. The cod survey recorded individuals at a total of 35 of the 58 tows in relatively low numbers, with 23 spawning cod caught. The survey determined that significant cod spawning did not take place within the Moray Firth zone.

Key fish and shellfish species of commercial importance occurring within the Moray West Site and along the Offshore Export Cable Corridor include king scallop (*Pecten maximus*), squid (*Loligo forbesi*), crab, lobster and Nephrops. Haddock accounts for the majority of the whitefish landings.

According to Barne *et al.* (1996), within the Moray Firth there are several species that migrate between fresh and salt waters, including Atlantic salmon (*Salmo salar*), sea trout (Salmo trutta), sea lamprey (Petromyzon marinus), river lamprey (*Lampetra fluviatilis*), European eel, twaite shad (Alosa fallax) and allis shad (*Allosa alosa*). Within the Moray Firth there are 8 river systems designated as SACs that support spawning populations of Atlantic salmon (*Salmo salar*) as detailed in Table 2.3.1. Additionally, the River Spey SAC which is situated in close proximity to the landfall area also support populations of sea lamprey. Non-designated river systems, including the River Deveron near to the landfall area, may also support migratory species that have the potential to interact with the Wind Farm site or the OfTI during key periods of migration.

2.3.2.4 Marine Mammals

To date, a total of 14 cetacean (whale, dolphin and porpoise) and two pinniped (seal) species have been recorded within the Moray Firth (Moray East ES, 2012, as adapted from Reid *et al*. 2003, Robinson *et al.* 2007, Thompson *et al.* 2010a), these are listed in Table 2.3.3 below. Of these, the most common species occurring within the Moray Firth include harbour and grey seals, harbour porpoise, minke whale and bottlenose dolphin.

All cetaceans are listed on Annex IV of the Habitats Directive and therefore are protected from physical injury (harm) and disturbance. Harbour porpoise, bottlenose dolphin, harbour seal and grey seal are also listed on Annex II of the Habitats Directive and, as such, are also protected through the designation of SACs. Harbour seals are a qualifying feature of the Dornoch Firth and Morrich More SAC. Bottlenose dolphin are a qualifying feature of the Moray Firth SAC and the primary reason for its designation. The current population estimate for the Moray Firth SAC is 195 animals. As discussed previously, minke whale is one of the main features of interest of the Southern Trench pNCMPA. Estimated densities for minke whales across the Moray Firth are generally low except for the Southern Trench NCMPA, where higher densities have been observed during the summer when minke whales move into the area for foraging. Harbour porpoise are the smallest and most abundant cetacean species in UK waters (Reid *et al.,* 2003) and are also the most abundant species in the Moray Firth. The abundance of the North Sea population of harbour porpoise is currently estimated at 345,373 porpoise (95% CI: 246,526 to 495,752) (Hammond *et al.,* 2017).

Marine mammals species recorded in the Moray Firth are listed in Table 2.3.3 below.

Table 2.3.3: Marine Mammal Species Recorded in the Moray Firth

Name	Frequency of Occurrence
Harbour seal	Common, all year
Grey seal	Common, all year
Harbour porpoise	Common, all year
Bottlenose dolphin	Common, all year
Common dolphin	Common, seasonal
White-beaked dolphin	Common, seasonal
Minke whale	Common, seasonal
Risso's dolphin	Occasional
White-sided dolphin	Occasional

Table 2.3.3: Marine Mammal Species Recorded in the Moray Firth	
Name	**Frequency of Occurrence**
Killer whale	Occasional
Pilot whale	Rare
Humpback whale	Rare
Fin whale	Rare
Sperm whale	Rare
Northern bottlenose whale	Rare
Beluga whale	Rare

2.3.2.5 Ornithology

A total of 35,372 seabirds were recorded during aerial surveys undertaken across the Moray West Site plus a 4 km buffer between April 2016 and March 2017. Results comprise a total of 21 species with guillemot, kittiwake and razorbill the three most frequently encountered species. These three species accounted for over 86% of all birds records. Only 5.6% of all records could not be assigned to species level. Key species assessed as part of the ornithological assessment undertaken for the EIA are detailed in Table 2.3.4.

Table 2.3.4: Key Species Assessed as part of the Ornithological Assessment Undertaken for the EIA	
Key Bird Species considered in the EIA Report	
Fulmar	Arctic skua
Gannet	Puffin
Razorbill	Herring gull
Guillemot	Great black backed gull
Kittiwake	Scaup*
Eider*	Goldeneye*
Long-tailed duck*	Red-breasted merganser*
Common scoter*	Red-throated diver*
Velvet scoter*	Great northern diver*

(*) denotes species relevant to the offshore export cable corridor only.

2.3.3 Human Environment

2.3.3.1 Commercial Fisheries

The principal commercial fisheries fleets operating in areas relevant to the Development have been identified as follows:

- Creel fleet (crabs and lobster) – mainly nearshore areas along the Offshore Export Cable Corridor and in the vicinity of the Landfall Area;
- Mackerel jigging – similar locations to the creel fleet, again focused more on nearshore / coastal areas;
- Demersal trawl fleet (Nephrops, squid and whitefish):

  - Nephrops – main grounds lie south of the Moray West Site therefore most activity along the Offshore Export Cable Route;
  - Squid – mainly along the Offshore Export Cable Route but also some activity in the Moray West Site; and
  - Whitefish (haddock) – mainly in the Moray West Site but low intensity.
- Scallop dredging fleet (king scallops) – mainly in the Moray West Site; and
- Scottish seine fleet (haddock) – throughout study area at low intensity.

2.3.3.2 Shipping and Navigation

The current shipping and navigation baseline was informed by 53 days of marine traffic data collection completed over two surveys: one summer survey and one winter survey. The study area comprised of the Moray West Site plus a 10 nm buffer and the Offshore Export Cable Corridor plus a 5 nm buffer.

During the summer survey, an average of approximately ten unique vessels were recorded within 10 nm of the Moray West Site, four of which intersected the site itself. Traffic levels dropped during winter (noting that non-AIS vessels will be underrepresented during winter), with an average of four unique vessels per day recorded within 10 nm of the Moray West Site, two per day of which intersected the site itself.

The most commonly recorded traffic recorded during both seasonal periods was from fishing vessels, and oil and gas support vessels associated with the Beatrice Oil Field operations. Other vessels included cargo / commercial vessels and recreational (cruise liners).

2.3.3.3 Military and Civil Aviation

The Moray West Wind Farm will be visible from the military Air Traffic Control (ATC) Primary Surveillance Radar (PSR) at RAF Lossiemouth and the civilian NATS (En Route) plc (NERL) PSR at Allanshill. Highlands and Islands Airport Ltd. (HIAL) also operate an airport at Wick to the north-east of the Moray West Site and a PSR at Inverness to the west of the Moray West Site. The Moray West Site is also located in the vicinity of and directly beneath helicopter main route (HMR) XRAY which routes between Aberdeen and Wick, and the helicopter approaches to helidecks on platforms in the Beatrice and Jacky Oil Fields.

2.3.3.4 Seascape, Landscape and Visual Receptors

The Moray Firth coastline is generally rural in character with a predominantly agricultural land use and a strong association with the sea. There are numerous settlements along the coastline and these are connected by roads, rail and other routes that generally run close to, or on, the coast. The Moray West Site, lies approximately 22 km from the Caithness Coast with the closest point located near Lybster. Once constructed the Wind Farm will visible from a number of locations along the Caithness, Sutherland, Ross and Cromarty, Moray and Aberdeenshire coastlines.

2.3.3.5 Archaeology and Cultural Heritage

The archaeological study area comprised the Moray West Site, the Offshore Export Cable Corridor and a 2 km buffer around both areas. Geologically, the surrounding landscape would have been subjected to glacial and interglacial cycles and at various times the area would have been covered by ice sheets, inundated by water from melting ice sheets and associated rising sea levels, and at certain points would have been dry land and therefore, may have been suitable for human settlement. There were no designated prehistoric archaeological sites located within the archaeological study area.

Within the study area, a total of 39 geophysical anomalies were identified from a review of geophysical data collected in 2010. Of these, 29 anomalies within the Moray West Site were identified as having possible archaeological potential, including a record from a recorded wreck. A further six wrecks and five obstructions were identified along the Offshore Export Cable Corridor from a review of UKHO datasets.

2.3.3.6 Other Human Activities

Offshore Wind Farms

Beatrice Wind Farm Demonstrator Project

The Beatrice Wind Farm Demonstrator Project is one of two operational offshore wind farms in Scottish waters and is located adjacent to the Beatrice oil field, immediately to the west of the Moray West site. This small wind farm comprises of two 5 MW wind turbines. All electricity generated by these two turbines is fed to a nearby oil platform. It is understood that these turbines will be decommissioned at the same time as the Beatrice Oil Field infrastructure, with decommissioning work expected to begin in 2024.

Beatrice Offshore Wind Farm

Beatrice Offshore Wind Farm is comprised of 84 wind turbines, two offshore transformer modules (or OSPs) and associated cable infrastructure. The BOWL lease area lies adjacent to the extreme north-east corner boundary of the Moray West Site approximately 13.5 km from the Caithness Coast in the Outer Moray Firth. BOWL's proposed export cable will travel approximately 65 km from the BOWL wind farm, through the Development, and make landfall at Portgordon.

The Beatrice Offshore Wind Farm received consent in 2014 and construction commenced in April 2017. The Project is scheduled to be fully commissioned in February 2019.

Moray East

Moray Offshore Renewables Limited (MORL) (now Moray East) were granted consent in 2014 for three adjacent projects (Telford, Stevenson and MacColl Offshore Wind Farms) in the Moray Firth. The project consents allow a total capacity of up to 1,116 MW and up to 186 turbines across the Moray East Site. Expected to be commissioned in 2022 in line with Contracts for Difference milestones.

Oil and Gas

Oil Fields and Platforms

The Development is located within an area surrounded by oil and gas activity and is in close proximity to, but not overlapping two producing oil fields. The "Beatrice" (Block 11/30a) oil field is located immediately to the immediate north of the Moray West Site, and was in production from 1981-2015, whilst "Jacky" (Block 12/21c) oil field located immediately adjacent to "Beatrice" and commenced production in 2009. The Beatrice platforms lie between 200 – 1,200 m from the Moray West Site boundary, whilst the Jacky platform lies approximately 2.5 km away. Both the Jacky and Beatrice oil fields are no longer producing and are scheduled for decommissioning.

Oil and gas extracted from the Beatrice Oil Field is exported to shore via an installed pipeline. This pipeline crosses the north-west corner of the Moray West Site and runs to shore at Nigg in the Cromarty Firth.

Marine Dredging and Disposal

Dredging and disposal activity within the Moray Firth is sporadic and associated with port and harbour maintenance and development and coastal marine disposal sites.

The closest 'open' marine disposal site to the Development is "Buckie" which lies 2 km from the Offshore Export Cable Corridor, followed by which lies 24.5 km from the Moray West Offshore Windfarm Site.

Subsea Cables and Pipelines

There is one existing subsea telecommunications cable in proximity to the Development. The SHEFA-2 fibre-optic telecommunications cable, owned by Faroese Telecom, links the Faroe Islands to mainland Scotland via the Northern Isles (Faroese Telecom, 2017). It runs south from the Orkney Islands to the Scottish mainland at Inverboyndie and is buried under the seabed surface as it transits the Moray Firth and makes landfall 5 nm (10 km) east of the Moray West landfall area.

SHE-T own the Caithness – Moray Link, a subsea High Voltage Direct Current (HVDC) reinforcement of the transmission network between Caithness and Moray (SHE-T, 2015). Installation of the Caithness Moray Interconnector Cable is due to be completed by the end of 2018, for commissioning and to commence operation in 2019.

3 Description of Items to be Decommissioned

3.1 Layout of the Development

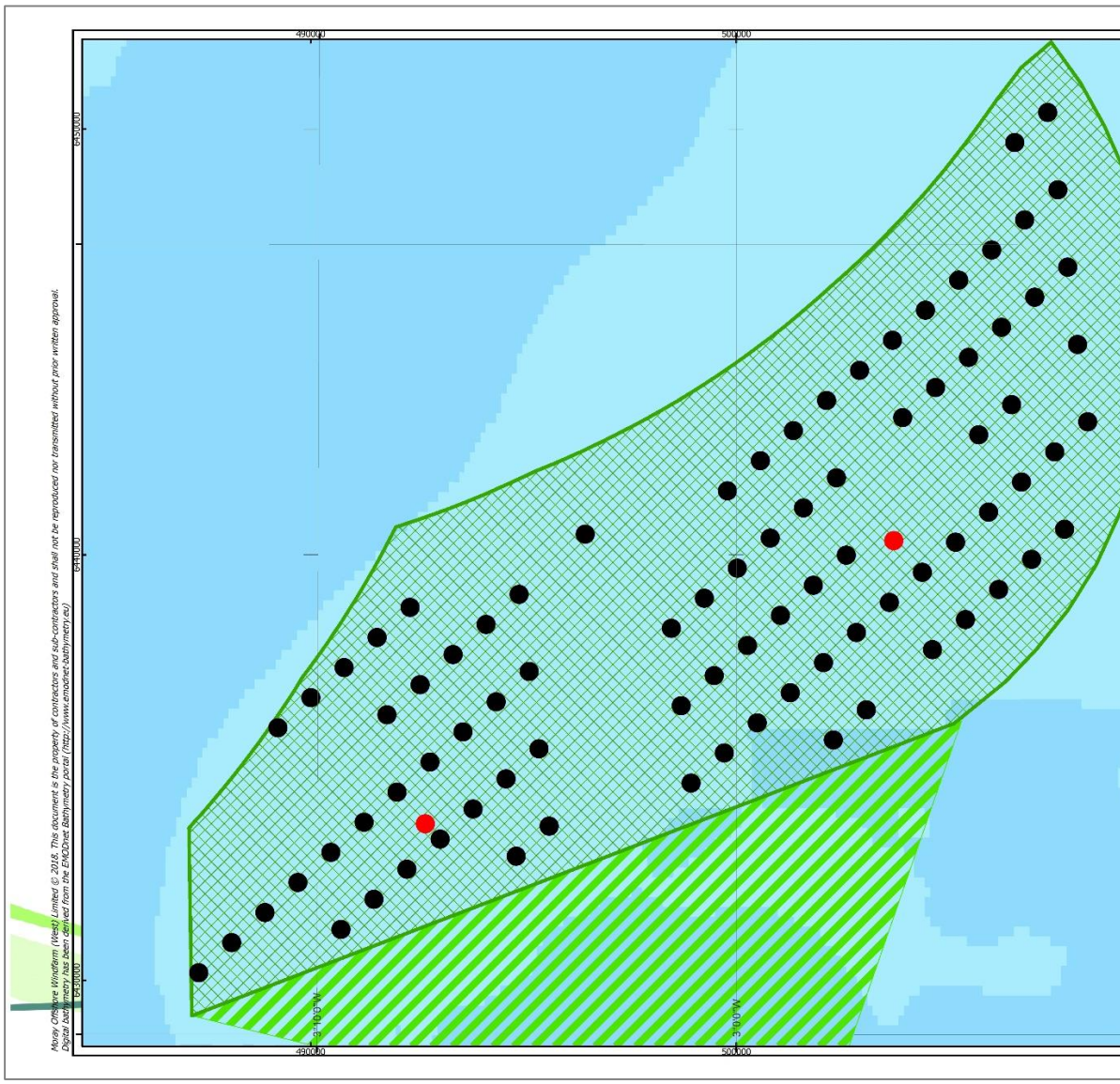

Figure 3.1 illustrates the layout of the Development.

3.2 Elements to be Decommissioned

The following elements of the Development will be decommissioned:

- WTGs and OSPs; and
- Support structures and foundations for the WTGs and OSPs.
- Substructures and associated seabed foundations;
- OSPs; and
- Subsea interconnector and export cables.

The plan is that buried cables (inter-array, OSP interconnector and offshore export cables) will be left in-situ. Where cables are exposed (above the seabed) and present a potential snagging risk or hazard to other sea users the exposed sections of cable will be removed to a cut-off point below the surface of the seabed.

Further details of the decommissioning process, including the decommissioning method for each of the major components, are set out in Section 5.

3.2.1 Wind Turbine Generators (WTGs)

Moray West requires flexibility in WTG choice to ensure that anticipated changes in available technology and project economics can be accommodated within the project design. The Design Envelope used within the EIA therefore sets maximum and, where relevant, minimum realistic worst-case scenario parameters. For the purposes of the EIA, four WTG model types have been considered and are referred to throughout the Offshore EIA Report as Model 1, Model 2, Model 3 and Model 4. Subject to final design it is possible that an alternative WTG, model types may be selected, however, the physical parameters of the WTGs such as maximum blade tip height, rotor diameter, and height of nacelle will remain within the maximum envelope described. Similarly, the DP considers the same design envelope parameters as detailed within the EIA Report.

The Development will comprise of up to 85 wind turbines. Although a range of WTG models will be considered, they will follow the traditional conventional offshore WTG design architecture with three blades and a horizontal rotor axis. The range of possible WTG models and the key parameters of each are presented in Table 3.2.1.

Table 3.2.1: WTG Parameters

Parameter	Maximum Design Envelope			
	Model 1 WTGs	Model 2 WTGs	Model 3 WTGs	Model 4 WTGs
Maximum number of WTGs	85	85	72	62
Minimum height of lowest blade tip above HAT (m)	22	22	22	22
Maximum blade tip height above HAT (m)	199	230	265	285
Maximum rotor blade diameter (m)	164	195	230	250

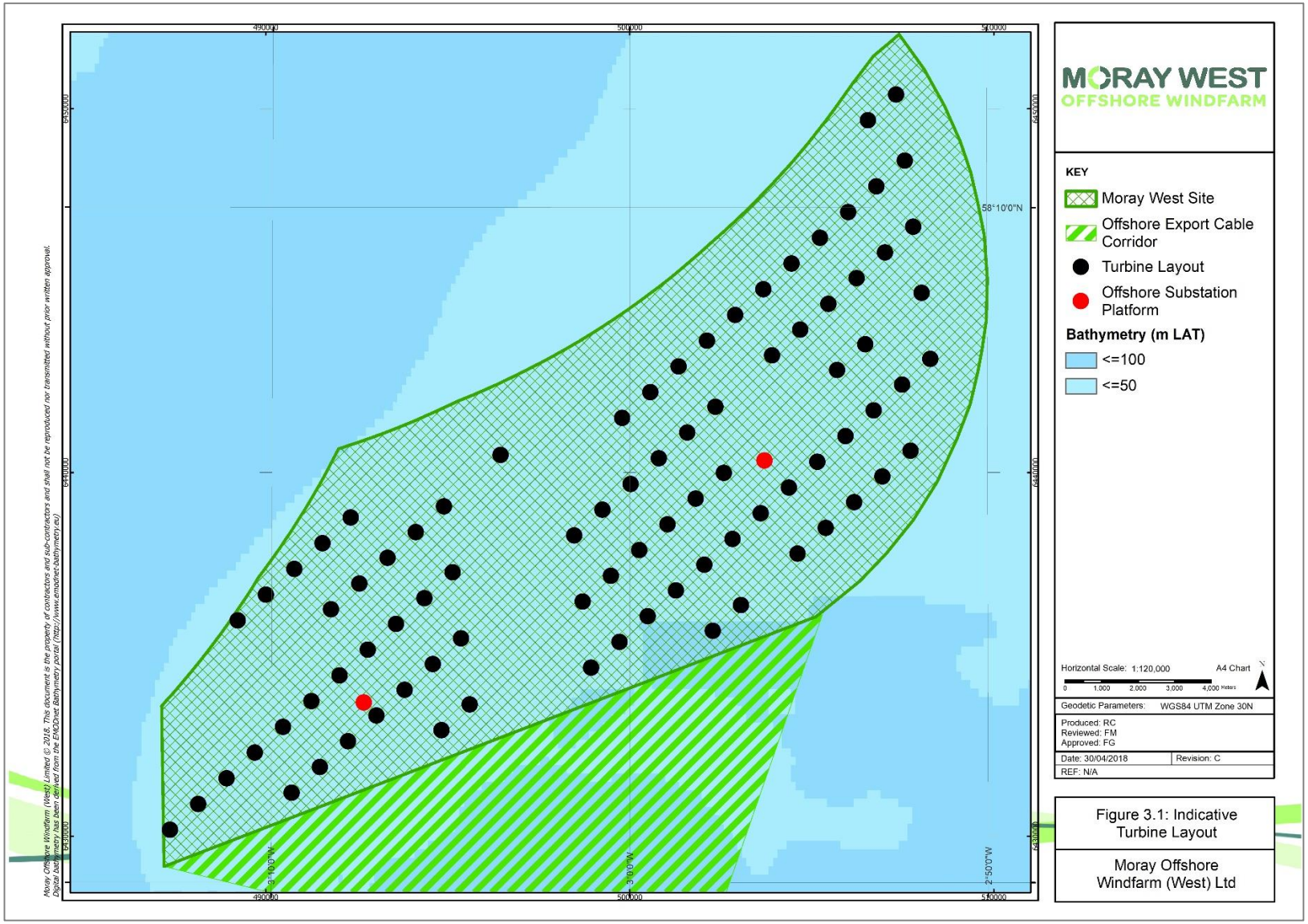

Figure 3.1: Indicative Turbine Layout

3.2.2 Foundations and Substructures for WTGs and OTMs

There are a number of substructure types that are being considered for the Moray West Offshore Wind Farm. As with WTG type, Moray West will require flexibility in substructure choice to ensure that anticipated changes in available technology and project economics can be accommodated within the project design. The final selection will depend on factors including WTG type, physical and environmental constraints, project economics and procurement approach.

The WTG substructures that will ultimately be constructed and decommissioned will utilise one of the following designs:

- Piled monopile foundations ('monopiles');
- Suction caisson monopile foundations;
- Pin-piled jacket foundations;
- Suction caisson jacket foundations; and
- Gravity base foundations.

If available to the market at the time of construction, hybrid substructure types may also be used, for example whereby monopile and gravity base structures may be used in combination.

Parameters for each type of substructure are listed in the tables below.

3.2.2.1 Monopiles

A monopile typically consists of a single tubular steel column (pile) embedded into the seabed and extending to approximately water surface level. A tubular steel transition piece (TP) of similar diameter is fitted on to the pile and secured mechanically (e.g. bolts) or by a grouted interface. The TP may include integrated ancillary components, such as boat landing, working platform, sacrificial anodes etc., as well as providing the connection to the wind turbine tower. The TP is usually painted yellow and marked according to relevant regulatory guidance and may be installed separately following the monopile installation. A fully integrated pile and TP structure may also be considered. The maximum dimensions of the monopile substructures can be seen in Table 3.2.2 below.

Table 3.2.2: Monopile Parameters

Parameter	Maximum Design Envelope	
	Model 1 WTGs	Model 4 WTGs
Number of monopiles	85 (for WTGs) 2 (for OSPs)	62 (for WTGs) 1 (for OSPs)
Diameter of monopile (m)	12	15
Embedment depth (below seabed)	50	50

3.2.2.2 Pin-Pile Jackets

Piled jacket substructures are formed of a steel lattice construction (comprising tubular steel members and welded joints) secured to the seabed by hollow steel pin-piles connected to the jacket feet. The TP and ancillary structure is fabricated as an integral part of the jacket. Pin-piles will typically be of a smaller diameter than monopiles. Jacket substructures would be three- or four-legged. The design envelope for jacket substructures with pin-piles is shown in Table 3.2.3 below.

Table 3.2.3: Pin-Pile Jacket Parameters		
Parameter	**Maximum Design Envelope**	
	Model 1 WTGs	**Model 4 WTGs**
Number of jackets	85 (for WTGs) 2 (for OSPs)	62 (for WTGs) 1 (for OSPs)
Number of legs per jacket	3 or 4	3 or4
Separation of adjacent legs at seabed level (m)	35	40
Leg diameter (m)	3	3.5
Piles per foundation	Up to 4	Up to 4
Pin pile diameter (m)	3.5	4
Embedment depth (below seabed)	60	60

3.2.2.3 Suction-Caisson Jackets

Suction caissons consists of a steel cylindrical skirt or skirts (the bucket) sealed at the top, which penetrate into the seabed under the weight of the jacket and hydrostatic forces created as a result of hydraulically excavating the internal cavity of the bucket. Once sealed into position these hydrostatic forces provide the structure with sufficient connection with the seabed for the environmental (wind, wave and tide) and turbine loads.

Suction caissons can be used with either jacket or monopile substructures. For both the jacket and monopile substructures the TP and ancillary structures may be fabricated as an integrated part of the substructure.

Suction caisson jacket substructures will be three or four-legged, whereas monopile caissons will comprise larger, singular structures. Consequently, the dimensions of the suction caissons required for jacket substructures compared to monopile substructures will be different. The design envelopes for suction caisson jacket substructures and suction caisson monopile substructures are presented in Table 3.2.4 and Table 3.2.5 respectively.

Table 3.2.4: Suction Caisson Jacket Parameters		
Parameter	**Maximum Design Envelope**	
	Model 1 WTGs	**Model 4 WTGs**
Number of jackets	85 (for WTGs) 2 (for OSPs)	62 (for WTGs) 1 (for OSPs)
Number of legs per jacket	3 or 4	3 or4
Separation of adjacent legs at seabed level (m)	35	40
Leg diameter (m)	3	3.5
Suction caissons per foundation	Up to 4	Up to 4
Suction caisson diameter (m)	20	25
Caisson penetration depth (below seabed) (m)	15	20

Table 3.2.4: Suction Caisson Jacket Parameters		
Parameter	**Maximum Design Envelope**	
	Model 1 WTGs	**Model 4 WTGs**
Height of caisson remaining above seabed once installed (m)	10	10

Table 3.2.5: Mono Suction Caisson Parameters		
Parameter	**Maximum Design Envelope**	
	Model 1 WTGs	**Model 4 WTGs**
Number of suction caissons	85 (for WTGs) 2 (for OSPs)	62 (for WTGs) 1 (for OSPs)
Suction caissons per foundation	1	1
Suction caisson diameter (m)	45	55
Caisson penetration depth (below seabed) (m)	30	35
Height of caisson remaining above seabed once installed (m)	10	10

3.2.2.4 Gravity Bases

Gravity base substructures are concrete or concrete-steel hybrid structures, sometimes including additional ballast (typically sand, gravel, rock or dredged material) that sit on the seabed to support the turbine tower. Gravity bases vary in shape, but are significantly wider at the base (at seabed level) to provide support and stability to the structure. Conical or upside down T-shaped bases are being considered for the Development.

The Design Envelope for gravity base substructures is shown in Table 3.2.6.

Table 3.2.6: Gravity Base Foundation Parameters		
Parameter	**Maximum Design Envelope**	
	Model 1 WTGs	**Model 4 WTGs**
Number of gravity base foundations	85 (for WTGs) 2 (for OSPs)	62 (for WTGs) 2 (for OSPs)
External diameter at sea surface (m)	12	15
External diameter at seabed (m)	45	55
Seabed preparation diameter (m)	85	95
Seabed excavated depth (m)	5	5
Height of installed base above seabed (m)	20	30
Gravel bed volume per foundation (m^3)	16592	22089

3.2.3 Scour Protection for Substructures

Scour protection may be required to prevent substructures for WTGs, OSPs and other offshore infrastructure, being undermined by hydrodynamic and sedimentary processes, resulting in seabed erosion and subsequent scour hole formation. Several types of scour protection exist, and the Development is considering use of the following:

- Graded rock placement – layers of graded stones placed around / on structures to inhibit erosion;
- Rock bags – rock-filled fibre mesh bags, which adopt the shape of the seabed/structure as they are lowered onto it;
- Concrete mattresses - typically several metres wide and long, of cast articulated concrete blocks which are linked by a polypropylene rope lattice, which are placed on / around structures to stabilise the seabed and inhibit erosion; and
- Frond mats – mats typically several metres wide and long, comprised of continuous lines of overlapping buoyant polypropylene fronds that create a drag barrier which prevents the sediment in their vicinity from being transported away. The frond lines are secured to a polyester webbing mesh base that is itself secured to the seabed by a weighted perimeter or anchors pre-attached to the mesh base by polyester webbing lines.

The amount and type of scour protection required will vary for the different substructure types being considered and the final design of the substructures. The final choice and detailed design of a scour protection solution for the Moray West Offshore Wind Farm will be made after detailed design of the foundation structure.

Scour protection options for WTG substructures and conservative material volumes are shown in Table 3.2.7 below.

Table 3.2.7: Scour Protection Parameters

Parameter	**Maximum Design Envelope**				
	Monopile	**Pin-Pile Jacket (per pin-pile)**	**Suction Caisson Jacket (per caisson)**	**Mono Suction Caisson**	**Gravity Base**
Scour protection options	Rock placement; rock bags; concrete mattressing; frond mats	Concrete mattressing; rock bags; Frond mats	Concrete mattressing; rock bags; Frond mats	Rock placement; rock bags; concrete mattressing; frond mats	Rock placement; rock bags; concrete mattressing; frond mats
Area of scour protection (including foundation) per foundation (m^2)	1,080	167	1100	4,712	4,712

3.2.4 Inter-Array Cabling

The inter-array cables will consist of a number of power conductor cores, usually made from copper or aluminium, and fibre optic communication cables surrounded by layers of insulating material as well as material to armour the cable for protection from external damage and material to keep the cable watertight.

The Design Envelope for inter-array cables is shown in Table 3.2.8 below.

Table 3.2.8: Inter-Array Cable Parameters	
Parameter	**Maximum Design Envelope**
Cable specification	3-core cable with integrated fibre optics
Total length of cable (km)	275
Voltage range (kV)	33 - 72.5

It is Moray West's preferred option to bury the inter-array cables. It is therefore not currently anticipated that cable protection material will be needed. Only close fitting mechanical protection between the seabed and J-tubes is anticipated. The exception to this would be where the intended depth of cover (i.e. the thickness of material on top of the cable after installation) is not achieved during installation.

3.2.5 Offshore Transmission Infrastructure

3.2.5.1 Offshore Substation Platform (OSP)

Up to two OSPs will be installed to transform the voltage of the electricity generated at the WTGs to a higher voltage suitable for transporting power to the onshore electricity transmission network. Either one large or two smaller OSPs will be installed.

In terms of appearance, the most common designs use a platform consisting of a single or multi-level 'topside' within or upon which sits the primary electrical equipment and ancillary components. The topside is supported above sea level on a foundation structure. The primary electrical equipment on the topside typically includes step-up transformers and switchgear with the purpose of increasing the voltage of the electricity generated offshore for transportation to shore and facilitating connection to the offshore export cables. The OSP(s) will be high voltage alternating current (HVAC). The ancillary components on the topside typically include communication and control equipment as well as emergency refuge facilities.

Table 3.2.9 presents the Design Envelope parameters for the OSPs.

Table 3.2.9: OSP Parameters	
Parameter	**Maximum Design Envelope**
Number of OSPs	2
Substructure options	Jacket with pin piles or suction caissons Jack-up Monopile Mono suction caisson Gravity base structure
Topside length (m)	100
Topside width (m)	100
Topside height above HAT (m)	70

The OSPs will be supported by jacket or jack-up, monopile, mono suction caisson or gravity base foundations. The characteristics of the foundations will be similar to those described previously. The jack-up concept, which is not considered for WTGs, is towed to site and then has its legs lowered to the seabed and jacked-up to appropriate clearance above the sea surface before being fixed in situ, most likely using pin-piles as for the jacket foundation.

3.2.6 Interconnector Cabling

If two OSPs are installed, an interconnector cable may be used to link the two OSPs. The extent of the possible cabling between OSP(s) has not yet been determined and cable length will depend upon the distance between OSP(s), which will be located within the Moray West Site. The maximum voltage for OSP interconnection cabling will not exceed the maximum export cable operational voltage and be in the region of 33 - 220 kV.

The Design Envelope for the OSP interconnection cable is shown in Table 3.2.10.

Table 3.2.10: Interconnector Cable Parameters

Parameter	Maximum Design Envelope
Cable specification	3-core cable with integrated fibre optics
Cable diameter (mm)	200 (subject to crossing agreement)
Total length of cable circuit (km)	15
Voltage range (kV)	33 - 400

3.2.7 Export Cables

Like the inter-array cables, the offshore export cables will consist of a number of conductor cores, usually made from copper or aluminium. These will be surrounded by layers of insulating material as well as material to armour the cable for protection from external damage, and material to keep the cable watertight. Export cables however, are typically larger in diameter than inter-array cables, due to the larger conductor cores required to transport greater volumes of power. The Offshore Export Cable will connect the OSPs to the Onshore Transmission Infrastructure at the landfall location.

The Design Envelope for export cables is shown in Table 3.2.11 below.

Table 3.2.11: Export Cable Parameters

Parameter	Maximum Design Envelope
Number of export cable circuits	Up to 2
Cable specification	3-core cable, most likely with integrated fibre optics
Total length of cable (km)	65 per circuit
Voltage range (kV)	132 - 400

3.2.8 Cable Protection

The inter-array, interconnector and export cables will be buried as far as possible. Where, during installation, it is not possible to reach the required target burial depth alternative means of protection will be used. The exact amount of cable protection required along each cable will depend on the burial success achieved during cable installation but is not expected to exceed 10% of the total length of the inter-array or OSP interconnector cabling or 20% of the two offshore export cable circuits.

Alternative methods of cable protection may include rock placement or use of concrete mattresses or grout bags and/or installation of a cable protection system (CPS) around the cable. Should cable protection need to be installed, its decommissioning will be considered in the final DP, with an approach to decommissioning developed in accordance with the Guiding Principles outlined in Section 4.4.

4 Description of Proposed Decommissioning Measures

4.1 Introduction

This section provides an overview of the decommissioning options available and sets out the proposed approach to the decommissioning of the Development as described in Section 3 above.

4.2 Decommissioning Considerations

This DP has been developed with reference to the guidance and standards outlined within the following publication: Decommissioning of Offshore Renewable Energy Installations under the Energy Act 2004: Guidance notes for Industry, DECC, January 2011 (revised), which in turn draws upon the following:

- Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone, International Maritime Organisation (IMO), 19th October 1989;
- Guidance Notes for Industry: Decommissioning of Offshore Installations and Pipelines under the Petroleum Act 1998, DECC, March 2011;
- OSPAR Guidance on Environmental Considerations for Offshore Wind Farm Development, 2008;
- Guidelines for Environmental Risk Assessment and Management – Green Leaves III, Defra, November 2011; and
- United Nations Convention on the Law of the Sea (UNCLOS), 1982.

In considering appropriate decommissioning provisions, Moray West have sought to adhere to the following key principles:

- Safety for all, at all times;
- Consideration of the rights and needs of legitimate users of the sea;
- Minimise environmental impact;
- Adherence to 'polluter pays' principle;
- Promote sustainable development;
- Maximise the reuse of materials;
- Commercial viability; and
- Practical integrity.

Moray West will also adhere to the concept of Best Practicable Environmental Option (BPEO); that is the option which provides the most benefit or least damage to the environment as a whole, at an acceptable cost, in both the long and short term.

4.3 Decommissioning Options

Moray West have considered alternative options for the decommissioning of the Development, and a brief summary of the options is set out below. When making a final decision on the approach to decommissioning towards the end of the operational lifetime of the Moray West Offshore Wind Farm, Moray West will take into consideration the BPEO, commercial viability and HSE risks.

The key aim is to restore the environment so that it can be used for other purposes, including safe navigation. In order to do this, it is expected by DECC (2011) that the decommissioning process will remove installations back to land for reuse, recycling, incineration with energy recovery or disposal at a licensed site. The situations in which other solutions (i.e. leaving in place or partially removing) may be considered include:

- The installation or structure will serve a new use, whether for renewable energy generation or for another purpose, such as enhancement of a living resource (provided it is not detrimental to other aims – e.g. conservation). This does not include leaving in place for colonisation and artificial reef purposes. However, in this situation, measures will be expected to put in place should the installation/structure finally become disused;
- Entire removal would involve extreme cost. It is considered that design decisions should, as far as possible, result in installations which are affordable to remove, but it is recognised that some elements, such as deep foundations, may nonetheless be costly to remove;
- Entire removal would involve an unacceptable risk to personnel;
- Entire removal would involve an unacceptable risk to the marine environment; and
- The installation of structure weighing more than 4000 tonnes in air (excluding any deck and superstructure) or is standing in more than 100 m of water and could be left wholly or partially in place without causing unjustifiable interference with other uses of the sea.

The current option for the decommissioning is set out in Section 4.5. However, a number of other options may be considered as set out immediately below.

4.3.1 Decommissioning and Construction of a New Wind Farm

For this scenario the assumption has been made that wind energy is still economically attractive in 2050 and the technical integrity of the Moray West Offshore Wind Farm is declining. If this were the case, installing new and better technology may be more profitable than increasing the O&M effort for a few extra years of running time on the existing wind farm. Under such a scenario, and subject to all necessary consents being granted, the existing wind farm would be decommissioned (following the process set out under Section4.5 below) and a new wind farm erected (with all appropriate consents having been obtained beforehand).

4.3.2 Re-powering

In this scenario it is assumed that wind energy is still economically attractive in 2050, the technical integrity of the wind turbines is declining but the electrical infrastructure and possibly the foundations remain sound. By closely monitoring the structural integrity of the asset, it could be possible, subject to any necessary consents being granted, to re-use electrical infrastructure and foundations in a re-powering of the wind farm – that is fitting new wind turbines to the existing foundation and electrical systems.

4.3.3 Step-down

This scenario assumes it is not profitable to invest in new technology but that most wind turbines will continue to perform sufficiently beyond the design lifetime of 50 years. Under this scenario, the Moray West Offshore Wind Farm would be decommissioned through a controlled step-down. In this case wind turbines would be gradually shut down as their technical integrity declined. A decommissioning campaign would most likely be undertaken when the complete wind farm was shut down, but could also be done stepwise if this was found to be more cost effective or if the prevailing regulatory regime required this approach. Any such step -own process would be set out for approval in the final DP.

4.3.4 Complete Removal

This scenario assumes it is not profitable to invest in new technology but that most wind turbines and/or their support structures and foundations will **not** continue to perform sufficiently beyond the design lifetime of 50 years. In this scenario the offshore wind farm and all associated components (as listed in Section 3.2 are removed with no intention of redeveloping the site.

4.4 Guiding Principles

Whatever the alternative scenario chosen, the decommissioning process will be in line with the following principles:

- BPEO, which is the option with the most benefit or least damage to the environment as a whole at an acceptable cost. This involves balancing the reduction in environmental risk with practicality and cost of reducing the risk;
- Consideration of the rights and needs of legitimate users of the sea;
- Safety of surface and subsurface navigation; and
- HSE considerations.

In accordance with DECC Guidance (DECC, 2011) the choice of BPEO should be informed by an EIA. The EIA used to inform this DP is the one prepared in support of application for consent, which is reported in the EIA Report dated 2018. The information relating to decommissioning in the EIA Report will be reviewed if the final decommissioning methods and programme are substantially different from those detailed within this DP. If necessary, more detailed assessment will be undertaken to accompany the application(s) for Marine Licence(s) which will be required for decommissioning of Moray West Offshore Wind Farm.

In considering the proposed DP for the Development, Moray West will seek solutions for each offshore element of the offshore wind farm that seek to follow the principles described in Table 4.4.1 below.

Table 4.4.1: Guiding principles in considering the proposed decommissioning programme for the Moray West Offshore Wind Farm

Guiding Principle	Comments
No harm to people	Moray West is committed to adhering to the highest standards for health and safety throughout the lifecycle of the project. Moray West seek to promote safe practices and minimise risk in the development and implementation of decommissioning solutions.
Consider the rights and needs of legitimate users of the sea	Moray West respects the rights and needs of other users of the sea. Decommissioning activities will seek to minimise the impact on stakeholders and emphasis will be placed on clear, open communication.
Minimise environmental impact	The BPEO, at the time of considering the precise decommissioning procedure, will be chosen in order to minimise impact on the environment at an acceptable cost.
Promote sustainable development	In decommissioning, Moray West will seek to ensure that, as far as is reasonably practicable, future generations do not suffer from a diminished environment or from a compromised ability to make use of marine resources.
Adhere to the Polluter Pays Principle	Moray West's decommissioning and waste management provisions acknowledge our responsibility to incur the costs associated with our impact on the environment.
Maximise re-use of materials	Moray West is committed to maximising the re-use of waste materials and pays full regard to the 'waste hierarchy'.
Ensure commercial viability	In order that commercial viability is maintained, the BATNEEC (Best Available Technique not Entailing Excessive Cost) decommissioning solutions will be sought.

Table 4.4.1: Guiding principles in considering the proposed decommissioning programme for the Moray West Offshore Wind Farm	
Guiding Principle	**Comments**
Ensure practical integrity	Solutions that are necessary to achieve one or more of the above objectives must be practicable.

Taking into account the UK's commitments under the United Nations Law of the Sea (UNCLOS); International Maritime Organisation (IMO) standards and the work of the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), Moray West's starting assumption in establishing the decommissioning requirements has been complete removal of all offshore components to shore for re-use, recycling or incineration with energy recovery or disposal at a licensed site. This assumption has been assessed for all components against the key principles presented above. In some instances this option has not been considered to be appropriate and alternative options have been considered. These alternatives have also been assessed according to the above principles and the optimum solution selected.

The DECC guidance (DECC, 2011) states that there are some cases where it may be possible to consider solutions other than complete removal. This includes where foundations or structures are located below the level of the seabed:

> *'Where an installation's foundations extend some distance below the level of the seabed, removing the whole of the foundations may not be the best decommissioning option, given the potential impact of removal on the marine environment, as well as the financial costs and technical challenges involved. In these cases, the best solution might be for foundations to be cut below the natural seabed level at such a depth to ensure that any remains are unlikely to become uncovered. The appropriate depth would depend upon the prevailing seabed conditions and currents. Contingency plans should be included in the decommissioning programme, to describe the action proposed if the foundations do become exposed.'*

The following sections on the approach to decommissioning identify those parts of the Development where Moray West propose that the infrastructure will therefore be left in situ and provides an assessment of the decommissioning options in relation to the guiding principles set out in Table 4.4.1 specifically in relation to:

- Wind turbine and OTM foundations; and
- Inter-array, OPS interconnector and export cables.

All work will follow the recommendations and requirements of the Construction (Design and Management) (CDM) Regulations 2015 (or applicable regulations at the time the work starts).

4.5 Proposed Decommissioning Process

4.5.1 Wind Turbine Generators

The wind turbines will be decommissioned in full. The removal of turbine components including blades, nacelle, and tower and will be a reversal of the installation process.

The general methodology for carrying out wind turbine decommissioning will be:

- De-energise wind turbines and isolate from the grid;
- Mobilise suitable heavy lift vessels to site;
- Remove turbine blades;

- Removal of all tower/nacelle internal cables that connect the generator and transformer as well as related control and communication cables;
- Remove nacelle including the gearbox and generator;
- Dismantle and remove turbine tower; and
- Transportation of all components to an onshore facility for processing.

Once onshore, components are likely to be processed as follows:

- All hazardous substances and fluids will be removed from the wind turbines (such as oil reservoirs and any hazardous materials and components). All such materials will then be disposed of in accordance with relevant regulations at the time of disposal;
- All steel components will be sold for scrap to be recycled. This forms the bulk of the wind turbine structures; and
- The wind turbine blades (fibreglass) will be disposed of in accordance with the relevant regulations in force at the time of decommissioning.

Table 4.5.1 provides an assessment of the WTG decommissioning process against the guiding principles outlined in Table 4.4.1.

Table 4.5.1: Assessment of Proposed Wind Turbine Decommissioning Process Against Guiding Principles

Guiding Principle	Comments
No harm to people	Safest option, involving standard procedures and minimal work offshore.
Consider the rights and needs of legitimate users of the sea	Complete removal of wind turbines considered best long term solution. Appropriate notification and consultation prior to temporary works to minimise disruption.
Minimise environmental impact	Risk of spillage minimal as a result of all potential pollutants being fully contained within the nacelle and nacelle being removed in a single lift. All subsequent dismantling takes place onshore thereby minimising potential for pollution incidents.
Promote sustainable development	Wind turbines and support structures completely removed from site ensures no ongoing environmental impacts and no restriction on future use of marine resources.
Adhere to the Polluter Pays Principle	Entirely consistent with this principle – full removal and disposal.
Maximise re-use of materials	All dismantling of individual major components (i.e. nacelle) to take place onshore. Maximum potential for re-use or recycling.
Ensure commercial viability	Most commercially viable solution – minimal works offshore and maximum potential for re-sale/re-use value from turbine components with minimum residual risk.
Ensure practical integrity	Known/tried and tested procedures and reduced risks due to minimising of offshore activity.

4.5.2 Support Structures

The following sections set out the proposed decommissioning approach for the support structures - piled foundation and jacket substructures.

4.5.2.1 Jackets and Transitional Pieces

Decommissioning of a jacket structure will be the reverse of the installation process. Following the separation of the jacket from the piles, the jacket will be lifted off the piles by a heavy lift vessel and recovered and taken ashore for re-use or scrap recycling.

Table 4.5.2 provides an assessment of the jacket substructure decommissioning process against the guiding principles outlined in Table 4.4.1.

Table 4.5.2: Assessment of Proposed Jacket Substructure Decommissioning Process Against Guiding Principles

Guiding Principle	Comments
No harm to people	Heavy lift and removal to shore for disassembly minimises work offshore.
Consider the rights and needs of legitimate users of the sea	Complete removal of structure considered best long-term solution. Appropriate notification and consultation prior to temporary works to minimise disruption.
Minimise environmental impact	Minimal risk of environmental impact arising from jacket lifting and removal; subsequent dismantling or cutting would take place onshore thereby minimising potential for environmental impacts at sea.
Promote sustainable development	Jacket substructures completely removed from site and ensures that no ongoing environmental impacts and no restriction on future use of marine resources.
Adhere to the Polluter Pays Principle	Entirely consistent with this principle – full removal and disposal.
Maximise re-use of materials	Any dismantling to take place onshore. Maximum potential for re-use or recycling.
Ensure commercial viability	Most commercially viable solution – minimal works offshore and maximum potential for re-sale/re-use value with minimum residual risk.
Ensure practical integrity	Known/tried and tested procedures and reduced risks due to minimising of offshore activity.

4.5.2.2 Pin-Pile Foundations

The proposed approach to the decommissioning of the pin pile foundations (wind turbines and OSPs) is to cut off the piles at or just below seabed level. Currently, abrasive diamond wire cutting is considered likely to be the preferred method for the cutting of the piled foundations, but other methods may be preferred at the time of decommissioning. The material cut off from the pin piles will be recovered and taken ashore for scrap recycling.

Table 4.5.3 provides an assessment of the piled foundation decommissioning options against the guiding principles outlined in Table 4.4.1.

Table 4.5.3: Assessment of Piled Foundation Decommissioning Options Against Guiding Principles

Criterion	Complete Removal of Piled Foundations	Cutting of Piled Foundations at a Depth That Does Not Pose a Danger to Other Sea Users
No harm to people	Significant excavation required to remove seabed material prior to pile recovery. Excavation would need to be undertaken by divers and hazards to dive teams would	Fewer activities to be undertaken over a shorter time period offshore, minimising risk to personnel. Post decommissioning site monitoring will identify any unlikely exposure with the result that safety risk is insignificant (see Section 0).

Table 4.5.3: Assessment of Piled Foundation Decommissioning Options Against Guiding Principles		
Criterion	**Complete Removal of Piled Foundations**	**Cutting of Piled Foundations at a Depth That Does Not Pose a Danger to Other Sea Users**
	be significant due to the nature of the work involved and duration of operations.	
Consider the rights and needs of legitimate users of the sea	Disadvantages to other users of the marine environment include disruption over a longer time period whilst the works are undertaken and remaining scour holes associated with excavation.	Negligible risk presented providing adequate consultation and notification, cutting is to a sufficient depth, site is monitored post decommissioning and any unlikely exposure identified.
Minimise environmental impact	Excavation pits over a wide area causing potentially significant impact to marine environment. Associated dumping of excessive volume of excavated waste material may be required. Disturbance would take place over long time period.	It is typical to cut piles 1m below the seabed. However, depth of cutting will be dependent on local ground conditions. The final depth of cutting will be determined prior to completing the final DP and take into consideration all available information at the time. Considerable excavation is required to cut below the seabed. Therefore, the depth of cutting should be informed by an assessment of impacts from the excavation diameter versus risks of foundations becoming exposed due to shifting sediments. By cutting below the seabed works would take place over reduced time period and involve less equipment, than complete removal. Seabed recovery time shorter than complete removal scenario.
Promote sustainable development	In the long term complete removal affords maximum flexibility over use of seabed, though considerable impacts are likely over the whole site in short to medium term.	Providing remaining structures do not become exposed most future activities will not be affected. Seabed recovery is considered highly likely.
Adhere to the Polluter Pays Principle	Consistent in principle, assuming a suitable disposal solution can be found for the excavated waste material and that the seabed can be restored.	Consistent as far as is reasonably practicable, all remains of piled foundations to be suitably buried.
Maximise re-use of materials	Maximum amount of piled foundations potentially available for re-use.	Less foundation material available for re-use relative to complete removal.
Ensure commercial viability	Not considered commercially viable - excavation and extreme lifting involves major equipment requirements over longer periods of time.	Less expensive alternative to complete removal, involving minimal excavation and minimising environmental impacts.
Ensure practical integrity	Not a practical solution: Extreme risk associated with heavy lift, considerable excavation needed with associated storage or disposal of large volume of waste.	Standard procedures and equipment.

4.5.3 Offshore Substation Platforms (OSPs)

The decommissioning of the OSPs will follow a similar method as described for the wind turbines and turbine foundations.

The complete OSP topside structure will be removed in a single lift, taken by suitable vessel to an onshore facility where the equipment and structure will be dismantled and the constituent parts processed for re-use, recycling and/ or disposal.

Following the separation of the piles and the jacket, the jacket will be lifted off the piles and recovered to land for re-use or recycling as scrap.

Decommissioning of pin piles will involve cutting off the substructure below seabed level. The material cut off from the pin piles will be recovered to land for recycling as scrap.

4.5.4 Inter-Array and Export Cables

The proposed approach to the decommissioning of the buried, subsea inter-array and export cables is to leave the cables in-situ having cut and sealed the ends of the cables and ensured that the cut ends are securely buried below the seabed. Loose ends of cable that remain from where the main cables are cut at the wind turbines and OTMs will be recovered to shore for subsequent recycling.

Table 4.5.4 provides an assessment of the subsea cable decommissioning options against the guiding principles outlined in Table 4.4.1.

Table 4.5.4: Assessment of Buried Subsea Cable Decommissioning Options Against Guiding Principles

Criterion	Complete Removal	Cutting Below Seabed
No harm to people	Risk to personnel not considered excessive.	Burial within the seabed does not pose safety risks to marine users. Post decommissioning site monitoring will identify any unlikely exposure with the result that safety risk is insignificant (see Section 14).
Consider the rights and needs of legitimate users of the sea	Removal affords maximum flexibility over use of seabed.	No risk presented from leaving buried cables in situ. Potential for extraction activities limited only within a limited corridor. Site is monitored post decommissioning and any unlikely exposure identified.
Minimise environmental impact	Given the considerable length of cable and the need for jetting techniques, removal would cause disruption to the seabed and benthic habitats.	Benign - no environmental impact associated leaving buried cables in situ.
Promote sustainable development	Disturbance of the seabed in the short-medium term, although complete removal would allow flexibility over use of seabed in the longer term.	Some future activities, e.g. extraction, may be limited but only in a limited corridor.
Adhere to the Polluter Pays Principle	Consistent, assuming suitable disposal option is found for surplus cable components.	Benign, no pollution risk from leaving cables in-situ.

Table 4.5.4: Assessment of Buried Subsea Cable Decommissioning Options Against Guiding Principles		
Criterion	**Complete Removal**	**Cutting Below Seabed**
Maximise re-use of materials	Maximum material, e.g. copper, potentially available for re-use.	No re-use possible if left in situ.
Ensure commercial viability	Extensive cost of removal.	Limited cost involved with re- burial of cable 'ends'.
Ensure practical integrity	Possible to undertake but would result in impacts on the seabed environment.	N/A

4.5.5 Cable and Scour Protection

Where cable or scour protection is required during the construction or operational phase of the Moray West Offshore Wind Farm a determination of the decommissioning procedure will be presented in the final DP. The final decommissioning procedure will consider the type of cable protection installed, for example, cable mattressing, rock dumping or gabion bags, the available technology at the time and will be developed in accordance with the principles outlined in Section 4.4.

4.6 Proposed Waste Management Solutions

Moray West is committed to maximising the re-use of waste materials and will give full regard to the 'waste hierarchy' which suggests that re-use should be considered first, followed by recycling, incineration with energy recovery and, lastly, disposal. In any event, waste management will be carried out in accordance with all relevant legislation and with any necessary disposal taking place at licensed facilities.

The proposed approach to disposal of the main components of the Wind Farm is set out in Table 4.6.1 but is subject to evolution of technology, change in regulations and demand for materials over the lifetime of the Moray West Wind Farm.

Table 4.6.1: Proposed Disposal Route for Main Wind Farm Components		
Waste Material	**Pre-Treatment**	**Re-use/ Recycle/ Disposal**
Wind turbine support structures (jacket substructures and pin piled foundations)	Establish available design life at end of 25 years.	Re-use by repowering with new/superior wind turbines or other renewable generation technology or dismantle and recycle the recovered material as much as possible.
Steel from wind turbine tower and nacelle removed to shore	Break down into transportable size.	Recycle.
Copper from power cables and transformers	Strip cable from power cables and transformers.	Recycle.
Glass-fibre Reinforced Epoxy (GRE) from wind turbine blades	Break down into transportable size.	Disposal or recycle where facilities exist.
Used lubricants from wind turbine	Filter.	Recycle.

Table 4.6.1: Proposed Disposal Route for Main Wind Farm Components		
Waste Material	**Pre-Treatment**	**Re-use/ Recycle/ Disposal**
Non-recyclable materials and fluids	None.	Incineration with energy recovery or disposal via landfill.

The final details of the DP will be confirmed prior to decommissioning to accommodate changes in legislation, guidance and technology. As part of this process, appropriate waste management regulations and guidelines will be reviewed. A Waste Management Plan (WMP) will be prepared in advance of the commencement of decommissioning to ensure that adequate time is allowed for the necessary provisions to be made with regards to waste management.

4.7 Lighting and Marking

The appropriate marks and lights shall be exhibited during the decommissioning of the Development.

In relation to aviation safety, the shape, colour and character of the lighting will be compliant with the Air Navigation Order 2009 (or then current regulation or as otherwise directed by the Civil Aviation Authority (CAA)).

In relation to navigational safety, lights and markings will be discussed with the Northern Lighthouse Board (NLB), in consultation with the Maritime and Coastguard Agency (MCA). In particular, the NLB will be consulted prior to decommissioning to specify any obstruction marking that may be required during the removal operations. In the event that any obstruction is left on site that may be considered to present a hazard to navigation the necessary marking specified by NLB shall be displayed.

5 Environmental Impact Assessment

In support of the consent applications for the Development, an EIA Report has been prepared (to which this Draft DP is appended).

In complying with the requirements the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017, the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 and the Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended) a lifecycle approach has been taken in assessing the potential effects of the Development and in seeking to mitigate and minimise the effect of the works. In all instances a 'worst case', Design Envelope approach has been taken to the assessment. The assessment of effects includes the process of decommissioning so far as it could be predicted at the time.

During preparation of a final DP for the Development, the information relating to decommissioning in the EIA Report will be reviewed. Subject to the results of this review and consultation, and provided that there have not been substantial changes to the baseline environment beyond those predicted in the EIA Report, to the legislative process or to the methods proposed for decommissioning, it is not currently proposed to undertake a new EIA for decommissioning.

Key criteria that will inform the decision as to the need for a new or updated EIA include consideration of:

- The understanding of the baseline environment at the time just prior to decommissioning, informed by the findings of the environmental monitoring of the development and engineering/ asset surveys such as cable burial monitoring;
- A review of other marine use (fishing, navigation, etc.) with potential to be affected by decommissioning;
- Amenities, the activities of communities and on future uses of the environment;
- Historic environment interests; and
- Seascape and landscape interests.

If required, then the decommissioning EIA would fill any information gaps in relation to these issues and would also describe the measures envisaged to avoid, reduce and, if possible, remedy any likely significant adverse impacts arising from the decommissioning process.

6 Consultations with Interested Parties

Section 105(7) of the Energy Act 2004 provides that a notice given under Section 105 may require the recipient of the notice to carry out consultation specified in the notice before submitting a DP.

On the granting of offshore consents for the Development, it is expected that the Scottish Ministers will issue a Section 105 notice and this this will identify those bodies to be consulted during preparation of the final DP.

In line with requirements of the notice, Moray West will commence formal consultation and feedback received will inform the final DP that will be submitted to the Scottish Ministers for approval.

Throughout the project lifespan the DP may be revised periodically as new information relevant to the decommissioning strategy becomes available. Consultee bodies listed in the Section 105 notice, and any other relevant consultees, will be provided with the opportunity to comment on the final decommissioning strategy prior to it being finalised. It is anticipated that the final revision process will commence two years prior to the initiation of decommissioning.

At the time of decommissioning, Moray West will issue timely and efficient Notices to Mariners (NtMs) and other navigational warnings of the position and nature of the decommissioning activities taking place. Efforts will be made to ensure that this information reaches mariners in the shipping and fishing industry as well as recreational mariners. The UK Hydrographic Office will be notified as appropriate on the progress and completion of the works.

7 Schedule

At this stage of planning Moray West is unable to commit to a decommissioning schedule prior to award of consents and construction. At the time of writing, no offshore wind farms worldwide have been decommissioned, so knowledge of the operational challenges is limited. Information gathered during construction and operation of the Development, and information available from the decommissioning of other wind farms (e.g. Moray East) will provide valuable insight into the timing, costs and operational challenges faced.

At present it is envisaged that the Development may be decommissioned in approximately 50 years from the date of construction. This includes an anticipated repowering of the sites after approximately 25 years. At the time of any repowering, decommissioning of redundant parts will be carried out as soon as reasonably practicable and with due regards to health and safety considerations.

The timing of any decommissioning is expected to be influenced by consideration of potential environmental impacts, market factors, vessel availability, synergy and coordination with other offshore works, the potential for phasing within and across the sites and available weather windows, which may mean that activities have to be spread over several seasons. However, in the case where decommissioning is delayed, a robust case will be submitted for the deferral.

A detailed schedule of the decommissioning works will be presenting in the final DP.

8 Project Management and Verification

Once the Moray West Offshore Wind Farm is nearing the end of its agreed operational life, Moray West will initiate a final review of this document and the proposed programme of works. Once this review is complete a DP will be developed outlining the discrete methods, measures and timing that will be employed. It will also identify those individuals and organisations that are responsible for ensuring decommissioning tasks are managed and completed.

Following completion of decommissioning, a post-decommissioning report will be prepared and submitted to the Scottish Ministers, detailing how the programme was carried out. The report will include:

Confirmation that decommissioning has been carried out in accordance with the approved decommissioning programme or an explanation of any major variances from the programme;

- Information on the outcome of decommissioning, including confirmation of seabed clearance;
- Confirmation that appropriate bodies, including the United Kingdom Hydrographic Office, the Kingfisher Information Service at the Sea Fish Industry Authority, Hull (Seafish), and the international Maritime Organisation, have been notified of removal and of any remains;
- Confirmation that appropriate aids to navigation have been installed, where required, for any remains of installations which protrude above the seabed and are considered to be a danger to navigation; and
- Information on the actual costs of decommissioning and an explanation of any major variances from forecast costs.

9 Costs

The decommissioning cost information required by the Scottish Ministers will be provided in confidence when the DP is updated prior to construction commencing.

10 Financial Security

The financial security information required by the Scottish Ministers will be provided in confidence when the DP is updated prior to construction commencing.

11 Seabed Clearance

Following decommissioning, a seabed survey will be carried out using appropriate remote surveying techniques (likely to include sidescan, magnetomer and bathymetric surveys, with possible use of drop-down video or ROV to ground truth the data where necessary) with independent, third party involvement to show that the site has been cleared. The area to be covered will be determined prior to decommissioning but consideration will be given to the guidance for oil and gas installations which specifies a 500 m radius around any installation.

These surveys will seek to identify any debris which may have arisen from the decommissioning activities and may pose a risk to navigation and other users of the sea or the marine environment. Where such items are identified, appropriate remedial action will be taken to ensure the safety of other sea users.

If, during decommissioning, discovery of potential archaeological importance is made, the protocol for reporting finds of archaeological interest will be followed. The appropriate competent authority will be approached regarding the identification of other anomalies that may be of archaeological interest.

12 Restoration of the Sites

The project area will be restored as far as possible and desirable to the condition that it was in prior to the original construction of the Development.

Consistent with the decommissioning provisions detailed above, the key restoration work will relate to:

- Ensuring that foundations are cut below the natural level of the seabed (turbines and platforms) and are made safe and adequately covered; and
- Ensuring that cable ends are adequately buried where cables have been cut and partially removed.

Active restoration relying on intervention with equipment is not proposed as it is considered that such works present unnecessary and unacceptable risk to personnel. Rather, it is considered that allowing the seabed to naturally settle is sufficient and less disruptive to marine life.

13 Post-Decommissioning Monitoring, Maintenance and Management of the Site

Given that the current proposal is leave some project components in situ (i.e. cables), some post-decommissioning monitoring and management are considered likely to be required in order to ensure that the remaining project infrastructure does not pose a threat to other sea users.

A post-decommissioning monitoring and maintenance plan will be developed as an output of the review of the project EIA. This will establish what future management of the site may be required and whether this can be carried out as part of an industry-wide programme.

The appropriate regime for monitoring will be determined taking account of factors such as scale, nature and the conditions of any remains, including the risk that any remains below the seabed may be become uncovered and the proximity to other maritime activity. The regime will also be adapted over time (to be agreed with the Scottish Ministers) and will use relevant data from all phases of development, construction and operation.

As a minimum the regime will include a post decommissioning seabed survey to identify any remaining obstacles at the time of completion of decommissioning, with further surveys scheduled for subsequent years, the first of which is not to be more than 4 years following this initial survey. The risk of exposure at the Moray West site is expected to be low as a result of the relative stability of the seabed in the area and the depth at which foundations will be cut and cables buried. Survey effort will tail off with time, the exact requirements will be determined, in conjunction with the Scottish Ministers, by the results of the surveys.

In the event of protrusion of a decommissioned element above seabed level, or in the event that scour protection materials are left on site following decommissioning, initially the UK Hydrographic Office will be notified so that suitable notation of a potential anchoring hazard can be marked on relevant charts and mariners informed accordingly. The removal or making safe (e.g. reburying) of this protrusion will be assessed and undertaken at the earliest opportunity.

Moray West propose to use an independent survey company to complete the surveys. The company will be requested to report in parallel to both Moray West and to the Scottish Ministers to ensure transparency. Subsequent proposals for any maintenance or remedial work will be agreed with the Scottish Ministers and other relevant stakeholders.

14 Supporting Studies

To date, a number of site investigation and environmental studies have been undertaken to inform project design and to inform EIA for the Moray West Offshore Wind Farm and the OfTI. As explained in Section 0, the EIA Report includes a description of the potential effects of decommissioning on the receiving environment and also includes a list of all of the desk based and site specific studies that have been used to inform this draft decommissioning programme.

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MORAY WEST
OFFSHORE WINDFARM

Offshore Wind Farm and OfTI Scoping Opinions

Moray Offshore Windfarm (West) Limited

Technical Appendix 5.1

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The Scottish Government
Riaghaltas na h-Alba

Moray Offshore Renewables Limited
Western Development Area

Scoping Opinion

THE ELECTRICITY WORKS (ENVIRONMENTAL IMPACT ASSESSMENT) (SCOTLAND) REGULATIONS 2000 (as amended)

THE MARINE WORKS (ENVIRONMENTAL IMPACT ASSESSMENT) REGULATIONS 2007 (as amended)

SCOPING OPINION FOR THE PROPOSED

SECTION 36 CONSENT AND ASSOCIATED MARINE LICENCE(S) APPLICATION FOR

Moray Offshore Renewables Ltd. – Western Development Area, Outer Moray Firth

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The Scottish Government
Riaghaltas na h-Alba

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1. Introduction

I refer to your correspondence of 12th May 2016 and follow up letter of 26th May 2016 requesting a scoping opinion from Marine Scotland Licensing Operations Team ("MS-LOT") under Regulation 7 of the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000 (as amended) and Regulation 13 and Schedule 4 of the Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended) (herein referred to as "the EIA Regulations"). The request was accompanied by a Scoping Report containing a plan sufficient to identify the site, which is the subject of the proposed Development and a brief description of the nature and purpose of the proposed Development and of its possible effects on the environment. The Scoping Report was accepted on 26th May 2016.

Under the EIA Regulations, Scottish Ministers are required to consider whether any proposal for an offshore renewable energy development is likely to have a significant effect on the environment. Scottish Ministers have considered your request for an opinion on the proposed content of the Environmental Statement ("ES") in accordance with regulations, and in formulating this opinion Scottish Ministers have consulted with the relevant organisations.

Any proposal to construct or operate an offshore power generation scheme with a capacity in **excess of 1 megawatt and within 12 nm** requires Scottish Ministers' consent under section 36 of The Electricity Act 1989 ("the Act").

Schedule 9 of the Act places on the developer a duty to "have regard to the desirability of preserving natural beauty, of conserving flora, fauna and geological or physiographical features of special interest and of protecting sites, buildings and objects of architectural, historic or archaeological interest". In addition, the developer is required to give consideration to the UK Marine Policy Statement, Scotland's National Marine Plan ("NMP"), Scottish Planning Policy ("SPP"), other relevant Policy and National Policy Planning Guidance, Planning Advice Notes ("PANs"), the relevant planning authority's Development Plans and any relevant supplementary guidance.

Please note that the Environmental Impact Assessment ("EIA") process is vital in generating an understanding of the biological and physical processes that operate in the area and those that may be impacted by the proposed offshore wind farm. We would however state that references made within the scoping document with regard to the significance of impacts should not prejudice the outcome of the EIA process.

It is important that any development to exploit renewable energy sources should be accompanied by a robust assessment of the potential environmental impacts. Any assessment should also consider how potential negative environmental impacts could be avoided or minimised, through the use of mitigating technologies or regulatory safeguards, in order to ensure that the quality and diversity of Scotland's wildlife and natural features are maintained or enhanced. Scottish Ministers welcome the commitment given in the report that the EIA process will identify mitigation measures in order to avoid, minimise or reduce any adverse impacts. MS-LOT would suggest that the range of options considered should be informed by the EIA process in order that these objectives can be achieved. You are advised

to consult with relevant nature conservation bodies in order to discuss this.

2. Aim of this Scoping Opinion

Scottish Ministers are obliged under the EIA Regulations to respond to requests from developers for a Scoping Opinion on outline design proposals.

Scoping provides the first identification and likely significance of the environmental effects and the information needed to enable their assessment. The Scoping process is designed to identify which issues will or will not need to be addressed in the forthcoming EIA. This includes the scope of issues to be addressed and the method of assessment to be used. The Scoping process also allows consultees to have early input into the EIA process, to specify what may be required to be addressed and to supply information that could be pertinent to the EIA process. In association with any comments herein, full regard has been given to the information presented in the Scoping Report submitted.

3. Description of development

Moray Offshore Renewables Limited ("MORL" or "the Company") is proposing to construct and operate an offshore windfarm in the outer Moray Firth. The Company was awarded Zone 1 ("the MORL Zone") of the nine UK Offshore Round 3 zones. Due to the size of the site, the Company decided to develop the MORL Zone in two phases. First, the Eastern Development Area ("EDA") for which necessary consents were awarded in 2014 for three offshore wind farms with a total capacity of 1,116 MW and associated transmission infrastructure. The second phase of offshore wind development in the MORL Zone is located in the Western Development Area ("WDA").

The WDA is located in the North-East of Scotland on the Smith Bank in the Outer Moray Firth, approximately 22.5 km from Caithness on the Scottish coast at its closest point and covers an area of 225 km^2. The Company intends to install within the WDA up to 90 wind turbine generators ("WTG") of a minimum 8 MW and maximum 15 MW capacity each, that will produce a potential generation capacity of up to 750 MW.

The Scoping Report submitted relates to the wind turbines, their substructures and foundations and inter-array cables and any potential meteorological masts for the WDA. The Company currently anticipates to also consent the associated transmission infrastructure (including offshore and onshore export cable circuits, offshore substation platform(s), onshore substation, ancillary onshore works and works in the inter-tidal zone). These were not discussed in detail within the submitted Scoping Report. A separate Scoping Report will be prepared for these offshore and onshore transmission works at a later date, when more details of the export cable routes and onshore substation location are known.

4. Consultation

On receipt of the Scoping Opinion request, the Scottish Ministers initiated a consultation on the contents of the Scoping Report. This commenced on 31st May 2016 and requests for consultations were sent to the Joint Nature Conservation Committee ("the JNCC"), Scottish Natural Heritage ("SNH"), Scottish Environment Protection Agency ("SEPA"), the Northern Lighthouse Board ("NLB"), the Maritime and Coastguard Agency ("MCA"), Aberdeenshire Council ("ASC"), Moray Council ("MC"), the Highland Council ("THC") and various other bodies whom the Scottish Ministers consider are likely to have an interest in the proposed development. The Scottish Ministers, in accordance with Legislation, stated that the end date for the consultation would be 28th June 2016. Extensions to this period were granted by request to Marine Scotland Science ("MSS"), the JNCC and SNH (the Statutory Nature Conservation Bodies ("SNCB")) and the Defence Infrastructure Organisation ("MoD"). Not including individual departments within bodies who were consulted, 40 consultees were contacted and a total of 22 responses were received.

The Scottish Ministers are satisfied that the requirements for consultation have been met in accordance with the EIA Regulations.

The purpose of the consultation was to obtain advice and guidance from each consultee in respect of the information which each of them believe should be scoped in or out of the EIA.

The sections below highlight several points raised in consultation responses and issues which are of particular importance with regards to any subsequent application and the Environmental Statement.

Full consultation responses are attached in Annex 1 and each should be read in full for detailed requirements from individual consultees.

5. Marine Planning

Offshore Renewable Energy development should be in accordance with the UK Marine Policy Statement and Scotland's National Marine Plan.

The UK Marine Policy Statement 2011 – The UK Administrations share a common vision of having clean, healthy, safe, productive and biologically diverse oceans and seas. Joint adoption of a UK-wide Marine Policy Statement provides a consistent high-level policy context for the development of marine plans across the UK to achieve this vision. It also sets out the interrelationship between marine and terrestrial planning regimes. It requires that when Scottish Ministers take authorisation decisions that affect, or might affect, the marine area they must do so in accordance with the Statement.

Scotland's National Marine Plan – developed in accordance with the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009 (as amended), provides a comprehensive statutory planning framework for all activities out to 200 nautical miles. This includes policies for the sustainable management of a wide range of marine industries,

including offshore wind and marine renewable energy (in chapter 11).

Scottish Ministers must make authorisation and enforcement decisions, or any other decision that affects the marine environment, in accordance with the NMP.

The NMP sets out a presumption in favour of sustainable development and use of the marine environment when consistent with the policies and objectives of the Plan.

Another potentially relevant marine planning document to be aware of, due to proximity to the development, is **The (non-statutory) Pilot Pentland Firth and Orkney Waters Marine Spatial Plan**. The final Pilot Pentland Firth and Orkney Waters Marine Spatial Plan will be a material consideration in the determination of marine licensing and Section 36 consent applications within the Pentland Firth and Orkney Waters area. Highland Council and Orkney Islands Council will be provided with the option to adopt the final pilot Plan as non-statutory planning guidance, acknowledging the status of the Plan as a material consideration in the determination of relevant planning applications. Orkney Islands Council will also be provided with the option to approve the Final Plan as a material consideration in the determination of works licence applications.

6. Land Use Planning

The Scottish Government's planning policies are set out in the National Planning Framework, Scottish Planning Policy, Designing Places and Circulars.

The National Planning Framework is the Scottish Government's Strategy for Scotland's long term spatial development.

Scottish Planning Policy ("SPP") is a statement of Scottish Government policy on land use planning and contains:

- The Scottish Government's view of the purpose of planning,
- the core principles for the operation of the system and the objectives for key parts of the system,
- statutory guidance on sustainable development and planning under Section 3E of the Planning etc. (Scotland) Act 2006,
- concise subject planning policies, including the implications for development planning and development management, and
- The Scottish Government's expectations of the intended outcomes of the planning system.

Other land use planning documents which may be relevant to this proposal include:

- Aberdeenshire Local Development Plan 2016

- Planning Advice Note ("PAN") 2/2011: Archaeology – Planning Process and Scheduled Monument Procedures
- PAN 50: Controlling the Environmental Effects of Surface Mineral Workings
- PAN 51: Planning, Environmental Protection and Regulation
- PAN 1/2011: Planning and Noise
- PAN 1/2013: Environmental Impact Assessment
- PAN 60: Planning for Natural Heritage
- PAN 62: Radio Telecommunications
- PAN 68: Design Statements
- PAN 75: Planning for Transport
- PAN 79: Water and Drainage
- Marine Guidance Note ("MGN") 543 (M+F) Safety of Navigation: Offshore Renewable Energy Installations (OREIs) – UK Navigational Practice, Safety and Emergency Response
- Moray Local Development Plan
- Moray Offshore Renewables – Buckie Harbour Development Plan
- Moray Structure Plan
- Moray Wind Energy Policy Guidance
- Online Planning Advice on Flood Risk, http://www.gov.scot/Resource/0047/00479774.pdf
- Highland Renewable Energy Strategy and Planning Guidelines
- Highland Coastal Development Strategy
- Highland-wide Local Development Plan
- Scottish Planning Policy ("SPP")
- National Planning Framework 3

7. Content of the Environmental Statement

Information on what must be included in an Environmental Statement can be found in The Marine Works (Environmental Impact Assessment) Regulations 2007, Schedule 3, and The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000, Schedule 4.

Format

Developers should be aware that the ES should in addition to a hard copy, be submitted in a user-friendly PDF format, which can be placed on The Scottish Government website. A description of the methodology used in assessing all impacts should be included.

It is considered good practice to set out within the ES the qualifications and experience of all those involved in collating, assessing or presenting technical information.

Non-Technical Summary

This should be written in simple non-technical terms to describe the various options for the proposed development and the mitigation measures against the potential adverse impacts, which could result from the proposed development. Under the EIA Regulations, the non-technical summary should include:

- a description of the project and of the regulated activity;
- a description of the aspects of the environment likely to be significantly affected;
- a description of the likely significant effects;
- the forecasting methods used to assess the main effects that the project and the regulated activity are likely to have on the environment;
- a description of the measures envisaged to prevent, reduce and offset any significant adverse effects, and;
- an outline of the main alternatives studied, including an indication of the main reasons for the primary choice of the project, taking into account the environmental effects of those alternatives and the project as proposed.

Mitigation

Within an ES it is important that all mitigating measures should be:

- clearly stated;
- fully described with accuracy;
- assessed for their environmental effects;
- assessed for their effectiveness;
- their implementation should be fully described;
- how commitments will be monitored; and
- if necessary, how they relate to any consents or conditions.

Refer to Annex 1 for consultee comments on specific baseline assessment and mitigation.

Where potential environmental impacts have been fully investigated but found to be of little or no significance, it is sufficient to validate that part of the assessment by stating in the report:

- the work that has been undertaken;
- what this has shown, i.e. what impact if any has been identified, and

- why it is not significant.

8. Archaeology and Cultural Heritage

General Principles

The ES should address the predicted impacts on the marine historic environment. It should also describe the mitigation proposed to avoid or reduce impacts to a level where they are not significant. Historic environment issues should be taken into consideration from the start of the site selection process and as part of the alternatives considered.

Codes of practice relating to heritage and seabed development:

- JNAPC Code of Practice for seabed development http://www.jnapc.org.uk/jnapc_brochure_may_2006.pdf
- COWRIE guidelines for offshore renewables and the historic environment http://www.thecrownestate.co.uk/media/5876/km-ex-pc-historic-012007-historic-environment-guidance-for-the-offshore-renewable-energy-sector.pdf
- Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector, January 2011 http://www.thecrownestate.co.uk/media/5901/km-ex-pc-historic-012011-offshore-geotechnical-investigations-and-historic-environment-analysis-guidance-for-the-renewable-energy-sector.pdf
- Model Clauses for Archaeological Written Schemes of Investigation: Offshore Renewables Projects http://www.wessexarch.co.uk/system/files/WSI%20Renewables_low%20res.pdf
- British Marine Aggregates Producers Association protocols for archaeological discoveries http://www.wessexarch.co.uk/projects/marine/bmapa/index.html
- Protocol for Archaeological Discoveries: Offshore Renewables Projects http://www.thecrownestate.co.uk/media/148964/ei-protocol-for-archaeological-discoveries-offshore-renewables-projects.pdf

National policy and advice for the historic environment is set out in:

- The NMP http://www.gov.scot/Publications/2015/03/6517
- SPP http://www.gov.scot/Topics/Built-Environment/planning/Policy
- The Historic Environment Scotland Policy Statement June 2016 https://www.historicenvironment.scot/umbraco/advice-and-support/planning-and-guidance/legislation-and-guidance/historic-environment-scotland-policy-statement/
- Planning Advice Note 02/2011 Planning and Archaeology (PAN 02/2011) http://www.scotland.gov.uk/Resource/Doc/355385/0120020.pdf

The Scottish Minister's policies for the historic environment are set out in paragraphs 110 – 124 of SPP and paragraphs 4.20 – 4.25 of the NMP. Amongst other things, SPP stresses that scheduled monuments should be preserved *in situ* and within an appropriate setting and states that developments must be managed carefully to preserve listed buildings and their settings to retain and enhance any special architectural or historic features of interest. Further information on setting can be found in the following document: Managing Change in the Historic Environment: Guidance notes https://www.historicenvironment.scot/advice-and-support/planning-and-guidance/legislation-and-guidance/managing-change-in-the-historic-environment-guidance-notes/ . Impacts on undesignated aspects of the historic environment should also be taken into account as part of any EIA.

Historic Environment Scotland recommend that you engage a suitably qualified archaeological/historic environment consultant to advise on, and undertake, the detailed assessment of impacts on the historic environment and advise on appropriate mitigation strategies.

Baseline Information

Information on the location of all archaeological/historic sites held in the National Monuments Record of Scotland, including the locations and, where appropriate, the extent of scheduled monuments, listed buildings and gardens and designed landscapes can be obtained from www.PASTMAP.org.uk

Data on scheduled monuments, listed buildings, Inventory gardens and designed landscapes, historic battlefields and properties in the care of Scottish Ministers can also be downloaded from Historic Environment Scotland Heritage Portal following the link http://portal.historicenvironment.scot/ .

Information about undesignated marine heritage assets is available from the NMP Interactive website https://marinescotland.atkinsgeospatial.com/nmpi/default.aspx?availablelayer=118

Guidance on setting is available at: https://www.historicenvironment.scot/advice-and-support/planning-and-guidance/legislation-and-guidance/managing-change-in-the-historic-environment-guidance-notes/

9. Ecology, Biodiversity and Nature Conservation

Refer to Annex 1 for specific comments from advisors on ecology, biodiversity and nature conservation.

Species

The ES should show that the applicants have taken account of the relevant wildlife legislation and guidance, namely:

- Marine (Scotland) Act 2010
- Marine and Coastal Access Act 2009 (as amended)
- Council Directive 92/43/EEC on The Conservation of Natural Habitats and of Wild Flora and Fauna
- Directive 2009/147/EC on the Conservation of Wild Birds Wildlife & Countryside Act 1981
- Nature Conservation (Scotland) Act 2004
- Wildlife and Natural Environment (Scotland) Act 2011
- Conservation (Natural Habitats, &c.) Regulations 1994
- Conservation of Habitats and Species Regulations 2010
- Offshore Marine Conservation (Natural Habitats, &c) Regulations 2007
- Marine Scotland - The Protection of Marine European Protected Species from Injury and Disturbance - Guidance for Inshore Waters (2014)
- The Protection of Seals (Designation of Seal haul-Out Sites) (Scotland) Order 2014,
- Marine Protected Areas
- The Scottish Biodiversity Strategy and associated Implementation Plans

In terms of The Scottish Government European Protected Species ("EPS") Guidance, applicants must give serious consideration to/recognition of meeting the three fundamental tests set out in this Guidance. It may be worthwhile for applicants to give consideration to this immediately after the completion of the scoping exercise.

It needs to be categorically established which species are present on and near the site, and where, before the application is considered for consent. The presence of protected species, such as Schedule 1 Birds or European Protected Species, must be included and considered as part of the application process, not as an issue which can be considered at a later stage. The company should therefore undertake a full Habitat Regulations Appraisal Screening prior to the submission of any application. Any consent given without due consideration to these species may breach European Directives with the possibility of consequential delays or the project being refused by Scottish Ministers. Likewise, the presence of species on Schedules 5 (animals) and 8 (plants) of the Wildlife & Countryside Act 1981 should be considered where there is a potential need for a licence under Section 16 of that Act.

10. Water Environment

The Scottish Environment Protection Agency ("SEPA"), as a statutory consultee under the EIA Regulations, encourages pre-application engagement to help the development process and to minimise risk of modifications later in the application process and avoidable delays or objections.

Information on energy proposals and issues that should be addressed in the ES can be found on the energy section of SEPA's website at http://www.sepa.org.uk/environment/energy/renewable/. The webpage also contains a link to SEPA Guidance Note 17, which provides more specific guidance for marine development and marine aquaculture planning.

If the proposal includes both onshore and offshore components the applicant should be aware that the development may be subject to a range of different consenting regimes. SEPA is the regulatory body responsible for the implementation of The Controlled Activities Regulations (CAR). Further information specifically in relation to the water environment and SEPA's water related regulations can be found at http://www.sepa.org.uk/regulations/water/.

Developers are strongly advised at an early stage to consult with SEPA to identify 1) if a CAR licence is necessary and 2) clarify the extent of the information required by SEPA to assess fully any licence application.

Construction contractors may be unaware of the potential for impacts such as those listed below but, when proper consultation with the local fishery board is carried out at an early stage, many of these issues can be averted or overcome:

- increases in silt and sediment loads resulting from construction works.
- point source pollution incidents during construction.
- obstruction to upstream and downstream migration both during and after construction.
- disturbance of spawning beds during construction – timing of works is critical.
- drainage issues.
- sea bed and land contamination

The Water Framework Directive ("WFD") was introduced in 2000 to establish systems to manage Europe's water environment – rivers, lochs, estuaries and coastal waters. This should be taken into account within the ES. Further information on the directive can be found at
http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32000L0060&from=EN

The ES should identify the location of, and protective/mitigation measures in relation to, all private water supplies within the catchments impacted by the scheme, including modifications to site design and layout.

Developers should also be aware of available Construction Industry Research and Information ("CIRIA") guidance on the control of water pollution from construction sites and environmental good practice (www.ciria.org). Design guidance is also available on river crossings and migratory fish (The Scottish Executive consultation paper, 2000) at http://www.gov.scot/Topics/marine/science/Publications/publicationslatest/rivercrossings.

11. Other Material Issues

Traffic Management

The ES should provide information relating to the preferred route options for delivering equipment etc. via the trunk road network. The EIA should also address access issues, particularly those impacting upon the trunk road network; in particular, potential stress points at junctions, approach roads, borrow pits, bridges, site compound and batching areas etc.

Economic Benefit

The concept of economic benefit as a material consideration is explicitly confirmed in the NMP and in SPP. Policies GEN 2 and GEN 3 of the NMP encourage economic and social benefit (respectively) to Scottish communities when consistent with the objectives and policies of the Plan. Renewable Energy Objective 2 of the Plan also relates to economic benefits. This fits with the priority of The Scottish Government to grow the Scottish economy. The application should include relevant economic information connected with the project, including the potential number of jobs, and economic activity associated with the procurement, construction, operation and decommissioning of the development.

Navigation

The ES should include the following details on the possible impact on navigation for both commercial and recreational craft.

- Collision Risk
- Navigational Safety
- Visual intrusion and noise
- Risk Management and Emergency Response
- Marking and lighting of the site and information to mariners
- Effect on small craft navigational and communication equipment
- Weather and risk to recreational craft which lose power and are drifting in adverse conditions
- Evaluation of likely squeeze of small craft into routes of larger commercial vessels.

12. General ES Issues

Requirement for Public Pre-Application Consultation

From 6th April 2014, applications received for certain activities will be subject to a public pre-application consultation requirement. Activities affected will be large projects with the potential for significant impacts on the environment, local communities and other legitimate

uses of the sea. The new requirement will allow those local communities, environmental groups and other interested parties to comment on a proposed development in its early stages – before an application for a marine licence is submitted.

Guidance on public pre-application consultation can be found at the following link: http://www.scotland.gov.uk/Resource/0043/00439649.pdf

Consent Timescale and Application Quality

In December 2007, Scottish Ministers announced an aspirational target to process new Section 36 applications within a 9 month period, provided a Public Local Inquiry ("PLI") is not held. This scoping opinion is specifically designed to improve the quality of advice provided to developers and thus reduce the risk of further information being requested and subject to further publicity and consultation cycles.

Developers are advised to consider all aspects of this scoping opinion when preparing a formal application, to reduce the need to submit further information in support of the application. The consultee comments presented in this opinion are designed to offer an opportunity to consider all material issues relating to the development proposals.

Given that the layout and design are still developing and evolving, the exact nature of the work that is required to inform the EIA may vary depending on the design choices. The EIA must address this uncertainty so that there is a clear explanation of the potential impact of each of the different scenarios. It should be noted that any changes produced after the ES is submitted may result in the requirement of further environmental assessment and public consultation, if deemed to be significant by the licensing authority

In assessing the quality and suitability of applications, the licensing authority will use the enclosed checklist and scoping opinion in assessment of the application. Developers are encouraged to seek advice on the contents of the ES prior to applications being submitted, although this process does not involve a full analysis of the proposals. In the event of an application being void of essential information, the licensing authority reserves the right not to accept the application. Developers are advised not to publicise applications in the local or national press, until their application has been accepted by the licensing authority and the date of consultation has been agreed.

Application and ES

A developer checklist is enclosed with this scoping opinion (Annex 2) to assist developers in consideration and collation of the relevant ES information to support their application. In advance of publicising the application, developers should be aware this checklist will be used by the licensing authority to carry out a gate check before the application is officially accepted. An EIA audit will also be carried out as part of that gate check. If information requested at scoping stage is found not to have been provided, then the applicant may be asked to provide that information before the application can be accepted. Further information is provided below.

Ordinance Survey ("OS") Mapping Records

Developers are requested at application stage to submit a detailed OS plan showing the site boundary and location of all turbines, access tracks and onshore supporting infrastructure in a format compatible with The Scottish Governments Spatial Data Management Environment ("SDME"), along with appropriate metadata. The SDME is based around Oracle RDBMS and ESRI ArcSDE and all incoming data should be supplied in ESRI shapefile format. The SDME also contains a metadata recording system based on the ISO template within ESRI ArcCatalog (agreed standard used by The Scottish Government); all metadata should be provided in this format.

Consultation

Where the developer has provided Scottish Ministers with an ES, the developer must publish their proposals in accordance with part IV of The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000 (as amended) and Regulation 16 of The Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended). Licensing information and guidance, including the specific details of the adverts to be placed in the press, can be obtained from Marine Scotland. In addition, requirements under The Electricity (Applications for Consent) Regulations 1990 must be met.

Developers are asked to issue the ES directly to consultees, dates to be agreed with Marine Scotland in advance of consultation. Consultee address lists can be obtained from Marine Scotland, the final consultee list will be agreed with Marine Scotland prior to consultation. Marine Scotland also requires 2 hardcopies to be submitted for onward distribution.

Applicants must, when the first statutory consultee response is received by MS-LOT, publish a notice in the Edinburgh Gazette and one or more local newspapers to say that additional information has been received by Scottish Ministers and has been placed on the Planning Register of the planning authority closest to the development. This allows the public and other stakeholders a further 28 calendar days from the date of the second advert to make a representation in light of the additional information. Subsequent statutory consultee responses also go to the closest planning authority for the register, and to the applicant, but no further press notices are required.
Scottish Natural Heritage ("SNH") has produced a Service Level Statement ("SLS") for renewable energy consultation. This statement provides information regarding the level of input that can be expected from SNH at various stages of the EIA process. Annex A of the SLS details a list of references, which should be fully considered as part of the EIA process. A copy of the SLS and other vital information can be found on the renewable energy section of their website – www.snh.org.uk

Gaelic Language

Where Section 36 applications are located in areas where Gaelic is spoken, developers are encouraged to adopt best practice by publicising the project details in both English and Gaelic.

E: MS.MarineRenewables@gov.scot

Judicial review

All cases may be subject to judicial review. A judicial review statement should be made available to the public.

Signed

Nicola Bain
15/08/2016

Authorised by the Scottish Ministers to sign on their behalf

Annex 1

Marine Scotland – Licensing Operations Team Scoping Opinion

Consultee Comments Relating to Moray Offshore Renewables Ltd. – Western Development Area, Outer Moray Firth

The following organisations provided a scoping opinion in relation to Moray Offshore Renewables Ltd. – Western Development Area, Outer Moray Firth.

Statutory Consultees

Aberdeenshire Council ("ASC")
Joint Nature Conservation Committee ("JNCC")
Maritime and Coastguard Agency ("MCA")
Moray Council ("MC")
Northern Lighthouse Board ("NLB")
Scottish Environmental Protection Agency ("SEPA")
Scottish Natural Heritage ("SNH")

Non Statutory Consultees

Civil Aviation Authority ("CAA")
Chamber of Shipping ("CoS")
Historic Environment Scotland ("HES")
Joint Radio Company ("JRC")
Marine Scotland Science ("MSS")
Moray Firth Partnership ("MFP")
Defence Infrastructure Organisation ("MOD")
NATS En-Route PLC ("NERL")
Royal Society for the Protection of Birds, Scotland ("RSPB Scotland")
Royal Yachting Association ("RYA")
Scottish Fisherman's Federation ("SFF")
Sport Scotland ("SS")
Scottish Wildlife Trust ("SWT")
Transport Scotland ("TS")
Whale & Dolphin Conservation ("WDC")

The following organisations were also consulted, but did not provide a scoping opinion in relation to the proposal

Association of Salmon Fishery Boards ("ASFB")
British Telecom, Radio Network Protection Team ("BT")

Cromarty Firth Port Authority (“CFPA”)
Marine Scotland Compliance, Buckie Fisheries Office (“FO-BCK”)
Marine Scotland Compliance, Fraserburgh Fisheries Office (“FO-FR”)
Marine Scotland Compliance, Scrabster Fisheries Office (“FO-SCR”)
Marine Scotland Compliance, Ullapool Fisheries Office (“FO-UL”)
Marine Safety Forum (“MSF”)
North & East Coast Inshore Fisheries Groups (“NEC-IFG”)
Surfers Against Sewage (“SAS”)
Scottish Canoe Association (“SCA”)
Scottish Fisherman's Organisation (“SFO”)
Scottish Government Planning (“SG-Planning”)
Scottish Surfing Federation (“SSF”)
The Crown Estate (“TCE”)
The Highland Council (“THC”)
Transport Scotland – Ports & Harbours (“TS-P&H”)
Visit Scotland (“VS”)

SCOPING OPINION

Marine Scotland – Licensing Operations Team

MS-LOT notes that Moray Offshore Renewables Limited ("MORL" or "the Company") is proposing to construct and operate an offshore windfarm in the outer Moray Firth. The Company was awarded Zone 1 ("the MORL Zone") of the nine UK Offshore Round 3 zones. Due to the size of the site, the Company decided to develop the MORL Zone in two phases. First, the Eastern Development Area ("EDA") for which necessary consents were awarded in 2014 for three offshore wind farms with a total capacity of 1,116 MW and associated transmission infrastructure. The second phase of offshore wind development in the MORL Zone is located in the Western Development Area ("WDA").

The WDA is located in the North-East of Scotland on the Smith Bank in the Outer Moray Firth, approximately 22.5 km from Caithness on the Scottish coast at its closest point and covers an area of 225 km^2. The Company intends to install within the WDA up to 90 wind turbine generators ("WTG") of a minimum 8 MW and maximum 15 MW capacity each, that will produce a potential generation capacity of up to 750 MW.

MS-LOT is issuing this Scoping Opinion under The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000 (as amended) and The Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended).

The scope of the Environmental Impact Assessment ("EIA") is defined in this Scoping Opinion through the opinions and comments provided by MS-LOT and all consultees that responded with advice/recommendations to the scoping opinion request.

The Environmental Statement ("ES") and application letter must detail how many consents/licences are being sought and what legislation the application is being made under. The Company should also confirm whether they intend to apply for a safety zone around the turbines under Section 95 of the Energy Act 2005; and whether a declaration under Section 36A will be applied for. The exact duration of the Marine Licence(s) and Section 36 Consent(s) ("S36") being sought must be confirmed by the Company and made clear within the ES and cover letter.

The opportunity to apply for deemed planning as part of the application process for S36 consent is now available to applicants seeking to construct and operate marine renewable energy developments. The Growth and Infrastructure Act 2013, through sections 4, 5 and 6, amend section 57 of The Town and Country Planning (Scotland) Act 1997 permitting Scottish Ministers, on granting or varying a consent under Section 36 of The Electricity Act 1989, to give a discretion for planning permission to be deemed to be granted, subject to such conditions as may be specified in the direction, for any development ancillary to the operation or change of use to which the consent relates. Should the Company decide to seek deemed planning permission, then this intention must be clear within the application letter and the ES, and the Company must ensure the ES submitted in support of any application has considered both the impacts on the marine and the terrestrial environment.

The Scoping Report submitted relates to the wind turbines, their substructures and foundations and inter-array cables and any potential meteorological masts for the WDA. The Company currently anticipates to also consent the associated transmission infrastructure (including offshore and onshore export cable circuits, offshore substation platform(s), onshore substation, ancillary onshore works and works in the inter-tidal zone). MS-LOT notes that these were not discussed in detail within the submitted Scoping Report, and that the Company intends to prepare and submit a separate Scoping Report for these offshore and onshore transmission works at a later date, when more details of the export cable routes and onshore substation location are known.

MS-LOT advises and recommends that a single ES is submitted to cover both the marine and terrestrial aspects of the development. This ES should be concise and clear without the need for superfluous or erroneous detail.

The "Good Practice Guidance" issued by the Scottish Government Energy Consents and Deployment Unit in January 2013, provides a good summary: "*In structuring the ES, proper consideration should be given to the usefulness of the document to the reader. For example, instead of separate sections detailing waste arising, it is more useful to the reader for the ES to include a specific section relating to waste, providing details of different types of waste generated at both construction and operation, and including a Site Waste Management Plan or waste section of a Construction Environmental Management Document setting out how that waste material will be managed."* In addition the same document states that *'it is good practice to have a section directly addressing the scoping opinion in the ES, referring to each issue raised in the scoping opinion and referencing where this has been addressed'.*

Further information on what the works and infrastructure comprise, including the on and offshore elements, must be detailed in the ES. Information about timings for operation, maintenance and decommissioning, as these may have environmental impacts; along with information about the number and type of vessels to be used, must also be included.

MS-LOT recommends the use of a Design Envelope (or Rochdale Envelope) for flexibility both in the EIA process and in the final ES. It is the Company's responsibility to give due consideration to what changes might be necessary, and to provide details as to what might be required. Where flexibility is required the Company should define either the alternatives or ranges within which parameters might fall. The ES should clearly state the reasoning for requiring such flexibility, the criteria for selecting the worst case scenario and the impacts which would arise from such a scenario.

Failure to give such consideration, or a major change to a parameter outside those considered, may invalidate the ES provided at consent, requiring the consent process to be repeated. It is expected that the EIA will reduce the degree of design flexibility required and that the ES provided for consent will be further refined in a Construction Method Statement ("CMS") to be provided before works commence. Information regarding the impacts from construction of the infrastructure and the types of vessels to be used will be required in the CMS. The CMS provided will freeze the design of the project and will be reassessed by MS-LOT to ensure that its parameters fall within the range granted at consent.

The Scoping Report presents a range of options for the foundation and support structures. MS-LOT notes that there is no final decision with respect to the foundation and substructure type for the development and therefore there is also no definite information regarding the footprint of the chosen foundation type. The Company, once again, must consider not only the likely scenario of impacts, but also the worst case scenario for the foundations and substructure options.

As recommended by the Maritime and Coastguard Agency ("MCA"), a Navigational Risk Assessment ("NRA") will need to be submitted in accordance with Marine Guidance Notices ("MGN") 543 (and 372) and the MCA Methodology for Assessing the Marine Navigational Safety & Emergency Response Risks of Offshore Renewable Energy Installations ("OREI"), which is available at www.gov.uk/mca.

MGN 543 Section 2 'Traffic Survey' states that *'an up to date traffic survey of the area concerned should be undertaken within 12 months prior to the submission of the Environmental Statement. This should include all the vessel types found in the area and total at least 28 days duration but also take account of seasonal variations in traffic patterns and fishing operations.'* The Company must undertake up to date surveys, and studies must be carried out in relation to shipping and navigation channels for inclusion in the ES.

Ships should carry and implement a ballast water management plan and further guidance can be found at the MCA or the IMO website.

Any antifoulants used on the devices or cables will impact encrusting communities at a highly localised (i.e. device-only) level. However, antifouling paint can be dispersed at distances greater than predicted (along tidal / main current directions). Effects on invertebrates may be detectable at these distances depending on the antifouling type and strength. The ES should specify a list of all antifouling paints to be used, their type, quantities and toxicity levels.

An Habitats Regulations Appraisal ("HRA") process will be required for this development as it has the potential to affect the site integrity and/or the qualifying features of nearby Natura (European) sites. The range of interests and potential impacts on these sites will need to be considered in relation to the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (as amended) (applying to the offshore zone beyond 12 nautical miles) and to the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) (applying to Scottish territorial waters). These regulations protect Natura sites – a network of designated sites across Europe which are internationally important for threatened habitats and species – encompassing Special Protection Areas (SPAs) designated for a range of important bird species, and Special Areas of Conservation (SACs) which include a variety of sensitive or rare marine habitats.

Under the above regulations, HRA is the process whereby potential impacts to Natura sites – SPAs and SACs – are considered. Please refer to the joint response from the JNCC and SNH in this Annex, which provides a detailed explanation of the HRA process. The responses from MSS and RSPB Scotland also provide further advice to the HRA process.

MS-LOT recommends that the Company submits an HRA screening report taking into account the scoping advice provided by the consultees, further guidance can be provided on this iterative process. The HRA screening report will be required for review and comment by the SNCBs and MSS at the earliest opportunity and in advance of the ES, i.e., prior to applying.

It should be noted that any application should incorporate a full HRA and applications for other relevant licencing requirements, such as European Protected Species ("EPS") and basking shark, should they be required.

The Company should be aware of the definition of 'disturbance' and the legal provisions on European Protected Species and that an EPS Licence may be required, to allow possible disturbance to marine mammals and basking sharks during construction and operation. MS-LOT notes that piling activities have been detailed within the Scoping Report. Therefore, MS-LOT recommends that an EPS risk assessment is submitted well in advance of any planned surveys or construction activities.

Furthermore, we recommend that the potential impacts on marine mammals from noise are carefully assessed in the ES. Mitigation for this impact may well be required and measures to reduce the effects of noise should also be set out in the ES. MS-LOT may require that JNCC accredited Marine Mammal Observers ("MMOs") are present during noisy construction activities, particularly during potentially noisy activities such as piling should this be a chosen method.

The Company must also be aware of the Marine Protected Areas ("MPA") located near to the proposed development area, and must assess and address the possible impacts of the project on these sites during the EIA process. The most important nature conservation sites requiring to be addressed in the ES are the Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) contributing to the Natura 2000 network. MS-LOT strongly recommend that the "draft" Moray Firth marine SPA should also be included in this assessment. More information can be found at:
http://www.scotland.gov.uk/Topics/marine/marine-environment/mpanetwork

MS-LOT expects any displacement of fishing opportunity to be recognised by the Company. The Company then must resolve any possible potential impacts by early and continued engagement and collaboration with fishing industry representatives. MS-LOT strongly recommends that early engagement with the fishing communities is undertaken and that surveys based upon commercial fishing are also undertaken and data is contained within the ES.

It is essential that this project is assessed alone and in combination with other plans and projects (renewable developments and other types of industry and activities which occur in the vicinity). All projects which have been scoped must be included. This applies not only to marine wildlife and birds, but also to marine navigation, shipping and location for maintenance and operations. Further discussion on cumulative effects will take place throughout the EIA process. MS-LOT will engage with the SNCBs, MSS and the Company to discuss a final list of projects and plans to take into consideration in the cumulative impacts

assessment.

MS-LOT vehemently recommends early engagement with the Civil Aviation Authority ("CAA"), the NATS En-Route PLC ("NERL"), and the Ministry of Defence ("MoD") to resolve potential operational problems with radar detection of aircraft traffic, otherwise the consenting timeline may be at risk.

The description of the development's components and equipment in the ES must be accompanied by figures that allow their correct visualisation, with a scale for visual aid comparison. This will allow members of the public, as well as consultees, to put the development into context. When figures are not possible to produce, a comprehensive description should be presented. This would apply for, amongst other components, the turbines and the sub-structure.

A Seascape, Landscape and Visual Impact Assessment ("SLVIA") will be required as part of the EIA and will need to include the cumulative visual impacts of current and proposed developments in the area. Recommendations from SNH must be taken into account and attention carefully paid to their guidelines, suggestions and viewpoints. The visual impact assessment of the proposal must be carried out in close co-operation with MS-LOT, the Local Authorities and the SNCBs, in particular when deciding photo-montage viewpoints. The list of viewpoints agreed with the Local Authorities and the SNCBs should be submitted to MS-LOT once completed. MS-LOT encourages the Company to carry out SLVIA in accordance with the Institute of Environmental Management and Assessment Guidelines for Landscape and Visual Impact Assessment, SNH guidelines and guidance given in response to the consultation by the Local Authorities. The Company must be aware of the wildlife habitats and protected areas surrounding the site, and this must be taken account of within the ES.

The Company must include in the ES a Reporting Protocol which sets out what the Company must do on discovering any marine archaeology during the construction, operation, maintenance and monitoring of the proposed transmission infrastructure.

The Crown Estate intends to launch in England and Wales a new cultural heritage reporting scheme for the seabed and intertidal zones. This scheme will be responsible for, and assist with, enhancing the environmental stewardship of underwater cultural heritage. The Marine Antiquities Scheme ("MAS") will closely mirror the Portable Antiquities Scheme ("PAS"). The MAS will fit in with, and is designed to enhance and compliment, statutory reporting mechanisms that already exist, principally the Merchant Shipping Act 1995. It is important to note that reporting through the scheme does not devolve the finder from any other legal requirements that apply. It is designed to effectively capture data about the historic marine environment, return information to the finder and make that data available to the public for research in an accessible way – in much the same way that the PAS has been doing for some time. Although this is a document produced for England and Wales, the Company should be aware of this document and, as a matter of best practice, should be guided by the information contained therein.

With regard to the contents of the ES, a section regarding waste is mandatory as set out in

Article 1(c) and Article 4(c) of Annex IV of the Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011, on the assessment of the effects of certain public and private projects on the environment; Article 3(1) of Schedule 3 of The Marine Works (Environmental Impact Assessment) Regulations 2007, regarding information to be included in an environmental statement; Article 1(c) of the Schedule 4 of The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000, regarding Content of an Environmental Statement; and according to the EIA (Scotland) Regulations 1999.

A section regarding water quality must be included on the onshore section of the ES, considering potential onshore impacts from the cable laying activities.

The decommissioning operation will be regulated by The Department of Business, Energy and Industry Strategy ("DBEIS") (formerly The Department of Energy and Climate Change ("DECC")). A Decommissioning Plan is to be presented to and agreed with DBEIS. It is also important to remember that a marine licence will be required for the removal of the devices and infrastructure as part of the decommissioning operation. This should be applied for at least six months prior to the removal of the devices.

Health and Safety Executive ("HSE") is the national independent watchdog for work-related health, safety and illness. They have a dedicated team that regulates occupational health and safety standards for the offshore renewable energies industry. You are advised to contact this team to discuss how you will manage health and safety during the planning, construction and operation of your offshore renewable project.

They are contactable at:

Health and Safety Executive
Belford House
59 Belford Road
Edinburgh
EH4 3UE
Trevor.johnson@hse.gsi.gov.uk
offshore.renewables@hse.gsi.gov.uk

MS-LOT advises and recommends that the structure and content of the ES is discussed with Marine Scotland at an early stage. The following are a number of points to aid early consideration of content and it is important that they are included for each topic.

- Methodology – some information to be provided on assessment methodologies.
- Legislation – brief description of the main pieces of legislation applicable to the topic
- Comments from Scoping Stage – individual comments from consultees
- Baseline – description of baseline environmental position.
- Data Gaps
- Impacts/effects – assessment of effects at each stage of development.
- Cumulative and in combination impacts/effects – assessment of these effects.

- Mitigation – measures proposed.
- Residual impacts/effects – description of impacts/effects after mitigation.
- Monitoring – an indication of the proposed monitoring.

The Non-Technical Summary ("NTS") should be written in simple non-technical terms to describe the various options for the proposed development and the mitigation measures against the potential adverse impacts, which could result.

Given that the layout and design are still developing and evolving, the exact nature of the work that is needed to inform the EIA may vary depending on the design choices. The EIA must address this uncertainty so that there is a clear explanation of the potential impact of each of the different scenarios. It should be noted that any changes produced after the ES is submitted may result in the requirement of further environmental assessment and public consultation if deemed to be significant by the licensing authority.

The EIA Directive includes the requirement for an assessment of alternatives and so it is necessary to clearly document the project's decision-making process. As set out in Scottish Planning Policy 6: Renewable Energy "*Applicants should use the assessment process to demonstrate the appropriateness of the chosen location for accommodating development. This will be particularly important where development is proposed out with broad areas of search identified in development plans*." Additionally, it is stated in the EIA (Scotland) Regulations 1999 Regulation 2(1) & Schedule 4, Part II, that "*an outline of the main alternatives studied by the applicant or appellant and an indication of the main reasons for his choice, taking into account the environmental effects*" must be present in the Environmental Statement. References to alternatives can also be found in article 3 (1) of Schedule 3 in The Marine Works (Environmental Impact Assessment) Regulations 2007.

The Environmental Statement should clearly identify the reasons for the options chosen, as well as the reasons why other options were discarded or considered unfeasible - Planning Advice Note 1/2013 – Environmental Impact Assessment: *"The ES must [also] give an indication of the main reasons for the choice made, taking into account the environmental effects*. (…) *4.8. The nature of certain developments and their location may make the consideration of alternative sites a material consideration. In such cases, the ES should record this consideration. More generally, the consideration of alternatives (including alternative sites, choice of process, and the phasing of construction) is widely regarded as good practice, resulting in a more robust application for planning permission."*

Further advice can be found in Planning Advice Note 1/2013: Environmental Impact Assessment and in SNH's Environmental Assessment Handbook.

When evaluating impacts, their effects may be predictable or unpredictable; direct or indirect; positive (beneficial) or negative (harmful); temporary or permanent: short, medium or long-term; immediate or delayed; one-off, intermittent or continuous; certain or uncertain; avoidable or unavoidable; reversible or irreversible; localised or widespread; small or large; individual or cumulative; and therefore may be significant or of no consequence. In the ES these types of criteria must be unambiguous to avoid misevaluations. Concepts like magnitude, significance, extension, nature or duration, or others, should be clearly defined.

The ES will have to go through the Gatecheck process, as it has to be considered in proportion to other projects of a similar type. MS-LOT undertakes a Gatecheck prior to formal submission of applications and advises the Company to take full advantage of this service. The Gatecheck is not designed as an in depth evaluation of the content of an ES. However, it will provide MS-LOT with the confidence that minimum legislative requirements have been met prior to formal submission of the ES.

To assist the Gatecheck process, a thorough gap analysis of the issues listed here by MS-LOT and the consultees' comments that follow, should be provided by the Company for submission with the ES. It should be noted that Gatecheck will only take place when the final version of the ES is submitted. This process will take up to three months to complete.

It is critical that the Company sets up post-scoping meetings to engage with stakeholders that responded to the scoping request in order to discuss any issues with the planned project.

We have provided you with our impressions on the Scoping Report and we trust this information is useful. Should you wish to discuss any aspect of this response please do not hesitate to contact MS-LOT.

A post-scoping meeting could be productive in order to discuss the issues mentioned in this document and to discuss the next steps in the consenting process.

Statutory Consultees

STATUTORY NATURE CONSERVATION BODIES

Joint Nature Conservation Committee ("JNCC")

Scottish Natural Heritage ("SNH")

Thank you for consulting JNCC and SNH on natural heritage interests to be addressed under Environmental Impact Assessment (EIA) and Habitats Regulations Appraisal (HRA) for the MORL offshore wind Round 3 western development area (WDA). This is a joint response as the proposed works are planned for areas within both of our jurisdictions. The location of the WDA is presented in Figure 1.1-2 (p17) of MORL's scoping report. Note the current consultation relates to the wind farm only; the transmission infrastructure and cable routes will be subject to a separate scoping exercise at a later date.

Three wind farms (Telford, Stevenson and MacColl) are consented in the eastern development area (EDA) of the MORL Round 3 zone. The work done for the EDA gives us a good starting point to consider this further proposed development in the WDA. However, there have been a number of changes to assessment processes and methodologies since the time of the EDA consents and these will need to be considered for the WDA. In particular, many of the recommendations for seabird impact assessments are currently under review, and there have been updates to our advice on marine mammal interests, particularly in relation to methods for underwater noise modelling.

We therefore think it would be helpful to **establish a timetable for pre-application discussions** in order to confirm the over-arching principles for the receptor-specific impact assessments as well as to agree the detail of relevant methodologies.

We note that potential impacts from the WDA will need to be considered in combination with those predicted from the EDA and Beatrice wind farm. There are a number of complexities around this matter and these will need to be discussed between the relevant parties. While the focus of cumulative impact assessment for the WDA is likely to be in relation to the consented wind farms, we will confirm as part of pre-application dialogue which other projects will need to be taken account of for HRA and for wider EIA and CIA scale assessments. We also note the scoping report makes reference to the cumulative impact discussion document produced by MORL and BOWL in 2011, provided as Appendix 1. While this was very useful at the time, we advise that much of the discussion has since been superseded.

The WDA scoping report makes repeated reference to the information submitted by MORL for the EDA (the environmental statement and supplementary environmental information). While this informed determination for the EDA, it was not the only information used by Marine Scotland in coming to a decision. In particular, we identify that Marine Scotland's appropriate assessment[1] gives a key summary of the approach taken to impact assessments (under HRA) for the qualifying interests of Special Protection Areas (SPAs) and Special Areas of Conservation (SACs), making reference to the full range of information that was considered.

[1] The appropriate assessment undertaken by Marine Scotland for wind farms in the MORL EDA and Beatrice is available from: http://www.gov.scot/Topics/marine/Licensing/marine/scoping/Moray3

At present, it is not possible to confirm a number of key approaches and methodologies in this scoping advice, therefore **we strongly recommend** that consideration is given as to how the ensuing receptor-specific discussions and agreements are to be formally captured for the public record. We note that this information will need to be referred to in addition to the scoping opinion issued by Marine Scotland.

NATURAL HERITAGE INTERESTS TO BE CONSIDERED

In principle, JNCC & SNH support the development of marine renewable energy where it's sensitively sited and designed. Below, we provide a summary of our scoping advice for WDA in relation to key natural heritage interests, supported (where indicated) by more detailed receptor-specific appendices.

- **Marine mammals**

Key species to address for the WDA are harbour seal, bottlenose dolphin, harbour porpoise, minke whale and grey seal. **Appendix A** provides our advice on the reference population for each species and the relevant assessments to consider (not all of which apply to every species): HRA, EIA and licensing requirements for European Protected Species (EPS).

Our key concern remains the potential disturbance of marine mammals due to construction noise (particularly from pile-driving the turbine foundations). We understand methods for noise modelling to inform assessment is likely to be updated and, at the appropriate time, we seek a meeting with Marine Scotland and MORL to discuss and agree requirements.

We also seek a meeting with Marine Scotland and MORL to discuss and agree any requirements for population modelling in respect of key marine mammal species. In this regard, we support the use of the harbour seal framework assessment and PCoD approach to address the population consequences of disturbance to relevant species.

We note the focus of cumulative impact assessment (CIA) for HRA species will relate predominantly to potential impacts from the WDA in combination with those predicted from the EDA and Beatrice wind farms. During pre-application dialogue, it should be established whether other projects need to be taken into consideration for this and wider EIA and EPS licensing requirements.

- **Ornithology**

In **Appendix B** we provide advice on scoping the ornithological interests which may need to be considered going forward. We attach the 'long-list' produced for pre-application discussion of EDA and Beatrice (spreadsheet, 11th February 2011) which provides a useful starting point. This long-list can be iterated for the WDA through pre-application dialogue, in light of the outputs from MORL's aerial survey and with regard to any potential cumulative impacts that could arise from WDA.

We also list the SPA breeding colonies identified as being within foraging range of EDA (Table 1). This information can be used to help consider which species need to be addressed under HRA. Currently, for HRA the assessment has focused on the breeding season as the period of key concern where there could be significant impacts on SPA breeding colonies. While the consequences of impacts outwith the breeding season on SPA breeding colonies are less clearly understood, further discussions are required on ornithological interests to be scoped in or out, reference populations and assessment approaches for both HRA, EIA and CIA processes as part of the pre-application discussions.

On the 4th July 2016, Scottish Government announced a public consultation on a suite of marine SPAs which are intended to provide protection for birds at sea including divers, seaducks and seabirds[2]. In **Appendix B** we provide advice in relation to the draft proposal for the Moray Firth dSPA, relevant to consider in respect of WDA.

Besides these SPA seabirds, there may be other bird interests to consider from the 'long-list' (including those previously scoped out for the EDA) and we wish to discuss this with Marine Scotland and MORL during pre-application dialogue.

Key impacts on bird interests are predicted to occur during wind farm operation and can arise due to displacement of birds and/or the risk of collision with turbines. Methods to quantify these impacts have changed since our previous advice to EDA and Beatrice. This can be addressed as part of the recommended pre-application discussions.

Once impacts on individual seabirds have been quantified through the technical assessments (such as numbers of birds displaced, numbers of birds killed through collision), they need to be considered in relation to agreed reference populations. Potential impacts from WDA will need to be considered in combination with those from other appropriate plans and projects and we will need to agree the approach during pre-application discussions. Please see **Appendix B** for further detail.

- **Seascape, landscape and visual impact assessment**

We provide our advice on seascape landscape and visual impact assessment (SLVIA) in **Appendix C**. We recommend that assessment focuses on the impacts of the WDA in combination with EDA and Beatrice and provide the relevant guidance to consider.

- **Benthic interests**

We provide our advice on benthic interests in **Appendix D**, noting that MORL intend to survey the WDA as there is only limited data currently available for this area. At the appropriate time, once the outputs from benthic survey are available, we suggest a meeting between the relevant parties in order to agree the appropriate assessment methodologies.

- **Fish of Conservation Concern**

We have discussed marine fish with Marine Scotland Science and they will provide advice on these interests, particularly in relation to cod, herring and sandeel.

SNH has reviewed the advice given at application stage for the EDA in relation to diadromous fish and freshwater pearl mussels as qualifying interests of Special Areas of Conservation (please see response to MORL, 8th July 2013). On the basis of this advice, and because MORL have committed to an extensive monitoring programme in support of the National Research and Monitoring Strategy for Diadromous Fish, we wish to discuss whether SAC fish interests can be scoped out of assessment for the WDA.

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[2] Announcement on the public consultation for marine SPAs:
http://scottishgovernment.presscentre.com/News/Sea-change-25eb.aspx
Further information available from: http://www.snh.gov.uk/protecting-scotlands-nature/protected-areas/proposed-marine-spas/

We therefore request a meeting with Marine Scotland and MORL in order to discuss this further.

- **Physical processes**

We provide our advice on physical processes in **Appendix E** and seek a pre-application meeting in order to agree how to use any available information for WDA and how best to update previous modelling work and assessments.

FURTHER INFORMATION AND ADVICE

JNCC and SNH can provide further advice on natural heritage interests, at appropriate stages, as work is undertaken by the applicant in support of their formal submission. We would be grateful if you could copy us into the formal scoping opinion in due course. In the meantime, if further information or advice is required in respect of this scoping response then please contact Sarah Canning at JNCC or Catriona Gall at SNH.

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MORL ROUND 3 OFFSHORE WIND FARM ZONE – WESTERN DEVELOPMENT AREA

APPENDIX A: MARINE MAMMALS

Marine mammal interests are addressed in Section 3.5 (p109-127) of MORL's scoping report. JNCC and SNH have reviewed this information in order to provide the following advice.

Key species

The frequency of marine mammal recordings in the Moray Firth are provided in Table 3.5-2 (p111) of the scoping report. Based on previous discussion and advice to the Moray Firth offshore wind developers' group (MFOWDG), we advise that harbour seal, bottlenose dolphin, harbour porpoise, minke whale and grey seal are the priority species for assessment in relation to the WDA.

At the appropriate time, we request a pre-application meeting with Marine Scotland and MORL in order to agree the current population estimates to be used as reference populations for each species under impact assessment.

- **Harbour seal**

Harbour seal are a qualifying interest of the Dornoch Firth SAC and we advise connectivity between the WDA and this designated site. As previously advised, the population of the Moray Firth seal management unit[3] should be used as the reference population for HRA and we take this as equivalent to the SAC population. The most up-to-date population estimate at time of assessment should be used for HRA licensing assessments.

- **Bottlenose dolphin**

Bottlenose dolphin are a qualifying interest of the Moray Firth SAC and we advise connectivity between the WDA and this designated site. We advise that the reference population for assessment should be that given in the SNCB guidance on management units for cetaceans in UK waters (2015)[4]. For bottlenose dolphin, this is the coastal east Scotland population. The most up-to-date population estimate at time of assessment should be used for HRA and EPS licensing assessments.

- **Harbour porpoise**

On the basis of the data collected so far, harbour porpoise are likely to be the most abundant marine mammal species recorded in the WDA. We advise that the reference population for the EPS licensing assessment should be that given in the SNCB guidance on management units for cetaceans in UK waters[4] and the most up-to-date population estimate at time of assessment be used.

- **Minke whale**

Although the consultation is delayed, SNH has submitted advice to Marine Scotland on the designation of four further Marine Protected Areas (MPAs) in Scottish territorial waters

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[3] Seal management areas are determined by the Special Committee on Seals (SCOS): http://www.smru.st-andrews.ac.uk/documents/SCOS.pdf

[4] Guidance on cetacean management units from: http://jncc.defra.gov.uk/pdf/Report_547_webv2.pdf

including the Moray Firth Southern Trench where minke whales are one of the interests[5]. We advise that the reference population for any MPA assessment and for EPS licensing should be that given in the SNCB guidance[4] and the most up-to-date population estimate at time of assessment be used.

- **Grey seal**

There are no SAC designations for this species in the Moray Firth and, for the purpose of assessment, we do not advise connectivity between the WDA and any grey seal SACs. As previously advised, the current population of the Moray Firth seal management unit should be used as the reference population for EIA, using the most up-to-date estimate at time of assessment.

- **European Protected Species (EPS)**

All cetacean species are EPS. As well as bottlenose dolphin, harbour porpoise and minke whale, Table 3.5-2 (p111) lists the other cetaceans which have been recorded within the Moray Firth and will need to be considered in relation to EPS licensing requirements. For this 'long-list' of species, relevant reference populations will be determined with reference to the SNCB guidance on management units for cetaceans in UK waters[4], and the most up-to-date estimates at time of assessment should be used.

Baseline surveys

As stated in the WDA scoping document (Section 3.5.1), extensive data is available on marine mammal abundance and distribution within the Moray Firth. This includes the passive acoustic monitoring array funded by Marine Scotland, as well as the programme of post-consent monitoring that has been agreed via the MFRAG marine mammal sub-group. We support this regional approach to monitoring which ensures as much co-ordination as possible in the data-gathering.

In addition to this, MORL indicate marine mammal data will be collected during digital aerial surveys currently underway for seabirds (Section 3.5.5).

We would like to highlight the Small Cetaceans in the European Atlantic and North Sea (SCANS) surveys, which have been used to estimate cetacean abundances in European Atlantic waters. The last surveys were conducted in 2005; new surveys are underway (summer 2016), with updated abundance estimates anticipated for release mid 2017.

Key impacts to consider

Section 3.5.3 of the scoping report (pp120 – 124) clearly summarises the range of potential effects to consider. In respect of the WDA EIA, we agree the probability of risk to marine mammals from toxic contaminants, operational noise or electromagnetic fields is low and these potential effects can be scoped out of assessment as indicated in Table 3.5.3.1.

We advise that the greatest potential effect to marine mammals is likely to be disturbance related to construction noise, particularly as a result of pile-driving turbine foundations. We therefore request underwater noise modelling is carried out for the five key species of

[5] Further information on the draft Southern Trench MPA is available from: http://www.snh.gov.uk/protecting-scotlands-nature/protected-areas/national-designations/marine-protected-areas-%28mpa%29/scottish-mpa-network-advice/

concern: harbour seal, bottlenose dolphin, harbour porpoise, minke whale and grey seal, in order to ascertain the number of individuals which could be disturbed by pile-driving activity.

We note that MORL intend to use the National Oceanic and Atmospheric Administration (NOAA) (2015) draft guidance for assessing the effects of anthropogenic sound on marine mammal hearing, rather than Southall *et al*. (2007). While we agree with the direction the NOAA work is taking, we would highlight this work is still at the draft stage. Current criteria require the use of sound pressure levels and cumulative sound exposure levels to assess injury. Models investigating disturbance are currently based on sound levels, however, it is now acknowledged the extent and duration of disturbance is influenced by several factors, not just the sound level.

As part of the pre-application discussions, we'll seek a meeting with Marine Scotland and MORL to discuss and agree the assumptions, parameters and methods to adopt for underwater noise modelling and, in particular, how cumulative impacts are to be addressed. We would note that while it was useful at the time, the discussion document produced by MORL and BOWL (referred to in Section 1.3.2.6 of the scoping report and provided in Appendix 1) is now largely superseded.

Assessing significance of impacts

As indicated above, HRA applies to harbour seal and bottlenose dolphin; EPS licensing requirements to bottlenose dolphin, harbour porpoise and the other cetacean species listed in Table 3.5-2 (p111). We advise that grey seal should be addressed under EIA, however, such assessment is **not** required for any of the other marine mammal species in addition to HRA or EPS licensing.

In order to consider the significance of underwater noise disturbance to marine mammals and the consequences of this on relevant populations, we remain supportive of the approaches that have been developed by MORL as part of MFOWDG. This includes the harbour seal assessment framework and application of the PCoD approach (population consequences of disturbance) to bottlenose dolphin.

Any requirements for population modelling will be determined by the outputs from underwater noise modelling, and will only apply to key species. Therefore, at the appropriate time, we seek a pre-application meeting with Marine Scotland and MORL to discuss and agree any requirements for population modelling, and to agree the approach to cumulative impact assessment for marine mammal interests for HRA, EIA and EPS licensing requirements.

Potential mitigation / monitoring

We recommend that the applicant considers and discusses the full range of mitigation techniques and guidance available for the proposed WDA.

Extensive discussions have been held by the MFRAG marine mammal sub-group regarding potential mitigation and monitoring methods in relation to underwater noise disturbance (as a result of pile-driving activity). We will continue discussion of these issues via MFRAG and, over time, the approach to noise mitigation for the WDA will be informed by best available evidence including any outputs from work undertaken on-the-ground during construction at Beatrice and EDA wind farms.

APPENDIX B: ORNITHOLOGY

Ornithological interests are addressed in Section 3.6 (p127-159) of MORL's scoping report. JNCC and SNH have reviewed this information in order to provide the following advice.

Key species

During pre-application discussion for EDA and Beatrice, the developers provided a 'long-list' of bird interests for consideration (received 11th February 2011). We attach this original list (which includes those subsequently scoped out for the EDA) as this provides a starting point to consider the full range of species which may potentially be affected by wind farm development in the Moray Firth and to inform scoping judgements for the WDA going forward.

During pre-application dialogue with Marine Scotland and MORL, the 'long-list' can be discussed and iterated in light of outputs from MORL's digital aerial survey and in relation to potential assessment requirements under both EIA and HRA. Further to this discussion there may be other bird interests to address, but in the meantime we are able to provide advice on the following aspects:

(i) Advice on seabird interests at SPA breeding colonies

In **Table 1** (see overleaf) we list the SPA breeding colonies identified as being within foraging range of the consented wind farm development (EDA and Beatrice). This list was based on the most up-to-date foraging information available at the time and it provides a good starting point for considering those SPA seabird interests which may also have connectivity to WDA.

While the process for identifying this connectivity will remain the same, there may now be updated information on seabird foraging ranges available from Birdlife International's seabird database[6] and/or from tracking projects such as FAME (Future of the Atlantic Marine Environment)[7]. We therefore advise that **Table 1** is reviewed in light of any more recent information and distance from the project to the developments sites clearly detailed in any future communication.

Currently, in respect of SPA breeding colonies, the HRA assessment has focused on the breeding season as the period of key concern where there could be significant impacts on SPA breeding populations. The consequences of impacts outwith the breeding season are less clearly understood and further discussions with Marine Scotland are required on ornithological interests to be scoped in or out, reference populations and assessment approaches for HRA, EIA and CIA processes as part of the pre-application discussions.

Advice on draft marine SPAs

On 4th July 2016, Scottish government announced a public consultation on proposals for a new suite of marine SPAs which are intended to provide protection for birds at sea including divers, seaducks and seabirds (see footnote 2 of the cover letter for further information). In this regard, we advise that further consideration will need to be given to the Moray Firth

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[6] http://seabird.wikispaces.com/

[7] http://www.rspb.org.uk/ourwork/projects/details/255106-future-of-the-atlantic-marine-environment-fame-

dSPA as discussed below. We have also considered the Scapa Flow dSPA and we can advise that there is no connectivity between the MORL WDA and this protected area.
Moray Firth dSPA is being proposed for the following interests:

- **Wintering** – great northern diver, red throated diver, Slavonian grebe, scaup, common eider, long-tailed duck, common scoter, velvet scoter, common goldeneye, red-breasted merganser, European shag.
- **Breeding** – European shag.

We have considered the range of potential impacts that could occur from WDA on the Moray Firth dSPA and we have the following advice to provide in relation to disturbance, collision risk and displacement:

Moray Firth dSPA – advice on disturbance

While it is possible that qualifying interests of the dSPA may be recorded during wind farm survey, we advise that any disturbance (during construction, operation or decommissioning) is only a concern if it affects birds when they are within the dSPA itself. As there is some distance between the closest boundary of the WDA and the dSPA we consider this to be highly unlikely. It is possible that disturbance of birds within the dSPA may need to be considered in relation to vessel movements and/or placement of the export cable. These issues should be further considered, if necessary, as part of any HRA and/or in relation to any subsequent scoping consultation for the offshore transmission works.

Moray Firth dSPA – advice on collision risk

We advise that the strategic collision risk assessment undertaken by Marine Scotland can be used to inform consideration of any such impacts in relation to the wintering interests of the dSPA (see next section). In this regard, we would advise that potential collision risk is scoped in to any HRA for the dSPA, however, it will be addressed on the basis of existing information. The area of the dSPA has been determined to include the key foraging habitats of the species for which it's been designated, which is why we think only migratory movements need to be considered in respect of collision risk, rather than day-to-day foraging activity. We note that if there is any risk of collision to European shag during the breeding season then this will be assessed in relation to the breeding colony at East Caithness Cliffs SPA so that we do not require any additional work in relation to the dSPA.

Moray Firth dSPA – advice on displacement

While it is possible that qualifying interests of the dSPA may be recorded during wind farm survey, we do not consider that displacement of birds from the wind farm foot print is a key concern in respect of the dSPA. This is because the area of the dSPA has been determined to include the key foraging habitats of the species for which it's been designated. Displacement from the wind farm footprint is therefore unlikely to give rise to any key impacts on populations of the dSPA interests (either breeding or wintering).

(ii) Advice on migratory (non-seabird) interests

We advise that for non-seabird migratory interests on the 'long-list', information presented in Marine Scotland's strategic collision risk assessment can be utilised[8]. No additional work is

[8] Marine Scotland strategic CRM, report available from:
http://www.gov.scot/Resource/0046/00461026.pdf

required by MORL in this regard, including with respect to wintering wildfowl interests of the Moray Firth dSPA (see preceding section).

The strategic assessment provides an overall estimate of collision risk that Scottish offshore wind farms may present to birds on migration, and we have confidence in the outputs for non-seabird migratory interests such as wildfowl and waders. While WDA is not explicitly addressed in this assessment (see Table 1 of the report, p19), we note that the modelling was done on a "worst case" basis.

Since the time of the report, a number of the wind farms included for assessment have now been withdrawn, and the design envelopes for consented schemes have been substantially refined reducing the levels of predicted collision risk. We therefore feel that there is sufficient "flex" in the report to indicate that any potential impacts from WDA lie well within the level of strategic collision risk that's been advised for migratory (non-seabird) interests.

Reference populations

As discussed above, we identify that the reference population for HRA in respect of current SPAs is the **breeding population**. SNH has recently published a report of the 2015 counts for East Caithness Cliffs SPA and this year (2016) carried out counts at North Caithness Cliffs SPA, which will be published in due course. For the qualifying interests of these SPAs, this is the most up-to-date information which should be used, except for Atlantic puffin where the counts are still under discussion.

Reference populations for other possible ornithology assessments (i.e. non-breeding, EIA or CIA) are yet to be agreed and will be discussed as part of the pre-application dialogue.

Baseline survey

The methods for digital aerial survey of the WDA (April 2016 to March 2017) were discussed and agreed at a meeting held 24th March 2016 and in ensuing correspondence.
Currently, MORL intend to undertake a single year of survey work to cover the WDA, and will also undertake environmental co-variate modelling in order to make predictions about seabird abundance in the WDA, based on all available seabird data collected for the Moray Firth (see Section 3.6.5 of the scoping report). JNCC and SNH have confirmed that we think there is merit in this approach (email, 27th April 2016) and we have agreed to meet to discuss it further once the survey data has been analysed and the initial literature review completed.

Key impacts to consider

As discussed in Section 3.6.3 of the scoping report, we agree that displacement (including barrier effects) and collision risk are likely to be the key impacts to seabird species during the operational phase of wind farm development. Displacement during wind farm construction or decommissioning may also be a concern. We advise that potential habitat loss and effects on prey species should also be scoped in to assessment and included in Table 3.6.3.1 (p147). Further advice on the way to consider impacts to SPA seabirds beyond SPA site boundaries is given in our original scoping advice to MORL EDA, letter dated 28th October 2010, Annex D.

Following our application advice to EDA and Beatrice (letters dated 8th July 2013) we had extensive discussion with Marine Scotland and the developers to agree a common approach to the impact assessments for seabird interests. Agreement was reached with regard to the following approaches for quantifying the levels of impact:

- the method to apportion impacts between breeding colonies (SPA and other),
- the approach to displacement assessment and associated assumptions,
- the approach to collision risk modelling and associated assumptions.

This agreement fed through into the appropriate assessment undertaken by Marine Scotland and issued in support of the Section 36 consents, 19th March 2014.

Since this time, there have been further updates to these assessment methods with a number of research projects commissioned to help inform the approach. Not all of the updates are final and not all of the projects have reported, so we think it's essential to **establish a timetable for pre-application discussions** going forward in order that we can agree the methods to use for WDA.

In the meantime, we provide a short summary of current work in relation to these issues:

- **Seabird sensitivity scores**

There have been some updates in relation to guidance on seabird sensitivity to offshore wind development, Wade *et al*. (2016) is the most up-to-date reference to use[9].

Much of the discussion in the WDA scoping report relating to seabird sensitivity and estimates of impact is based on information submitted by MORL for the EDA. We note that much of this was superseded by post-application dialogue so that it is Marine Scotland's appropriate assessment which should be referred to for the final list of seabirds potentially at risk of impact, and the amounts of collision mortality and displacement that were predicted (see footnote 1 of the cover letter).

- **Apportioning**

For breeding season HRA, we can advise that predicted impacts will need to be apportioned between the breeding colonies (SPA and other) within foraging range. At present, the recommended method for apportioning is set out in SNH guidance[10] and this is the approach that was used for EDA and Beatrice. As noted above, new information may become available on foraging ranges so that this should be discussed with Marine Scotland and ourselves as part of pre-application dialogue.

We are also aware that Marine Scotland has commissioned a project on apportioning[11] which is currently underway. Depending on timescales and outputs, this may need further discussion in respect of the assessments for WDA.

- **Seabird collision risk**

We welcome the approaches to collision risk modelling outlined in Section 3.6.3.3 of the scoping report, which proposes to use Band (2012) guidance[12] alongside R code developed

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[9] Wade, H.M., Masden, E.A., Jackson, A.C. and Furness, R.W. 2016. Incorporating data uncertainity when estimating potential vulnerability of Scottish seabirds to marine renewable energy developments. Marine Policy, 70: 108-113.
http://www.sciencedirect.com/science/article/pii/S0308597X1630241X
[10] SNH guidance on apportioning: http://www.snh.gov.uk/docs/A1355703.pdf
[11] Attributing Seabirds at Sea to Appropriate Breeding Colonies and Populations, CR 2015 19.

by Masden (2015)[13], and will consider any updates to avoidance rates should results from the Offshore Joint Industries Project (ORJIP)[14] become available in time. We recommend these aspects are discussed as part of the pre-application dialogue.

- **Seabird displacement**

There has been extensive discussion of methods to address seabird displacement, particularly at the workshop held 6 & 7 May 2015. Following this, the SNCBs have been working together to produce joint guidance on assessing seabird displacement, due to be published shortly. We recommend that the approach to assessing seabird displacement is also discussed as part of the pre-application dialogue.

Assessing significance of impacts

Any requirements for population modelling will be determined by the predicted levels of impact for WDA on seabird interests, particularly in the context of impacts predicted for the EDA and Beatrice. Therefore, at the appropriate time, we seek a pre-application meeting with Marine Scotland and MORL to discuss and agree any requirements for population modelling and to agree an approach to cumulative impact assessment for seabird interests.
In the meantime, the review of seabird demographic rates commissioned by JNCC has been published and can be used to inform the construction of any necessary population models[15].

Potential mitigation / monitoring

Potential mitigation can be discussed at the appropriate time, if it appears that significant impacts are likely. In respect of consented development (EDA and Beatrice), there has been extensive discussion of post-consent monitoring requirements via the Moray Firth Regional Advisory Group and a programme of work has been agreed. At the appropriate time, any monitoring requirements for WDA can be considered in light of this work.

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[12] Collision risk guidance (2012) available from: http://www.bto.org/science/wetland-and-marine/soss/projects
[13] R code available from: http://marinedata.scotland.gov.uk/dataset/developing-avian-collision-risk-model-incorporate-variability-and-uncertainty-r-code
[14] ORJIP seabird avoidance study: http://www.bou.org.uk/bouproc-net/marine-renewables/davies-et-al-b.pdf
[15] Horswill, C. & Robinson R. A. 2015. Review of seabird demographic rates and density dependence. *JNCC Report No. 552*. Joint Nature Conservation Committee, Peterborough. http://jncc.defra.gov.uk/pdf/JNCC_Report_552_March_2015.web.pdf

TABLE 1 – SPA seabird interests to consider for WDA, based on previous advice

Seabird Species	SPAs within foraging range of EDA
Northern fulmar	East Caithness Cliffs Troup, Pennan & Lion's Head North Caithness Cliffs Hoy, Orkney Copinsay, Orkney Calf of Eday, Orkney Rousay, Orkney West Westray, Orkney
Cormorant	East Caithness Cliffs Inner Moray Firth
Black-legged kittiwake	East Caithness Cliffs Troup, Pennan & Lion's Head North Caithness Cliffs Hoy, Orkney Copinsay, Orkney
Great black- backed gull	East Caithness Cliffs Hoy, Orkney
Herring gull	East Caithness Cliffs Troup, Pennan & Lion's Head
Common guillemot	East Caithness Cliffs Troup, Pennan & Lion's Head North Caithness Cliffs Hoy, Orkney
Razorbill	East Caithness Cliffs Troup, Pennan & Lion's Head North Caithness Cliffs
Atlantic puffin	East Caithness Cliffs North Caithness Cliffs Hoy, Orkney
European shag Gannet	East Caithness Cliffs Sule Skerry and Sule Stack Fair Isle North Rona and Sula Sgier Noss Forth Islands Hermaness, Saxa Vord & Vala

Arctic skua	Hoy, Orkney West Westray, Orkney Fair Isle
Great skua	Hoy, Orkney Noss Hermaness, Saxa Vord & Vala

APPENDIX C: SEASCAPE, LANDSCAPE & VISUAL IMPACT ASSESSMENT

Seascape, landscape and visual interests are addressed in Section 4.5 (p191-200) of MORL's scoping report. SNH has reviewed this information in order to provide the following advice.

Approach to assessment and available guidance

For seascape, landscape and visual interests, it will be key to focus on any additional impacts from proposed development in the WDA in combination with the consented wind farms – Telford, Stevenson and MacColl in the MORL Round 3 zone and Beatrice in Scottish territorial waters.

SNH has published the following guidance that should inform seascape, landscape and visual impact assessment (SLVIA), all of which are available from our website:

- *Offshore renewables – guidance on assessing the impact on coastal landscape and seascape.* SNH (2012).
  www.snh.gov.uk/docs/A702206.pdf
  This guidance is the primary point of reference for SLVIA at scoping stage.
  It includes our advice on use of 'design envelopes' for offshore wind development and how this aspect might be addressed under SLVIA (see Annex 2).

- *Visual Representation of Wind Farms*. SNH (2014).
  www.snh.gov.uk/planning-and-development/renewable-energy/visual-representation/
  This guidance provides advice on the production of visual material and illustrations in support of the assessment. It updates the 2006 guidance referenced in MORL's scoping report (see Section 4.5.1, p192 and Section 4.5.4, p196). The recommendations apply to offshore wind as well as those onshore.

- *Siting and designing wind farms in the landscape*. SNH (2014).
  www.snh.org.uk/pdfs/strategy/renewables/Guidance_Siting_Designing_wind_farms.pdf
  While this guidance applies to onshore wind farm development there may be some aspects that are relevant to consider in respect of offshore proposals.

- *SNH advice on offshore wind design statements*. SNH (2016).
  Applications for offshore wind development in Scotland have usually been made on the basis of a 'design envelope' so that wind farm layout, choice of turbine and other aspects are not finalised until after consent is granted for the project. With this background, SNH's advice note considers the design process for offshore wind, focusing on the purpose and content of design statements. We circulated this to Marine Scotland on 11th February 2016 and can provide a copy on request.

While the scoping report doesn't mention the above guidance, it does make reference to SNH's forthcoming guidance on coastal character assessment (currently being finalised).
In light of the discussion in Section 4.5.4 (see p198), we advise that MORL do not need to carry out any further studies on baseline coastal character (see next section) as the previous work they commissioned adopts good practice and can be used to inform assessment for the WDA. We're surprised that this information is not included as one of the relevant datasets in Table 4.5.1.

We highlight that we are concerned by the discussion of Scott *et al*. (2005) given on p193 as it misinterprets the outputs from this commissioned study. In the first instance, please refer to our current guidance on undertaking SLVIA, as noted above (SNH, 2012).

Coastal character – baseline information

We advise that MORL can utilise the baseline assessment they commissioned from OPEN to define the coastal character units in the study area for the EDA (see Section 4.5.1). We do not anticipate a significantly different study area for the WDA so that this existing information can be used to inform the SLVIA. Where necessary these existing coastal character units should be reviewed to ensure they take account of all operational (or in-construction) terrestrial wind farms to ensure currency of the baseline.

Note that SNH advises use of the term "coastal character" in preference to "seascape character".

Visibility and zones of theoretical visibility

We note that it will be key to determine those areas where the WDA may potentially extend the zone of wind farm visibility when considered in combination with EDA and Beatrice.
Comparative ZTV modelling is typically helpful in informing any changes or extensions to patterns of cumulative visibility and in turn viewpoint selection (discussed in the next section). We anticipate that the consented development (EDA and Beatrice) will be built, so that in most instances the WDA would be seen together with these wind farms.

Viewpoint Selection and Assessment

The viewpoint selection that was agreed for the EDA provides the starting point for discussion in respect of the WDA. As a first step we advise reviewing the viewpoints agreed for cumulative impact assessment between EDA and Beatrice to focus on those where the WDA might expand the extent of development, and / or increase the density of turbines seen on the horizon. Then if the zone of theoretical visibility indicates any areas where the WDA is likely to introduce turbines into views that are not currently affected by either the EDA or Beatrice, these should also be considered.

Further guidance on visual impact assessment is provided in *Offshore Renewables – guidance on assessing the impact on coastal landscape and seascape.* SNH (2012). As set out in this guidance, there should be a consultation meeting to discuss viewpoint selection between Marine Scotland, the relevant planning authorities, the developer and SNH. This meeting should also agree the "worst case" design and layout that will be illustrated on the visualisations (see next section). If any examples of initial visualisations are to be discussed, then these should be supplied as hard copy prior to meeting.

Visualisations

We recommend that visualisations are produced in accordance with SNH's guidance on *Visual Representation of Wind Farms,* available from our website as indicated above. This aspect can be discussed as part of the consultation meeting recommended above.
We note that it may be possible to utilise the existing baseline photography for those viewpoints previously assessed in relation to EDA. This photography should be checked on-site to ensure that there have been no significant changes to the baseline, particularly in respect of inland viewpoints, where changes such as tree growth, new power lines or other new development may alter the foreground of the view.

Potential Mitigation and Monitoring

MORL should clearly articulate the design principles for the WDA particularly its relationship with the consented development (Beatrice and the EDA). From experience, we understand that much of the detailed design will take place post-consent, however, at application stage it should still be possible to set out the design principles and the key constraints which may affect turbine siting and design. In this regard, please refer to the SNH guidance listed above, particularly that in relation to offshore wind design statements.

APPENDIX D: BENTHIC INTERESTS

Benthic interests are addressed in Section 3.3 (p71-89) of MORL's scoping report. JNCC and SNH have reviewed this information in order to provide the following advice.

Baseline survey

Most of the available datasets are focused on the EDA and cable route, and there is only limited information for the WDA. Site-specific surveys are therefore proposed for the WDA, and we agree that this is necessary. Survey will include seabed sampling, video surveillance and scientific trawling. The modelled geophysical data from the coarse grid survey (2010) will be used to identify the target areas for this survey and it will be designed to supplement the existing data. We consider that the proposed approach is reasonable, and it builds on previous experience. The methodology is informed by Cefas guidance, and methods are described in Section 3.3.5. In respect of survey methods, we also highlight the recent guidance provided in Hitchin *et al*. (2015)[16].

We recommend that the ES presents clear information on, and identification of, the main biotopes found on-site. The occurrence of any priority marine features[17] (which may include Annex I habitats) should be recorded. We Note that Ocean Quahog (*Arctica islandica*), a Scottish PMF and listed on the OSPAR list of threatened/declining species is known to be present in the Moray Firth and a small number of juveniles were recorded in the EDA (MORL, 2012). JNCC advice regarding this feature is currently being updated and will be available shortly.

The biotopes/habitat map should be used by the applicant to inform their finalised wind farm layout, considering any potential use of scour protection. We note that MORL are including

[16] Hitchin et. al. (2015) Epibiota remote monitoring from digital imagery: operational guidelines. http://www.nmbaqcs.org/media/1591/epibiota_operational_guidelines_final.pdf
[17] Hitchin et. al. (2015) Epibiota remote monitoring from digital imagery: operational guidelines. http://www.nmbaqcs.org/media/1591/epibiota_operational_guidelines_final.pdf

gravity base foundations within their intended design envelope (Section 1.2.4.4, Table 1.2-2, p29-31) and we seek further discussion with the relevant parties to agree how to account for this in any “worst case” assessment for benthic interests.

Key impacts to consider

A summary of potential effects on benthic interests is given in Table 3.3.3.1 and discussed in detail in the following sections. We consider the list to be comprehensive and we have no additional suggestions.

We would, however, highlight that disturbance to seabed habitats as a result of jack-up placement and the installation of cables (as described in Section 3.3.3.2) is not always temporary, for example if rock dump is left after being used to stabilise jack-up vessels. We recommend discussing this further during the pre-application dialogue and, if necessary, dealing with these potential effects as temporary/permanent.

The approach to impact assessment for benthic interests is discussed in Section 3.3.4. The intention is to use best practice available at the time of the assessment along with experience gained from the EDA and BOWL assessments. At the appropriate time, following completion of the benthic survey work, we suggest that there’s a meeting between the relevant parties in order to agree the assessment methodologies.

Potential Mitigation

Potential mitigation can be discussed at the appropriate time, if it appears that significant impacts are likely.

APPENDIX E: PHYSICAL PROCESSES

Physical processes are addressed in Section 2.2 (p46-62) of MORL’s scoping report. JNCC and SNH have reviewed this information in order to provide the following advice. As noted in Section 1.1 of the scoping report the current consultation is in relation to the wind farm only, so that we are not providing any advice on the transmission infrastructure and cable routes as these will be subject to a separate scoping exercise at a later date.

Available information

We recommend a meeting to discuss available information in respect of bathymetry (Section 2.2.1), metocean conditions (Section 2.2.2), geology, sedimentary environment & water quality (Section 2.2.3). On the basis of the scoping report, we are not yet in a position to confirm that this information is sufficient to characterise the baseline conditions for the WDA, or to say that these conditions are the same as for the EDA. In particular, we would highlight the following points as needing further consideration:

- Bathymetry survey work was undertaken in 2010 and covered 20% of the WDA in a varying sample design (four different grid patterns were used). We seek confirmation of the level of confidence in this data, and further discussion of how the seabed bedform may relate to hydrodynamics.
- In respect of tidal regime, there in an observation in Section 2.2.2.1 (p53) that current speeds are ca.0.3m/s, apparently 33% lower than in the EDA.
- In the sections on wave and wind climate (p53 – 55), there needs to be further discussion and explanation of the similarities or differences between the WDA and EDA.

- The only bedforms mentioned in Section 2.2.3 are 0.3m high ripples in gravelly areas, despite larger sandwaves being noted in Section 2.2.1. We recommend further synthesis across the available information on bathymetry, geology and sedimentary environment in order to characterise baseline conditions at WDA.

As noted, we recommend a meeting to further discuss these issues to ensure that the available data is sufficient to inform the baseline for physical processes assessment.

Key impacts to consider

Potential effects are discussed in Section 2.2.4 of the scoping report, however, we do not agree with scoping out these effects at this initial stage in the process (as seems to be suggested by Table 2.2.4.1). We advise that these potential effects are considered in the physical processes assessment for WDA. We agree with the suggestion (under 2.2.5) that modelling undertaken for EDA will be updated in light of any more recent data. We advise that this modelling (sediment transport modelling as well as hydrodynamic modelling) is reviewed and any required updates are discussed and agreed at the meeting we recommend above.

As part of this discussion we will need to agree which receptors are a focus for assessment. As well as priority marine features (see discussion under Appendix D on benthic interests) we advise including the marine and coastal habitats of the Moray Firth, the Dornoch Firth and Culbin Bar Special Areas of Conservation.

We note that MORL are including gravity base foundations within their intended design envelope (Section 1.2.4.4, Table 1.2-2, p29-31) and we seek further discussion with the relevant parties to agree how to account for this in respect of physical processes.

Cumulative impacts are mentioned in Section 2.2.6 where reference is made to the discussion document produced by MORL and BOWL. While this was very useful at the time, much of the contents have since been superseded so that we recommend any pre-application meeting also determines the scope of cumulative impact assessment for WDA in respect of physical processes.

ABERDEENSHIRE COUNCIL ("ASC")

Aberdeenshire Council consider that Marine Scotland are generally well placed to provide the expertise required to determine if the offshore elements of the Scoping Report are acceptable and if the proposals can be adequately managed with low risk to the marine environment. Officers from the Planning Service are working closely with the applicants in relation to the onshore elements of the wider project.

Having appraised the offshore elements of the project, the following issues should be considered: In terms of mitigation of any potential adverse effects associated with this proposed development, Aberdeenshire Council would suggest that following known industry best practice in terms of constructing and erecting offshore wind turbines, would be appropriate.

Landscape and Seascape visual impacts are of primary interest to Aberdeenshire Council. The scope and methodology outlined within the Scoping Report generally appears to be acceptable, particularly as this draws on experience and the approach taken with the 2012 ES prepared in relation to a related MORL project.

In the seascape, landscape and visual impact assessment for the proposed development, information should be primarily graphic, based on ZTV information for hub height and tip height of an appropriate wind energy development layout. Panoramas, photomontages and wireline models should be produced of the proposal with accompanying assessment of seascape, landscape and visual effects. Any proposed wind monitoring masts, maintenance platforms etc. should also be included in the seascape, landscape and visual impact assessment.

A detailed ZTV should be produced as a basis for the viewpoint selection process when the final development layout and wind turbine specification is confirmed. Cognisance should be made to onshore visual receptors throughout this part of the process.

The applicant needs to fully address the issue of cumulative impact as part of the seascape, landscape and visual impact assessment to fully address the potential combined visual affects between the MORL West proposed development and the onshore wind energy projects that fall within the agreed extent of a cumulative ZTV.

The proposed MORL West development will potentially be seen in combination with other onshore wind energy developments in Aberdeenshire, and potentially in Moray and Highland Council areas, and this issue needs to be fully assessed. For the cumulative impact assessment, appropriate common viewpoints and sensitive receptors that may have been used for other wind energy applications should be identified. The cumulative seascape, landscape and visual impact assessment should be primarily graphic based, with ZTV information, panoramas, photomontages and wireline models etc. An assessment of cumulative visual affects should be supplied in accordance with up to date SNH guidance etc. The appropriate extent of the base map and related ZTV for the cumulative assessment of all publicly known wind energy development should be confirmed with SNH.

Aberdeenshire Council would also welcome and request further consultation on viewpoint selection for all visual, land and seascape assessments.

The environmental statement (ES) accompanying any application should fully assess any impacts of the works on the interests of all the protected areas. This should include, but not be limited to, potential impacts on habitats as a result of any pollution event and disturbance to relevant species as a result of noise, vibration and other construction activities. Offshore Archaeology should also be considered as outlined within the Scoping Report.

MARITIME AND COASTGUARD AGENCY ("MCA")

I have now had an opportunity to review the Scoping Report provided by EDP Renewables UK Ltd for the proposed MORL Western Development Area in the outer Moray Firth and would comment as follows:

The Environmental Statement should supply detail on the possible the impact on navigational issues for both commercial and recreational craft, viz.

- Collision Risk
- Navigational Safety
- Visual intrusion and noise
- Risk Management and Emergency response
- Marking and lighting of site and information to mariners
- Effect on small craft navigational and communication equipment
- The risk to drifting recreational craft in adverse weather or tidal conditions
- The likely squeeze of small craft into the routes of larger commercial vessels.

A Navigational Risk Assessment will need to be submitted in accordance with MGN 543 (and MGN 372) and the MCA Methodology for Assessing the Marine Navigation Safety & Emergency Response Risks of Offshore Renewable Energy Installations (OREI).

Particular attention should be paid to cabling routes and where appropriate burial depth for which a Burial Protection Index study should be completed and, subject to the traffic volumes, an anchor penetration study may be necessary. If cable protection are required e.g. rock bags, concrete mattresses, the MCA would be willing to accept a 5% reduction in surrounding depths referenced to Chart Datum.

The cumulative and in combination effects require serious consideration, particularly with the adjacent MORL Eastern Development Area and Beatrice wind farm projects. Although layout plans will be decided at a much later stage, due consideration must be given for either lines of orientation that allow a continuous passage of vessels and/or SAR helicopters through the sites, or for sufficient air space between sites to allow SAR helicopters to safely manoeuver outside the turbine boundaries when conducting SAR operations.

Given that neither the capacity nor structures of the individual wind turbine generators have been decided, the principles of the Rochdale envelope should be used in the EIA.

The shipping and navigation study should include radar and manual observations in addition to AIS data to ensure commercial vessels of less than 300GT, fishing vessels less than 15m and recreation craft are captured. Given the potential to displace current traffic routes, full consideration of the implications to all identified marine users will need to be assessed.

Particular consideration will need to be given to the implications of the site size and location on SAR resources and Emergency Response Co-operation Plans (ERCOP) for both construction and operation phases.

Reference to the Maritime Accident Investigation Branch should be amended to the Marine Accident Investigation Branch.

References to Exclusion Zones during construction activities should be amended to Safety Zones. It should not be assumed Safety Zones will be automatically applied. These are subject to successful applications made to DECC.

References to MCA Marine Rescue Coordination Centres (MRCC) should be replaced with Coastguard Operations Centres (CGOC). The nearest CGOC is Aberdeen.

MORAY COUNCIL ("MC")

A formal Scoping Opinion has been requested from Moray Offshore Renewables Limited regarding the content of an Environmental Statement which is to be submitted at a later date to the Moray Council for consideration as part of the any planning application for the above proposed development. Apologies for the delay in responding to the scoping request.

We note the content of the Environmental Impact Assessment Scoping Report, and would make the following comments.

1. The Seascape, Landscape and Visual Impact Assessment relating to the Moray coast line should have several key viewpoints within settlements along the coastline, and Moray Council would wish to be party to the selection process of such viewpoints and the form and content of photos, wirelines and photomontage figures provided. Agreement with stakeholders in with para 4.5.5 suggests such involvement.

2. As suggested, figures showing the visual impact of any nautical or aviation lighting on the turbines from the Moray coast would also be beneficial.

3. Moray Council is also the harbour authority and would wish early engagement about what facilities are available to MORL and on any likely impact if Moray harbours are to be used. If the anticipated use of harbours are known this would be relevant to assessing the infrastructure and socio economic impact of the proposal.

NORTHERN LIGHTHOUSE BOARD ("NLB")

With regard to the consultation and the scope of assessment, we would only comment on that part relating to Shipping and Navigational Safety contained within several sections of the consultation document.

We would advise that any marking and lighting recommendations required for the Western Area Development will be made in a formal response through the Marine Licence consultation process, and will be based on IALA Recommendation O-139 with a continuity of Marking and Lighting relative to the previously constructed Eastern Area. It may also be necessary to mark the landfall site of the export cable routes as previously stated in our response regarding the development of the MORL wind farm as a whole and depending on the location chosen after the OFTO process has been completed. All navigational marking and lighting of the site or its associated marine infrastructure will require the Statutory Sanction of the Northern Lighthouse Board prior to deployment.

We would require the Navigational Risk Assessment to be in accordance with the information given at sections 4.2.4 and 4.3.4, and in line with the requirement of MCA Marine Guidance Notice 543. We note that the vessel traffic analysis and data has been mostly derived from the MORL ES 2012 which may need to be updated to meet MCA guidance but that land observations, consultation with users at a local level and a desk top study will be conducted to ensure a more complete Navigational Risk Assessment.

We would welcome and encourage engagement with the Moray Firth Offshore Wind Developers Group to work together to minimise the cumulative impact of site development, including any developers within the Scottish Territorial Waters awards.

SCOTTISH ENVIRONMENT PROTECTION AGENCY ("SEPA")

We note that this Scoping Opinion is for the offshore components only of the Moray Offshore Renewables Ltd (MORL) Western Development Area Wind Farm Infrastructure, Moray Firth and have reviewed a copy of the Scoping Report 'Western Development Area Offshore Wind Farm Infrastructure: Offshore Wind Turbines, Foundations/Substructures and Inter-Array Cables' prepared by EDP renewables dated May 2016.

As we only now comment on proposals for works above MLWS which fall under the appropriate Town and Country Planning (Scotland) Act ,we have no comments to make on the Scoping Report for the offshore element of this proposal.

Please refer to our standing advice on marine consultations within guidance document SEPA standing advice for The Department of Energy and Climate Change and Marine Scotland on marine consultations.

If, after consulting this guidance, you consider that a particular part of this proposal is novel or raises a particular environmental issue relevant to our interests which is not addressed by the standing advice, then we would welcome the opportunity to be re-consulted. Please note that the site specific issue on which you are seeking our advice must be clearly indicated in the body of your consultation request.

We do note however that the proposed offshore wind farm will require transmission cabling and other associated infrastructure works and that a further Scoping Report will be prepared for these onshore works. We will welcome future engagement through the appropriate Town and Country Planning (Scotland) Acts in due course.

Non Statutory Consultees

MARINE SCOTLAND SCIENCE ("MSS")

Marine Scotland Science has reviewed the submitted scoping report and has provided the following comments.

Ornithology

Discussion with SNH, JNCC and MSS regarding how the Masden (2015) version of the Band Collision Risk Model will be used to estimate the number of collisions, and how these outputs will be used, is strongly advised. Similarly, discussion with SNH, JNCC and MSS on the PVA approaches to be used to assess population level consequences of estimated effects should take place. The analyses of the various seabird data sets available for the area have the potential to be complex and challenging due to the varying methods used, spatial and temporal scales of survey, and ages of data. Regular updates on progress made and challenges encountered, alongside discussions on how the outputs could/ will be used should therefore take place with SNH, JNCC and MSS.

Marine Mammals

MSS welcome the opportunity to provide comments on this scoping document. As this development is immediately adjacent to an already consented proposal, we anticipate that the EIA process will be informed by, and learn the lessons from the previous EIA process. This is evident from the scoping report, whereby the important receptors and potential impact pathways are identified. MSS would encourage the most recently available data to be used to inform the ES, including work undertaken as part of the MMMP for the currently consented development, which Marine Scotland has contributed to funding. Depending upon the respective timelines, this may also include data from the SCANS-III surveys.

Species for consideration

Harbour seal – *Phoca vitulina*

Since the MORL EDA ES (2012) more telemetry data have become available, and we welcome the updated modelling of harbour seal distribution. We would welcome the inclusion of data collected under the MMMP, particularly where this can help to inform the HRA.

Grey seal – *Halichoerus grypus*

We are content with the use of updated seal usage maps as per Jones et al. (2013) however we would like the developer to be aware that these maps are likely to be updated on the Marine Scotland website within the next few months. It is worth MORL remaining in contact with MSS regarding updated seal usage maps.

Harbour porpoise – *Phocoena phocoena*

Whilst recognising that the density map shown (Fig. 3.5-3) is the current best available porpoise distribution map, we encourage the updating of predicted density of harbour porpoise within the Moray Firth through the inclusion of new data from aerial surveys and potentially also from static passive acoustics, where this is appropriate. MSS are content that aerial survey data and passive acoustic data that are held by us can be requested by

MORL. However, in some cases, it may be easier for pre-processed outputs to be used and so we would welcome discussion about the most appropriate way in which to take this forward.

Bottlenose dolphin – *Tursiops truncates*

In paragraph 1, p. 117, it states that bottlenose dolphins are restricted to coastal waters. This is generally true of the east coast population, but not necessarily true of the species in general. However, the main concern around bottlenose dolphins is in relation to the potential for an effect on the conservation status of the Moray Firth SAC. We would again welcome the inclusion of data collected under the MMMP on the population size and any information that may be useful on demography, for use within the HRA.

Minke whale – *Balaenoptera acutorostrata*

We recognise that SCANS II density estimates are currently the best available and most conservative estimates of minke whale abundance available. If the data are available in time, we would welcome the inclusion of SCANS-III data in the ES, which are being collected during summer 2016.

Pathways for impact

MORL has identified potential impact pathways from the construction, operation and decommissioning of the wind farm, and we believe has scoped in the potentially important effects. The most important impact in this context is the noise generated as a result of pile driving and we welcome the statement of intent to consider piling options that produce lower noise levels. We consider that there will be a requirement for noise propagation modelling to inform the assessment and that this should be carried out on the worst case scenario for impacts to marine mammals, in terms of the options in the Rochdale Envelope. These results will then be required to feed into impact assessments for marine mammal species. MSS are content that the seal assessment framework (Thompson et al. 2013) is used for this, but would also point out that other frameworks have been developed more recently (e.g. interim PCOD and DEPONS) and that these may useful in this assessment process. There will also be a need to assess the cumulative impacts to these populations (also see comments below).

If gravity bases, or other bases that require substantial seabed preparation works, are scoped into the project, then we would consider that loss of foraging habitat for marine mammals will require assessment, and that this should be coordinated with the assessments for fish ecology.

Refinement of the Rochdale envelope will reduce the extent of the assessment that requires to be undertaken and we would encourage MORL to consider areas where this may be appropriate.

Cumulative effects

MSS considers that there is potential for cumulative effects with the MORL EDA project and the BOWL project. MSS would welcome further discussion about other developments that should be included in the cumulative impact assessment; we consider that any licensed or consented project that may impact upon the same populations should be included, as well as other projects that are further along in the planning process. MS-LOT should be included in further discussion of this and will be able to provide lists of projects that are currently in the planning process.

HRA

MSS welcome the stated intention to discuss the SACs that require HRA with us and the SNCBs. We would add auditory injury (PTS) to the list of assessment criteria. Mitigation options are likely to mean that this does not occur, but at this stage in the assessment process we would like to ensure that this is considered.

References

Thompson PM, Hastie GD, Nedwell J, Barham R, Brookes KL, Cordes LS, Bailey H, McLean N (2013) Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population. Environmental Impact Assessment Review, 43:73–85.

Marine Fish Ecology

The scoping report outlines proposed datasets to identify baseline characteristics for the fish and shellfish ecology EIA in table 3.4-1. MSS is content with this aspect and welcomes inclusion of such up to date information within the EIA.

Table 3.4.1.1 identifies the potential effects of development in the WDA on fish and shellfish ecology. MSS agrees with the scoping report that each should be scoped into the EIA and is content with the identified associated phases.

The scoping report provides a good and comprehensive list of marine fish species for consideration however, whilst it identifies those potential effects of development in the WDA on fish and shellfish ecology, it does not seem to clearly identify whether these species are to be scoped in or out of the EIA. For example, table 3.4-5 provides the conservation status of fish species recorded in landings data (2000 – 2009) within the regional study area. This list, for completeness, includes black scabbardfish, blue ling and Greenland halibut however given that these are generally associated with deep-water, it would be expected that they are scoped out of the EIA. The scoping report highlights assessments for the MORL EDA, including the species considered and, whilst it is not expected that there would be much, if any, deviation from this within the WDA EIA, clarification from the applicant on species to be scoped into the WDA assessments would be welcome. MSS are happy to engage with the applicant to discuss, should it be of benefit.

Commercial Fisheries

MSS has reviewed MORL Western Development Area EIA Scoping Report with an emphasis on commercial fisheries and has provided the following comments:

Section 4.2.1 provides the commercial fisheries baseline characterisation and list potential effects associated with the Western Development Area. Most information have been derived from the MORL ES in 2012. It is advised that more recent data should be used to describe the baseline (5 most recent years' worth of data 2011-2015). This will be possible with MMO landings data by ICES rectangles as listed in Table 4.2-1.

Table 4.2-1 listing 'Datasets for the Commercial Fisheries EIA' should expand to cover landings and numbers of active fishing vessels broken down by length classes, by adjacent fishing ports, and ICES rectangle level (see Scottish Sea Fisheries Statistics). Information should be put in context (e.g. percentage share of the national landings etc.) to highlight importance.

It is stated that MORL EDA assessment predicted moderate effects on the scallop fishery and minor effects on the whitefish fishery. In order to reduce these effects, MORL agreed a draft Commercial Fisheries Mitigation Strategy with the Scottish Fishermen's Federation and established the Moray Firth Commercial Fisheries Working Group to discuss concerns and mitigation measures. No reference to either the proposed function of the MFCFWG in relation to the WDA is made or the cumulative impacts. It should be noted that combined effects from EDA and WDA might not simply be additive. It is stated that "the extent of displacement will be a function of the temporary loss or restricted access to traditional fishing grounds during the construction phase". It should be added that the significance of displacement will also be a function of the available fishing space (availability of target species in sufficient amounts and commercial sizes as well as remaining suitable habitat e.g. for scallops) over time. Most effects from the EDA are discussed and mitigated through a Commercial Fisheries Mitigation Strategy and the Moray Firth Commercial Fisheries Working Group. There has been no reflection on how the effects from the WDA will be mitigated e.g. as part of the MFCFWG. Therefore, MSS cannot comment on the potential effectiveness of proposed mitigations measures.

Scallop dredge gear modification trials study developed by Bangor University is referenced. However, no statement surrounding plans to undertake the trials are mentioned in the report. The applicants should provide more information about their plans.

BERR guidance (2008) reference has been update to FLOWW in 2014. Best Practice Guidance for Offshore Renewables Developments: Recommendations for Fisheries Liaison (FLOWW, 2014). Other best practice guidance documents include:

- Best Practice Guidance for Fishing Industry Financial and Economic Impact Assessments (Seafish, 2009);
- Guidance on overlaps with fishing (Subsea Cables UK, 2012);
- Emergency procedures for fouling gear (Subsea Cables UK, 2015); and
- SeaPlan. Options for Cooperation between Commercial Fishing and Offshore Wind Energy Industries. A Review of Relevant Tools and Best Practices. 2015

Section 4.2.6 refers to the 'Moray Firth Offshore Wind Developers Group Cumulative Impact Assessment Discussion Document'. The document dates since 2011 and is advised to be listed as an agenda item in the next appropriate MFCFWG meeting. This will give the opportunity to fisheries stakeholders to consider the document, and updates to be undertaken on datasets and relevant projects to be considered, as well as available methodologies after 5 years.

- Section 4.2.7 states that one of the proposed mitigation measures will be the establishment of a Moray Firth Commercial Fisheries Working Group. Rather than plain establishment of the group, mitigation measure should be explicit on the proposed function of the group.

Benthic Ecology

MSS is generally in agreement with the statements and approaches discussed and described in the Scoping Report. However, a couple points need to be made.

Page 29. Foundations and Substructures. The type of foundation to be used needs to be clarified as soon as practicable as the design options described have varying degrees of

impact on seabed and benthic ecology. Gravity bases in particular will have a significant impact on the benthos.

Page 59. Sediment changes as a result of foundation activities. The document states that the dredging required to prepare the seabed would result in increases in suspended sediment levels which would be within the natural range of variability. Some data to support this statement is required. Data on local sediment types, locations and their silt content (PSA data) would be useful here. Information on potential particle suspension levels expected from dredging operations are also needed as will modelling of dispersion plumes. Estimates on accumulation rates and depths would be useful to support the statement "reworked and dispersed to background concentrations on short to medium term time scales". A discussion on impacts of smothering on sessile, slow-moving and burrowing organisms needs to be assessed.

Page 80. Potential Effects**.** The table indicates that all potential effects of development in the WDA on benthic features have been scoped out. MSS suggest that topics 3,6 and 7 are scoped in as these are important effects which may have significant impacts on the benthic community.

Diadromous Fish

The main potential impact mechanisms during the construction and operation phases are correctly identified.

Section 4.2.2 Data Gaps correctly recognises the need to update the information in the MORL ES 2012. This will need to include an updated authoritative view on the likely distribution of the various life stages of the diadromous fish species, including salmon, sea trout and eels, in the development locality, whether they are likely to be close to the coast or offshore, and the extent to which they are likely to be in the immediate vicinity of the development, and swimming depths, based as far as possible on real information for the locality or elsewhere. In the case of salmon and sea trout this should include updated information on the likely origin / destination of fish using the area.

Updated information, bringing in the latest knowledge, on the likely impacts of underwater noise on diadromous fish and their behaviour, and appropriate mitigation to minimise impacts of pile driving noise during construction.

Section 4.2.2 Data Gaps refers to MORL's existing commitment for the presently approved phase of the development for smolt tagging studies which will contribute to the National Research and Monitoring Strategy for Diadromous Fish. There will need to be consideration of what further research and monitoring relating to diadromous fish with respect to this new phase of the work will be appropriate.

Table 3.2-3 and elsewhere in the document only list nearby salmon SACs as ones which could potentially be affected. Because of the long range movements of salmon, developments could have the potential to impact on salmon populations associated with rivers substantial distances from the development site. Logically the ES should review first what information is available on where salmon in the area are likely to be from, or destined for, before the selection is made.

Table 3.4-3 includes a wide range of diadromous species as potentially present in the Moray Firth area. I would note that there are few records of shad or smelt in the area.

MSS notes that the consultees include District Salmon Fishery Boards and Trusts, MSS and SNH/JNCC. The Moray Firth Trout Group should also be included.

Reasonably frequent contact during assembly of the material will be helpful.

Aquaculture

MSS aquaculture planning has no specific comments to make on the Offshore Wind Farm, Moray Firth – Environmental Impact Assessment – Scoping Report. There are no further comments to add to those made on 24/02/2016 in response to the Project 1 Piling.

Socio Economics

MSS is content with the proposals for the Human Environment part of the assessment for WDA. We welcome the commitment to update the baseline information from MORL ES 2012

CIVIL AVIATION AUTHORITY ("CAA")

Having reviewed the Scoping Report provided, the appropriate aviation consultees (NATS, the MoD, the Maritime and Coastguard Agency, and Highlands and Islands Airport Ltd) have been identified although the positions of each consultee regarding the proposed development should be established by consultation.

We also note comments made in the Scoping Report concerning the potential mitigation of radar effects through utilisation of a Transponder Mandatory Zone (TMZ). While the CAA have previously approved the use of TMZs for other wind turbine developments in this area, TMZs should not be assumed to be approved in all cases. Should a TMZ be proposed by the developer, it would be subject to a separate application under the airspace change process: we would be happy to discuss this requirement with the developer if necessary.

In terms of aviation lighting, any wind turbine generator the height of which is 60 metres or more above the level of the sea at the highest astronomical tide and which is situated in waters within or adjacent to the United Kingdom must be lit in accordance with the Air Navigation Order and should be appropriately marked. Further information concerning the lighting of offshore wind turbines is contained within CAPs 764 and 437.

In terms of charting, there is an international civil aviation requirement for all structures of 300 feet (91.4 metres) or more to be charted on aeronautical charts. Accordingly such structures should be reported to the Defence Geographic Centre (DGC) which maintains the UK's database of tall structures (the Digital Vertical Obstruction File) at least 10 weeks prior to the start of construction. The point of contact is Nigel Whittle (0208 818 2702, mail to dvof@mod.uk). The DGC will require the accurate location of the turbines/meteorological masts, accurate maximum heights, the lighting status of the turbines and / or meteorological masts and the estimated start / end dates for construction together with the estimate of when the turbines are scheduled to be removed. Please note, maximum height is to the blade tips, not just the hub or nacelle.

In order to ensure that aviation stakeholders are aware of the turbines and / or meteorological masts while aviation charts are in the process of being updated, developments should be notified through the means of a **Not**ice to **A**ir**m**en (NOTAM). To arrange an associated NOTAM, a developer should contact CAA Airspace Regulation (AROps@caa.co.uk / 0207 453 6599); providing the same information as required by the DGC at least 14 days prior to the start of construction.

CHAMBER OF SHIPPING (“CoS”)

Thank you for the opportunity to comment on the Scoping Report for the Outer Moray Firth Western Development Area. The traffic data used was for the Eastern Development area and will need to be updated and will need to take account of the development of the EDA to inform a full navigational risk assessment. In addition to routine movements tracked using AIS, routing options take during bad weather, as well as anchorages must be considered. Many vessels are not equipped with AIS and thus radar or other means may need to be used to gain a full picture of the shipping activity. When considering turbine layout and boundaries, the guidelines given in MGN543 should be followed.

DEFENCE INFRASTRUCTURE ORGANISATION ("MOD")

I am writing to advise you that the MOD objects to the proposal. Our assessment has been carried out on the basis that there will be 90 turbines, 272 metres in height from ground level to blade tip, this assessment has been based on the boundary outline for the development at the grid references below as stated in the planning application or provided by the developer:

Turbine	100km Square letter	Easting	Northing
1		328204	902286
2		328204	905456
3		328204	906265
4		328204	906701
5		328248	906747
6		328282	906783
7		328311	906815
8		328511	907032
9		328769	907320
10		329023	907614
11		329270	907912
12		329514	908215
13		329751	908521
14		329793	908577
15		329822	908614
16		330054	908924
17		330280	909239
18		330501	909557
19		330717	909880
20		330909	910178
21		331058	910371
22		331290	910682
23		331516	910996
24		331701	911262
25		331801	911407
26		332016	911728
27		332226	912055
28		332429	912385
29		332628	912718
30		332820	913055
31		333007	913394
32		333166	913696
33		333336	913747
34		333705	913863
35		334073	913986
36		334439	914115
37		334802	914250
38		335164	914392
39		335522	914540
40		335530	914543
41		335530	914543

42		335639	914589
43		335995	914743
44		336347	914904
45		336457	914955
46		336509	914975
47		336870	915116
48		337229	915265
49		337585	915419
50		337937	915580
51		338287	915747
52		338354	915780
53		338419	915811
54		338767	915984
55		339110	916163
56		339215	916220
57		339393	916316
58		339452	916348
59		339789	916538
60		340123	916735
61		340454	916937
62		340781	917146
63		341104	917359
64		341424	917579
65		341740	917804
66		342052	918034
67		342360	918270
68		342663	918511
69		342963	918758
70		343257	919009
71		343463	919189
72		343469	919195
73		343764	919446
74		344055	919703
75		344341	919965
76		344622	920232
77		344898	920503
78		345170	920779
79		345437	921061
80		345699	921347
81		345957	921637
82		346208	921931
83		346455	922230
84		346697	922534
85		346933	922842
86		347164	923153
87		347390	923469
88		347408	923497
89		347428	923524
90		347445	923548

91		347513	923632
92		347755	923936
93		347991	924243
94		348002	924258
95		348206	924421
96		348505	924668
97		348728	924859
98		349404	923891
99		349952	922874
100		350362	921904
101		350487	921515
102		350487	921515
103		350648	921017
104		350828	920169
105		350986	919306
106		351055	918099
107		351006	916957
108		350878	916156
109		350757	915543
110		350533	914672
111		350533	914672
112		350164	913727
113		349594	912546
114		348932	911516
115		348163	910588
116		347428	909846
117		346215	908884

Air Traffic Control (ATC) Radar

The turbines will be 33.6km – 61.9 km from, detectable by, and will cause unacceptable interference to the ATC radar used by RAF Lossiemouth.

Wind turbines have been shown to have detrimental effects on the performance of Primary Surveillance Radars. These effects include the desensitisation of radar in the vicinity of the turbines, and the creation of "unwanted" aircraft returns which air traffic controllers must treat as aircraft returns. The desensitisation of radar could result in aircraft not being detected by the radar and therefore not presented to air traffic controllers. Controllers use the radar to separate and sequence both military and civilian aircraft, and in busy uncontrolled airspace radar is the only sure way to do this safely. Maintaining situational awareness of all aircraft movements within the airspace is crucial to achieving a safe and efficient air traffic service, and the integrity of radar data is central to this process. The creation of "unwanted" returns displayed on the radar leads to increased workload for both controllers and aircrews, and may have a significant operational impact. Furthermore, real aircraft returns can be obscured by a turbine's radar return, making the tracking of both conflicting unknown aircraft and the controllers' own traffic much more difficult.

An operational assessment of this proposal has been conducted by an ATC subject Matter Expert (SME) who considered the position of the turbines weighed against a number of operational factors. Close examination of the proposal has indicated that the proposed

turbines would have a significant and detrimental effect on operations and on the provision of air traffic services at RAF Lossiemouth. MOD therefore objects to the development at Moray Offshore Renewables LTD Western Development Area Windfarm. The reasons for this objection include, but are not limited to:

a. Restrictions the development would impose upon departure routes including Standard Instrument Departures (SIDS)
b. Restrictions the development would impose upon approach and arrival procedures
c. Restrictions the development would impose upon traffic patterns, in particular the Radar to Visual profile
d. Restrictions the development would impose upon LARS/ZONE traffic patterns
e. Restrictions the development would impose upon manoeuvring areas
f. Restrictions the development would impose upon Tactical Aid to Navigation (TACAN) procedures
g. Restrictions the development would impose upon holding areas
h. The position of the development in relation to controlled airspace
i. The position of the development in relation to restricted/danger areas
j. The position of the development in relation to entry/exit points to/from the Low Flying System
k. Air traffic density in the vicinity of the proposed windfarm
l. Existing clutter or windfarms in the vicinity of the proposed windfarm
m. The complexity of the ATC task
n. The workload of controllers

If the developer is able to overcome the issues stated above, the MOD will request that all turbines be fitted with aviation lighting in accordance with CAA direction and CAP 393 Air Navigation Order Section 1 part 28.

MOD Safeguarding wishes to be consulted and notified about the progress of planning applications and submissions relating to this proposal to verify that it will not adversely affect defence interests.

I hope this adequately explains our position on the matter. Further information about the effects of wind turbines on MOD interests can be obtained from the following website: https://www.gov.uk/government/publications/wind-farms-ministry-of-defence-safeguarding

HISTORIC ENVIRONMENT SCOTLAND ("HES")

We have reviewed the details in terms of our historic environment interests. This covers scheduled monuments and their settings, category A listed buildings and their settings, inventory gardens and designed landscapes, Inventory battlefields, world heritage sites and Historic Marine Protected Areas (HMPAs). In this case, our advice also includes matters relating to marine archaeology outwith the scope of the terrestrial planning system.

The relevant local authorities' archaeological and cultural heritage advisors will also be able to offer advice on the scope of the cultural heritage assessment. This may include heritage assets not covered by our interests, such as unscheduled archaeology, and category B and C listed buildings.

Proposed Development

I understand that the proposed development would consist of an offshore wind farm of up to 90 turbines, with a maximum height to tip of 272m. The development area is located in the north-east of Scotland, 22.5km from the Caithness coast on the Smith Bank in the Moray Firth.

The current consultation relates to the offshore wind farm infrastructure. A separate scoping consultation will take place in relation to the offshore and onshore transmission infrastructure. Our comments here therefore relate specifically to potential impacts within the identified development area (WDA) and its vicinity, and the impact of the turbines on the setting of terrestrial heritage assets.

Off-shore Impacts

There are no HMPAs in the vicinity of the site or the wider area. However, we welcome that the assessment will consider direct disturbance and loss to known and unknown assets of historic importance and indirect impacts and indirect potential for impacts relating to disturbance and changes to the physical environment and coastal sediment dynamics of the area.

We welcome the identification of the charted wreck of the vessel Sunbeam in the scoping report. We note that there are a number of other potential sites of archaeological value within the WDA that have been identified at this stage.

We consider the identified assessment methodologies and mitigation measures for these potential impacts to be adequate.

On-shore Impacts

In light of the fact that this scoping report does not cover the potential impacts from transmission infrastructure, we consider it unlikely that there will be any direct impacts on our terrestrial historic environment interests.

Our comments here therefore focus only on the potential setting impacts on terrestrial heritage assets from the offshore infrastructure. In light of the intervening distances (in excess of 20km) we are content that these are unlikely to be significant.

I note that section 4.6.4.2 refers to setting impacts on designated heritage receptors. The study proposed refers to establishing the baseline setting of assets in the cable route

corridor search area. However, it does not appear that the search area has been identified in this scoping report, and we therefore cannot comment on whether or not we consider this to be an adequate search area. We are content for this area to be identified in the scoping report for transmission infrastructure, and to provide comments at that stage.

If a study is to be undertaken to identify potential setting impacts from the wind farm infrastructure, we would recommend that this uses the ZTV data to identify sensitive receptors in the first instance. We would also recommend that the methodology uses our Managing Change guidance note on setting as a starting point. This has recently been updated, and as available to download from the following link:
https://www.historicenvironment.scot/advice-and-support/planning-and-guidance/legislation-and-guidance/managing-change-in-the-historic-environment-guidance-notes/

General Points

We welcome the inclusion of a comprehensive list of guidance which will inform the assessment. As above, we advise that our Managing Change guidance note on setting has recently been updated.

As the current scoping report does not cover the transmission infrastructure of the proposed development, we will be happy to comment on these details when they become available.

JOINT RADIO COMPANY LIMITED (“JRC”)

Name/Location: Moray Offshore - Western Development (SCOPING OPINION REQUEST FOR THE PROPOSED SECTION 36 AND MARINE LICENCE APPLICATION FOR THE MORAY OFFSHORE RENEWABLES LTD (“MORL”) WESTERN DEVELOPMENT AREA WIND FARM INFRASTRUCTURE, MORAY FIRTH)

Site Centre at NGR: ND 41066 13471

Development Radius: 10km

Hub Height: 90m Rotor Radius: 50m

This proposal ***CLEARED*** with respect to radio link infrastructure operated by:

The Local Electricity Utility & Scotia Gas Networks

JRC analyses proposals for wind farms on behalf of the UK Fuel & Power Industry. This is to assess their potential to interfere with radio systems operated by utility companies in support of their regulatory operational requirements.

In the case of this proposed wind energy development, JRC does not foresee any potential problems based on known interference scenarios and the data you have provided. However, if any details of the wind farm change, particularly the disposition or scale of any turbine(s), it will be necessary to re-evaluate the proposal.

In making this judgement, JRC has used its best endeavours with the available data, although we recognise that there may be effects which are as yet unknown or inadequately predicted. JRC cannot therefore be held liable if subsequently problems arise that we have not predicted.

It should be noted that this clearance pertains only to the date of its issue. As the use of the spectrum is dynamic, the use of the band is changing on an ongoing basis and consequently, developers are advised to seek re-coordination prior to considering any design changes.

MORAY FIRTH PARTNERSHIP (“MFP”)

The Moray Firth Partnership continue to remain a neutral body and as such do not respond to license applications. We do however keep a record of such applications on file and appreciate being kept on the circulation list submissions for information purposes.

NATS En-Route PLC (“NERL”)

NERL are pleased to note that the developer intends to undertake a study into the impacts of the development on the Allanshill radar. A number of Specialist Advisors are listed in 4.9 and NERL will work with the identified parties in order to quantify the impact, at both a technical and operational level, and develop the proposed regional approach to mitigation if required.

ROYAL SOCIETY FOR THE PROTECTION OF BIRDS ("RSPB") Scotland

Our principal areas of interest fall under the following proposed headings for the Environmental Statement ("the ES"): 4.1 Designated Sites; 4.5 Ornithology; and 6.1 Habitats Regulations Appraisal (HRA). Our detailed comments are set out under those headings below.

Overall, the scoping report proposes a sensible structure and range of issues for the ES. We note that cumulative and in-combination assessments will be presented within each discipline section. The proposed structure of the ES appears to allow all of the pertinent issues to be addressed; we are unable to identify at this stage any new discipline sections that might require to be added in order to ensure that all of the relevant impacts are able to be addressed.

Designated sites

Currently, the most important nature conservation sites requiring to be addressed in the ES are the Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) contributing to the Natura 2000 network. Tables 3.2-2 and 3.2-3 appear to us to identify all of the SACs that could possibly be affected by the proposal. Table 3.2-1 appears to include all of the currently designated SPAs that could possibly be affected by the proposal. We strongly recommend that the "draft" Moray Firth marine SPA ("the dSPA") should also be included in this section, as there has been no announcement by the Scottish Ministers that this site will no longer be progressed in light of last week's referendum result. Therefore at present we recommend that the site be treated as if it were already classified, and that it should be subjected to a "shadow" HRA process, on the basis that the current timetable would see the site designated before the application and ES are submitted.

At this stage we consider that the sites with the potential to be most significantly affected, and thus meriting the greatest attention in the ES and HRA report are marine mammal SACs, and SPAs classified for breeding seabirds, with those closest to the project being those most likely to be affected, but with effects also possible to sites further afield, depending on the foraging range of qualifying species. This will in turn have a bearing on cumulative and in combination effects, in particular (but not only) for gannet as a qualifying feature of the Forth Islands SPA, as well as seabird colony SPAs around the Moray Firth itself, classified for a range of cliff-breeding seabirds. The RSPB is involved in bird tracking research with the potential to inform assessments based on foraging range and behaviour of seabird species; we would welcome the opportunity to be involved in the EIA process as the proposals progress towards application.

Marine mammals

We anticipate there being specialist and detailed comments and advice from Whale and Dolphin Conservation (WDC), and consequently have nothing to add under this subject heading at present.

Ornithology

Overall, the scoping report appears to have identified an appropriate range of species and issues, and to have referenced a reasonable range of guidance and published science. The methods proposed for survey and the assessment of impacts seem in general to be appropriate. We have a small number of specific suggestions for inclusion:

At section 3.6.1, where there is a list of guidance and published work, the following should be included:

- Cook, A.S.C.P. and Robinson, R.A. (2015). The Scientific Validity of Criticisms made by the RSPB of Metrics used to Assess Population Level Impacts of Offshore Wind Farms on Seabirds. BTO Report 665
- Cook, A.S.C.P. and Robinson, R.A. (2016). Testing sensitivity of metrics of seabird population response to offshore wind farm effects. JNCC Report 533
- Green, R.E., Langston, R.W.H., McCluskie, A., Sutherland, R. & Wilson, J.D. (in press) Lack of sound science in assessing wind-farm impacts on seabirds. *Journal of Applied Ecology*
- Wade, H. M., Masden, E. A., Jackson, A. C., & Furness, R. W. (2016). Incorporating data uncertainty when estimating potential vulnerability of Scottish seabirds to marine renewable energy developments. *Marine Policy* 70:108-113.

In addition, we have the following comments:

3.6.3.2. Disturbance, para 2: Consideration should also be given to Wade *et al*. (2016) – listed in our comment on section 3.6.1 above – as well as Furness *et al*. (2013) when assessing sensitivity to disturbance

3.6.3.3. Collision: We welcome use of the R code of Masden (2015).

3.6.3.3 Barrier effects: we note that Marine Scotland are currently investigating the application of CEH's Forth and Tay energetic model to the Moray Firth; we observe from our participation in the steering group for the Forth and Tay work that at that time CEH anticipated additional work being needed to identify and validate the parameters required when applying the Forth and Tay model to other sites. Nevertheless, we cautiously welcome this proposed approach as one of the more promising ways of assessing population-level impacts of barrier effects and displacement from foraging areas.

3.6.3.3. Final 2 paragraphs. Any PVA or similar model-based population-level assessment of impact should be interpreted in light of Cook *et al*. (2015, 2016) and Green *et al*. (2016), all listed in our comment on section 3.6.1 above.

3.6.5. If possible, data on flight speed should be collected during aerial survey.

3.6.8 Habitats Regulations Appraisal. We recommend redrafting the five bullet points in this section to reflect the fact that SPA integrity can be adversely affected if any one of the objectives is sufficiently compromised. This will need to take into account in-combination effects, in particular with other consented and proposed offshore wind farms also likely to have a significant effect on the SPAs identified in Table 3.2-1 of the scoping report.

Mitigation for ornithological impacts might include: removal, or relocation of turbines within the WDA (on the basis that collision, displacement and barrier effects are all likely to some extent to increase/decrease roughly in proportion to the number of turbines); temporary or seasonal shutdown of some or all turbines (depending on the availability of reliable technology to identify abnormal levels of risk, and implement shutdown and restart within appropriate timescales and with minimal impact on turbine durability). Measures to improve seabird survival and/or breeding performance might not meet the strict criteria necessary to

be classed as mitigation; however, their ability to offset survival and/or breeding performance impacts arising from collision, displacement and/or barrier effects would potentially merit consideration as compensatory measures in the event that those were required to maintain overall coherence of the SPA network, in the event that Scottish Ministers were minded to grant consent on the basis of there being imperative reasons of over-riding public interest and no alternative solutions.

ROYAL YACHTING ASSOCIATION ("RYA") SCOTLAND

Section 4.3.1.4 describes recreational vessel activity. Surveys by AIS and radar underestimate the number of recreational vessels on passage, only about 20% of which will have been transmitting an AIS signal. The Pentland Firth and Orkney Waters Shipping Study (http://www.gov.scot/Publications/2012/12/1868/1), which was published in 2012, includes and analysis of recreational vessel activity in Wick. The site is indeed intersected by a 'medium use' cruising route as decided by expert opinion. However, the RYA has been carrying out an update to the UK Atlas of Recreational Boating and when published this will provide a much better indication of routes taken by recreational vessels.

I agree with the statement in section 4.3.3.2 that there will be little disruption to recreational vessels during the construction phase. Mitigation measures will of course include widespread publicity about the timing and location of construction.

I also agree with the equivalent statement in 4.3.3.3. Note that it is RYA policy that there is no need for an operational safety zone for small vessels.

Table 4.7.1 should, for completeness, include the recently published Scottish Marine Tourism and Recreation Survey (http://www.gov.scot/Topics/marine/seamanagement/national/RecandTourism). Note, however, that the methodology used does not provide a comprehensive representation of cruising routes. I agree that the effects of the three phases of operation on those aspects of tourism relating to recreational boating can be scoped out.

SCOTTISH FISHERMEN'S FEDERATION ("SFF")

The Scottish Fishermen's Federation is pleased to respond to this scoping report on behalf of its constituents, the Anglo-Scottish Fishermen's Association, the Clyde Fishermen's Association, the Fife Fishermen's Association, the Fishing Vessel Agents & Owners Association (Scotland) Limited, the Mallaig and North-West Fishermen's Association Ltd, the Orkney Fishermen's Association, Scallop Association, the Scottish Pelagic Fishermen's Association Ltd, the Scottish Whitefish Producers' Association Ltd and the Shetland Fishermen's Association whose membership encompasses over 500 fishing vessels/businesses.

In the report on pages 32, 33 and 78 the export cables are discussed, which are not the subject of this scoping report but, since they are mentioned, the SFF would nevertheless express concern about the lack of detail on cable parameters, assertion of there being 3m burial and the problem of the many cable crossings to be considered.

On page 81 referring to seabed disturbance the SFF would like to see more information on the Anchor berms as we believe they cause another unique problem for our industry.

Referring to pages 91-94, the EIA should pay close attention to the latest advice from ICES on any development operations during spawning seasons for the species identified, and should also give more attention to the Squid and Scallop spawning and nursery grounds.

The table 3.4.3.1 on page 102 needs to be examined particularly the final line "Changes to Fishing Activity" which seems to be claiming Construction and Decommissioning will have no impact, and together with the statement on page 105 that fishing will continue, needs to be substantiated as the SFF remains sceptical of these claims.

Given that the Smith Bank is a major scallop fishery the SFF would seek clarity on the claim that the suspension of sediment during this development will only have a minor impact on Scallop survival rates.

And finally in the Section on Human Environment, table 4.2.1 on Datasets omits the UKFIM project which would undoubtedly help in this work.

SPORT SCOTLAND ("SS")

In relation to sports interests that may be affected, we note that the Scoping Report makes reference to potential impact on recreational vessels, and we welcome that this will be considered.

We note that the report does not identify other sports interests as being affected. **sport**scotland does not have detailed knowledge of the sport interests at or in the vicinity of the site in question and it will be important not to rely solely upon **sport**scotland for a view from the sport sector. We therefore advise the applicant to consult with relevant local clubs and sports groups, and with relevant Scottish Governing Bodies of Sport (SGBs), for both onshore and offshore interests. The Governing Bodies of Sport should be able to put the applicant in touch with relevant club interests in the area that it would be beneficial to consult with. Contact details for SGBs can be found on our website at the following link: http://www.sportscotland.org.uk/sport-a-z.aspx .

We also note the information available from the Scottish Marine Recreation and Tourism Survey 2015, please see below link. It should, however, be noted that this may not include all recreation and tourism interests.

http://www.gov.scot/Topics/marine/seamanagement/national/RecandTourism.

It will also be important for the land-based elements of the proposal not to impact negatively on access rights in the area – we would advise consultation with Council's Access Officers to address any potential impacts on access rights, and with the Local Access Forum, as well as with the Council's Sports Development and Outdoor Education staff.

SCOTTISH WILDLIFE TRUST ("SWT")

The Trust recognises that renewable energy production will play a key role in reducing Scotland's carbon emissions and believes large scale developments such as the MORL wind farm can, if appropriately planned and managed, play a key role in meeting these targets. The size and location of the proposed MORL wind farm will present challenges for ensuring all environmental impacts are kept to a minimum, in particular the impact of noise pollution on marine mammals during construction, seafloor disturbance and its impact on benthic species, and the impact on local seabird populations during operation. Therefore the Trust believes it is important to take an ecosystems approach during the decision-making process and when planning the deployment of the wind turbines.

Overall, the Trust would like to raise the following concerns with the scoping report:

1. When the options for turbine structure are discussed, we would like to see what implications their design has for decommissioning – for example, which has the least environmental impact, which is easiest to remove, which can be recycled and reused?
2. There has been no consideration to the use of floating wind turbines in the report. Although the use of floating wind is still only at the test stage, it would be of interest to see how floating structures would compare to the other designs discussed, particularly with respect to environmental impacts during construction.
3. The presence of ~90 wind turbines will have an ecological impact in the development area – the increased presence of hard surfaces and the reduction in fishing effort will lead to increases in local biodiversity. We would like to know whether any consideration was given to using turbine designs that encourages species recruitment, by providing various habitats, and increases biodiversity. For example, a steel lattice jacket would provide a more diverse range of habitats (e.g. shaded surfaces, surfaces of different orientation…) than a monopole design. When comparing possible turbine structure designs, we would like to see an assessment of what ecological impact each of them would have.
4. If drilling is required in construction, we would like to see a plan for removal and disposal of drill cuttings rather that leaving them on site.
5. We would like to see construction/decommissioning activities to occur outside of breeding periods for local marine mammals, when animals are more vulnerable to disturbance.
6. We believe the upcoming Hywind pilot floating wind farm and the proposed Kincardine floating wind farm off of the Aberdeenshire coast should also be included in the cumulative impact assessment.
7. We would like to see a strategic and detailed plan for surveying and monitoring the site prior to construction, during operation, and post decommissioning of the wind farm. This will provide a valuable overview of the total environmental impact throughout the entire life of the wind farm.

TRANSPORT SCOTLAND ("TS")

This information has been passed to JMP Consultants Limited for review in their capacity as Term Consultants to Transport Scotland – Trunk Road and Bus Operations (TRBO). Based on the review undertaken, we would provide the following comments.

Development Proposals & Site Location

We understand that the proposed development is for an offshore wind farm comprising up to ninety 8-15MW wind turbine generator units providing up to 750MW of power.

The Western Development Area (WDA) is located in the north-east of Scotland, 22.5 km from the Caithness coast in the Moray Firth. The nearest Trunk Road to the site is the A9(T) between Helmsdale and Lybster.

It is noted that the SR relates to the wind turbines, their substructures and foundations and inter-array cables and any potential meterological masts for the WDA. A separate SR will be prepared for offshore and onshore transmission works at a later date when more details of the export cable routes and onshore substation location are known. Transport Scotland will provide comment on these aspects of the proposal separately if consulted.

Construction/ Access

It is noted that only limited information is available at present on the nature of the construction process, since the major parameters of the development have not yet been defined in detail. The Assembly Port where the substructures will be assembled has yet to be confirmed. We accept that the majority of components are likely to come in by sea so we do not require an assessment of the increased traffic (or associated environmental impacts) on the trunk road network.

We would however, advise that if any abnormal loads associated with the offshore elements of the project are required to be transported on the Trunk Road network, then a separate report will require to be provided to assess the route to site in terms of its suitability for the transportation of these abnormal loads.

In addition, it is noted that dredging may be required for the installation of the foundations, the nature and volume of which will be determined through further ground investigation. It is understood that MORL will explore the possibility of disposing dredged material on-site or at an alternative appropriate licensed disposal site. In the event that the disposal material requires to be transported on the Trunk Road network, Transport Scotland would request an assessment of the number of construction/ dredging related HGVs and their potential impact on the Trunk Road network is undertaken and presented within the ES.

WHALE AND DOLPHIN CONSERVATION ("WDC")

We understand that MORL Western Development Area (WDA) Wind Farm will be located approximately 22.5 kilometres (km) from the Scottish coast on the Smith Bank in the Outer Moray Firth at a depth of 35 – 54 meters. The development is anticipated to consist of up to 90 wind turbines with a potential generation capacity of up to 750 MW.

Thank you for the opportunity to provide comments on the MORL Western Development Area Wind Farm Infrastructure Scoping Opinion Request. Given our area of interest, we have only focused on the marine mammal sections.

WDC are endeavouring to assist with the environmentally sustainable development of marine renewable energy in Scotland. Whilst welcoming the Scottish Governments' commitment to renewable energy generation, particularly noting the potential consequences of climate change for cetaceans, we have concerns about current levels of uncertainty and the possible negative impacts these developments, both individually and cumulatively, may have on cetaceans (whales, dolphins and porpoises) and seals in Scottish waters.

In summary

Overall, we are happy that the scoping document appears to have included all the information required for the Environmental Statement and HRA to be produced. We are content with what has been 'scoped in' for potential impacts in Table 3.5.3.1.

Pile driving

There is still considerable scientific uncertainty surrounding the impacts of pile driving during construction on all species, and in this region. As a result, our preference is that pile driving is not used at all during construction.

Alternatives to pile driving should be considered. Use of noise-reducing techniques could considerably reduce the radius of impacts of this development and those in the region, would reduce cumulative impacts and could mean that there is less dependence on mitigation and less risk to developers. Should pile driving be conducted, further information on the pile driving method and mitigation techniques to reduce the impact of underwater noise generated during pile driving needs to be covered significantly. Considerable uncertainty remains about the efficacy of active acoustic deterrent devices, and the impacts resulting from their use and we do not consider their use to be a suitable or adequate mitigation.

However, we understand that construction of the MORL WDA Wind Farm will begin after construction of MORL and BOWL. Therefore the data generated during and post construction will be vital to help inform on best practice.

Harbour seals

Recently, connectivity between harbour seals in the Moray Firth and Orkney has been shown from tagged data. Due to the significantly declining population in Orkney, harbour seals in the Moray Firth should be given the same level of protection from disturbance and displacement as harbour seals in Orkney. See http://synergy.st-andrews.ac.uk/harbourseals/ blog post on 3rd June 2016 for more information on the connectivity.

Annex 2

DEVELOPER APPLICATION AND ENVIRONMENTAL STATEMENT CHECKLIST

	Enclosed
1. Applicant cover letter and fee	☐
2. Copies of ES and associated OS maps	☐
3. Copies of Non-Technical Summary	☐
4. Confidential Bird Annexes	☐
5. Draft Adverts	☐
6. E Data – CDs, PDFs and SHAPE files	☐

Environmental Statement	Enclosed	ES Reference (Section & Page No.)
1. Development Description	☐	
2. Planning Policies, Guidance and	☐	
3. Economic Benefits	☐	
4. Site Selection and Alternatives	☐	
5. Baseline Assessment data – air emissions	☐	
6. Design, Landscape and Visual Amenity	☐	
7. Construction and Operations (outline	☐	
8. Archaeology	☐	
9. Designated Sites	☐	
10. Habitat Management	☐	
11. Species, Plants and Animals	☐	
12. Water Environment	☐	
13. Sub-tidal benthic ecology	☐	
14. Hydrology	☐	
15. Waste	☐	
16. Noise	☐	
17. Traffic Management	☐	
18. Navigation	☐	
19. Cumulative Impacts	☐	
20. Other Issues	☐	

N.B. Developers are encouraged to use this checklist when progressing towards application stage and formulating their Environmental Statements. The checklist will also be used by officials when considering acceptance of formal applications. Developers should not publicise applications in the local or national press, until their application has been checked and accepted by officials.

marine scotland

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Marine Scotland - Licensing Operations Team Scoping Opinion

THE MARINE WORKS (ENVIRONMENTAL IMPACT ASSESSMENT) (SCOTLAND) REGULATIONS 2017 (AS AMENDED)

THE MARINE WORKS (ENVIRONMENTAL IMPACT ASSESSMENT) REGULATIONS 2007 (AS AMENDED)

SCOPING OPINION FOR THE PROPOSED MARINE LICENCE APPLICATION FOR MORAY WEST OFFSHORE TRANSMISSION INFRASTRUCTURE

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Table 2 The applicant's summary of the potential effects on physical process and water quality over the development lifecycle (in columns 1 to 3) and whether or not the effect should be scoped out of the assessment (column 4) . Where Scottish Ministers agree, the cell is marked green and where Scottish Ministers disagree, the cell is marked red and a commentary is provided below the table. 19

Table 3 The applicant's summary of the potential effects on benthic and intertidal ecology over the development lifecycle (in column 1 to 3) and whether or not the effect should be scoped out of the assessment (column 4). Where Scottish Ministers agree, the cell is marked green and where Scottish Ministers disagree, the cell is marked red and a commentary is provided below the table. 21

Table 4 The applicant's summary of the potential effects on fish and shellfish over the development lifecycle (in columns 1 to 3) and whether or not the effect should be scoped out of the assessment (column 4). Where Scottish Ministers agree, the cell is marked green and where Scottish Ministers disagree, the cell is marked red and a commentary is provided below the table. 25

Note regarding changes to the Environmental Impact Assessment Directive

On the 16 May 2017, The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 came into force, transposing the requirements of the 2014 amendment (2014/52/EU) to the Environmental Impact Assessment ("EIA") Directive. These regulations were subsequently amended by The Environmental Impact Assessment (Miscellaneous Amendments) (Scotland) Regulations 2017 which came into force on 30 June 2017 and introduced minor changes.

The Marine Works (EIA) (Scotland) Regulation 2017 revoke The Marine Works (EIA) Regulations 2007 (as amended) for Scotland (i.e. the Scottish marine area out to 12 nautical miles). Past 12 nautical miles ("nm") in waters adjacent to Scotland, the Marine Works (EIA) Regulation 2007 (as amended) are applicable. These regulations are hereinafter referred to together as "the EIA Regulations". The Marine Works (EIA) Regulation 2007 were amended by The Marine Works (EIA) (Amendment) Regulations 2017 on the 16 May 2017 which also transposed the requirements of the 2014 amendments to the EIA Directive.

As Moray Offshore Windfarm (West) Limited submitted their Scoping Report on 24 May 2017 the 2017 EIA Regulations therefore now apply.

0 Executive Summary

This is the scoping opinion adopted by the Scottish Ministers as to the scope and level of detail of information to be provided in the Environmental Impact Assessment Report ("EIA report") for the proposed Moray West Offshore Transmission Infrastructure ("OfTI").

This document sets out the Scottish Ministers' opinion on the basis of the information provided in Moray Offshore Windfarm (West) Limited's ("Moray West") Scoping Report, dated 24 May 2017. This scoping opinion can only reflect the proposal as currently described by Moray West in the Scoping Report. The matters addressed by Moray West in the Scoping Report have been carefully considered and use has been made of professional judgment (based on expert advice from stakeholders and Marine Scotland's in-house expertise) and experience in order to adopt this opinion. It should be noted that when it comes to considering the Environmental Impact Assessment report ("EIA report"), the Scottish Ministers will take account of relevant legislation and guidelines (as appropriate). The Scottish Ministers will not be precluded from requiring additional information if it is considered necessary in connection with the EIA report submitted with the application for a Marine Licence (s).

This scoping opinion is valid for 12 months from the date of issue. If an application is not received within 12 months, then Moray West must contact the Scottish Ministers to determine whether this scoping opinion requires updating.

The Scottish Ministers have consulted on the Scoping Report and the responses received have been taken into account in adopting this scoping opinion. The Scottish Ministers are satisfied that the descriptions identified in Moray West's request for a scoping opinion encompass those matters identified in Regulation 14 of The Marine Works (EIA) (Scotland) Regulations 2017 (as amended) and Regulation 13 and Schedule 4 of The Marine Works (EIA) Regulations 2007 (as amended).

The Scottish Ministers draw Moray West's attention to the general points and those made in respect of the specialist topics in this scoping opinion.

The main potential issues identified are:

- Increases in suspended sediment through construction activities and effects on sensitive receptors;
- Disturbance of acoustically sensitive receptors through construction and operation;
- Scoping out of effects too early in the assessment process; and
- The implementation of the 2017 EIA Regulations.

Matters are not scoped out unless specifically addressed and justified by Moray West and confirmed as being scoped out by the Scottish Ministers. Table 1 details topics proposed to be scoped out within the Scoping Report and provides the Scottish Ministers' advice on this. Detailed information is provided in the specialist topic sections.

Table 1 Effects proposed by Moray West to be scoped out of the EIA report with the Scottish Ministers summarized scoping opinion.

Topics presented in the Scoping Report	**Potential effect proposed to be scoped out by Moray West**	**The Scottish Ministers' decision**
Physical processes and water quality	Changes to water quality from sediment disturbance	The Scottish Ministers disagree that these effects can be scoped out of the assessment if the cable makes landfall at Cullen Bay. The potential changes to water quality from sediment disturbance should be scoped into the EIA under these circumstances.
	• Changes to water quality from chemical release • Changes to water quality from contaminated sediment	The Scottish Ministers disagree that these effects can be scoped out at this stage of the assessment cycle. Mitigation measures will need to be secured in relation to these effects through the EIA process.
Benthic and intertidal ecology	• Accidental release of chemicals from infrastructure installation processes from vessels • Electromagnetic effects • Seabed sediment heating from subsea cables	
Fish and Shellfish	• Operational noise from electrical equipment on Offshore Substation Platform ("OSP") (s), vessels and maintenance activities. • Seabed sediment heating from subsea cables (interconnector and export cables). • Electromagnetic Fields ("EMF") from subsea cables (interconnector and export cables).	

Marine Mammals	• Displacement as a result of operational noise • EMF from Interconnector and Export Cables	The Scottish Ministers agree that no further assessment of these effects is required as part of the EIA.
Ornithology	• Barrier effects • Collision risk	The Scottish Ministers agree that no further assessment of these effects is required as part of the EIA.
Shipping and Navigation	Electromagnetic interference with vessel navigational equipment	The Scottish Ministers agree that this effect is scoped out of further assessment. Additional studies are proposed by stakeholders with a navigational remit and requires due consideration.
Military and Civil Aviation	• Degradation of National Air Traffic Services (En-Route) PLC ("NERL") Allanshill Primary Surveillance Radar ("PSR"), Lossiemouth PSR, Air Surveillance and Control Systems Buchan Air Defence Radar ("ADR"). • Effects on Wick operations at Wick Airport • Effects on operation of Helicopter Main Route ("HMR") X-Ray • Effects on operations at offshore installations • Increase in Minimum Safe altitude	The Scottish Ministers agree that these effects should be scoped out, however, due consideration should be given to the vulnerability of the works to risks of major accident and/or disasters.
Other Human Activities	• Effects on disposal, dredging and dumping activity • Effect on telecommunications	The Scottish Ministers agree that these effects should be scoped out of further assessment.

1 Introduction

1.1 Background to this scoping opinion

1.1.1 In reference to your email/letter of 24 May 2017 requesting a scoping opinion from the Scottish Ministers, under Regulation 14 of the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (as amended) and Regulation 13 and Schedule 4 of the Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended) (hereinafter referred to together as "the EIA Regulations"). Your request was accompanied by a Scoping Report containing a plan sufficient to identify the site which is the subject of the proposed regulated activities. A brief description of the nature and purpose of the proposal and of its possible effects on the environment was also provided. The Scoping Report was accepted by the Scottish Ministers on 02 June 2017.

1.2 The requirement for Environmental Impact Assessment

1.2.1 Under the EIA Regulations the Scottish Ministers must not grant a Marine Licence (s) for an EIA project unless an EIA has been carried out in respect of that project and in carrying out such assessment the Scottish Ministers must take the environmental information into account. The works described in your Scoping Report fall under Schedule 2, paragraph 3 (j) of The Marine Works (EIA) (Scotland) Regulations 2017 (as amended) and Schedule 2, paragraph 21 of The Marine Works (EIA) Regulations 2007 (as amended). An EIA is required owing to the proposals exceeding the stated thresholds in these regulations.

1.2.2 The outcomes of the EIA will result in the preparation of an EIA Report to support the applications, under Part 4 of the Marine (Scotland) Act 2010, and Part 4 of the Marine and Coastal Access Act 2009. In determining an application for a Marine Licence (s) the Scottish Ministers must have regard to the need to protect the environment, protect human health, prevent interference with legitimate users of the sea and such other matters as the Scottish Ministers consider relevant.

1.2.3 The intention to produce a single EIA report that captures the outcomes of the EIA for both the Moray West Offshore Wind Farm and the associated Offshore Transmission infrastructure is highlighted in the Scoping Report. The Moray West Offshore Wind Farm has sought a scoping opinion under the 2011 EIA Directive criteria and the scoping opinion contained here within is provided under the 2014 EIA Directive criteria. Due consideration is required to the structure of the EIA report to allow the Scottish Ministers to

make a clear determination under the appropriate criteria without confusion.

1.2.4 Moray West is required to give consideration to the UK Marine Policy Statement, Scotland's National Marine Plan ("NMP"), Scottish Planning Policy, other relevant Policy and National Policy Planning Guidance, Planning Advice Notes, the relevant planning authority's Development Plans and any relevant supplementary guidance.

1.3 The content of the scoping opinion

1.3.1 With regard to your request for a scoping opinion on the proposed content of the required EIA report, the Scottish Ministers have considered the documentation provided to date and consulted with the appropriate consultation bodies and with Marine Scotland Science (see Appendix I and II) in reaching their scoping opinion in accordance with the EIA Regulations.

1.3.2 Please note that the EIA process is vital in generating an understanding of the biological, chemical and physical processes operating in and around the proposed site and those that may be impacted by the proposed activities. References made within the scoping opinion with regard to the significance of impacts should not prejudice the outcome of the EIA process. It is therefore expected that these processes will be fully assessed in the EIA report unless scoped out.

1.4 Consent conditions

1.4.1 Where possible the Scottish Ministers recommend that Moray West and relevant stakeholders have discussions, prior to submission of any application, to resolve any issues. Time could be saved post consent if agreements could be reached and agreed by both parties as this could result in a condition not being needed. This could apply to, for example, the Fisheries Management and Mitigation Plan.

2 Description of development

2.1 Background to the development

2.1.1 The Scoping Report describes the Moray West OfTI associated with the Moray West Offshore Windfarm. The Moray West Offshore Windfarm is proposed approximately 22 km off the Caithness coast in the outer Moray Firth (see Figure 1) and has been subject to a separate scoping exercise and scoping opinion. The OfTI will act to collect the electricity generated from the Wind Turbine Generators and distribute it to the onshore national

electricity transmission system and would only ever be developed in conjunction with the Moray West Offshore Windfarm.

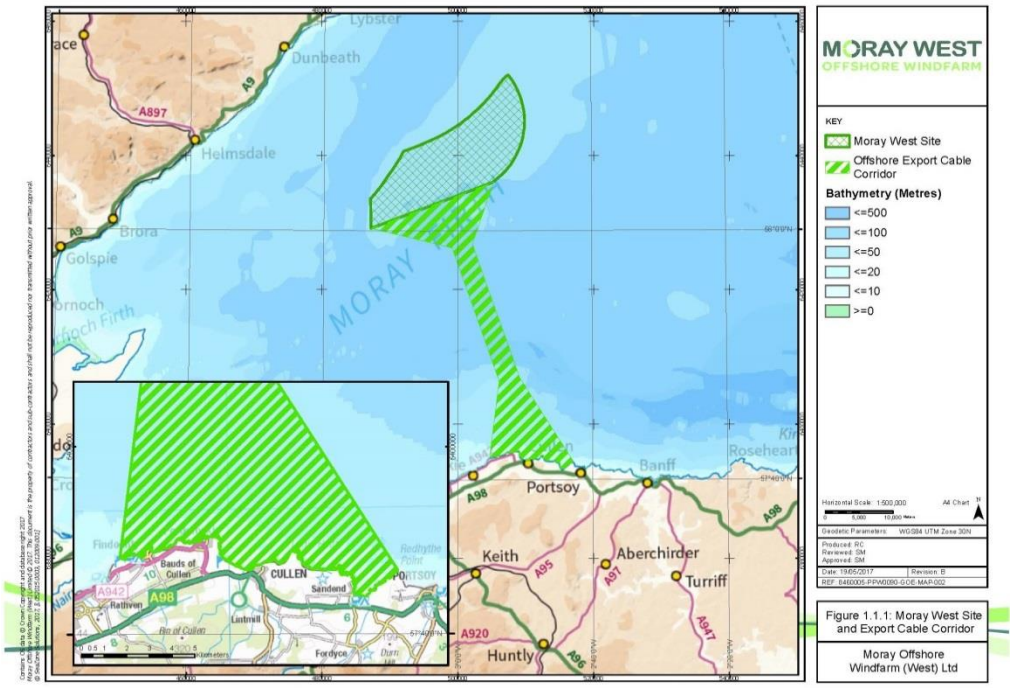

Figure 1 Location of the proposed Moray West Site and Export Cable Corridor (as reproduced from Moray West Offshore Transmission Infrastructure Scoping Report)

2.2 Description of the Development

2.2.1 The OfTI comprises of the following components:

- One or two Offshore Substation Platform(s) ("OSP")(s);
- An interconnector cable running between the two OSP(s) (if two OSPs are installed); and
- Offshore export cables running from OSP(s) to landfall.

2.2.2 The OfTI Scoping Report proposes that an EIA will be prepared for the Moray West Offshore Windfarm, OfTI and the relevant part of the Moray West Onshore Transmission Infrastructure ("OnTI") in a single EIA report.

2.2.3 A separate scoping exercise will be presented to the relevant Local Planning Authority for the connection from the landfall site to the onshore national transmission system, the OnTI.

2.2.4 The OfTI is proposed to cross the limits of the Scottish marine area as determined under section 126(2) of the Scotland Act 1998 (c.46). Consideration of Marine Works (EIA) (Scotland) Regulations 2017 (as amended) will be required for proposal in the Scottish marine area (within 12

nm). In waters adjacent to Scotland (outside of the Scottish Marine area and the 12 nm limit) consideration will be required of the Marine Works (EIA) Regulations 2007 (as amended). As more than one set of regulations apply the most stringent requirements should be adhered to in terms of, for example, consultation timelines and public notice requirements.

3 Aim of this Scoping Opinion

3.1 Scoping process

3.1.1 Scoping is a key phase of the EIA process, providing an opportunity for the applicant to identify those potentially significant environmental effects that should be considered for further assessment in the EIA report. This includes the scope of impacts to be addressed and the method of assessment to be used. The scoping process also allows consultees to have early input into the EIA process, to specify their concerns and to supply information that could be pertinent to the EIA process. In association with any comments herein, full regard has been given to the information contained within the Scoping Report submitted.

3.1.2 The Scottish Ministers have also used this opportunity to provide advice in relation to the licensing requirements in addition to the EIA requirements (see Appendix III).

4 Consultation

4.1 The consultation process

4.1.1 On receipt of the scoping opinion request documentation, the Scottish Ministers, in accordance with the EIA Regulations, initiated a 30-day consultation, which commenced on 02 June 2017. The following bodies were consulted, those marked in **bold** provided a response, those marked in *italics* sent nil return or stated that they had no comments:

- **Aberdeenshire Council "AC"**
- **Beatrice Offshore Windfarm Ltd "BOWL"**
- *British Telecom Radio Network Protection Telecom "BT"*
- Canoe Scotland
- Civil Aviation Authority "CAA"
- Cromarty Firth Port Authority "CFPA"
- Defence Infrastructure Organisation "DiO"
- Fisheries Management Scotland "FMS"
- **Historic Environment Scotland "HES"**
- Inshore fisheries "IF"

- Joint Nature Conservation Committee "JNCC"
- Joint Radio Company "JRC"
- Marine Safety Forum "MSF"
- Marine Scotland Compliance (Buckie) "MSC (Buck)"
- Marine Scotland Compliance (Fraserburgh) "MSC (Fras)"
- Marine Scotland Compliance (Scrabster) "MSC (Scrab)"
- Marine Scotland Compliance (Ullapool) "MSC (Ull)"
- **Maritime & Coastguard Agency "MCA"**
- Defence Infrastructure Organisation "DIO"
- **Moray Council "MC"**
- Moray Firth Partnership
- National Air Traffic Services "NATS"
- North & East Coast Inshore Fisheries Group "N&ECIFG"
- **Northern Lighthouse Board "NLB"**
- **Royal Society for the Protection of Birds Scotland "RSPB"**
- **Royal Yachting Association Scotland "RYAS"**
- **Scottish Environmental Protection Agency "SEPA"**
- Scottish Government Planning "SG Planning
- **Scottish Fishermen's Federation "SFF"**
- Scottish Fishermen's Organisation "SFO"
- **Scottish Natural Heritage "SNH"**
- Scottish Surfing Federation "SSF"
- Scottish Wildlife Trust "SWT"
- Sports Scotland "SS"
- Surfers Against Sewage "SAS"
- The Crown Estate "TCE"
- **The Highland Council "THC"**
- **Transport Scotland "TS"**
- Transport Scotland Ports and Harbours "P&H"
- **UK Chamber of Shipping "CoS"**
- **Visit Scotland "VS"**
- **Whale and Dolphin Conservation "WDC"**

4.2 The responses received

4.2.1 A total of 16 responses were received. Advice was also sought from Marine Scotland Science ("MSS") and their response is attached in Appendix II. The purpose of the consultation was to obtain advice and guidance from each consultee or advisor as to which potential effects should be scoped in or out of the EIA.

4.2.2 The Scottish Ministers are satisfied that the requirements for consultation have been met in accordance with the EIA Regulations. Section 6 highlights issues which are of particular importance with regards to the EIA report. Full

consultation responses are attached in Appendix I and each should be read in full for detailed requirements from individual consultees. The Scottish Ministers expect all consultee concerns to be addressed in the EIA report unless an agreed justification can be provided to why this should not be the case.

5 Contents of the EIA report

5.1 Requirements of the EIA Regulations

5.1.1 An EIA report must be prepared in accordance with Regulation 6 and Schedule 4 of Marine Works (EIA) (Scotland) Regulations 2017 (as amended) and Regulation 12 and Schedule 3 of The Marine Works (EIA) Regulations 2007 (as amended).

5.1.2 The EIA Regulations require that the EIA report is prepared by competent experts and must be accompanied by a statement from Moray West outlining the relevant expertise or qualifications of those experts.

5.1.3 The EIA report must be based on the scoping opinion and must include the information that may be reasonably required for reaching a reasoned conclusion, which is up to date, on the significant effects of the regulated activities on the environment, taking into account current knowledge and methods of assessment.

5.1.4 Procedures should be coordinated for projects which are subject to assessment under Directive 92/43/EEC ("the Habitats Directive") or under Directive 2009/147/EC ("the Wild Birds Directive") and Directive 2014/52/EU ("the EIA Directive").

5.1.5 The EIA must be based on the environmental factors outlined in relevant EIA Regulations noting the requirements of both sets of applicable regulations. These factors are updated by the new EIA regulations; note that biodiversity was previously referred to as flora and fauna and population previously referred to human beings. Consideration is also required of the new factor, where relevant, '*the impact of the works on climate and the vulnerability of the works to climate change'*. The EIA report is required to document how this and all the other requirements have been met.

5.1.6 The requirements for considering alternatives within the EIA report are to include "an indication of the main reasons for selecting the chosen option, including a comparison of the environmental effects" Schedule 4 paragraph 2 of Marine Works (EIA) (Scotland) Regulations 2017 (as amended).

5.1.7 EU guidance on EIA identifies the following qualities of a good EIA report::

- Includes a clear structure with a logical sequence, for example describing existing baseline conditions, predicted impacts (nature, extent and magnitude), scope for mitigation, agreed mitigation measures, significance of unavoidable/residual impacts for each environmental topic.
- Includes a table of contents at the beginning of the document.
- Includes a clear description of the regulated activities' consent procedure and how EIA fits within it.
- Reads as a single document with appropriate cross-referencing.
- Is concise, comprehensive and objective.
- Is written in an impartial manner without bias.
- Includes a full description of the proposals.
- Makes effective use of diagrams, illustrations, photographs and other graphics to support the text.
- Uses consistent terminology with a glossary.
- References all information sources used.
- Has a clear explanation of complex issues.
- Contains a good description of the methods used for the studies of each environmental topic.
- Covers each environmental topic in a way which is proportionate to its importance.
- Provides evidence of good consultations.
- Includes a clear discussion of alternatives.
- Makes a commitment to mitigation (with a programme) and to monitoring.
- Has a Non-Technical Summary ("NTS") which does not contain technical jargon

5.1.8 Further guidance can be found at
http://ec.europa.eu/environment/eia/eia-support.htm

5.1.9 The Scottish Ministers are aware that the Commission is currently working on guidance to reflect the 2014 amendment to the Directive. This guidance can be found using the above link when published.

5.2 Non-Technical Summary ("NTS")

5.2.1 The EIA report must contain an NTS which should be concise and written in a manner that is appealing to read and easily understood. The NTS should highlight key points set out in the EIA report and must include (at least) the following:

- a description of the proposal comprising information on the site, design, size and other relevant features of the proposal;
- a description of the likely significant effects of the proposal on the environment;
- a description of the features of the proposal and any measures envisaged in order to avoid, prevent or reduce and, if possible, offset likely significant adverse effects on the environment;
- a description of the reasonable alternatives studied by Moray West, which are relevant to the development and its specific characteristics, and an indication of the main reasons for the option chosen, taking into account the effects of the proposal on the environment; and
- a summary of the information provided under paragraphs 1 to 9 of Schedule 4 of The Marine Works (EIA)(Scotland) Regulations 2017 (as amended) and paragraphs 1 to 8 of Schedule 3 of the Marine Works (EIA) Regulations 2007 (as amended)

5.3 Mitigation

5.3.1 Within the EIA report it is important that all mitigating measures are:

- clearly stated;
- accurate;
- assessed for their environmental effects;
- assessed for their effectiveness;
- fully described with regards to their implementation and monitoring, and;
- described in relation to any consents or conditions

5.3.2 The EIA report should contain a mitigation table providing details of all proposed mitigation discussed in the various chapters. Moray West should refer to Appendix I for consultee comments on specific baseline assessment and mitigation.

5.3.3 Where potential environmental impacts have been fully investigated, but found to be of little or no significance, it is sufficient to validate that part of the assessment by stating in the EIA report:

- the work has been undertaken;
- what this has shown i.e. what impact if any has been identified, and
- why it is not significant?

5.4 Design Envelope

5.4.1 Where flexibility in the design envelope is required, this must be defined within the EIA report and the reasons for requiring such flexibility clearly stated. Moray West must also describe the criteria for selecting the worst case, and the most likely, scenario, and the impacts arising from these. The Scottish Ministers will determine the application based on the worst-case scenario. The EIA will reduce the degree of design flexibility required and that the detail will be further refined in a Construction Method Statement ("CMS") to be submitted to the Scottish Ministers, for their approval, before works commence. Please note, however, the information provided in section 10 regarding multi-stage regulatory consent. The CMS will freeze the design of the project and will be reviewed by the Scottish Ministers to ensure that the worst-case scenario described in the EIA report is not exceeded.

5.5 EIA Scope

5.5.1 Matters are not scoped out unless specifically addressed and justified by Moray West and confirmed as being scoped out by the Scottish Ministers. The matters scoped out should be documented and an appropriate justification noted in the EIA report.

6 Interests to be Considered Within the EIA report

6.1 Introduction

6.1.1 The Scoping Report has considered the environment under the following headings and topics;

- Physical Processes and Water Quality;
- Benthic and Intertidal Ecology;
- Fish and Shellfish;
- Marine Mammals;
- Ornithology;
- Commercial Fisheries;
- Shipping and Navigation;
- Military and Civil Aviation;
- Landscape, Seascape and Visual Impact;
- Archaeology and Cultural Heritage;
- Socioeconomic, Tourism and Recreation;
- Other Human Activities; and
- Other Material Issues (additional heading provided by the Scottish Ministers).

6.1.2 The Scoping Report commented on cumulative impacts in each of the above sections. A separate section has been provided in this scoping opinion to address cumulative impacts.

6.1.3 These topics are addressed in turn below. Each section also contains a summary of main points raised by consultees and the Scottish Ministers' opinion on whether the EIA topics should be scoped in or out of further assessment. The consultation responses are contained in Appendix I and Moray West is advised to consider these responses carefully and use the advice and guidance contained within them to inform the EIA report.

6.1.4 The Scottish Ministers are broadly satisfied that the topics identified in the Scoping Report encompass those matters identified in Schedule 4 and Schedule 3 of the EIA Regulations. However, Moray West should provide guidance to how the environmental factors outlined in the EIA Regulations are specifically addressed in the EIA report. Notwithstanding this, the Scottish Ministers consider that the EIA report should sufficiently address the assessment of topics noted below. These are presented as detailed in the Scoping Report.

6.1.5 The Scoping Report presents a series of tables summarising the potential effects and indicates at which stage of the development lifecycle the effect is anticipated. Where an effect is anticipated, this is recorded as 'yes' in the table and where no effect is anticipated 'no' is recorded. The final column of the table indicates whether the effect should be scoped out of EIA assessment (noted as yes) or not (noted as no). The Scottish Ministers have considered these tables and where there is a discrepancy between this summary and the view of the Scottish Ministers and stakeholders the table is replicated. Areas of agreement between Scottish Ministers and Moray West on the potential effect are noted in green and disagreement in red in these tables. A summary of the reasoning for this disagreement is given below each table in Sections 6.2 to 6.4. Where the Scottish Ministers and stakeholders agree with the effects and scope of a topic in the Scoping Report only a narrative is provided.

6.2 Physical Processes and Water Quality

6.2.1 Moray West's summary of the potential effects on physical processes and water quality over the development lifecycle and whether or not the effect should be scoped out of the assessment together with the Scottish Ministers' view are presented in Table 2. The rationale for the Scottish Ministers' views, drawing on the consultation exercise, are noted below the table.

6.2.2 In review of the consultation responses, the Scottish Ministers note the following and request that due consideration is provided by Moray West:

- The applicability of the existing survey data is questioned by SNH and a detailed justification is sought in its use in respect to reviewing 'potentially susceptible sedimentary features'. If it is not possible to justify this approach, then the EIA report should be informed by a new bathymetric survey of the development area which is integrated with benthic survey observations.
- SNH note the potential effect 'disturbance of coastal morphology at the landfall site' does not currently consider the potential for adverse impacts to the hard-rock interest of the Cullen to Stake Ness Coast SSSI. Due consideration is required of the potential effect to the national designation.
- SNH request more clarity on the applicability of the modelling undertaken for Moray East and BOWL to Moray West OfTI in respect to hydrodynamics and sediment transport. SNH have requested a detailed comparison should be presented in support of the final proposed methodologies and recommend that further detailed technical discussions are held.

Table 2 The applicant's summary of the potential effects on physical process and water quality over the development lifecycle (in columns 1 to 3) and whether or not the effect should be scoped out of the assessment (column 4) . Where Scottish Ministers agree, the cell is marked green and where Scottish Ministers disagree, the cell is marked red and a commentary is provided below the table.

Column Number	1	2	3	4
Potential Effect	Construction	Operation	Decommissioning	Scoped out
Increase in suspended sediment concentration as a result of OSP installation activities	Yes	No	Yes	No
Increase in suspended sediment concentrations as a result of export cable installation activities	Yes	No	Yes	No
Disturbance of coastal morphology at the landfall site	Yes	No	Yes	No
Changes to hydrodynamic (wave and tidal) conditions due to the presence of the OSP foundations	No	Yes	No	No
Scour effects due to the presence of the export cables	No	Yes	No	No
Scour effects due to the	No	Yes	No	No

cable protection measures				
Changes to water quality from sediment disturbance	Yes – except for Cullen Bay Bathing Waters	Yes – except for Cullen Bay Bathing Waters	Yes – except for Cullen Bay Bathing Waters	Yes – except for Cullen Bay Bathing Waters
Changes to water quality from chemical release	Yes	Yes	Yes	Yes
Changes to water quality from contaminated sediment	Yes	Yes	Yes	Yes

6.2.3 The Scottish Ministers are in agreement with the rationale put forward in the Scoping Report in relation to 'changes to water quality from sediment disturbance'. However, it is considered that this has been misrepresented in Table 5.1.1 of the Scoping Report as reproduced in Table 2. Potential effects are reported as "Yes – except for Cullen Bay" whereas "No -except for Cullen Bay" would more accurately reflect the narrative and the Scottish Ministers' view. The effect should be scoped in if it is proposed that the cable makes landfall at Cullen Bay.

6.2.4 Moray West have proposed that "changes to water quality from chemical release" can be scoped out at this stage of the assessment. The Scottish Ministers do not agree with this position. The effect should be taken forward to the EIA report where appropriate mitigation measures can be secured. This view is supported by consultation comments from SNH and SEPA. SEPA refers Moray West in their consultation response to pollution prevention guidelines and notes that the EIA process should "systematically identify all aspects of site work that might impact upon the environment, potential pollution risks associated with the proposals and identify the principles of preventative measures and mitigation".

6.2.5 Moray West have further proposed to scope out "changes to water quality from contaminated sediment", however, SNH identified in their consultation response on benthic ecology the requirement to consider the potential for buried contaminant to be released by the works. The Scottish Ministers, therefore, do not agree that "changes to water quality from contaminated sediment" should be scoped out of any further assessment. Evidence should be presented to support the notion that there is 'no significant contamination present within the sediment' as referenced in Section 5.1.4.1 of the Scoping Report.

6.3 Benthic and Intertidal Ecology

6.3.1 Moray West's summary of the potential effects on benthic and intertidal

ecology over the development lifecycle and whether or not the effect should be scoped out of the assessment together with the Scottish Ministers' view are presented in Table 3. The rationale for the Scottish Ministers' views, drawing on the consultation exercise, are noted below the table.

6.3.2 In review of the consultation responses, the Scottish Ministers note the following and request that due consideration is provided by Moray West:

- Comments provided by SNH on benthic ecology are general and will be updated on review of the technical survey report.
- MSS references the potential presence of the anemone *Arachnanthus sarsi* and indicate that data on the animal's distribution and abundance would be useful.
- Smothering effects on benthic species from increased water column suspended sediments as a result of construction activities, particularly dredge activities to prepare the seabed for gravity base structures and cable burial requires consideration in the EIA report.
- SNH have identified the need to consider buried contaminants that may be released.
- Habitat loss should be estimated for the worst-case scenario and potential changes in benthic communities reported.
- Indirect effects on other receptors through changes to benthic communities should be reported.

Table 3 The applicant's summary of the potential effects on benthic and intertidal ecology over the development lifecycle (in column 1 to 3) and whether or not the effect should be scoped out of the assessment (column 4). Where Scottish Ministers agree, the cell is marked green and where Scottish Ministers disagree, the cell is marked red and a commentary is provided below the table.

Column Number	1	2	3	4
Potential Effect	Construction	Operation	Decommissioning	Scoped out
Habitat loss / habitat disturbance	Yes	Yes	Yes	No
Increased suspended sediments/sediment deposition	Yes	No	Yes	No
Noise and Vibration	Yes	No	Yes	No
Accidental release of chemicals from infrastructure installation processes or from vessels	Yes	Yes	Yes	Yes
Scouring of benthic habitats at OSP foundations and cable protection	No	Yes	No	No
Creation of new substrate and habitat	No	Yes	No	No
Change in hydrology	No	Yes	Yes	No

EMF	No	Yes	No	Yes
Seabed sediment heating from subsea cables	No	Yes	No	Yes
Risk of introduction of Marine Invasive Non-Native Species ("MINNS")	Yes	Yes	Yes	No

6.3.3 Moray West propose in the Scoping Report to scope out "Accidental release of chemicals from infrastructure installation processes or from vessels". The Scottish Ministers do not agree this can be scoped out at this stage of the assessment. The effect should be taken forward to the EIA report where appropriate mitigation measures can be secured. This view is supported by comments from SNH and SEPA as noted above in Section 6.2.4.

6.3.4 Moray West have further proposed to scope out "Electromagnetic effects during operation" and "seabed sediment heating from subsea cables during operation" The Scottish Ministers do not agree that these effects can be scoped out at this stage of the assessment. They are required to be taken forward to the EIA report where appropriate mitigation measures can be secured. This view is supported by comments from SNH and MSS. SNH further added that knowledge of benthic communities' is required to provide a comprehensive assessment.

6.4 Fish and Shellfish

6.4.1 Moray West's summary of the potential effects on fish and shellfish over the development lifecycle and whether or not the effect should be scoped out of the assessment together with the Scottish Ministers' view are presented in Table 4. The rationale for the Scottish Ministers' views, drawing on the consultation exercise, are noted below the table.

6.4.2 In review of the consultation responses, the Scottish Ministers note the following and request that due consideration is provided by Moray West:

- SNH advise that potential impacts to migratory fish and freshwater pearl mussels are considered through the EIA rather than a Habitats Regulations Assessment ("HRA").
- MSS comment that the points covered in their advice for the wind farm Scoping Opinion should be mirrored for the OfTI. These include:
    - Updating information on the distribution of the various life stages of diadromous fish species
    - Consideration of further research and monitoring relating to diadromous fish and how this can contribute to the National Research and Monitoring Strategy for Diadromous Fish

    - Consideration of the long range movements of salmon and how the development may have the potential to impact on salmon populations associated with rivers substantial distances from the development site
- Smothering effects on less mobile fish and shellfish species as well as the eggs of species which spawn in the area from increased water column suspended sediments as a result of construction activities, particularly dredge activities to prepare the seabed for gravity base structures and cable burial, requires consideration in the EIA report. Advice from MSS and comments from SFF require that further consideration on this effect on scallops and nephrops is provided. To address this issue a recommended approach is outlined in Section 6.4.3 below.
- SNH have identified the need to consider buried contaminants that may be released.
- Habitat loss should be considered for fish and shellfish and the effects of potential changes in benthic communities reported.
- MSS and SNH have also highlighted that consideration of potential effects of noise should not solely focus on the sound pressure component as acoustic particle motion is reported to be a primary mechanism of disturbance to sensitive receptors. SNH acknowledge that understanding of this is at a very early stage. To address this issue a recommended approach is outlined in Section 6.4.5 below.

6.4.3 For fish and shellfish ecology further work to assess the impact of sediment on scallops and nephrops is recommended. MS-LOT would suggest that the following two pieces of work are undertaken:

- A review of literature on effects of suspended sediments to scallops and nephrops (including different life stages); and
- Physical process modelling of likely spatial extent of suspended sediments from activities of concern.

6.4.4 These could be used to provide a comparison with the spatial extent of the scallop and nephrops fisheries, identified from commercial fisheries data (e.g. VMS data as described by Kafas et al (2012)[1] and found online at Kafas et al (2013)[2]. This would allow an understanding of the spatial extent

[1] Kafas, A., Jones, G., Watret, R., Davies, I., Scott, B., 2012. Representation of the use of marine space by commercial fisheries in marine spatial planning. ICES CM I:23.

[2] Kafas, A., Jones, G., Watret, R., Davies, I., Scott, B., 2013.2009 - 2013 amalgamated VMS intensity layers, GIS Data. Marine Scotland, Scottish Government. doi: 10.7489/1706-1

of effects, if any, to scallops and nephrops and provide a context within which to consider them in the EIA report.

6.4.5 The effects from particle motion, and extent of these effects is currently an area for further development, and there are various initiatives being progressed. MSS considers that the currently available evidence suggests that particle motion could be an important mechanism of effect on fishes and invertebrates. As the 2017 EIA Regulations require the Scottish Ministers to come to a reasoned conclusion on the significant effects on the environment of the development, based on up to date information, this information needs to be taken into account. MSS suggests that Moray West takes the following approach:

- Provide an overview of currently available information on particle motion within the vicinity of noise producing construction and operational activities, including, for example, pile driving, dredging and explosions – both within the water column and the sea bed. This should include consideration of the likely distances at which elevated levels of particle motion may be detected.
- Provide an overview of the published information on sensitive species and potential physiological and behavioural effects of particle motion.
- Give consideration to the potential effects of particle motion on species known to occur around the development site, making use of information on species distribution previously collected and any new information that is now available. Particular attention should be given to potential effects on species of commercial or conservation concern.
- Provide information on opportunities that the Revised Development may present to investigate effects of particle motion on fish and invertebrates.

6.4.6 The Scottish Ministers agree that the potential impact of particle motion should be assessed and suggests that Moray West follows the approach outlined by MSS. Moray West should note that this advice is also relevant to the assessment of the wind farm.

6.4.7 References which may be useful in respect to the effect of particle motion on fish are provided for reference in Appendix V (not necessarily a comprehensive listing).

Table 4. The applicant's summary of the potential effects on fish and shellfish over the development lifecycle (in columns 1 to 3) and whether or not the effect should be scoped out of the assessment (column 4). Where Scottish Ministers agree, the cell is marked green and where Scottish Ministers disagree, the cell is marked red and a commentary is provided below the table.

Column number	1	2	3	4
Potential Effect	Construction	Operation	Decommissioning	Scoped out
Habitat loss / disturbance (particularly spawning and nursery areas) due to installation / maintenance of OSP(s), interconnector cables, export cables and associated protection works.	Yes	Yes	Yes	No
Increase in sediment concentration/smothering due to the installation of OSP(s), interconnector cables, export cables and associated protection works.	Yes	No	Yes	No
Pile driving creating noise and vibration due to Installation of OSP foundations and noise emissions from cable laying.	Yes	No	No	No
Changes to tides, current speeds due to the presence of OSP foundations and subsea cabling with scour protection.	No	Yes	No	Yes
Creation of new substrate materials due to the presence of OSP foundations and subsea cabling with scour protection.	No	Yes	No	No
Operational noise from electrical equipment on OSP(s), vessels and underwater maintenance activities.	No	Yes	No	Yes
Seabed sediment heating from subsea cables (interconnector and export cables).	No	Yes	No	Yes
EMF from subsea cables (interconnector and export cables).	No	Yes	No	Yes

6.4.8 Moray West proposed to scope out operational noise from electrical equipment on the OSP, vessels and underwater maintenance. The Scottish Ministers do not agree that this effect can be scoped out of the assessment. SNH noted in their consultation response to consider this potential impact further at the EIA assessment stage.

6.4.9 Moray West further proposed to scope out electromagnetic effects and seabed sediment heating. The Scottish Ministers do not agree that can be scoped out of the assessment. These effects are required to be taken forward to the EIA report where appropriate mitigation measures can be secured. This view is supported by comments from SNH who reflect this view indicating that the impact pathways are included and assessed in the EIA report. MSS agree there should be consideration of the effect of electromagnetic fields on salmon and sea trout.

6.5 Marine Mammals

6.5.1 The Scottish Ministers agree that the cetacean and pinnipeds species noted in the Scoping Report require consideration and note SNH's direction, to which of these species requires assessment also for a Special Area of Conservation ("SAC"). SNH also highlight minke whale in relation to the Southern Trench area which is being looked at as a potential MPA.

6.5.2 Moray West's proposed noise assessment is required to cover all of the species noted in SNH's consultation response and appropriate cross referencing between the benthic ecology and fish and shellfish sections of the EIA report will ensure that indirect effects are considered.

6.5.3 The Scottish Ministers agree with the effects highlighted in the Scoping Report and the proposal to scope them in and out of the EIA assessment accordingly. The consultation responses received also reflect this view. Moray West should review these responses for further information and in particular the European Protected Species ("EPS") licensing requirements.

6.5.4 Cumulative impacts on marine mammals are specifically referenced by SNH in their consultation response. Careful consideration will be required of the developments noted and the comprehensive list of plans, projects and activities reference in Section 3.5 of the Scoping Report should be agreed prior to undertaking the EIA report.

6.6 Ornithology

6.6.1 The Scottish Ministers refer Moray West to consultation comments provided

by SNH and RSPB on the species relevant to the assessment of the impacts.

6.6.2 The Scottish Ministers agree with the effects highlighted in the Scoping Report and the proposal to scope them in and out of the EIA assessment accordingly. Potential disturbance to waterfowl and waders is considered by SNH as a key ornithological impact and both RSPB and SNH noted the indirect impact on seabirds from potential impact to their prey species. SNH further highlighted the consideration of offshore substation lighting requirements in respect of seabirds would be welcome.

6.6.3 The Scottish Ministers note the requirements as stipulated in the EIA Regulations to consider biodiversity, and in particular species and habitats protected under the Habitats Directive and Wild Birds Directive. This is particularly relevant to the assessment of marine mammals and ornithological interests.

6.7 Commercial Fisheries

6.7.1 The Scottish Minister highlights SFF's consultation response in which it is noted that the shortest and most direct route to landfall is unacceptable to the fishing industry, gravity base structures are likely to result in the worst impact on fishing and decommissioning of assets by leaving them in place is not considered by SFF to be a normal starting point for discussions. Further, SFF's consultation responses references limited data sources being quoted for scallops which should be addressed by Moray West.

6.7.2 The Scottish Ministers advise Moray West to consider the detail of SFF's response and work with SFF, other relevant stakeholders and the Scottish Ministers to agree measures that reduce the impact to the fishing grounds. The Scottish Ministers note that, where possible, agreeing e.g. the Fisheries Management and Mitigation Plan prior to submitting the application will save time post consent.

6.7.3 The Scottish Ministers, in consultation with stakeholders, agree with the potential effects highlighted in the Scoping Report and the scoping of the EIA assessment. However, Moray West are required to clarify the potential for the increased suspended sediment in the water column during operation as noted by SFF and the approach noted above in Section 6.4.3. Moray West should note in SFF's response a requirement for appropriate cross referencing between the benthic ecology and fish and shellfish assessments, in consideration of effects on habitats and (it is assumed) commercial fisheries. The Scottish Ministers further request that due consideration is

provided to the commentary on scallops and nephrops contained in SFF's response.

6.8 Shipping and Navigation

6.8.1 Consultation with relevant navigational stakeholders on the proposed contents of the EIA, as outlined in the Scoping Report, has seen agreement on the effects and proposed scope. Moray West is directed to consultation responses from MCA, NLB, CoS and RYA Scotland. Moray West should note the requirements outlined by the MCA for additional studies and consideration to be given to search and rescue requirements.

6.8.2 The Scottish Ministers recommend Moray West has further discussions with the MCA regarding the content and scope of the Navigational Risk Assessment and take account of the comments already provided for the 'generating infrastructure' as noted in the MCA's consultation response.

6.9 Military and Civil Aviation

6.9.1 The Scottish Ministers have not received consultation responses from the DIO, NATS or the CAA. The Scottish Ministers are in agreement with Moray West that potential effects listed in the Scoping Report in relation to this topic are scoped out. However, due consideration should be applied to the EIA Regulations and the requirements to consider the vulnerability of the works to risks of major accidents and/or disasters. The Scottish Ministers consider the potential mitigation measures listed in the Scoping Report to frame appropriate steps to offset risk but thought will need to be given to how these are communicated and secured through the EIA report.

6.10 Landscape, Seascape and Visual

6.10.1 The Scottish Ministers are in agreement with the consultation responses from SNH, MC and AC on the proposed scope of the SLVIA to support the EIA report. AC noted the generalised nature of the development plans and their advice is subject to change as the scheme's details are finalised. As such the Scottish Ministers support the intention outlined in the Scoping Report, to discuss changes in the scheme's details with relevant stakeholders and would request that these consultations are documented through the EIA report.

6.10.2 Moray West is guided to AC's consultation response for further details on the views/receptors to be assessed, guidance etc. and the requirements of the cumulative impact assessment. MC's consultation response notes a

requirement to detail the extent of nautical or aviation lighting on the platforms.

6.10.3 The Scottish Ministers note AC's requirement to consider oil/gas platforms in the assessment and due consideration should be given to the status of assets and decommissioning schedules (where applicable), seeking confirmation from the decommissioning bodies, where necessary, prior to scoping them out the assessment.

6.11 Archaeology and Cultural Heritage

6.11.1 Stakeholders with a remit for archaeology and cultural heritage agree that effects scoped into the EIA, as noted in the Scoping Report, are appropriate. Moray West is to note the commentary provided by HES on the provision of geophysical data and setting impacts on terrestrial assets. Clarification should be provided to HES on these matters through the EIA assessment process.

6.12 Socioeconomic, Tourism and Recreation

6.12.1 The Scottish Ministers agree with the potential effects that have been scoped in or out as noted in the Scoping Report. The Scottish Ministers draw Moray West's attention to a Marine Scotland publication on licensing guidance for socio-economic applications with a particular case study focus on offshore wind that will be available soon as this may be helpful.

6.13 Other Human Activities

6.13.1 The Scottish Ministers agree with the majority of potential effects that have been scoped in or out as noted in the Scoping Report. The Scottish Ministers note that the nearest marine disposal site, noted in the Scoping Report is at Buckie, 2km from the cable corridor. This requires further consideration to be provided. The Scottish Ministers note that if disposal activities are to coincide with construction there is a potential cumulative impact that will require careful consideration.

6.13.2 Moray West is directed to the consultation response from Beatrice Offshore Windfarm Limited in which it is noted that the MORL OfTI cable corridor intersects BOWL's 'Designated Area'. The response notes a requirement to acknowledge this area as a potential constraint on the development plans along with early engagement on proximity and crossing agreements.

6.14 Other Material Issues

6.14.1 The EIA report should provide information relating to the preferred route options for delivering equipment etc. via the trunk road network. The EIA should also address access issues, particularly those impacting upon the trunk road network where appropriate. TS's consultation response provides reference to guidelines to evaluate whether further assessment is required.

6.15 Cumulative Impacts

6.15.1 Section 3.5 of the Scoping Report notes that a comprehensive list of plans, projects and activities will be created and agreed with the Scottish Ministers from the development categories outlined, prior to the EIA commencing. It is also noted that the assessment will be undertaken with due regard to stated guidance. The Scottish Ministers agree with this approach and highlight the importance of seeking agreement of the relevant plans, projects and activities to be included with both MS-LOT and the relevant planning authorities prior to the EIA commencing.

7 Marine Planning

7.1 Background

7.1.1 Offshore Renewable Energy development should be in accordance with the UK Marine Policy Statement and Scotland's National Marine Plan ("NMP").

7.1.2 **The UK Marine Policy Statement 2011** – The UK Administrations share a common vision of having clean, healthy, safe, productive and biologically diverse oceans and seas. Joint adoption of a UK-wide Marine Policy Statement provides a consistent high-level policy context for the development of marine plans across the UK to achieve this vision. It also sets out the interrelationship between marine and terrestrial planning regimes. It requires that when the Scottish Ministers make decisions that affect, or might affect, the marine area they must do so in accordance with the Statement.

7.1.3 **Scotland's NMP 2015** – Developed in accordance with the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009 (as amended), the NMP provides a comprehensive statutory planning framework for all activities out to 200 nautical miles. This includes policies for the sustainable management of a wide range of marine industries. The Scottish Ministers must make authorization and enforcement decisions, or any other decision that affects the marine environment, in accordance with the NMP.

The NMP sets out a presumption in favour of sustainable development and use of the marine environment when consistent with the policies and objectives of the Plan.

8 Land Use Planning

8.1 Background

8.1.1 The Scottish Government's planning policies are set out in the National Planning Framework, Scottish Planning Policy, Designing Places and Circulars.

8.1.2 The National Planning Framework is the Scottish Government's Strategy for Scotland's long term spatial development.

8.1.3 Scottish Planning Policy ("SPP") is a statement of Scottish Government policy on land use planning and contains:

- The Scottish Government's view of the purpose of planning,the core principles for the operation of the system and the objectives for key parts of the system,
- statutory guidance on sustainable development and planning under Section 3E of the Planning etc. (Scotland) Act 2006,
- concise subject planning policies, including the implications for development planning and development management, and
- The Scottish Government's expectations of the intended outcomes of the planning system.

8.1.4 Other land use planning documents which may be relevant to this proposal include:

- Aberdeenshire Local Development Plan 2016
- Planning Advice Note ("PAN") 2/2011: Archaeology – Planning Process and Scheduled Monument Procedures
- PAN 50: Controlling the Environmental Effects of Surface Mineral Workings
- PAN 51: Planning, Environmental Protection and Regulation
- PAN 1/2011: Planning and Noise
- PAN 2/2011: Planning and Archaeology
- PAN 1/2013: Environmental Impact Assessment
- PAN 60: Planning for Natural Heritage
- PAN 62: Radio Telecommunications
- PAN 68: Design Statements

- PAN 75: Planning for Transport
- PAN 79: Water and Drainage
- Marine Guidance Note ("MGN") 543 (and MGN 372) and MCA Methodology for Assessing the Marine Navigation Safety & Emergency Response Risks of Offshore Renewable Energy Installations (OREI)
- Moray Local Development Plan
- Moray Offshore Renewables – Buckie Harbour Development Plan
- Moray Structure Plan
- Moray Wind Energy Policy Guidance
- Online Planning Advice on Flood Risk, http://www.gov.scot/Resource/0047/00479774.pdf
- Highland Renewable Energy Strategy and Planning Guidelines
- Highland Coastal Development Strategy
- Highland-wide Local Development Plan
- Scottish Planning Policy ("SPP")
- SNH Visual Representation of Wind Farm Guidance (2017)
- National Planning Framework 3

9 General EIA report Issues

9.1 Gaelic Language

9.1.1 Where proposals are located in areas where Gaelic is spoken, applicants are encouraged to adopt best practice by publicising the project details in both English and Gaelic.

9.2 Application and EIA report

9.2.1 A gap analysis template is attached at Appendix IV to record the environmental concerns identified during the scoping process. This template should be completed and used to inform the preparation of the EIA report. Please note that the EIA report must contain all of the information specified in the scoping opinion. On submission of the application and supporting EIA report, the Scottish Ministers, via a gatecheck process, will review the template in conjunction with the EIA report to ensure this has been completed. The gatecheck will also include an EIA audit. If information requested at scoping stage has not been provided in the EIA report then Moray West will be asked to provide that information before the application will be accepted.

9.2.2 Please note all aspects of this scoping opinion should be considered when preparing a formal application to reduce the need to submit additional information in support of the application. The consultee comments presented

in this opinion are designed to offer an opportunity to consider all material issues relating to the development proposals.

9.2.3 The exact nature of the work that is needed to inform the EIA may vary depending on the design choices. The EIA must address this uncertainty so that there is a clear explanation of the potential impact of each of the different scenarios. It should be noted that any changes produced after the EIA report is submitted may require further environmental assessment and public consultation.

9.2.4 In assessing the quality and suitability of applications, the Scottish Ministers will use the gap analysis and this scoping opinion in the assessment of the application. In addition to scoping, applications are required to go through a gate check process. See Appendix III for further information on this. In the event of a submitted application not containing essential information, the Scottish Ministers reserve the right not to accept the application. Applicants are advised not to publicise applications in the local or national press, until their application has been accepted by the Scottish Ministers.

10 Multi-Stage Regulatory Consent

10.1.1 The Marine Works (EIA) (Scotland) Regulations 2017 (as amended) contain provisions regulating the assessment of environmental impacts. A multi-stage consent process arises where a consent procedure comprises more than one stage, one stage involving a principal decision and one or more other stages involving an implementing decision(s) within the parameters set by the principal decision. While the effects which a project may have on the environment must be identified and assessed at the time of the procedure relating to the principal decision if those effects are not identified or identifiable at the time of the principle decision, assessment must be undertaken at the subsequent stage.

10.1.2 The definition in The Marine Works (EIA) (Scotland) Regulations 2017 (as amended) is as follows: “application for multi-stage regulatory approval means an application for approval, consent or agreement required by a condition included in a regulatory approval where (in terms of the condition) that approval, consent or agreement must be obtained from the Scottish Ministers before all or part of the works permitted by the regulatory approval may be begun”.

10.1.3 A Marine Licence, if granted, by the Scottish Ministers for the regulated activities of the Moray West OfTI is likely to have several conditions attached requiring approvals etc. which fall under this definition, for example the

approval of a Construction Method Statement.

10.1.4 When making an application for multi-stage consent Moray West must satisfy the Scottish Ministers that no significant effects have been identified in addition to those already assessed in the EIA report. In doing so, Moray West must account for current (meaning at the time of the multi-stage application) knowledge and methods of assessment which address the likely significant effects of the regulated activities on the environment so to enable the Scottish Ministers to reach a reasoned conclusion which is up to date.

10.1.5 If during the consideration of information provided in support of an application for multi-stage consent the Scottish Ministers consider that the regulated activities may have significant environmental effects which have not previously been identified in the EIA report (perhaps due to revised construction methods or updated survey information), then information on such effects and their impacts will be required. This information to be dealt with as additional information under the EIA Regulations, and procedures for consultation, public participation, public notice and decision notice of additional information will apply.

11 Judicial review

11.1.1 All decisions may be subject to judicial review. A judicial review statement would be made available to the public under these circumstances.

Signed

Tracy McCollin

30 August 2017

Authorised by the Scottish Ministers to sign on that behalf.

Appendix I: Consultee Responses

Aberdeenshire Council

I refer to your request for a consultation response for the above EIA Scoping request received on 2 June 2017.

Having reviewed the EIA Scoping Report and its contents, I can advise that the primary areas of interest for Aberdeenshire Council relate to Archaeology and Cultural Heritage, Biological Environment and Landscape, Seascape and Visual Impacts. Having reviewed the Scoping Report and consulted with relevant internal colleagues, I can confirm that Aberdeenshire Council are broadly content and satisfied with the scope and approach taken towards the preparation of the EIA Report. With regard to specific topics, I can advise that:

- Archaeology and Cultural Heritage: Aberdeenshire Council Archaeology Service agree with the identified potential effects as detailed in Table 7.5.3 on archaeological and cultural heritage assets, and for these three elements to be scoped in for further assessment within the EIA. There are no further considerations of potential or known impacts on archaeology and cultural heritage that require further assessment. There are no further recommendations for mitigation requirements or assessments other than those identified within Section 7.5.6 “Potential Mitigation Measures”.
- Biological Environment: The proposed range of surveys contained within the Scoping Report appears comprehensive and there are no comments to make on the issues that have been retained or scoped out of the EIA process.
- Landscape, Seascape and Visual: The scope and nature of the SLVIA including Baseline Data Sources, inclusion of BOWL as an operational development as well as the range of viewpoints initially selected are generally considered to be appropriate, with some additional comments. I would draw attention to Table 7.4.1 and would advise that the Aberdeenshire Local Development Plan 2012 has now been superseded by the Aberdeenshire Local Development Plan 2017 and so details and associated reference points throughout this chapter should be updated accordingly. Aberdeenshire Council’s Environment Planner for Landscape has also advised that graphical based information should be provided within any finalised EIA Report illustrating the visual impacts of the infrastructure proposed (fully cross referenced with the wider development), including ZTV, panoramic and photomontage images in line with relevant guidance. It is also requested that flexibility is allowed for in terms of viewpoint selection to account for the evolution of the scheme and changing requirements which may arise as the project parameters become better defined. Further specific information on the visual extent of the Offshore Substation Platforms would be welcomed at this stage in order to help inform the wider assessment process and viewpoint

selection stages, to this end further discussion as outlined in paragraph 7.4.1 is considered to be appropriate and necessary. Cumulative Impact Assessments may also require to take account of other large scale seascape infrastructure such as oil/gas platforms or similar along with other wind energy schemes. Clarification should also be sought on the status of the Beatrice Demonstrator Turbines and timelines for their removal.

There are no additional matters aside from those raised above which we would highlight as being necessary for inclusion within the EIA Report and we are in agreement with the conclusions of the report in terms of matters to be "scoped in" in terms of Aberdeenshire Council's interests.

Full internal consultation comments will be forwarded as an appendix to this formal response.

Aberdeenshire Council – Appendix – Archaeology

Thank you for consulting me with regard to the above Scoping Opinion request and how it relates to impacts on archaeology. Having reviewed the documentation, including Chapter 7.5 'Archaeology and Cultural Heritage' of the submitted Scoping Report, I can make the following comments:

1) I agree with the identified potential effects as detailed in Table 7.5.3 on archaeological and cultural heritage assets, and for these three elements to be scoped in for further assessment within the EIA.
2) There are no further considerations of potential or known impacts on archaeology and cultural heritage from my perspective that require further assessment.
3) I have no further recommendations for mitigation requirements or assessments other than those identified within Section 7.5.6 'Potential Mitigation Measures'.

Taking all of the above into consideration I can confirm that I have no additional requirements for the Scoping Request, and that those already scoped in for further assessment are appropriate.

Aberdeenshire Council – Appendix – Environment

Having looked through the scoping report the proposed range of surveys appears comprehensive and I have no comments to make on the issues that have been retained or scoped out of the EIA process.

Aberdeenshire Council – Appendix – Landscape

Introduction:

These comments are written primarily in relation to Section 7.4, the Seascape/Landscape and Visual section of the Moray Offshore Windfarm (West) Ltd, Moray West Offshore Transmission Infrastructure most up to date Scoping Report.

The scheme this scoping process is understood to be for is a proposed one or two offshore substation platforms from which an undersea cable line will be established running to a coastal site located between Cullen Bay and Sandend Bay.

In addition to the agreed view points of the SLVIA assessment of the main offshore MORL wind energy development, within which the proposed offshore substation platforms will be located in, the applicant identifies that an additional viewpoint will be identified to be located between Findochty and Portsoy to illustrate the location of where the Offshore Transmission Infrastructure cable line approaches landfall.

In term of the information supplied for an application for Offshore Transmission Infrastructure, a Landscape, Seascape and Visual Impact Assessment should be carried out independently of previous or other Seascape, Landscape and Visual Impact Assessment work carried out for any other element of the MORL project in terms of the assessment process and related visualisations etc.

The EIA process in principle is intended to be fundamental to the detailed scheme layout and designing process and on that basis the SLVIA should contribute from the outset to the decision making process for locating and specifying scheme infrastructure etc. to test and minimise any predicted adverse impact on the seascape/landscape visual resource and affected environment.

In terms of information provided by the applicant for the proposed elements of the offshore transmission infrastructure, at this stage information is currently more general than specific. One or two offshore substation platforms are referred to with the cable line intended to come ashore somewhere between Cullen and Sandend. This consultation response is based on this level of scheme information. Advice relating to the scoping request for seascape/landscape and visual impact issues and the above proposed scheme may alter in future depending on the finalised specification of the offshore substation platforms, their scale , finishes and locations as well as the exact cable route, and particularly where and how it’s intended to bring it ashore.

Seascape/Landscape and Visual Impact Assessment:

For a full planning application ES, the applicant needs to carry out a seascape landscape and visual impact assessment which should be produced in accordance with the Guidelines for Landscape and Visual Impact Assessment (third edition), and the most up to date guidance on (seascape) landscape and visual impact assessment of wind farms from SNH, and any other relevant organisation.

In the seascape/landscape and visual impact assessment section of an environmental statement, information should be primarily graphic with decisions on the locations of appropriate viewpoints and receptors based on ZTV mapped information created in relation to the offshore substation platforms etc.

In terms of viewpoint selection, it is important that a degree of flexibility remains with identifying particular receptors. Certain views/receptors only become apparent as being important, as the applicant further specifies the details of the scheme and the determination process of the application proceeds. Because of the location of this proposed development and the possible extent of potential landscape and visual affects, in relation to a number of potentially sensitive visual receptors, and other implemented and potential wind energy developments in the SLVIA study area, it is important that all parties to a future application take a flexible approach to producing further landscape and visual impact assessment information, should that be identified as required during an application for consent determining process.

In terms of design best practice the character of the offshore substation platforms should be designed to be similar to that of the main wind energy development and also positively assimilate into the valued seascape and the landscape character context of the setting of the proposed development.

Cumulative impact:

The applicant needs to fully address the issue of cumulative visual impact as part of a seascape landscape and visual impact assessment particularly in relation to the location and design of the offshore substation platforms. All consented and built wind energy developments in the agreed study area of the offshore substation platforms should be fully taken into consideration in this process, as well as any wind energy proposals at planning and application stage in the agreed SLVIA study area. A cumulative seascape/landscape visual impact assessment should also take into consideration any other large scale fixed artificial infrastructure(s) that could/can be seen in combination with the planned substation platforms such as oil/gas platforms.

In terms of the cumulative seascape/landscape visual impact assessment process

the visual relationship with onshore as well as off shore wind energy developments should also be taken into consideration.
The cumulative seascape/landscape and visual impact assessment should be primarily graphic based, with ZTV information, panoramas, photomontages and wireline models. An assessment of cumulative visual and landscape affects should be supplied. Where possible viewpoints used for other wind energy developments, which can be seen in combination with the proposed development site, should be adopted. The cumulative impact assessment should be carried out in accordance with SNH Cumulative Effect of Windfarms Guidance and other relevant guidance and best practice. The required extent and detail of the cumulative assessment, including of the cumulative assessment base plan should be confirmed with SNH.

Conclusion:

For this stage in the scoping process of the Seascape, Landscape and Visual Impact element of an EIA, ZTV information should be provided of the predicted visual extent of the proposed offshore substation platforms to identify the potential visual affects of these structures, and allow an informed decision to be made on the identification of viewpoints/visual receptors for the seascape/landscape visual impact assessment element of an EIA at this stage. Even if the final specification for such platforms is yet to be finalised the work could begin using standard/average dimensions with resulting information qualified to indicate the resulting ZTV is based on interim, not finalised information.

In terms of providing a reasonably comprehensible Environmental Statement for this element of the scheme, it is recommended that the applicant produce a single up to date comprehensive volume to cover this specific part of the project that fully cross references with other parts of the MORL project.

Beatrice Offshore Windfarm Ltd

BOWL have reviewed the Moray West OfTI scoping report and provide the following comments in response.

Subsea Cables and Pipelines

It should be noted that on 31 March 2016 and 1 April 2016, BOWL and The Crown Estate Commissioners signed a sea bed lease for the sub-station site at the Beatrice offshore wind farm. The lease allows for the installation of two export cables within the export cable route corridor (referred to in the lease as the ‘Designated Area’). The Moray West offshore export cable corridor, indicated in green diagonal striped

on Figure 7.2.1: Navigational Features, in the scoping report appears to intersect with the BOWL Designated Area. The lease requires The Crown Estate to obtain BOWL's consent (which shall not be unreasonably withheld or delayed) before a lease, licence, or consent can be granted for the construction of any works within the Designated Area.

BOWL request that MORL acknowledged the BOWL Designated Area as a potential constraint on any plans submitted as part of a consent application. Furthermore BOWL encourages early engagement regarding any proximity and crossing agreements.

Timescales and consideration of BOWL development

How the Beatrice offshore wind farm is considered in an environmental assessment is crucial and should be given careful consideration. By the time the Moray West OfTI consent application is submitted BOWL will have constructed a significant amount of the Beatrice offshore wind farm and at the likely point of consent will have substantially completed the wind farm, see the Moray West OfTI anticipated development timescales in the table below (extract from figure 2.2.1). BOWL anticipates that the Beatrice offshore wind farm will be fully commissioned by Q2 2019. With this in mind it would appear appropriate to treat the Beatrice offshore wind farm as part of the baseline for the Moray West OfTI environmental assessment. As a minimum, the use of Consent Plans that BOWL have submitted as part of their discharge of conditions should be considered as they will provide a more up to date picture of BOWL's development than the BOWL Environmental Statement.

Activity	**Proposed Date**
Moray West OfTI consent application submitted	Q1 2018
Consent granted	Q4 2018
Financial close	Q3 2020
FEED	Q4 2018 – Q3 2020
Foundation and substructure installation (includes the WTG foundations & substructures)	Q3 2022 – Q3 2023
OSP installation	Q2 2023 – Q3 2023
Export cable installation	Q3 2023 – Q1 2024
1st Generation	Q1 2024
Full generation	Q4 2024

Environmental surveys and data use

MORL propose utilising some environmental data already available and undertaking some additional surveys. As with the export cable interactions early engagement

with BOWL is recommended to ensure that the full benefit of work already completed or being undertaken can be cost effectively and methodologically best developed. A list of proposed use of BOWL data by MORL is provided in Annex 1 to this letter.

BOWL would welcome the opportunity to further discuss some of the interactions and points raised with MORL to ensure that benefits for offshore wind in the Moray Firth are maximised.

Annex 1 – BOWL Data Use

The Moray West OfTI scoping report references use of BOWL data in the areas set out in the table below.

Section	BOWL Data Reference
5.1 Physical Processes and Water Quality	1. CMACS (2012). Beatrice Offshore Wind Farm Cable Route Benthic Technical Report. Report to BOWL February 2012.
6.1 Benthic and Intertidal Ecology	1. Pre-construction Benthic Sampling and DDV Survey – Scope of Works 2. CMACS (2012). Beatrice Offshore Wind Farm Cable Route Benthic Technical Report. Report to BOWL February 2012.
6.2 Biological Environment Fish and Shellfish Ecology	1. Pre-construction Baseline Sandeel Survey – Technical Report. March 2014. 2. Pre-construction Baseline Herring Larval Survey – Technical Report. December 2014. 3. Pre-construction Baseline Cod Spawning Survey – Technical Report. March 2015. 4. Pre-construction Baseline Herring Larval Survey – Technical Report. January 2016. 5. Brown and May Marine Ltd. (2011). Fish and Shellfish Ecology Technical Report.

Historic Environment Scotland

Thank you for your consultation which we received on 02 June 2017 about the above scoping report. We have reviewed the details in terms of our historic environment interests. This covers world heritage sites, scheduled monuments and their settings, category A-listed buildings and their settings, inventory gardens and designed landscapes (GDLs), inventory battlefields and historic marine protected areas

(HMPAs). In this case, our advice also includes matters relating to marine archaeology outwith the scope of the terrestrial planning system.

The relevant local authorities' archaeological and cultural heritage advisors will also be able to offer advice on the scope of the cultural heritage assessment. This may include heritage assets not covered by our interests, such as unscheduled archaeology, and category B- and C-listed buildings.

Proposed Development

I understand that the proposed development comprises the Offshore Transmission Infrastructure (OfTI) for the Moray West offshore wind farm. The OfTI will consist of either 1 or 2 Offshore Substation Platforms (OSPs), an interconnector cable running between the OSPs (if more than 1 is required), offshore export HVAC cables and works at the landfall site.

The current consultation relates to the OfTI. A consultation for the wind farm infrastructure itself has already been scoped and a separate scoping consultation is currently being undertaken for the Onshore Transmission Infrastructure.

Scope of assessment

We note that the Environmental Impact Assessment for the OfTI intends to use the Design Envelope or Rochdale Envelope approach to assess the worst case/ most adverse scenario for the potential range of options proposed for this aspect of the development. We are content that this is an appropriate approach to the assessment.

<u>Marine Assets</u>

There are no HMPAs in the vicinity of the site or in the wider area. However, we welcome that the assessment will consider direct disturbance, contamination and loss to historic environment assets and de-stabilisation of sites through changed sedimentary regimes.

We welcome the identification of the charted wrecks, reported losses and other sites of potential archaeological value within the OfTI area that have been identified at this stage. We consider the identified methodologies for these potential impacts to be adequate. We consider that the mitigation measures proposed are likely to be adequate taking into account the information below.

The scoping report identifies that further geophysical survey, to provide data for the area of the wind farm site not already covered and the export cable route, will be undertaken post-consent. Best practice would allow for the surveys to be completed prior to a design being finalised and consent being granted and this would ensure that any potential assets of national importance are avoided. By proposing to undertake further survey work post-consent, there is a risk to the project of reaching an impasse where you can neither excavate nor avoid a significant historic environment asset, rendering your cable route or site unusable.

Terrestrial Assets

Given that the exact locations of the offshore export cable landing point has not yet been identified it is not yet clear whether there will be any direct impacts on terrestrial assets within our remit. The potential for direct impacts should therefore be considered within the assessment.

We welcome that the potential impacts to the setting of terrestrial assets within our remit will be identified and that a ZTV analysis will be used to identify assets for assessment. We also welcome that our up to date Managing Change guidance note on Setting has been referenced and we strongly recommend its use in any setting impact assessment.

We consider the identified methodologies for these potential impacts to be adequate, however, we note that the baseline data for this section of the report refers only to marine archaeological receptors and there is no mention of any baseline data for terrestrial historic environment assets which may receive setting impacts. While we are content that there may be some crossover with the SLVIA section of the assessment, given that only Inventory GDLs are identified in the baseline data for that section it will be important to ensure that all setting impacts are addressed properly and that no historic environment assets are missed out of the assessment. Up to date information on all designated historic environment assets can be accessed from our website here.

We hope this is helpful. Please contact us if you have any questions about this response.

Maritime & Coastguard Agency

Thank you for your email dated 2 June 2017 requesting our response on the proposed marine licence for the above project. I have now had an opportunity to review the scoping report provided by Moray Offshore Windfarm (West) Limited for the transmission infrastructure (1 or 2 Offshore Substation Platforms and export cable route) and I would comment as follows:

The intended approach to the assessment of the potential effects outlined in Section 7.2.7.2 is acceptable. A Navigational Risk Assessment will need to be submitted in accordance with MGN 543 (and MGN 372) and the MCA Methodology for Assessing the Marine Navigation Safety & Emergency Response Risks of Offshore Renewable Energy Installations (OREI). We would be content for this to be combined with the NRA for the generating infrastructure, however if they are to be separated the use of the proposed additional 28 days traffic data remains acceptable.

Particular attention should be paid to cabling routes and where appropriate burial

depth for which a Burial Protection Index study should be completed and, subject to the traffic volumes, an anchor penetration study may be necessary. If cable protection are required e.g. rock bags, concrete mattresses, the MCA would be willing to accept a 5% reduction in surrounding depths referenced to Chart Datum. If it is assessed that depths are likely to be reduced by more than 5% we would welcome discussions with the applicant.

Although layout plans will be decided at a much later stage, due consideration must be given for straight lines of orientation that allow a continuous passage of vessels and/or SAR helicopters through the site. The proposed Offshore Substation Platform(s) must be located in line with the turbine row or column.

Consideration will need to be given to the implications of the site size and location on SAR resources and Emergency Response Co-operation Plans (ERCOP) for both construction and operation phases.

It should not be assumed Safety Zones will be automatically applied. These are subject to successful applications made to BEIS.

I hope you find this information useful.

Moray Council

I refer to the above request and would confirm that Moray Council are content with the content of the Scoping Report subject to the following clarification.

In terms of the impact on seascape/landscape and related visual impact assessment, whilst noting the scale of the proposed Offshore Substation Platforms, it is presumed that appropriate photomontages will be prepared in support of the EIA Report from the Moray coastline. The Report should also make clear the extent of any nautical or aviation lighting requirement on the platforms and how they might be observed from the coast.

Northern Lighthouse Board

Thank you for your correspondence dated 02 June 2017 requesting a response to the submission by **Moray Offshore Wind Farm (West) Limited** in which they seek confirmation that Northern Lighthouse Board is satisfied with the topics covered in preparation of an Environmental Impact Assessment submission for the revised development layout and associated infrastructure at the Moray (West) OWF.

We would advise that the Northern Lighthouse Board are content with the topics to be included in the EIA and those sections requiring updated data. NLB are likewise content with the extension of operational life to 50 years at this site.

Royal Society for the Protection of Birds Scotland

RSPB Scotland welcomes this opportunity to comment on the scoping report for the above noted proposed offshore transmission infrastructure.

As indicated in the scoping report there exist a number of Special Protection Areas (SPAs), including the Moray Firth proposed SPA, in addition to nationally designated sites. A robust Environmental Impact Assessment and Habitats Regulations Appraisal must comprehensively assess the projects impacts (direct and indirect) on the internationally important numbers of seabirds, sea ducks, divers and other water birds found in this region.

We recommend the assessment specifically focuses on the impacts to relevant habitats, their structure, function and the supporting processes of these habitats that may result from the construction phase, including the trenching of cable infrastructure. This will include considering the implications of these impacts on the ability of the habitats, both within and beyond the protected areas, to support the qualifying species. To do this, both the type and extent of impact and the distribution, extent and condition of the supporting habitat should be presented.

We are keen to offer our support where clarification or further discussion is required.

Royal Yachting Association Scotland

I have read the relevant parts of the scoping report on behalf of RYA Scotland. For recreational vessels, the presence of offshore substation platforms should not increase any risk associated with wind turbine generators. Cable laying operations are covered by the International Rules for the Prevention of Collisions at Sea with which all recreational sailors are expected to be familiar. Cable landfalls rarely cause issues for recreational craft although we would expect to be consulted were no anchoring zones be proposed in waters less than 10 m deep.

Comments made in relation to the Moray East scoping document are thus equally applicable here.

Table 7.2.1 should also include the revised UK Coastal Atlas of Recreational Boating which is now based on AIS transmissions as about 20% of recreational craft transmit

such signals and experience has shown that the routes of these vessels are representative of those of all recreational craft except close inshore and any other places where small local boats may go.

I welcome the commitment in section 7.2.6 to send information about the scheme for inclusion in the Clyde Cruising Club Sailing Directions. However, the scheme lies on the boundary between existing Sailing Directions and a new volume based on the old Forth Yacht Clubs Association pilot handbook which is currently in preparation. I have contacted the publishers seeking clarification but some decisions have still to be made. I will be happy to forward relevant information to whoever will be including this area of sea. Note that the Sailing Directions books only include details of renewable schemes where there is a danger to navigation or indeed where the structures can assist navigation.

The best source of information on recreational activity mentioned in Table 7.6.1 is the Scottish Marine Recreation and Tourism Survey carried out in 2015 (http://www.gov.scot/Topics/marine/seamanagement/national/RecandTourism).

Scottish Environmental Protection Agency

Thank you for your email consultation to SEPA dated 2 June 2017 requesting a scoping opinion for the above development proposal.

Advice for Marine Scotland

1.1 We note that this Scoping Opinion is for the offshore transmission infrastructure only of the Moray Offshore Windfarm (West). We confirm we have also received a Scoping Report for the Onshore Transmission Infrastructure and will comment on this separately.

1.2 We note it is currently the applicant's intention to produce a single Environmental Report (ER) to capture the outcomes of the Environmental Impact Assessment (EIA) for both the Moray West Offshore Wind Farm and the associated Offshore Transmission Infrastructure and that a separate ER will be produced for the associated Onshore Transmission Infrastructure in support of a planning application to the relevant Planning Authority.

1.3 However, as there is a geographical overlap between the various consenting regimes (i.e. the area between Mean Low Water (MLW) and Mean High Water (MHW), we would encourage the applicant to consider producing a single ES, which covers all aspects of the proposed development. This will enable a full assessment of the potential effects of the development as a whole within this overlap, rather than assessing certain details of the development individually. We would welcome the possibility of Marine Scotland taking the lead in coordinating/overseeing the

submission of all documents and encourage the applicant to submit all supporting documents required for the planning application at the same time as the Marine Licence application.

1.4 As we only now comment on proposals for works above MLWS which fall under the appropriate Town and Country Planning (Scotland) Act, please refer to our standing advice on marine consultations within guidance document SEPA standing advice for The Department of Energy and Climate Change and Marine Scotland on marine consultations.

1.5 If, after consulting this guidance, you consider that a particular part of this proposal is novel or raises a particular environmental issue relevant to our interests which is not addressed by the standing advice, then we would welcome the opportunity to be re-consulted. Please note that the site specific issue on which you are seeking our advice must be clearly indicated in the body of your consultation request.

1.6 The Scoping Report invites consultees to consider four questions:

<u>Are there any baseline data sources available that could be used to inform the Environmental Impact Assessment?</u>

We note and welcome that our Water Body data collated in support of the Water Framework Directive has been referenced in the report. This data is available on the Scottish Environment. A summary table of the ‘overall status’ and an indication of whether there has been ‘change’ or ‘no change’ in status in the last year is provided for each water body in the search results, below the spotfire map. Classification results are updated annually (following any necessary verification requiring to be completed post-publication).If the applicant requires further information for a water body which has undergone a change in status in the last year they can request verification of the change by emailing the RBMP Unit (rbmp@sepa.org.uk.) entitling your email “Urgent request for data verification”

<u>Have all potential effects resulting from the Offshore Transmission Infrastructure been identified for each of the Environmental Impact Assessment topics within this Scoping Report?</u>

In relation to our interests we agree with the effects that have been scoped in and out. In particular we welcome the potential effect of the possible introduction of marine non-native species being identified.

<u>Do you agree with the effects to be scoped in, and out, of the Environmental Impact Assessment?</u>

In relation to our interests we agree with the effects that have been scoped in and out.

<u>For those effects scoped in, do you agree that the methods described are sufficient to inform a robust impact assessment?</u>

In relation to our interests we agree that the methods described are sufficient to inform a robust impact assessment.

One of SEPA's key interests in relation to major developments is pollution prevention measures during the periods of construction, operation, maintenance, demolition and restoration. We advise that the applicant should, through the EIA process, to systematically identify all aspects of site work that might impact upon the environment, potential pollution risks associated with the proposals and identify the principles of preventative measures and mitigation. This will establish a robust environmental management process for the development. A draft Schedule of Mitigation should be produced as part of this process. This should cover all the environmental sensitivities, pollution prevention and mitigation measures identified to avoid or minimise environmental effects. Please refer to the Pollution prevention guidelines.

An Environmental Management Plan is a key management tool to implement the Schedule of Mitigation and welcome the fact that one will be produced prior to construction. We recommend that the principles of this document are set out in the ES outlining how the draft Schedule of Mitigation will be implemented. This document should form the basis of the more detailed site specific Environmental Management Plan which, along with detailed method statements, may be required by condition.

Regulatory advice for the applicant

1.7 Details of regulatory requirements and good practice advice for the applicant can be found on the Regulations section of our website. If you are unable to find the advice you need for a specific regulatory matter, please contact a member of the regulations team in your local SEPA office at: 28 Perimeter Road, Pinefield, Elgin, IV30 6AF Tel: 01343 547663

Scottish Fishermen's Federation

The Scottish Fishermen's Federation (SFF) is pleased to respond to this application on behalf of The 500 plus fishing vessels in membership of its nine constituent associations:- the Anglo Scottish Fishermen's Association, the Clyde Fishermen's Association, the Fife Fishermen's Association, the Fishing Vessel Agents and Owners Association (Scotland) Ltd, the Mallaig and North-West Fishermen's Association, the Orkney Fisheries Association, the Scottish Pelagic Fishermen's Association Ltd, the Scottish White Fish Producers Association Ltd and the Shetland Fishermen's Association.

The first comment the SFF feels necessary to make is that given the acknowledgement in 1.2.1 that the project is all about creating value for EDPR's stakeholders and shareholders. This must not be at the expense of the original stakeholders in the marine environment, FISHERMEN. It is unfortunate that the

chapter continues on to justify itself by quoting from Scotland's National Marine Plan without noting General Planning principles 1,4 and 17.

In chapter 2 the stark statement that "the offshore export cable with take the shortest and most direct route to landfall" is unacceptable to the fishing industry, the route must be engineered to provide the least impact on fishing grounds.

In terms of the options for OSP foundations and substructures it is quite clear that the GBS is likely to have the worst impact on fishing during operation and be the most problematic when it comes to decommissioning and SFF would welcome these being ruled out, but the other options will also have negative impacts on the seabed they are installed on.

Regarding the interconnector cables in 2.2.2.3 the SFF preference is burial, and recent studies on protection are clear that protection by rock does not need the same depth as burial, other options must consider the area they are to be used in before deciding which to use. The same comments refer to the expert cable.

Comments following on here, are relevant to 3 sections (Benthos, Fish and Shellfish and commercial fisheries, as necessary). Regarding chapter 6.1 on Benthos, the SFF would certainly expect Habitat loss/disturbance, the increase in sediments (suspended and deposited), scarring effects and creation of substrate/habitats to be assessed for both OSP and OCTI.

The SFF would take issue with the statement on decommissioning "leaving all in place" as not what is required, for SFF the normal starting point for this discussion is to return the seabed to its original state.

The SFF notes that in the data sources listed for the Fish and Shellfish scoping, despite scallops being a major species in the area there is no specific data source listed. Surveys have been done for sand eels, herring and cod, but none for scallops and nephrops, which omission must be addressed in the scoping report.

As with the previous chapter the SFF would expect habitat loss/disturbance and creation scoped in, both suspended and deposited sediments and scarring effects both during installation and operation.

The historical baseline for scallops needs to be as long as feasible since the fishery is very cyclical and any given snapshot could miss the peaks of the fishery, which could be anything from 5 – 10 years apart.

The SFF would agree with the chart 7.1.3 listing the impacts to be scoped in, but believe the project is already down playing most of them and needs to give serious consideration to the issue of loss of access and displacement of fishing. The recent Crown Estate report on these phenomena in the Irish Sea shows that fishing still had not resumed 2 years after construction of a windfarm. Embedded mitigation for all these factors is only the start of the story and assessment should also include the effects of construction vessel movements outside the site on the local fishing vessels.

The SFF would expect the project to validate its data baseline with a cross-section of industry, for which the membership of the Commercial Fisheries Working Group would be ideal. As scallop fishing is a widely dispersed, mobile nomadic activity the cumulative impact of all relevant projects across UK waters needs to be considered.

Scottish Natural Heritage

Thank you for your consultation of the 02 June 2017 requesting our advice on the natural heritage interests to be addressed in the Environmental Impact Assessment (EIA) report for the Moray West Offshore Transmission Infrastructure (OfTI) proposal for the Moray West Ltd Offshore Wind farm.

Habitats Regulations Appraisal

We note the intention (1.5.2.2) to consult separately on the Habitats Regulations Appraisal (HRA) screening report and as such the Scoping report intentionally makes only limited reference to Habitats Regulations and Offshore Habitats Regulations requirements. This appears to be duplication in effort as it would be more helpful to consider these aspects in conjunction with the EIA scoping stage. We provide advice on the likely short list of SPA and SAC sites and their qualifying features and narrative on the relevant potential effect to be considered. We would encourage all parties to consider a more efficient co-ordinated approach to EIA and HRA requirements.

Scoping out of potential effects

We understand the desire to scope out certain potential effects; however, we suggest that in many instances this is, in our view, too premature. A potential impact pathway can only be scoped out where there is no effect or where mitigation is not required to reduce the significance of the potential effect. Where mitigation is required to reduce an effect to an acceptable level, then to our mind this needs to be carried through from Scoping to Application stage. The EIA report needs to outline the assessment of effects and to present (confirm) the mitigation to be adopted to avoid or reduce effects, which can then inform any consent conditions should the development be consented.

SNH Advice

Our advice relates to the natural heritage interests to be addressed in the Moray West Offshore Transmission Infrastructure Environmental Impact Assessment Report. We provide advice on the following aspects in **Appendix A:**

1. Hydrodynamic Processes & Coastal Geomorphology
2. Benthic Ecology
3. Fish and Shellfish of Conservation Concern
4. Marine Mammals
5. Ornithology
6. Landscape, Seascape and Visual Impact Assessment

We hope these comments are helpful. If further information or advice is required please contact me in the first instance: karen.taylor@snh.gov.uk or 01546 603611.

APPENDIX A

MORAY WEST OFFSHORE TRANSMISSIONS INFRASTRUCTURE: SNH ADVICE

1. **Hydrodynamic Processes & Coastal Geomorphology**

The Scoping report indicates assessment will be informed by previous surveys of the export corridors for the Moray East and BOWL developments (There is also the Caithness Moray SHET Transmission Project that may be able to provide information). However, it's not clear how ‘potentially susceptible sedimentary features’ will be ‘reviewed’ (Table 5.1.2) / assessed without recording detailed bathymetry of the area of transmission infrastructure. We request that the developer explores whether existing survey data is applicable / informative to this project, taking account of achievable survey resolution and provides a more detailed justification for this approach. If it is not possible to justify the above approach, then we recommend that the EIA report should be informed by new bathymetric survey of the development area, to at least the same resolution as the previous surveys, and appropriately integrated with the benthic survey observations.

We agree with the potential effects scoped in and the proposed assessment methods, subject to the following points:

- There is potential for landfall works to adversely impact the nationally important hard-rock (Dalradian) interest of Cullen to Stake Ness Coast SSSI, through physical damage and/or by obscuring outcrops (except in relatively small areas of sandy bays where this interest does not exist). The greatest potential impact would be through trenching in hard rock areas, although this seems unlikely given the availability of sandy bays. These issues are not currently considered in Table 5.1.2 - “Disturbance of coastal morphology at the landfall site”. We recommend these impact pathways should form a separate category of potential effects to be assessed.

- Further clarity is needed on the assessment of potential effects on hydrodynamics and sediment transport. The proposal to apply previous modelling done for Moray East and/or BOWL depends on whether "there is sufficient similarity in the environmental setting and nature of proposed activities" (5.1.7.2). A detailed comparison in this regard should be presented "in support of the final proposed methodologies" (page 50, last paragraph).

  We recommend the following approach: further detailed technical discussions on these methods well in advance of EIA report preparation. It is essential that sufficient detail is presented and understood on how previous modelling would be applied, or on the alternative "complementary quantitative analytical methods".

- Regarding assessment of "Disturbance of coastal morphology at the landfall site", we support the reference in Table 5.1.2 to previous assessments of similar relevant activities. We have useful experience in this regard having provided support to the BOWL and SHET projects to achieve landfalls through the nationally important coastal geomorphology of Spey Bay SSSI and are happy to provide further information as required, both on the pre planning, but also in terms of our understanding through monitoring of these works**.**

- We refer Moray West to the National Coastal Change Assessment which provides Scotland-wide historical analysis of sea-level and coastal changes - www.dynamiccoast.com. This resource can help inform future projections of future coastal change. This is highly relevant to the intention that the landfall installation "must remain suitably protected" throughout its design life (5.1.4.1), in the context of predicted sea-level rise and changing coastal sediment supply.

Minor clarification is needed on the landfall corridor, as although the text (e.g. 2.2.2.5) indicates that the western end is Portknockie, Fig 1.1.1 appears to show it as Findochty.

2. Benthic Ecology

We previously provided advice on the benthic survey scope of works proposed for April 2017, but have not as yet had sight of the final technical survey report. We are mindful that provision of this information will help inform the approach to assessment including the identification of any mitigation measures and so emphasise that our advice is general at this stage. Upon receipt of the technical survey report we will be able to provide more comprehensive advice should this be required.

We agree with the potential effects identified in section 6.1.3.1 and offer the following

additional comments:

- **Smothering effects / suspended sediment:** the applicant should consider the potential for benthic species to be smothered by sediment released from cable-laying, trench-digging and/or installation of the substation platforms. The potential for any buried contaminants to be released from such work should also be considered.

- **Habitat loss** will need to be estimated, using a worst case scenario for each option being considered, so that comparisons can be made.

- **Habitat change:** the applicant needs to consider any reef effects or changes in benthic communities arising from any scour protection used for the export cable or the offshore substation foundation(s).

- **Electromagnetic effects**: the applicant will also need to consider the potential impacts on benthic communities from any thermal load (seabed sediment heating) or electro-magnetic fields (EMF) arising from the cables during operation. We do not agree that this impact pathway should be scoped out at this stage. The reduction of these effects is linked to the potential mitigation measure identified (6.1.6) and knowledge of benthic communities interests along the cable corridor route and landfall area – we consider that this issue is being scoped out too early.

- **Release of chemical release**; as per EMF above, we do not agreed with the scoping out of this potential impact at this stage given the reliance on mitigation.

- **Indirect effects:** the applicant will also need to consider the indirect effects on other receptors (i.e. marine mammals and seabirds) if prey species could be impacted by the offshore cable works. This assessment will depend on the benthic species and communities present along the cable corridor route and landfall area. We note the inclusion of reduction in prey availability in Table 6.3.5 (Marine Mammals).

The scoping report provides a preliminary appraisal on the baseline environmental including consideration of Annex 1 habitats and Priority Marine Features[3], BAP habitats and species and the OSPAR list of threatened species and habitats. We welcome the approach to include the proposed Southern Trench MPA[4].

[3] http://www.snh.gov.uk/protecting-scotlands-nature/priority-marine-features/priority-marine-features/
[4] http://www.snh.gov.uk/protecting-scotlands-nature/protected-areas/national-designations/marine-protected-areas-%28mpa%29/scottish-mpa-network-advice/

3. Fish & Shellfish

As previously discussed (see cover letter and section 3 above) we understand the desire to scope out EMF and seabed sediment heating impacts to fish and shellfish species, however we recommend both these impact pathways are included and assessed in the EIA report.

We note that 6.2.3 (existing environment) includes narrative on the SAC rivers that may need consideration with respect to Atlantic salmon, freshwater pearl mussel and sea lamprey features. We no longer advise it is possible to undertake site-specific HRA for migratory Atlantic salmon or other migratory fish because we cannot apportion impacts correctly to SACs. There is a lack of information on SAC populations to inform decisions on site integrity. As our knowledge improves and assessment methods develop this position may change. Potential impacts to migratory fish and therefore as a consequence freshwater pearl mussel (FWPM) should be considered under EIA rather than HRA.

We note that the following impacts will need consideration in respect of marine fish and shellfish including Atlantic salmon and FWPM

- **Smothering effects / suspended sediment:** the applicant should consider potential smothering from sediment release in respect of less mobile fish and shellfish species as well as for the eggs of species which spawn in the area. Clarification on the location and footprint of the export cables route and the timing / seasonality of operations can help in the assessment of these potential effects. The potential for any **buried contaminants** to be released from suspended sediment should also be considered.

- **Habitat loss:** benthic interests are discussed above, however, the applicant should also consider the extent of habitat loss in respect of marine fish and shellfish.

- Habitat change: the applicant needs to consider any reef effects or creation of habitat arising from any scour protection used for the export cable or OSP(s).

- **Changes to tides and current speeds:** we agree this can be scoped out at this stage.

- **Electromagnetic effects**: the response of fish and shellfish to electromagnetic fields (EMF)
  .
- **Operational noise from OSP equipment, vessels and underwater maintenance**: we note the inconsistency in approach in considering the

potential effect of underwater noise originating from operating OSP equipment, vessel and underwater maintenance. Table 6.2.3 proposes to scope out these effects whereas 6.2.7.2 (subsea noise assessment) includes consideration of operation and maintenance phase. We therefore suggest these effects are scoped into the EIA report for further consideration.

- **Particle motion:** we highlight that there is growing awareness of this potential impact, but consider that this is at very early scientific understanding to undertake a detailed assessment.

4. Marine Mammals

There is extensive information available on marine mammals in the Moray Firth, as captured in 6.3.2 (baseline data) and 6.3.3 (Existing environment). Table 6.3.2 sets out the range of marine mammals recorded in the Moray Firth and Table 6.3.3 considers those likely to forage within range of OfTI components. We refer you to our previous advice covering the scope of the Moray West Offshore wind farm development footprint (letter dated 05 July 2016) for information on relevant management units and reference populations required for consideration under EIA. In addition, where assessment is also required for an SAC or pMPA interest feature, we offer the following comments:

- **Bottlenose dolphin** (Moray Firth SAC): we highlight the importance of the south coast of the Moray Firth for bottlenose dolphin originating from the Moray Firth SAC and travelling down the East coast, with frequent records within 3km of the coast.

- **Harbour seal** (Dornoch Firth and Morrich More SAC): We confirm only Dornoch Firth and Morrich More SACs require consideration.

- **Grey seal:** Impact to this species should be considered under EIA only.

- **Harbour porpoise**: we do not agree with scoping in harbour porpoise with respect to the Southern North Sea cSAC. This species should be considered under EIA only.

- **Minke Whale** (Southern Trench pMPA): the cable corridor route and landfall overlap with the Southern Trench MPA proposal which includes minke whale as an interest. In addition to the data sources listed in the Scoping report, we recommend contacting the Cetacean Research and Rescue Unit[5] who have done a lot of work on minke whale in the area as well as Whale & Dolphin

[5] Cetacean Research and Rescue Unit: www.crru.org.uk/

Conservation[6].

Each of the cetaceans listed in Table 6.3.2 is a European Protected Species (EPS) and our scoping advice on the Moray West offshore wind farm provides advice in this regard (see letter dated 05 July 2016) which will also be applicable to this proposal. The risk of disturbance particularly in the coastal waters of the southern Moray Firth where bottlenose dolphin and minke whale are most frequent suggests an EPS licence may be required. Information should be provided to help inform considerations of any subsequent EPS licence application.

We agree with the scope of impacts to be considered for marine mammals as discussed in the Table 6.3.4 and offer the following additional comments:

- We agree that the probable risk to marine mammals from **operational noise or electromagnetic fields** is low and are content that these effects are scoped out at this stage.

- **Disturbance / displacement as a result of construction / operational noise:** particularly relevant for the installation of the offshore substation platform(s), depending on foundation type, and the placement of scour protection if needed for the OSP(s) or along the cable route. As discussed above, the southern Moray coast is important for marine mammals, so particular care will be needed for working in these coastal waters. We welcome the inclusion of the marine mammals in the subsea noise assessment as proposed in 6.2.7 and recommend this cover all of the five species listed above. We recommend that directional drilling (HDD) is considered for the cable landfall and connection to the offshore export cables.

- **Indirect effects resulting from impacts on prey species:** this issue can be informed by the results from benthic survey work together with the fish and shellfish ecology assessment. We are satisfied that this aspect can be considered via desk-based appraisal as proposed in the scoping report.

We also highlight the likelihood that cumulative impacts on marine mammals will need to be addressed for these proposed transmission works. There is a range of development consented, or proposed, that may impact on marine mammals in the Moray Firth including the Beatrice and Moray East offshore wind farms, their associated transmission works, the Caithness / Moray subsea cable link and a range of harbour developments – as well as other development proposals further afield.

We would welcome further discussion of possible cumulative impacts at the appropriate time, probably best co-ordinated by Marine Scotland via the proposed

[6] Whale & Dolphin Conservation: http://uk.whales.org/

regional advisory group.

As previously advised (05 July 2016) we reiterate our support of the approaches that have been developed by Moray Offshore as part of the MFOWDG. This includes the harbour seal assessment framework, and application of the iPCoD approach (population consequences of disturbance) to bottlenose dolphin. Moreover, extensive discussions have been held by the MFRAG marine mammal sub group regarding potential mitigation and monitoring methods in relation to underwater noise disturbance (as a result of pile driving). These discussions and recent outputs including the piling strategy for the Moray East offshore wind farm will continue to be of value to this proposal going forward.

5. Ornithology

As for marine mammals above, there is growing information available on ornithological interests in the Moray Firth, as captured in 6.4.2 (baseline data) and 6.4.3 (existing environment). Tables 6.4.1, 6.4.2 and 6.4.3 set out the range of seabird species recorded in the Moray Firth including within the Moray West wind farm development footprint. Table 6.4.3 considers those likely to forage within range of OfTI components however limited commentary is provided in 6.4.3 as to why some species within individual SPAs are considered relevant and why some are not or in some instances some qualifiers are omitted.

Moreover, this table includes three SSSIs none of which overlap with the landfall search area – we remind the applicant of the site-based protection afforded to the notified features of SSSI which does not include the connectivity component inherent in the assessment of SPA qualifying species.

We anticipate full commentary within the HRA screening report as to the development of the short list of sites and species for appraisal. In the meantime we refer you to our previous advice covering the scope of the Moray West Offshore Windfarm development footprint (letter dated 05 July 2016) as a useful starting point.

Moray Firth proposed SPA[7] – this pSPA is located in the inner Moray Firth and is proposed for wintering diver and seaduck interests, as well as for European shag. While there is no connectivity between the Moray West wind farm development footprint, the cable corridor route and landfall search area do overlap. The species of interest have a coastal distribution and are recorded in greatest numbers within the proposed SPA.

We agree with the scope of impacts to be considered for ornithological interests as

[7] http://www.snh.gov.uk/protecting-scotlands-nature/protected-areas/proposed-marine-spas/moray-firth/

discussed in the Table 6.4.5 including the scoping out of barrier effects and collision risk. We offer the following additional comments:

- Potential **disturbance** to waterfowl and waders is, in our view, the key ornithological impact to be assessed with respect to the construction of the export cable and landfall. We do not identify any requirement for boat-based or aerial survey work in respect of seabird species along the cable route, although review of the data that Moray Offshore has already collected for the wind farms may be informative. Timing of installation is likely to be a key mitigation measure particularly in respect of wintering interests of the Moray Forth pSPA. Displacement from the OSPs is likely to be localised to a small area, but should also be assessed.

- We consider that desk-based appraisal is sufficient to consider potential disturbance or indirect impacts on seabird species arising from the export cable works. Consideration of any indirect impacts on seabirds from potential impacts to their prey species can be informed by the results from benthic survey work.

- We would also welcome consideration of offshore substation lighting requirements in respect of seabirds.

6. Landscape, Seascape and Visual Impact Assessment

As noted in 7.4 Landscape, seascape and visual there was a comprehensive seascape, landscape and visual impact (SLVI) assessment provided in the ES supporting the Section 36 and marine licence applications for the MORL Round 3 wind farms.

We welcome the proposal to assess the landscape and visual impacts of the offshore substation platforms such that that their location and design is considered as part of the overall design process for Moray West wind farm.

The Highland Council

The Council has no comment to make on the Marine Licence Applications for the OfTI for either East or West as it does not impact on directly on our shores.

Transport Scotland

With reference to your recent correspondence on the above development, we acknowledge receipt of the Offshore Transmission Infrastructure Scoping Report prepared by GoBe Consultants Ltd (GoBe) in support of the above development.

This information has been passed to SYSTRA Limited for review in their capacity as Term Consultants to Transport Scotland – Trunk Road and Bus Operations (TRBO). Based on the review undertaken, we would provide the following comments.

We understand that the Scoping Report (SR) has been prepared in support of the Moray West Offshore Transmission Infrastructure (OfTI) application. This application is associated with the Moray West Offshore Wind Farm located in the Outer Moray Firth approximately 22 km from the Caithness coastline. It is noted that the Scoping Report assumes that the Moray West OfTI would only ever be developed in conjunction with the Moray West Offshore Wind Farm. It is also noted that final connection to the onshore national electricity transmission system will be made via the Moray West Onshore Transmission Infrastructure (OnTI), which will comprise onshore export cables running from the landfall point to an onshore substation. The proposed OnTI will be subject to a separate scoping exercise and a separate EIA process.

OfTI Components

The OfTI will comprise up to two Offshore Substation Platforms (OSPs), an interconnector cable (if two OSPs are required) and offshore export cables from the OSP(s) to landfall. The SR indicates that it is anticipated that the topsides of the OSP(s) will be assembled as a single unit onshore and delivered to site before being lifted and secured to the installed foundation and substructure.

Construction Phase

We note that at present only limited information is available regarding the construction process, with the major parameters not yet defined in detail. In particular, the manufacturing bases and ports to be used for the construction phase are yet to be agreed. The SR indicates, however, that the principal stages of manufacturing will be as follows:

- Manufacture of components (including foundations, cables and OSP topsides);
- Transport of components to the Moray West OfTI Site;
- Storage and assembly of components as required at the port location(s) to be used during construction;

- Marine transportation of components to the Moray West OfTI Site for installation; and
- Movement of construction vessels to the Moray West OfTI Site.

While it is accepted that limited construction information is available, we would advise that, if any abnormal loads are required to be transported on the Trunk Road network, a report will require to be provided to assess the route to site in terms of its suitability for the transportation of these abnormal loads.

In addition, it is noted that dredging, drilling and spoil disposal may be required during the installation but we assume that there will be no need for any material to be transported via the trunk road network. The Environmental Statement should confirm that this is the case and should detail any HGV movements that will be required via the trunk road network associated with any of the construction activities.

We do not anticipate that there will be large volumes of traffic via the trunk road associated with the construction stage. However, we would note that potential trunk road related environmental impacts (associated with increased traffic) such as driver delay, severance, pedestrian amenity, safety etc should be considered and assessed where appropriate (i.e. where Institute of Environmental Management and Assessment (IEMA) Guidelines for further assessment are breached). These specify that road links should be taken forward for assessment if:

- Traffic flows will increase by more than 30%, or
- The number of HGVs will increase by more than 30%, or
- Traffic flows will increase by 10% or more in sensitive areas.

I trust that the above is satisfactory and should you wish to discuss any issues raised in greater detail, please do not hesitate to contact Alan DeVenny at SYSTRA's Glasgow Office on 0141 226 6923.

UK Chamber of Shipping

With shipping and safety of navigation in mind, the requirements of MGN 542 (M+F) should be followed. The AIS and vessel tracking data mentioned is dated and 7 years old in some cases. This needs to be refreshed to ensure the level of risk remains valid.

Whale and Dolphin Conservation

Thank you for including WDC in this consultation. Overall, we are happy with the potential effects on marine mammals that have been scoped-in and the methods proposed to review these effects for the MORL (West) Offshore Transmission Infrastructure Scoping Opinion.

Appendix II: Advice from Marine Scotland Science

Marine Scotland Science has reviewed the submitted document and has provided the following comments.

Commercial Fisheries

Section 7.1.2 of the report states that " ICES rectangles are the smallest spatial unit available for the collation of fisheries data and will therefore be used to describe fishing activity throughout the report. [...] Consultation is of particular importance as smaller vessels are underrepresented in many of the available datasets". This is only true for catches information, not for effort patters. VMS data (as listed in table 7.1.1) are available to the developers. Similarly, ScotMap data layers can assist the developers with the smaller vessels, but currently not listed in their sources of information.

Table 7.1.2 could be accompanied by a map of the rectangles in the future to aid reader's understanding

Section 7.1.4 omits FLOWW Best practice guidance references

A list of all the projects in consideration in section 7.1.5 is needed to ensure consistency in the projects identified as part of the cumulative impacts assessments in the Forth & Tay region where relevant

Section 7.1.6 refers to the use of guard vessels as a mitigation option. No explicit reference is made to the potential of local fishing vessels acting as guard vessels in order to offer alternative employment opportunities for the impacted fleet. Furthermore, cable protection measures should also be an item for discussion with the local fishing fleet.

Table 7.1.4, row on " Loss of or restricted access to traditional fishing grounds" suggests that the surveys to be undertaken only include stakeholder consultation. Consultation should be complementary to baseline characterisation from ICES and VMS data as described earlier in the commercial fisheries section.

Benthic Ecology

MSS is generally happy with the information provided on benthic ecology for the Moray East OfTI plan described in the documents.

The major point for concern is the continued proposal to employ gravity base structures as foundations for the two OSP installations. These would require

considerable seabed modification of an area estimated at <190m dredge affected diameter per OSP with associated increases in water column suspended solids (SS) load followed by potenetial smothering of some areas. Information on increases in SS levels, direction of plume drift and on smothering levels would be useful here.

Concerns regarding the burying of export and interconnect cables are relevant. Both jetting and/or ploughing will also increase SS loads with some smothering effects.

The proposal to micro-site all cabling and the OSP structures to avoid impacting sensitive habitats and species in the area is to be welcomed however, further to this, the presence of the anemone *Arachnanthus sarsi* is of some interest and data on the animal's distribution and abundance would be useful.

Socio Economics

MSS has no comments on socio economics

Marine Fish Ecology

Thank you for sight of the scoping report for the Moray West Offshore Transmission Infrastructure. MSS has reviewed this in relation to marine fish ecology and is largely content with the proposed approach. The following comments are provided:

MSS welcomes the use of existing fish survey data for informing the baseline characterisation. The scoping report highlights a number of relevant studies such as those undertaken by MORL East and BOWL, the use of which MSS finds appropriate. As such, MSS is content with the statement on page 75 that "it is not proposed to undertake any site-specific baseline fish surveys".

MSS also welcome the desk review of fish sensitivity maps and suggest here that it may be useful to incorporate recent publications on the spawning areas of cod (González-Irusta & Wright 2015), haddock (González-Irusta & Wright 2016) and whiting (González-Irusta & Wright 2017). These publications may provide a level of spatial definition to the indicative maps provided within the referenced Coull *et al* (1998) literature.

MSS is broadly content with the approach for the assessment of potential effects on fish and shellfish ecology, as outlined in table 6.2.4. With regard to smothering effects, MSS note that previous advice was provided to MS-LOT regarding potential assessment for effects of sediment on scallops within the area. It may be useful to provide this here. MSS also note here that the approach relating to potential effects arising from noise does not specify whether this relates solely to the underwater sound pressure component; we understand that particle motion is the primary

mechanism by which some species of fish detect the impacts of noise from pile driving.

As a note, there is a reference to the BOWL herring surveys on page 69 that concludes that no seasonal restrictions were required during piling as herring did not spawn on the wind farm site. Whilst it was indeed considered that it was unlikely a significant spawning event had taken place at the wind farm site, it was considered that it was unlikely that the 'zone of influence', as identified by sound modelling, was unlikely to have an effect on spawning herring, given that back calculations identified larva were likely to have been spawned out with the potential impact area.

References

González-Irusta, J. M., & Wright, P. J. (2015). Spawning grounds of Atlantic cod (Gadus morhua) in the North Sea. ICES Journal of Marine Science, 73(2), 304-315.

González-Irusta, J. M., & Wright, P. J. (2016). Spawning grounds of haddock (Melanogrammus aeglefinus) in the North Sea and West of Scotland. Fisheries Research, 183, 180-191.

González-Irusta, J. M., & Wright, P. J. (2017). Spawning grounds of whiting (Merlangius merlangus). Fisheries Research, 195, 141-151.

Appendix III: Licensing Process

Consent Timescale and Application Quality

In December 2007, the Scottish Ministers announced an aspirational target to process new section 36 applications within a 9 month period, provided a Public Local Inquiry ("PLI") is not held. This scoping opinion is specifically designed to improve the quality of advice provided to applicants and thus reduce the risk of additional information being requested and subject to further publicity and consultation cycles.

Application

The application letter must detail how many licences are being sought, what marine licensable activities are proposed and what legislation the application is being made under.

Applicants are required to submit two hard copies of the EIA report together with an electronic copy in a user-friendly PDF format which will be placed on the Scottish Government website. If requested to do so Moray West must send to the Scottish Ministers such further hard copies of the EIA report as requested. applicants may be asked to issue the EIA report directly to consultees and in which case consultee address lists should be obtained from the Scottish Ministers.

Scottish Natural Heritage ("SNH") has produced a Service Level Statement ("SLS") for renewable energy consultation. This statement provides information regarding the level of input that can be expected from SNH at various stages of the EIA process. Annex A of the SLS details a list of references, which should be fully considered as part of the EIA process. A copy of the SLS and other vital information can be found on the renewable energy section of their website – www.snh.org.uk.

Requirement for Public Pre-Application Consultation ("PAC")

From 6th April 2014, applications received for certain activities are subject to a public pre-application consultation requirement. Activities affected will be large projects with the potential for significant impacts on the environment, local communities and other legitimate uses of the sea. This requirement allows local communities, environmental groups and other interested parties to comment on a proposed development in its early stages and before an application for a Marine Licence is submitted.

The Marine Licensing (Pre-application Consultation) (Scotland) Regulations 2013 can be accessed via

http://www.legislation.gov.uk/ssi/2013/286/made

Guidance on marine licensable activities subject to Pre-application Consultation can

be obtained at:

http://www.gov.scot/Topics/marine/Licensing/marine/guidance/preappconsult

The licensing authority reserves the right not to accept an application in the absence of an acceptable PAC report.

Ordnance Survey ("OS") Mapping Records

Applicants are requested at application stage to submit a detailed OS plan showing the site boundary and location of all deposits and onshore supporting infrastructure in a format compatible with The Scottish Government's Spatial Data Management Environment ("SDME"), along with appropriate metadata. The SDME is based around Oracle RDBMS and ESRI ArcSDE and all incoming data should be supplied in ESRI shape file format. The SDME also contains a metadata recording system based on the ISO template within ESRI ArcCatalog (agreed standard used by The Scottish Government); all metadata should be provided in this format.

Gatecheck

The Scottish Ministers undertakes a gatecheck prior to formal submission of applications and advises you to take full advantage of this service. The gatecheck is not designed as an in depth evaluation of the content of an EIA report. However, it will allow the Scottish Ministers the confidence that minimum legislative requirements have been met prior to formal submission of the EIA report. This should reduce the risk of the potential requirement for you to submit additional information to the EIA report and therefore be subject to re-advertisement and re-consultation. In order to assist the gatecheck process, a thorough gap analysis (Appendix III) of the issues identified in this Scoping Opinion should be drawn up for submission with the EIA report. It should be noted that gatecheck will only take place if the final and full version of the EIA report is submitted. The timeline will be agreed with Moray West.

Advertisement

Where Moray West has provided the Scottish Ministers with an EIA report, Moray West must publish their proposals in accordance with Regulation 17 of The Marine Works (EIA) (Scotland) Regulations 2017 (as amended).and Regulation 16 of The Marine Work (EIA) Regulations 2007 (as amended). Licensing information and guidance, including the specific details of the adverts to be placed in the press, can be obtained from the Scottish Ministers. If additional information is submitted further public notices will be required.

EPS licence

European Protected Species ("EPS") are animals and plants (species listed in Annex

IV of the Habitats Directive) that are afforded protection under The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) and The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (as amended). All cetacean species (whales, dolphins and porpoise) are European Protected Species. If any activity is likely to cause disturbance or injury to a European Protected Species a licence is required to undertake the activity legally.

A licence may be granted to undertake such activities if certain strict criteria are met:

- there is a licensable purpose;
- there are no satisfactory alternatives, and;
- the actions authorised will not be detrimental to the maintenance of the population of the species concerned at favourable conservation status in their natural range.

Applicants must give consideration to the three fundamental tests and should refer to the guidance on the protection of marine European Protected Species for more detailed information in relation to Scottish Inshore Waters. Applicants may choose to apply for an EPS licence following any grant of consent once construction methods have been finalised, however it is useful to include a shadow EPS assessment within the EIA report.

Basking sharks are also afforded protection under the Wildlife & Countryside Act 1981 (as Amended by the Nature Conservation (Scotland) Act 2004).

Appendix IV: Gap Analysis

APPLICATION - Consultation Gap Ana

Project:	
Date issued:	

Legend:
- Closed
- Ongoing
- Open

APPLICANT TO COMPLETE

	Consultee								Applicant				
	Consultee	Number/reference	Consultee's response	ES/Addendum	Chapter/paragraph	Objection (yes/no)	Condition requested	Summary of response (Key concern, etc)	Response from applicant	Action required	Evidence	Evidence sent to MS-LOT (date)	Comments
Example	SNH		*From our review of the supporting information for the application, including both the Environmental Statement (ES) and Habitat Regulations Appraisal (HRA) reports, we conclude that for this proposal alone there is no adverse effect on site integrity for bird interests.*	ES	6 Para 1.19	No	No	Conclusion of no adverse effect on site integrity for bird interests	No response required				
			We have assessed all other natural heritage interests and can confirm that we raise no other issues which could significantly impact on international or national interests.		6 Para 1.20		No	no significantly impact on international or national interests.	No response required		e.g. meeting minutes, emails, agreements, etc.		
			We support the commitment provided in the ES (Chapter 2) to agree and implement a Project Environmental Management Plan (PEMP).		6 Para 1.23		if yes, Copy condition requested by consultee	Need to submit PEMP	PEMP will be developed after/during consent and submitted to MS LOT	Meetings with MS LOT to discuss draft PEMP	Meeting minutes (doc ref numberxxx) *Include further updates regarding meetings, resolution on issues, etc*	Evidence sent to LOT on 01/01/2016 *Include further updates regarding meetings, resolution on issues, etc*	

MS LOT: each individual comment raised by the consultee should be on a separate line.

Appendix V: References applicable to particle motion

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MORAY WEST
OFFSHORE WINDFARM

Cumulative Impact Assessment Screening List

Moray Offshore Windfarm (West) Limited

Technical Appendix 5.3

Table of Contents

1 List of Projects and Activities Screened in to Cumulative Impact Assessment 1

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1 List of Projects and Activities Screened in to Cumulative Impact Assessment

Moray West undertook a Cumulative Impact Assessment (CIA) screening exercise in January 2018, in which they set out the intended approach to CIA and a proposed list of projects, activates and plans for consideration in CIA for the Development.

The results of the screening exercise were shared with the Marine Scotland Licensing Operations Team (MS-LOT), Marine Scotland Science (MSS) and Scottish Natural Heritage (SNH); based on their written responses received in January 2018, a list of projects and activities for inclusion in the Development CIA was finalised and is presented in Table 1.1 below.

The CIA assessments presented in the EIA Report topic chapters have as a minimum taken the projects and activities identified in Table 1.1 into account, as relevant to each assessment.

Table 1.1: Offshore Projects and Activities			
Project or Activity	**Summary**	**Information Source**	**Technical Area of Relevance**
Offshore Wind Farm Projects			
Moray East Offshore Wind Farm (Telford, Stevenson and MacColl Offshore Wind Farms)	Consented Three adjacent consented projects (Telford, Stevenson and MacColl Offshore Wind Farms), developed by Moray Offshore Renewables Limited (MORL) (now Moray East), in the Moray Firth. The project consents allow a total capacity of up to 1,116 MW and up to 186 turbines across the Moray East Site. Expected to be commissioned in 2022 in line with Contracts for Difference milestones.	http://www.morayoffshorerenewables.com/Home.aspx https://lowcarboncontracts.uk/cfds/moray-offshore-windfarm-east-phase-2	All
Beatrice Offshore Wind Farm	Under Construction The Beatrice Offshore Wind Farm, to be developed by Beatrice Offshore Wind Limited (BOWL), will consist of up to 84 wind turbines, two OSPs and generate up to 588 MW. The project, in the Moray Firth, commenced construction in April 2017 and will be fully commissioned and operational in early 2019.	https://www.beatricewind.com/ http://www.gov.scot/Topics/marine/Licensing/marine/scoping/Beatrice	All
Beatrice Wind Farm Demonstrator Project	Operational Two 5 MW wind turbines in the Moray Firth, operational since 2007. The site is 22 km from the Scottish coast and in 45 m of water. This project is a joint venture between Scottish and Southern Energy and Talisman Energy (UK) Limited and is due to be decommissioned in the near future.	http://www.hi-energy.org.uk/HI-energy-Explore/talisman-beatrice-project.htm https://www.repsolsinopecuk.com/pdfs/uploads/Beatrice_Decomm_EIA_Scoping_Report_Public_Copy.pdf	All
Inch Cape Offshore Wind Farm	Consented In 2014 Inch Cape Offshore Limited (ICOL) gained offshore consents (Section 36 and Marine Licence) for the construction and operation of an offshore wind farm (up to 784 MW and no more than 110 turbines) and associated Offshore Transmission Works, situated in the Outer Firth of Tay off the east coast of Scotland.	http://www.inchcapewind.com/home http://www.gov.scot/Topics/marine/Licensing/marine/scoping/InchCape	Marine Mammals Ornithology

Table 1.1: Offshore Projects and Activities			
Project or Activity	**Summary**	**Information Source**	**Technical Area of Relevance**
Inch Cape Offshore Wind Farm Revised Design	Proposed Development of a revised offshore wind farm comprising up to 784 MW and up to 72 turbines. The alternative design comprises larger but fewer turbines. A Scoping Request for the proposal has recently been submitted (April 2017) and the project is expected to enter construction in 2020.	http://www.inchcapewind.com/home and http://www.gov.scot/Topics/marine/Licensing/marine/scoping/ICOLRevised-2017	Marine Mammals Ornithology
Neart na Gaoithe Offshore Wind Farm	Consented A project consisting of up to 75 wind turbines, with a total capacity of up to 450 MW. The project is being developed by Neart na Gaoithe Offshore Wind Limited (NnGOWL).	http://www.gov.scot/Topics/marine/Licensing/marine/scoping/Mainstream-NeartnaGaoithe	Marine Mammals Ornithology
Neart na Gaoithe Offshore Wind Farm Revised Design	Proposed A new consent application for a revised offshore wind farm comprising larger but less turbines and with greater spacing between turbines. There will be no more than 54 turbines with total capacity of 450 MW. A consent application has recently been lodged (March 2018). Construction intended to commence in 2021.	http://www.neartnagaoithe.com/about.asp and http://www.gov.scot/Topics/marine/Licensing/marine/scoping/NnGRev2017	Marine Mammals Ornithology
Seagreen Alpha and Bravo Offshore Wind Farms	Consented Two offshore wind farms, being developed by Seagreen Wind Energy Limited (SWEL), each consisting of up to 75 wind turbines and generating up to 525 MW.	http://www.seagreenwindenergy.com/	Marine Mammals Ornithology
Seagreen Phase I Wind Farm	Proposed A new consent application for a revised offshore wind farm in place of Seagreen Alpha and Bravo Offshore Wind Farms, which will comprise 70 to 120 turbines of up to 15 MW, with 1 km spacing between turbines. The revised proposal has recently submitted a Scoping Request (May 2017).	www.seagreenwindenergy.com and http://www.gov.scot/Topics/marine/Licensing/marine/scoping/SeagreenPhase1-2017/SeagreenPhase1-ScopingReport	Marine Mammals Ornithology
Aberdeen Offshore Wind Farm	Consented Consists of up to 11 wind turbines, generating up to 8.4 MW each, located immediately off Aberdeen. It is being developed by Aberdeen Offshore	https://corporate.vattenfall.co.uk/projects/wind-energy-projects/european-offshore-wind-deployment-centre/	Marine Mammals Ornithology

Table 1.1: Offshore Projects and Activities			
Project or Activity	**Summary**	**Information Source**	**Technical Area of Relevance**
	Wind Farm Limited (AOWFL) and construction will take place and be completed during 2017.		
Hywind Demo	Constructed Statoil's demonstration floating wind farm (moored floating spar type structure) off the Scottish coast. The consented project is located near Buchan Deep, approx. 25-30 km off the coast of Peterhead in Aberdeenshire. It consists of five wind turbines and is a 30 MW pilot project.	http://www.statoil.com/en/TechnologyInnovation/NewEnergy/RenewablePowerProduction/Offshore/HywindScotland/Pages/default.aspx?redirectShortUrl=http%3a%2f%2fwww.statoil.com%2fHywindScotland	Marine Mammals Ornithology
Kincardine Floating Offshore Windfarm	Consented A pilot-scale offshore wind farm project utilising floating foundation technology. Proposed by Kincardine Offshore Wind Limited (KOWL), the project is located south-east of Aberdeen approximately 15km from the coastline.	http://www.gov.scot/Topics/marine/Licensing/marine/scoping/Kincardine.	Marine Mammals Ornithology
Forthwind Wind Farm Demonstrator Project – Phase 1	Consented A two turbine project located 1.5km offshore of Methil in the Firth of Forth with a capacity of up to 18MW.	http://www.gov.scot/Topics/marine/Licensing/marine/scoping/FW-Methil/s36consent	Marine Mammals Ornithology
Forthwind Wind Farm Demonstrator Project – Phase 2	Proposed Currently at the scoping stage, this Forthwind project will consist of up to 9 wind turbines with a total capacity of up to 65 MW located in the Firth of Forth.	www.gov.scot/Topics/marine/Licensing/marine/scoping/fowda	Marine Mammals Ornithology
ORE Catapult Levenmouth	Operational A 7 MW demonstration offshore wind turbine located at the Fife Energy Park off the East Fife coast. Looking at ways in which to drive cost efficiencies in offshore turbines. Operational since March 2014 with current operation proposed until 2019.	https://ore.catapult.org.uk/our-services/test-demonstration-assets/levenmouth-turbine/	Marine Mammals Ornithology
Dounreay Trì Floating Wind Demonstration Project	Under Construction (currently in administration) A commercial demonstration project, comprising two 5 MW wind turbine generators on a semi-submersible platform to be installed off the North coast of Scotland within a site approximately 9 km off Dounreay,	http://www.hexicon.eu/dounreay-tri/ and http://www.gov.scot/Topics/marine/Licensing/marine/scoping/DTFWDP	Marine Mammals Ornithology

Table 1.1: Offshore Projects and Activities			
Project or Activity	**Summary**	**Information Source**	**Technical Area of Relevance**
	Caithness. Construction started in March 2017 and commissioning is planned for September 2018.		
Other East Coast offshore wind farms (e.g. Blyth Offshore Demonstrator, Thanet, Teesside, Dogger Bank, Dudgeon, Hornsea projects, East Anglia projects, Kentish Flats, West of Duddon Sands, Scroby Sands, Sheringham Shoal, Greater Gabbard, Gunfleet Sands, Thanet Extension).	Various offshore wind farms currently seeking consent, consented or operational on the east coast of England.	Individual project specific websites / information.	Ornithology Marine Mammals
Other North Sea offshore wind farms off Belgium, France, Denmark, the Netherlands and Germany.	Various offshore wind farms in the wider North Sea.	Individual project specific websites / information.	Marine Mammals
Tidal Energy Projects			
MeyGen Pentland Firth	Operational Developed by Atlantis Resources, this is a 395 MW project comprising of various phases. The first Phase (1A) involves deployment of four 1.5 MW tidal turbines. Phases 1B (additional four 1.5 MW turbines) and 1C (additional 49 turbines of 73.5 MW capacity) are also consented.	http://www.gov.scot/Topics/marine/Licensing/marine/scoping/MeyGen https://www.atlantisresourcesltd.com/projects/meygen/	Marine Mammals

Table 1.1: Offshore Projects and Activities			
Project or Activity	**Summary**	**Information Source**	**Technical Area of Relevance**
NOVA Innovation Tidal Turbine Array - Bluemull Sound	Operational A five turbine offshore tidal array off the coast of Shetland with maximum generating capacity of 500 kW.	http://www.gov.scot/Topics/marine/Licensing/marine/scoping/nova	Marine Mammals
Churchill Barriers -	Proposed Construction of a tidal energy extraction scheme and a wave overtopping solution. At screening stage (April 2016).	http://www.gov.scot/Topics/marine/Licensing/marine/scoping/churchill-barriers	Marine Mammals
Ness of Duncansby Tidal Array	Proposed ScottishPower Renewables (UK) Ltd proposed to develop a commercial tidal array at Ness of Duncansby in the Pentland Firth. The array would have a capacity of 95MW and comprise Andritz Hydro Hammerfest tidal turbines. Atlantis acquired the project in 2016.	https://www.atlantisresourcesltd.com/projects/duncansby/ and http://www.gov.scot/Topics/marine/Licensing/marine/scoping/duncansby	Marine Mammals
Brims Tidal Array	Proposed Array of tidal turbines with a total capacity of up to 200MW. Two phases were proposed; Phase 1 up to 30MW and Phase 2 up to 170MW (15 turbines. Up to 200 turbines.	http://www.gov.scot/Topics/marine/Licensing/marine/scoping/BrimsArray	Marine Mammals
Lashy Sound Tidal Array	Proposed Scotrenewables Tidal Power Limited proposal to develop a tidal array for up to 30MW of installed capacity. Two phases were proposed; Phase 1 up to 10MW (5 turbines) and Phase 2 up to 30MW (15 turbines).	http://www.gov.scot/Topics/marine/Licensing/marine/scoping/LashySound and http://www.scotrenewables.com/projects/lashy-sound	Marine Mammals
Oil and Gas Projects (Producing / Recently Producing Licences)			
P187 (Beatrice Oil Field) – Block 11/30a P1031 (Beatrice Oil Field) – Block 11/25a P982 (Beatrice Oil Field) - Block	Production Ceased The Beatrice Field commenced production in 1981 and is currently owned by Repsol Sinopec Resources UK Ltd and operated by Talisman. There are four platforms: Beatrice Alpha Drilling Platform (263m within Moray West Site boundary); Beatrice Alpha Production Platform (280 m within the boundary); Beatrice Bravo (1194 m outwith boundary); and Beatrice Charlie (204 m outwith the boundary). There is also a mid-line structure between Beatrice Alpha and the Jacky Platform which was installed in	Oil and Gas Authority Offshore Interactive Map https://www.ogauthority.co.uk/data-centre/interactive-maps-and-tools/.	Other Human Activities Other technical areas also, depending upon confirmed decommissioning programme; current programme suggests structure removal activity

Table 1.1: Offshore Projects and Activities			
Project or Activity	**Summary**	**Information Source**	**Technical Area of Relevance**
	2008. Decommissioning of the Beatrice Oil Field is currently anticipated to commence in 2017 and be completed by 2027 and is set out within the Decommissioning Report. It is understood that a decommissioning EIA is currently underway.		will occur when Moray West is operational.
P1031 – Block 12/21a	Producing Owned by Repsol Sinopec Resources UK Ltd and operated under a Traditional Licence from Round 26, with an expiry date of August 2037.	Oil and Gas Authority Offshore Interactive Map https://www.ogauthority.co.uk/data-centre/interactive-maps-and-tools/.	Other Human Activities
P1392 (Jacky Oil Field) – Block 12/21c	Producing The Jacky Platform commenced production in 2009 and is currently owned and operated by Ithaca Energy. Preparatory works for decommissioning of the Jacky Platform commenced in the summer of 2016 with removal of the platform expected to take place in 2017 subject to receiving consent. The Jacky Platform is located 2870m outwith the boundary.	Oil and Gas Authority Offshore Interactive Map https://www.ogauthority.co.uk/data-centre/interactive-maps-and-tools/.	Other Human Activities
Cables and Pipelines			
Caithness to Moray Interconnector	Under Construction Developed by Scottish and Southern Electricity Networks (SSEN) Transmission and will span the Moray Firth. Due to be installed by the end of 2017. The cable runs from Spitall Substation / Noss on the Caithness coastline to a landfall close to Portgordon on the Moray coastline. It will then connect to Blackhillock Substation. The cable will intersect the Moray West OfTI Site.	http://www.4coffshore.com/windfarms/interconnector-caithness-moray-icid2.html.	Other Human Activities
SHEFA-2 Telecom Cable	Operational Faroese telecommunications cable between the Faroes Islands and Banff, which is located offshore to the east of the Moray West OfTI Site	https://www.submarinecablemap.com/#/submarine-cable/shefa-2.	Other Human Activities
Other Coastal Developments			
Ports and Harbours			

Table 1.1: Offshore Projects and Activities			
Project or Activity	**Summary**	**Information Source**	**Technical Area of Relevance**
Port of Ardersier	Consented Redevelopment of Former McDermott Fabrication Yard. Involves quay realignment, vibro piling, and dredging. A proportion of the dredged material is to be stored on site for future use as ballast material in gravity base foundations, another portion will be used to infill the "scalloped" area on Whiteness Head and the remainder will be disposed of at the Whiteness Sands disposal site. A marine licence was granted in September 2016.	http://www.gov.scot/Topics/marine/Licensing/marine/scoping/PortArdersierLtd.	Other Human Activities and Marine Mammals
Port of Nigg / Nigg Yard	Plan Stage Nigg Development Masterplan 2013 sets out a strategy for future development of the Port of Nigg over the next 15 to 12 years. Includes proposals for enhancing 334 hectares of the area for the marine renewables market and development of the oil terminal and fabrication yard. Most of the development appears to be onshore but there would be an increase in noise and vessel activity.	http://www.highland.gov.uk/downloads/file/1328/nigg_development_masterplan_-_march_2013.	Other Human Activities and Marine Mammals
Port of Cromarty Firth	Proposed Cromarty Firth Port Authority has plans for a Phase 4 port expansion project. The proposals include a new berth of 350m, a Ro-Ro facility and reclamation of additional land for lay down areas. A scoping opinion was provided in November 2015.	http://www.cfpa.co.uk/Port-Expansion/Phase-4.aspx	Other Human Activities and Marine Mammals
Aberdeen harbour expansion project	Construction Aberdeen Harbour Board has now commenced construction of the £350 million "South Harbour". The expansion will provide 1,400 metres of quay at water depths of up to 10.5 metres (LAT), with a turning circle of 300 metres and a channel width of 165 metres. The quayside is designed to accommodate the greatest range of activity possible, to provide our customers with flexibility and opportunity. The loading capacity of the quays is considerable, and it is estimated that the port can accommodate a transfer load of 6,000 tonnes plus (higher load capacities will be accommodated via engineered solutions).	http://www.aberdeen-harbour.co.uk/article/south-harbour-capabilities/	Marine Mammals

Table 1.1: Offshore Projects and Activities			
Project or Activity	**Summary**	**Information Source**	**Technical Area of Relevance**
Coastal Capital and Maintenance Dredging and Sea Disposal			
Burghead Disposal Site	Approximately 35.2km from the OfTI and 36.4km from the Moray West site.	Moray Council website http://www.moray.gov.uk/moray_standard/page_41056.html	Other Human Activities
Buckie Disposal Site	Approximately 2km from the OfTI and 36.9km from the Moray West site.	Moray Council website http://www.moray.gov.uk/moray_standard/page_41056.html	Other Human Activities
Helmsdale Disposal Site	Approximately 24.5km from the OfTI and 24.9km from the Moray West site.	The Highland Council website https://www.highland.gov.uk/directory_record/717679/helmsdale_bridge_car_park_shore_street_kw8_6jz/category/483/recycling_banks	Other Human Activities
Macduff Disposal Site	Approximately 14.7km from the OfTI and 49.5km from the Moray West site.	Aberdeenshire Council website https://www.aberdeenshire.gov.uk/waste/recycling-centres-and-points/recycling-centres-and-points/	Other Human Activities
Lossiemouth Disposal Site	Approximately 21.2km from the OfTI and 27.3km from the Moray West site.	Moray Council website http://www.moray.gov.uk/moray_standard/page_41056.html	Other Human Activities
Military			
Military Practice Danger Areas at Moray Firth, Tain, Fort George and Binhill	No further information is currently available on activities.	https://marinescotland.atkinsgeospatial.com/nmpi/	Defence and Aviation

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Physical Processes Baseline

Moray Offshore Windfarm (West) Limited

Technical Appendix 6.1

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Acronyms	
Acronym	**Expanded Term**
ABP	Associated British Ports
BGS	British Geological Survey
Cefas	Centre for Environment, Fisheries and Aquaculture Science
COWRIE	Collaborative Offshore Wind Research into the Environment
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DTI	Department of Trade and Industry
EA	Environment Agency
EIA	Environmental Impact Assessment
ES	Environmental Statement
GIS	Geographical Information System
HAT	Highest Astronomical Tide
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
LiDAR	Light Detection and Ranging
MALSF	Marine Aggregate Levy Sustainability Fund
MEPF	Marine Environment Protection Fund
MHWN	Mean High Water of Neap Tides
MHWS	Mean High water of Spring Tides
MLWN	Mean Low Water of Neap Tides
MLWS	Mean Low water of Spring Tides
MMO	Marine Management Organisation
MSL	Mean Sea Level
OfTI	Offshore Transmission Infrastructure
OfTO	Offshore Transmission Operator
OSP	Offshore Substation Platform
REA	Regional Environmental Assessment
SAC	Special Area of Conservation
SEA	Strategic Environmental Assessment
SPA	Special Protection Area
SPM	Suspended Particulate Matter
SSC	Suspended Sediment Concentration
SSSI	Site of Special Scientific Interest
UK	United Kingdom

Acronyms	
Acronym	**Expanded Term**
UKCP09	United Kingdom Climate Projections 2009
UKHO	United Kingdom Hydrographic Office
WTG	Wind Turbine Generator

Executive Summary

The Moray West Site spans the crest and western flank of Smith Bank and is characterised by water depths in the range 35 to 54 m below LAT. The shallowest depths are found in the north of the Moray West Site and the greatest depths are found in the south.

The Moray West Site is situated within a meso-tidal setting and is characterised by a mean spring tidal range of 3.1 m and a maximum astronomic range (HAT to LAT) of approximately 4.4 m. There is some variation in tidal range along the Moray West Offshore Export Cable Corridor, with relatively greater water level ranges experienced at the landward end.

Depth-averaged peak spring current speeds in the Moray West Site are around 0.3-0.25 m/s, with the fastest speeds recorded in the north of the Moray West Site. Peak spring current speeds are low (0.3 m/s or less) elsewhere in the Moray Firth.

The wave regime in the Outer Moray Firth includes both swell waves generated elsewhere in the North Sea and locally generated wind waves. The wave regime in the Outer Moray Firth is typically characterised by wind waves although longer period swell waves can be identified within the observational wave records collected from within and nearby to the Moray West Site. Even though water depths within the Moray West Site are no less than 35 m, storm waves sufficiently large to cause water motion at the seabed are not uncommon.

The Outer Moray Firth may experience some seasonal thermal stratification. The natural strength and position of seasonal stratification fronts is governed by the magnitude of tidal current flows in the adjacent inshore areas and of seasonal stratification in adjacent offshore areas.

Seabed sediments within the Moray West Site generally consist of Holocene gravelly sand and (fine to medium) sand with a minor proportion of fines (<5 to 10% silt and clay sized). Within the Moray West Offshore Export Cable Corridor, sediments become progressively finer in deeper water along the route, becoming relatively muddy (30 to 65% fines) in the deepest parts due to reduced tidal current speeds and wave disturbance.

Across much of the Moray West Site, surficial marine sediments are generally thick (~5 to 15 m in the west of the Moray West Site, up to 30 m in the east). In some limited locations, the underlying glacial till is very close to the surface (<2 m thickness).

Within the Moray West Site, suspended sediment concentrations are typically very low (approximately < 5 mg/l). However, during storm events, near bed SSC can be significantly increased in the short-term due to the influence of waves stirring of the seabed.

Active bedforms (e.g. low sediment waves and sharp edged sand patches) are present in the north of the Moray West Site, where current speeds are typically greater. Elsewhere, relic bedforms (e.g. glacially formed tunnel valleys) are visible but are not active under present day processes.

The characteristics of the Moray Firth coastline are highly variable, ranging from the predominantly hard rock Caithness and Buchan coastline to the soft coastlines of the Inner Firth.

Climate change is not expected to have any effect on the above parameters over the lifetime of the Development.

1 Introduction

1.1 Overview

ABPmer has been appointed by Moray Offshore Windfarm (West) Limited to consider the physical processes aspect of the Environmental Impact Assessment (EIA) for the Moray West Offshore Wind Farm and the associated offshore transmission infrastructure (OfTI) the 'Development', on the western side of the Moray Firth Round 3 Zone. The Moray West Offshore Wind Farm will be constructed within the Moray West Site, which is located approximately 22 km from the Caithness coast at its closest point and covers an area of 225 km². The landfall for the cables will be located between Findlater Castle and Redhythe Point, referred to as the 'Landfall Area' on the Aberdeenshire Coast (Figure 1.1).

Physical processes is a collective term for the following:

- Water levels;
- Currents;
- Waves (and winds);
- Sediments and geology: (including seabed sediment distribution and sediment transport);
- Seabed geomorphology; and
- Coastal geomorphology.

This Appendix provides a detailed description of the baseline environment within the physical processes study area (Figure 1.1). This baseline has been used to underpin the impact assessment of physical processes receptors, presented in Volume 1, Chapter 6: Physical Processes and Water Quality and in more detail in Appendix 6.3: Physical Processes Impact Assessment. The results are used to inform (and are informed by) numerical modelling tools, as described in Appendix 6.2: Physical Processes Numerical Modelling. The results have also been used to inform assessments in other technical chapters of Volume 1 which may contain other EIA receptor groups potentially sensitive to changes in physical processes.

The assessments in the other reports listed above consider the potential impact of the Development seaward of Mean High Water Springs (MHWS) during the construction, operation and maintenance, and decommissioning phases. The study is supported by a range of data and assessment techniques including new numerical modelling. The 'evidence base' of results from pre-existing numerical modelling/ desk based assessments undertaken to support EIA for other sufficiently analogous offshore wind farms are also used, in particular the adjacent Moray East Offshore Wind Farm.

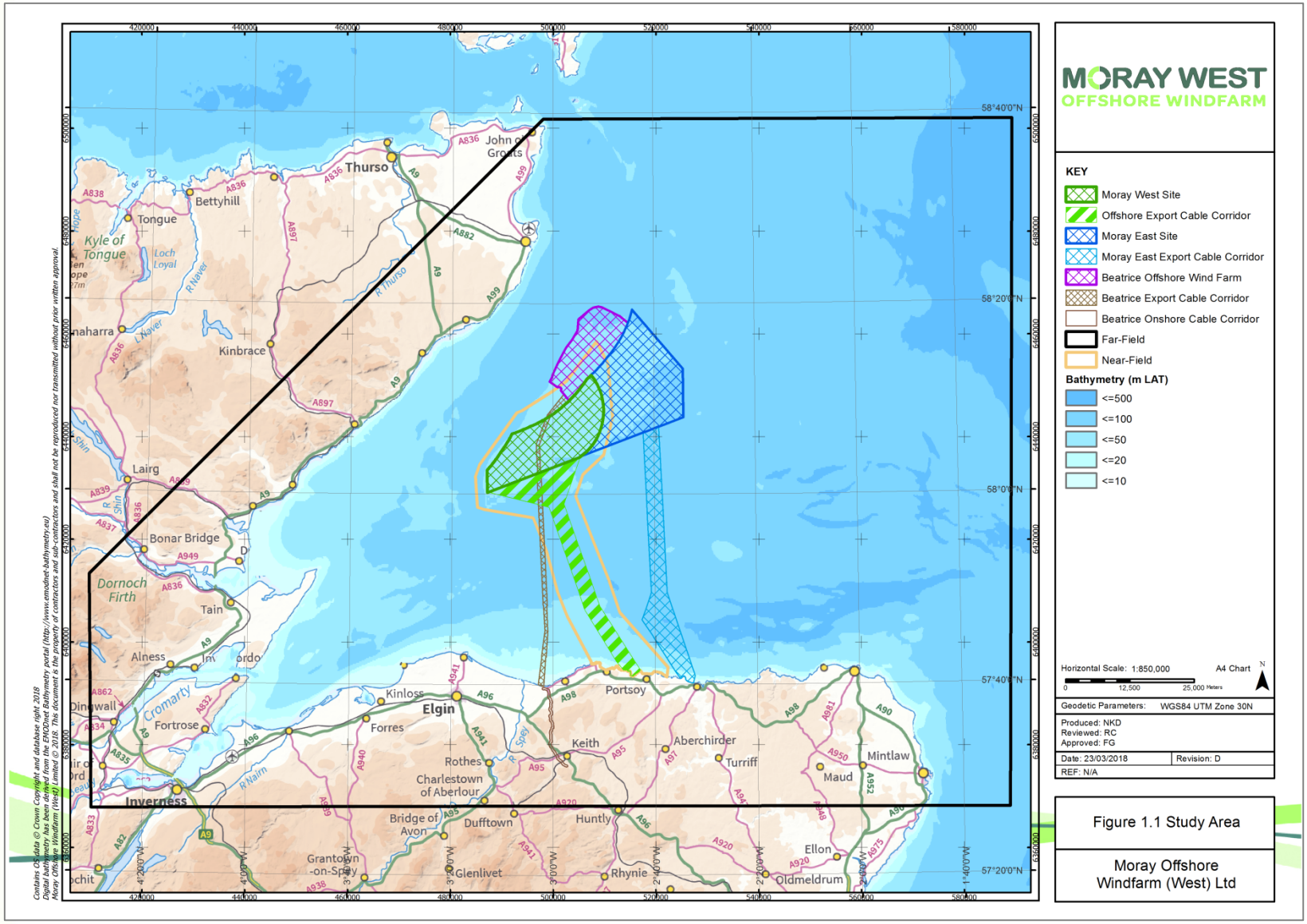

Figure 1.1: Study Area

1.2 The Moray West Offshore Wind Farm

The Moray West Site has been identified for development within the Moray Firth Round 3 Zone. A more detailed and complete description of the Moray West Offshore Wind Farm characteristics, including details of all planned infrastructure, is given in Chapter 4: Description of the Development.

The Moray West Site encompasses part of the summit and the western flank of Smith Bank, a morphological high point in the Outer Moray Firth measuring, approximately, 35 km long from south-west to north-east, 20 km wide (295 km^2). Water depths across the site range from approximately 35 to 55 m CD (below Chart Datum), with the greatest depths found along the south-eastern margin of the site. Smith Bank is separated from the Caithness coast by a relatively deep (up to approximately 75m CD) channel (Figure 1.1)

The north-eastern edge of the Moray West Site is also the boundary to the adjacent Moray East Offshore Wind Farm Site. The northern edge of the Moray West Site also has a short boundary to the adjacent Beatrice offshore wind farm development. The Moray East and Beatrice offshore wind farm sites also encompass part of the summit and the eastern and northern flanks of Smith Bank.

Figure 1.1 illustrates the 'near-field' and 'far-field' boundaries for the present study, also referenced in associated physical processes scheme impact assessment studies. The near-field boundary includes the array of wind turbines and substructures and its immediate surroundings and is the area in which direct effects to the physical environment are expected to occur during the lifecycle of the development. The far-field boundary broadly delineates the wider area which might also be affected indirectly by the development, e.g. due to the potential disruption of waves, tides or sediment pathways passing through the Moray West Site.

1.3 The Moray West OfTI

The offshore transmission network owner (OFTO) will operate the various components of the OfTI that exports electricity from the wind farm to the onshore national power grid. The Moray West OfTI Site is the area within which the OfTI will be located, including the Moray West Site (within which the Offshore Substation Platform(s) and a portion of the export cables will be located), and the Moray West Offshore Export Cable Corridor (within which the remainder of the offshore export cables will be located). The baseline metocean conditions along the Moray West Offshore Export Cable Corridor (also shown in Figure 1.1) are provided in this report in order to inform other related impact assessment studies.

The Moray West Offshore Export Cable Corridor extends from the southern edge of the Moray West Site, south-southeast towards the Landfall Area (Findlater Castle to Redhythe Point) on the Aberdeenshire Coast. In the Moray West Offshore Export Cable Corridor, water depths are typically 50 m at the Moray West Site, deepening to 70-90 m in the central part of the Moray Firth with the deepest areas associated with the western end of the Southern Trench. Water depths then shallow relatively gradually towards the Landfall Area where water depths of 20 m are approximately 1.5 to 2 km offshore from the coastline and associated beach area, respectively. The proposed route avoids the deeper parts of the Southern Trench, which has steep slopes and maximum water depths of up to 220 m (Admiralty Chart 115).

The maximum near-field extent for effects from the Moray West Offshore Export Cable Corridor is also shown as one tidal excursion distance in Figure 1.1. However, in practice, direct impacts are likely to be limited to a small distance from the actual installed position of the cable (order of metres to tens of metres) and are therefore likely to be contained within the extent of the Moray West Offshore Export Cable Corridor.

2 Approach to Baseline Characterisation

2.1 Overview

This assessment of baseline physical processes has been sub-divided into three categories, namely:

- **Hydrodynamic regime:** water levels, currents, waves and stratification;
- **Sediment regime:** seabed sediment distribution, bedload and suspended load transport; and
- **Morphodynamic regime:** form and function of both the coast and offshore, the morphodynamic regime is defined as a response to both the hydrodynamic and sediment regime.

The baseline assessment describes the natural variability of these regimes prior to the construction of the Moray West Offshore Wind Farm and the associated Moray West OfTI. This provides the reference condition against which to compare the proposed wind farm enabling, and providing the basis to inform the assessment of the significance of any consequential changes to the baseline.

The baseline environment is not static and will exhibit some degree of natural change with or without the wind farm in place due to naturally occurring cycles and processes. Therefore, when undertaking impact assessments it becomes relevant to place any potential impacts of the Moray West Offshore Wind Farm in the context of the envelope of change that might occur naturally over the timescale of the development. For example, it is generally anticipated that climate change will result in global scale effects which will be represented at regional scales by the trends in rising mean sea level and increased storminess (Lowe *et al*., 2009).

This baseline assessment of the physical processes has been developed through the analysis and interpretation of data and information from a variety of sources, including a programme of site surveys (undertaken in 2010/2011 for the Moray West Site and in 2017 for the Moray West Offshore Export Cable Corridor), pre-existing datasets, available literature sources and output from numerical modelling. These are further detailed below, in Section 1.1 below.

The impact assessment of the Development in relation to physical processes is presented in a separate report (Appendix 6.3: Physical Processes Impact Assessment) which draws upon the conceptual understanding developed here.

2.2 Key Guidance Documents

Guidance on the generic requirements, including spatial and temporal scales, for coastal process studies is provided in the following key documents:

- 'Environmental impact assessment for offshore renewable energy projects.' (BSI, 2015).
- 'Review of environmental data associated with post-consent monitoring of licence conditions of offshore wind farms.' MMO Project No: 1031. (Fugro-EMU, 2014).
- 'Offshore wind farms: guidance note for Environmental Impact Assessment in respect of Food and Environmental Protection Act (FEPA) and Coast Protection Act (CPA) requirements: Version 2' (Department for Environment, Food and Rural Affairs (Defra), Centre for Environment, Fisheries and Aquaculture Science (Cefas) and Department for Transport (DfT), 2004) - in the process of being superseded by;
- 'Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects' (Cefas, 2011);
- 'Guidance on Environmental Impact Assessment in Relation to Dredging Applications' (Office of the Deputy Prime Minister, 2001);

- 'Nature Conservation Guidance on Offshore Wind Farm Development' (Defra, 2005);
- 'Marine Renewable Energy and the Natural Heritage: An Overview and Policy Statement' (Scottish Natural Heritage, 2003);
- 'Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment' (COWRIE, 2009); and
- 'Marine Scotland Licensing and Consents Manual covering marine renewables and offshore wind energy development. Report commissioned for Marine Scotland (ABPmer, 2012a). ' ().

It is noted that Marine Scotland commissioned a set of guidance documents to be produced for the marine renewable industry, specifically wave and tidal devices, which included reference to Environmental Impact Assessment (EIA) requirements (ABPmer, 2012a). It is considered that some elements of the advice offered can be transferred across to the Scottish offshore wind industry, and as such is referenced within this study. ABPmer is currently unaware of any similar guidance from Scottish Environmental Protection Agency (SEPA) and are, therefore, presently assuming that those listed above can be adopted for the present study.

The purpose of the available generic guidance is to provide an overall consistency in approach and methodology to the identification and assessment of potential impacts. Using the recommended approaches, Moray West Site specific issues and methodologies have been determined during the EIA scoping and consultation process.

2.3 Spatial Scales

Baseline characterisation for tidal, wave and sedimentological processes is provided with respect to the following general spatial length scales:

- Near-field (i.e. the area inside and within one tidal excursion of the Moray West Site and the Moray West Offshore Export Cable Corridor); and
- Far-field (i.e. the wider area in which effects of the wind farm could potentially extend).

The following terminology is used to characterise geographical regions of the study area (Figure 1.1):

- Nearshore area (0 m Lowest Astronomical Tide (LAT) contour out to ~ -5 mLAT contour);
- Inshore area (~ -5 mLAT contour out to ~ -20 mLAT contour); and
- Offshore area (seaward of the ~ -20 mLAT contour).

2.4 Temporal Scales

There are four main phases of development that require consideration in the physical processes part of the EIA. These are:

- Baseline (pre-construction);
- Construction (from the start to the completion of installation for all major wind farm and OfTI infrastructure);
- Operation (the working lifetime of the Development, excluding major additions, changes or removal of infrastructure but including normal maintenance); and
- Decommissioning (from the start to the completion of all agreed and necessary decommissioning activities).

In order to provide the context for the usage of this baseline report, a brief description of each phase is summarised in the following sub-sections. The study of impacts during other phases is the subject of a companion report (Technical Appendix 6.3: Physical Processes Impact Assessment).

The time scale of baseline physical processes and changes or impacts to those processes is typically defined specifically where needed, but may also be referred to more generally as:

- Short term (occurring or persisting for seconds to hours, up to 3 days);
- Medium term (occurring or persisting for many days or weeks, up to 6 months); and
- Long term (occurring or persisting for many months or years, up to and beyond the lifetime of the Development).

2.4.1 Baseline

The baseline includes the ranges and interactions of naturally occurring physical processes occurring historically, at present, and over the anticipated lifetime of the Development (in the absence of the proposed infrastructure). The baseline provides a description of the environmental conditions to which the Development will be exposed, and against which any potential impacts on physical processes can be compared, throughout the lifecycle of the development.

Consideration will also be included in this phase, of any predicted naturally occurring variability or long-term changes to physical processes within the lifetime of the array (e.g. seasonality, natural cycles or meteorological processes) and climate change (e.g. sea level rise). Aside from relatively small magnitude and long timescale evolution of the physical environment, the present day baseline (determined using historical data) is likely to continue as described for timescales of at least tens, to hundreds of years.

2.4.2 Construction

The construction phase could last in the order of two years. Up to 85 wind turbine generator (WTG) foundations and up to two offshore substation platforms (OSPs) may be installed within the Moray West Site, with associated electrical inter-array, interconnector and export cables.

2.4.2.1 Tidal and wave regimes

Impacts upon the hydrodynamic regime, as a consequence of the construction phase, are typically only likely to be associated with the presence of engineering equipment, for example, jack-up barges placed temporarily on site to install, the turbine structures. As such equipment is only likely to be positioned at one site at a time for a relatively short duration (of the order of days), the consequential effects upon the hydrodynamic regime is deemed to be small in magnitude and localised in both temporal and spatial extent.

In addition, health and safety regulations make it likely that construction operations will only be undertaken during relatively benign metocean conditions.

2.4.2.2 Sedimentological regime

It is during the construction phase that the greatest impact upon suspended sediment concentrations and consequential sediment deposition are anticipated. However, this impact is only expected to occur over the short-term (order of days) at any given location during the construction period. The effects could be as a consequence of sediment being disturbed locally during the:

- Installation of foundations; and/or
- Cable laying processes.

2.4.3 Operation

The operational phase of the wind farm (during which time all of the relevant infrastructure will be present) will be similar to the duration of the initial lease period (50 years). Effects during the operational phase have the potential to be larger in magnitude and in temporal and spatial extent than during other phases.

2.4.3.1 Tidal regime

Potential effects may include changes to the naturally occurring water levels, current speeds and directions.

2.4.3.2 Wave regime

Potential effects may include changes to the naturally occurring wave heights, periods and directions.

2.4.3.3 Sedimentological regime

Effects upon the sediment regime during the operational phase of the modelling may occur due to the effects on the tidal and wave climate as above, potentially manifesting as:

- The alteration of suspended and/or bed load sediment transport pathways within both the near and far-fields;
- Scour around the turbine foundations and/or the cables, with the potential for the eroded material to be transported away from the Moray West Site; and
- Changes to longshore transport processes along adjacent coastlines.

2.4.4 Decommissioning

The decommissioning phase could last in the order of two years. Specific details of the decommissioning phase are presently unknown. However, it is expected that on expiry of the lease the developer will remove all structures and return the seabed to a usable state, in accordance with Department of Energy and Climate Change decommissioning guidelines (DECC, 2011).

It is assumed that the decommissioning phase will involve the removal and/or burial of any structures related to the wind farm development. Therefore, impacts upon tidal, wave and sedimentological regimes as a consequence of this phase will be comparable to those identified for the construction phase.

Post-decommissioning, the Moray West Site is expected to return to baseline conditions (allowing for some measure of climate change).

2.5 Consultation and Scoping of EIA Issues

The scope of this baseline characterisation must meet the requirements of the subsequent environmental impact assessments. The scope and nature of the assessments was discussed and agreed through consultation and scoping and is summarised here and in the following Section 2.6.

The EIA Scoping report for the Moray Offshore Wind Farm was circulated to relevant parties in May 2017, with a Scoping Opinion received in late August 2017. Following the scoping exercise for the Development alone, the scope for the assessment of cumulative impacts was also developed and consulted upon in January 2018.

A number of issues and particular concerns to address in the EIA were raised by in the various scoping responses. Those that are of direct relevance to the assessment of physical processes are presented in Table 2.1.

Table 2.1: Physical Process Issues and Concerns Expressed During the EIA Consultation and Scoping Process		
Physical Process Issue	**Consultee**	
	Marine Scotland	**SNH**
Changes to sediment transport (and other sediment disturbance issues).	Notes the potential limitations of the proposed (evidence based) assessment approach and possibility of 'transport of suspended sediment into new areas not previously considered'. Also notes that the proposed method 'should suffice for this wind farm'.	Concern regarding the proposed (evidence based) assessment method – anticipated to be adequate but noting that new modelling might be required if found to be insufficiently conservative.
Coverage of the existing bathymetric survey data	Coverage in the Moray West Site is less than 100%, which may affect the ability of the assessment to consider 'potentially susceptible sedimentary features'.	
Disturbance of coastal morphology at the Landfall Area	Should consider the potential for adverse impacts to the hard-rock interest of the Cullen to Stake Ness Coast SSSI.	

Potential concerns regarding the quality of surfing waves on the Moray Firth coastline have also been anticipated, following the guidance provided in a publication by Surfers Against Sewage (2009).

The above concerns and comments have been considered and addressed in this and other related reports.

2.6 Physical Processes Potential Impacts, Pathways and Receptors

The nature and scope of the baseline information required is determined by the nature and scope of the impact assessments that will be undertaken. This section provides a summary of that information.

Waves and tides are not environmental receptors that are directly or inherently sensitive to the presence of the development, they are rather 'pathways' that can transmit the potential effect of the Development, in this case manifesting through resulting changes to local and regional rates and patterns of sediment erosion, transport and deposition. These rates and patterns directly influence short- and long-term net morphological change on the seabed and at the coast and so it is rather the morphological features that are sensitive receptors in the physical processes domain. In this context, Smith Bank (the major morphological feature upon which the proposed development will be located and where any near-field impacts may occur) is considered as the primary near-field physical receptor.

A list of potential impacts and changes (pathways and receptors) to be considered in the physical processes impact assessment is provided in Table 2.2.

The majority of the physical and ecological receptors identified within the far-field study area are the conservation sites located along the Moray Firth coast (Table 2.3; Figure 2.1). The main characteristics of the Moray Firth coastline are summarised in Figure 2.2. This information has been distilled from more detailed publications on the geomorphology of the Moray Firth coast, in particular: The coastline of Scotland (Steers, 1973); The beaches of North East Scotland (Ritchie *et al*., 1978); The Beaches of East Sutherland and Easter Ross (Smith and Mather, 1973) and The Beaches of Caithness (Ritchie and Mather, 1970).

The Moray Firth and Caithness areas are noted for the richness of their natural heritage and much of the Caithness coastline is designated under international or national nature conservation orders. Most of the sites are protected on the basis of the habitats they contain; however, several designated areas have been assigned conservation status because of the geological and geomorphological interests they

contain, which are maintained by present-day physical processes. Examples include the actively prograding spit at Whiteness Head and the active gravel beach complex at the mouth of the River Spey which are both afforded SSSI (Site of Special Scientific Interest) status. A separately undertaken assessment of impacts of the wind farm will focus upon the potential for significant modification of the naturally occurring processes at these designated sites which could indirectly impact the habitats they support. The further assessment of effects on the biological environment in terms of the faunal and floral populations found within the Firth will be informed by these results (but will be reported elsewhere in the project, separate from the physical processes discussion).

The only designated areas to be directly affected by the Development footprint are the Moray Firth SPA and the Southern Trench pMPA (proposed Marine Protected Area). The Moray Firth pSPA (proposed Special Protection Area) is proposed for designation with respect to shallow sandy substrates, coastal rocky outcrops and deep muddy channels in coastal and more nearshore areas that provide habitats for a variety of bird species. The Southern Trench pMPA is proposed for designation with respect to a variety of geological features (the Southern Trench itself is an example of an enclosed glacial seabed basin), ecological habitats (burrowed muds in deeper parts of the trench) and other oceanographic features (seasonal stratification and fronts off Fraserburgh).

As shown in Figure 2.1, The route of the Moray West Offshore Export Cable Corridor will not transect the deeper parts of the Southern Trench (and so will avoid the more muddy seabed habitat areas in the Moray Firth pSPA and Southern Trench pMPA), and will be relatively distant (more than 6 spring tidal excursion lengths) from the stratification features off Fraserburgh.

Key recreational receptors relate primarily to the locations of surf beaches along the Moray Firth coastline. Changes to baseline wave characteristics could potentially be detrimental to the quality or frequency of certain surfing wave conditions. Surf beaches within the Moray Firth region have previously been identified in a report by Surfers Against Sewage (SAS) (2009) and are listed in Table 2.3.

Table 2.2: Summary of Potential Impacts / Changes Considered in the Physical Processes Assessment

Potential Impact / Change	Pathway / Receptor
Construction	
Increases in SSC and deposition of disturbed sediments to the seabed due to dredging for seabed preparation prior to foundation installation.	Pathway
Increases in SSC and deposition of disturbed sediments to the seabed due to the release of drill arisings during foundation installation.	Pathway
Increases in SSC and deposition of disturbed sediment to the seabed due to cable installation within the Moray West Site and within the export cable corridor.	Pathway
Indentations left on the seabed by jack-up vessels and large anchors.	Pathway
Impacts to designated marine and coastal geomorphological features (due to construction activities).	Receptor
Impacts to Smith Bank (due to construction activities).	Receptor
Operation	
Changes to the tidal regime.	Pathway
Changes to the wave regime.	Pathway

Table 2.2: Summary of Potential Impacts / Changes Considered in the Physical Processes Assessment	
Potential Impact / Change	**Pathway / Receptor**
Changes to sediment transport and sediment transport pathways.	Pathway
Scour of seabed sediments.	Pathway
Impacts to designated marine and coastal geomorphological features (due to operation).	Receptor
Impacts to recreational surfing venues (due to operation).	Receptor
Impacts to stratification fronts (due to operation).	Receptor
Impacts to Smith Bank (due to operation).	Receptor
Decommissioning	
Increases in SSC and deposition of disturbed sediment to the seabed within the Moray West Site and within the export cable corridor.	Pathway
Impacts to designated marine and coastal geomorphological features (due to decommissioning activities).	Receptor
Impacts to Smith Bank (due to decommissioning activities).	Receptor

Table 2.3: Physical Processes Receptors Identified Within the Study Area		
Receptor	**Designation**	**Description**
Smith Bank	(None)	A submerged bathymetric high in the Outer Moray Firth, covered by a veneer of sands and gravels of variable thickness and proportion.
Southern Trench	pMPA	An enclosed (glacial) seabed basin with associated benthic habitat types. Notable stratification and frontal systems off Fraserburgh supporting local primary production and feeding habitats.
Moray Firth	pSPA	Shallow sandy substrates, coastal rocky outcrops and deep muddy channels
Cullen to Stake Ness Coast	SSSI	Structural and metamorphic geology exposures (the Dalradian succession). Coastal slopes and raised beach habitats: coastal grasslands; cliff vegetation and vegetation associated with shingle shores; calcareous sand dunes; and limestone outcrops.
Loch of Strathbeg	SPA and Ramsar	Marshes, reedbeds, grassland and dunes
Troup, Pennan and Lion's Heads	SPA	Sea-cliffs, occasionally punctuated small sand or shingle beaches
The Moray and Nairn Coast	SPA and Ramsar	Intertidal flats, saltmarsh and sand dunes

Table 2.3: Physical Processes Receptors Identified Within the Study Area		
Receptor	**Designation**	**Description**
The Inner Moray Firth	SPA and Ramsar	Extensive intertidal flats and smaller areas of saltmarsh.
Cromarty Firth	SPA and Ramsar	Extensive intertidal flats and salt marsh
The Dornoch Firth	SPA and Ramsar	Large estuary containing extensive sand-flats and mud-flats, backed by saltmarsh and sand dunes
The East Caithness Cliffs	SPA	Old Red Sandstone cliffs, generally between 30 to 60 m high, rising to 150 m at Berriedale.
The Inner Moray Firth	SAC	(Highly varied)
Dornoch Firth and Morrich More	SAC	Extensive areas of mudflats and sandflats. Sub-tidally, the Firth supports rich biogenic reefs
Berriedale and Langwell, Oykel, Moriston and Spey	SACs	(Riverine systems emptying into the Moray Firth)
Culbin Bar	SAC	Extensive dunes, vegetated shingle and salt meadows
Culbin Sands, Culbin Forest and Findhorn Bay SSSI	SSSI	Extensive dunes, vegetated shingle and salt meadows (Culbin Bar). Intertidal flats, saltmarsh and sand dunes (Findhorn Bay)
Morrich More SSSI	SSSI	Large coastal emerged strand plain, attached sandy barriers and spits, stabilized dunes, saltmarshes and sandflats
Whiteness Head SSSI	SSSI	Shingle spit complex with examples of curved shingle bars, ancient bars and shortened bars
Frontal Systems	(Tidal front)	Vertical stratification front
Skirza	(Surf beach)	Sand beach (with particular wave climate).
Freswick Bay	(Surf beach)	Sand beach (with particular wave climate).
Keiss	(Surf beach)	Sand/ shingle beach (with particular wave climate).
Sinclair’s Bay	(Surf beach)	Sand/ shingle beach (with particular wave climate).
Ackergill	(Surf beach)	Sand/ shingle beach (with particular wave climate).
Lossiemouth	(Surf beach)	Sand beach (with particular wave climate).
Spey Bay	(Surf beach)	Sand/ shingle beach (with particular wave climate).
Cullen	(Surf beach)	Sand/ shingle beach (with particular wave climate).

Table 2.3: Physical Processes Receptors Identified Within the Study Area		
Receptor	**Designation**	**Description**
Sunnyside Bay	(Surf beach)	Rocky beach (with particular wave climate).
Sandend Bay	(Surf beach)	Sand beach (with particular wave climate).
Boyndie Bay	(Surf beach)	Sand/ Shingle beach (with particular wave climate).
Banff Beach	(Surf beach)	Sand beach (with particular wave climate).
Pennan	(Surf beach)	Rocky beach (with particular wave climate).
Widemans	(Surf beach)	Sand/ shingle beach (with particular wave climate).
Phingask	(Surf beach)	Sand/ shingle beach (with particular wave climate).
West Point	(Surf beach)	Sand/ shingle beach (with particular wave climate).
Fraserburgh	(Surf beach)	Sand beach (with particular wave climate).
St Combs to Inverallochy	(Surf beach)	Sand beach (with particular wave climate).

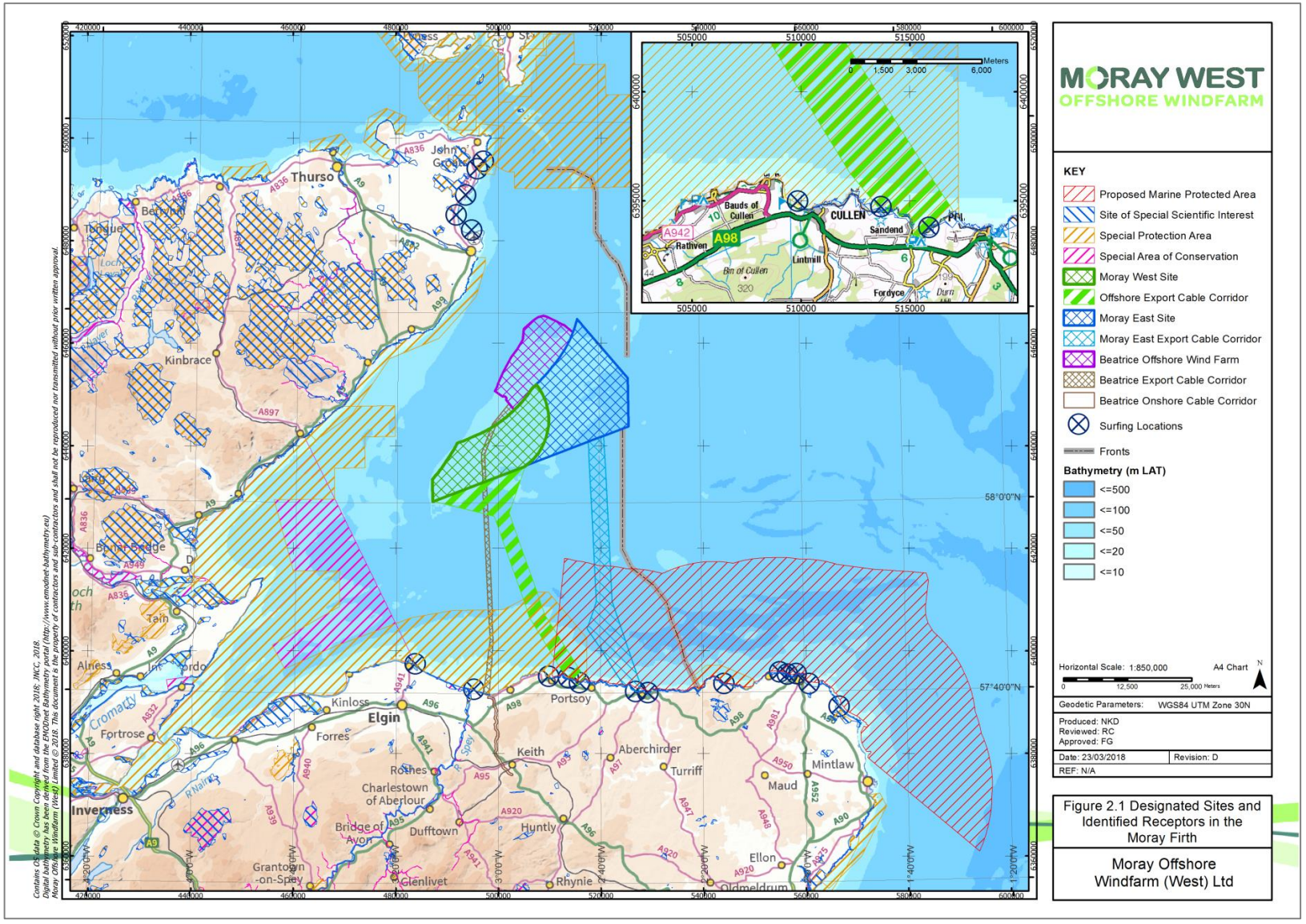

Figure 2.1: Designated Sites and Identified Receptors in the Moray Firth

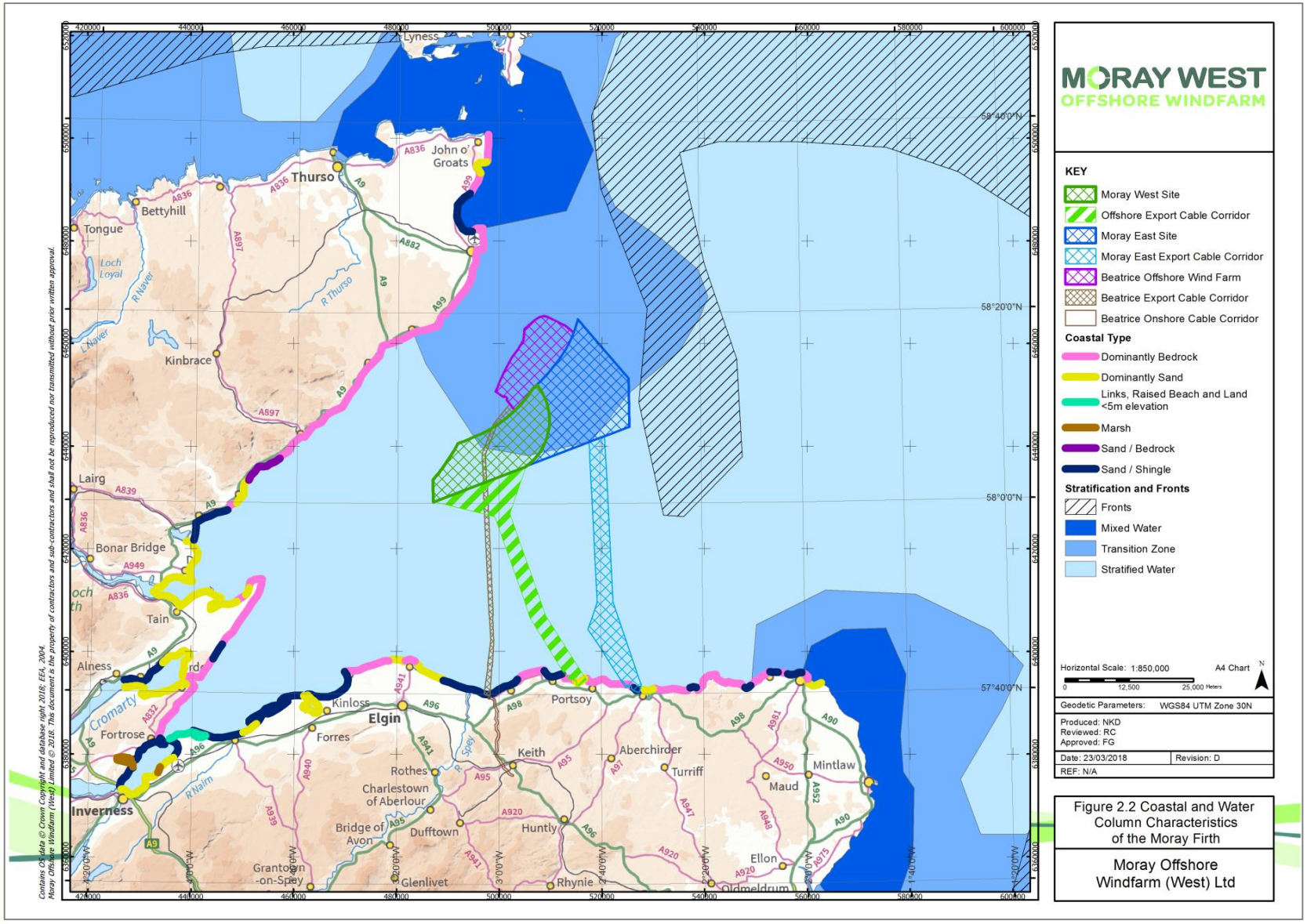

Figure 2.2: Coastal Characteristics of the Moray Firth

2.7 Data Sources

Relevant information from a wide range of data sources has been incorporated into the baseline environmental characterisation provided in this report. The location of key named data sources is shown in Figure 2.3. Data sources include surveys and other direct measurements, numerical modelling results, and various collated maps, reports and literature.

2.7.1 Survey Data

Survey data specifically collected by Moray West for use in this and previous studies are summarised in Table 2.4. As part of the planning process, a programme of geophysical, benthic and metocean surveys was undertaken in 2010/11 providing coverage of the whole Moray Firth Zone, including the Moray West Site. Additional benthic surveys have also been carried out in 2017 within the Moray West Offshore Export Cable Corridor.

A range of additional measured and other secondary data sources (of varying type and quality) are also available for other locations in the wider study area. These data sources are summarised in more detail in the following parameter specific sections (Sections 0 to 0).

Simulations of characteristic wave and tidal conditions within the study area have been undertaken as part of the present study using numerical models. More details of the models used, including details of their setup, calibration and validation may be found in Appendix 6.2: Physical Processes Numerical Modelling. The results of these validated models provide quantitative data throughout the study area and thereby address any residual data gaps relating to spatial and temporal coverage of the available measured data.

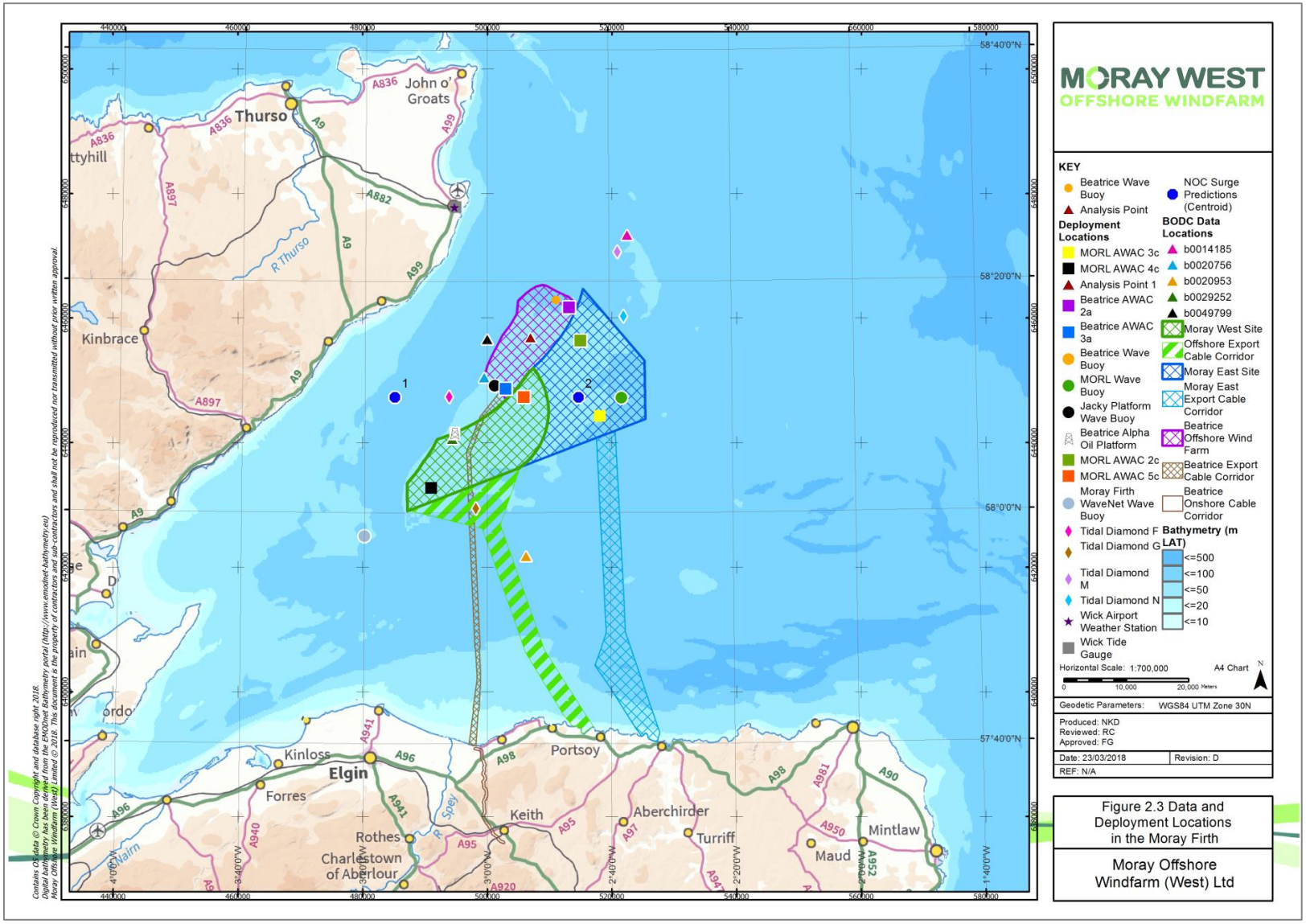

Figure 2.3: Data and Deployment Locations in the Moray Firth

Table 2.4: Survey Data Collected by Moray West in the Moray Firth Zone and Moray West Offshore Export Cable Corridor

Survey/Study	Date of Survey	Undertaken By	Description
Geophysical Surveys	1/04/2010 to 21/05/2010	Osiris	High-resolution swath bathymetric survey Side Scan Sonar survey Sub-bottom seismic profiling survey
Benthic Survey	25/5/2017 to 3/6/2017	PMSL	Baseline information on the benthic communities within the Moray Firth Zone has been collected. Grab samples have been used for particle size analysis (PSA) and this information has been augmented with grab samples collected from the adjacent Beatrice Offshore Wind Farm as well as available British Geological Survey (BGS) grab sample data
	12-16/10/2010	EMU	
	12-14/10/2011	CMACS	
	09-10/04/2010	Partrac	PSA from five additional grab samples within the Moray Firth Zone at the locations of the deployed metocean survey equipment.
Geotechnical Survey	2/11/2010 to 14/12/2010.	Fugro	25 geotechnical boreholes plus cone penetration tests (CPT) from the Moray Firth Zone.
Metocean Surveys	10/02/10 to 14/02/2011	Partrac	Data collected for periods of months to years at five locations within the Moray Firth Zone, including current speed, water levels, wave heights/directions and suspended sediment concentrations.

2.7.2 Numerical Modelling

Simulations of baseline wave and tidal conditions within the study area, and assessments of potential scheme impacts, have been undertaken using numerical modelling. A best practice approach to the modelling has been taken, according to COWRIE (2009). More details of the models used, including details of their setup, calibration and validation may be found in Appendix 6.2: Physical Processes Numerical Modelling.

These models have also been used to establish the baseline and will be used to determine the scale of the likely effects of potential development phases (construction; operational; decommissioning) upon the existing physical processes. The numerical modelling is designed to include both far and near-field areas relevant to the present study.

The Danish Hydraulics Institute ‘MIKE by DHI’ suite of numerical models has been used to create a tidal model (MIKE21FM HD) and a wave model (MIKE21FM SW) of the Moray Firth and surrounding area for the purposes informing the baseline characterisation and assessments of potential scheme effects.

The procedure for model calibration/validation is based on the need to demonstrate that each of the models is 'fit-for-purpose' for the range of scenario tests required. For example, the tidal model has been calibrated and validated over a range of tidal conditions, including mean neap and spring ranges. Likewise, the wave model has been calibrated and validated in its ability to reproduce a range of wave event types and intensities. Predicted values from the models are shown to compare closely to the target measured data (i.e. water levels, current speeds and directions, wave heights, periods and directions).

Model performance in representing baseline conditions is considered to be very good with the model reproducing tidal and wave processes with regards magnitude, direction and phase. The models are therefore considered fit for the purposes of the present study, informing the baseline understanding of physical processes across the study area and therefore providing a suitable basis for the simulation of potential scheme effects.

2.7.3 Maps, Reports and Literature

Additional regional scale data and information is also used, including but not limited to:

- (BGS 1:250,000 surface sediment maps, used to provide a more regional indication of the seabed material. This has been broadly verified using data collected during the Moray East Offshore Wind Farm site benthic survey;
- Modelled data generated by the Met Office European Waters, UK Waters (UKW) and Wave Watch III models providing up to 20 years wind and wave data time-series for the Outer Moray Firth;
- Extreme storm surge predictions from the Proudman Oceanographic laboratory (POL);
- UKCP09 (UK Climate Projections 2009) predictions of future changes to the hydrodynamic regime due to climate change;
- Strategic Environmental Assessment - SEA 2; SEA 5 (Balson *et al*., 2001; Holmes *et al*., 2004);
- Dynamic Coast - National Coastal Change Assessment: Cell 3 - Cairnbulg Point to Duncansby Head (Hansom *et al*. 2017);
- JNCC Coastal Directory Series: Regional Report 3 North East Scotland; Cape Wrath to St Cyrus (Barne *et al*., 1996);
- Scotland's National Coastal Change Assessment (www.dynamiccoast.com) (Scottish Government *et al*. 2017);
- Scotland's Marine Atlas: Information for the national marine plan. (Baxter *et al*. 2011);
- The Beaches of North East Scotland (Ritchie *et al*., 1978);
- United Kingdom Offshore Regional Reports Series: The Moray Firth (Andrews *et al*., 1990); and
- Sand banks, sand transport and offshore wind farms (Kenyon and Cooper, 2005).

The following sections provide a more detailed summary of the key baseline data sources and the characteristic range of natural variability for the physical environmental parameters relevant to this study.

3 Hydrodynamic Regime

3.1 Overview

The hydrodynamic regime encompasses the range of processes that together describe the physical marine environment in and around the Moray West Site, namely:

- Water levels;
- Currents;
- Winds (as a driving force for waves);
- Waves; and
- Stratification.

These parameters are described in more detail in the following sub-sections. This information has subsequently been used to develop a conceptual understanding of the sedimentary and morphological regimes at the Moray West Site (see Sections 0 and 0).

3.2 Water Levels

Marine water level measurements typically contain both a predictable astronomical tidal signal (caused by the sun and moon) and a more random non-tidal signal, typically related to meteorological influences and referred to as the 'tidal residual'.

3.2.1 Sources of Water Level Data

Multiple sources of water level data are available from within and near to the Moray West Site. These datasets are listed in Table 3.1 and their locations are shown in Figure 2.3.

Table 3.1: Sources of Water Level Data

Data Source	Latitude (°N)	Longitude (°E)	Period Analysed	Duration
Metocean survey - AWACs in the Moray Firth Zone	58.248	-2.746	Jul/10 to Dec/10	100 days
	58.140	-2.695	Oct/10 to Feb/11	106 days
	58.036	-3.152	Jul/10 to Jan/11	124 days
	58.167	-2.900	Jul/10 to Feb/11	103 days
Wick tide gauge	58.441	-3.086	1965 to present	~ 52 years
Admiralty Tide Tables (Wick)	58.441	-3.086	N/A	N/A
NOC CSM Surge Statistics Location 1	58.167	-3.250	N/A	N/A
NOC CSM Surge Statistics Location 2	58.167	-2.750	N/A	N/A
Published Storm Surge Statistics (Flather, 1987; Dixon and Tawn 1997)	N/A	N/A	N/A	N/A
Admiralty tidal co-range chart	Variable	Variable	N/A	N/A
Numerical tidal model	Variable	Variable	Variable	Variable

3.2.2 Astronomical Tidal Water Levels

The astronomical tide is harmonic and periodic, i.e. in this context the tide is repeatable and predictable, as described by the summation of a number of harmonic components of differing amplitude and phase, and exhibits cycles on a variety of timescales including:

- Semi-diurnal - a complete tidal cycle (including one high and one low water) occurs approximately twice every day in the Moray Firth;
- Spring-neap - the semi-diurnal tidal range varies smoothly between a relatively larger (spring) and relatively smaller (neap) range over an approximately 14 day cycle;
- Solstice-equinox - the relative size of spring and neap ranges vary during the year. The largest spring and smallest neap tidal ranges occur in March and October, around the solar equinox, whilst the difference in range between springs and neaps is least in December and June, around the solar solstice;
- Inter-annual - spring-neap and solstice-equinox cycles vary from year to year due to variation in the relative positions of the sun and the moon in their orbits relative to the earth; and
- Metonic cycle - the relative positions of the sun and the moon (and the above patterns) nearly repeat on an approximately 18.6 year cycle.

Approximately three months of water level measurements were collected by Partrac (2011) on behalf of Moray West at each of four locations within and nearby to the Moray West Site (Table 3.1). A subset of these data, including one neap-spring-neap cycle, is compared directly in Figure 3.1, whilst summary water level statistics for both the Moray West Site and selected primary/secondary tide gauges within the Moray Firth is provided in Table 3.2.

The survey data shows that the Moray West Site is situated within a meso-tidal setting and characterised by a mean spring tidal range of approximately 3 m. There is only a small (~0.15 m) difference in spring tidal range over the length of the site, with the largest tidal range experienced in the southwest. This is in agreement with the trend of increasing tidal range into the Moray Firth indicated by Admiralty Tide Table publications and by Admiralty tidal co-range charts. The Admiralty Tide Table publications and Admiralty tidal co-range charts also suggest only very small (approximately 0.2 m) change in water levels within the Moray West Offshore Export Cable Corridor.

Tidal information for the secondary port of Buckie is presented in Table 3.2 and provides water level information in the vicinity of the Landfall Area. At Buckie, the mean spring range is 3.4 m (i.e. slightly larger than in the Moray West Site) which suggests there is little (approximately 0.2 m) variation in tidal range within the Moray West Offshore Export Cable Corridor. Data from secondary ports is not as robust as that from primary ports; however, the difference in values is sufficiently large to be confident when interpreting the general trend and magnitude of the difference.

Table 3.2: Astronomical Tidal Water Level Statistics

Water Level Statistic		Level (mCD)		
		Wick (Primary Port)	Buckie (Secondary Port)	Moray West Site (MORL AWAC 4c)*
Highest Astronomical Tide	HAT	4.0	4.7	4.4
Mean High Water of Spring Tides	MHWS	3.5	4.1	3.9
Mean High Water of Neap Tides	MHWN	2.8	3.2	3.1
Mean Sea Level	MSL	2.1	2.4	2.3

Table 3.2: Astronomical Tidal Water Level Statistics				
Water Level Statistic		**Level (mCD)**		
		Wick (Primary Port)	**Buckie (Secondary Port)**	**Moray West Site (MORL AWAC 4c)***
Mean Low Water of Neap Tides	MLWN	1.4	1.6	1.5
Mean Low Water of Spring Tides	MLWS	0.7	0.7	0.8
Lowest Astronomical Tide	LAT	0.1	0.1	0.1
Mean Spring Range	MHWS to MLWS	2.8 (m range)	3.4 (m range)	3.1 (m range)
Mean Neap Range	MHWN to MLWN	1.4 (m range)	1.6 (m range)	1.5 (m range)
* Inferred from the Wick tide gauge statistics on the basis of an approximate + 10% observed difference in tidal range between the two locations over the metocean survey period, rounded to 1 decimal place.				

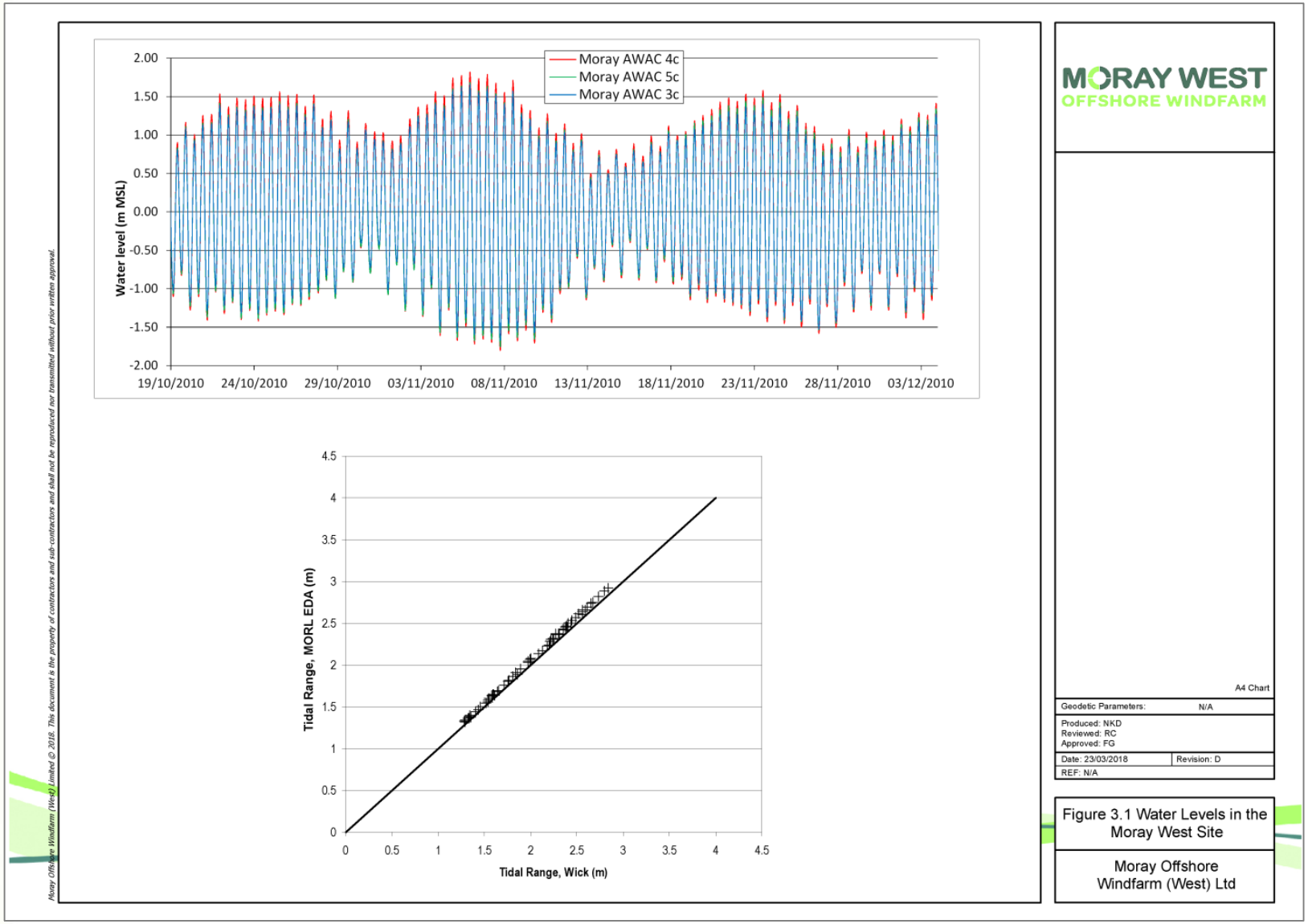

Figure 3.1: Water Levels in the Moray West Site

3.2.3 Non-Tidal Influences on Water Level

In addition to the astronomical tide, water levels may be influenced by meteorology. For example, higher than average atmospheric pressure causes the water level to be relatively depressed (negative surge) whilst low pressure causes water levels to be relatively elevated (positive surge). Either effect can be enhanced or reduced by the additional effect of winds if sufficiently strong and persistent enough, depending upon the direction, location and timing. Moving low pressure systems and associated strong and persistent wind fields may generate a strong positive surge, often referred to as a 'storm surge'. The difference between the predicted astronomical tidal water level and that actually observed is termed the tidal residual.

A study of tidal surge water levels and currents was undertaken by the National Oceanography Centre (NOC, originally known as the Institute of Ocean Sciences, (IOS), and more recently as the Proudman Oceanographic Laboratory, (POL)) (NOC, 2010). The results of the study are presented here to provide return period information as required for the present study (Table 3.3). Estimates of surge water level residuals are derived from differencing the results of two numerical model simulations, one of the astronomical tide alone and another of tide and surge combined over a 40 year period (1955 to 1994). The ten most significant positive surge levels in each year were extracted and statistical extremes analysis was then applied.

On the basis of Table 3.3 as well as estimates for 50-year return presented in HSE (2002), it is found that in general even large storm surges are reported to be of relatively small amplitude (approximately 1 to 1.25 m) in the Moray West Site, becoming smaller with distance into the Firth. This situation in the Moray Firth contrasts with larger values observed elsewhere, e.g. in the southern North Sea where positive storm surges can be between 2 to 3 m (e.g. HSE, 2002). This difference can largely be explained by the configuration and orientation of the two water bodies, including their relative positions within the North Sea basin.

Table 3.3: Extreme Positive Surge Level Estimates Hindcast by the POL CSX Continental Shelf Model for the 40-year Period 1955 to 1994

Return Period (years)	Location 1: 58.167° N; 3.250° W *(To the west of the Moray West Site)*		Location 2: 58.167° N; 2.750° W *(To the east of the Moray West Site)*	
	Positive Surge Height (m)	Surge Height Uncertainty (±m)	Positive Surge Height (m)	Surge Height Uncertainty (±m)
2	0.83	0.02	0.82	0.02
5	0.94	0.02	0.93	0.02
10	1.01	0.03	1.00	0.03
20	1.07	0.04	1.06	0.04
50	1.13	0.05	1.12	0.05
100	1.17	0.06	1.16	0.06

None of the reports include information regarding the phasing of surges relative to high water periods. Comparison with extreme total still water levels from the same data sources at equivalent return periods indicates that surges do not necessarily coincide with high water periods but it is not known if there is a consistent pattern of tide-surge interaction.

3.2.4 Future Changes to the Baseline

Mean sea level in the Moray West Site is likely to alter over the initial lease period of the wind farm (50 years). This change is generally accepted to include contributions from global eustatic changes in mean sea level and also as a result of regionally varying vertical (isostatic) adjustments of the land.

Information on the rate and magnitude of anticipated relative sea level change in the Moray Firth during the 21st Century is available from the UKCP09 (United Kingdom Climate Projections, http://ukclimateprojections.metoffice.gov.uk/). Summary predictions of 21st Century changes in relative sea level at a location to the northwest of the Moray West Site (Bruan, 12 km south of Wick) are presented in Table 3.4. These findings suggest that by 2050, relative sea level in the Moray West Site and surrounding area will have risen between 0.22 and 0.35 m above 1990 levels.

Table 3.4: Summary statistics of 21st Century sea level rise at Bruan (Caithness Coast), relative to 1990 levels

Year	Relative Sea Level Rise Based On Low Emissions Scenario (m)	Relative Sea Level Rise Based On Medium Emissions Scenario (m)	Relative Sea Level Rise Based On High Emissions Scenario (m)
1990	0.00	0.00	0.00
2000	0.03	0.04	0.04
2010	0.06	0.07	0.09
2020	0.09	0.12	0.15
2050	0.22	0.28	0.35
(All values quoted at 95th percentile confidence interval)			

UKCP09 also includes projections of changes to storm surge magnitude in the future as a result of climate change (Lowe *et al*., 2009). For a 'medium emissions' scenario, the 1 in 50-year storm surge event will increase by between 0.08 and 0.36 mm/yr (values apply until 2099), which is approximately equivalent to adding 2 to 9 mm to the values in Table 3.4 over a nominal 25 year lifetime for the wind farm. The resulting effect is evidently small in comparison to natural variability and would not constitute a measurable change.

3.3 Currents

At the regional scale, the tidal streams present in the Moray Firth are relatively complex and variable in direction (Adams and Martin, 1986). The main tidal wave in the open water of the North Sea approaches from the north and progresses south; essentially only the edge of the tidal wave is diverted into the Moray Firth, leading to the observed complexity. Owing to the less restricted passage of the tidal wave across the Outer Firth, tidal currents are stronger here than inshore, where flows are more topographically constrained (Adams and Martin 1986).

In addition to astronomically driven tidal currents, meteorological forcing may also cause an increase in locally observed current speeds. Of particular note in the Moray Firth are (i) currents associated with storm surges; and (ii) orbital currents associated with the passage of waves, both of which have the potential capacity to stir the seabed.

3.3.1 Sources of Current Data

Current speed and direction data for the Moray West Site and surrounding area are available from several sources. These datasets are listed in Table 3.5 and their locations are shown in Figure 2.3.

Table 3.5: Sources of Current Speed Data

Data Source		Latitude (°N)	Longitude (°E)	Period Analysed	Duration
AWACs in the Moray Firth Zone		58.248	-2.746	Jul/10 to Dec/10	100 days
		58.140	-2.695	Oct/10 to Feb/11	106 days
		58.036	-3.152	Jul/10 to Jan/11	124 days
		58.167	-2.900	Jul/10 to Feb/11	103 days
AWACs in the Beatrice Offshore Wind Farm site		58.179	-2.950	10/02/2011- 10/03/2011	(29 days)
		58.297	-2.775		
BODC Data Archive	B0014185	58.400	-2.617	04/11/74 to 08/12/74	(34 days)
	B0049799	58.25	-3.00	04/07/82 to 13/07/82	(9 days)
	B0020756	58.194	-3.001	28/04/81 to 20/06/81	(53 days)
	B0029252	58.106	-3.095	27/05/78 to 28/06/78	(32 days)
NOC CSM Surge Statistics Location 1		58.167	-3.250	N/A	N/A
NOC CSM Surge Statistics Location 2		58.167	-2.750	N/A	N/A
TotalTide (UKHO tidal diamonds)		58.375	-2.642	N/A (Representative spring and neap tidal cycle)	N/A
		58.283	-2.625		
		58.167	-3.100		

3.3.2 Tidal Currents

A numerical tidal model has been created for use in the present study. The design of the model and its inputs, together with a more detailed description of the accuracy and limitations of the model are available in Appendix 6.1 B: Numerical Modelling. The model was calibrated using the discrete observed data sets described in the following sub-sections and so model outputs are in close agreement with the measured data (within the levels of confidence established during model validation). As a result, the model provides a coherent and continuous source of quantitative astronomical tidal water level and depth mean current data over a large area, encompassing both the near-field and potential far-field extent of any effects of the wind farm.

Tidal current predictions from the tidal model have been plotted to show both the near-field (Figure 3.2) and regional (far-field, Figure 3.3) patterns of peak flood and peak ebb currents during spring and neap tides. Summary information from the Moray Firth Zone metocean survey as well as from the BODC and UKHO (Chart 115: 'Moray Firth') is also provided in Figure 3.4, Figure 3.5 and Table 3.6. Collective, the data shows that;

- In the far-field, the highest current speeds are observed to the north of the Moray West Site associated with exchange through the Pentland Firth, and in localised areas to the southeast off the Fraserburgh - Peterhead coast;
- Elsewhere in the Outer Moray Firth, peak spring current speeds are generally less than 0.3 to 0.4 m/s and approximately half the corresponding value on neap tides;
- Generally, peak current speeds decrease in magnitude from the Outer to the Inner Moray Firth, except in narrow tidal inlets where flow speed may be locally increased;

- In the north and northwest of the Moray West Site, peak spring current speeds are typically approximately 0.3 m/s. During the slack water period, current speeds tend toward zero. The flow speeds observed in the north of the site are higher than is generally observed in the Moray Firth as the site is located at the edge of the zone of effect of the Pentland Firth which enhances both flood and ebb tidal current speeds;
- In the southwest of the Moray West Site, peak spring current speeds are typically approximately 0.25 m/s. During the slack water period, current speeds do not tend to reduce below 0.1 m/s throughout the tidal cycle, but rather rotate in direction with a more continuous low speed in this range.
- During neap tides, peak current speeds at all locations in the Moray West Site are typically half of that observed on spring tides;
- Within the Moray West Site, tidal currents are directed generally to the south or south-south-west during the flood tide and to the north or north-north-east during the ebb tide;
- There is little consistent asymmetry between flood and ebb in tidal current speeds and directions;
- The expected vertical profile in current speed for open water un-stratified flows is apparent at all of the Moray Firth Zone AWAC deployment locations, i.e. exhibiting a decrease in current speed towards the bed; and
- Along most of the Moray West Offshore Export Cable Corridor, mean spring peak current speeds are typically relatively uniform and less than ~0.2 to 0.3 m/s. Closer to the Landfall Area, current speeds increased in the vicinity of Spey Bay, off Portknockie, west of the Landfall Area. Here, peak spring tidal currents speed are more typically circa 0.4 to 0.5 m/s immediately adjacent to the coast due to acceleration around the headland.

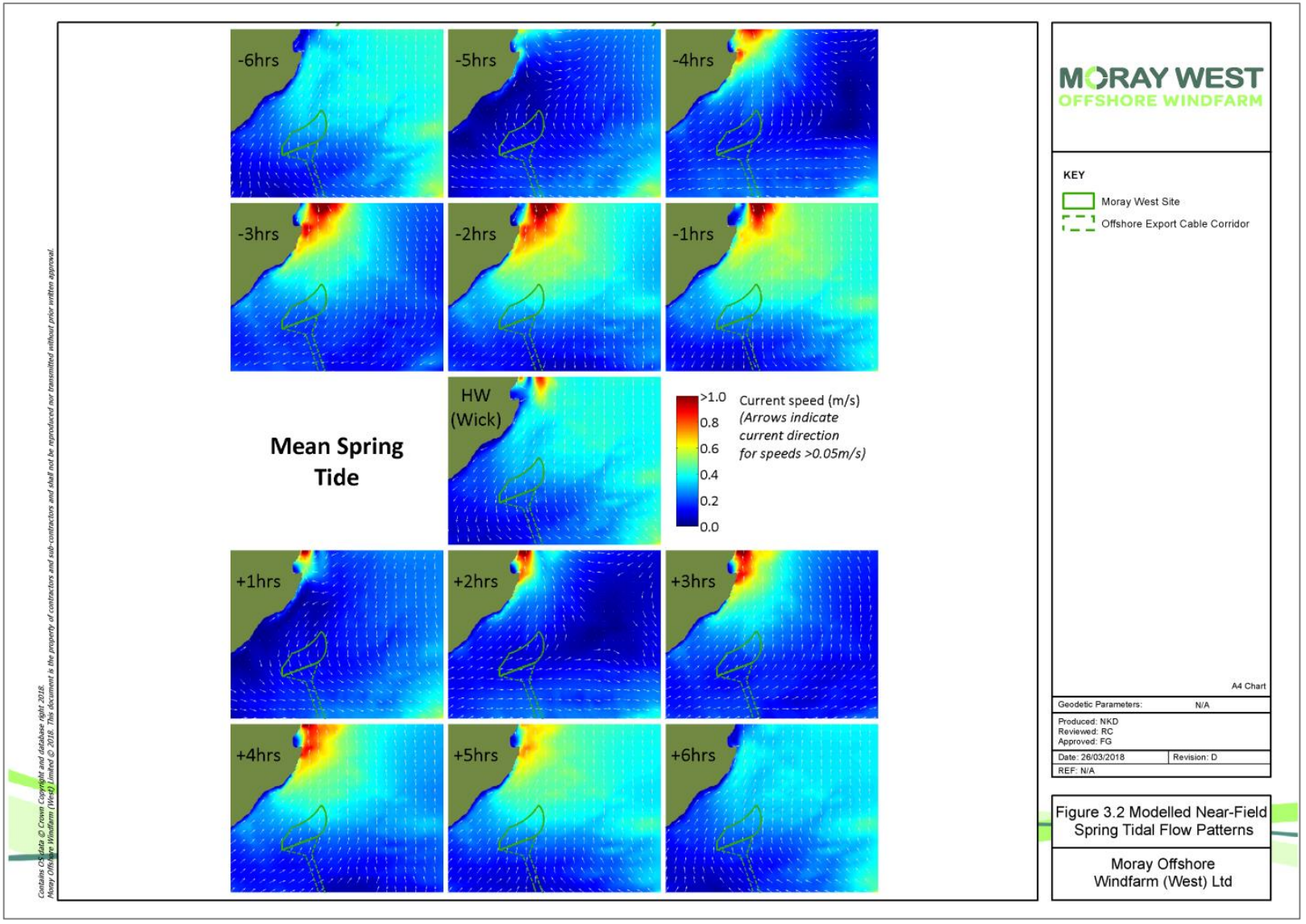

Figure 3.2: Modelled Near-Field Spring Tidal Flow Patterns

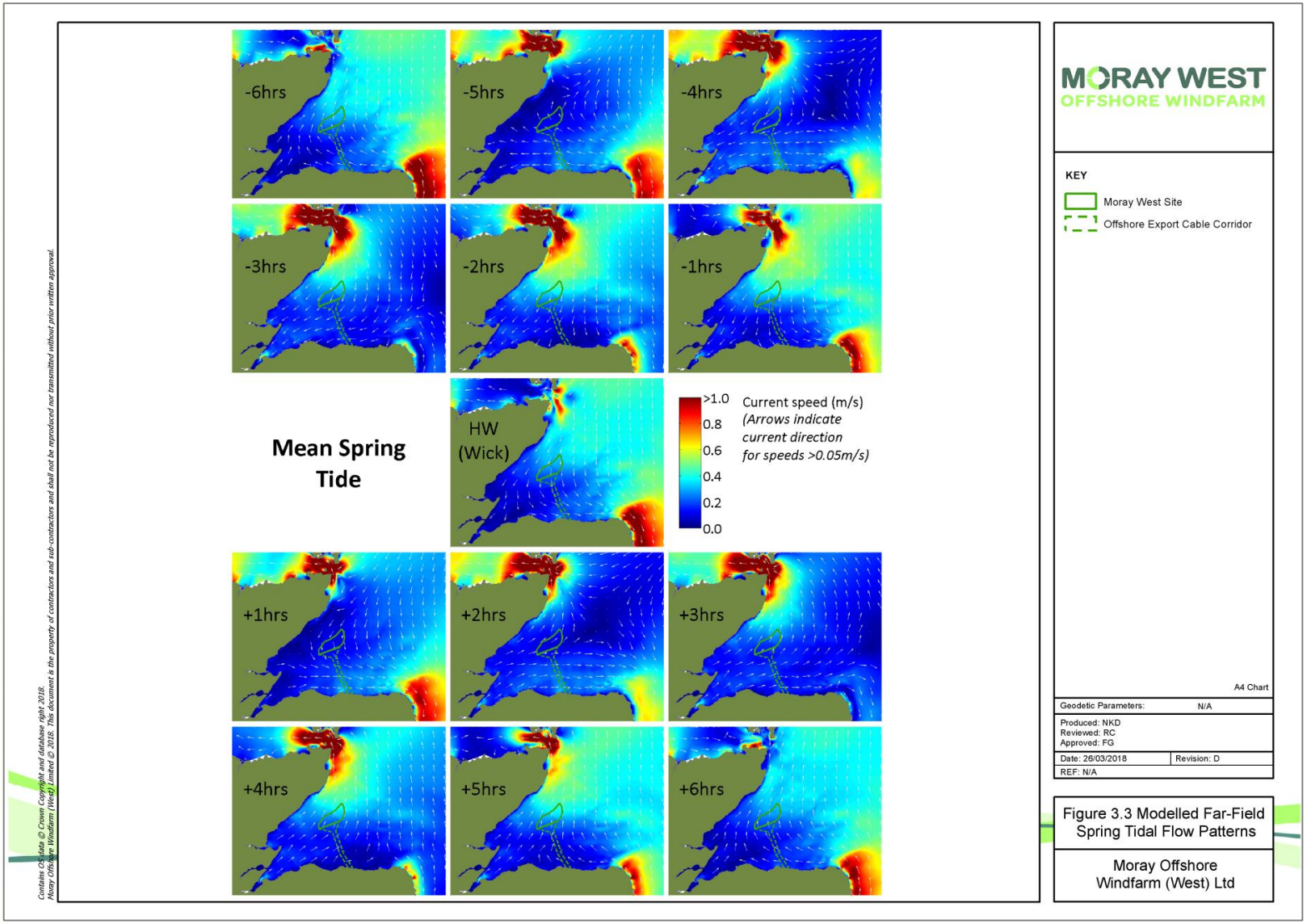

Figure 3.3: Modelled Far-Field Spring Tidal Flow Patterns

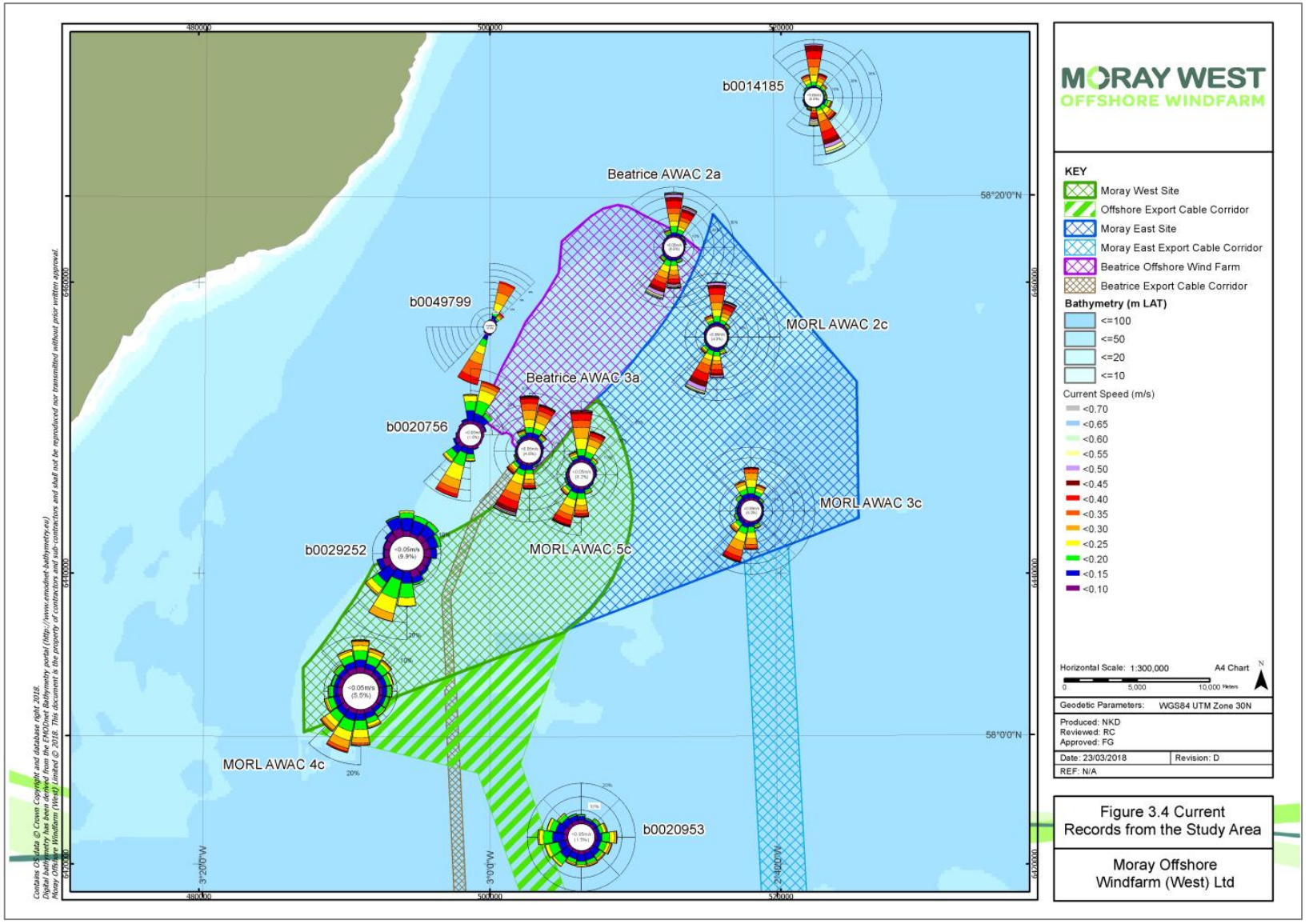

Figure 3.4: Observational Current Records from the Study Area

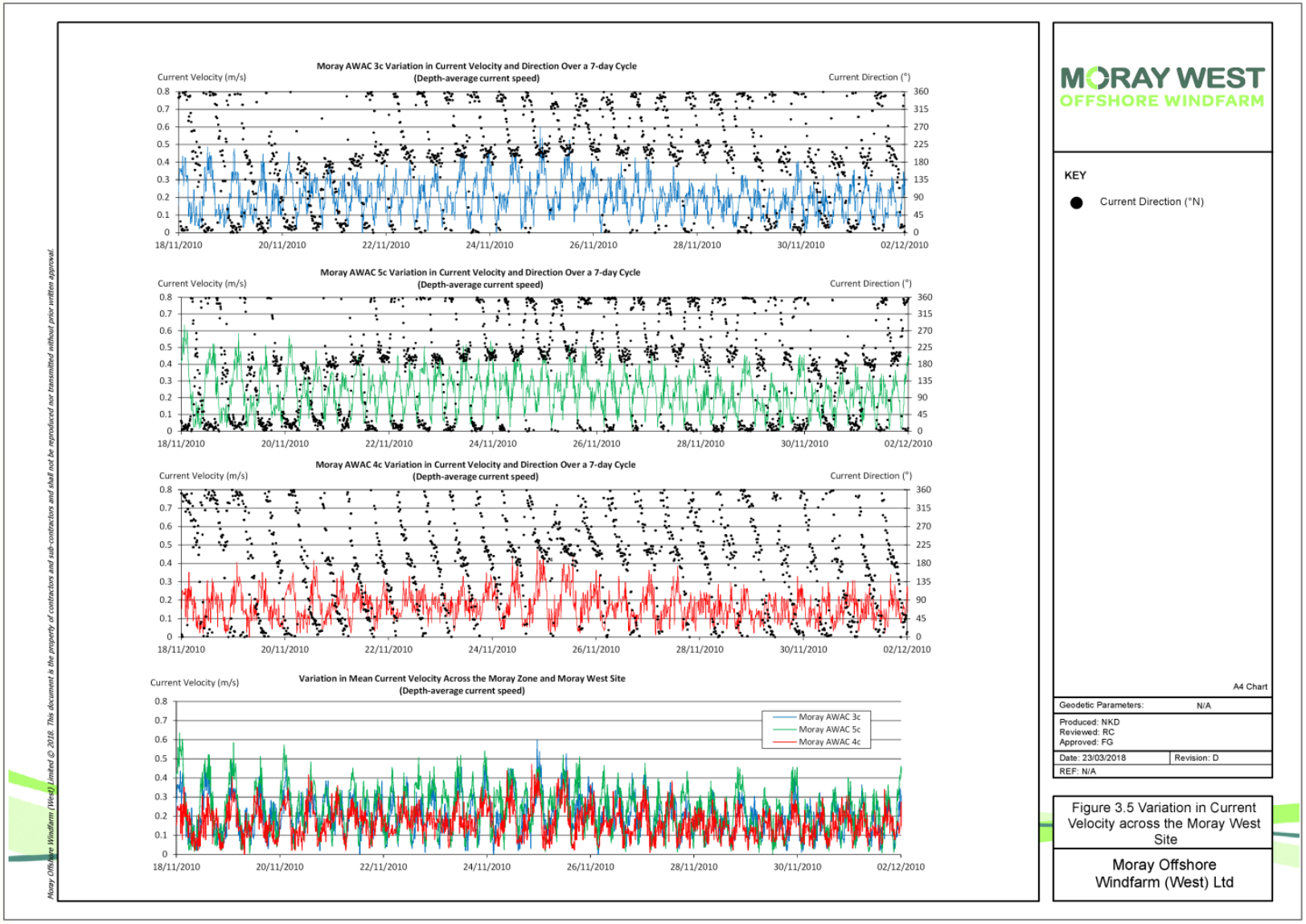

Figure 3.5: Variation in Current Speed within the Moray West Site

Table 3.6: Summary of Tidal Stream Data from Admiralty Chart 115

Hours		Tidal Diamond M			Tidal Diamond N			Tidal Diamond F			Tidal Diamond G		
		58°22.50'N, 2°38.50'W			58°17.00'N, 2°37.50'W			58°10.00'N, 3°06.00'W			58°00.20'N, 3°02.00'W		
		Direction ºN	Spring (m/s)	Neaps (m/s)	Direction ºN	Spring (m/s)	Neaps (m/s)	Direction ºN	Spring (m/s)	Neaps (m/s)	Direction ºN	Spring (m/s)	Neaps (m/s)
After HW	-6	115°	0.21	0.10	094°	0.10	0.05	253°	0.26	0.15	229°	0.10	0.05
	-5	148°	0.31	0.15	143°	0.26	0.10	257°	0.26	0.15	215°	0.15	0.10
	-4	161°	0.36	0.21	156°	0.46	0.21	253°	0.21	0.10	203°	0.15	0.10
	-3	174°	0.41	0.21	165°	0.57	0.26	264°	0.15	0.05	192°	0.15	0.10
	-2	185°	0.36	0.21	178°	0.62	0.31	230°	0.05	0.00	185°	0.10	0.05
	-1	210°	0.21	0.10	179°	0.26	0.10	118°	0.10	0.05	173°	0.05	0.00
HW	0	298°	0.15	0.10	227°	0.05	0.00	082°	0.21	0.10	042°	0.10	0.05
After HW	1	342°	0.26	0.10	334°	0.26	0.10	072°	0.21	0.10	041°	0.21	0.10
	2	347°	0.31	0.15	338°	0.46	0.21	074°	0.21	0.10	024°	0.21	0.10
	3	345°	0.31	0.15	341°	0.62	0.31	071°	0.21	0.10	013°	0.15	0.05
	4	343°	0.36	0.21	347°	0.51	0.26	067°	0.10	0.05	004°	0.10	0.05
	5	353°	0.26	0.15	359°	0.31	0.15	253°	0.15	0.05	290°	0.05	0.00
	6	090°	0.15	0.05	055°	0.10	0.05	252°	0.26	0.10	235°	0.10	0.05
Maximum			0.41	0.21		0.62	0.31		0.26	0.15		0.21	0.1

3.3.3 Non-Tidal Influences on Currents

In addition to modifying water levels, storm surges may also modify the locally observed current speed from that expected from astronomical forcing alone. Because they are induced by meteorological forcing, surge currents are not directly related to the modified tidal range or the rate of water level change during the surge event. In addition to storm surges, individual storm waves can generate significant oscillatory currents through the water column and at the seabed.

Directional 50-year return period surge currents were obtained directly from the NOC (2010) study report. Values for each of 24 times 15° directional sectors were obtained for Locations 1 and 2 which are to the west and east of the site, respectively (Figure 3.6). Estimates for the maximum depth-mean currents associated with a 50-year return period storm surge are 0.23 m/s and 0.75 m/s for Locations 1 and 2 respectively, i.e. decreasing rapidly with distance into the Moray Firth along the length and axis of the Moray Firth Zone. Estimates of total current speed (which take into account surge currents associated with a 1 in 50-year return period storm surge, combined with the mean spring astronomical tidal current contribution) are reported as 0.39 m/s and 1.17 m/s for Locations 1 and 2 respectively. At Location 1, the strongest surge-induced currents are to the south-west whilst at Location 2, the strongest currents are to the south. The large difference between these values over such a short distance does also lead to the conclusion that values may vary greatly within the Moray West Site and that the accuracy of the predicted surge statistics may be sensitive to uncertainty.

The findings from the NOC surge analysis for the Moray Firth Zone are broadly consistent with the depth averaged 1 in 50 year surge currents predictions presented in HSE (2002) for the Moray Firth, which range from approximately 0.2 m/s in the inner Firth to 0.8 m/s in the outer Firth. The orientation of the peak surge current also varies between offshore and coastally constrained areas; generally, the strongest surge currents are directed into the Firth.

Surge currents of the magnitude described above exceed the peak astronomical tidal flows commonly observed across the site, although storm surge currents of this magnitude are experienced only infrequently. This information is considered further in the context of sediment transport in and around the Moray West Site in Section 4.8.

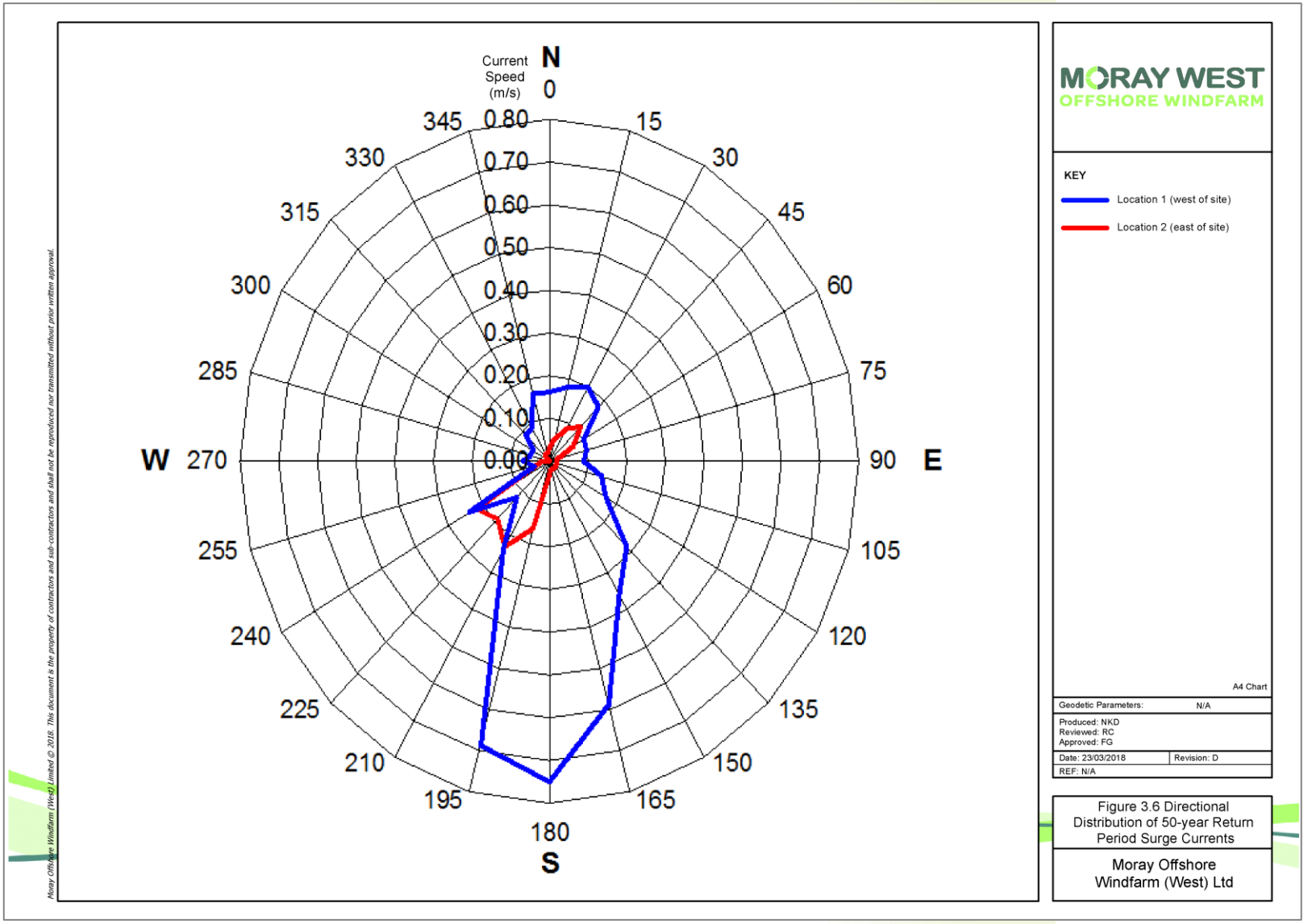

Figure 3.6: The Directional Distribution of 50-year Return Period Surge Currents.

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In addition to surge currents, individual waves induce circular or elliptical movements through the water column. If this motion extends to the seabed, an oscillatory near-bed current will result. Wave induced currents oscillate at wave-period time-scales (order of seconds), typically with a symmetrical near-sinusoidal pattern unless in particularly shallow water. The amplitude of these oscillatory currents can be estimated as a function of wave height, period and the local water depth (Dean and Dalrymple, 1991) and are estimated in Table 3.7 for a series of extreme wave events at two nominal locations and water depths in the Moray West Site (Table 3.7). The return period wave conditions were obtained from analysis of a long hindcast data from UK Met Office meteorological models (see Section 1.1 for further details).

Table 3.7: Maximum Orbital Current Velocities (m/s) at the Seabed Associated with a Series of Low Frequency, High Magnitude Storm Events

	Return Period (years)			
	1	10	50	100
Significant Wave Height Hs(m)	6.7	8	8.9	9.2
Zero Crossing Wave Period Tz (s)	11.0	11.8	12.2	12.4
Orbital Velocity Amplitude (m/s) (MORL AWAC 4c; ~47 mLAT)*	0.65	0.88	1.02	1.08
Orbital Velocity Amplitude (m/s) (MORL AWAC 5c; ~39 mLAT)*	0.82	1.08	1.25	1.31
* Orbital velocities calculated at time of mean water level which is approximately 2 m above LAT				

From Table 3.7 it is apparent that the highest nearbed orbital current amplitudes will be found in the shallowest parts of the Moray West Site. The shallowest depths are encountered along the eastern margin of the Moray West Site and shallow to approximately 35 mLAT. Here, current velocities are approximately 0.8 m/s for a 1 in 1-year return period storm event and over 1 m/s in all areas of the Moray West Site for a 1 in 100-year event. Orbital current speeds of this magnitude are considerably greater than observed peak spring tidal flow speeds described above. The implications of these findings for sediment mobility across the Moray West Site are discussed further in Section 4.8.2.

3.4 Winds

Although not part of the hydrodynamic regime, the wind regime is relevant to the generation of local wind waves and/or larger swell waves, depending upon the direction and strength of the forcing. The relationship between wave generation and meteorological forcing means that the wind and wave regimes are similarly episodic and exhibit both seasonal and inter-annual variation in proportion with the frequency and magnitude of changes in wind strength and direction.

3.4.1 Sources of Wind Data

Several wind datasets are available from different locations within the Moray Firth (Table 3.8 and shown in Figure 3.3).

Table 3.8: Sources of Wind Data in the Moray Firth

Data Source	Latitude (ºN)	Longitude (ºW)	Period Analysed	Duration
Wick Airport Anemometer	58.46	003.09	Jan 1996 to 2010	~ 14 years
Lossiemouth Anemometer	57.72	003.32	1976 to 1988	~ 12 years

Table 3.8: Sources of Wind Data in the Moray Firth				
Data Source	**Latitude (ºN)**	**Longitude (ºW)**	**Period Analysed**	**Duration**
Beatrice Alpha Oil Platform	58.12	003.09	02/1990 to 01/1991	~ 1 year
Met Office UKW Archive	58.17	002.75	Mar 2000 to Nov 2008	8 years, 8 months
Met Office WW3 Archive (modelled data)	58.11	002.83	Nov 2008 to present	~ 2 years
Met Office European Waters Archive (modelled data)	58.3	002.9	Nov 1988 to Nov 2008	~ 20 years
Measured wind data are typically obtained at around 20 m above ground or sea level. The Met Office winds are reported at the same height.				

A wind rose for Wick Airport (for the period 1996 to 2010) is provided in Figure 3.7 whilst extreme return period statistics from the Met Office WW3 model are presented in Table 3.9. Frequency analysis of the Wick Airport wind data shows that the most common wind directions are from the west (247.5 to 292.5 ˚N), accounting for almost 20% of the record, and from the south (157.5 to 202.5 ˚N) and south-east (112.5 to 157.5 ˚N), together accounting for around 35% of the total record. Over 70% of the record contains wind speeds in the range 2 to 8 m/s and observed wind speeds only infrequently (<1% of time) exceed 16 m/s. On the basis of the Met Office WW3 data analysis, the strongest winds occur from the west, with a 1 in 50 year event associated with winds of approximately 30 m/s.

A comparison between the Met Office modelled wind data and the Wick Airport wind record has been undertaken by ABPmer (2010). Although the records are found to be broadly similar, the Wick Airport anemometer consistently reports a lower wind speed than the coincident UKW model data. The differences between the measured and modelled data can potentially be explained by the distance between Wick Airport and the Moray West Site, the differential exposure of an onshore and offshore location, and the unknown positioning or shielding of the Wick Airport anemometer itself.

Table 3.9: Extreme Return Period Wind Speeds (m/s) and Associated Directional Sectors in the Moray West Site								
Wind Speed* m/s								
Return Period (years)	**North 337.5 to 022.5˚ N**	**NE 022.5 to 067.5˚ N**	**E 067.5 to 112.5˚ N**	**SE 112.5 to 157.5˚ N**	**S 157.5 to 202.5˚ N**	**SW 202.5 to 247.5˚ N**	**W 247.5 to 292.5˚ N**	**NW 292.5 to 337.5˚ N**
1	23.51	18.68	19.01	22.67	22.38	23.36	24.03	23.17
10	27.31	22.10	22.47	25.70	25.50	26.39	27.60	26.60
50	29.70	24.24	24.65	27.59	27.45	28.28	29.83	28.73
100	30.68	25.11	25.53	28.36	28.24	29.05	30.74	29.60
* Based on Met Office model data provided with UK Waters & Wave Watch III wave model data.								

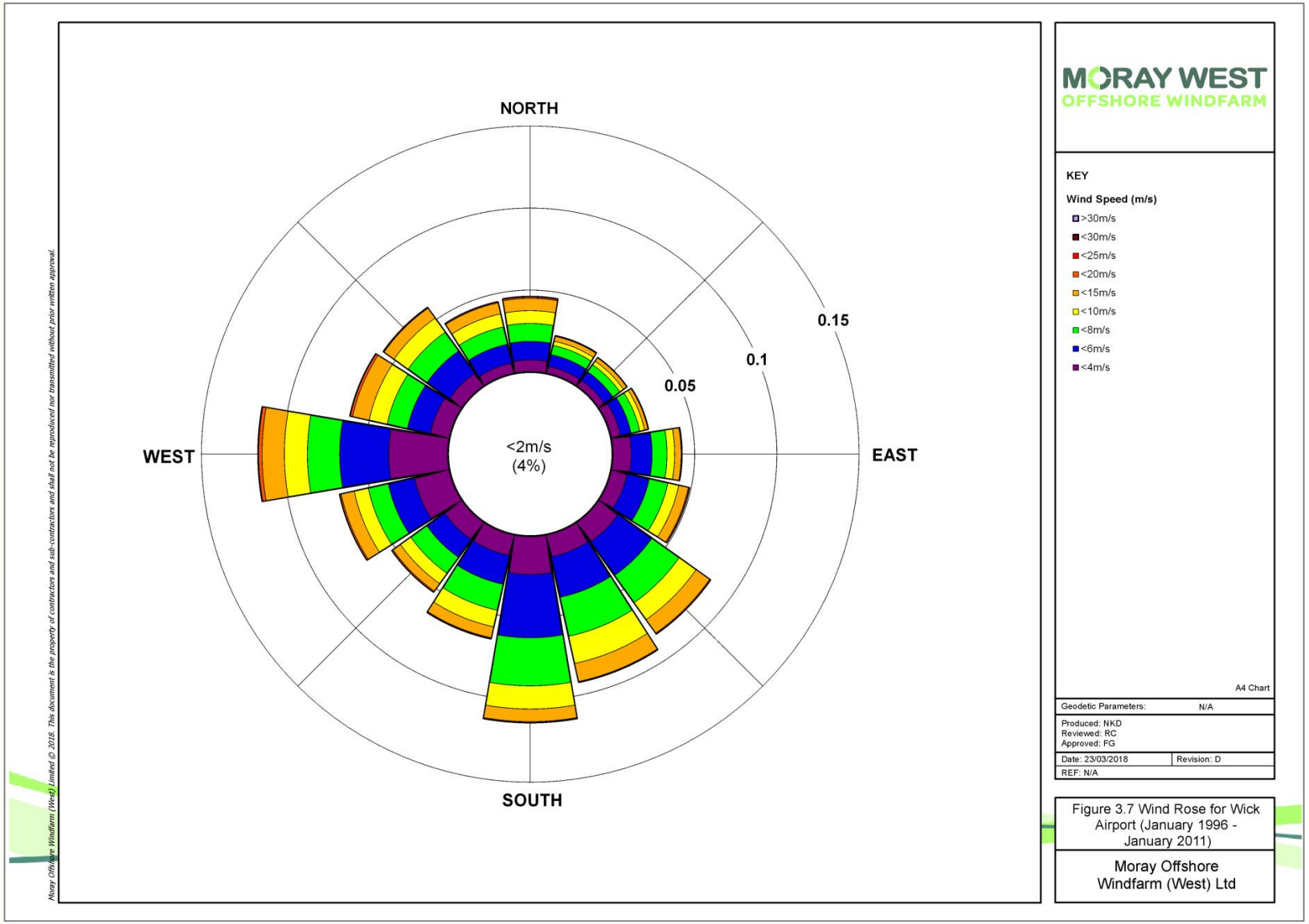


Figure 3.7: Wick Airport Wind Rose (1996-2010)

3.5 Waves

In an area such as the Moray Firth, which is generally characterised by low tidal current energy, winds and waves are critical energy inputs to the coastal system (Reid and McManus, 1987). The wave regime is defined here as the combination of locally generated wind waves and swell waves.

Wind waves result from the local transfer of wind energy to the water surface. The amount of wind energy transfer and wind-wave development is a function of the available fetch (distance of open water across which the wind blows), the wind speed, the wind duration and the original state of the sea. The longer the fetch distance, the stronger the wind and the greater the duration of the wind, the greater the potential there is for the wind to interact with the water surface and generate larger waves. In sufficiently shallow water, depth may become a limiting factor on the further growth of waves. Once further wind input ceases, small wind waves will be dissipated without travelling significant distances.

Swell waves are long-crested, uniformly symmetrical waves, originally wind waves created by a significant storm event outside of the Moray Firth or even outside of the North Sea. Swell waves are different from wind waves as they continue to efficiently propagate over long distances in the absence of any further wind energy input. The longest open fetches over which swell waves can be generated and enter the Moray Firth are approximately 500 to 850 km, from north-north-easterly through south-easterly directions (22 to 135 °N).

Large waves associated with storms occurring several times per year have the potential to cause water movement at the seabed within the Moray West Site. Wave action at the coastline typically has a controlling influence on erosion processes and littoral drift rates at the coast. The rates and directions of these processes are influenced by both the height and direction of the waves reaching the coast. (Sediment transport is considered further in Sections 4.5 and 4.8).

The observed and modelled wave data are presented and discussed in the following sections.

3.5.1 Sources of Wave Data

Wave data for the study area are summarised in Table 3.10. It is important to note that the data sources available are of varying quality and duration. The highest quality datasets are the local observational wave records, e.g. those from the metocean survey deployments and from the WaveNet Moray Firth wave buoy. However, with the exception of the WaveNet Moray Firth wave buoy record, the metocean survey wave records are only relatively short-term (less than 12 months) duration and so do not reliably reflect the longer term (> 3 to 5 years return period) wave climate of the region if used alone. The observational records have however been employed to calibrate numerical models that can be used, in conjunction with other long-term hindcast data sources, to extend the measured data sets and to characterise both the near and far-field wave regime.

The datasets described in Table 3.10 have been used to calibrate and validate a numerical wave model being used to support the Moray West Development EIA studies. The design of and inputs to the model, together with a more detailed description of the accuracy and limitations of the model are available in a separate report (Appendix 6.2: Physical Processes Numerical Modelling). Model outputs are shown to be in suitably close agreement with the measured data (within the levels of confidence established during model validation). As a result, the model provides a coherent and continuous source of quantitative tidal data over a large area including both the Moray West Site and the Moray West Offshore Export Cable Corridor.

Table 3.10: Wave Data Available from the Moray Firth				
Data Source	**Latitude (°N)**	**Longitude (°E)**	**Period Analysed**	**Duration**
Directional Wave Buoy in the Moray East Offshore Wind Farm	58.166	-2.634	Jun/2010-May/11	~11 months
AWACs in the Moray Firth Zone	58.248	-2.746	Jul/10 to Dec/10	100 days
	58.140	-2.695	Oct/10 to Feb/11	106 days
	58.036	-3.152	Jul/10 to Jan/11	124 days
	58.167	-2.900	Jul/10 to Feb/11	103 days
Directional Wave Buoy in the Beatrice Offshore Wind Farm site	58.307	-2.810	11/02/10 - 15/11/2010	~9 months
WaveNet Moray Firth wave buoy (Cefas)	57.97	-3.33	29/08/08 - 06/01/11	~ 2 years
Jacky Platform Wave Buoy	58.183	-2.979	30/09/2008-10/03/2009	~ 6 months
Beatrice Alpha Oil Platform (Comber, 1993)	58.12	-3.09	Summer/ winter 1990	< 1 year
Outer Moray Firth Geosat Altimeter (NERC, 1992)	-	-	1986-1989	~ 3 years
Met Office UKW Archive (modelled data)	58.17	-2.75	Mar 2000 - Nov 2008	8 years, 8 months
Met Office WW3 Archive (modelled data)	58.11	-2.83	Nov 2008 - 2010	~ 2 years
Met Office European Waters Archive (modelled data)	58.3	-2.9	Nov 1988 - 2010	~ 22 years

3.5.2 Wave Climate

A series of wave roses summarizing the available observational wave data from the Moray Firth are shown in Figure 3.8 whilst a frequency analysis of this data is presented in Table 3.11.

. Outputs from the wave model showing spatial variation in patterns of wave height across the Moray Firth associated with winds from selected directional sectors are also shown in Figure 3.9 and Figure 3.10. Finally, information on the seasonal variability in wave conditions (based on the 20 year wave hindcast from the MetOffice) is presented in Table 3.12 and Table 3.13. In summary, it is found that:

- The wave regime in the Outer Moray Firth includes both swell waves generated elsewhere in the North Sea and locally generated wind waves. The wave regime in the Outer Moray Firth is typically characterised by wind waves although longer period swell waves can be identified within the observational wave records collected from within and nearby to the Moray West Site;
- The most frequent wave direction is from the north-east and east with around 75% of all waves originating from this direction;
- The Moray West OfTI is likely to be exposed to waves of smaller size than the wind farm itself with wave heights generally decreasing with increased proximity to the coast. The size of waves will vary along the route depending upon the wind direction and corresponding

fetch. The large range of water depths along the route mean that the ability of a given wave condition to penetrate to the seabed will also be variable;

- Even though water depths across the Moray West Site are no less than 35 m, storm waves sufficiently large to cause water motion at the seabed are not uncommon;
- Along the coastlines of the mid and Inner Moray Firth, waves have a critical role to play in driving sediment transport through the process of longshore drift; and
- The combination of higher, longer period waves experienced during the winter months results in a strong seasonal divide in wave energy reaching the Moray Firth coast with the highest incident energy experienced in the late winter months (Comber, 1993).

Analysis has also been undertaken to quantify the baseline wave climate at surfing venues identified in the Moray Firth (Figure 2.1). Table 3.14 summarises the occurrence of various surf conditions (in days/year), defined according to Surfers Against Sewage (2009), after Halcrow (2006). The values in Table 3.14 are based upon 2 years of modelled wave climate (2007-2008) extracted from the ABPmer wave model at locations 500m offshore of each of the identified surf venues. The 1 in 1 year return period extreme wave has been determined by ranking the wave heights in the data record at each location and assigning a return probability.

These two years of data suggests that large “classic” surfing waves do not occur at any of the Moray Firth surfing venues. Similarly large wave height events do occur, however, they are not typically of a sufficiently long wave period to meet the “classic” criteria; this is likely due to the relatively restricted fetch length in comparison to other UK venues exposed directly to the Atlantic.

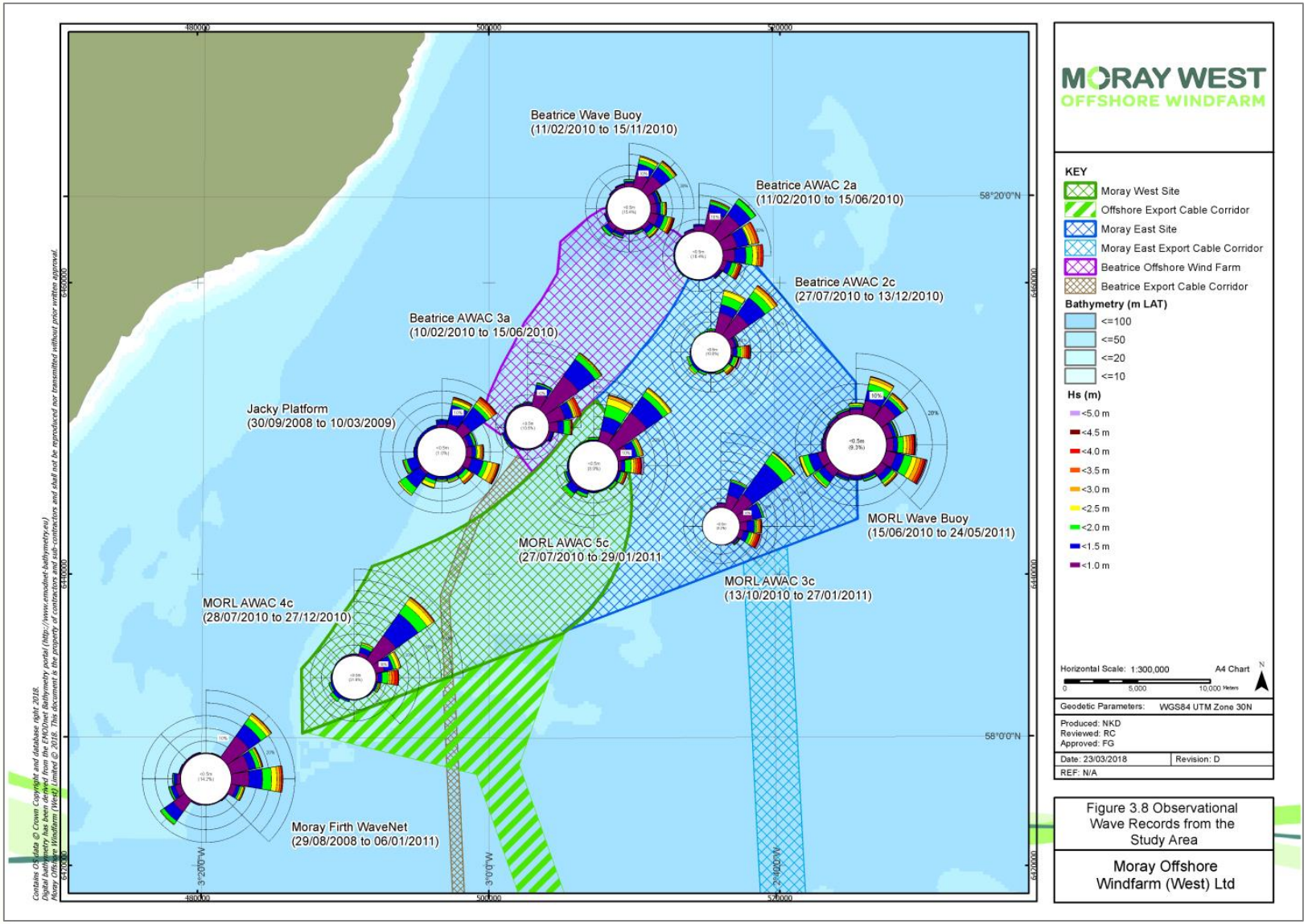


Figure 3.8: Observational Wave Records from the Study Area

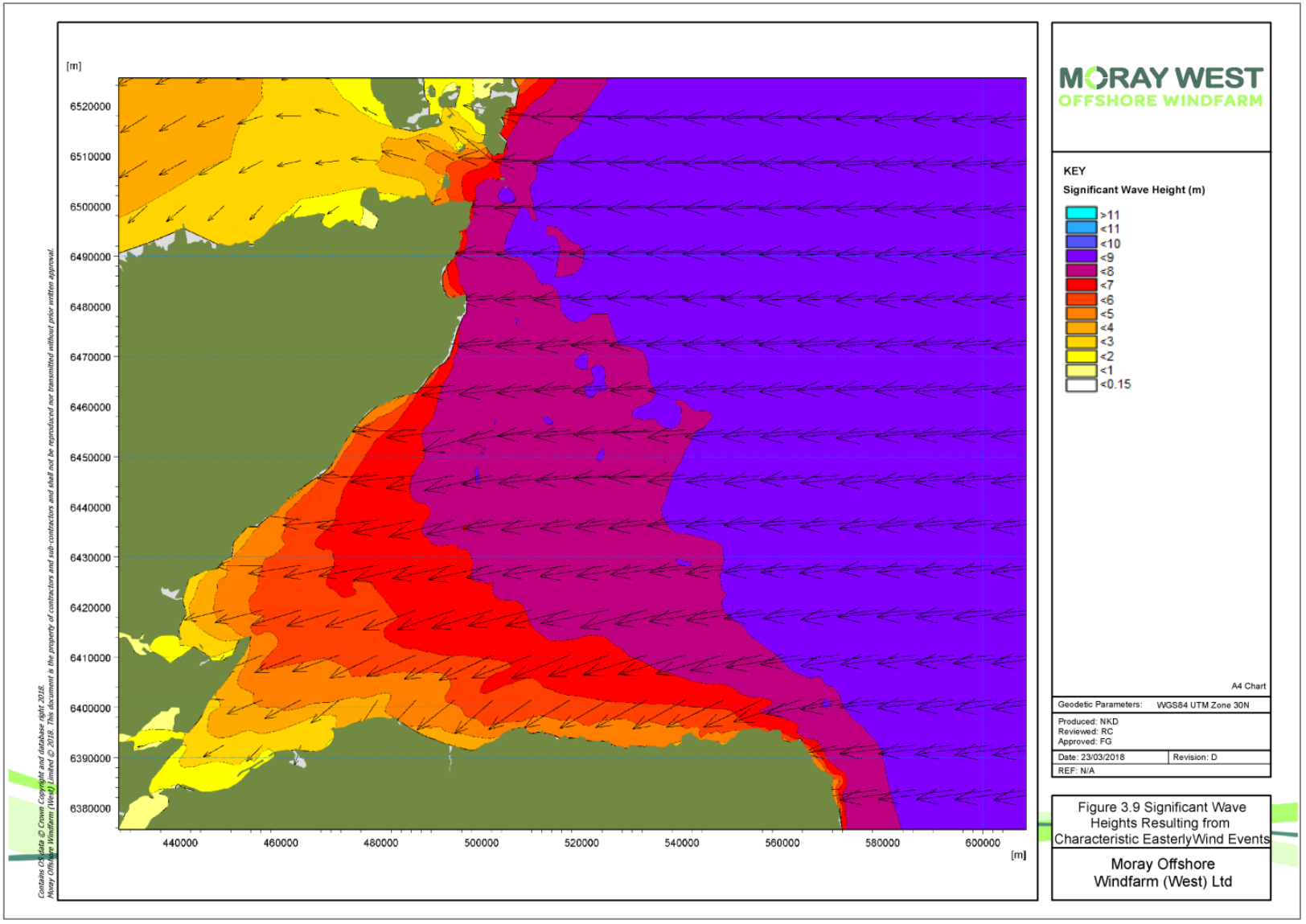


Figure 3.9: Significant Wave Heights Resulting from Characteristic Easterly Wind Events

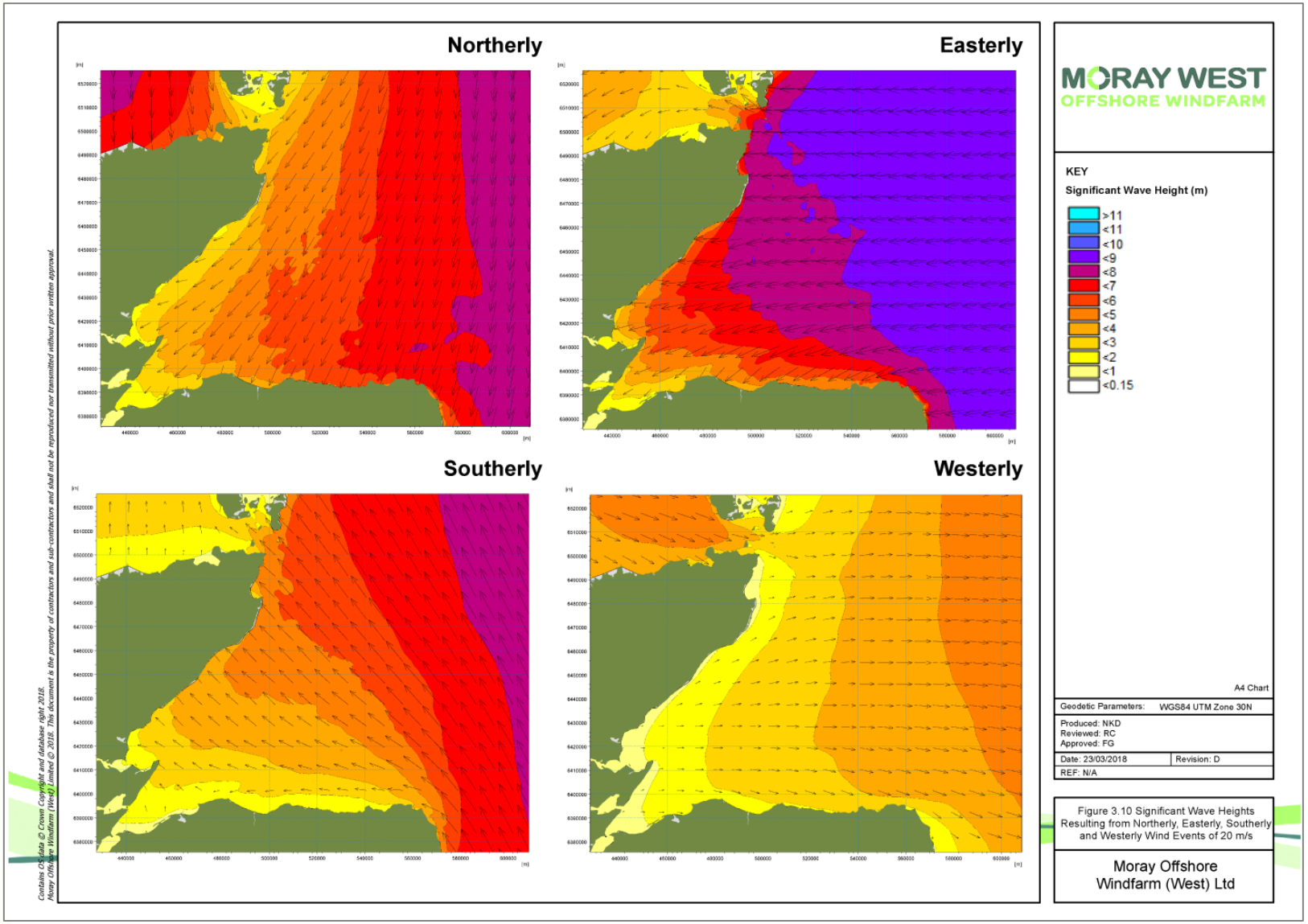


Figure 3.10: Significant Wave Heights Resulting from Winds of 20m/s

Table 3.11: Summary of Frequency Analysis of Observational Wave Records

Buoy/ Deployment	Dates of Deployment	Most Frequent Wave Direction and Percentage of Record	Most Frequent Wave Height and Percentage of Record	Maximum Observed Significant Wave Height and Associated Direction Sector	Most Frequent Mean Wave period and Percentage of Record	Largest Observed mean Wave Period and Associated Direction Sector
MORL AWAC 4c	28/07/2010-27/12/2010	NE (37%)	1-1.5 (27%)	4.69 (E)	5-6 seconds (34%)	8.15 sec. (NE)
MORL AWAC 5c	27/07/2010-29/01/2011	NE (34%)	0.5-1 (30%)	5.55 (E)	4-5 seconds (37%)	8.35 sec. (NE)
MORL Directional Wave Buoy	15/06/2010-15/11/2010	NNE (15%)	0.5-1 (34%)	6.17 (E)	3-4 seconds (34%)	10.3 sec. (E)
MORL AWAC 2c	27/07/2010-13/12/2010	NE (34%)	0.5-1 (28%)	6.61 (ESE)	4-5 seconds (41%)	8.16 sec. (NNE)
MORL AWAC 3c	13/10/2010-27/01/2011	NE (39%)	1-1.5 (41%)	6.29 (ESE)	7-8 seconds (51%)	10.78 sec. (NE)
BOWL Directional Wave Buoy	11/02/10 - 15/11/2010	NE (21%)	0.5-1 (36%)	5.53 m (ESE)	4-5 seconds (34%)	8.9 sec. (NNE)
BOWL AWAC 2a	11/02/2010-15/06/2010	NE (24%)	0.5-1 (37%)	4.48 m (ESE)	3-4 seconds (42%)	8.4 sec. (NE)
BOWL AWAC 3a	10/02/2010-15/06/2010	NE (40%)	0.5-1 (45%)	4.18 m (ENE)	3-4 seconds (47%)	8.5 sec. (NE)
Moray Firth WaveNet Buoy record	29/08/2008-06/01/2011	NE (27%)	0.5-1 (40%)	5.43 m (ENE)	3-4 seconds (45%)	10.3 sec. (NE)
Jacky Platform Wave Buoy	30/09/2008-10/03/2009	NE (18%)	1-1.5 (45%)	5.2 m (ESE)	5-6 seconds (28%)	12.5 sec. (NNE)
Percentages are rounded to the nearest integer						

Table 3.12: Probability of Wave Height Occurrence (% by month)

From (m)	To (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.5	0.2	1.4	2.0	2.4	6.7	8.1	10.6	8.5	2.7	1.2	0.1	2.8
0.5	1	6.4	11.8	13.1	21.4	28.3	33.1	39.6	37.0	24.2	8.9	5.4	8.8
1	1.5	22.0	18.9	26.2	34.1	36.5	33.1	30.7	32.1	32.9	22.8	22.2	20.9
1.5	2	21.7	23.0	21.7	21.5	13.5	15.5	13.5	12.5	20.6	23.0	25.4	23.8
2	2.5	19.1	16.0	15.0	9.8	8.3	6.7	3.4	6.6	10.4	17.9	16.9	17.7
2.5	3	13.8	11.6	9.2	5.0	4.5	1.8	1.8	2.4	5.2	11.7	11.0	10.2
3	3.5	7.6	6.2	5.1	2.9	1.5	1.0	0.4	0.7	2.9	6.3	7.3	6.5
3.5	4	4.3	4.9	3.8	1.1	0.6	0.4	0.0	0.1	0.6	3.7	4.0	3.9
4	4.5	2.1	2.4	2.2	0.8	0.1	0.2	0.0	0.0	0.1	2.0	2.9	2.1
4.5	5	1.1	1.4	0.8	0.6	0.0	0.0	0.0	0.0	0.1	1.3	2.0	1.6
5	5.5	0.6	1.2	0.5	0.2	0.0	0.0	0.0	0.0	0.1	0.9	1.3	1.1
5.5	6	0.8	0.8	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.9	0.5
6	6.5	0.3	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2
6.5	7	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0
7	7.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
7.5	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 3.13: Probability of Wave Height Occurrence/Exceedance (% by month)

From (m)	To (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
0.5	1	99.8	98.6	98.0	97.6	93.3	91.9	89.4	91.5	97.3	98.8	99.9	97.2
1	1.5	93.4	86.8	84.8	76.2	65.0	58.8	49.9	54.5	73.1	89.9	94.5	88.4
1.5	2	71.4	67.9	58.6	42.1	28.5	25.7	19.1	22.4	40.2	67.1	72.3	67.6
2	2.5	49.7	44.9	37.0	20.5	15.0	10.1	5.6	9.9	19.5	44.1	46.9	43.8
2.5	3	30.6	28.9	22.0	10.8	6.7	3.4	2.2	3.3	9.1	26.3	30.0	26.0
3	3.5	16.8	17.3	12.8	5.8	2.2	1.6	0.4	0.9	3.9	14.5	19.0	15.8
3.5	4	9.2	11.0	7.8	2.9	0.7	0.6	0.0	0.1	1.0	8.3	11.7	9.3
4	4.5	4.9	6.2	4.0	1.8	0.1	0.2	0.0	0.0	0.4	4.6	7.7	5.4
4.5	5	2.8	3.8	1.8	1.0	0.0	0.0	0.0	0.0	0.3	2.6	4.8	3.4
5	5.5	1.7	2.4	1.0	0.4	0.0	0.0	0.0	0.0	0.2	1.2	2.8	1.8
5.5	6	1.2	1.2	0.6	0.1	0.0	0.0	0.0	0.0	0.1	0.3	1.5	0.7
6	6.5	0.3	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.6	0.2
6.5	7	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.0
7	7.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
7.5	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3.14: Summary of Occurrence of Surf Conditions (days/year) at Various Locations around Moray Firth

SAS (2009) Description	Hs (m)	Tp (s)	Fraserburgh	Lossiemouth	Banff Beach	Sandend	Boyndie Bay	Inverallochy	Ackergill	Sinclairs Bay	Keiss	Freswick Bay	Skirza	Spey Bay	Cullen Bay	Sunnyside Bay	Pennan	Wisemans	Phingask	West Point
Small waves	1	7	47.7	31.0	36.9	36.9	36.1	36.1	29.3	29.3	39.0	43.6	41.2	36.1	60.4	29.3	39.0	43.6	41.2	40.6
Annual mean wave			1.12m 7.2s	0.72m 5.9s	0.89m 6.4s	0.83m 6.3s	0.86m 6.3s	1.19m 7.3s	0.69m 5.9s	0.77m 6.0s	0.97m 6.5s	1.00m 6.6s	1.03m 6.7s	0.63m 5.3s	0.81m 6.3s	0.85m 6.3s	1.02m 6.8s	1.20m 7.1s	1.17m 7.3s	1.23m 7.3s
	2	10	15.2	6.6	14.3	14.3	12.9	12.9	6.4	6.4	8.1	8.6	7.6	12.9	12.3	6.4	8.1	8.6	7.6	8.4
	3	12	5.2	2.3	6.2	6.2	3.1	3.1	2.6	2.6	1.4	1.6	1.3	3.1	0.7	2.6	1.4	1.6	1.3	1.9
	4	14	0.4	0.2	0.1	0.1	0.0	0.0	0.2	0.2	0.2	0.1	0.0	0.0	0.2	0.2	0.2	0.1	0.0	0.2
Large “classic” wave	4	16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1:1 extreme wave height			5.09m	3.96m	5.36m	5.09m	5.18m	4.35m	4.40m	4.89m	6.07m	5.27m	6.41m	3.24m	4.89m	5.18m	5.41m	6.77m	6.75m	6.80m

3.5.3 Extreme Waves

Modelled wave data from the Met Office UKW and WW3 models have been used to characterise storm events for this region, with details of a series of key low-frequency events in the vicinity of the Moray West Site presented in Table 3.15. Table 3.15 shows that the largest significant wave heights occur from the north-east and range in magnitude from 6.7 m (for a 1 in 1-year return period storm event) to 9.2 m (for a 1 in 100-year return period storm event).

Table 3.15: Extreme Value Analysis Used to Estimate the Significant Wave Height (Hs, in metres) for Given Return Periods for Location 58.25° N 2.86° W

Sector	Directional Range (°N)	Return Period – Hs (m)			
		1	10	50	100
N	337.5 to 22.5	6.3	7.2	7.6	7.9
NE	22.5 to 67.5	6.7	8.0	8.9	9.2
E	67.5 to 112.5	6.7	7.5	8.0	8.2
SE	112.5 to 157.5	6.3	7.1	7.6	7.9
S	157.5 to 202.5	4.6	6.0	6.7	7.0
SW	202.5 to 247.5	4.9	5.8	6.4	6.6
S	247.5 to 292.5	4.7	5.6	6.2	6.4
NW	292.5 to 337.5	4.1	5.0	5.5	5.6
Any direction		6.7	8.0	8.9	9.2

3.5.4 Future Changes to the Baseline

There is now strong evidence to suggest that longer-term changes in storminess have taken place across this region (e.g. Alexandersson *et al*., 2000). These changes may be related to long-term changes in the strength of the North Atlantic Oscillation, a hemispheric meridional oscillation in atmospheric mass with centres of action near Iceland and over the subtropical Atlantic (Visbeck *et al*., 2001). Storminess in this region was relatively high during the late 19th and early 20th Century; followed by a decrease up until about 1970. A subsequent rise in the late 20th century can be clearly identified although most recent years have seen a decline in storminess (Matulla *et al*., 2007). These findings are broadly consistent with published investigations into 21st Century wave climate changes in the North Sea (e.g. Bacon and Carter, 1991; Leggett *et al*., 1996; Weiss and Stawarz, 2005). For example, Leggett *et al*., (1996) analysed wave climate data between 1973 and 1995 and found that in the open northern North Sea:

- Mean significant wave heights increased by approximately 0.2 to 0.3 m (5 to 10%) between 1973 and 1995;
- Peak Hs values between 1988 and 1995 were generally higher than those from the period 1973 to 1987. (Peak Hs values recorded before 1987 were around 11-12 m compared with values of between 12.5-14 m in the period 1988 to 1995); and
- From the early 1980's up until the end of the record, wave conditions became calmer in autumn and more severe in winter.

Climate change modelling as part of UKCP09 (Lowe *et al*., 2009) currently gives the most up-to-date projection of the likely future wave climate. Changes in climate over the 21st century may include changes in mean wind speed and direction which will in turn affect the wave regime. Despite many effects of climate change being associated with an increase in values, UKCP09 indicates that in the

Moray Firth, mean annual maxima of significant wave heights between 1960-1990 and 2070-2100 may decrease slightly (by approximately 0 to 0.5 m). The effect of climate change on wave height over the relatively shorter lifetime of the Development is therefore likely to be negligible in comparison to typical inter-annual or inter-decadal variability.

3.6 Stratification and Frontal Systems

In a large body of water such as the sea, the water column may become vertically stratified where a more buoyant surface layer develops as a result of local solar heating or fresh water input, and where the strength of local mixing forces are not sufficient to mix it with the underlying less buoyant layer.

In the UK shelf seas, vertical stratification of the water column is typically controlled by tidally driven mixing from the bottom (spatially varying - higher under stronger tidal currents and in shallower water) and wind or wave driven mixing from the top (temporally varying - seasonal) balanced by the stratifying influence of solar heating or freshwater input at the surface (also temporally varying - seasonal) (Dye, 2006). In coastal waters the direct input of freshwater from land run-off and rivers dominates changes in salinity. The inner parts of the Moray Firth are considered to be areas of freshwater influence, owing to the input from large rivers draining into the Firth (Baxter *et al*., 2008).

In practice, stratification can be caused by vertical gradients in either temperature and/or salinity and as a result may also be associated with gradients in nutrient concentration and any resulting biological activity. Away from regions of particularly strong fresh water influence (e.g. at the mouth of a river entering an estuary), stratification does not measurably affect the physical action of currents or waves or any related sediment transport processes

Vertical fronts in shelf seas are the transitional boundary between bodies of more vertically mixed and more stratified water. They are also often associated with sharp horizontal gradients in salinity, temperature and bio-chemical quantities and tend to be most pronounced in the summer months when solar heating is strongest. Such fronts typically develop at generally predictable locations where the water depth and tidal current speeds are consistently just sufficient to overcome the typical input of heat or fresh water to a given area.

Since their discovery, tidal fronts have been a focus of attention for their potential role as locations of enhanced biomass production (Hill *et al*., 1993). Indeed, frontal features can also influence the availability of light and nutrients to plankton, enhancing both primary and secondary productivity.

3.6.1 Sources of Stratification and Frontal Data

An assessment of intra-annual patterns of stratification in the North Sea has been undertaken using a long term (51 year) regional scale hydrobiogeochemical model simulation by van Leeuwen *et al*. (2015). The model was forced using 6 hourly meteorological data provided by the European Centre for Medium-range Weather Forecasts (ECMWF) ERA 40 and Operational Analysis Hindcasts (www.ecmwf.int, including pressure, air temperature, wind speed at 10 m height, dew point humidity, and total cloud cover).

A series of predictive maps providing a synoptic illustration of the seasonal variability of stratification features in the pelagic environment are available from UKSeaMap (Connor *et al*., 2006). These maps are based upon hydrographic datasets obtained from the Proudman Oceanographic Laboratory and provide information on (*inter alia*) salinity, temperature, seasonal variation in the probability of fronts forming and seasonal variation in the degree of water column stratification.

A relatively small number of measured temperature and salinity profiles from the previously described metocean survey campaigns are available from both the Beatrice and Moray Firth Offshore Wind Farm application areas. These data provide examples of seasonal variation in the degree of stratification found in the area.

The locations of frontal systems in the study area (also indicating the general states of stratification) have been documented in a number of publications and reports including:

- Temperature and salinity data collected during the Moray Firth Zone and BOWL metocean surveys;
- The OSPAR Quality Status Report 2000, Region II - Greater North Sea (OSPAR, 2000);
- The JNCC Coastal directory series (Barne *et al*. 1996); and
- The DTI SEA 5 Environmental Report (Holmes *et al*., 2004).

However, although the biological aspects of fronts in this region have been considered in some detail, less information is available regarding the physical processes that support them.

3.6.2 Seasonal Stratification

Within the Moray Firth, solar heating causes the water temperature to vary unevenly with depth and season (e.g. Adams and Martin, 1986; Connor *et al*., 2006; van Leeuwen *et al*. 2015). In the summer, the water becomes seasonally stratified due to temperature-related density differences between warmer surface waters and cooler deeper waters, typically forming a weak thermocline at 10 to 15 m depth in the vicinity of the Moray Firth Zone (Figure 3.11). The field data collected indicate that there is no significant freshwater / salinity contribution to the observed stratification. The stratification breaks down at the end of summer and the water column remains well mixed during the winter months due to the increased frequency and severity of storms and a reduced rate of heat input. Temperature and salinity may fluctuate to a greater extent at the coast and in the Inner Moray Firth, due to more highly variable local river input; local temperature stratification in summer may also be associated with relatively warm, fresh river water overlying colder, more saline sea water (Adams and Martin, 1986).

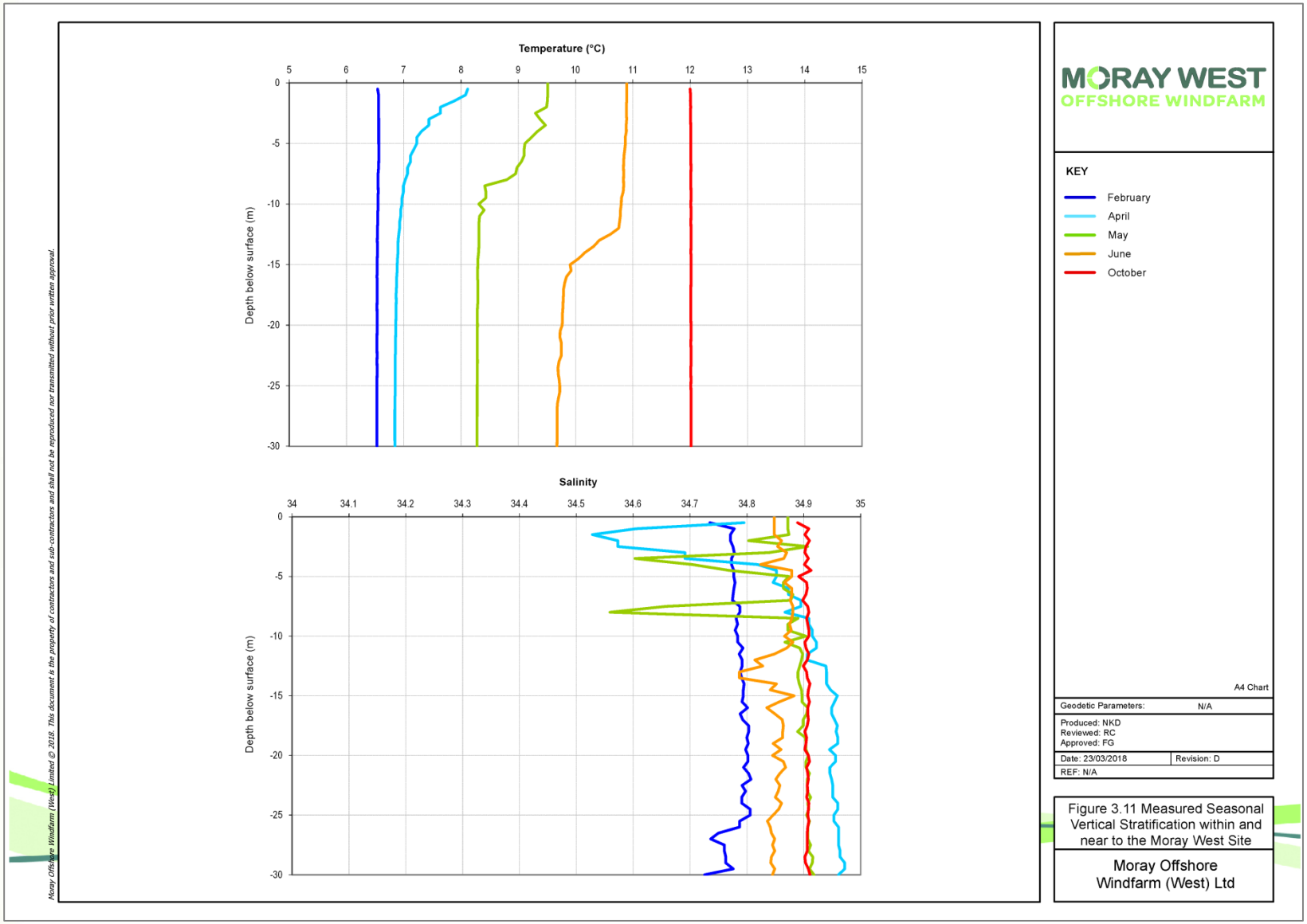


Figure 3.11: Measured Seasonal Vertical Stratification in and near to the Moray West Site

3.6.3 Frontal Systems

Weak thermal fronts are also present in the Moray Firth and their locations have been deduced from infrared satellite images (OSPAR, 2000). Based on the information provided in OSPAR (2000), the fronts represent the boundary between deeper, weakly seasonally stratified water offshore and an area of more intense mixing inshore due to a combination of shallower water depths and relatively stronger tidal currents. On this basis, the position of the fronts are likely to migrate in an onshore-offshore direction in response to the spring-neap cycle and its measurable signal may become weak or absent altogether in proportion to the strength of local (offshore) seasonal stratification.

Fronts are present offshore of the Moray East and Beatrice Offshore Wind Farm Sites and also offshore of Fraserburgh, both in response to areas of locally relatively greater current speeds.

3.6.4 Future Changes to the Baseline

Although temperature and salinity are standard oceanographic parameters, few studies or time-series observations have been undertaken of long-term changes to stratification in the shelf seas around the UK. Thus, although the dynamics of stratification in shelf seas are fairly well understood, confidence in understanding long-term change in shelf stratification is regarded as low (Sharples *et al*., 2013).

The present understanding of climate change predicts variability in many of the parameters affecting stratification, but all with a high degree of uncertainty and with unknown net result. It is therefore assumed that the future baseline situation within the lifetime of the wind farm will be broadly similar to the present.

4 Sediment Regime

4.1 Overview

The surficial seabed sediments present on the UK Continental Shelf vary spatially in character (e.g. grain size distribution) and thickness. The potential for the transport of these sediments is locally controlled by the net action of currents and waves in variable proportions; the relative contribution and dominance of these different driving factors is both spatially and temporally variable (e.g. Kenyon and Cooper, 2005). Mobilisation of sediments will occur when the shear stress imposed on the seabed by these hydrodynamic forces exceeds a critical threshold relevant to the specific material. Once mobilised, sediment will be eroded, transported and eventually redeposited at rates proportional to the shear stress applied in excess of the critical value. Spatial gradients in the properties and availability of sediment and the erosive forcing normally applied to them leads to the natural formation of areas of net erosion ('sources') or deposition ('sinks'), connected by sediment transport pathways. Over longer time-scales, changes to these components of the sediment regime will determine the net morphological evolution of an area.

Within the Outer Moray Firth, previous surveys have revealed that the seabed is typically devoid of contemporary large scale bedform features, indicating that in terms of sediment transport this is a low energy region in most locations for most of the time. This is further confirmed by models of maximum bed-stresses presented in UKSeaMap which are typically very low (Conner *et al*., 2006). Net sediment transport pathways are directed into the Firth in the north and due to the relatively benign tidal regime it is suggested that transport is limited in frequency and related to low-frequency, high-energy events. This assertion is supported by the observed trend of decreasing sediment grain size with increasing water depth within the Firth, reflecting the relative importance of wave energy to sediment transport processes (Reid and McManus, 1987). Supplies of new sedimentary material from the land into the Firth are very limited (Barne *et al*., 1996).

The sediment regime in and around the Moray West Site has been considered in the following sections:

- The composition and distribution of seabed sediments across the Moray West Site and the wider far-field study area;
- The composition of the sediment sub-strata across the Moray West Site and the wider far-field study area;
- Sediment transport pathways in the vicinity of the Moray West Site in the form of a conceptual understanding of the sediment regime; and
- The key process controls on sediment mobility and thresholds of sediment motion.

4.2 Sources of Sediment and Geological Data

Key sediment and geological data for the Moray West Site is available from several sources which are summarised in Table 4.1.

Table 4.1: Sediment and Geological Data Available from the Moray Firth

Data Source	Reference
Moray West OfTI benthic survey	PMSL (2017)
Moray East Offshore Wind Farm benthic survey	EMU (2011)
Moray Firth Zone geophysical survey	Osiris (2011)
Moray Firth bathymetric survey (inc. Moray West and Moray East)	MCA (2006)
BGS seabed sediment maps	BGS (1984, 1987)

Table 4.1: Sediment and Geological Data Available from the Moray Firth	
Data Source	**Reference**
Regional Geology and Geomorphology	Andrews *et al*. (1990); Holmes *et al*. (2004)
MORL (Moray East) AWAC deployments (OBS turbidity sensors)	Partrac (2011)
BOWL AWAC deployments (OBS turbidity sensors)	Partrac (2010)
BGS Rock/ Hard Substrate Map	Gafeira *et al*. (2010)

4.3 Seabed Sediments: Composition and Distribution

The distribution of sediments across the Moray West Site and surrounding area is shown in Figure 4.1. The following description of seabed sediment type is based mainly on the information provided by grab samples and other acoustic backscatter based methods. Descriptions of sedimentary bedforms and features are informed by and consistent with the various high resolution bathymetric surveys of the area, including partial coverage of the Moray West site from Osiris (2011) and full coverage of a much wider area, including both the Moray West and Moray East sites, by MCA (2006).

All of the grab samples collected during the Moray West and Moray East Offshore Wind Farm survey campaign were analysed using the GRADISTAT grain size distribution and statistics package (Blott and Pye, 2001) and classified using the Folk (1954) sediment classification scheme (for consistency with pre-existing broad-scale mapping such as that offered by the BGS). Sample locations have been plotted overlying the BGS Moray-Buchan and Caithness seabed sediment maps BGS (1984; 1987). The benthic samples share the same colour scheme as that employed in the BGS seabed sediment map in order to facilitate comparison between the two datasets.

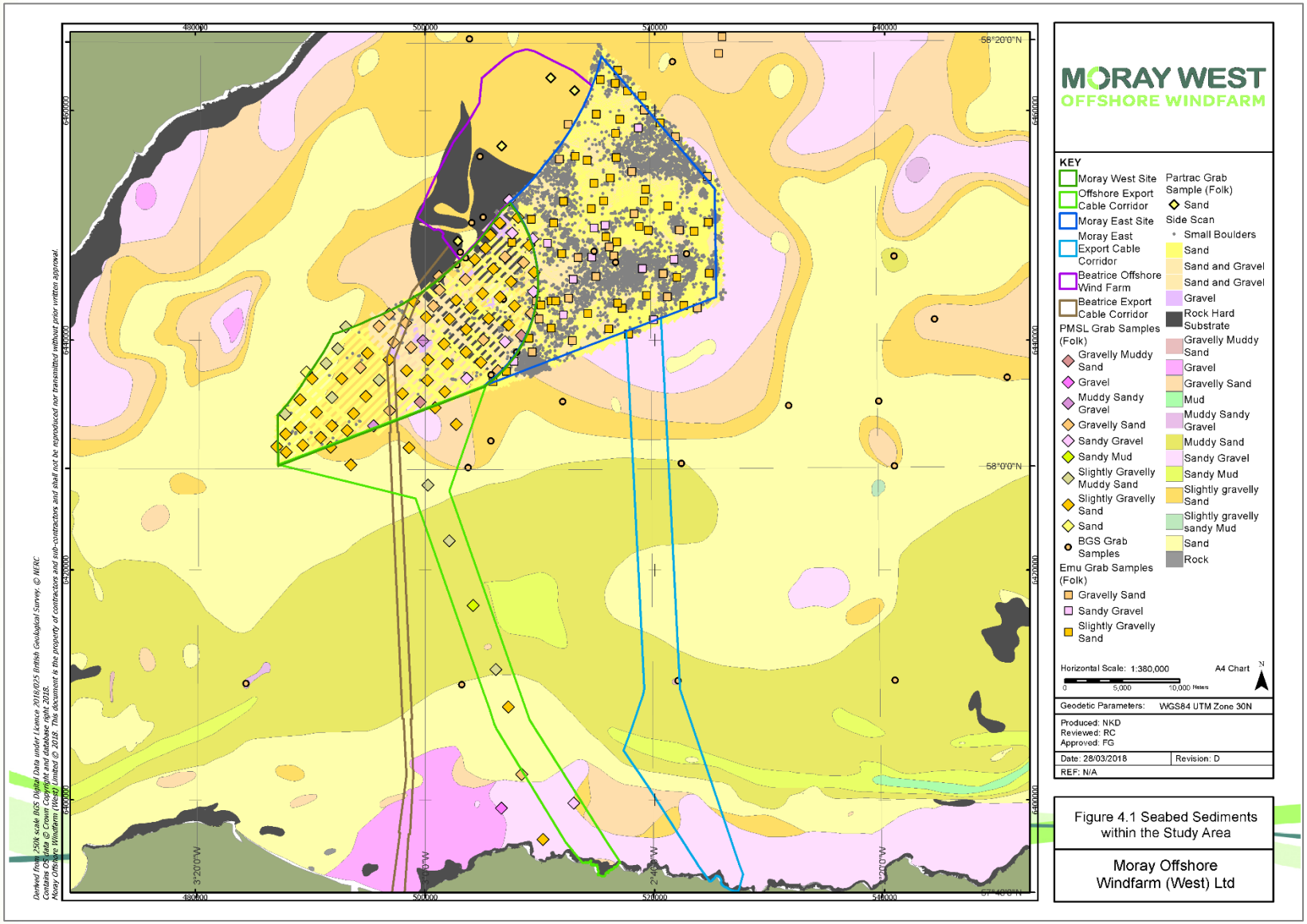


Figure 4.1: Seabed Sediments within the Study Area

Figure 4.1 shows that, according to the locally collected grab samples and regional BGS data, the Moray West Site is dominated by coarse grained (sand and gravel) seabed sediments in variable proportions. Fine grained (muddy) material is only present in very low proportions (<5 to 10 %). Almost the entire western section of the site is characterised by sandy sediments whilst isolated patches of gravel sediments are found in central and north-eastern areas. These findings are in broad agreement with the region-scale mapping provided by the BGS, which also highlights the generally lesser presence of finer grained sediments around the crest of Smith Bank.

Most (82%) of the benthic samples were found to have a unimodal distribution. Modal particle sizes were found to be variable across the site, ranging in size from 24,000µm (pebble gravel) to 150µm (fine sand). However, the majority of samples have a modal value of 150 to 215 µm (fine sand). Over half of the samples are either poorly or very poorly sorted. Poor sorting of material is indicative of low seabed sediment mobility and is consistent with the seabed in this area being a lag gravel deposit.

Small boulders are also present across the Moray West Site. These are thought to have been winnowed out of the underlying glacial till unit although the larger boulder sized clasts (>1.0m) may also represent glacial erratics, deposited during the last glacial period.

Carbonate sediments (comprised mainly of shell fragments) make a significant contribution to the sediment deposits of the Moray Firth and the proportion of shell content in the benthic grab samples from nearby to the Moray West Site are frequently in excess of 50% (EMU, 2011; BGS, 1987). The proportion of carbonate material in seabed sediments decreases with distance from the source (in this case thought to be the Shetland and Orkney Islands).

The BGS was commissioned by Defra to produce a digital data layer (map) of the distribution of hard substrate at, or near (~ <0.5 m), the seabed surface across all areas of the United Kingdom Continental Shelf (UKCS) (Gafeira *et al*., 2010). This study was undertaken to help improve understanding of where rock or hard ground outcrops occur in the marine environment. The data layer was compiled using a variety of published and unpublished survey data and indicates that the eastern half of the Moray West Site is characterised in some localised areas by a hard seabed substrate. Across this area, surficial sediments are generally thin (<0.5 m) with the underlying glacial till of Smith Bank very close to the surface. However, BGS core sampling (unpublished) also indicate that seabed and superficial sediments on the crest of the bank can be greater than 2 m thick in places (Holmes *et al*., 2004).

On the basis of the available BGS seabed mapping, the surficial sediment distribution along the OfTI is found to be highly variable, reflecting variations in tidal current speed and water depth (which influences the effectiveness of wave stirring of the bed). At both the offshore end of the Moray West Offshore Export Cable Corridor (where it meets the Moray West Site) and at the coast, fine to medium sandy sediments dominate, with a small proportion of gravel in some areas. In contrast, muddy and sandy mud deposits are widespread through middle sections of the route, where it crosses the western end of the Southern Trench.

4.4 Sediment Sub-Strata: Composition and Distribution

The offshore surface geology in the Outer Firth is comprised predominantly of Cretaceous rocks whilst both Jurassic and Permo-Triassic rocks are encountered along the southern/inner margins of the Firth. An extensive blanket of Quaternary deposits is present across almost the entire Firth with sediment thicknesses of around 70 m commonly observed (Chesher & Lawson, 1983). Chesher & Lawson (1983) have classified the Quaternary deposits within the Moray Firth and have defined a series of sedimentary units based upon the thickness of the deposits. The units in the north of the Firth are generally thinner whilst the southern units were found to be much thicker. Stratigraphic details of the sediments of the Moray Firth are presented in Chesher & Lawson (1983) whilst a more comprehensive account of the geology of the Moray Firth is given by Andrews *et al*., 1990.

A summary of the sedimentary units encountered at the Moray West Site is given in Table 4.2 and has been compiled from the geophysical survey undertaken by Osiris (2011). These individual units have been arranged into larger sediment groupings separated by 'isopachytes' (lines connecting points on the seabed with an equal depth of sediment). (Similarly detailed understanding of the spatial variation in sediment sub-strata along the OfTI corridor is presently lacking.)

Table 4.2: Summary of Sedimentary Units Within the Moray West Site, from Osiris (2011)

Description and Sections	Designation	Sediment Grouping
SAND/SILT (Surface Unit)	Unit 1 (Holocene)	Marine Sediments
SAND	Unit 2a (Holocene/Late Pleistocene)	
Fine SAND/SILT/CLAY	Unit 2b (Holocene/Late Pleistocene)	
Isopachyte 1 - Base of Marine Sediments		
Layered sandy silty CLAY	Unit 3a (Mid to Late Pleistocene)	Mid to Late Pleistocene Sediments
Sandy silty CLAY (chaotic to featureless appearance)	Unit 3b (Mid to Late Pleistocene)	
Very stiff to hard CLAY/dense SAND generally poorly ordered	Unit 4a (Mid to Late Pleistocene)	
Very stiff to hard CLAY/dense SAND parallel bedded	Unit 4b (Mid to Late Pleistocene)	
Very stiff to hard CLAY/dense SAND generally massive/chaotically bedded	Unit 4c (Mid to Late Pleistocene)	
Isopachyte 2 – Top of ice pushed sediments		
Very hard CLAY/ dense sand	Unit 5a (Early Pleistocene/Lower Cretaceous)	Ice pushed Formations
Isopachyte 3 – Top of unaltered Lower Cretaceous		
Very hard CLAY (intact bedded formations)	Unit 5b (Lower Cretaceous)	(Cretaceous Rocks)

Total sediment thicknesses are highly variable across the Moray Firth Wind Farm site, ranging from ~5 to 15 m in the west of the Moray West Site, up to 30 m in the east (Osiris, 2011). An overview of each of the four main sediment groupings is provided in Cathie Associates (2011) and repeated below.

Unit 1 – Surficial Marine Sediments

The surface sediments were generally shown to comprise very loose to medium dense sand, occasionally dense to very dense and soft to firm slightly sandy clay. The unit was encountered across the Moray West Site as thin deposits at seabed level and is suggested to have accumulated since the Holocene transgression, in marine conditions similar to the present day. In places, these sediments may be mobile, migrating slowly down slopes and in response to wave motion.

Unit 2 – Marine Sediments

This unit generally occurs as thin deposits, however is locally thicker infilling channels in the central eastern part of the Moray West Site. Here, the marine sediments reach a maximum of 34 m within a localised channel feature (Osiris, 2011). The sediments are typically medium dense to very dense sometimes silty sand with some gravel and shell fragments, typically becoming looser/more cohesive with depth. Clay beds, up to 2.4 m thick bands of very soft to very stiff sandy clay were noted in places. Unit 2 is thought to represent Holocene to Upper Pleistocene (Possible Forth Formation) aged marine sediments.

Unit 3 – Chaotic/Lag Till

Likely to be part of the Forth Formation and found as a notably variable lag/chaotic till unit. The unit, as presented on geotechnical boreholes logs comprises very soft to occasionally very stiff sandy clay. A smaller fraction of loose to very dense sometimes silty sand, occasionally with some shell fragments and gravel is also noted.

Unit 4 – Over-consolidated Till

Likely to be part of the Coal Pit or other older formations and generally comprises interbedded medium dense to very dense silty Sand with shell fragments and gravel or pockets of clay, or stiff to very hard sandy Clay with laminae/beds of silty fine sand and occasional gravel and cobbles. Occasional black or organic material is noted. In places these deposits reach 65 m thick although are more typically in the range 10 to 40 m (Osiris, 2011).

Unit 5 – Lower Cretaceous Sediments

Determined through palynolgical testing to be from the Lower Cretaceous era and is described as dense (occasionally medium dense) to very dense silty SAND with thin to thick beds or pockets of clay, and very stiff to very hard sandy CLAY with thin laminae to medium beds of silty sand. The soil descriptions indicate little difference between unit 5a and 5b.

The boundary between the ice pushed sediments and the overlying Pleistocene sediments is complex, and occasionally the older ice pushed sediments are encountered over the Pleistocene sediments suggesting multiple ice movement/ glaciation events.

4.5 Conceptual Understanding of the Sediment Regime

In comparison to other areas of the North Sea, relatively little has been previously published about the dynamics of sediment transport in the Moray Firth. By far the most comprehensive account of sediment exchange within the Moray Firth has been provided by Reid and McManus (1987). Some discussion is also provided by Holmes *et al*. (2004). Findings from these investigations are summarised in the following sub-sections.

There are two primary mechanisms of sediment transport:

- **Bed-load transport.** This mechanism refers to all sedimentary grains that move, roll or bounce (saltation) along the seabed as they are transported by currents. This mode of transport is principally related to coarser material (sands and gravels); and
- **Suspended-load transport.** This mechanism refers to particles of sediment that are carried above the seabed by currents and are supported in the water without recourse to saltation.

These two mechanisms of transport can be variably controlled or dominated by different processes (e.g. currents, waves or some combination of the two) and hence require separate consideration.

4.6 Bed Load Transport

Although there is a general scarcity of well-defined bedforms characteristic of frequent bedload transport in the Moray Firth, a limited number of observations have been made outside of the Moray West Site in previously collected geophysical data. Sand ribbons and sand waves have been identified in the vicinity of the Caithness coastline and longitudinal and transverse sand patches have been observed as the dominant bedform in the centre of the Outer Moray Firth. Using information contained in references such as Stride (1982) to interpret the likely net transport associated with these bedforms, Reid and McManus (1987) inferred a number of sediment transport paths within the Moray Firth. They suggest that material is circulating through the Firth entering from the north, moving along the Caithness coast and into the Inner Moray Firth (Figure 4.2). Once within the Firth, marine sediments become dispersed along routes broadly parallel to the tidal flow axis. Sediment is also exiting the Firth in the south-east, with eastward transport noted along the southern coast, particularly to the east of the River Spey; in the Outer Firth, to the south of the Moray West Site. Some sediment transport pathways also branch in a southerly direction from the Pentland Firth, bypassing the Moray Firth altogether.

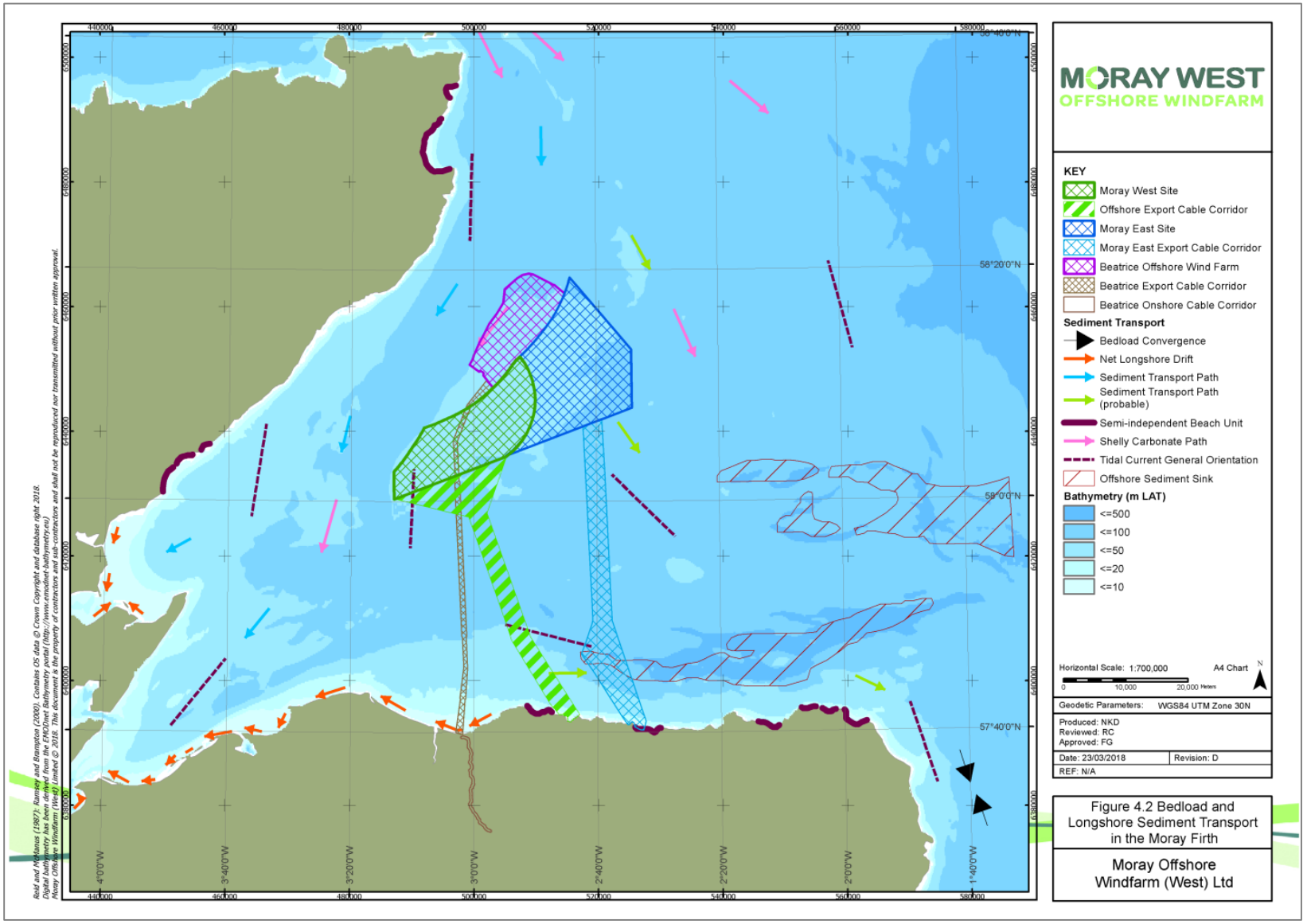


Figure 4.2: Bedload and Longshore Sediment Transport in the Moray Firth

Modelling analysis presented in Holmes *et al*. (2004) has provided an insight into the relationship between tidal state, storminess and sediment movement in the Moray Firth. For example, during fair weather mean peak spring tide near-bed current speeds and directions were not found to closely follow observed sediment transport directions in the Moray Firth; however, stormy conditions in conjunction with the same tidal scenario was found to more closely correlate with the observed net sediment transport directions. This analysis indicates that tidal currents modified by stormy conditions and storm surge (typically directed into the Firth along the Caithness coast – see Section 3.3) are the major influence on the net movement of seabed sediments in the Moray Firth.

4.7 Suspended Load Transport

Information on the naturally occurring range of suspended sediment concentrations is available from several reference sources:

- Suspended sediment concentrations measurements collected during the MORL (Moray East) Moray Firth Zone survey and BOWL metocean surveys (Partrac, 2010; 2011);
- Satellite-based observations of suspended particulate matter in surface waters (Cefas *et al*., 2016); and
- An ecosystem model of suspended sediment concentrations (Baxter *et al*., 2008).

Suspended sediment concentration (SSC) has been inferred from Optical Backscatter Sensors (OBS) deployed together with the each AWAC device as part of the metocean surveys undertaken for the Moray Firth Zone and Beatrice Offshore Wind Farm. The OBS units were mounted approximately 0.75 m above the seabed on the AWAC frame and recorded water turbidity by measuring the backscatter intensity from a pulse of light emitted into the adjacent water. The raw units of turbidity measurement were calibrated to a suspended sediment concentration in a laboratory using artificial suspensions of the locally present sediments. A subset of measurements (14/10/10 to 27/01/11) from the Moray Firth Zone are presented in Figure 4.3, alongside measurements from the adjacent Beatrice Offshore Wind Farm. Hydrodynamic data collected during the same time interval are also shown to demonstrate the relationship between the forces potentially driving sediment resuspension and the resulting levels of SSC.

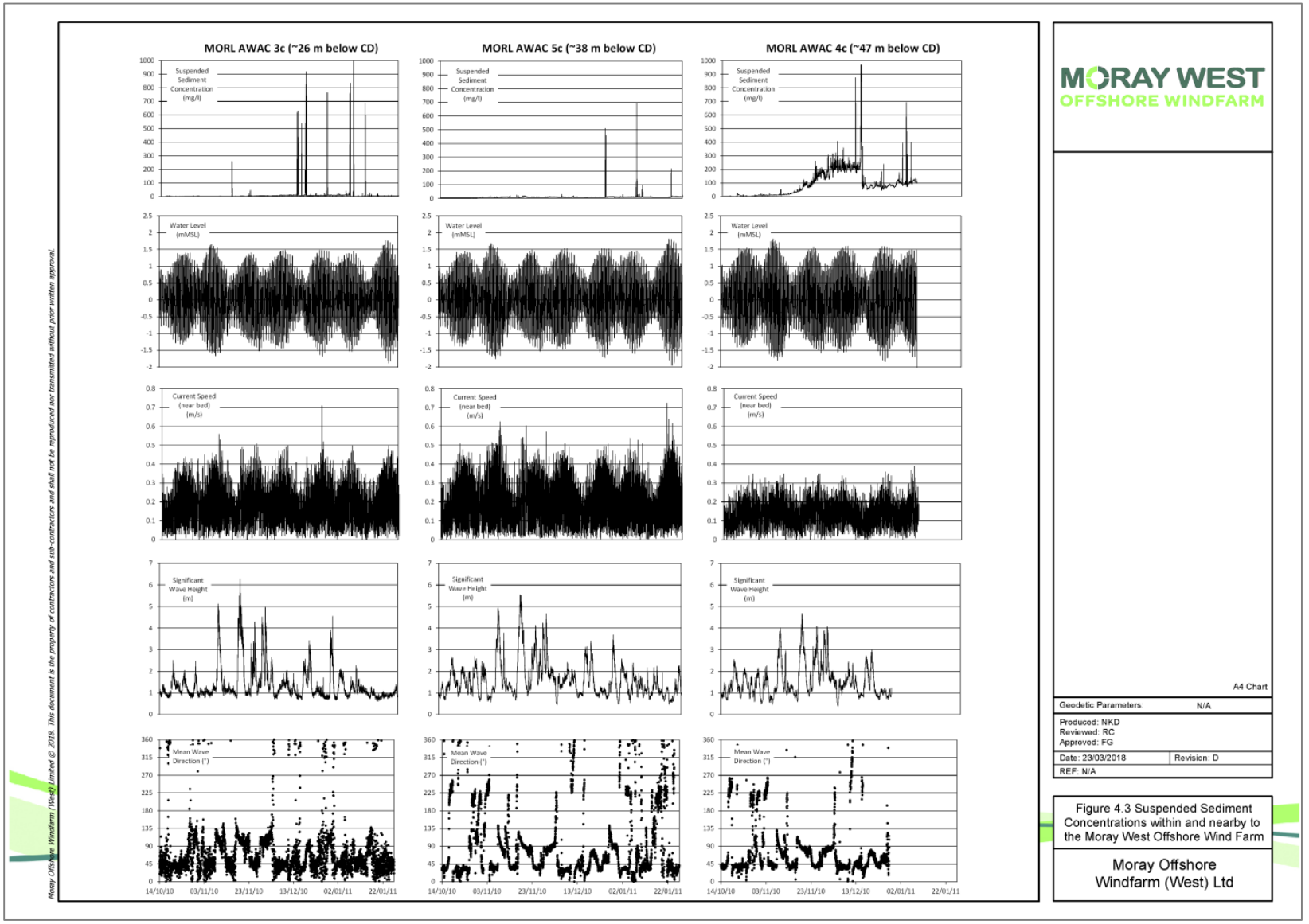


Figure 4.3: Suspended Sediment Concentrations within and nearby to the Moray West Offshore Wind Farm

Inspection of the SSC data available from the Moray Firth Zone and Beatrice Offshore Wind Farm site reveals that SSC's are typically in the range 0 to 10 mg/l, interspersed with short periods of very high (> ~100 mg/l) concentrations. These low values of SSC occur because (i) there is little fine sediment available in the surficial seabed sediments (see Section 4.3); (ii) tidal currents are generally of insufficient strength to mobilise the majority of the surficial sediments - (this is explored further in Section 4.8); and additionally (iii) there are no known large fluvial sources of SSC in the Outer Moray Firth.

On the basis of the findings presented in Table 3.7 (which show the relationship between wave height, water depth and orbital current speeds at the bed), one might expect there to be some correlation between SSC's and storm events at all measurement locations. However, this relationship is only apparent in the measurements from the Beatrice Offshore Wind Farm site (Beatrice AWAC 3a). The Beatrice AWAC 2a and 3a record includes two storm events: the first occurs on the 17 February 2010, with significant wave heights of up to 4.5 m, resulting in a significant increase in near-bed SSC to 30 to 50 mg/l; the second event peaks around 28 February 2010, with significant wave heights of up to 3.5 to 4 m, resulting in an also significant but smaller increase in near-bed SSC to 15 to 20 mg/l. Following the peak of the storm event, SSC gradually decreases (as the sediment settles out of suspension) to the baseline condition which is controlled by the ambient regional tidal regime.

The observed discrepancy between the observations from the Moray Firth Zone and Beatrice Offshore Wind Farm cannot readily be explained by differences in water depths and/or the magnitude of storm events during the two analysis periods. Instead, differences in the Beatrice Offshore Wind Farm site and Moray Firth Zone records may be explained by known problems encountered when calibrating the OBS sensors, which are sensitive to both variations in the colour and size of the sediment grains in suspension and to the presence of material other than sediment in suspension (e.g. biofouling of the sensor or free-floating detritus or marine growth). Given the very strong correlation between storm events and SSC in the Beatrice Offshore Wind Farm site it seems likely that across Smith Bank, large waves do stir the bed causing short term increases in SSC.

Due to the seasonal nature of the frequency and intensity of storm events, levels of SSC will likely follow a broadly seasonal pattern with higher values observed more frequently during late spring, winter and early autumn months. It is also possible that seasonal blooms of marine plankton may also contribute to apparent seasonality in measurements of total turbidity, but this is not directly associated with the resuspension of (inorganic) sediments.

A series of monthly regional scale surface turbidity maps are also available from Dolphin *et al.* (2011) and Cefas (2016) based on satellite derived measurements of Suspended Particulate Matter (SPM) in surface waters (Figure 4.4). On the basis of the available data, it is found that SPM readings are very low (< ~5 mg/l) throughout the year and are at their highest in winter months. Little spatial variation is observed either across the Moray West Site or along the Moray West OfTI. Turbidity tends to be highest at the seabed, decreasing with height above the bed. Turbidity measured at the water surface is therefore likely to be a low estimate of conditions lower in the water column and at the seabed.

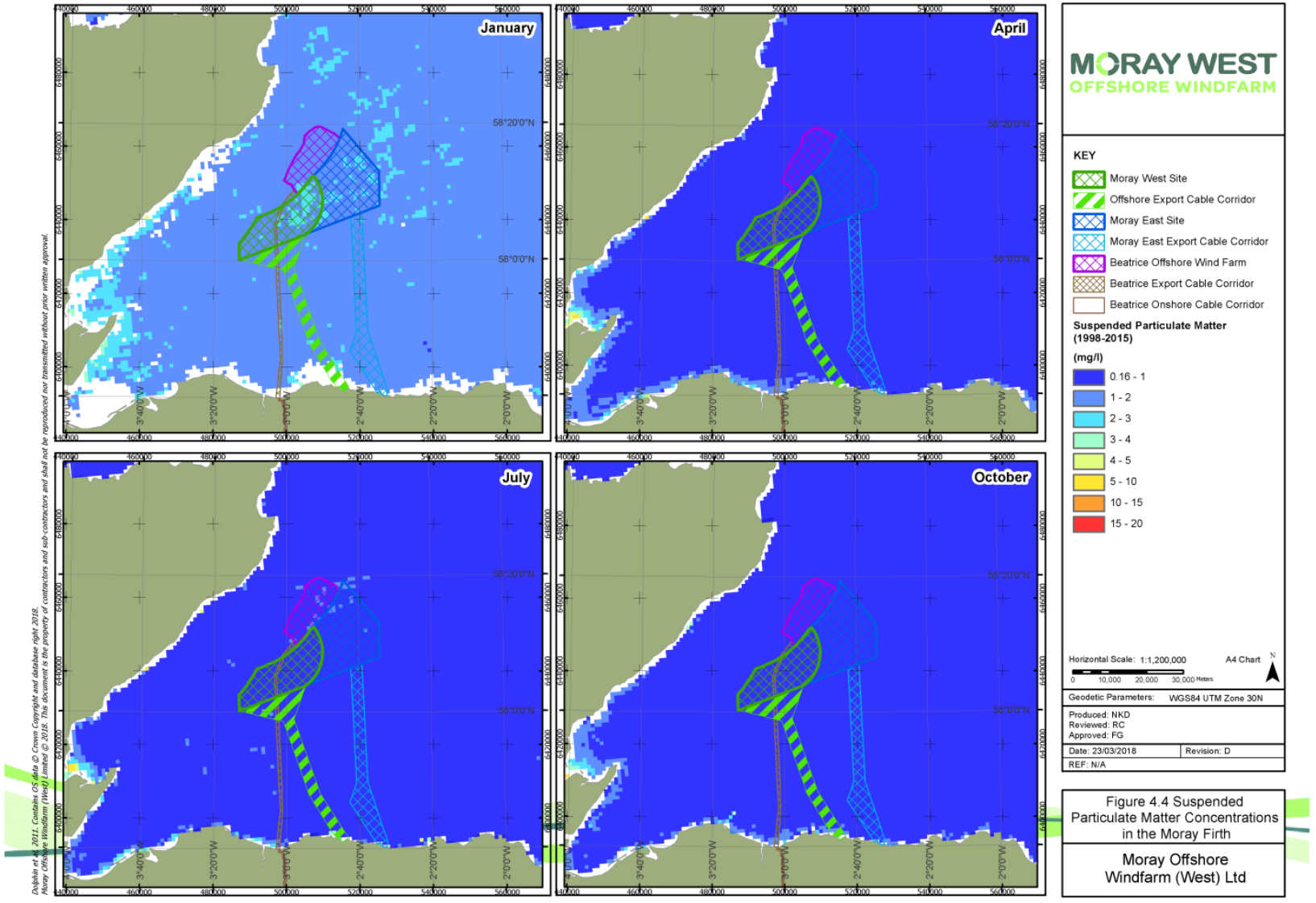


Figure 4.4: Suspended Particulate Matter Concentrations in the Moray Firth

Finally, Baxter *et al*., (2008) used a numerical ecosystem model to produce a map of typical SSC in the North Sea including the Moray Firth. The reported range of depth mean SSC in the Firth was approximately <5-10 mg/l. This finding is broadly consistent with both the project specific and satellite derived observations described above from Cefas (2016) and supports the inference of low turbidity in this area.

4.8 Process Controls on Sediment Mobility

An assessment has been made of the potential for sediment mobility within (and nearby to) the Moray West Site. This has been achieved by identifying the modal sizes of sediments (from the 80 samples provided by PMSL, 2017) and calculating the bed shear stresses required to initiate transport (using standard methods described in Soulsby, 1997).

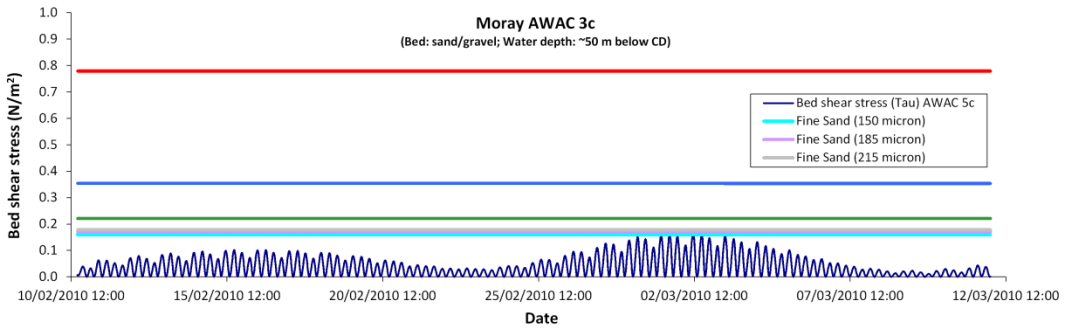
Table 4.3 provides a summary of the most commonly occurring median grain size classes, their frequency of occurrence and critical shear stress values for transport.

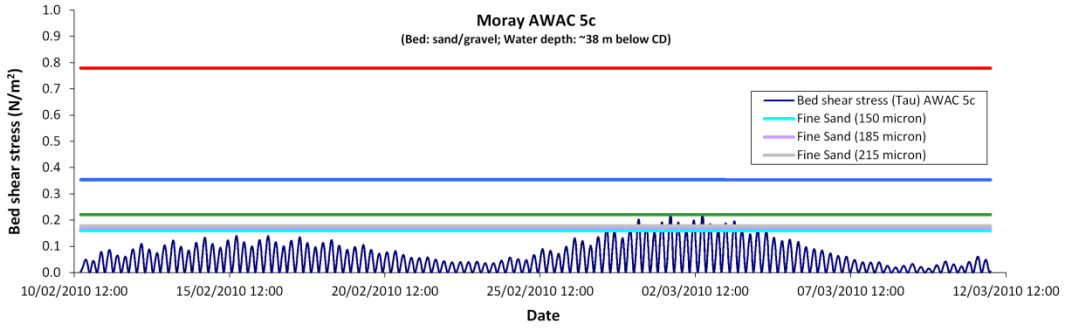
Table 4.3: Summary of the Main Sediment Types within the Vicinity of the Moray West Site including Associated Theoretical Bed Shear Stress Thresholds for Mobility

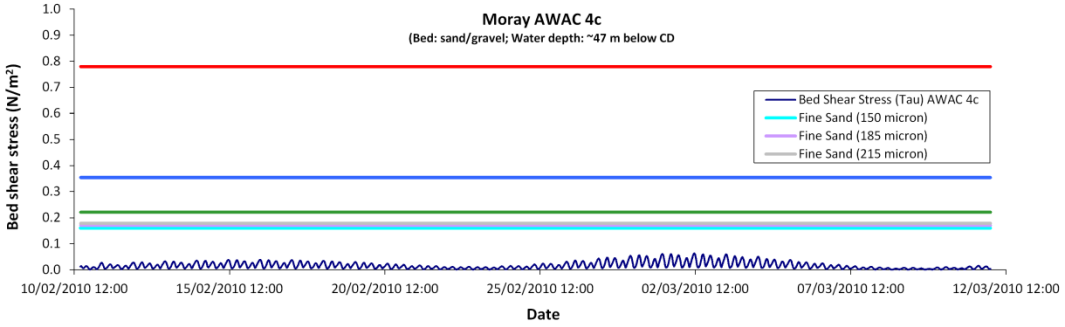
Modal Grain Size (µm)	Size Class	Bed Shear Stress Threshold (N/m^2)	Number of Occurrences in 80 Samples
150	Fine sand	0.160	26
185	Fine sand	0.170	22
215	Fine sand	0.179	19
375	Medium sand	0.221	4
750	Coarse sand	0.354	3
1500	Very coarse sand	0.779	3
3000	Granule gravel	2.02	2
24000	Pebble gravel	20.95	1

4.8.1 Potential Mobility Due to Tidal Currents Alone

The regional tidal current regime has been described in more detail in Section 3.3. Here, tidal current time series have been extracted from the tidal model at two locations within the Moray West Site (MORL AWAC 4c and MORL AWAC 5c) and at the location of the Moray WaveNet wave buoy further west in to the Moray Firth (Figure 2.3). These have been used to calculate an equivalent bed shear stress time-series (due to currents only) for a 30-day period (encompassing two spring-neap cycles). The proportion of the time series during which each sediment fraction is potentially mobilised is summarised in Table 4.4. The predicted bed shear stress values are also shown graphically for locations within the Moray West Site in Figure 4.5 and compared to the threshold values for mobility of the sediment grain sizes listed in Table 4.3. Elsewhere in the Moray West Offshore Export Cable Corridor, the tidal current regime and resulting tidal bed shear stresses are similar or less than to that described for MORL AWAC 4c and at the Moray WaveNet wave buoy.







MORAY WEST
OFFSHORE WINDFARM

A4 Chart

Geodetic Parameters:	N/A
Produced: NKD Reviewed: RC Approved: FG	
Date: 23/03/2018	Revision: D
REF: N/A	

Figure 4.5 Tidally-Induced Bed Shear Stress and Mobility Thresholds

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Figure 4.5: Tidally-Induced Bed Shear Stress and Mobility Thresholds within and nearby to the Moray West Offshore Wind Farm

Table 4.4: Estimated Potential Sediment Mobility (due to Tidal Currents Only) Within the Moray West Site and Offshore Export Cable Corridor

Location		Fine Sand (150 µm)	Fine Sand (185 µm)	Fine Sand (215 µm)	Medium Sand (375 µm)	Coarse Sand (750 µm)
MORL AWAC 5c (39 mLAT)	Mobility Summary	Only mobile during larger spring tides	Only mobile during larger spring tides	Not mobile	Not mobile	Not mobile
	Mobility % time	3%	2%	2%	0%	0%
MORL AWAC 4c (47 mLAT)	Mobility Summary	Only mobile during larger spring tides	Only mobile during larger spring tides	Only mobile during larger spring tides	Not mobile	Not mobile
	Mobility % time	2%	2%	1%	0%	0%
Moray WaveNet wave buoy (49 mLAT)	Mobility Summary	Only mobile during larger spring tides	Only mobile during larger spring tides	Only mobile during larger spring tides	Not mobile	Not mobile
	Mobility % time	2%	1%	1%	0%	0%

It is apparent from Table 4.4 that there is only limited potential for sediment mobilisation by tidal currents and the largest sized material that will be mobilised by the action of tidal currents alone within the Moray West Site and elsewhere in the Moray West Offshore Export Cable Corridor is fine sand. Tidally induced mobilisation events (when the critical bed shear stress values are exceeded) are generally confined to brief periods around peak current flow on mean spring or larger tidal ranges (Figure 4.5).

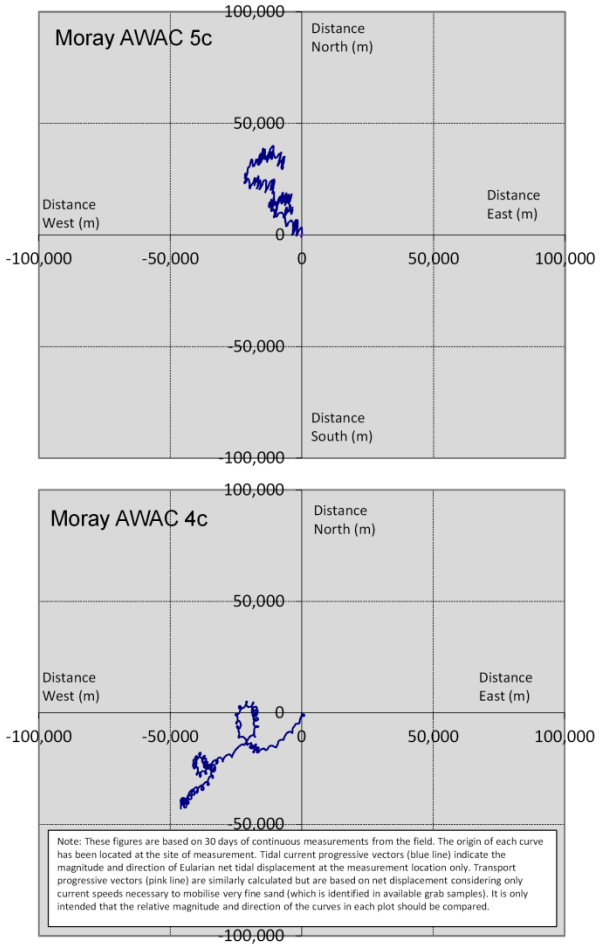
In general, the potential for sediment mobilisation in response to tidally induced bed shear stress decreases from east to west, reflecting gradients in flow speed (Figure 3.2). These predictions of spatial and temporal variations in sediment mobility are considered further in Section 4.8.2 where they have been used to inform the conceptual understanding of the seabed morphology across the Moray West Site.

It is important to note that the calculated bed shear stress is sensitive to the assumed 'roughness' of the seabed with coarser grained and/or more rippled surfaces inducing greater flow turbulence and hence bed shear stress than a fine grained and/or flat surface for the same flow speed. In terms of both grain size and the potential for the development of ripple bedforms, there is known to be variability within the Moray West Site (see Section 4.3, Figure 4.1). This variation might result in a degree of spatial variability in the effective actual bed shear stress and sediment mobility potential within the Moray West Site. For the purposes of the present study, where the sediment is typically immobile, the seabed is assumed to be largely featureless at the scale of a few meters (i.e. without very small bedforms).

Although Figure 4.5 provides information on the duration of exceedance of various mobilisation thresholds, it is important to note that these episodes of exceedance may not be of equal duration on both the ebb and flood tide. Indeed, any asymmetry in the tide (both in terms of the duration of the ebb and flood and the magnitude of peak flows) will result in variations in the direction of sediment transport for different sized sediment particles.

To investigate the effect of asymmetry further, progressive vector analyses have been undertaken using current data obtained from the two AWACs deployed within the Moray West Site (AWAC 4c and AWAC 5c). Spatial variation in residual flow and residual sediment displacement patterns over a 30-day period

for very fine sand are shown in Figure 4.6; residual sediment displacement (the net advective pathway) is calculated as the net displacement of water only when current speeds are above the threshold for sediment mobility. The absolute magnitude of residual sediment displacement calculated in this way is not quantitatively meaningful and is anyway very small in these cases as the threshold for mobility is not typically exceeded (as shown in Figure 4.6); however, the net direction can be used together with the relative magnitude to draw a qualitative comparison between the different sites.



MORAY WEST
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KEY
Net Potential Advection

A4 Chart

Geodetic Parameters: N/A

Produced: NKD
Reviewed: RC
Approved: FG

Date: 23/03/2018 | Revision: D

REF: N/A

Figure 4.6 Residual Flow and Projected Displacement of Fine Sediment after 30-Days

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Figure 4.6: Residual Flow and Projected Displacement of Fine Sediment after 30-Days

Residual tidal flow is found to be variable between the two locations, with residual flow to the southwest in the west of the Moray West Site (MORL AWAC 4c) and residual flow to the northwest in the east of the Moray West Site (MORL AWAC 5c). This potentially means that finer material held in suspension will generally be transported in these directions; however it is important to note that the observational records of flow contain both tidal and non-tidal signals and therefore are subject to considerable temporal variation, especially in areas such as this which are characterised by weak tidal flow. Despite the variation in net residual flow between the two measurement locations, both records are consistent in suggesting minimal sediment displacement over the analysis period.

4.8.2 Potential Mobility Due to Waves and Wave-Current Interaction

The regional wave climate is described in more detail in Section 1.1. Significant wave heights in excess of 6 m were observed in the Moray Firth Zone during the approximately 12 month metocean survey period and are expected to be as high as 9 m during a 1 in 50-year return period extreme storm event. Significant wave heights generally decrease in magnitude towards the Landfall Area although may still exceed 5 m close to shore in response to stronger northerly or north-westerly winds.

In comparison to tidal currents, the near bed orbital current velocities associated with such waves in the water depths found within the vicinity of the Moray West Site can result in significantly higher bed shear stresses and therefore sediment mobility. As tidal currents (perhaps modified by storm surge) are also present during storm events, the combined influence of both waves and currents was also investigated. (This point is further emphasised in Section 4.5 and Figure 4.3 which suggests that larger waves have the capacity to stir the bed, resulting in the increased mobility or suspension of finer sediment). Spatial variations in sediment mobility (due to both currents and waves) are summarised in Table 4.5. Once mobilised, re-suspended sediments are transported at a rate and direction dependent upon the ambient currents.

Table 4.5: Spatial Variation in Sediment Mobility (due to Peak Mean Spring Currents and Waves of Varying Height) within the Moray West Site and within the Offshore Export Cable Corridor

Location (Depth)	Mean Spring Current + Significant wave height (m)	Sediment Fraction					
		Granule Gravel (3,400 µm)	Very Coarse Sand (1700 µm)	Coarse Sand (850 µm)	Medium Sand (430 µm)	Fine sand (215 µm)	Very fine sand (110 µm)
MORL AWAC 4c (47 mLAT, mean spring current speed 0.3m/s)	0 (current only)	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	1	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	2	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	3	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	4	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	5	Not Mobile	Not Mobile	**Mobile**	**Mobile**	**Mobile**	**Mobile**
	6	Not Mobile	**Mobile**	**Mobile**	**Mobile**	**Mobile**	**Mobile**
MORL AWAC 5c (39 mLAT, mean spring current speed 0.45m/s)	0 (current only)	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	**Mobile**
	1	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	**Mobile**
	2	Not Mobile	Not Mobile	Not Mobile	Not Mobile	**Mobile**	**Mobile**
	3	Not Mobile	Not Mobile	Not Mobile	Not Mobile	**Mobile**	**Mobile**
	4	Not Mobile	Not Mobile	**Mobile**	**Mobile**	**Mobile**	**Mobile**
	5	Not Mobile	**Mobile**	**Mobile**	**Mobile**	**Mobile**	**Mobile**
	6	**Mobile**	**Mobile**	**Mobile**	**Mobile**	**Mobile**	**Mobile**

Table 4.5: Spatial Variation in Sediment Mobility (due to Peak Mean Spring Currents and Waves of Varying Height) within the Moray West Site and within the Offshore Export Cable Corridor

Location (Depth)	Mean Spring Current + Significant wave height (m)	Sediment Fraction					
		Granule Gravel (3,400 µm)	Very Coarse Sand (1700 µm)	Coarse Sand (850 µm)	Medium Sand (430 µm)	Fine sand (215 µm)	Very fine sand (110 µm)
OfTI Export Cable Corridor Location 1 (88 mLAT, mean spring current speed 0.3m/s)	0 (current only)	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	1	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	2	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	3	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	4	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	5	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	6	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
OfTI Export Cable Corridor Location 2 (30 mLAT, mean spring current speed 0.3m/s)	0 (current only)	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	1	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	2	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile
	3	Not Mobile	Not Mobile	Not Mobile	Not Mobile	Not Mobile	**Mobile**
	4	Not Mobile	**Mobile**	**Mobile**	**Mobile**	**Mobile**	**Mobile**
	5	**Mobile**	**Mobile**	**Mobile**	**Mobile**	**Mobile**	**Mobile**
	6	**Mobile**	**Mobile**	**Mobile**	**Mobile**	**Mobile**	**Mobile**

* Orbital velocities calculated at time of mean water level which is approximately 2 m above LAT

From Table 4.5 it is apparent that when taking into consideration the combined influence of tidal currents and wave-induced orbital currents, significantly larger sediment size fractions can become mobile than under tidal currents alone. Spatial variation in both peak current speeds and water depths (affecting the strength of wave penetration to the seabed) results in the variability described in the table. In general, wave action is shown to dominate the magnitude and frequency of sediment mobility, and sediment is therefore generally considered to be more mobile in shallower water within the study area.

In (shallower) eastern areas of the Moray West Site (MORL AWAC 5c), a 4 m high wave in conjunction with a spring tide is sufficient to mobilize fine and medium-sized sand which is the major constituent of almost all available sediment samples collected from the Moray West Site (Section 4.3). Waves of this size (or greater) are relatively common and account for approximately 3 to 5% of each of the five observed wave records shown in Figure 3.8. On the basis of the above discussion, it is therefore probable that the seabed across much of the eastern half of the Moray West Site is relatively 'active'.

However, the combination of weaker tidal currents in the west of the Moray West Site (MORL AWAC 5c) and generally deeper depths means these areas will be less mobile. Indeed, waves of approximately 5 m height would be required to mobilise medium sized sand. This means that sand sized material will only be mobilised relatively infrequently (circa a few times a year) during large storms.

Gravel-sized material may potentially become temporarily mobile during very large (Hs equal to or greater than 6 m) storm events. Such waves are present in the observational wave records from this area (Table 3.11 to Table 3.13) but are only likely to occur infrequently (a few times each year at most). Gravel may be moved in-situ but is unlikely to be significantly displaced during such episodes.

Along the Moray West OfTI, the large range in water depths means there will be a high degree of spatial variability in the degree to which the seabed is mobile. In the deep (circa 90 mLAT) sections, the bed is expected to be almost entirely immobile, except during exceptionally large storm events which may mobilise very fine sand. Conversely, in shallower areas closer to the shore, seabed sediments will become increasingly mobile with gravel sized material expected to be mobilised during large (circa 5) storm events. In water depths less than approximately 20 mLAT, it is anticipated that the sands and gravels at the bed will be frequently mobilised

5 Morphodynamic Regime

5.1 Overview

The contemporary morphology of the Moray West Site as well as the coastal characteristics of the Moray Firth is described in this section. Seabed morphology is considered alongside knowledge of regional sediment transport to develop a conceptual understanding of the seabed morphology in the Moray Firth and to assess the degree to which areas of the seabed may be active and changing in form or level in a net sense over time.

Across the Moray Firth, seabed topography and sediment substrate are variably influenced by the structure and composition of underlying bedrock, the configurations and composition of features originating at former terrestrial and submarine ice-sheet margins, carbonate biological sedimentary input and by the interactions of all these with near bed tidal and wave induced currents (Holmes *et al*., 2004).

During the late Devensian glaciation, ice spread into the Moray Firth and diverged northwards towards Caithness and the Orkney Isles as well as eastwards approximately parallel to the present day Grampian coast (Barne *et al*., 1996). This ice sheet was at its maximum extent approximately 25,000 years ago and covered this region up until around 15,000 years ago. Since the last glacial maximum, the position of sea level has varied considerably in response to both glacio-isostatic rebound of the land and rising glacio-eustatic sea level. However, model simulations of past sea level change suggest that at no point over the past 20,000 years, has the Moray West Site become sub-aerially exposed (Brooks *et al*. 2011; Bradley *et al*., 2011; Sturt *et al*., 2013).

5.2 Sources of Morphological Data

Information regarding the morphological regime for the Moray West Site and surrounding area is available from those sources previously identified in Table 4.1.

5.3 Seabed Morphology and Smith Bank

The detailed bathymetry of the Moray West Site is most clearly described by a combination of the swath bathymetry data collected by Osiris in 2011 during the geophysical survey (Figure 5.1) and the larger area of swath bathymetry data collected by the MCA in 2006 (Figure 5.2). Seabed levels range from ~35 m below LAT within eastern areas of the Moray West Site, approaching the crest of Smith Bank, to ~54 m below LAT along its southern margin. In the northern section of the Moray West Site, seabed levels dip irregularly from west to east across an undulating seabed, whereas, in the southern section, seabed levels dip more towards the south east, where the edge of the Smith Bank is encountered (Osiris, 2011). The regional morphology surrounding the Moray West Site is also shown in Figure 5.1 and Figure 5.2.

When examined in more detail, the geophysical survey data also reveals a large number of raised sand ridges and associated shallow troughs over the edges of Smith Bank. Individual ridges stand between 0.3m to 1.2m above surrounding seabed and generally trend north-northwest to south-southeast or west to east. Maximum gradients of approximately 0.7° can be found around the edges of some of the ridges (Osiris, 2011). The multibeam swath backscatter data previously collected during the DTI SEA surveys also reveals the presence of these same sediment (likely gravel) wave features found only on the northern flanks of Smith Bank (Holmes *et al*., 2004) (Figure 5.3).

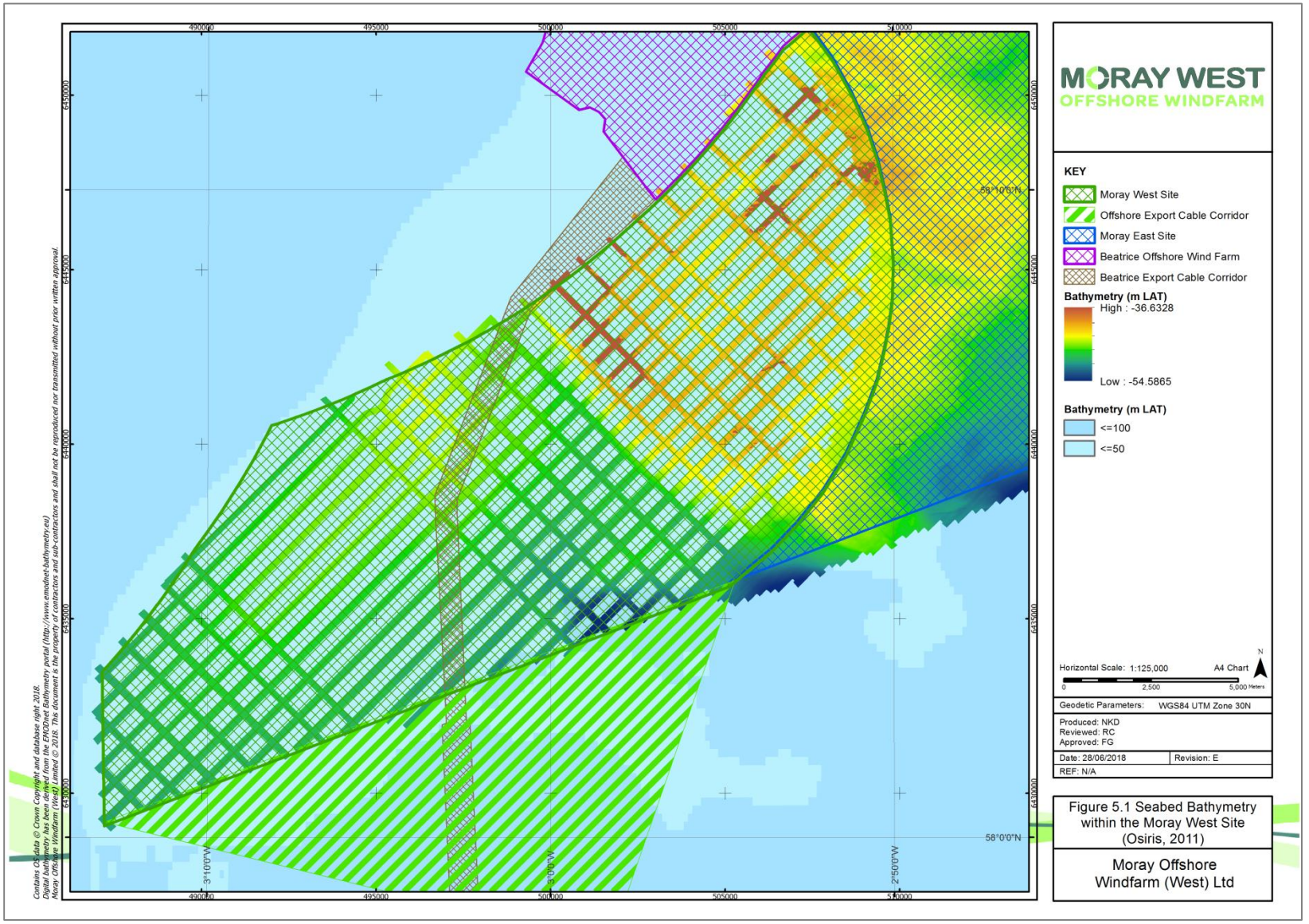

Figure 5.1: Seabed Bathymetry within the Moray West Site (Osiris, 2011)

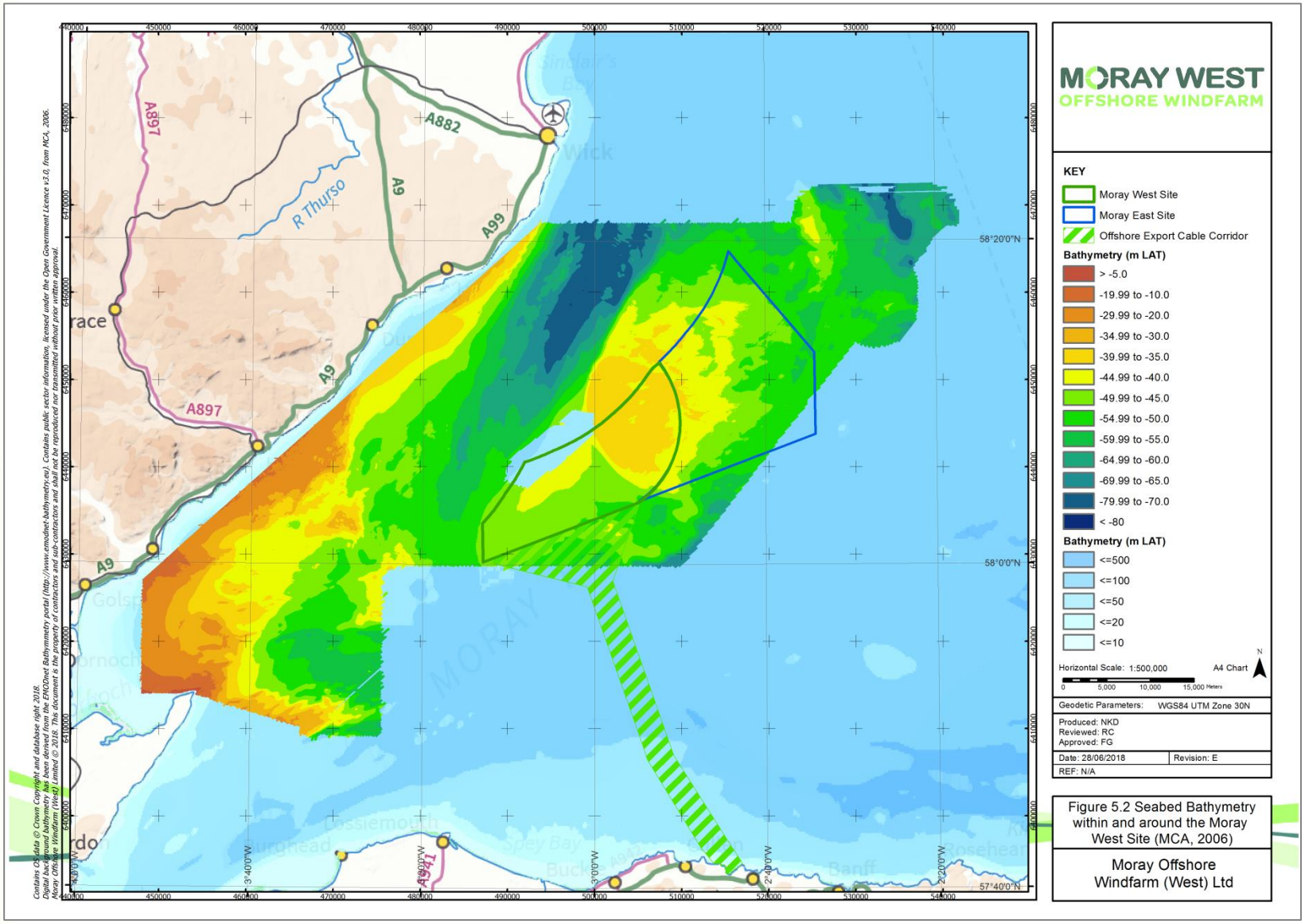

Figure 5.2: Seabed Bathymetry within and around the Moray West Site (MCA, 2006)

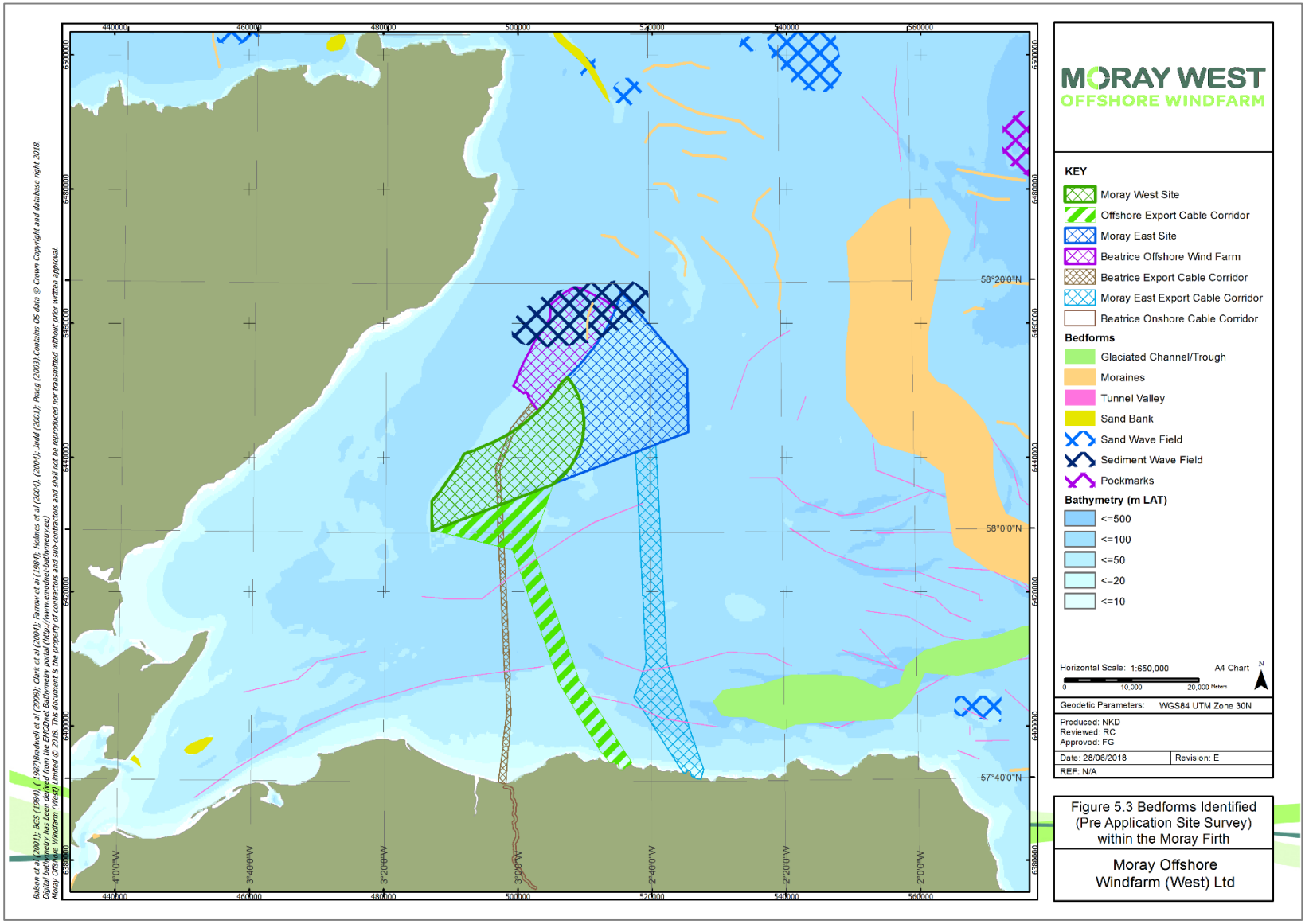

Figure 5.3: Bedforms Identified (Pre Moray Firth Zone Survey) within the Moray Firth

The DTI SEA survey report also makes reference to the presence of sharp edged sand patches on Smith Bank, in the vicinity of the Moray West Site. These are elongate features commonly 500 m long and around 2 m thick in their centre (Holmes *et al*., 2004). The orientation of their long axis is typically (but not exclusively) north-northwest to south-southeast, i.e. not orientated to the tidal axis but approximately to the direction of approach for large waves. This was found to consistent with the published literature concerning the genesis of these features, i.e. indicating a wave dominated, relatively tidally benign environment.

Across the far-field region, numerous ridges and channels have previously been mapped from echo sounder records compiled by Olex (www.olex.no) (Figure 5.3). Ridges range in length from 500 m to 20 km and are typically ~500 m wide and <10 m high. Most of the channels exceed 10 km in length, are often several 10's of metres deep and frequently possess branching, sinuous courses (Bradwell *et al*., 2008).

5.4 Coastal Morphology

Coastal morphology as well as the nature of longshore sediment transport will strongly influence the susceptibility of the coast to any changes in the baseline wave and current regime.

The coastal characteristics of this region have previously been described by Barne *et al*. (1996) and are summarised in Section 5.5. The overview provided by Barne *et al*., is also presented below.

The coastline of the Moray Firth can be described according to its solid geology and its degree of exposure to climatic and tidal influences. There are three distinctive zones:

- (i) The hard Old Red Sandstone rocks of Caithness, together with the predominantly cliffed coastline from Portknockie to Fraserburgh on the north Grampian coast. These areas are exposed to the full force of winter storms. These conditions allow few opportunities for accretionary habitats such as sand dunes to develop, except in the shelter of kyles (narrow straits) and bays;
- (ii) West from Portknockie. Here, the Outer Moray Firth is less exposed, though there are still tidal and storm effects, which have moved shingle and sandy sediments to create the extensive sand and shingle formations on either side of the Firth; and
- (iii) The sheltered inlets of the firths (Dornoch, Cromarty and the Inner Moray Firth and Beauly Firth). These environments have a much lower energy environment, in which wave attack is reduced and intertidal mudflats and saltmarshes can develop.

The land shelves steeply into the sea off the coasts of Caithness, Banff and Buchan. Along much of the coast, currents have swept the bedrock clean and this is particularly apparent along the Caithness and north Grampian coasts.

Longshore sediment transport along the Moray Firth coastline has previously been described by Ramsey and Brampton (2000). Findings from this investigation have been summarised in Figure 4.2. The Figure shows that beaches with sediment available for longshore transport are generally confined to the inner parts of the Moray Firth. Where beaches are present (instead of rocky cliff coastline morphology), the beach material generally fines with distance into the Moray Firth, i.e. moving from east to west along the Caithness coastline, beaches are initially boulders and pebbles, becoming gravelly, then progressively sandy and finer into the Inner Firth, where muddy salt marshes dominate the more protected inner estuaries.

5.5 Landfall Area Morphology

The Moray West OfTI will make landfall at a location within the Landfall Area (shown in Figure 5.4), located approximately south of the Moray West Site, on the southern coast of the Moray Firth. The Landfall Area extends from Findlater Castle to Redhythe Point on the Aberdeenshire Coast. This section

of the coastline comprises a mixture of rocky cliffs and outcrops interspersed with small sandy beaches either side of a larger embayment (Sandend Bay).

The Landfall Area includes the Cullen to Stake Ness Coast Site of Special Scientific Interest (SSSI). The SSSI occupies a coastline nearly 20 km long, bordered by the settlements of Cullen, Sandend and Portsoy. The majority of the Landfall Area comprises a low, narrow coastal platform with extensive rocky shores, sand and shingle bays, and a low vegetated raised beach. This is typically backed by a vegetated raised cliffline, which includes cliff-top heath. The Landfall Area has both biological and geological interests, the latter of which are briefly summarised below. The rocks exposed in the SSSI are metamorphic (rocks which have been altered by heat and pressure), and belong to the Dalradian Supergroup, which makes up most of the Central Highlands.

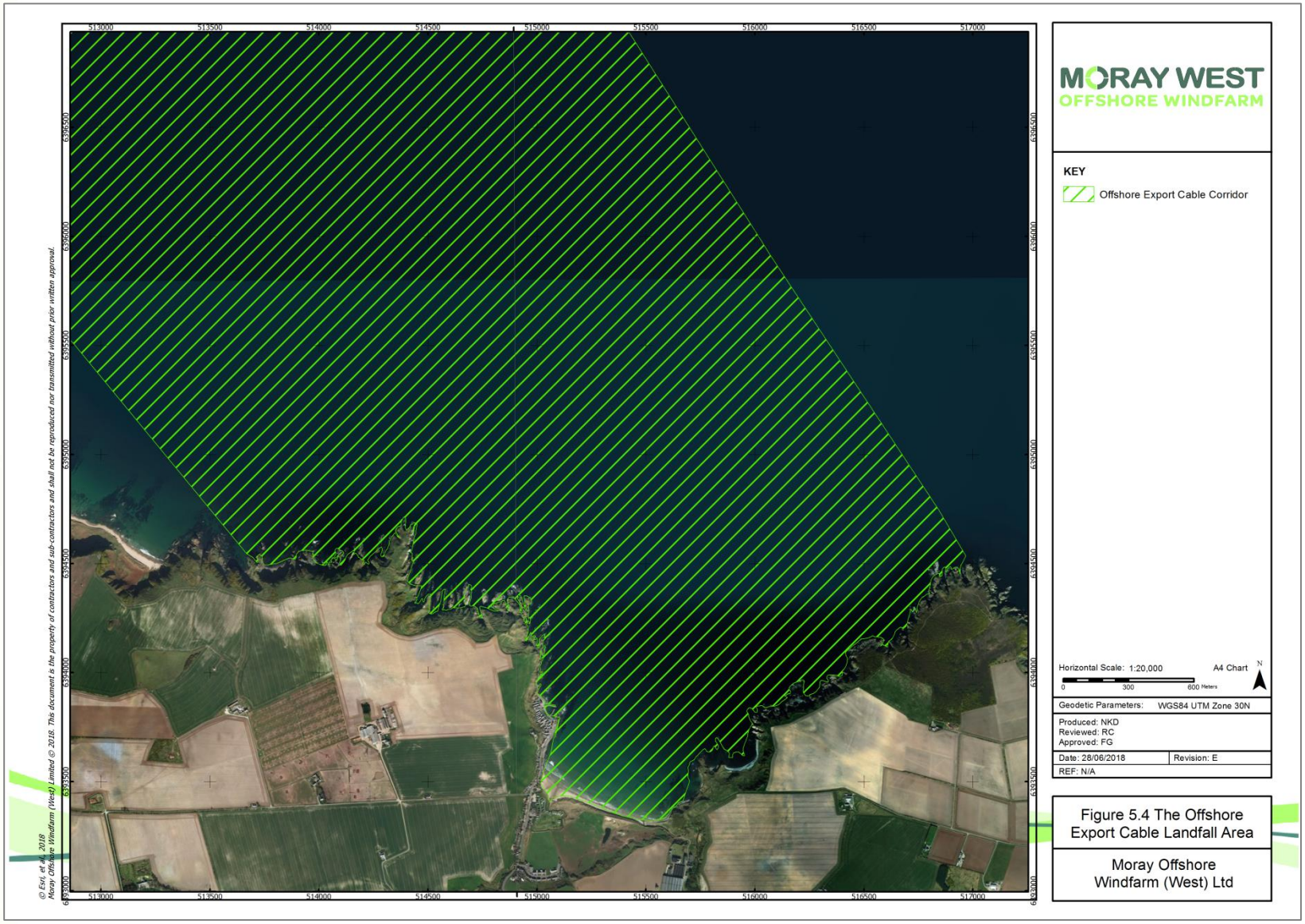

Figure 5.4: The Offshore Export Cable Landfall Area

5.5.1 Findlater Castle to Sandend Bay Including Garron Point

To the west of Sandend Bay, the Landfall Area is characterised as a north and northeast facing exposed rocky coastline. There are frequent narrow rocky inlets with narrow gravel and cobble beaches overlying shallow rocky platforms. This is typically backed by a vegetated raised cliffline.

5.5.2 Sandend Bay

The coastline in Sandend Bay is generally characterised as an exposed northwest facing embayment. The beach is backed by a mixture of coastal defences, managed ground and mature vegetated sandy dunes. The beach is constrained by rocky headlands and underpinned by a bedrock platform.

The beach material within Sandend Bay is predominantly sandy. It is likely that the main body of sediments immediately offshore is also predominantly of a similar type. In other parts of Sandend, areas of bedrock are visibly exposed in the nearshore, especially around headlands. This suggests that, regionally, the nearshore and beach sediments are a veneer on a rocky platform. The thickness of the (predominantly) sand veneer is not known in detail but is likely to vary both spatially and temporally due to variations in the relative elevation of the rock horizon and in the distribution of the overlying sand in response to storms and seasonal and other cycles.

Sandend is classified as a semi-independent beach unit ('Cell 3a') within which sediment circulates, but does not regularly exchange with or along the adjacent coastlines (Ramsay and Brampton, 2000). As a result, regional net longshore sediment transport in this cell is considered to be minimal.

Available information from Scotland's National Coastal Change Assessment (Scottish Government *et al*. 2017) suggests that at Sandend, little horizontal movement in the position of the MHWS contour has occurred since the start of the 20th Century. The only exception to this general observation is in the west of the bay, associated with historic migration of Scattery Burn across the beach. The 'Future Look' provided in Scotland's National Coastal Change Assessment suggests that by 2050, the position of the MHWS will not have appreciably altered from present.

5.5.3 Sandend Bay to Redhythe Point including Redhaven Bay

To the east of Sandend Bay, the Landfall Area is characterised as a north and northwest facing rocky coastline that may be relatively sheltered from larger waves coming from offshore, but is still exposed to waves coming from elsewhere within the Moray Firth. There are frequent narrow (and some wider) rocky inlets with narrow gravel and cobble beaches overlying shallow rocky platforms. This is typically backed by a vegetated raised cliffline.

5.6 Designated Marine and Coastal Geomorphological Features

The Moray Firth and Caithness areas are noted for the richness of their natural heritage and much of the Caithness coastline is designated under international or national nature conservation orders (Figure 2.1). Most of the sites are protected on the basis of the habitats they contain; however, several designated areas have been assigned conservation status because of the geological and geomorphological interests they contain, which are maintained by present-day physical processes.

Designated marine features that might potentially be directly affected by the Development footprint are the Moray Firth pSPA (proposed Special Protection Area) and the Southern Trench pMPA (proposed Marine Protected Area). The Moray Firth pSPA is proposed for designation with respect to shallow sandy substrates, coastal rocky outcrops and deep muddy channels in coastal and more nearshore areas that provide habitats for a variety of bird species. The Southern Trench pMPA is proposed for designation with respect to a variety of geological features (the Southern Trench itself is an example of an enclosed glacial seabed basin), ecological habitats (burrowed muds in deeper parts of the trench) and other oceanographic features (seasonal stratification and fronts off Fraserburgh).

Designated coastal geomorphological feature examples include the geological exposures of the Cullen to Stake Ness Coastline, the actively prograding spit at Whiteness Head and the active gravel beach complex at the mouth of the River Spey, all of which are afforded SSSI (Site of Special Scientific Interest) status.

5.7 Conceptual Understanding of Seabed Morphology

As previously described, the Moray West Site is situated on Smith Bank. Overall, Smith Bank is approximately 35 km long from south-west to north-east, around 20 km wide, rising from a base level of between 50 and 60 m below sea level to less than 35 m at the crest. The position, elevation and orientation of the bank is closely associated with the underlying Smith Bank Fault block and the geophysical survey undertaken by Osiris (2011) reveals that Cretaceous sediments are relatively close (<10 m) to the seabed across much of the crest of the bank. The main body of Smith Bank is underpinned by solid bedrock, with variable thickness layers of stable overlying sedimentary deposits and a more mobile sediment veneer. The position and form of Smith Bank is therefore controlled by the underlying geology and so is not sensitive as a whole to minor changes in sediment transport onto, over or off the Bank.

Side scan sonar and multibeam swath backscatter data collected during the Moray Firth Zone geophysical survey reveals a number of raised sand ridges and associated shallow troughs over the edges of Smith Bank (Osiris, 2011). These ridges generally trend north-northwest to south-southeast or west to east (Figure 5.1). Given available information on the tidal current regime (Section 3.3), conditions under which sediment is mobilised (Table 4.4 and Table 4.5) and bedforms develop (Belderson *et al*. 1982), it is unlikely that the ridges identified within the Moray West Site are sediment waves being actively maintained by tidal currents.

It is possible that these ridge features are either relict, formed in periods of lower sea level and other tidal patterns, or contemporary but infrequently mobile features that are the result of the particular wave-current regime in these areas. However, the most probable explanation is that they are sharp edged sand patches, similar to those imaged during the DTI SEA surveys from Smith Bank (Holmes *et al*., 2004). This interpretation is lent further support by the orientation of the ridges which are broadly perpendicular to the direction of approach for large waves (Section 1.1).

Sharp edged sand patches have also been mapped elsewhere in the central North Sea (e.g. in the western Dogger Bank region) and are found to be one of the most widespread of all shelf bedforms (Kenyon and Cooper, 2005). They have previously been found in areas where the currents present (tidal and surge induced) are too weak on their own to move sediment as bedload, except on rare occasions, and are found in areas experiencing peak tidal current speeds of less than about 0.35 m/s (Sager and Sammler, 1975). (The modelled extreme, depth averaged, surge currents over 50 years are about 0.6 to 0.9 m/s in the Moray West Site - Section 3.3). Instead, such a bedform typically becomes mobile when long-period storm waves enhance sediment erosion whilst subsequent transport is controlled by other tidal and non-tidal currents. This observation is consistent with the findings presented in Table 4.5.

The mechanism by which the patches maintain a fairly constant 2 m height and thickness, together with steep sides, is not fully understood (Holmes *et al*., 2004). However, Belderson *et al*. (1982) note that it might be because storm-wave currents sweep sand from the gravel areas into the patches and that 2m is the typical maximum height to which the storm waves can carry the sand into suspension.

The large ridges shown in Figure 5.3 which are present across much of the far-field region have been interpreted as relict glacial moraines. Similarly, the channels found mainly to the south and south-east of the Moray West Site are also suggested to be relict features, formed by the pressurised flow of glacial meltwater beneath the British Ice Sheet (Bradwell *et al*., 2008).

6 Summary

This report provides a baseline assessment of physical processes in the Moray West Site, the Moray West Offshore Export Cable Corridor and the surrounding area. This has primarily been achieved on the basis of data collected during targeted metocean and geophysical survey campaigns, data created using numerical models, and data and information from previously published studies. Overall the findings of the baseline can be summarised as follows:

6.1 Hydrodynamic Regime

6.1.1 Water Levels

The Moray West Site is situated within a meso-tidal setting and is characterised by a mean spring tidal range of 3.1 m and a maximum astronomic range (HAT to LAT) of approximately 4.4 m.

There is some variation in tidal range along the Moray West Offshore Export Cable Corridor, with the highest water levels experienced at the landward end. At Buckie, (near the Landfall Area), the mean spring range is 3.4 m.

Storm surges may cause short term modification to predicted water levels and under an extreme (1 in 50-year return period) storm surge, water levels may be up to 1.25 m above predicted levels.

It is probable that relative sea levels will rise in this region during the course of the 21st Century and by 2100 is likely to be approximately 0.5 to 0.8 m higher across the Moray West Site.

Climate change may be expected to slightly increase the mean water level over the lifetime of the proposed development; however, the tidal range about the new mean level will likely remain not measurably affected.

6.1.2 Currents

Information available on the strength of tidal currents in the region of the Moray West Site shows that recorded (depth-averaged) peak spring current speeds are around 0.3-0.25 m/s, with the fastest speeds recorded in the north of the Moray West Site.

Peak spring current speeds increase to the North of the Moray West Site towards the Pentland Firth. Peak spring current speeds are similarly low (0.3 m/s or less) elsewhere in the Moray Firth.

Along most of the Moray West Offshore Export Cable Corridor, peak spring current speeds are typically less than 0.3 m/s.

Both storm waves and storm surges may cause short term modification of astronomically-driven tidal currents. During a 1:1 year storm event, orbital currents are likely to approach 1 m/s in the north of the Moray West Site, in the relatively shallow water over the crest of Smith Bank. Currents of this magnitude are considerably greater than that observed during peak spring tidal flows. Similarly, under an extreme (1 in 50-year return period) storm surge, current speeds may be more than twice that encountered under normal peak spring tide conditions.

Residual tidal currents (over a period of days to weeks) are directed generally into the Moray Firth.

Climate change is not expected to have any effect on the local tidal current regime (currents are largely controlled by the corresponding tidal range) over the lifetime of the proposed development.

6.1.3 Waves

The wave regime in the Outer Moray Firth includes both swell waves generated elsewhere in the North Sea and locally generated wind waves. The wave regime in the Outer Moray Firth is typically

characterised by wind waves although longer period swell waves can be identified within the observational wave records collected from within and nearby to the Moray West Site.

The Moray West Offshore Export Cable Corridor is likely to be exposed to waves of equal or possibly larger size than the Moray West Site from exposed offshore sectors; the size of waves from other fetch limited sectors will vary along the route depending upon the wind direction and corresponding fetch. The variable and on average greater water depths along the Moray West Offshore Export Cable Corridor mean that the ability of a given wave condition to penetrate to the seabed may also be variable.

Even though water depths within the Moray West Site are no less than 35 m, storm waves sufficiently large to cause water motion at the seabed are not uncommon.

Along the coastlines of the mid and Inner Moray Firth, waves have a critical role to play in driving sediment transport through the process of longshore drift.

Climate change is predicted to cause variability in the inter-annual wave climate over the lifetime of the proposed development; however, historical trends have shown that this variability may include both increases and decreases in mean storminess on decadal timescales.

6.1.4 Stratification and Fronts

The Outer Moray Firth may experience some seasonal thermal stratification.

Applying general oceanographic theory, it is likely that the strength and natural position of seasonal stratification fronts is governed by the magnitude of tidal current flows in the adjacent inshore areas and of seasonal stratification in adjacent offshore areas.

Climate change is not expected to have any effect on the range of natural variability in the location or strength of stratification and fronts over the lifetime of the proposed development.

6.2 Sedimentary and Morphodynamic Regimes

6.2.1 Sediments

Seabed sediments across the Moray West Site generally consist of Holocene gravelly sand and sand with a minor proportion of fines (<5 to 10% silt and clay sized). A modal peak grain size between 150 to 215 µm (fine sand) was found in the majority of the grab samples collected from the Moray West Site. Other modal peak grain sizes were also variably observed, ranging from 24,000 µm (pebble gravel) to 350 µm (medium sand). The proportion of shell in sediment samples from and nearby to the Moray West Site are frequently in excess of 50% (Partrac, 2010; BGS, 1987).

Seabed sampling was successfully undertaken at 12 locations within the Moray West Offshore Export Cable Corridor. Near to the Moray West Site, in intermediate water depths, the Moray West Offshore Export Cable Corridor transits areas of mixed sands and gravels, with a small proportion of fines (<5 to 10%) present. Seabed sediments become progressively finer in deeper water along the route, becoming relatively muddy (30 to 65% fines) in the deepest parts. The sediment character and distribution in these offshore sections is the result of the relatively benign tidal regime and the spatially variable effect of wave action at the seabed, depending upon the local water depth.

Across much of the Moray West Site, surficial marine sediments are generally thick (~5 to 15 m in the west of the Moray West Site, up to 30 m in the east) In some locations, the underlying glacial till is very close to the surface (<2 m thickness).

An extensive blanket of Quaternary deposits are present across almost the entire Moray Firth with sediment thicknesses in excess of 100 m commonly observed. Within the Moray West Site the Quaternary units are of variable thickness, ranging from <10 m to c. 150 m. These sediments are underlain by a thick unit of firm to very hard Lower Cretaceous clay.

The available evidence suggests that (bedload) material is travelling into the Firth from the north, passing along the Caithness coast and towards the Inner Moray Firth. Tidal currents are largely incapable of mobilising anything larger than fine sand-sized material within the Moray West Site and as a result, there is only limited net bedload transport of sediment due to tidal currents alone.

However, the combination of tidal and non-tidal currents and wave induced currents during storms results in considerably higher current speeds at the bed. As a result, it is likely that the commonly present fine sand is regularly mobilised within the Moray West Site during storms. Owing to the combination of slightly higher tidal current speeds and smaller water depths, it is likely that the northern areas of the Moray West Site are most active in this way.

Within the Moray West Site, SSC is typically very low (approximately < 5 mg/l). However, during storm events, near bed SSC can be significantly increased in the short-term due to the influence of waves stirring of the seabed. Coarser sediments may be transported a short distance in the direction of ambient flow or down-slope under gravity before being redeposited. Finer material that persists in suspension will eventually be transported in the direction of net tidal residual flow, i.e. to the south-west, into the Firth.

Climate change is not expected to have any effect on the type or distribution of sediments within the extent of and over the lifetime of the proposed development.

6.2.2 Morphology

The Moray West Site spans the crest and western flank of Smith Bank and is characterised by water depths in the range 35 to 54 m below LAT. The shallowest depths are found in the north of the Moray West Site and the greatest depths are found in the south.

Bedforms identified within the Moray West Site have been considered alongside the findings from the sediment mobility analysis as well as published literature from this region to develop a conceptual understanding of the morphological regime. Particular attention has been focused on ascertaining those mapped bedforms which are likely to be active and those that are relict.

Active seabed bedforms are controlled by the combination tidal flows and wave-induced orbital currents. Low sediment waves orientated transverse to the main axis of tidal flow are suggested to be present in the north of the Moray West Site whilst sharp-edged sand patches are suggested to be present across much of the Moray West Site.

Relict seabed bedforms exist as a result of past processes (mainly glacial) and therefore are not maintained by contemporary physical processes. Of particular note are a series of tunnel valleys cut by pressurised flow beneath the former British Ice Sheet, along with glacial moraine ridges deposited between approximately 15,000 to 20,000 years ago.

The coastal characteristics of the Moray Firth coastline are highly variable, ranging from the predominantly hard rock Caithness and Buchan coastline to the soft coastlines of the Inner Firth.

Climate change is not expected to have any effect on the form or function of Smith Bank over the lifetime of the proposed development.

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MORAY WEST
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Physical Processes
Numerical Modelling

Moray Offshore Windfarm (West) Limited

Technical Appendix 6.2

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Acronyms	
Acronym	**Expanded Term**
2D / 3D	Two-dimensional / three-dimensional
ABP	Associated British Ports
ABPmer	ABP Marine Environmental Research Limited
AWAC	Acoustic Waves and Currents sensor
BODC	British Oceanographic Data Centre
BOWL	Beatrice Offshore Windfarm Limited
COWRIE	Collaborative Offshore Wind Research into the Environment)
DHI	Danish Hydraulic Institute
ETOPO2	Earth TOPOgraphy database (2 arc minute resolution) from NOAA
ETSU	Energy Technology Support Unit
HD	Hydrodynamics
Hs	Significant wave height (m)
km	kilometre
MCA	Maritime and Coastguard Agency
MDir	Mean wave direction (°from)
MIKE21FM	MIKE by DHI, MIKE21 Flexible Mesh software suite.
MORL	Moray Offshore Renewables Limited
NCEP	National Centers for Environmental Prediction
NOAA	National Oceanic and Atmospheric Administration
SEPA	Scottish Environment Protection Agency
SW	Spectral Wave
Tp	Spectral peak period (s)
Tz	Mean zero up crossing period (s)
WL	Water Level

1 Introduction

This appendix provides a description of the tide and wave numerical models created to inform:

- Chapter 6: Physical Processes and Water Quality
- Appendix 6.1: Physical Processes Baseline
- Appendix 6.3: Physical Processes Impact Assessment

For each of the models, the model extent, spatial and temporal resolution, and sources of input data (e.g. bathymetry and boundary conditions) are described. The performance of the models following calibration is described through comparison with the measured data used in the calibration process. The performance of the models (without further adjustment) is also validated and described through comparison with other additional measured data.

Following calibration and validation, these models are used elsewhere in this study (separately reported in the documents listed above) to inform both the description of baseline conditions in the study area, and assessments of potential impacts on these parameters.

The model suite used in this study is MIKE21FM provided by the Danish Hydraulic Institute (DHI). MIKE21FM is capable of modelling in both 2D (depth-averaged) and 3D (depth-resolved) mode as required. It comprises various modules enabling the simultaneous modelling of water levels, currents, waves and sediments if required. This software has been used extensively in similar offshore wind farm investigations, both in the UK and elsewhere in Europe.

Two modules of the MIKE21FM model have been applied here in 2D to resolve the key physical processes over both the near-field (array scale) and far-field (regional scale). The MIKE21FM Hydrodynamic module (MIKE21FM HD) has been used to resolve the tidal dynamics of the site and the MIKE21FM Spectral Wave module (MIKE21FM SW) has been used to assess the wave conditions.

The model design and application and the specification of data input required, follow the best practice guidance outlined in COWRIE (2009). It is noted that there are no widely adopted industry standards defining model calibration and validation. Therefore, ABPmer maintains its own guidelines for the calibration and validation of numerical models (ABPmer, 2011). These guidelines incorporate elements of COWRIE (2009) , which provides general guidelines for model calibration and validation.

2 Modelling Input Resources

This section describes the data sources used in the creation, calibration and validation of the tide and wave models. These include bathymetry, wind boundary conditions for the wave model, tidal water level boundaries for the tidal model, and various site specific and regional measured data.

2.1 Bathymetry

Site specific swath bathymetry has been collected for the application site by Osiris in 2010. Swath bathymetry collected by the MCA (Maritime and Coastguard Agency) in 2006 has been appended to the application site's specific data. This ensures that a suitable portion of the Moray Firth is captured in high detail for inclusion in the numerical models. The coverage of these data sets is shown in Figure 2.1.

Bathymetry data are also available at a lower resolution throughout the Moray Firth as part of the ETOPO2 global bathymetry data set.

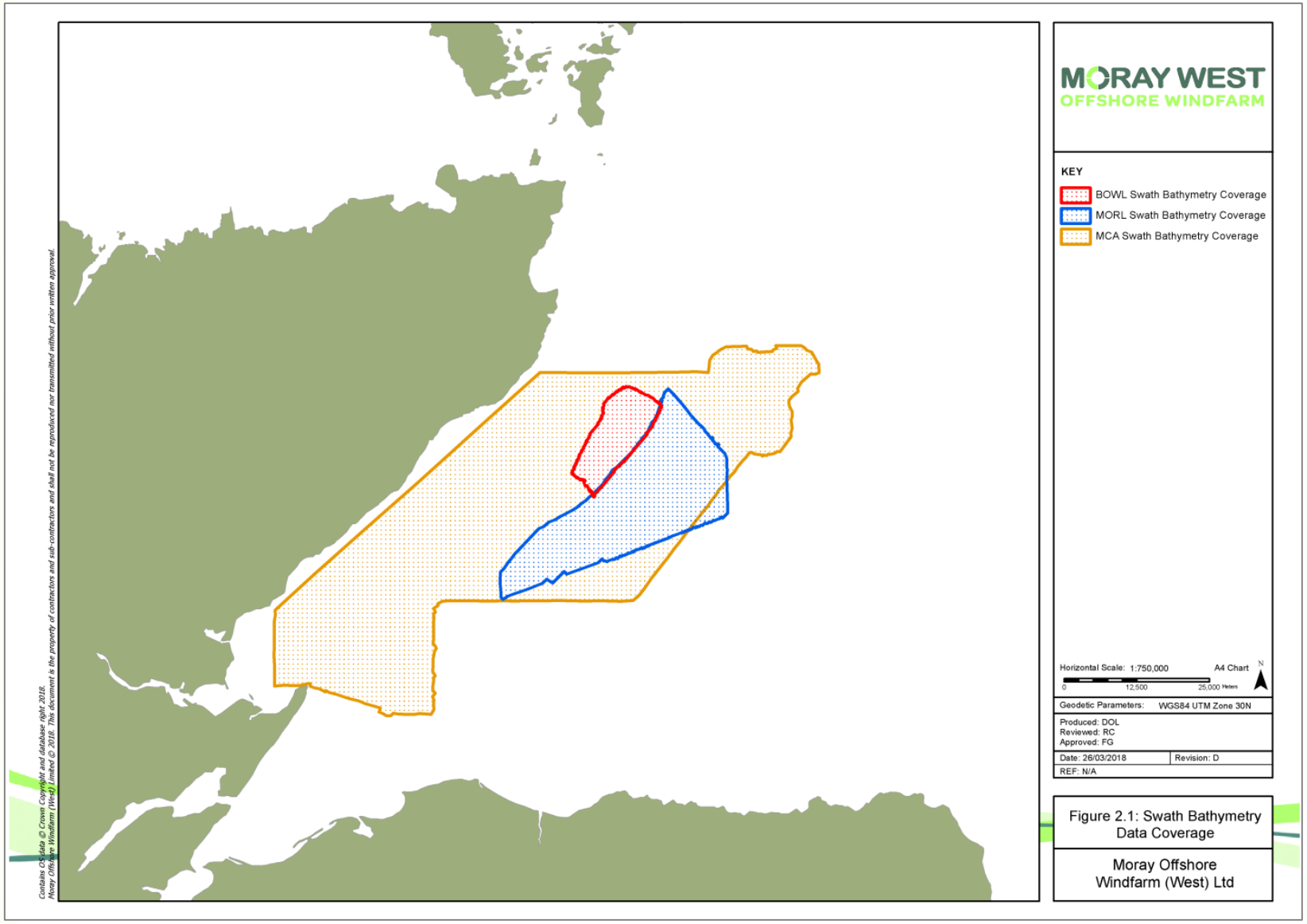


Figure 2.1: Swath Bathymetry Data Coverage in the Moray Firth

2.2 Metocean Survey Data

Partrac Ltd has undertaken an on-site metocean survey for Moray Offshore Renewable Ltd. These data are utilised in the development of these modelling tools in support of the present study. Deployments began in February 2010. Those deployments applicable for the Moray West area are:

- Four seabed frames in the Moray Firth R3 Zone with AWAC (Acoustic Wave And Current) devices measuring water levels, current profiles and waves;
- One wave buoy located at the north western edge of the Moray Firth R3 Zone;

The spatial and temporal extent of collected data was specified by ABPmer in order to inform and support robust numerical modelling as described here.

Additional observations of waves at a location further into the Moray Firth are also available from the 'Moray Firth' Wavenet wave buoy.

More details regarding the data collected may be found in Appendix 6.1: Physical Processes Baseline.

2.3 NCEP Winds (1990 to Present)

Hindcast winds for the North Sea region and the North East Atlantic have been extracted from the freely-available NOAA NCEP models and applied as the wind field over the wave model numerical domain. These modelled winds provide the driving boundary of the wave model.

2.4 DHI Global Harmonic Tidal Constituents

The DHI modelling software provides the means to predict harmonic water levels for any period of time based upon the satellite derived KMS tidal harmonic database. This is utilised to provide the water level variations that provide the offshore boundary conditions for the tidal model.

2.5 BODC Current Data

The British Oceanographic Data Centre (BODC) provides a number of data sets free of charge. Following quality checks, these data provide a means of assessing model performance over a wider spatial extent than is otherwise available from the site-specific metocean deployments.

2.6 Tide and Admiralty Chart Diamonds

Admiralty tidal predictions provide some limited information about the tidal streams in the Firth. These data provide an opportunity to make further comparisons with model output.

3 Mesh Construction

Two separate model domains form the basis of the tide and wave models. The spatial extent of these domains is shown in Figure 3.1. The extent of the tidal model is determined by the location of tidal amphidromes and the performance of the harmonic boundaries. The wave model extent is determined by the relevant fetch lengths over which winds can generate waves. For both models, the finest resolution (in the order of 200 m) is within the Moray Firth Zone (including the Moray West and Moray East Sites) and the Beatrice Offshore Wind Farm. Resolution decreases gradually from this near-field area of interest to not less than 1 km within the Moray Firth and not less than 40 km further offshore in the North Sea. This variable resolution approach ensures that the numerical models adequately represent local and regional scale bathymetric features that are relevant to the correct simulation of both tidal processes and any potential effects of the wind farm infrastructure.

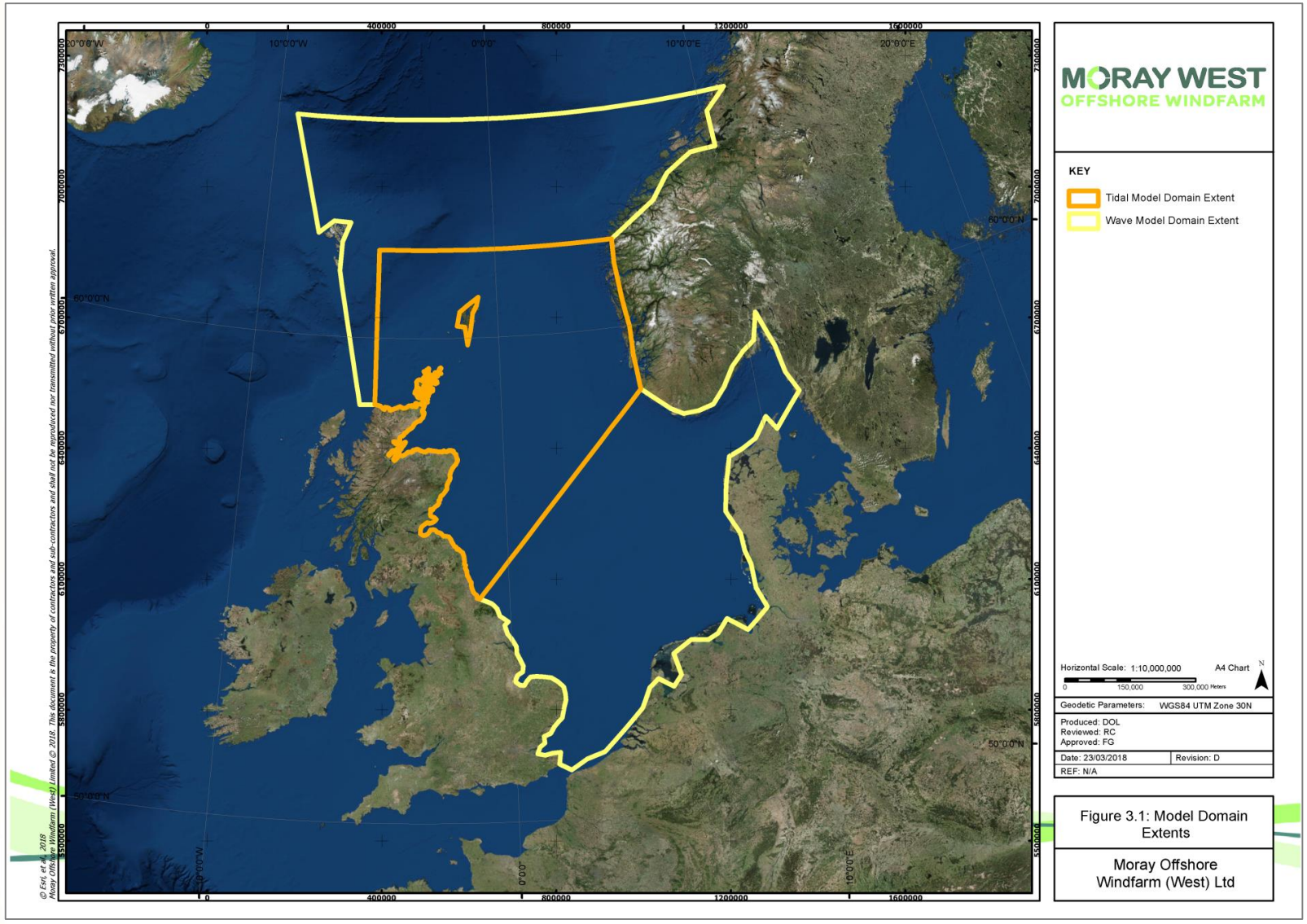


Figure 3.1: Tide and Wave Model Domain Extents.

Each model domain (tide and wave) is based upon the same bathymetry data, which include:

- ETOPO2 (far-field areas);
- MCA swath bathymetry (near-field areas); and
- Osiris swath bathymetry of the Moray West and Moray East Sites.

4 Tidal Model

4.1 General Design and Setup

4.1.1 Model Mesh

The extent of the tidal model mesh is shown in Figure 3.1. A flexible mesh design is used (a series of interlocking triangles of varying size and shape). The spatial resolution of the mesh in the vicinity of the application site is of the order of 200 m. Resolution decreases gradually to not less than 1 km within the Moray Firth while further offshore in the North Sea the lowest resolution is 40 km.

The various bathymetry data sets were collated for use, with priority given to higher resolution and reliability (e.g. swath survey) data locally. All data were referenced to mean sea level and interpolated onto the model mesh.

4.1.2 Open Boundaries

The boundaries of the tidal model are driven by predictions of spatially and temporally varying harmonically derived tidal water levels using DHI's KMS global tidal harmonic database.

4.1.3 General settings

A large range of settings and options are available within the MIKE21FM HD model software. This relatively simple tidal model uses largely default settings for the majority of options (e.g. the effects of wind, air pressure, waves, ice, precipitation or evaporation, etc., are not included in the simulation). Changes to the bed roughness parameter were made in order to achieve calibration (as described in Section 4.2).

4.2 Tidal Model Calibration

The model was calibrated with respect to the local measurements of water levels, current speed and direction obtained from the metocean survey within the Moray West Site. The calibrated model results are compared with the measured data used to calibrate the model in Figure 4.1 to Figure 4.9

4.2.1 AWACs (Water Levels and Currents) in the Moray West Site

In order to obtain the best agreement between the model predictions and the records from the site specific metocean surveys, the (spatially uniform) bed roughness model input parameter was iteratively adjusted. In this process, agreement was assessed both visually and through the use of various quantitative statistical metrics.

Time series of modelled and measured water levels and current speed and direction at the AWAC location in the central part of the Moray East Site (M3), in the eastern part of the Moray West Site (M5) and in the western part of the Moray West Site (M4) are shown in Figure 4.1 to Figure 4.3.

Additional scatter and polar plots of modelled and measured water levels and current speed are shown in Figure 4.4 to Figure 4.9.

The corresponding quantitative statistical description of the model's performance is detailed for the two locations within the Moray West Site in Table 4.1.

for water levels and Table 4.2 for currents. Negative values indicate occasions where there is under prediction, while positive values indicate over prediction.

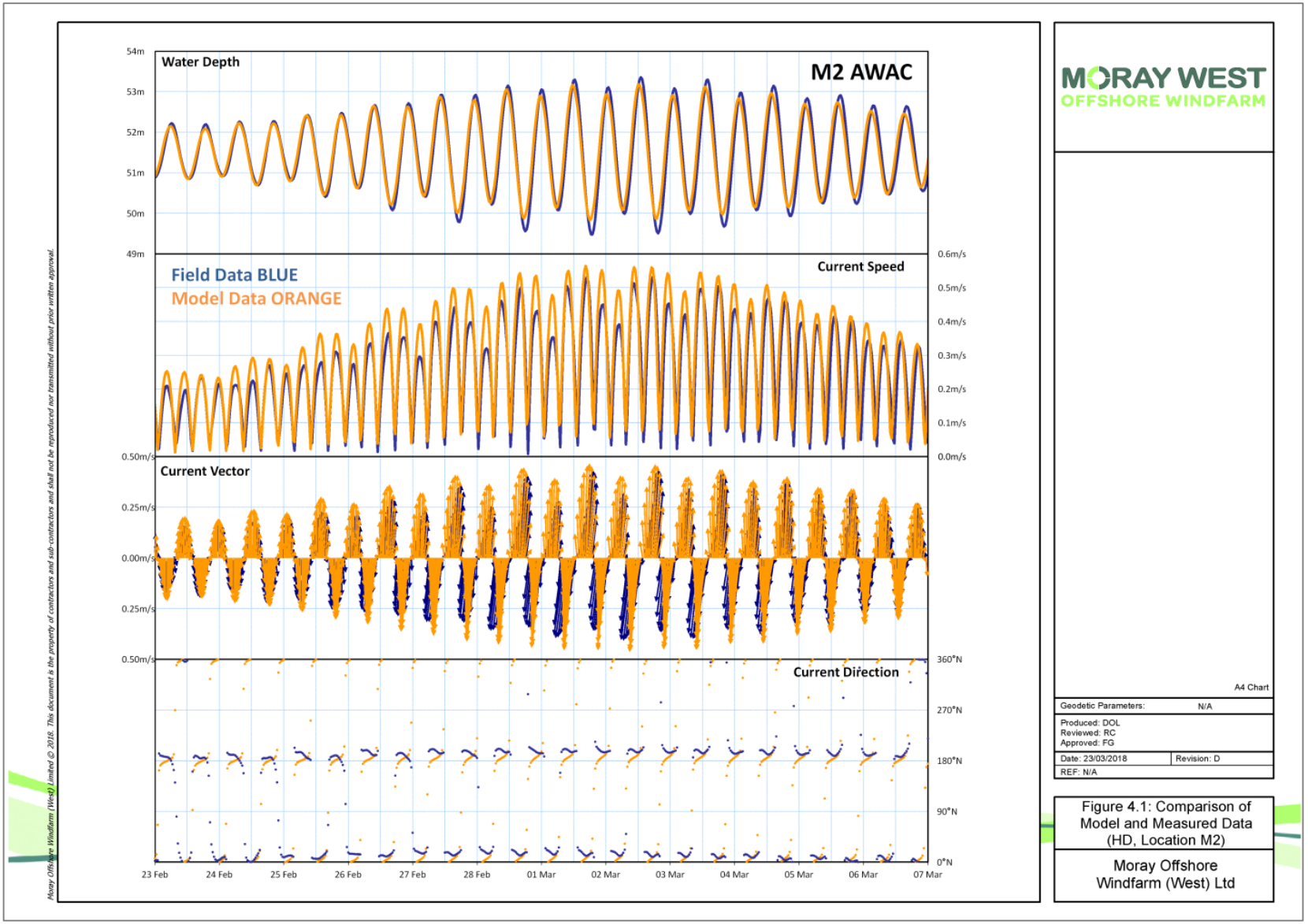
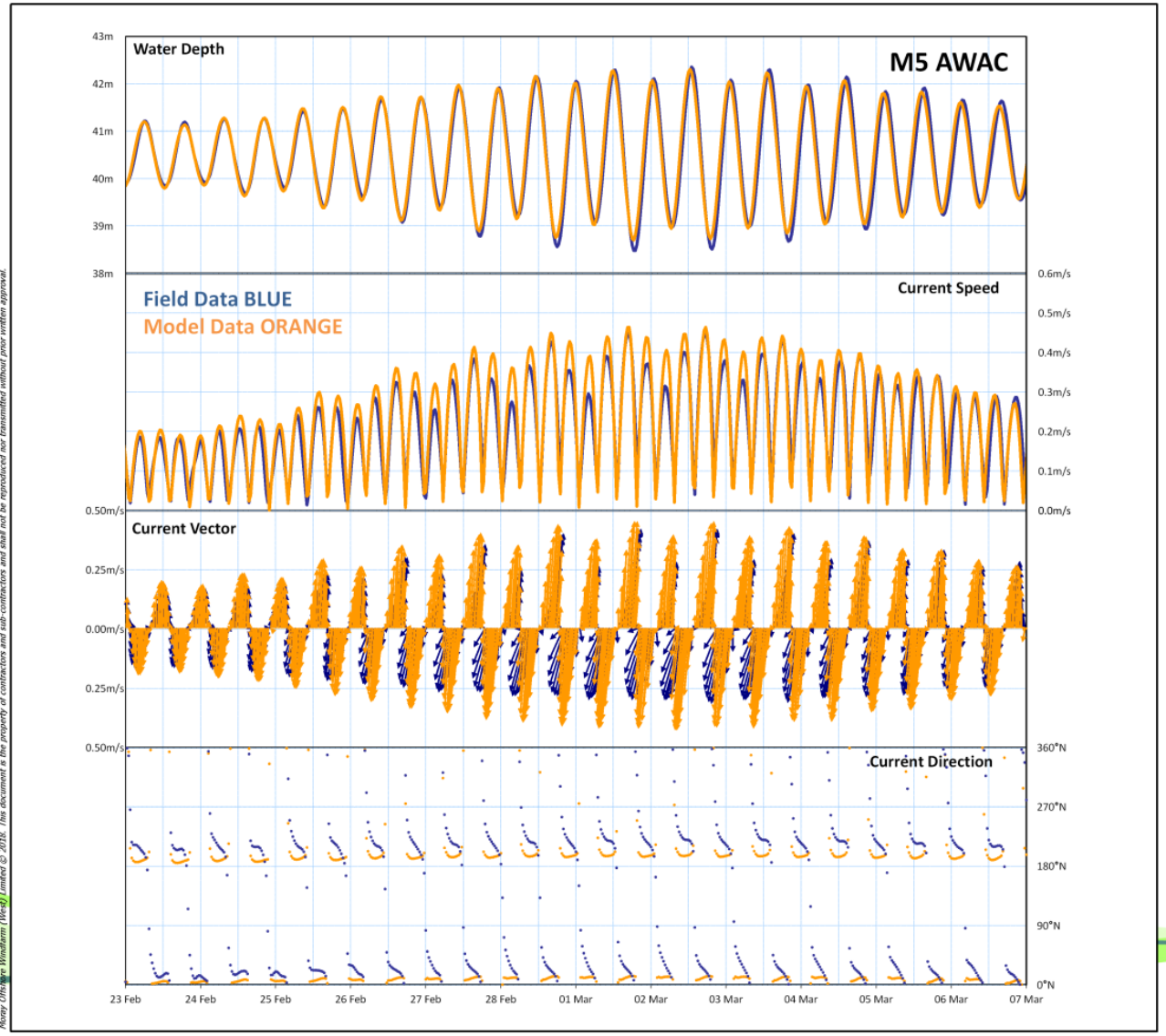


Figure 4.1: Comparison of Model and Measured Water Level and Current Timeseries Data (Location M3)



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A4 Chart

Geodetic Parameters:	N/A
Produced: DOL Reviewed: RC Approved: FG	
Date: 23/03/2018	Revision: D
REF: N/A	

Figure 4.2: Comparison of Model and Measured Data (HD, Location M5)

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Figure 4.2: Comparison of Model and Measured Water Level and Current Timeseries Data (Location M5)

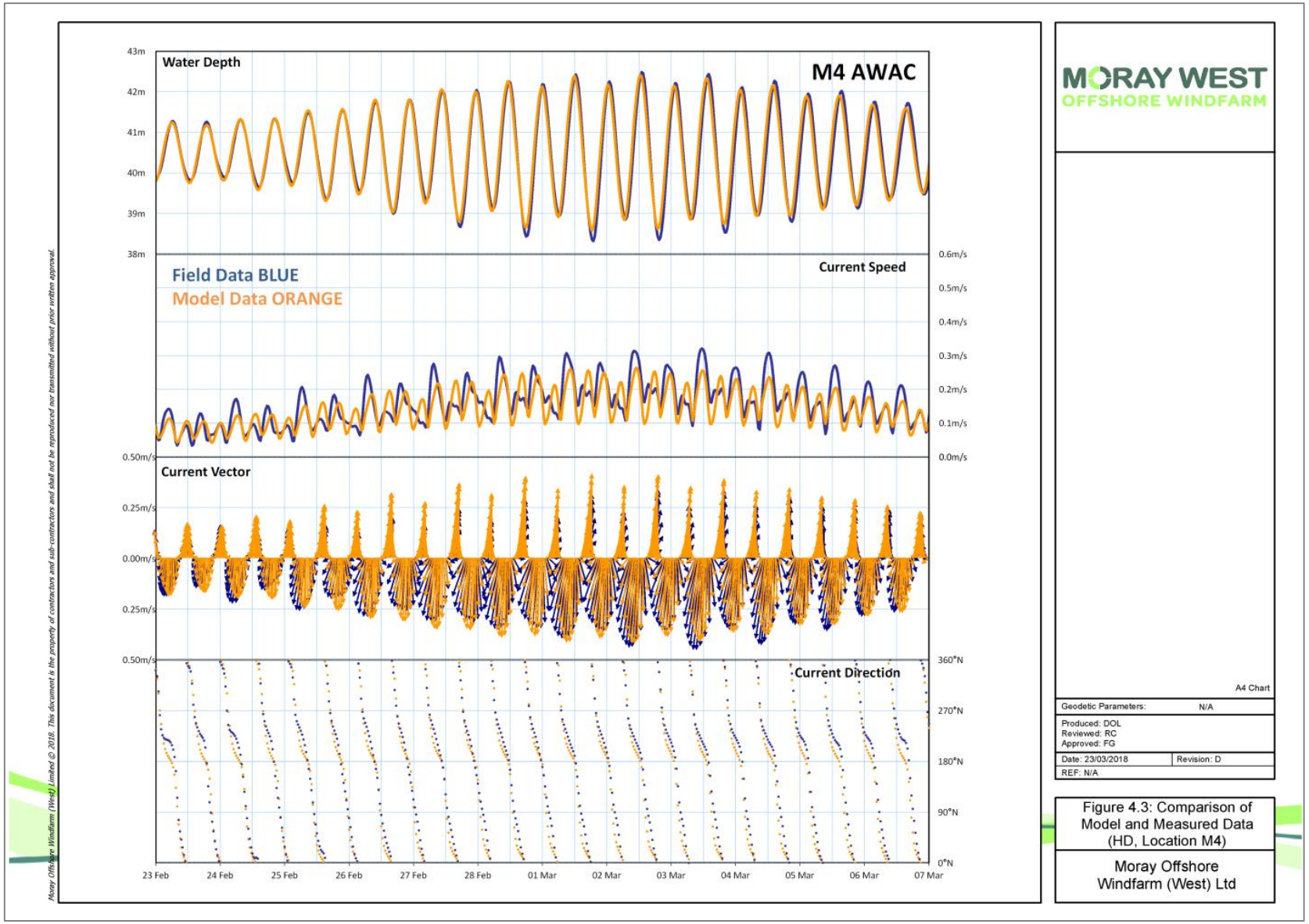


Figure 4.3: Comparison of Model and Measured Water Level and Current Timeseries Data (Location M4)

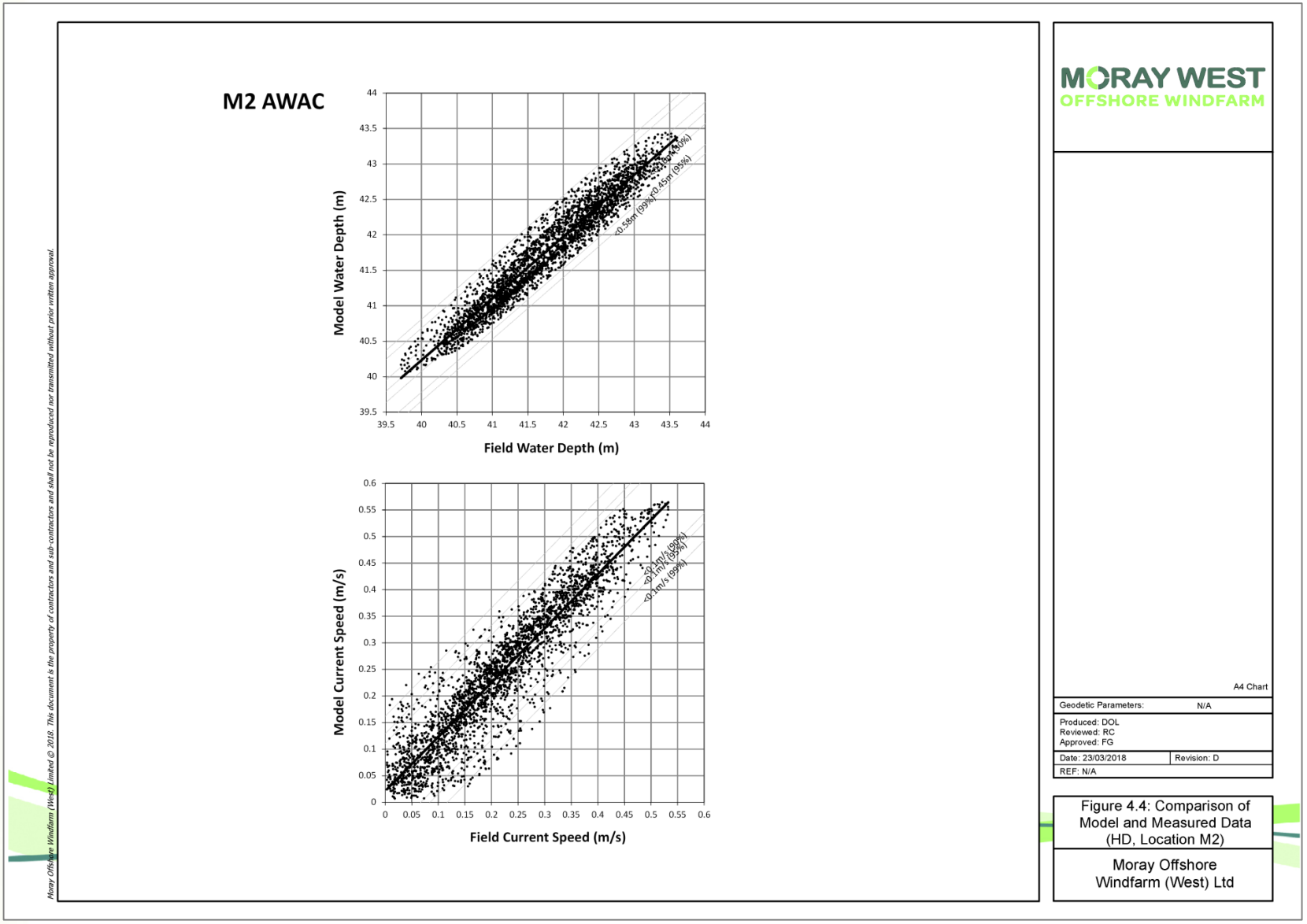


Figure 4.4: Comparison of Model and Measured Water Level and Current Speed Data (Location M3)

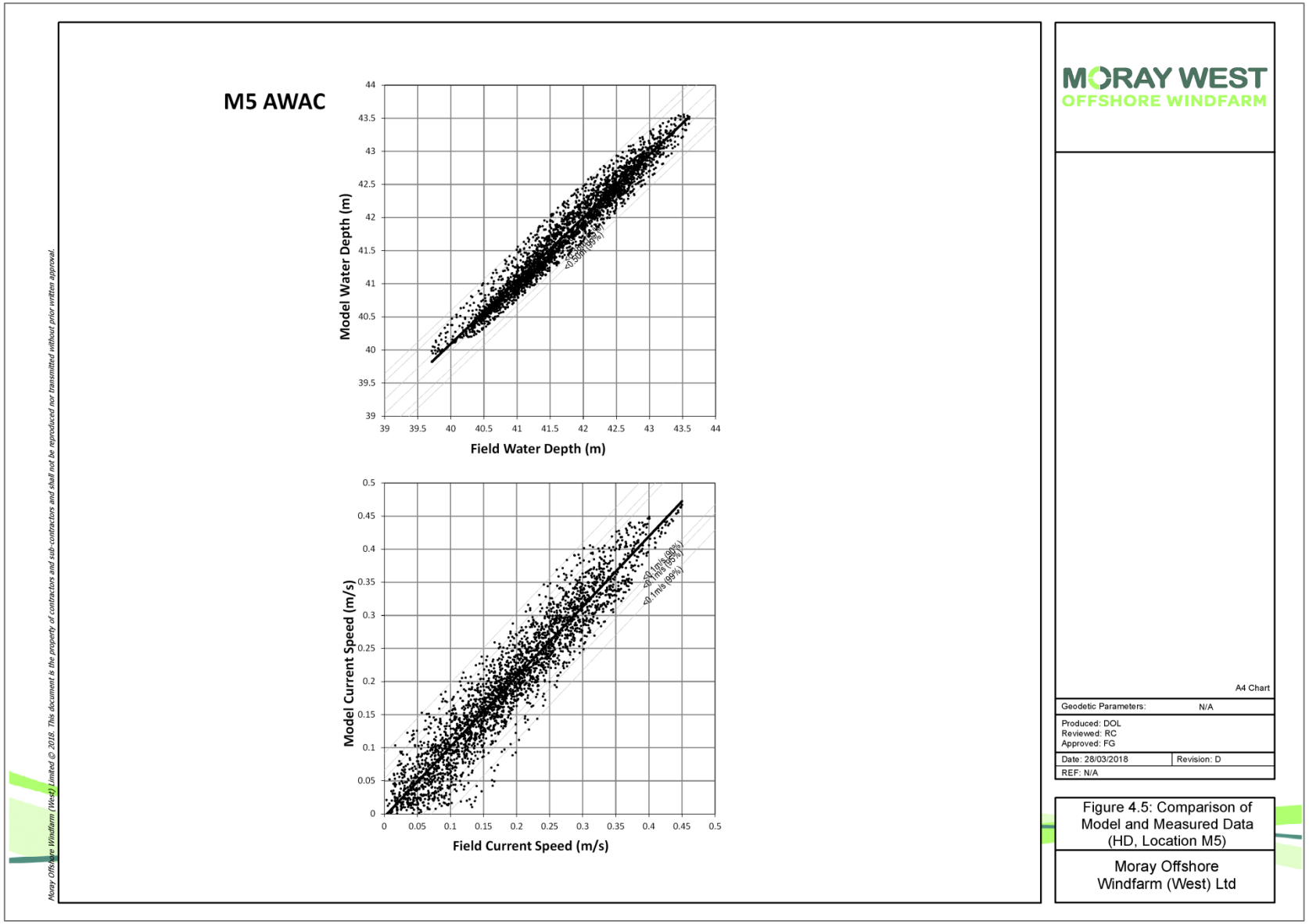


Figure 4.5: Comparison of Model and Measured Water Level and Current Speed Data (Location M5)

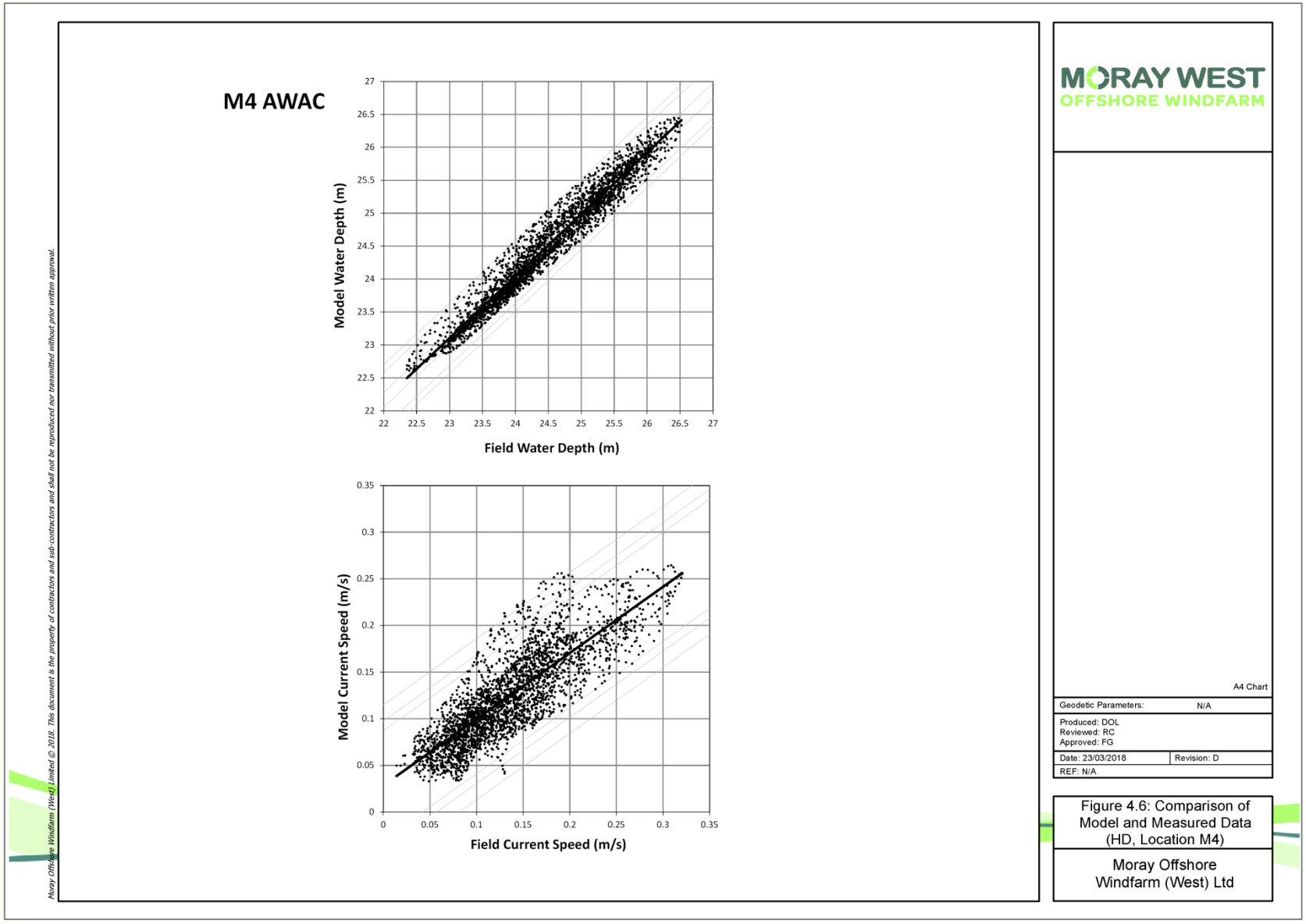


Figure 4.6: Comparison of Model and Measured Water Level and Current Speed Data (Location M4)

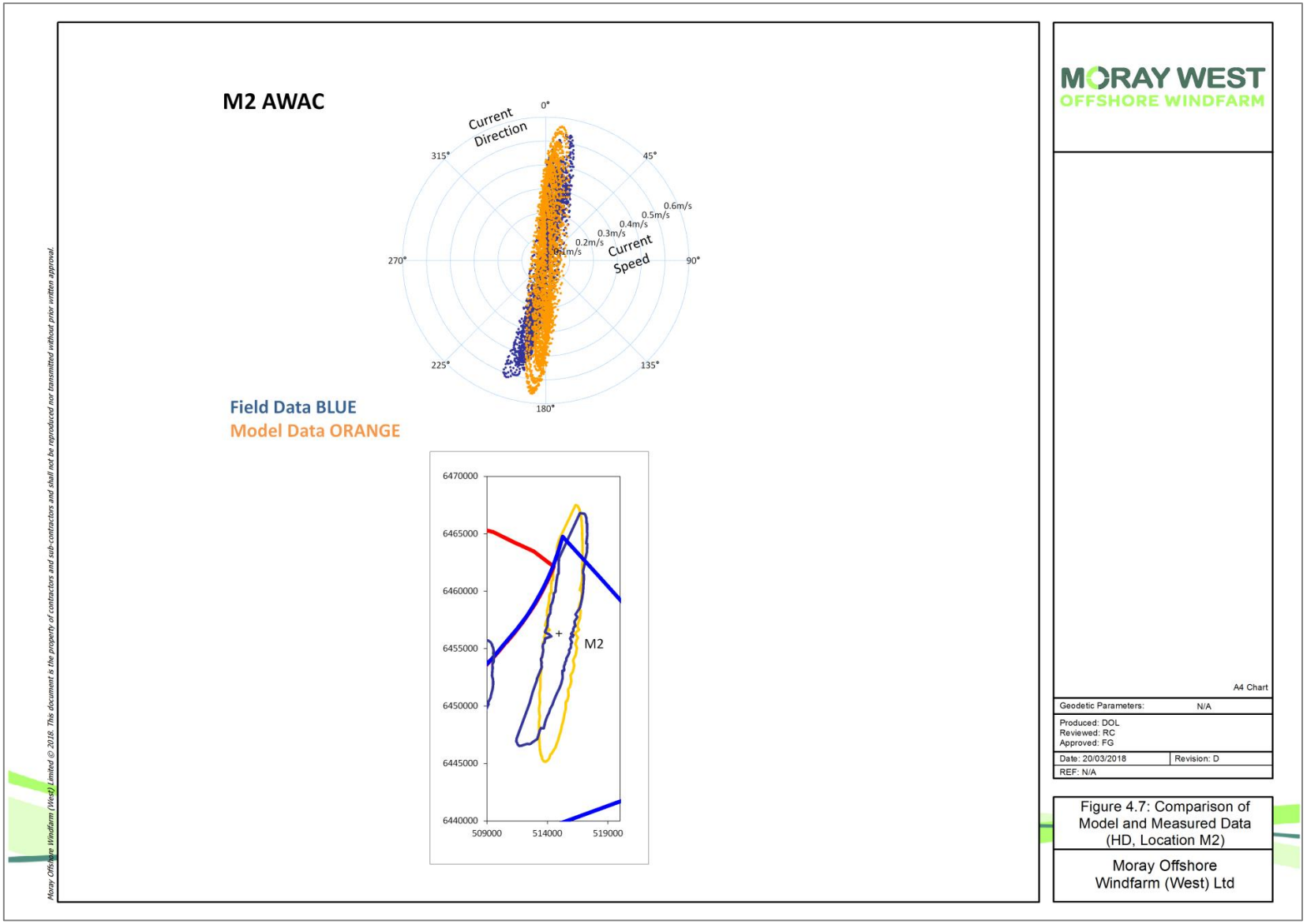


Figure 4.7: Comparison of Model and Measured Current Speed Envelope (Location M3)

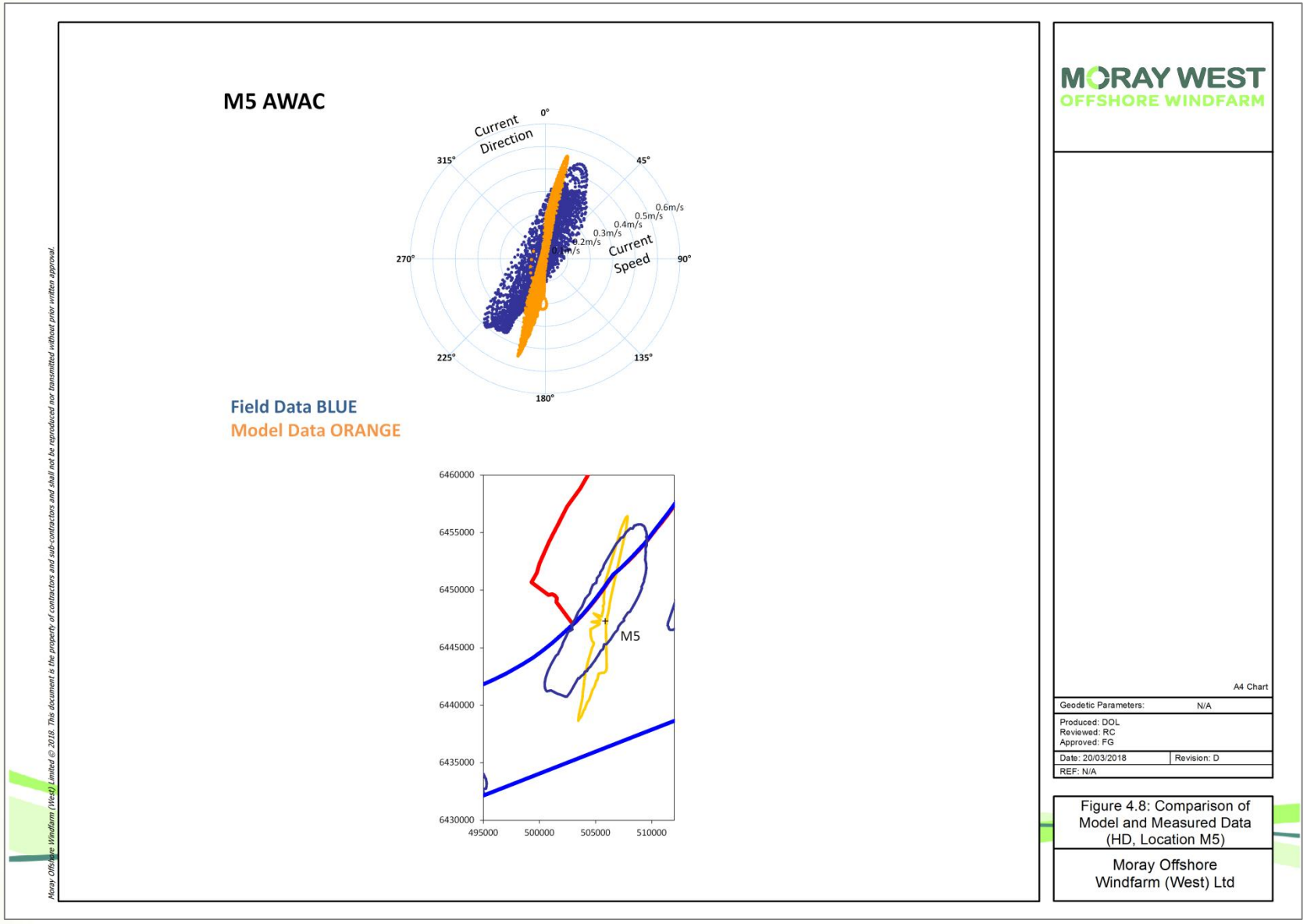


Figure 4.8: Comparison of Model and Measured Current Speed Envelope (Location M5)

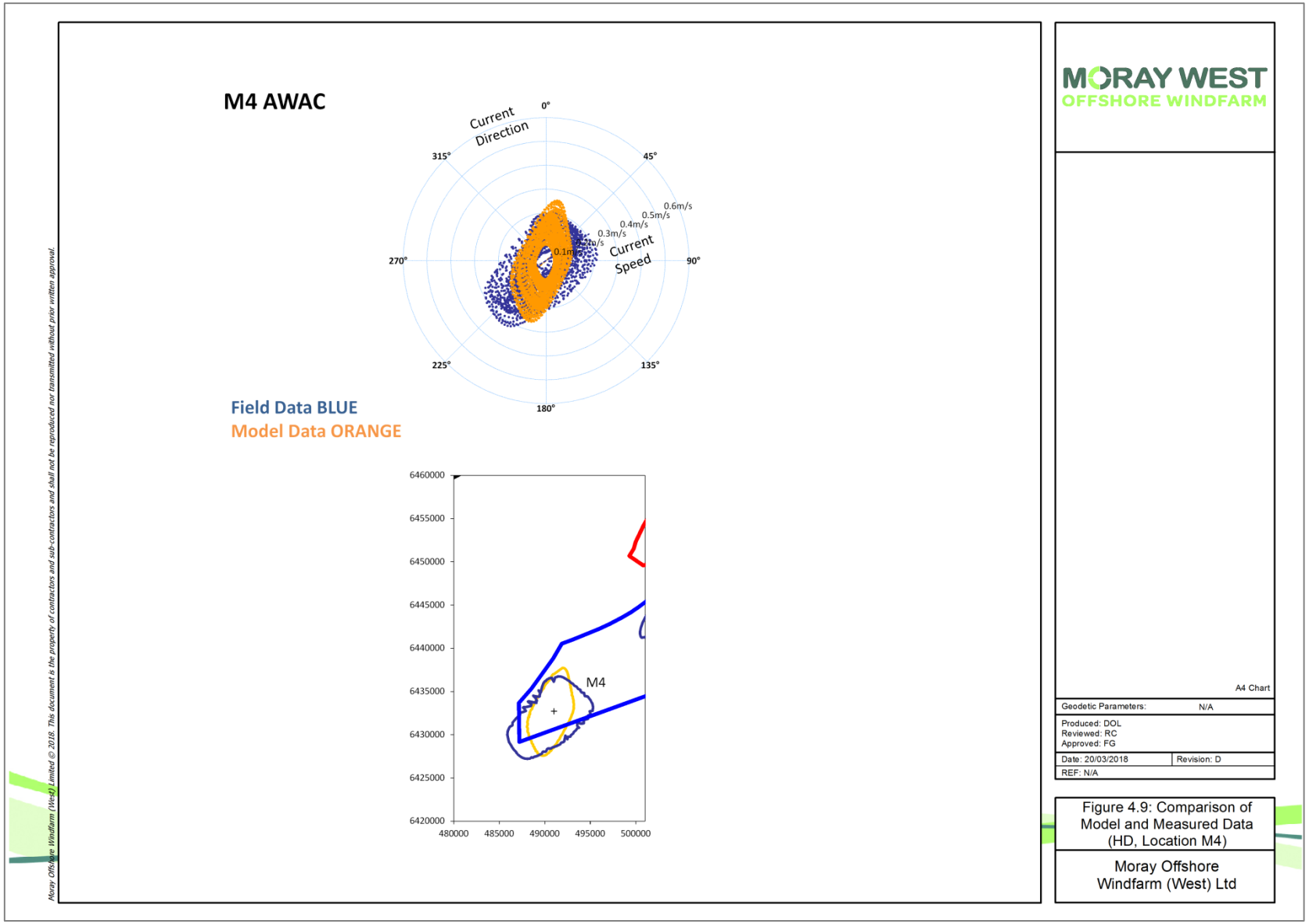


Figure 4.9: Comparison of Model and Measured Current Speed Envelope (Location M4)

Table 4.1: Calibration statistical analysis, water level.

Parameter	M4	M5
Mean High Water WL difference (modelled - observed) (m)	-0.04	-0.02
Mean Low Water WL difference (modelled - observed) (m)	0.03	0.02
Standard deviation of High Water WL difference (m)	0.05	0.05
Standard deviation of Low Water WL difference (m)	0.12	0.11
Mean High Water phase difference (mins)	-23.51	-23.49
Mean Low Water phase difference (mins)	-23.81	-24.20
Standard deviation of High Water phase difference (mins)	15.58	15.22
Standard deviation of Low Water phase difference (mins)	6.03	6.61
High Water difference relative to tidal range (%)	-1.41	-0.80
Low Water difference relative to tidal range (%)	0.97	0.65

Table 4.2: Calibration statistical analysis, current speed and direction.

Parameter	M4	M5
Mean speed difference, peak ebb (modelled - observed) (m/s)	0.03	0.03
Mean speed difference, peak flood (modelled - observed) (m/s)	-0.04	0.03
Standard deviation of peak ebb speed difference (m/s)	0.02	0.03
Standard deviation of peak flood speed difference (m/s)	0.02	0.02
Mean direction difference, peak ebb (°)	-25.78	-11.11
Mean direction difference, peak flood (°)	-35.23	-21.67
Standard deviation of ebb direction difference (mins)	38.97	3.59
Standard deviation of flood direction difference (mins)	9.22	2.27
Mean difference relative to max observed speed, peak ebb (%)	15.50	7.46
Mean difference relative to max observed speed, peak flood (%)	-13.20	8.35

Figure 4.1 to Figure 4.6 and Table 4.1 show that, following calibration, the model performs well in reproducing the magnitude and pattern of measured variation water levels in the Moray West Site. The mean difference in predicted high and low water levels is less than 0.05m. It is noted that the model reproduces the high-low-high pattern in both the high and low water levels as identified in the field records (Figure 4.1 to Figure 4.3) and that the tidal axis and degree of rotation is also similarly replicated (Figure 4.4 to Figure 4.9.).

Phase difference in the predicted tide in the Moray West Site is minor, around -23 to -24 minutes. A negative phase difference indicates that the model is ahead in time (early) relative to observed values. The overall consistency in the phase errors and the small standard deviations (approximately 15 minutes) relative to the total phase lag suggests that the model is correctly reproducing hydrodynamic processes related to the speed of tidal wave progression at these locations.

Figure 4.1 to Figure 4.9and Table 4.2 show that, following calibration, the model is also performs well in reproducing the overall magnitude and pattern of current speed and direction over spring and neap conditions.

The directional patterns of tidal currents at sites M3 and M5 (in the Moray East Site and in the north-east of the Moray West Site, respectively) are relatively rectilinear in nature (i.e. with a well-defined flood and

ebb direction), with current speeds becoming slack or nearly slack during the transition between flood and ebb.

The directional pattern of tidal currents at site M4 (in the west of the Moray West Site) is relatively rotational in nature (with less well defined flood and ebb directions), with current speeds varying over flood and ebb periods but not becoming slack (not falling below 0.1m/s during spring conditions). In addition to the timeseries plots in Figure 4.1 to Figure 4.3, the rounder shape of the tidal ellipse is shown in Figure 4.6and Figure 4.9.

Other minor differences between modelled and measured tidal current speed around the peak of spring tides are small in absolute terms (~0.05 m/s at M4 and ~0.05 to 0.1 m/s at M5). Differences are of a similar or smaller magnitude to the expected natural deviation from the tidal signal due to storm surge effects, which are themselves also variable in magnitude and direction.

Mean peak ebb and peak flood current speeds are compared in Table 4.2. Mean speed differences between the modelled and measured data are less than 0.05 m/s at both sites. It must be noted that the accuracy of the field data may be less than the accuracy to which the differences between it and the model are quoted.

4.3 Tidal Model Validation

Following calibration and without further adjustment of the model setup, the model was also validated against other data sources to demonstrate satisfactory performance beyond the area of immediate interest. Validation was achieved by comparing the model's performance with other field data collected independently of the data used for model calibration. Validation is undertaken for both water levels and for currents.

4.3.1 Water Levels at Wick

Model water level output is compared to predicted tidal high and low water levels (using the Admiralty 'Tidecalc' software) for Wick Harbour in Table 4.3. The Wick tide gauge provides a long-term data measurement record and is part of the primary tide gauge network, therefore, the harmonics contained in the Tidecalc software provide a robust representation of tidal water level high and low water levels at this nearby location.

Table 4.3: Validation statistical analysis, high and low water levels at Wick.

Parameter	Wick
Mean High Water WL difference (modelled - observed) (m)	-0.03
Mean Low Water WL difference (modelled - observed) (m)	0.03
Standard deviation of High Water WL difference (m)	0.06
Standard deviation of Low Water WL difference (m)	0.08
Mean High Water phase difference (mins)	22.3
Mean Low Water phase difference (mins)	38.0
Standard deviation of High Water phase difference (mins)	14.07
Standard deviation of Low Water phase difference (mins)	15.59
High Water difference relative to tidal range (%)	-1.60
Low Water difference relative to tidal range (%)	1.71

Mean water level differences at both high water and low water are very small, in the order of ±0.03m. There is, therefore, good agreement between the model and Tidecalc predictions.

Mean phase differences between the model and Tidecalc at high and low waters are approximately 22 and 38 minutes, respectively. This is deemed acceptable as it largely consistent for high and low water periods (i.e. the difference is largely due to the slightly later passage of the tidal wave into and through the Moray Firth in the model). The close comparison of tidal wave water level range and rate of variation noted above (driving exchange of water volume and patterns of currents speed and direction) is considered to be more important in the present study.

4.3.2 Current Speed and Direction at BODC Current Meters

Depth averaged current speed and direction from the model was compared with measured data from numerous historical current meter deployments from the BODC archives. Although similar in concept, these data sets were collected by a range of instrument types at different dates and times, and at different depths in the water column. The locations of the various BODC data sets used are shown in Figure 4.10.

The measured current data were standardised prior to use by the application of harmonic analysis to isolate the tidal signal and to obtain data in a coincident time frame (the same spring-neap period used for calibration and validation elsewhere in this report). No adjustment was made for the height of data collection in the water column (which may account for some of any potential disagreement between measured and modelled data in the following comparisons).

Figure 4.10 also shows the scatter envelope of current speed and direction for the measured and modelled data. The similarity of overall shape, scale and orientation between the envelopes indicates that the model performs well in simulating patterns of current speed (in particular the magnitude of peak spring current speed) and direction (including the degree of tidal asymmetry and rectilinearity).

Figure 4.11 provides a semi-quantitative box and whisker graphical comparison of the distribution of measured and modelled current speeds at each location. Modelled time-mean current speeds are generally within 0.07m/s of the observed time-mean values. The overall range and distribution of more marginal values (including 5, 25, 75 and 95 % probabilities of non-exceedance) is also generally well represented in the model.

Table 4.4 provides additional quantitative validation statistics for each location. A generally good fit is also demonstrated by these statistics.

Sites b0433415 and b0012615 (shown in Figure 4.10) are located adjacent to the Banffshire and Aberdeenshire coastlines approximately 60 km south and south east of the application site, near to the export cable landfall in Sandend Bay. At these two locations the field data suggests a measureable asymmetry was present in the flow occurring during the period of data collection, where current speeds were consistently higher to the east during the flood tide. In comparison, the model produces a more symmetrical flow pattern in these locations.

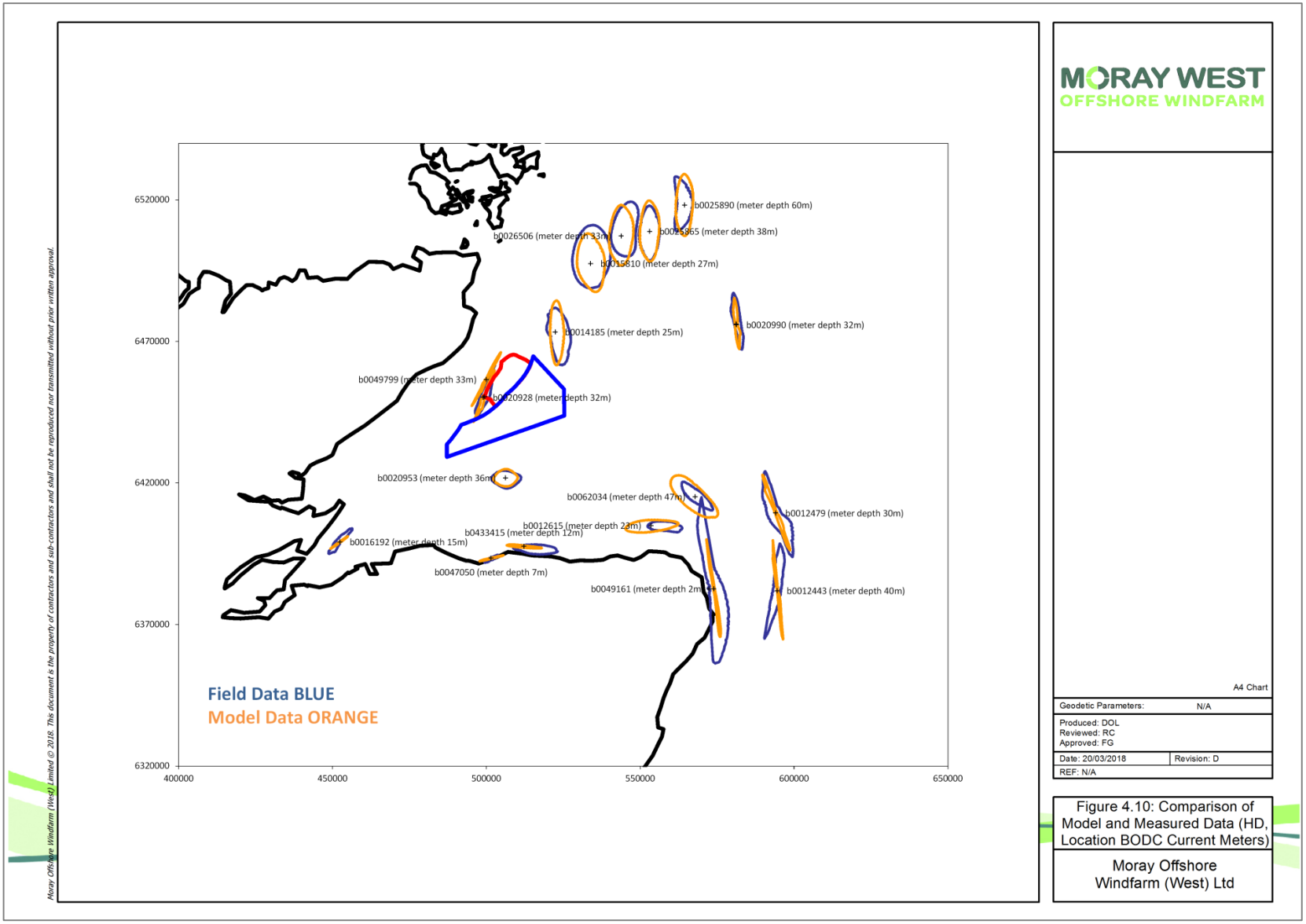


Figure 4.10: Comparison of Model and Measured Current Speed Envelope (Locations of BODC Current Meters)

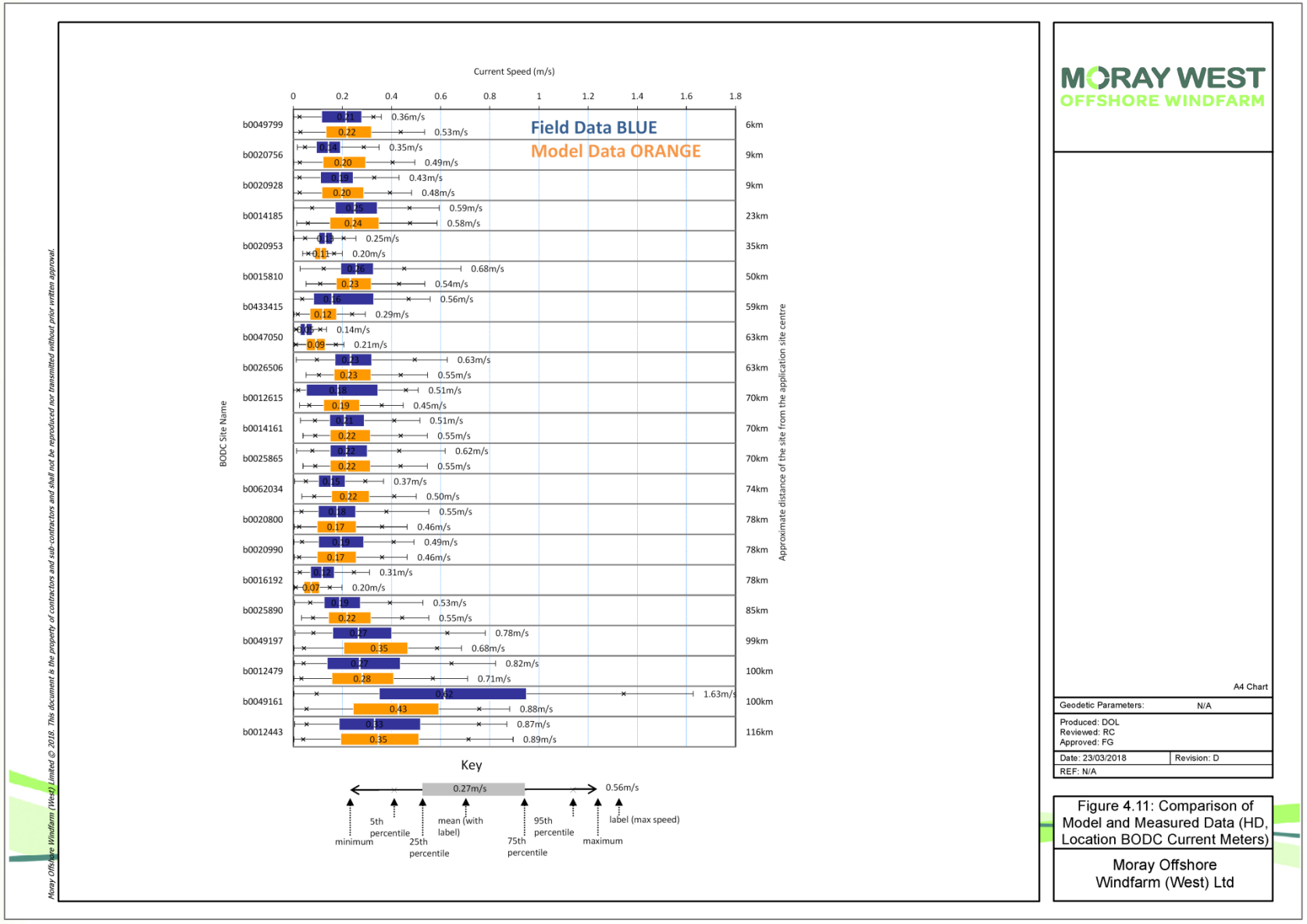


Figure 4.11: Comparison of Model and Measured Current Speed Distribution (Locations of BODC Current Meters)

Table 4.4: Validation statistical analysis, current speed and direction at the BODC current meters.

BODC site identifier	b0012443	b0012479	b0012615	b0014161	b0014185	b0015810	b0016192
Mean speed difference, peak ebb (modelled - observed) (m/s)	-0.05	-0.11	-0.12	0.06	0.05	-0.01	-0.09
Mean speed difference, peak flood (modelled - observed) (m/s)	0.04	0.04	0.13	-0.02	-0.04	0.00	-0.07
Standard dev of peak ebb speed difference (m/s)	0.10	0.08	0.05	0.09	0.11	0.09	0.03
Standard dev of peak flood speed difference (m/s)	0.16	0.14	0.08	0.08	0.07	0.06	0.05
Mean direction difference, peak ebb (°)	-21.23	2.41	10.10	0.39	0.72	3.65	8.92
Mean direction difference, peak flood (°)	-9.79	16.70	125.91	1.67	8.99	-3.18	18.87
Standard dev of ebb direction difference (°)	2.23	3.66	2.11	8.21	8.92	19.74	24.33
Standard dev of flood direction difference (°)	3.99	60.44	91.52	3.42	6.87	6.05	23.80
Mean difference relative to max observed speed, peak ebb (%)	-5.70	-13.79	-23.57	13.43	12.34	-1.52	-27.52
Mean difference relative to max observed speed, peak flood (%)	5.11	5.63	42.12	-2.96	-6.57	1.13	-23.48
BODC site identifier	**b0020756**	**b0020800**	**b0020928**	**b0020953**	**b0020990**	**b0025865**	**b0025890**
Mean speed difference, peak ebb (modelled - observed) (m/s)	0.12	0.01	0.04	-0.04	0.03	0.03	0.06
Mean speed difference, peak flood (modelled - observed) (m/s)	0.09	-0.02	0.03	-0.03	-0.07	-0.01	0.03
Standard dev of peak ebb speed difference (m/s)	0.08	0.08	0.08	0.02	0.08	0.08	0.08
Standard dev of peak flood speed difference (m/s)	0.05	0.05	0.04	0.03	0.04	0.05	0.05
Mean direction difference, peak ebb (°)	4.20	0.42	-19.78	-2.74	-7.59	-6.87	22.78
Mean direction difference, peak flood (°)	-3.60	4.26	-19.63	115.53	-3.38	17.24	-19.79
Standard dev of ebb direction difference (°)	5.33	6.43	3.20	45.17	10.99	31.50	20.37
Standard dev of flood direction difference (°)	5.31	4.56	3.75	176.76	4.79	6.95	3.83
Mean difference relative to max observed speed, peak ebb (%)	35.33	1.06	10.42	-14.86	6.84	4.28	11.76
Mean difference relative to max observed speed, peak flood (%)	25.45	-3.65	6.65	-10.17	-15.00	-2.01	5.72
BODC site identifier	**b0026506**	**b0047050**	**b0049161**	**b0049197**	**b0049799**	**b0062034**	**b0433415**
Mean speed difference, peak ebb (modelled - observed) (m/s)	-0.04	0.05	-0.49	-0.05	0.04	0.11	-0.24
Mean speed difference, peak flood (modelled - observed) (m/s)	0.03	0.08	-0.28	0.08	0.02	0.08	0.05
Standard dev of peak ebb speed difference (m/s)	0.10	0.03	0.23	0.09	0.11	0.07	0.04
Standard dev of peak flood speed difference (m/s)	0.08	0.03	0.21	0.09	0.10	0.05	0.07
Mean direction difference, peak ebb (°)	-19.94	7.09	-0.08	8.92	-3.56	-9.17	-2.50
Mean direction difference, peak flood (°)	15.49	9.45	-3.88	-23.90	5.05	8.75	83.11
Standard dev of ebb direction difference (°)	5.02	5.43	2.24	1.93	1.73	3.77	3.18
Standard dev of flood direction difference (°)	6.63	48.98	3.40	12.18	1.42	5.77	69.05
Mean difference relative to max observed speed, peak ebb (%)	-6.38	37.88	-30.21	-6.87	11.97	32.37	-42.87
Mean difference relative to max observed speed, peak flood (%)	8.65	57.58	-21.32	13.03	5.67	22.56	22.78

4.3.3 Bed Shear Stress Exceedance

In addition to the more direct calibration and validation of water levels and currents described in previous sections, consideration has also been given to the ability of the model to predict the proportion of time above and below certain levels of tidally-induced bed shear stress. Bed shear stress acts at the sea bed to mobilise and erode sediment, enabling transport by the ambient currents. The critical bed shear stress is the threshold level at which sediment of a certain size will become initially mobilised. Sediment is immobile when the bed shear stress is less than the critical threshold level. The potential sediment transport rate (assuming sediment is available to transport) increases non-linearly with bed shear stress in excess of the critical threshold level.

Here, the ability of the model to reproduce the net duration above and below certain bed shear stress levels is tested as a proxy for its ability to predict the proportion of time that certain sediments will be mobilised and / or transported. To this end, exceedance curves of bed shear stress determined from the measured and modelled current speed data are compared in Figure 4.12. Bed shear stress is calculated using the local water depth and current speed, using the quadratic stress law method (assuming a 1/7th power law vertical current velocity profile) as follows and described in more detail in Soulsby (1997).

$$\tau_{current} = \rho u_*^{\,2}$$

$$\frac{u_*}{U} = \frac{1}{7}\left(\frac{d_{50}}{h}\right)^{\frac{1}{7}}$$

Where:

$\tau_{current}$ = bed shear stress due to currents

ρ = density of sea water

u_* = friction velocity

d_{50} = median sediment grain size

U = current speed

The surficial seabed sediments in the Moray West Site are characterised as glacial till containing sands, gravels and a low fraction of silt. Figure 4.12 shows that these sediment types are largely immobile under the majority of tidal conditions.

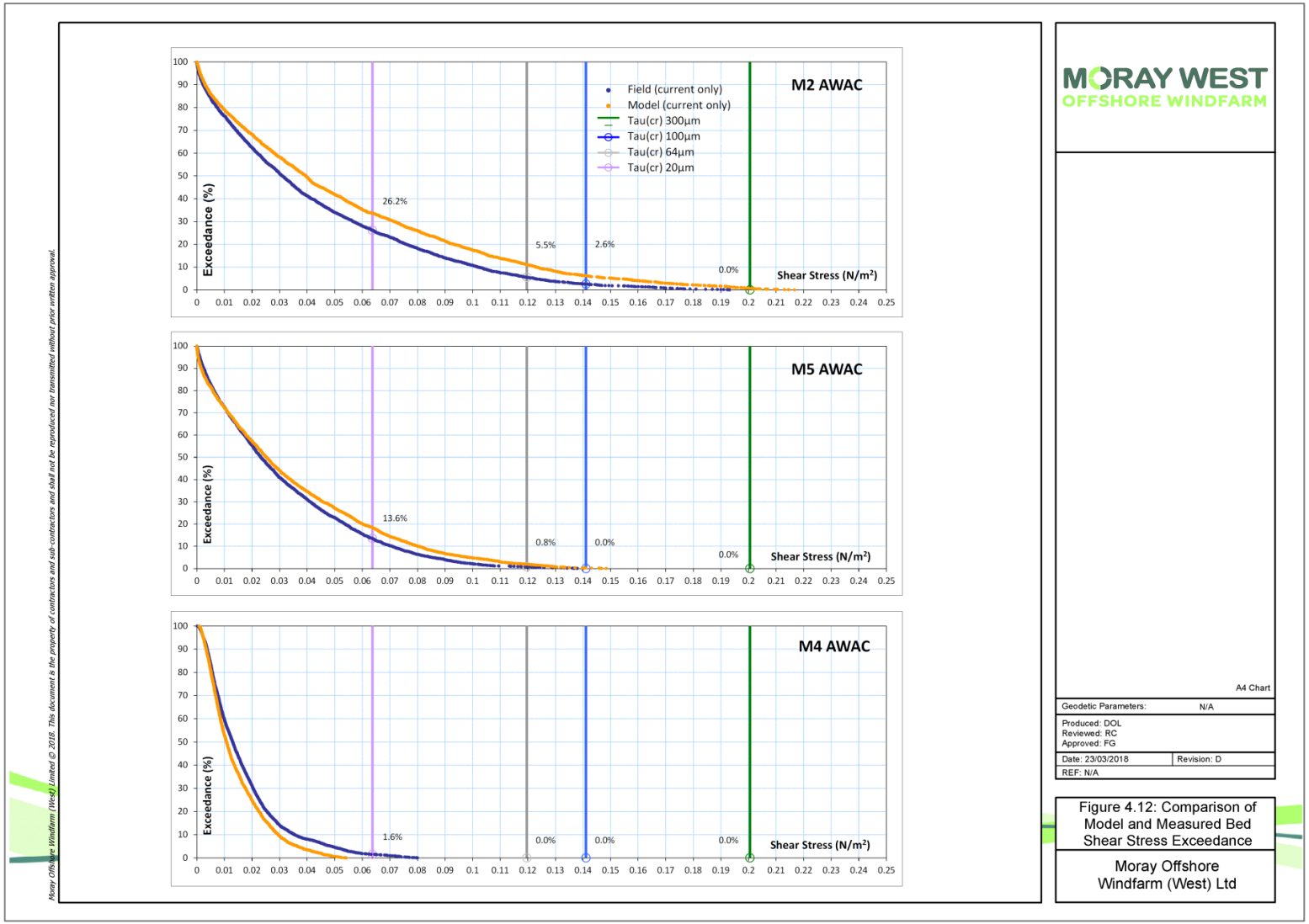


Figure 4.12: Comparison of Bed Shear Stress Occurrence Determined from Model and Measured Current Speed (Location BODC Current Meters). Also Showing Relative Thresholds for Sediment Mobility.

4.3.4 Validation Conclusion

The graphical comparisons of measured and modelled data, and the quantitative statistics based on the same data, validate that the tide model is capable of reproducing the magnitude, timing and general pattern of variance in water levels and tidal current speeds and directions, over a range of spring and neap conditions, at locations both within and nearby but outside of the Moray West Site.

The tide model is validated as being fit for the intended purpose of providing baseline information and a realistic basis for impact assessment related to foundations in the Moray West Site and other nearby wind farms.

4.4 Simulating the Effect of Wind Farm Foundations

For the assessment of array-scale (near-field) processes and potential impacts, the wind farm foundation structures are represented in the model using the sub grid-scale 'pier resistance' function. In this approach, the resistance to the flow attributable to the presence of sub-grid scale structures (e.g. turbine foundations) is modelled by accounting for the drag force on the structure in the form of an equivalent additional bed shear stress. This is an established approach recommended as best practice (ETSU, 2002).

Using this approach, the baseline and 'with scheme' models are run over a spring-neap cycle, thus covering a wide range of tidal conditions. The difference in results (in terms of patterns of water level and current speed and direction) between these two scenarios provides the corresponding potential impact of the wind farm foundations.

5 Wave Model

5.1 General Design and Setup

5.1.1 Model Mesh

The extent of the wave model mesh is shown in Figure 3.1. A flexible mesh design is used (a series of interlocking triangles of varying size and shape). The spatial resolution of the mesh in the vicinity of the application site is of the order of 200 m. Resolution decreases gradually to not less than 1 km within the Moray Firth while further offshore in the North Sea the lowest resolution is 40 km.

The extent of the wave model is larger than that of the tidal model and includes all of the relevant fetches for development of larger waves by winds that might enter the Moray Firth.

The various bathymetry data sets were collated for use, with priority given to higher resolution and reliability (e.g. swath survey) data locally. All data were referenced to mean sea level and interpolated onto the model mesh.

5.1.2 Open Boundaries

The outer sea boundaries of the wave model are closed and all waves in the domain are developed by the wind field applied. This is representative of the actual processes by which waves affecting the Moray Firth are naturally created.

5.1.3 General settings

A large range of settings and options are available within the MIKE21FM SW model software. This relatively simple wave model uses largely default settings for the majority of options (e.g. the effects of currents, water levels, ice, etc., are not included in the simulation). The main driving force for the model

is the wind speed and direction, which is spatially and temporally variable when used to simulate a realistic timeseries, or spatially uniform for simulation of discrete events.

5.2 Wave Model Calibration

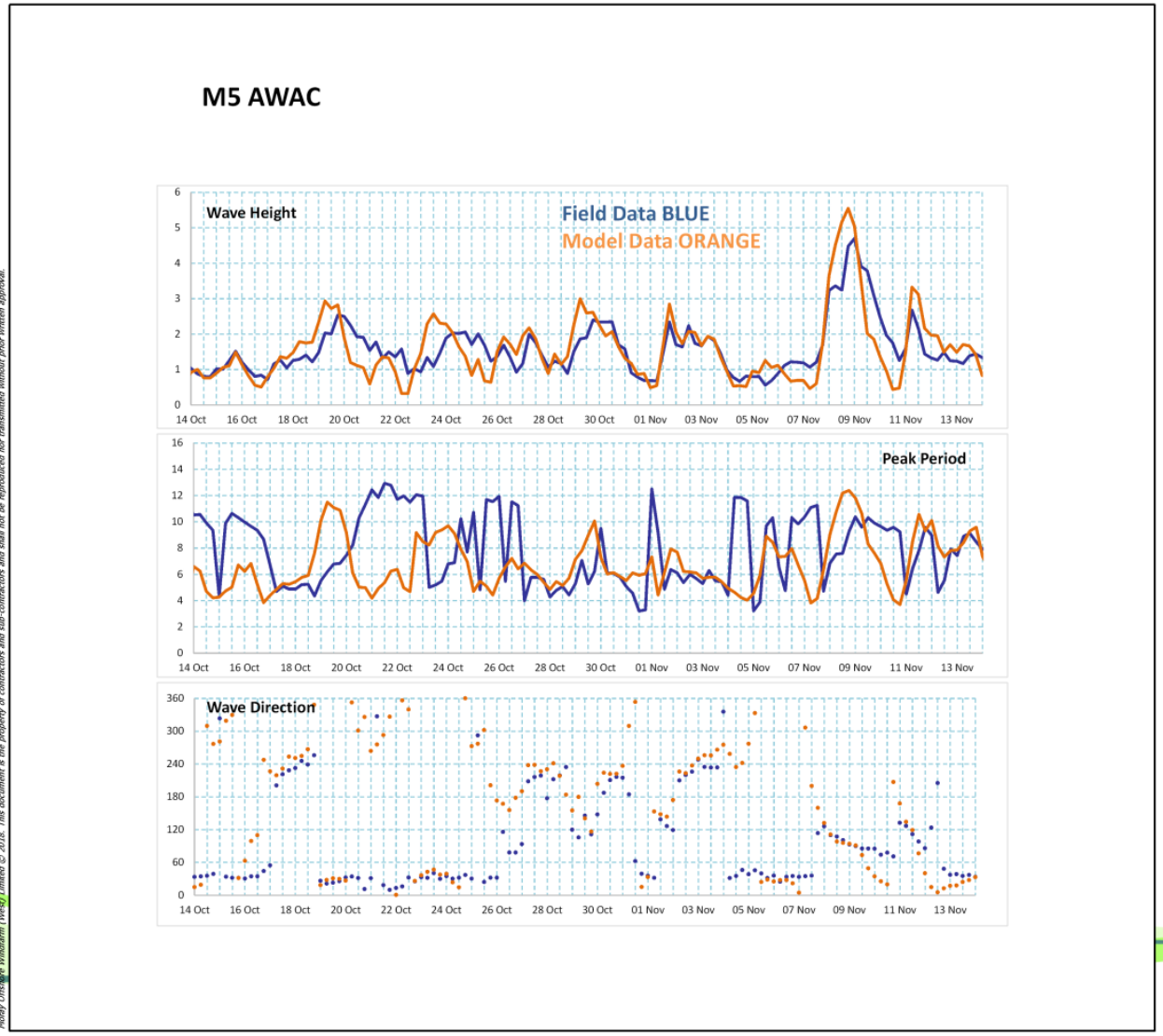
The model was calibrated with respect to the local measurements of wave height, period and direction obtained from the metocean survey within the Moray West Site (AWAC data from sites M5 and M4).

5.2.1 AWACs (Waves) in the Moray West Site

Calibration was performed by simulating wave conditions for the period 14th October 2010 to 14th November 2010, corresponding with the period of available survey data from within the Moray West Site. Validation was undertaken by comparing the model's performance against measured data from the Moray Firth WaveNet wave buoy during the same period.

The level of calibration achieved by the wave model at the AWAC locations in the eastern (M5) and western (M4), parts of the Moray West Site are shown in Figure 5.1 to Figure 5.4. A quantitative statistical assessment is provided in Table 5.1 and Table 5.2.

The time series of modelled and measured wave height, period and direction are compared in Figure 5.1 and Figure 5.2Scatter plot comparisons of the same data are provided in Figure 5.3 and Figure 5.4.



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A4 Chart

Geodetic Parameters:	N/A
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Figure 5.1: Comparison of Model and Measured Data (Waves, Location M5)

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Figure 5.1: Comparison of Model and Measured Wave Timeseries Data (Location M5)

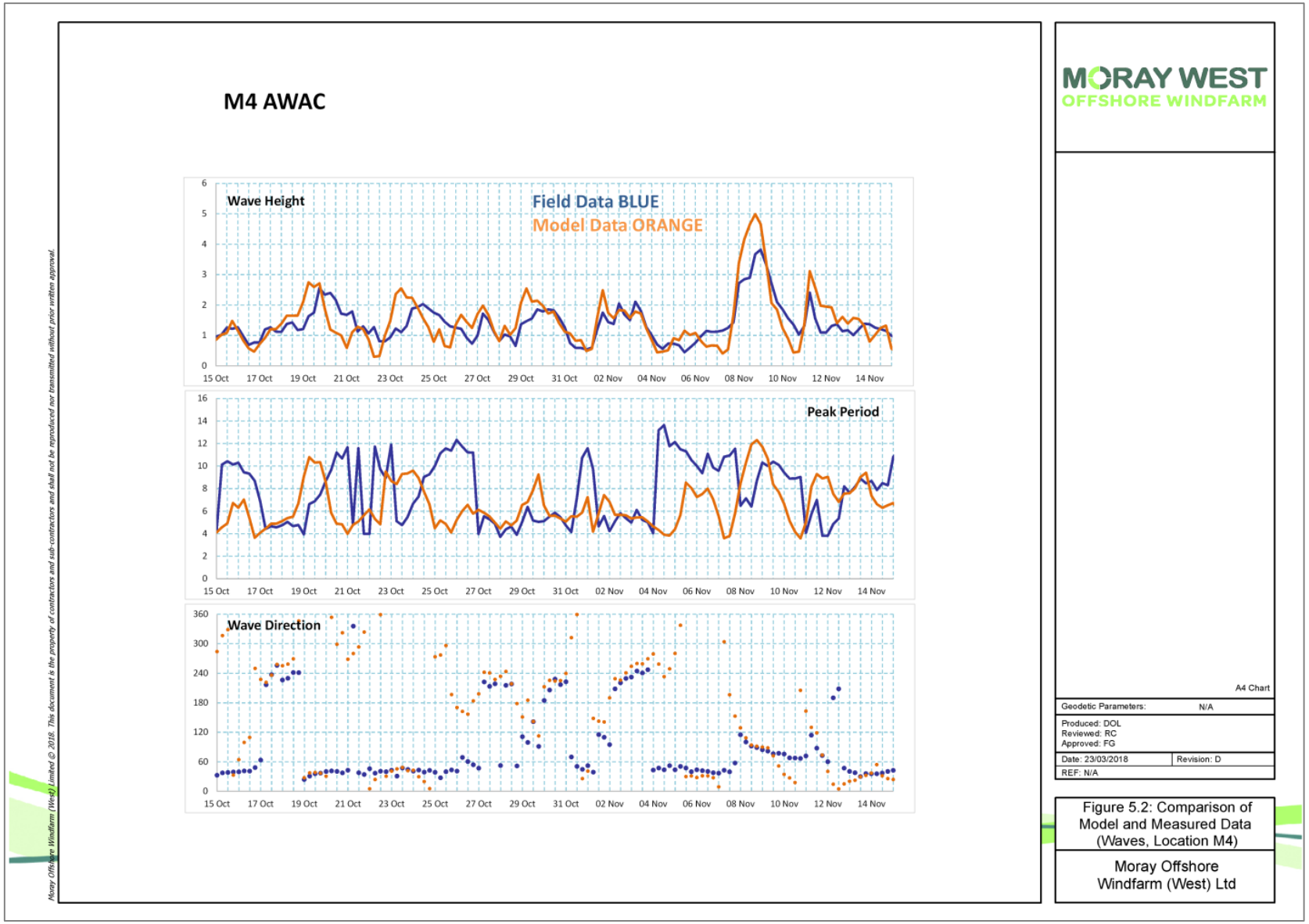

Figure 5.2: Comparison of Model and Measured Wave Timeseries Data (Location M4)

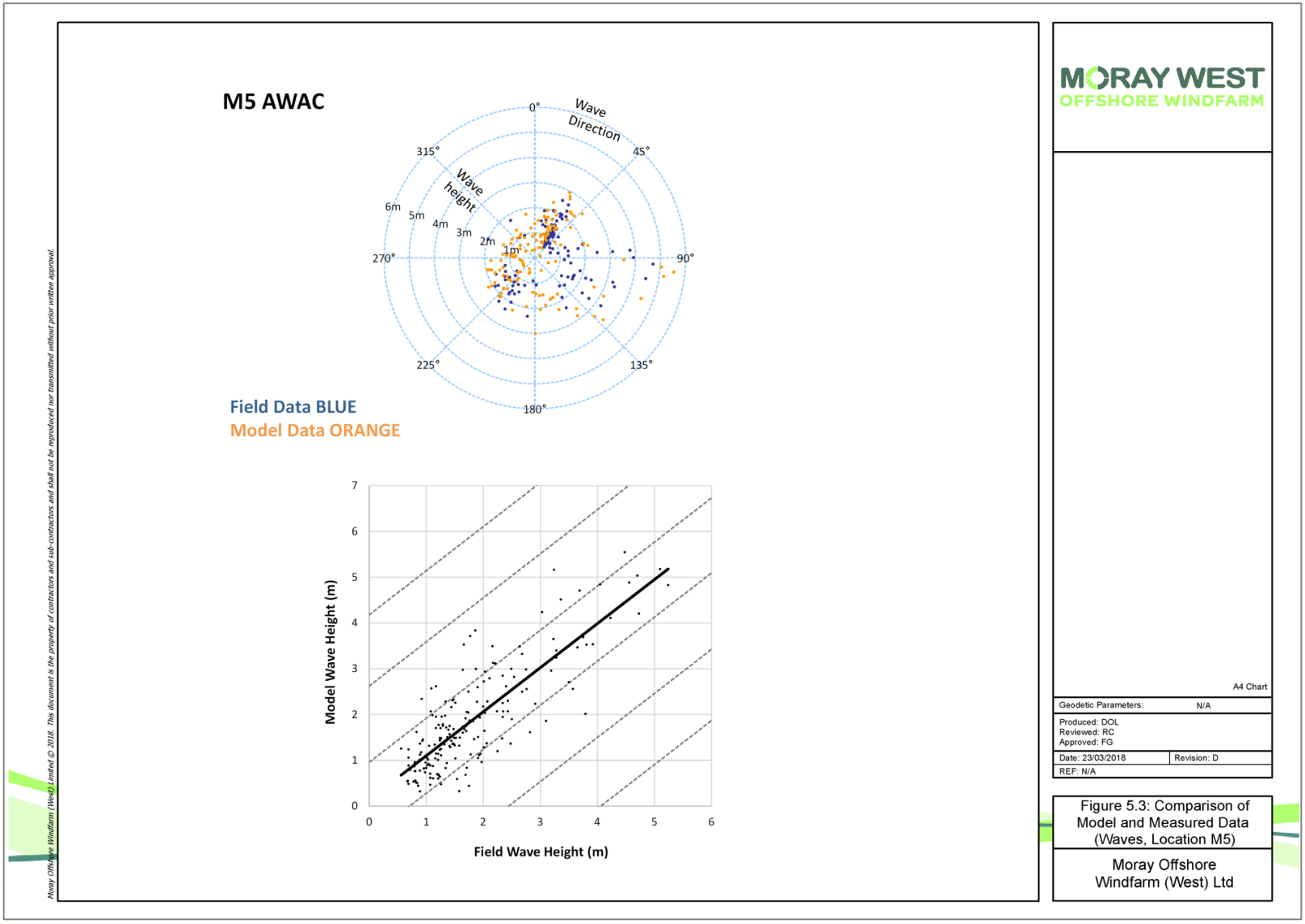

Figure 5.3: Comparison of Model and Measured Wave Data (Location M5)

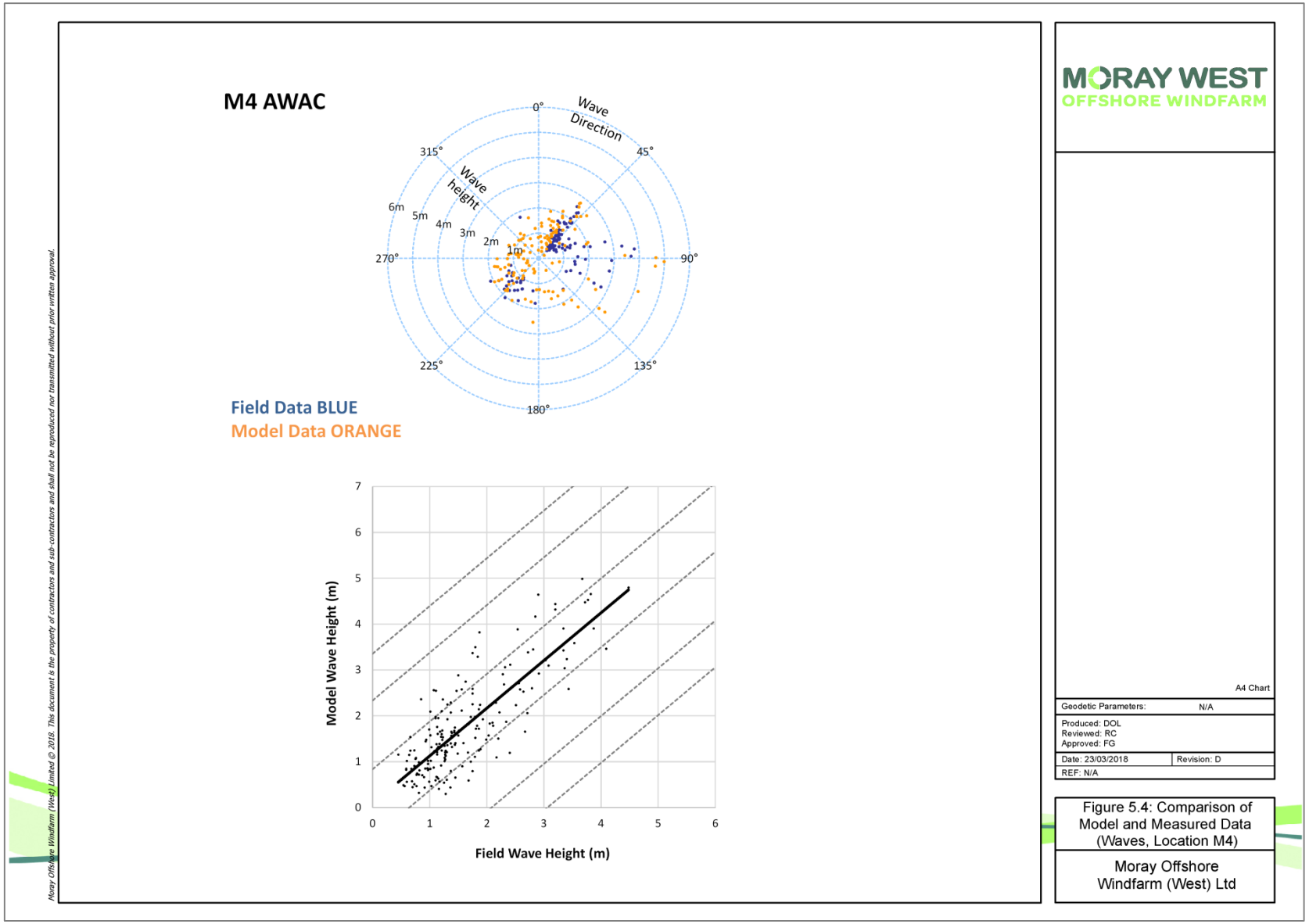

Figure 5.4: Comparison of Model and Measured Wave Data (Location M4)

Statistics of the modelled and measured wave climate for the two locations within the Moray West Site are compared in Table 5.1 and Table 5.2.

Table 5.1: Calibration statistical analysis, wave parameters at Location M4.

Parameter	Significant Wave Height (m)		Peak Wave Period (s)		Wave Direction (°N) [from]	
	Field	**Model**	**Field**	**Model**	**Field**	**Model**
Mean	1.4	1.5	7.8	6.5	62	61
Mode	1.3	1.2	5.1	5.6	40	31
99th percentile	3.6	4.7	13.0	11.8		

Table 5.2: Calibration statistical analysis, wave parameters at Location M5.

Parameter	Significant Wave Height (m)		Peak Wave Period (s)		Wave Direction (°N) [from]	
	Field	**Model**	**Field**	**Model**	**Field**	**Model**
Mean	1.6	1.6	7.9	6.8	71	70
Mode	1.2	1.1	5.5	4.7	32	15
99th percentile	4.3	5.1	12.7	12.1		

The various comparisons provided above demonstrate that the calibrated wave model is able to reproduce the overall magnitude and spatial patterns of wave events recorded in the field.

5.3 Wave Model Validation

Following calibration and without further adjustment of the model setup, the model was also validated against other data sources to demonstrate satisfactory performance beyond the area of immediate interest. Validation was achieved by comparing the model's performance with other field data collected independently of the data used for model calibration. Validation is undertaken for wave height, period and direction.

5.3.1 Waves at the Moray Firth WaveNet Wave Buoy

Modelled wave parameters are compared with those measured at the WaveNet wave buoy, an independent site located approximately 30 km to the south west of the Moray West Site.

A visual comparison of the measured and modelled time series data is shown in Figure 5.5. A scatter plot comparison of the same data is shown in Figure 5.6.

A quantitative comparison of measured and modelled wave climate statistics is provided in Table 5.3.

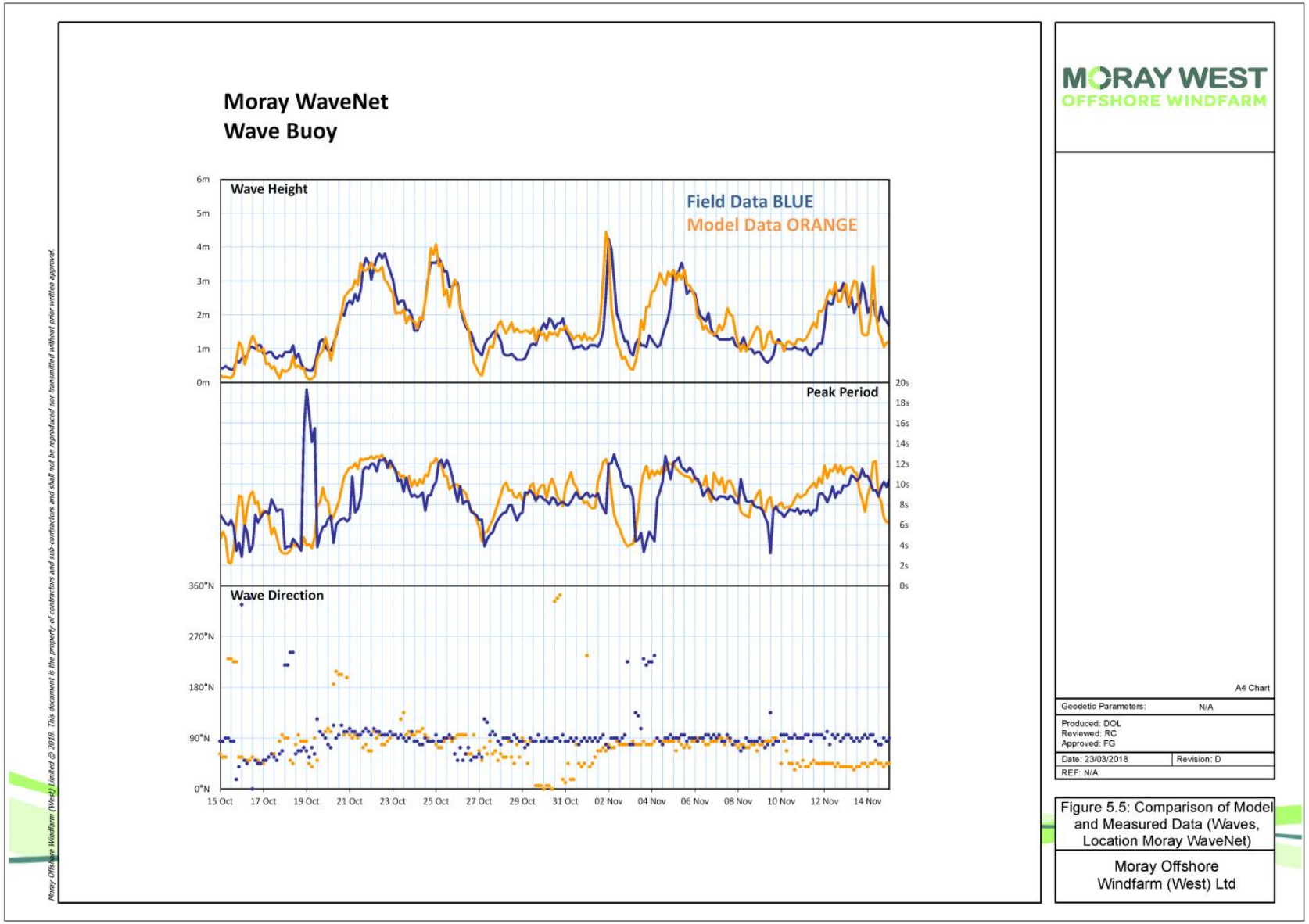

Figure 5.5: Comparison of Model and Measured Wave Timeseries Data (Location Moray WaveNet Wave Buoy)

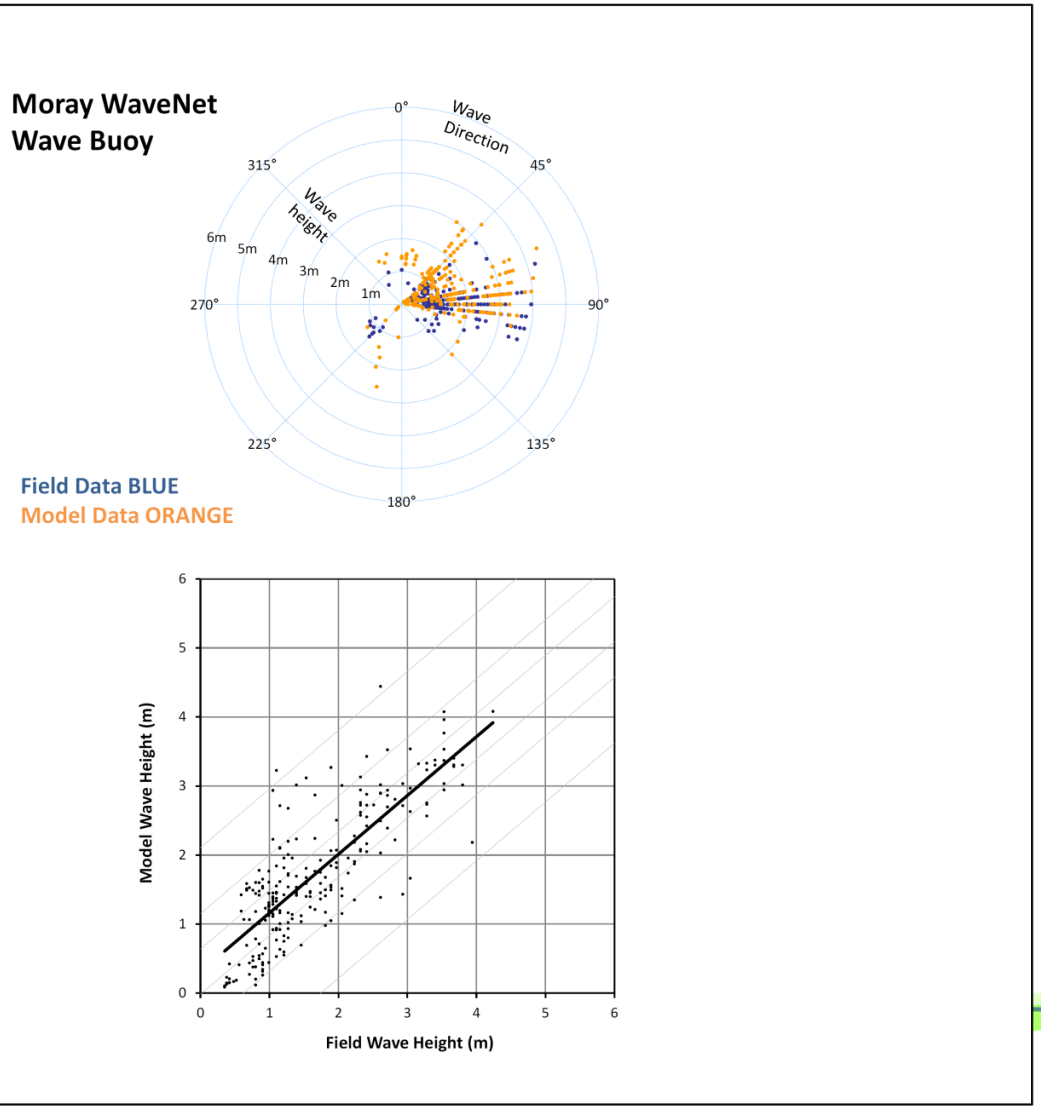

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Figure 5.6: Comparison of Model and Measured Data (Waves, Location Moray WaveNet)

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Figure 5.6: Comparison of Model and Measured Wave Data (Location Moray WaveNet Wave Buoy)

Table 5.3: Validation statistical analysis, wave parameters at Location Moray WaveNet wave buoy.

Parameter	Significant Wave Height (m)		Peak Wave Period (s)		Wave Direction (°N) [from]	
	Field	**Model**	**Field**	**Model**	**Field**	**Model**
Mean	1.64	1.71	8.28	8.70	89.00	72.00
Mode	1.00	1.50	9.00	13.00	90.00	90.00
99th percentile	3.80	4.00	15.00	12.40	-	-

The data shows that small differences in the timing of events lead to the greatest apparent difference in instantaneous wave height, period and direction.

5.3.2 Validation Conclusion

The graphical comparisons of measured and modelled data, and the quantitative statistics based on the same data, validate that the wave model is capable of reproducing the magnitude, timing and general pattern of a range of wave conditions, from everyday waves to storm events, at locations both within and nearby but outside of the Moray West Site.

The wave model is validated as being fit for the intended purpose of providing baseline information and a realistic basis for impact assessment related to foundations in the Moray West Site and other nearby wind farms.

5.4 Simulating the Effect of Wind Farm Foundations

For the assessment of array-scale (near-field) processes and potential impacts, the wind farm foundation structures are represented in the model using the sub grid-scale 'pier resistance' function. In this approach, the wave energy blockage and reflection attributable to the presence of sub-grid scale structures (e.g. turbine foundations) is modelled by reducing the transmission of wave energy through affected cells in proportion to the ratio of the cell dimension and the blockage width of the structure.

Using this approach, the baseline and 'with scheme' models are used to simulate the same wave conditions with and without the additional blockage present. The difference in results (in terms of patterns of wave height primarily, but also wave period and direction) between these two scenarios provides the corresponding potential impact of the wind farm foundations.

6 Conclusions

Numerical models have been constructed simulating tides and waves in the Moray Firth. These models have been firstly calibrated, and then separately validated, using various measured data. This process has shown that the numerical models are suitable to assist in the establishment of a conceptual understanding of physical processes of the region. In the context of the present study, tidal water levels, tidal current speed and direction, and wave height, period and direction have been shown to be reproduced well in and around the Moray West Site.

The tidal model provides a sufficiently accurate and realistic representation of tidal water level ranges and tidal current speeds and directions throughout the Moray Firth. The tidal model may, however, locally underestimate the (measured) degree of asymmetry of tidal currents at two locations off the Banffshire and Aberdeenshire coasts, which is close to the proposed Moray West export cable landfall location.

The wave model provides a sufficiently accurate and realistic representation of wave heights, periods and directions throughout the Moray Firth resulting from given wind conditions. A range of wave conditions have been tested including lower energy everyday conditions, and more energetic storm conditions.

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Physical Processes Impact Assessment

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Technical Appendix 6.3

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Acronyms	
Acronym	**Expanded Term**
ABP	Associated British Ports
ABPmer	ABP Marine Environmental Research
BERR	Department for Business, Enterprise and Regulatory Reform
BGS	British Geological Survey
BOWL	Beatrice Offshore Windfarm Limited
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
COWRIE	Collaborative Offshore Wind Research into the Environment
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DTI	Department of Trade and Industry
EIA	Environmental Impact Assessment
GBS	Gravity Base Structure (foundation type)
GIS	Geographical Information System
HAT	Highest Astronomical Tide
HDD	Horizontal Directional Drilling
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
MALSF	Marine Aggregate Levy Sustainability Fund
MCA	Maritime and Coastguard Agency
MEPF	Marine Environment Protection Fund
MHWN	Mean High Water of Neap Tides
MHWS	Mean High water of Spring Tides
MLWN	Mean Low Water of Neap Tides
MLWS	Mean Low water of Spring Tides
MMO	Marine Management Organisation
MORL	Moray Offshore Renewables Limited (now Moray Offshore Windfarm (East) Limited)
MSL	Mean Sea Level
MW	Megawatt(s)
OfTI	Offshore Transmission Infrastructure
OSP	Offshore Substation Platform
REA	Regional Environmental Assessment
SAC	Special Area of Conservation
SEPA	Scottish Environmental Protection Agency
SPM	Suspended Particulate Matter

Acronyms	
Acronym	**Expanded Term**
SSC	Suspended Sediment Concentration
SSSI	Sites of Special Scientific Interest
TSHD	Trailer Suction Hopper Dredger
UK	United Kingdom
UKHO	United Kingdom Hydrographic Office
USA	United States of America
WTG	Wind Turbine Generator

1 Introduction

1.1 Overview

ABPmer has been appointed by Moray Offshore Windfarm (West) Limited to consider the physical processes aspect of the Environmental Impact Assessment (EIA) for the Moray West Offshore Wind Farm and the associated offshore transmission infrastructure (OfTI), on the western side of the Moray Firth Round 3 Zone. The Moray West Offshore Wind Farm will be constructed within the Moray West Site, which is located approximately 22 km from the Caithness coast at its closest point and covers an area of 225 km² (Figure 1.1). The export cable landfall will be located on the Banffshire coast, at Sandend Bay between Findlater Castle to Redhythe Point, referred to as the 'Landfall Area'. The Moray West Offshore Wind Farm and OfTI are collectively referred to as 'The Development'.

Physical processes is a collective term for the following environmental parameters:

- Water levels;
- Currents;
- Waves (and winds);
- Sediments and geology: (including seabed sediment distribution and sediment transport);
- Seabed geomorphology; and
- Coastal geomorphology.

This Technical Appendix provides the detailed technical information underpinning each of the significance of effect assessments for physical processes receptors, presented in Chapter 6 (Volume 1): Physical Processes and Water Quality. The results are also been used to inform assessments for other EIA receptor groups which may potentially be sensitive to changes in physical processes.

The assessment considers the potential impact of the Development seaward of Mean High Water Springs (MHWS) during the construction, operation and maintenance, and decommissioning phases. The study is supported by a range of data including field monitoring and assessment techniques including new numerical modelling. The study also refers to the 'evidence base' of results from pre-existing numerical modelling/ desk based assessments undertaken to support EIA for other sufficiently analogous offshore wind farms, in particular the adjacent Moray East Offshore Wind Farm.

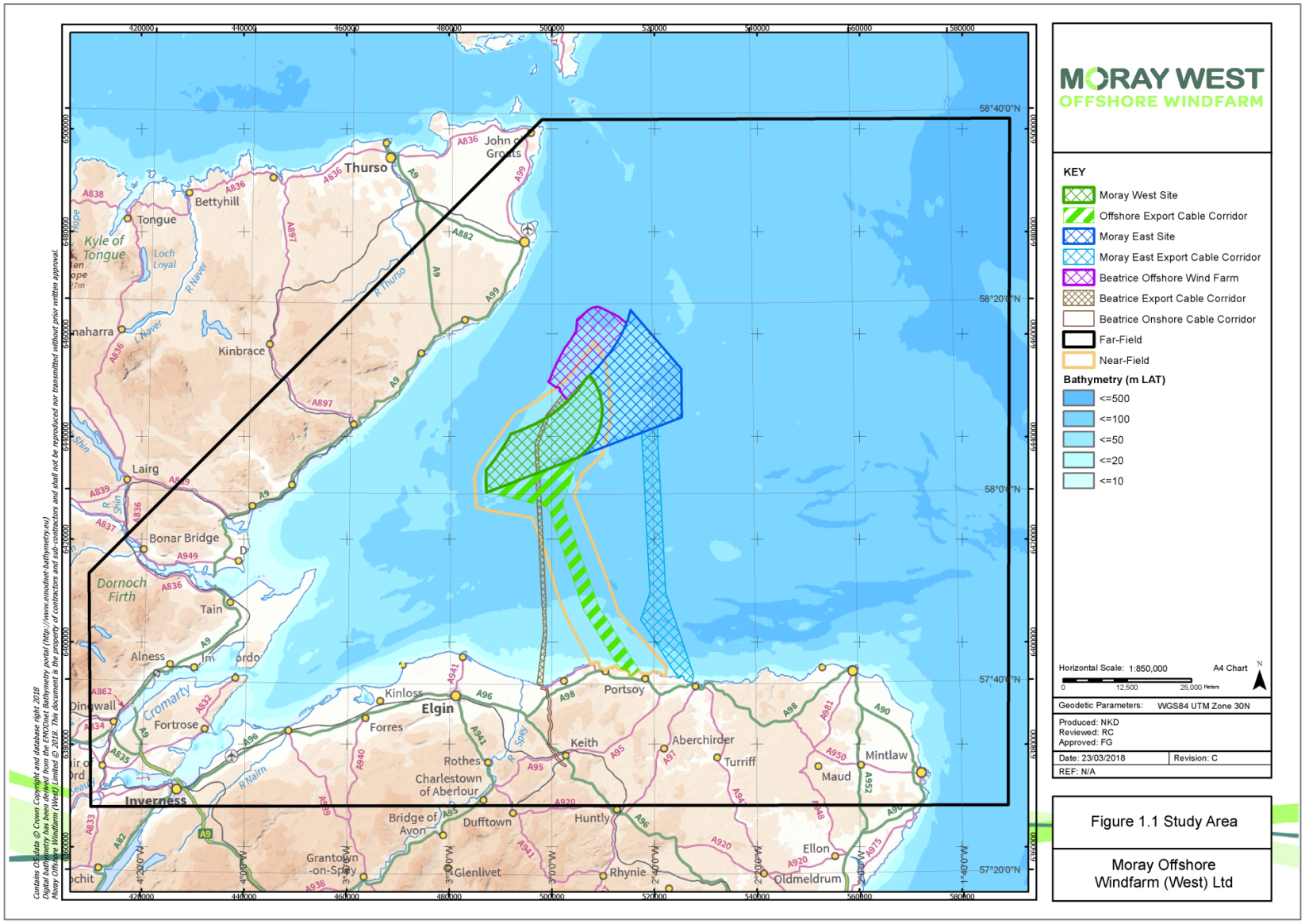


Figure 1.1: Study Area

1.2 The Moray West Offshore Wind Farm and OfTI

Up to 85 wind turbine generator (WTG) foundations may be installed within the Moray West Site, supported by monopile, jacket, suction caisson or gravity base structure (GBS) foundations. Summary descriptions of the proposed dimensions of these foundation types for Moray West are provided in Table 1.1. Drilling may be required to assist with the installation of monopiles or jacket foundations using pin piles. GBS and jacket foundations using suction caissons may require the seabed to be prepared by dredging prior to installation.

Inter-array cables will be installed to connect the WTGs to (up to two) Offshore Substation Platforms (OSPs), which would in turn be connected by a single interconnector cable. Up to two export cables will be installed to transmit the generated electricity onshore. The OSPs will utilise either monopile, jacket or GBS foundations. The dimensions of monopile foundations for OSPs will be similar, but jacket and GBS foundations will be larger, to that described for WTGs. Cables will be buried into the seabed for most of their length but, where this is not practically possible, they may also be laid onto the seabed surface and other protection applied.

Table 1.1: Moray West Offshore Wind Farm WTG Substructure and Foundation Option Descriptions

Foundation Type	Description
Monopile	Cylindrical steel pile - up to 15 m diameter. Penetration up to 50 m depth below seabed level.
Jacket with pin piles or suction caissons	Three or four sided lattice structure. Spacing between upright legs up to 40 m. Primary members up to 3.5 m diameter and secondary members up to 2 m diameter. Mounted on pin piles or suction caisson foundations. Steel pin piles – up to 4 pin piles, up to 4 m diameter, up to 60 m penetration. Suction caissons – up to 4 suction caissons, up to 25 m diameter, up to 10 m of suction caisson remaining above bed during operation.
Gravity base	Cone or inverted T shape. Base diameter up to 55 m at the seabed and up to 30 m above the seabed. Tapering to a monopole tower up to 15 m diameter no less than 10 m below the water surface.
Suction caisson	Monopile and jacket substructures might alternatively be mounted onto a single suction caisson foundation – up to 55 m diameter, up to 10 m of suction caisson remaining above bed during operation.

1.3 Scope of the Assessment

The potential impacts to be assessed in relation to physical processes for the Moray West Offshore Wind Farm and associated OfTI are specified in the respective wind farm and OfTI Scoping Reports (Moray West, 2016; Moray West, 2017), and are summarised in. The nature of the impacts scoped in for this assessment is similar to that previously considered for the (now consented) Moray East Offshore Wind Farm and OfTI (Moray East, 2012), and the (now consented and being built) Beatrice Offshore Wind Farm and OfTI (BOWL, 2012).

In most cases, physical processes that are impacted are not in themselves receptors but are, instead, 'pathways' which have the potential to indirectly affect other environmental receptors. Accordingly, although outputs from the physical processes assessments will be reported in a stand-alone EIA Report chapter (and accompanying technical report), for the most part they will not be accompanied by statements of ‘effect significance.’ Instead, the information on changes to physical processes pathways will be used to inform other EIA Report topic assessments, namely:

- Marine Water Quality;
- Benthic Ecology;

- Fish and Shellfish Ecology;
- Marine Mammals;
- Offshore Ornithology; and
- Commercial Fisheries.

Whilst physical processes can largely be considered as pathways, a small number of features have been identified as potentially sensitive physical processes receptors. These are summarised below:

- Smith Bank;
- Designated coastal habitats/ features;
- Stratification fronts; and
- Recreational surfing venues.

Where these receptors have the potential to be affected by changes to physical processes, a full impact assessment (i.e. assigning sensitivity, magnitude and significance) is provided in Chapter 6 (Volume 1): Physical Processes and Water Quality.

The potential changes resulting from each phase of the wind farm life cycle are summarised in Table 1.2. This table also highlights which potential impacts/ changes are considered as pathways and which are considered as receptors.

Table 1.2: Summary of Potential Impacts / Changes Considered in the Physical Processes Assessment

Potential Impact/ Change	Pathway / Receptor
Construction	
Increases in SSC and deposition of disturbed sediments to the seabed due to dredging for seabed preparation prior to foundation installation.	Pathway
Increases in SSC and deposition of disturbed sediments to the seabed due to the release of drill arisings during foundation installation.	Pathway
Increases in SSC and deposition of disturbed sediment to the seabed due to cable installation within the Moray West Site and within the export cable corridor.	Pathway
Indentations left on the seabed by jack-up vessels and large anchors.	Pathway
Impacts to designated marine and coastal geomorphological features (due to construction activities).	Receptor
Impacts to Smith Bank (due to construction activities).	Receptor
Operation	
Changes to the tidal regime.	Pathway
Changes to the wave regime.	Pathway
Changes to sediment transport and sediment transport pathways.	Pathway

Table 1.2: Summary of Potential Impacts / Changes Considered in the Physical Processes Assessment	
Potential Impact/ Change	**Pathway / Receptor**
Scour of seabed sediments.	Pathway
Impacts to designated marine and coastal geomorphological features (due to operation).	Receptor
Impacts to recreational surfing venues (due to operation).	Receptor
Impacts to stratification fronts (due to operation).	Receptor
Impacts to Smith Bank (due to operation).	Receptor
Decommissioning	
Increases in SSC and deposition of disturbed sediment to the seabed within the Moray West Site and within the export cable corridor.	Pathway
Impacts to designated marine and coastal geomorphological features (due to decommissioning activities).	Receptor
Impacts to Smith Bank (due to decommissioning activities).	Receptor

1.4 Report Structure

This Technical Appendix 6.3 (Volume 3): Physical Processes Impact Assessment, is structured as follows:

- Section 2: Assessment Approach;
- Section 3: Key Guidance
- Section 4: Changes to Suspended sediment concentrations, bed levels and sediment type;
- Section 5: Changes at the landfall;
- Section 6: Changes to the tidal regime;
- Section 7: Changes to the wave regime;
- Section 8: Changes to the sediment transport regime;
- Section 9: Changes to water column stratification;
- Section 10: Scour and seabed alteration;
- Section 11: Decommissioning; and
- Section 12: Summary.

2 Assessment Approach

2.1 Overview

A Physical Processes method statement (position paper) was compiled by ABPmer (ABPmer, 2017), setting out the proposed approach for assessing potential changes to physical processes resulting from construction, operation and decommissioning of the Moray West Offshore Wind Farm and associated OfTI. For the impact assessment, the following combination of approaches was proposed (as summarised in Table 2.1):

- Use of the 'evidence base' of monitoring data collected during the construction, operation and maintenance of other sufficiently analogous offshore wind farms;
- Use of the 'evidence base' of results from pre-existing numerical modelling and desk based assessments undertaken to support EIA for other sufficiently analogous offshore wind farms, in particular the adjacent Moray East Site;
- New analytical assessments of project-specific infrastructure design and activities, including the use of numerical modelling for tides and waves, and other spreadsheet based tools; and
- Standard relationships describing (for example) hydrodynamic interactions with obstacles, sediment transport including settling and mobilisation, seabed scour, etc.

Table 2.1: Assessment Approach for the Moray West Development

Issue	Assessment Approach
Potential changes to suspended sediment concentrations, bed levels and sediment type	Refer to previous numerical modelling results to characterise the effect of individual operations. To be supplemented if necessary using a spreadsheet based numerical models or calculations, validated using modelling outputs from analogous studies (e.g. EIA previously undertaken for Moray East and Beatrice Offshore Wind Farms).
Potential changes to the seabed caused by jack up legs and anchors	Desk based assessment of areas of effect and likely timescales for recovery on the basis of baseline sediment transport rates.
Potential changes to morphology in the Landfall Area	Desk based assessment of historic variability to beach/ coastline, informed by quantitative analysis of available topographic beach data.
Potential changes to the tidal regime	New numerical modelling of Moray West Offshore Wind Farm, alone and in combination with the consented designs of Moray East and Beatrice Offshore Wind Farms. Using the models previously developed to inform Moray East (2012a) and BOWL (2012). Project designs to be modelled are described in Table 2.2 and Table 2.3. Only the consented versions of Moray East and Beatrice Offshore Wind Farms will be considered in the cumulative assessment.
Potential changes to the wave regime	
Potential changes to the sediment transport regime	WTG and OSP foundations – desk based assessment supported by the analysis of potential changes to the tidal and wave regimes, in conjunction with wider understanding of baseline sediment transport. Cable protection measures – desk based assessment, supported by the existing evidence base and empirical equations considering, e.g. the volume of sediment that might be realistically blocked by the obstacle dimensions.

Table 2.1: Assessment Approach for the Moray West Development	
Issue	**Assessment Approach**
Potential changes to the water column stratification	Desk based assessment using literature and previous studies that consider this potential impact for more generically for wind farms in the North Sea and informed by the results of site specific modelling of the effects of Moray West on tidal currents.
Scour	Desk based assessment using standard empirical equations and geometry to estimate equilibrium scour pit characteristics (depth and horizontal extent) from the foundation design.

An overview summary of selected key project details relevant to the physical processes assessment are set out in Table 2.2. For comparative purposes, equivalent details for the various design and consenting iterations of the Moray East Site are also included in this table.

Table 2.2: Summary of Key WTG Foundation Metrics for the Moray West and Moray East Offshore Wind Farms						
Moray West Offshore Wind Farm		**Moray East Offshore Wind Farm**			**Beatrice Offshore Wind Farm**	
Metric	**To Be Assessed**	**Assessed**	**Consented**	**Alternative Design, Proposed**	**Assessed**	**Built**
Moray West Site	225 km²	295 km²	295 km²	295 km²	131 km²	131 km²
Water depth range	36 to 54 mCD	35 to 55 mCD	35 to 55 mCD	35 to 55 mCD	35 to 55 mCD	35 to 55 mCD
Max. no of WTGs	Up to 85	Up to 339	186	Up to 137	Up to 277	84
Turbine capacity	8.1 to 15 MW	3.6 to 8 MW	6 to 8 MW	8.1 to 15 MW	3.6 to 7 MW	7 MW
Project capacity	850 MW	1500 MW	1116 MW	1116 MW	1000 MW	588 MW
Foundation options (maximum dimensions)	GBS (55 m); jacket (40 m, pin piles or suction caissons); monopiles (15 m); suction caissons (30 m)	GBS (65 m);	GBS (55 m); jacket (40 m, pin piles or suction caissons); monopiles (15 m); suction caissons (30 m)	GBS (65 m);	GBS (60 m)	Jacket (4 legs, 24 m base, 2.2 m pin piles, 35 to 60 m depth)
Minimum WTG separation distance	1200 m downwind x 1050 m crosswind	840 m downwind x 600 m crosswind	1200 m downwind x 1050 m crosswind	1200 m downwind x 1050 m crosswind	642 m	1100 m
Indicative WTG density	0.38 mean 0.79 max	1.15 mean 1.98 max	0.63 mean 0.79 max	0.46 mean 0.79 max	2.11 mean 1.56 max	0.64 mean 0.83 max

Table 2.2: Summary of Key WTG Foundation Metrics for the Moray West and Moray East Offshore Wind Farms						
Moray West Offshore Wind Farm		**Moray East Offshore Wind Farm**			**Beatrice Offshore Wind Farm**	
(WTGs/km²)						
Indicative worst case blockage density (m/km²)	10.1 (GBS) 6.8 (Jacket) 5.7 (Monopile)	44.2 (GBS) 20.7 (Jacket)	20.3 (GBS) 11.3 (Jacket)	15.0 (GBS) 8.4 (Jacket)	81.4 (GBS) 38.1(Jacket)	11.5 (Jacket)

Having reviewed the designs tested and the evidence previously developed for the Moray East and Beatrice Offshore Wind Farms, and having compared their previously assessed project designs to the Moray West Offshore Wind Farm description (Table 2.2), it is considered that (only limited) site specific modelling is required to quantify the influence of the wind farm(s) on waves and currents. This is because:

- Sufficient data are available to characterise the spatial and temporal ranges of natural baseline variability of the key parameters of interest. The numerical models previously used were supported by adequate suitable data and remain valid for use without further updates;
- Moray West Offshore Wind Farm is closely analogous to the previously modelled developments in relation to individual operation/activity/foundation types and dimensions; and
- Moray West Offshore Wind Farm alone, and the cumulative magnitude of potential effect (e.g. numbers of foundations, volumes of sediment disturbed, etc.) from all wind farms in the Moray Firth is much less than was previously assessed.

New wave and current modelling has been proposed because the reduction in foundation numbers and size (and therefore blockage density) in the Moray East and Beatrice Offshore Wind Farms means that the previous assessments were relatively conservative and are therefore no longer representative. It is noted that the impacts of the relatively more conservative scheme in the Moray East Offshore Wind Farm were previously assessed as negligible (Moray East, 2012a), both alone and in combination with the nearby Beatrice Offshore Wind Farm.

No new modelling has been proposed to support the assessment of sediment disturbance related changes (e.g. sediment plumes and the level change) because:

- The proposed methods for activities such as bed preparation for individual GBS foundations, drilling to assist individual pin pile installation, and trenching for cable burial, are similar or smaller than that previously assessed for Moray East and Beatrice Offshore Wind Farms; and
- The Moray West Offshore Wind Farm is located immediately adjacent to Moray East and Beatrice Offshore Wind Farms, and the OfTI export cable corridors follow a similar general route south to the southern coast of the of the Moray Firth. Accordingly, the baseline conditions and processes within the Development are anticipated to be similar in nature to that for the Moray East and Beatrice Offshore Wind Farm and OfTI areas.

The position paper was reviewed by Regulators and stakeholders in August 2017. Specific responses to the position paper and the EIA Scoping Report were provided in letters from Marine Scotland Science and Scottish Natural Heritage which broadly accepted the proposed approaches. These responses are summarised in Chapter 6.1: Physical Processes and Water Quality. Accordingly, the proposed approaches (incorporating any subsequent further comments from Regulators and stakeholders) have been used to undertake the assessments in this Technical Appendix.

2.2 Realistic Worst Case Design Scenarios

The Realistic Worst Case (RWC) design information and scenarios for the Development in relation to the potential impacts assessed in this Technical Appendix is summarised in Table 2.3 below.

Table 2.3: Design Envelope Parameters Relevant to the Physical Processes Impact Assessment

Potential Impact	Realistic Worst Case Scenario	Justification
Construction		
Increases in SSC and deposition of disturbed sediments to the seabed due to dredging for seabed preparation prior to foundation installation.	<u>Greatest volume of sediment disturbed and released at a single WTG foundation location</u> • Largest GBS WTG foundation (Model 4), associated base diameter of 55 m; • Excavated diameter up to 95 m, maximum excavated depth of 5 m; and • Spoil volume per WTG location 35,441 m^3. <u>Greatest volume of sediment disturbed and released at a single OSP foundation location</u> • Largest GBS OSP foundation, associated base diameter of 80 m, • Excavated diameter up to 120 m, maximum excavated depth of 8 m; and • Total spoil volume per foundation 90,478 m^3. <u>Greatest volume of sediment disturbed and released within the Moray West Site</u> • 85x smaller GBS WTG foundations (Model 1), associated base diameter of 45 m. Excavated diameter up to 85 m, maximum excavated depth of 5 m, total spoil volume for all WTG foundations 2,411,663 m^3; • 1x GBS OSP foundation, associated base diameter 80 m, excavated diameter up to 120 m, maximum excavated depth of 8 m, total spoil volume for all OSP foundations 90,478 m^3; • Total spoil volume for all WTG and OSP foundations 2,502,141 m^3; <u>For all dredging scenarios</u> • Dredging carried out using a representative trailer suction hopper dredger (5,000 m^3 hopper capacity, filled in 3 to 4 hours, 30 kg/s overspill rate when working, with split bottom for spoil disposal). • Multiple dredgers may be working simultaneously;	Seabed preparation could be required prior to installation of GBS and suction caisson foundations. Three realistic worst scenarios are identified, corresponding to the greatest volume of sediment disturbance locally (from individual WTG and OSP foundations) and across the entire array (total from all foundations). The greatest volume of dredging related sediment disturbance for a single WTG foundation is associated with the largest diameter GBS (Model 1), whereas, for all WTGs it is associated with a larger number of smaller diameter GBS foundations (Model 4). Suction caisson foundations have the same associated seabed diameter as the corresponding GBS option. It is assumed a similar or smaller area and volume of seabed preparation will be required for suction caisson foundations.

Table 2.3: Design Envelope Parameters Relevant to the Physical Processes Impact Assessment		
Potential Impact	**Realistic Worst Case Scenario**	**Justification**
	• Disposal of material onto the seabed 'close' to the installation works within the Moray West Site; and • Foundation installation phase lasting up to 2 years.	
Increases in SSC and deposition of disturbed sediments to the seabed due to the release of drill arisings during foundation installation.	<u>Greatest volume of sediment disturbed and released at a single WTG or OSP foundation location</u> • Largest monopile WTG (Model 4), and OSP foundations, associated drill diameter 15 m, drilling to 50 m penetration depth, spoil volume per foundation 8,836 m^3; <u>Greatest volume of sediment disturbed and released within the Moray West Site and Moray West OfTI</u> • 62x larger monopile WTG foundations (Model 4), associated drill diameter 15 m, drilling to 50 m penetration depth, total spoil volume for all WTG foundations 547,815 m^3; • 2x OSP monopile foundations, associated drill diameter 15 m, drilling to 50 m penetration depth, total spoil volume for all OSP foundations 17,671 m^3; • Total spoil volume for all WTG and OSP foundations 565,486 m^3; <u>For all drilling scenarios</u> • Drilling rate of up to 2 m/hour (minimum drilling duration of 25 hours for each foundation and <48 hours per pile); • Up to 2 simultaneous drilling operations; • Assumes 100% release of material from each foundation; • Disposal of drill arisings at or above the water surface 'close' to the installation works within the Moray West Site; and • Foundation installation phase lasting up to 2 years.	Although the volumes of material released via drilling (for monopiles, or for pin piles for jacket foundations) are less than for seabed preparation via dredging, drilling has the potential to release larger volumes of relatively finer sediment. Two realistic worst scenarios are identified, corresponding to the greatest volume of sediment disturbance locally (from individual WTG or OSP foundations) and across the entire array (total from all foundations). The greatest potential volume of drill arisings from both individual and all WTG and OSP foundations is associated with the largest diameter monopile foundation. Drilling pin piles for jacket foundations disturbs a much smaller volume of sediment.
Increases in SSC and deposition of disturbed sediment to the seabed due to cable installation within the Moray West Site and within the export cable corridor.	<u>Inter-array cables</u> • Installation method: Ploughing, jetting, trenching, rock cutting; • Multiple inter array cable trenches, up to 275 km total length within the Moray West Site;	Cable installation may utilise a range of standard techniques, including jetting, ploughing, trenching and/or cutting. Of these, jetting type techniques will most energetically disturb the greatest volume of sediment in the trench profile and as such is considered to be the maximum

Table 2.3: Design Envelope Parameters Relevant to the Physical Processes Impact Assessment		
Potential Impact	**Realistic Worst Case Scenario**	**Justification**
	• V-shape trench; width = 3 m; depth = 3 m; total volume of disturbance = (275 km x 3 m x 3 m x 0.5) = 1,237,500 m^3; • Maximum cable laying rate of 1,000 m/hr; • Construction phase lasting up to 6 months; and • Up to 4 simultaneous operations. <u>OSP Interconnector cable</u> • Only required in conjunction with two OSPs; • Installation method: Ploughing, jetting, trenching, rock cutting; • One interconnector cable trench, up to 15 km in length between two OSPs within the Moray West Site; • V-shape trench; width = 3 m; depth =3 m; total volume of disturbance= (15 km x 3 m x 3 m x 0.5) = 67,500 m^3; • Maximum cable laying rate of 1,000 m/hr; and • Construction phase lasting up to ~3 months; and • Up to 4 simultaneous operations. <u>OfTI export cables</u> • Installation method: jetting; • Up to two export cable trenches, each up to 65 km in length from the Moray West Site boundary to the Landfall Area (130 km in total); • V-shape trench; width = 3 m; depth =3 m; total volume of disturbance= (130 km x 3 m x 3 m x 0.5) = 585,000 m^3; • Maximum cable laying rate of 1,000 m/hr; • Construction phase lasting up to ~3 months; and • Up to 4 simultaneous operations.	adverse scenario for sediment dispersion. Certain ploughing tools may affect a greater seabed width (up to 15 m), however, the maximum depth of disturbance is only achieved in a limited width (order of a few metres) in the center of the tool and the sediment volume affected to the sides is less likely to be fully disturbed (resuspended) in this way. Any prior seabed preparation (e.g. localized boulder clearance or levelling) has a smaller potential to cause sediment disturbance than the realistic worst case cable burial activity being assessed.
Indentations left on the seabed by jack-up vessels and large anchors.	• Jack-up barge with up to 6 legs in total, area of up to 275 m^2 per spudcan; • Maximum area of seabed disturbance for the jack-up vessel of 1,650 m^2, with a penetration depth of approximately 0.5 m to 11 m for each spudcan; • The maximum vessel anchor size is assumed to be 3 m.	Representative estimates. Based on typical but conservative values for presently available vessels being used for offshore wind farm construction.

Table 2.3: Design Envelope Parameters Relevant to the Physical Processes Impact Assessment		
Potential Impact	**Realistic Worst Case Scenario**	**Justification**
Impacts to designated marine and coastal geomorphological features (due to construction activities).	<u>Landfall Area</u> • Sandend Bay (between Findlater Castle to Redhythe Point) <u>Open cut trenching in the Landfall Area</u> • Up to two cable trenches through mobile sediments in intertidal areas; • Burial depth up to 3 m below seabed or beach (to be confirmed by cable burial risk assessment); • Trench width up to 3 m wide; • Trenches to be open for a period of days to a few weeks. <u>Horizontal Directional Drilling (HDD) in the Landfall Area</u> • Underground routing of the cable requiring no surficial sediment disturbance; • May be used as an alternative to open cut trenching in the Landfall Are (between the onshore side and extending typically no further than 2km offshore). • Cable transition and HDD exit pits will be located onshore (above MHWS) and sufficiently set back to avoid any interaction with the beach during construction and during the operational lifetime of the Development.	The methods that may be used to install cables across the inter-tidal area include HDD and open-cut (trenching). There are two primary means by which the morphology of the Landfall Area could potentially be impacted during the construction phase: • Disturbance of sediments during (open cut) cable trenching across the beach, resulting in associated changes to bed levels; and • Changes to the nearshore wave regime/longshore sediment transport due to the presence of (open) HDD exit pits and temporary installation structures (e.g. cofferdams).
Impacts to Smith Bank (due to construction activities).	<u>WTG and OSP Foundations</u> • Greatest seabed area impacted (496,509 m^2, associated with installation of 85 smaller WTG GBS foundations (Model 1) with scour protection diameter 85 m, and two OSP GBS foundations with scour protection diameter 95 m); <u>Inter-array and interconnector cables</u> • Greatest seabed area impacted (4,350,000 m^2, associated with installation of 275 km of inter-array cables and 15 km of interconnector cable, 15 m width of trenching related seabed disturbance. <u>Jack-up barge spudcan imprints</u> • Greatest area impacted (143,550 m^2, associated with jack-up barge spudcan imprints of 1,650 m^2 for each jack-up barge, 85 WTG and 2 OSP foundations in total)	Defined as the greatest total area of direct seabed change or disturbance (irrespective of associated depth and volume).

Table 2.3: Design Envelope Parameters Relevant to the Physical Processes Impact Assessment		
Potential Impact	**Realistic Worst Case Scenario**	**Justification**
	<u>All direct changes</u> • Greatest total seabed area impacted 4,990,059 m^2.	
Operation		
Changes to the tidal regime. Changes to the wave regime. Changes to sediment transport and sediment transport pathways. Impacts to designated marine and coastal geomorphological features (due to operation). Impacts to recreational surfing venues (due to operation). Impacts to stratification fronts (due to operation). Impacts to Smith Bank (due to operation).	<u>Foundations</u> • 62 x larger 'inverted T' shape GBS WTG foundations (Model 4), associated base diameter of 55 m, base plate height up to 30 m above seabed, monopole diameter 15 m above the base plate to the water surface; • 2 x 'inverted T' shape GBS OSP foundations, associated base diameter of 55 m, base plate height up to 20 m above seabed, monopole diameter 15 m above the base plate to the water surface; • Minimum spacing 1,200 m downwind and 1,050 m crosswind; and • Operational phase lasting 50 years. <u>Cable burial</u> • All cables (inter-array, OSP interconnector and export cable) will be buried to a target depth of 1 m. Depending on seabed conditions it may be possible to achieve burial depths of up to 3 m; and • Where it is not possible to achieve 1 m burial depth, additional cable protection will be required (see below). <u>Cable protection measures (all)</u> • Options include rock placement, concrete mattresses, polymer/steel sleeve protection and/ or grout bags; • Rock berm width 1.5 m and height 1 m. Sloped profile above seabed level; and • Total length (and location) of cables which may potentially require seabed protection to be calculated during FEED but anticipated to be up to 20% of the export cable length (20% of 130 km = 26 km) and up to 10% of the inter-array and interconnector cable length (10% of 275 + 15 km = 29 km). <u>Cable crossings</u> • Up to 6 cable crossings per export cable; • Area per crossing = 200 m length x 6 m width = 1,200 m^2;	The greatest total in-water column blockage to currents, waves and sediment transport processes is associated with the smaller number (62) of larger WTG GBS foundations and the larger number (2) of smaller OSP GBS foundations. This combination was determined via calculations that quantitatively compare the blockage presented by a range of minimum and maximum sizes of varying foundation types and numbers. Of the various possible cable protection measures (including cable crossings), rock placement presents the greatest height of obstacle above the seabed. Maximum lengths or proportions of cable protection are in addition to the length of protection used at cable crossings.

Table 2.3: Design Envelope Parameters Relevant to the Physical Processes Impact Assessment		
Potential Impact	**Realistic Worst Case Scenario**	**Justification**
	• Total area of all crossings = 14,400 m^2 (2 export cables x 6 cable crossings x 1,200 m^2 per crossing); and • Rock berm height 1 m in the footprint of the cable crossing. Sloped profile above seabed level.	
Scour of seabed sediments.	(The realistic worst case is defined on the basis of the outputs of the scour assessment, which includes all foundation types).	Each foundation type may produce different scour patterns therefore GBS, jacket and monopiles are all considered. The combination of foundation type, size and number producing the greatest area and/ or volume of influence cannot be identified in advance of the assessment and may vary depending on the parameter of interest.
Decommissioning		
Increases in SSC and deposition of disturbed sediment to the seabed within the Moray West Site and within the export cable corridor.	• 85x smaller GBS WTG foundations (Model 1), 2 x GBS OSP foundations; • Buried inter-array, interconnector and export cables to be left in situ (but to be determined in consultation with key stakeholders as part of the decommissioning plan and following best practice at the time); • Scour and cable protection left in-situ; and • Decommissioning phase lasting up to approximately 2 years.	When removing foundations, it is assumed that the greatest disturbance will be associated with the greatest number of relatively large foundations. Other infrastructure assumed to be left in-situ.
Impacts to Smith Bank (due to decommissioning activities).		
Impacts to designated marine and coastal geomorphological features (due to decommissioning activities).	• Removal of export cables from shallow trenches within intertidal / shallow subtidal areas only; and • Decommissioning phase lasting up to approximately 2 years.	Maximum disturbance of seabed resulting from removal of cable(s). Cables buried more deeply by HDD assumed to be left in-situ.

2.3 Baseline Environmental Description

A separate report (Technical Appendix 6.1 (Volume 3): Physical Processes Baseline) provides a detailed description of the physical processes baseline environment relevant to this impact assessment, including the Moray West Site and surrounding area. The baseline understanding was developed using data collected during targeted metocean and geophysical survey campaigns, data created using numerical models, and data and information from previously published studies.

Relevant details from Technical Appendix 6.1 (Volume 3): Physical Processes Baseline are provided at the start of each of the following assessment sections.

2.4 Spatial Scales

Baseline characterisation and potential impact assessments for tidal, wave and sedimentological processes is provided with respect to the following general spatial length scales:

- Near-field (i.e. the area inside and within one tidal excursion of the Moray West Site and the Moray West OfTI export cable corridor, see Figure 2.1); and
- Far-field (i.e. the wider area in which effects of the wind farm could potentially extend).

The following terminology is used to characterise geographical regions of the study area (Figure 1.1):

- Nearshore area (0 m Lowest Astronomical Tide (LAT) contour out to ~ -5 mLAT contour);
- Inshore area (~ -5 mLAT contour out to ~ -20 mLAT contour); and
- Offshore area (seaward of the ~ -20 mLAT contour).

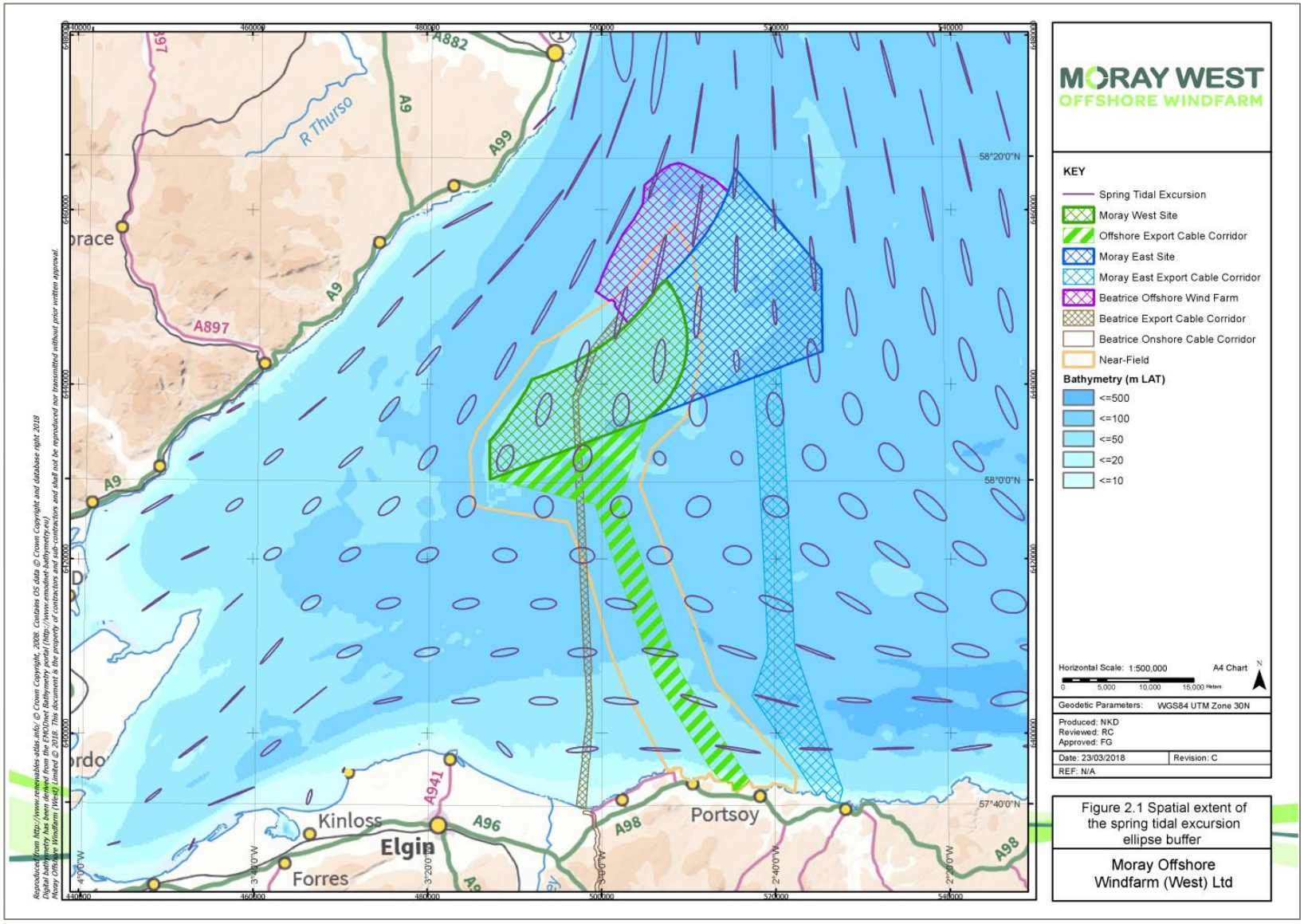


Figure 2.1: Spatial extent of spring tidal excursion ellipse buffer around the Moray West Site

2.5 Temporal Scales

There are four main phases of development that require consideration in the physical processes part of the EIA. These are:

- Baseline (pre-construction);
- Construction (from the start to the completion of installation for all major wind farm and OfTI infrastructure);
- Operation (the working lifetime of the Development, excluding major additions, changes or removal of infrastructure but including normal maintenance); and
- Decommissioning (from the start to the completion of all agreed and necessary decommissioning activities).

The time scale of baseline physical processes and changes or impacts to those processes is typically defined in each assessment, but may also be referred to more generally as:

- Short term (occurring or persisting for seconds to hours, up to 3 days);
- Medium term (occurring or persisting for many days or weeks, up to 6 months); and
- Long term (occurring or persisting for many months or years, up to and beyond the lifetime of the Development).

2.6 Numerical Modelling

Simulations of baseline wave and tidal conditions within the study area, and assessments of potential scheme impacts, have been undertaken using numerical modelling. A best practice approach to the modelling has been taking, according to Collaborative Offshore Wind Research into the Environment (COWRIE) (2009). More details of the models used, including details of their setup, calibration and validation may be found in Technical Appendix 6.2 (Volume 3): Physical Processes Numerical Modelling. The baseline tidal and wave models and the methods used to include the potential effect of foundations are the same as those used previously to assess the Moray East and Beatrice Offshore Wind Farms and OfTI.

These models have also been used to establish the baseline and will be used to determine the scale of the likely effects of potential development phases (construction; operational; decommissioning) upon the existing physical processes. The numerical modelling is designed to include both far and near-field areas relevant to the present study.

The Danish Hydraulics Institute 'MIKE by DHI' suite of numerical models has been used to create a tidal model (MIKE21FM HD) and a wave model (MIKE21FM SW) of the Moray Firth and surrounding area for the purposes of informing the baseline characterisation and assessments of potential scheme effects.

The procedure for model calibration/validation is based on the need to demonstrate that each of the models is appropriate for the range of scenario tests required. For example, the tidal model has been calibrated and validated over a range of tidal conditions, including mean neap and spring ranges. Likewise, the wave model has been calibrated and validated in its ability to reproduce a range of wave event types and intensities. Predicted values from the models are shown to compare closely to the target measured data (i.e. water levels, current speeds and directions, wave heights, periods and directions).

Model performance in representing baseline conditions is considered to be very good with the model reproducing tidal and wave processes with regards magnitude, direction and phase. The models are therefore considered appropriate for the present study, informing the baseline understanding of physical processes across the study area and therefore providing a suitable basis for the simulation of potential scheme effects.

3 Key Guidance Documents

Guidance on the generic requirements, including spatial and temporal scales, for coastal process studies is provided in the following documents:

- 'Environmental impact assessment for offshore renewable energy projects.' (BSI, 2015).
- 'Review of environmental data associated with post-consent monitoring of licence conditions of offshore wind farms.' MMO Project No: 1031. (Fugro-EMU, 2014).
- A handbook on environmental impact assessment Guidance for Competent Authorities, Consultees and others involved in the Environmental Impact Assessment Process in Scotland (Scottish Natural Heritage (SNH), 2013)
- 'Offshore wind farms: guidance note for Environmental Impact Assessment in respect of Food and Environmental Protection Act (FEPA) and Coast Protection Act (CPA) requirements: Version 2' (Department for Environment, Food and Rural Affairs (Defra), Centre for Environment, Fisheries and Aquaculture Science (Cefas) and Department for Transport (DfT), 2004);
- 'Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects' (Cefas, 2011);
- 'Guidance on Environmental Impact Assessment in Relation to Dredging Applications' (Office of the Deputy Prime Minister, 2001);
- 'Nature Conservation Guidance on Offshore Wind Farm Development' (Defra, 2005);
- 'Marine Renewable Energy and the Natural Heritage: An Overview and Policy Statement' (SNH, 2003);
- 'Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment' (COWRIE, 2009); and
- Marine Scotland Licensing and Consents Manual covering marine renewables and offshore wind energy development. Report commissioned for Marine Scotland (ABPmer, 2012a) ; and
- ‘Scotland’s National Marine Plan’ (Scottish Government, 2015).

It is noted that Marine Scotland commissioned a set of guidance documents to be produced for the marine renewable industry, specifically wave and tidal devices, which included reference to EIA requirements (ABPmer, 2012a). It is considered that some elements of the advice offered can be transferred across to the Scottish offshore wind industry, and as such is referenced within this study. Moray West is currently unaware of any similar guidance from the Scottish Environmental Protection Agency (SEPA) and as such, the Marine Scotland guidance is considered to be the most relevant / appropriate.

The purpose of the available generic guidance is to provide an overall consistency in approach and methodology to the identification and assessment of potential impacts. Using the recommended approaches, Moray West site specific issues and methodologies have been determined during the EIA scoping and consultation process (Technical Appendix 5.1).

4 Changes to Suspended Sediment Concentrations, Bed Levels and Sediment Type

4.1 Overview

Local increases in suspended sediment concentration (SSC) may result from the disturbance of sediment by construction related activities, most notably due to:

- Seabed preparation by dredging prior to jacket suction caisson and GBS foundation installation;
- Drilling of monopile foundations and pin piles for jacket foundations; and
- Cable burial.

Sediments put into suspension may be transported away from the disturbance location by local currents. The sediment will gradually settle downwards over time (at a rate depending on the individual clast grain size and other ambient conditions) and will eventually be redeposited to the seabed. Where sediment is redeposited in a measurable thickness, a change in the local seabed level and / or the surficial seabed sediment type may occur.

According to the source-pathway-receptor model:

- Disturbance and release of sediment is considered as the source of potential changes to SSC in the water column;
- Tidal currents act as the pathway for transporting the suspended sediment; and
- The receptor is a feature potentially sensitive to an increase in suspended sediment concentration, smothering through redeposition, and / or a change in surficial seabed sediment type.

The magnitude, duration, rate of change and frequency of recurrence of changes to SSC and bed level are variable between operation types and in response to natural variability in the controlling environmental parameters, primarily the distribution of grainsizes in the disturbed sediment and the speed of ambient currents.

4.2 Baseline Conditions

A summary of the relevant baseline characteristics within and nearby to the Development is provided below. Full details are provided in a separate report (Technical Appendix 6.1 (Volume 3): Physical Processes Baseline).

- Mean spring peak current speeds within the Moray West Site are in the approximate range 0.25 m/s to 0.3 m/s. Neap speeds are typically half of that observed on spring tides;
- Tidal currents are directed generally to the south or south-south-west during the flood tide and to the north or north-north-east during the ebb tide and there is little consistent asymmetry between flood and ebb in tidal current speeds and directions;
- Along most of the Moray West OfTI export cable corridor, mean spring peak current speeds are relatively uniform and less than ~0.3 m/s. There is some evidence of tidal asymmetry close to the Landfall Area where current speeds are relatively greater towards the east;
- The thickness of Quaternary seabed sediment cover (potentially mobile sands, gravels and fines overlying older hard rock geology) is highly variable across the Moray West Site and OfTI, ranging from ~ 5 to 15 m in the west of the Moray West Site, up to 30 m in the east.
- Cretaceous rocks (comprising of very hard clay) are overlain by glacial and mid to late Pleistocene marine sediments, which are in turn overlain by marine sediments. The coverage

of the different units varies across the site, resulting in the large range in sediment thickness determined within the Moray West Site;

- Seabed sediments within and nearby to the Moray West Site are typically characterised by the presence of granular (fine to medium sand and gravel) sediments. Fine grained (muddy) material is only present in very low (<5%) quantities. The western section of the site is characterised by sandy sediments whilst isolated patches of gravel sediments are found in central and north-eastern areas;
- Seabed sediments along the Moray West OfTI are variable, reflecting variations in tidal current speed and water depth (which influences the effectiveness of tidal and wave stirring of the bed). Seabed sediments are predominantly fine to medium sands at both the offshore end of the Moray West OfTI export cable corridor (where it meets the Moray West Site) and at the coast near the Landfall Area, with a small proportion of gravel also present in some areas. In contrast, the deeper central sections of the route are characterised by mud and sandy mud.
- Sediment is naturally re-suspended by the action of currents and waves at the seabed. Sediment grains in suspension naturally settle downwards under gravity but are also re-suspended upwards by turbulence in the water, which is greater nearer the seabed. This normally results in a non-linear profile of SSC (i.e. highest at the seabed, rapidly decreasing with height);
- Measurements of SSC approximately 0.5 m above the seabed in the Moray West Site indicate that nearbed SSC is very low (< ~5-10 mg/l) in response to normal tidal conditions. Occasional storms can cause an increase in SSC (in the order of a few hundreds of mg/l) that declines gradually to background levels over a period of days to one week. Very nearbed SSC during storm events is not directly measured but is likely to be higher (in the order of hundreds to thousands of mg/l); and
- Regional statistics of time average suspended particulate matter (SPM, closely related to SSC) in surface waters across the Development are typically very low (< ~5 mg/l) throughout the year.

The Moray West Site is located on Smith Bank. The morphology baseline characteristics which are relevant to inform this assessment are set out below:

- Smith Bank is approximately 35km long from south-west to north-east, around 20km wide, rising from a base level of between 50 and 60 m below sea level to less than 35 m. The position, elevation and orientation of the bank is closely associated with the underlying Smith Bank Fault block and the geophysical survey undertaken by Osiris (2011) reveals that Cretaceous sediments are relatively close (<10 m) to the seabed across much of the crest of the bank. The main body of Smith Bank is underpinned by solid bedrock, with variable thickness layers of stable overlying sedimentary deposits and a more mobile sediment veneer. The position and form of Smith Bank is therefore controlled by the underlying geology and so is not sensitive as a whole to minor changes in sediment transport onto, over or off the Bank.
- Smith Bank is predominantly characterised by sand and gravel, with more consistent gravel patches and glacial till exposures towards the crest of the bank.
- Available geophysical survey data indicates the presence of a large number of raised sand ridges and associated shallow troughs over the edges of Smith Bank. Individual ridges stand up to 2 m above surrounding seabed and generally trend north-north-west to south-south-east or west to east. Maximum gradients of approximately 0.7° can be found around the edges of some of the bedforms (Osiris, 2011). The multibeam swath backscatter data previously collected during the DTI SEA surveys also reveals the presence of these same

sediment (likely gravel) wave features found only on the northern flanks of Smith Bank (Holmes *et al*., 2004). These features are considered to be controlled by infrequent large waves.

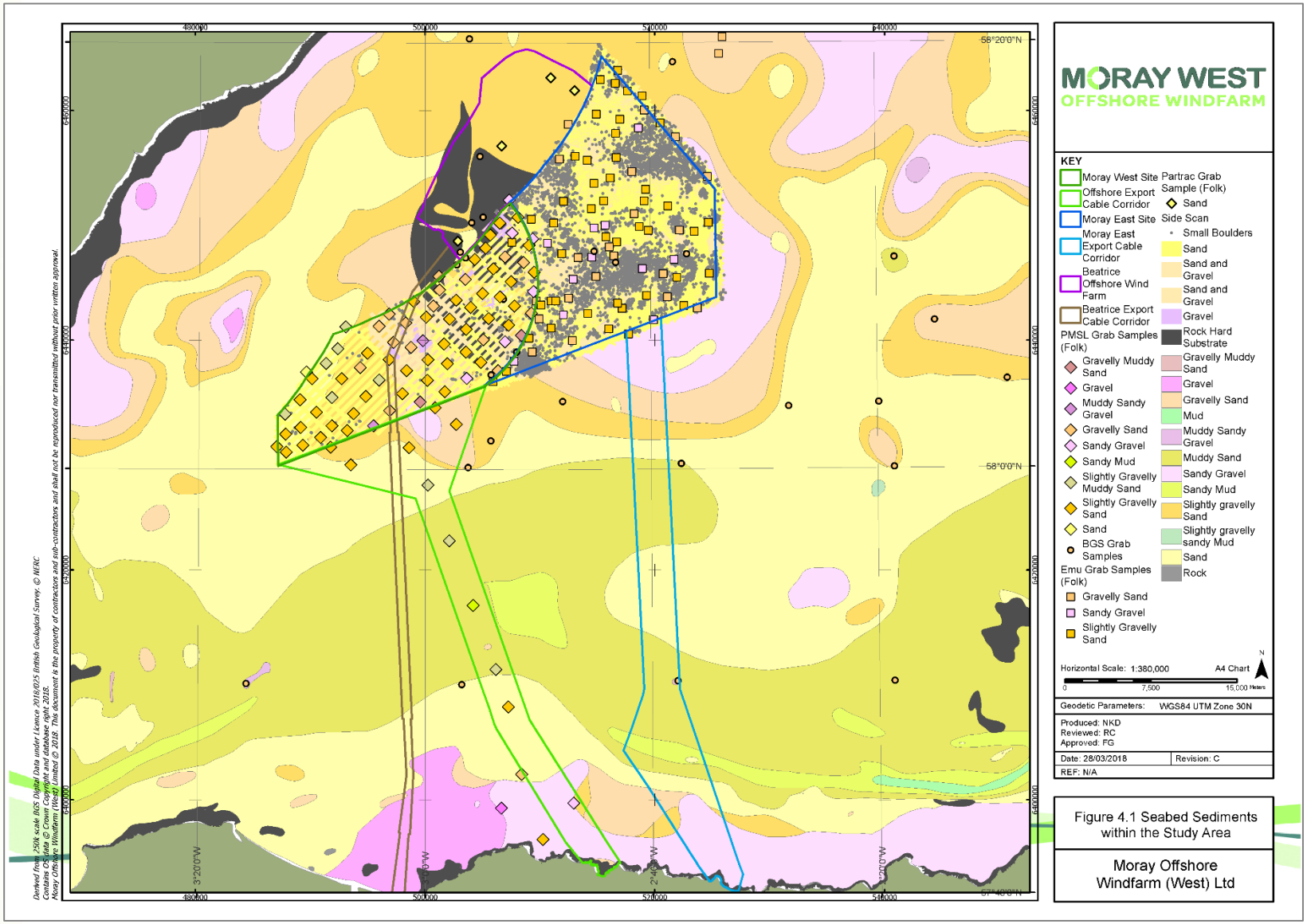


Figure 4.1: Distribution and thickness of geological units within the Moray West Site

4.3 Assessment

4.3.1 Methodology

Sediment disturbed and released into the water column during construction will settle downwards at a rate depending upon its grain size. During settling, the sediment plume will be advected away from the point of release by any currents that are present, and will also be dispersed laterally by turbulent diffusion. The horizontal advection distance will be related to the flow speed and the physical properties of the sediment. The maximum near-bed level of SSC is expected to be found where the main body of the settling plume of sediment reaches the seabed.

Coarser grained (i.e. sand/ gravel) sediments will behave differently to fine grained (i.e. silt/ clay) sediments when released into the water column. The disturbance of coarser grained material is likely to give rise to higher SSCs in the vicinity of the release location, but is also likely to settle out of suspension quickly (e.g. in the order of seconds to minutes) so any sediment plumes are likely to be localised. In contrast, finer grained material may remain in suspension for a longer period of time (in the order of hours to days), potentially resulting in an increase in SSC for longer, affecting a larger area, but at a progressively reducing concentration due to ongoing advection and dispersion.

Similar differences are expected when considering any resulting changes in bed level due to resettlement of the material in suspension. Coarser material settling out faster will tend to result in greater thicknesses of accumulation in relatively localised areas, whereas, finer grained material will tend to result in smaller (potentially unmeasurably so) thicknesses of accumulation over a wider area. The exact pattern of re-deposition of sediment to the seabed will depend on the particular combination of operational method, sediment type and the ambient environmental conditions at the time of the event, which may all be variable. The total volume of sediment disturbed is, however, known with greater certainty and a range of potential combinations of deposit shape, thickness and area (corresponding to the same total volume) can be more reliably provided, as a subset of all possible combinations.

In order to inform the assessment of potential changes to SSC and bed levels arising from construction related activities, a number of spreadsheet based numerical models have been developed for use. Similar models were developed and used to inform the environmental impact assessments for similar activities at Burbo Bank Extension, Walney Extension and Navitus Bay offshore wind farms (DONG Energy, 2013a,b; and Navitus Bay Development Ltd, 2014 respectively). The spreadsheet based numerical models used here are based upon the following information, assumptions and principles:

- Re-suspended coarser sediments (sands and gravels) will settle relatively rapidly to the seabed and their dispersion can therefore be considered on the basis of a 'snapshot' of the ambient conditions which are unlikely to vary greatly between the times of sediment release and settlement to the seabed. Re-suspended finer sediments may persist in the water column for hours or longer and so their dispersion is considered instead according to the longer-term residual patterns of water motion in the area, which vary both temporally and spatially in speed and direction;
- A representative current speed for the Moray West Site is 0.25 m/s, which is representative of higher tidal flow conditions occurring on most flood and ebb cycles for a range of spring and neap conditions. Assuming a higher value will increase dispersion, decrease SSC and reduce the thickness of subsequent deposits and vice versa;
- Lateral dispersion of SSC in the plume is controlled by the horizontal eddy dispersion coefficient, Ke, estimated as $Ke = \kappa u^* z$ (Soulsby, 1997), where, z is the height above the seabed (a representative value of half the water depth is used), κ is the von Kármán coefficient ($\kappa = 0.4$) and u^* is the friction velocity ($u^* = \sqrt{(\tau/\rho)}$). Where ρ is the density of seawater ($\rho = 1027$ kg/m³) and τ is the bed shear stress, calculated using the quadratic stress law ($\tau = \rho\ Cd\ U2$, Soulsby, 1997) using a representative current speed for the Moray West Site (U = 0.25 m/s) and a drag coefficient value for a rippled sandy seabed (Cd = 0.006);

  - The available sediment data for the area of the Development indicate there are a number of characteristic surficial sediment types. In addition, there are frequent occurrences of small boulders on the seabed, particularly within the Moray West Site.
  - Within the Moray West Site, the prevalent sediment types are:
    - Gravelly sand;
    - Sandy gravel; and
    - Sand.
  - Within the Moray West OfTI export cable corridor, the prevalent sediment types are:
    - Sand;
    - Muddy sand; and
    - Sandy mud.
- To estimate the time-scale in suspension, sediment is assumed to settle downwards at a calculated (theoretical) settling velocity for each grain size fraction (0.0001 m/s for fines, 0.05 m/s for (medium) sands and 0.5 m/s for gravels and generally coarser sediments, including clastic drill arisings).

The numerical model for SSC resulting from the release of sands and gravels is constructed as follows:

- The time required for sediment to settle at the identified settling velocity through a range of total water depths representative of the site is calculated, to yield the duration for settlement;
- The horizontal distance downstream that the plume is advected is found as the product of the representative ambient current speed and the duration for settlement;
- The horizontal footprint area of the plume at different water depths is calculated from the initial dispersion area, increasing at the horizontal dispersion rate over the elapsed time for the plume to reach that depth; and
- The estimate of SSC at different elevations is found by dividing the sediment mass in suspension at a given water depth (the product of the sediment release rate and the duration of the impact, divided by the water depth) by the representative plume volume at that depth (horizontal footprint area at that depth x 1 m).

The numerical model for sediment deposition thickness resulting from the release of sands and gravels is constructed as follows:

- The area over which sediment is deposited depends on the lateral spreading of the sediment plume footprint with depth, but also with tidal variation in current speed and direction, including the possibility of flow reversal. This is an important factor if the release occurs for more than tens of minutes as it affects the distance and direction which the plume is advected from the source;
- The width of the footprint of (instantaneous) deposition onto the seabed is estimated as the square root of the near-bed plume footprint area (calculated using the model for SSC above). For monopile foundations, the point of sediment release is likely to be static and so the width of deposition is characterised directly as the footprint of deposition. For jacket suction caisson foundations, the point of sediment release is likely to move within an area equivalent to the size of the jacket foundation or dredged area, in which case the overall width of deposition is characterised as the footprint of deposition plus the diameter of the suction caisson foundation;

- The length of the footprint of deposition onto the seabed over multiple tidal cycles is estimated as twice the advected distance of the plume at the representative current speed, representing the maximum length over consecutive flood and ebb tides. If the operation lasts less than 12.4 hours (one full tidal cycle), the length is reduced proportionally;
- The average seabed deposition thickness is calculated as the total volume of sediment released, divided by the footprint area (width times length) of deposition; and
- This model provides a conservative estimate of deposition thickness as it assumes that the whole sediment volume is deposited locally in a relatively narrow corridor. In practice, the deposition footprint on the seabed will probably be normally wider and frequently longer than is assumed, and the proportion of all sediment deposited locally will vary with the distribution in grain size (leading to a greater area but a correspondingly smaller average thickness).

The numerical model for SSC resulting from dispersion of fine sediment is constructed as per the following example:

- The vessel is likely to be stationary during precision dredging operations so the water movement relative to the vessel is dominantly tidal (at the representative current speed 0.25 m/s);
- Sediment is discharged at a representative rate (e.g. 30 kg/s for dredging over-spill) into a minimum volume of water 100 m^3 = 10 m x 10 m x 1 m deep;
- This volume of water will be refreshed every 40 seconds (10 m / 0.25 m/s);
- The total sediment input is 40 s x 30 kg/s = 1200 kg;
- The resulting initial concentration in the receiving water is 1200 kg / 100 m^3 = 12 kg/m^3 = 12,000 mg/l;
- The initial concentration would then be subject to turbulent dispersion both laterally and vertically. Given the starting mass of sediment and water volume above, levels of SSC will vary rapidly in proportion to the dilution of the same sediment mass as the plume dimensions and volume increase; and
- Assuming a faster current speed, faster vessel motion or larger footprint of release would reduce the mass of sediment introduced to the fixed volume of the receiving waters (and so SSC) at the point of initial dispersion, and vice versa.

The assessments report specific values of SSC and deposition thickness in relation to specific length scales and timeframes, however, due to natural variation in the processes involved, results should be more generally interpreted according to the corresponding order of magnitude (e.g. tens of metres or seconds, tens of thousands of milligrams per litre, tens of centimetres thickness, etc).

4.3.2 Drilling of Monopile Foundations and Pin-Piles for Jacket Foundations

Monopile foundations and pin piles for jacket foundations will be installed into the seabed using standard piling techniques. In some locations, the particular geology may present some obstacle to piling, in which case, some or all of the seabed material might be drilled from within the pile footprint to assist in the piling process.

The impact of drilling operations mainly relates to the release of drilling spoil at or above the water surface which will put sediment into suspension and the subsequent re-deposition of that material to the seabed. The nature of this disturbance will be determined by the rate and total volume of material to be drilled, the seabed and subsoil material type, and the drilling method (affecting the texture and grain size distribution of the drill spoil). These changes are quantitatively characterised in this section using the spreadsheet based numerical models described in Section 4.3.1.

4.3.2.1 Evidence base

The evidence-base does not presently include many measurements of SSC or bed level change resulting from drilling operations for monopile or pin pile installation. This is due to the relatively small number of occasions that such works have been necessary.

Limited evidence from the field is provided by the during- and post-construction monitoring of monopile installation using drill-drive methods into chalk at the Lynn and Inner Dowsing offshore wind farms (CREL, 2008). However, the geology in the Moray West Site is different to that at Lynn and Inner Dowsing, and the foundation dimensions and drilling apparatus will likely also differ. In the Moray West Site, it is also not yet known how the drilled sedimentary units will disaggregate. All of the above factors limit the extent to which the Lynn and Inner Dowsing monitoring evidence can be considered to be indicative of the proposed construction activities for Moray West.

At Lynn and Inner Dowsing, the installation of steel monopiles (4.7 m diameter and up to 20 m penetration depth) was assisted in some cases by a drill-drive methodology. The drill arisings were mainly in the form of rock (chalk) chippings that were released onto the seabed a short distance away in a controlled manner using a pumped riser. The particular concern in that case was the possibility of sub-surface chalk arisings leading to high levels of SSC of an atypical sediment type. The result of sediment trap monitoring (located as close as 100 m from the operation) was that the chalk was not observed to collect in significant quantities. However, direct measurements of SSC were not possible at the time of the operation.

The dimensions of the deposit that the chalk drill arisings created were measured by geophysical survey and characterised as a conical mound, approximately 3 m thick at the peak, extending laterally (from the peak to ambient bed level) up to 10 m in what is assumed the downstream direction and 5 m in the other. The volume of the partially consolidated deposit (measured as approximately 290 m^3) was comparable to the total volume of the drilled hole (347 m^3). It is noted that the deposited material is likely to be less consolidated than its original in-situ state. If all of the drilled material had been deposited into and retained in the mound, assuming a typical packing density of 0.6 (ratio of solids to voids), the mound would be expected to have a larger volume of approximately 578 m^3, i.e. the mound is likely to contain approximately 50% of the drilled material. The drilled material not deposited in the local mound may have been subject to different patterns of initial settling or subsequent transport, leading to some material being moved away from the main deposit location. These processes are consistent with seabed photographs indicating that the material in the deposit is horizontally graded, with the largest clasts located closer to the centroid of the deposit. It is also possible that the combination of drill and drive did not necessarily release a volume of material equivalent to 100% of the internal volume of the pile, or that the full burial depth may not have been achieved in this example.

Sediment disturbance associated with drilling of jacket pin piles and dredging for GBS bed preparation activities was previously considered for the Moray East Offshore Wind Farm using numerical modelling (Moray East, 2012). The nature of the sediment disturbance, the sediment type and other environmental conditions are sufficiently similar to that being considered in the Moray West Site that the previous modelling is considered to provide directly relevant evidence in this regard. Only dredging overspill was previously assessed in relation to changes to SSC, as the worst case instantaneous rate of sediment release due to dredging overspill (30 kg/s) was greater than the equivalent rate of release for drilling (26 kg/s). The sediment plumes resulting from the 30 kg/s dredging overspill release rate are summarised in Section 4.3.3.1. In comparison, in the Moray West Site, the realistic worst case dredging overspill release rate is the same (30 kg/s) but the realistic worst case sediment release rate associated with the drilling of monopiles is greater (260 kg/s). The results shown in Section 4.3.3.1 are therefore more directly representative of the Moray West Site dredging scenario but should be scaled up in proportion to the difference in modelled release rate (260/30 = 8.3 times greater) for the drilling scenario. For drilling at the higher rate (260 kg/s), the previous modelling would therefore suggest:

- The maximum localised instantaneous increase in SSC is predicted to be 250 to 300 mg/l, depending on the state of the tide and the local water depth at the time and location of the

release. These maximum levels of effect are contained within 50 to 100 m of the drilling activity and only occur during sediment release;

- SSC in the advected main plume (centred along the downstream tidal axis) is reduced to 160 mg/l or less by 500 to 1000 m downstream and to 80 mg/l or less by 2000 to 3000 m downstream;
- See Section 4.3.3.1 for further relevant details relating to extent and duration of effect.

4.3.2.2 Assessment of change

The greatest volume of sediment disturbed locally by drilling (causing a potential increase in SSC and thickness of sediment deposition) would occur as a result of fully drilling (100% of) the volume of a single largest diameter WTG and OSP monopile foundation (15 m diameter, 50 m seabed penetration depth, drilling rate 2 m/hour).

The greatest volume of sediment disturbed in the whole Moray West Site would occur as a result of fully drilling (100% of) the volume of the maximum number (up to 62 WTG) of the largest (Model 4) WTG and two of the largest OSP monopile foundations (15 m diameter, 50 m seabed penetration depth, drilling rate 2 m/hour). Foundations would have a minimum spacing of 1050 m crosswind and 1200 m downwind. Up to two foundations might be simultaneously drilled.

The distribution of grain and clast sizes in the drill arisings for individual WTG foundations is not known in advance, so results are provided separately for scenarios where 100% of the material is assumed to be either fines, (medium) sand or (coarse) gravel sized. In practice, depending on the actual ground conditions and drilling tools used, the distribution of grain and clast size in the spoil will be some variable mixture of these with a corresponding intermediate duration, extent and magnitude of change.

It is noted that naturally occurring SSC normally refers to suspensions of sand and finer sediments. The nominal increase in SSC for gravels and larger clasts in suspension is reported but should be treated with caution if used to inform assessments of impacts on baseline conditions or other sensitive receptors.

The realistic worst case design scenario for sediment release by drilling activities is summarised in Table 2.3.

Levels of SSC resulting from drilling of the largest (Model 4) WTG and OSP monopile foundation assuming 100% of the drill arisings are fines are shown in Table 4.1 for the following range of dispersion scenarios:

- Source concentration at the point of release (total mass evenly dispersed in a volume of water 10 m wide, 10 m length, 1 m depth);
- Vertical diffusion to 5 m, 20 m lateral spread in footprint dimensions (1 to 2 minutes after release, 15 to 30 m downstream);
- Vertical diffusion to 20 m (from surface to approximately half the water depth), 50 m lateral spread in footprint dimensions (10 to 20 minutes after release, 150 m to 300 m downstream); and
- Vertical diffusion to 40 m (so affecting the seabed in shallower locations), 100 m lateral spread in footprint dimensions (1 hour after release, 900 m downstream).

The approximate timeframe and distance downstream from the point of release for each dispersion scenario is indicated, based on the representative rates of settling, lateral dispersion and current speeds previously described in Section 4.3.1. Fines are dispersed widely and to such low concentrations prior to resettlement to the seabed that no locally measureable thickness of accumulation is realistically expected.

Table 4.1: Suspended sediment concentration as a result of drilling 100% of the volume of the largest (Model 4) WTG and OSP monopile foundation (100% drill arisings as fines)

Parameter			Value
Rate of sediment release (kg/s)			260
Total mass released into receiving water (kg)			10,406
Representative current speed (m/s)			0.25
Plume Width (m)	**Plume Depth (m)**	**Plume Section Length (m)**	**Resulting SSC (mg/l)**
10	1	10	104,065
20	5		10,407
50	20		1,041
100	40		260
N.B. Results should be interpreted according to the corresponding order of magnitude (e.g. tens of metres or seconds, tens of thousands of milligrams per litre, tens of centimetres thickness, etc).			

Levels of SSC and the estimated area and average thickness of sediment thickness resulting from drilling assuming 100% of the drill arisings are sands or gravels are shown in Table 4.2 for the largest (Model 4) WTG and OSP monopile foundation.

Table 4.2: Suspended sediment concentration and sediment deposition as a result of drilling 100% of volume of the largest (Model 4) WTG and OSP monopile foundation (100% drill arisings as sands or gravels)

Sediment Type	Water Depth (m)	Settling Rate (m/s)	Duration of Settlement (s)	Distance Plume Advected by Peak Current (m)	Maximum Mass in Suspension (kg)	Area of Seabed Deposition (m²)	Average Thickness of Seabed Deposition (m)
100% Sand	35	0.05	700	350	182,114	26,468	0.56
	42		840	420	218,537	35,881	0.41
	48		960	480	249,757	45,042	0.33
	54		1,080	540	280,976	55,211	0.27
100% Gravel	35	0.5	70	35	18,211	1,473	10.00
	42		84	42	21,854	1,898	7.76
	48		96	48	24,976	2,297	6.41
	54		108	54	28,098	2,728	5.40
Sediment Type	**Water Depth (m)**	**Diameter of Midwater SSC Influence (m)**	**Area of Midwater SSC Influence (m²)**	**Midwater Average SSC (mg/l)**	**Diameter of Near-Bed SSC Influence (m)**	**Area of Near-Bed SSC Influence (m²)**	**Near-Bed Average SSC (mg/l)**
100% Sand	35	35	938	5,546	43	1,430	3,639
	42	38	1,163	4,475	48	1,825	2,852

Table 4.2: Suspended sediment concentration and sediment deposition as a result of drilling 100% of volume of the largest (Model 4) WTG and OSP monopile foundation (100% drill arisings as sands or gravels)

Sediment Type	Water Depth (m)	Settling Rate (m/s)	Duration of Settlement (s)	Distance Plume Advected by Peak Current (m)	Maximum Mass in Suspension (kg)	Area of Seabed Deposition (m²)	Average Thickness of Seabed Deposition (m)
	48	42	1,374	3,786	53	2,201	2,364
	54	45	1,603	3,245	58	2,613	1,991
100% Gravel	35	21	353	1,476	24	443	1,175
	42	22	395	1,318	25	511	1,019
	48	23	433	1,201	27	572	909
	54	25	473	1,100	28	638	816

N.B. Results should be interpreted according to the corresponding order of magnitude (e.g. tens of metres or seconds, tens of thousands of milligrams per litre, tens of centimetres thickness, etc).

Estimates of the area and average thickness of sediment deposition are provided in the preceding tables based on the approximate footprint of the plume and tidal advection factors. The extent, thickness and shape of sediment deposits on the seabed will be highly variable in practice. However, given the total volume of sediment, a range of potential alternative combinations can be calculated. For a given volume of sediment, a smaller area of extent will correspond to a greater thickness of accumulation, and vice versa.

A steeper sided cone shape deposit will have a greater thickness and a smaller area of change than a less steep sided cone or flat deposit shape. A range of possible value combinations are provided in Table 4.3. The table demonstrates the changing spatial scale of the impact between two end members of: (i) maximum possible thickness (although also the smallest footprint or extent of impact); and (ii) the most extensive accumulation (to a smallest thickness of 0.05 m).

More concentrated and localised deposits (associated with coarse gravels and large clastic materials) are assumed to deposit naturally into a cone shape where the maximum thickness is in the centre of the deposit and thickness decreases gradually from the centre towards the edges. Operationally, very thick deposits in shallow water (not likely in the Moray West Site) may affect safe navigation or other engineering considerations and so would not be planned or allowed to occur. The greatest possible thickness (at the central point of the cone, also corresponding to the smallest possible area) is associated with a cone that has the steepest possible slope angle (i.e. the angle of repose for such loose sediments = 32°). The height of cones with two and three times the diameter of the steepest cone are provided for comparison. The largest possible areas impacted by uniformly distributed thicknesses of 0.5 m, 0.25 m and 0.05 m (more likely associated with sand sized material) are also provided (making no assumptions regarding the shape of the area).

Table 4.3: Alternative potential extents and thicknesses of local sediment deposition as a result of drilling 100% of the volume of the largest (Model 4) WTG and OSP monopile foundation (100% drill arisings as sands or gravels)

Foundation Type / Operation	Deposition Scenario	Nominal Diameter of Influence (m)	Thickness of Deposit (m)*
	Cone	56 (steepest)	17.6

Table 4.3: Alternative potential extents and thicknesses of local sediment deposition as a result of drilling 100% of the volume of the largest (Model 4) WTG and OSP monopile foundation (100% drill arisings as sands or gravels)

Foundation Type / Operation	Deposition Scenario	Nominal Diameter of Influence (m)	Thickness of Deposit (m)*
Drilling of largest WTG (Model 1) or OSP monopile (8,836 m³ drill arisings per foundation; equivalent volume when deposited at seabed = 14,726 m³ (based on a packing density of 0.6)).		113	4.4
		169	2.0
	Uniform thickness	194	0.50
		274	0.25
		612	0.05

* Height of peak for cones and average uniform thickness. The dimensions of the steepest cone are provided here to indicate the smallest possible area that could be impacted. It is not realistically expected that cone deposits of greater thicknesses (e.g. >5 to 10 m) will be allowed to accumulate in practice. All value pairs are part of a continuous scale of possible outcomes.

N.B. Results should be interpreted according to the corresponding order of magnitude (e.g. tens of metres or seconds, tens of thousands of milligrams per litre, tens of centimetres thickness, etc).

The following observations based on the spreadsheet based numerical model results set out in Table 4.1 to Table 4.3, are consistent with similarly modelled patterns of change in assessments for other wind farms, and the wider monitoring evidence base.

Assuming that a mixture of sediment grain sizes is present, the overall spatial pattern of change in SSC due to drilling of a single monopile foundation is summarised as follows:

- SSC will be increased by tens to hundreds of thousands of mg/l at the point of sediment release (at or near the water surface) for the duration of the drilling activity;
- SSC of low tens of mg/l will be present in a narrow plume (tens to a few hundreds of metres wide), up to one tidal excursion in length (up to ~3.5 to 4.2 km on spring tides, see Figure 2.1, and half that distance on neap tides) aligned to the tidal stream downstream from the source;
- If drilling occurs over more than one flood or ebb tidal period, the plume feature may be present in both downstream and upstream directions;
- Outside of the area up to one tidal excursion upstream and downstream of the foundation location, SSC less than 10 mg/l may occur more widely due to ongoing dispersion and dilution of material;
- Following the end of drilling, local SSC effects will recover quickly (within minutes) to background levels as the sediment plume is advected away and coarser sediments or clasts settle back onto the seabed;
- Sufficiently fine sediment may persist in suspension for hours to days or longer, but will become diluted to very low concentrations (<5 mg/l, indistinguishable from natural background levels and variability) within timescales of around one day; and
- Over longer timescales, net movement of any fine grained material persisting in suspension would generally be in an approximate southerly (south-easterly through south-westerly) direction across most of the Moray West Site in accordance with the direction of residual flow in this area.

Assuming that a mixture of sediment grain sizes is present, the overall spatial pattern of change in bed level due to drilling of a single monopile foundation is summarised as follows:

- Deposits of mainly coarse grained (gravel) and clastic sediment deposits will be concentrated within an area in the order of approximately 10 to 50 m downstream/upstream and a few tens of metres wide from individual foundations, with an average thickness in the order of 5 to 10 m (limited to realistically likely values);
- Deposits of mainly sandy sediment deposits will be concentrated within an area in the order of approximately 100 m to 500 m downstream/upstream and tens to one hundred metres wide from individual foundations, with an average thickness in the order of tens of centimetres to one metre;
- Fine grained material will be dispersed widely within the surrounding region and will not settle with measurable thickness; and
- The absolute width, length, shape and thickness of local sediment deposition as a result of drilling cannot be predicted with certainty and is likely to vary due to the nature of the drill spoil, the local water depth and the ambient environmental conditions during the drilling activity. A range of possible combinations of shape, area and thickness of sediment deposition are provided in Table 4.3.

The local patterns of change to SSC and sediment deposition are described above for drilling individual WTG and OSP monopile foundations. In the Moray West Site, up to 62 larger WTG (Model 4) and up to two OSP monopile foundations may be installed using drilling. The maximum total unconsolidated volume of sediment that could theoretically be released from drilling all foundations (62 larger WTG (Model 4) and up to two OSP monopile foundations) is 942,478 m³ and it is found that:

- If the total volume of drill arisings from all foundations was distributed equally over the Moray West Site area (225 km²), the average increase in bed elevation would be 0.0042 m (i.e. ~4 mm); and
- A maximum area of 18.85 km² (approximately 8.4% of the Moray West Site area) could potentially be covered by an average thickness of 0.05 m of material.

If drilling, or any other activity causing sediment disturbance, is undertaken simultaneously at two or more locations that are aligned in relation to the ambient tidal streams, then there is potential for overlap between the areas of effect on SSC and sediment deposition. The potential for in-combination effects on SSC is discussed in Section 4.4.

4.3.3 Seabed Preparation by Dredging Prior to Gravity Base Installation

To provide a stable footing for GBS foundations or jacket suction caisson foundations, standard dredging techniques will be used to remove or lower the level of the mobile seabed sediment veneer within a footprint slightly larger than the foundation base. Dredging has the potential to cause elevated SSC through: sediment over-spill at the water surface during dredging; and by the subsequent release of the dredged material from the dredger during spoil disposal at a nearby location. The subsequent settlement of the sediment disturbed by dredging will lead to sediment accumulation of varying thickness and extent on the seabed. These changes are quantitatively characterised in this section using spreadsheet based numerical models.

4.3.3.1 Evidence base

Sediment disturbance associated with GBS foundation bed preparation activities was previously considered for the Moray East Offshore Wind Farm using numerical modelling (Moray East, 2012). The nature of the sediment disturbance, the sediment type and other environmental conditions are sufficiently similar to that being considered in the Moray West Site that the previous modelling is considered to provide directly relevant evidence in this regard. The spatial pattern and magnitude of

elevated SSC (and associated levels of deposition) due to dredger overspill during GBS foundation bed preparation activities within the Moray West Site are shown in Figure 4.2 and Figure 4.3, and are summarised below:

- Figure 4.2 shows the resulting levels and distribution of SSC at the end of dredging for ten consecutive foundations in the Moray East Site. The dredger has similar dimensions (5,000 m^3 capacity) and overspill rates (30 kg/s) as assumed for Moray West Site. It is assumed that 100% of the overspilled material is fine in nature, maximising the potential effect.
- The figure shows that, following the end of dredging at the last foundation, the signature of all preceding foundation installations is no longer evident at measurable concentrations;
- The maximum localised increase in SSC is predicted to be 30 to 35 mg/l, depending on the state of the tide and the local water depth at the time and location of the release. These maximum levels of effect are contained within 50 to 100 m of the dredger and only occur during sediment release;
- SSC in the advected main plume (centred along the downstream tidal axis) is reduced to 20 mg/l or less by 500 to 1000 m downstream and to 10 mg/l or less by 2000 to 3000 m downstream;
- The effects described above are only present during and up to 1 hour after the cessation of dredging, after which time SSC is reduced to < 4 mg/l due to dispersion and deposition of sediment to the seabed;
- In principle, the maximum length of the advected main plume is limited to the tidal excursion (7.1 km on spring tides, 3.6 km on neap tides in the Moray East Site, see Figure 2.1) but will normally be less than this as each dredging (release) event lasts less than one half tidal cycle;
- Material deposited to the seabed can be resuspended by stronger currents (> 0.3 to 0.4 m/s) during spring tides, or during storm events, leading to a dispersed low level increase in SSC of 1 to 4 mg/l;
- Material put into suspension by the dredging or by subsequent remobilisation is redeposited to the seabed (resulting SSC <1 mg/l) when current speeds fall below the locally critical value (i.e. typically during neap tides and around slack water periods during spring tides);
- The dispersed low magnitude effects on SSC are advected in a south or south westerly direction outside of the site, i.e. the direction of residual transport by tidal currents;
- Figure 4.2 shows the distribution and thickness of the fine sediment deposit that might result from the total volume of dredging overspill for 339 foundations in the Moray East Site; and
- The figure shows that sediment deposits will tend to occur in the central Moray Firth. The local thickness of accumulation will be less than 1 mm.

The effects on SSC from dredging overspill as part of bed preparation for GBS foundations, in a similar environmental setting to the Moray West Site, are shown by the previous numerical modelling to be generally of a magnitude consistent with the natural range of variability (order 100's to 1000's mg/l near bed and order 10's to 100's mg/l higher in the water column). Local effects around the dredger in the upper and middle parts of the water column may however be potentially in excess of the natural range of variability (a small magnitude of difference, in the order of 10's to 100's mg/l) but will be localised and temporary on short term time scales (order of hours to days).

Fine sediment deposits occur in the central Moray Firth where the current speeds are low, the water depth is larger and (as a result) where finer material is already known to naturally accumulate. The local thickness of accumulation will be less than 1 mm, which is a small volume in both absolute and relative terms, and would not be measurable in practice. Such a small additional volume of fine material locally is

unlikely to change the overall grainsize distribution of the surficial seabed sediments. Deposited sediment will rejoin the natural sedimentary environment and may be subject to further naturally occurring sediment transport and dispersion.

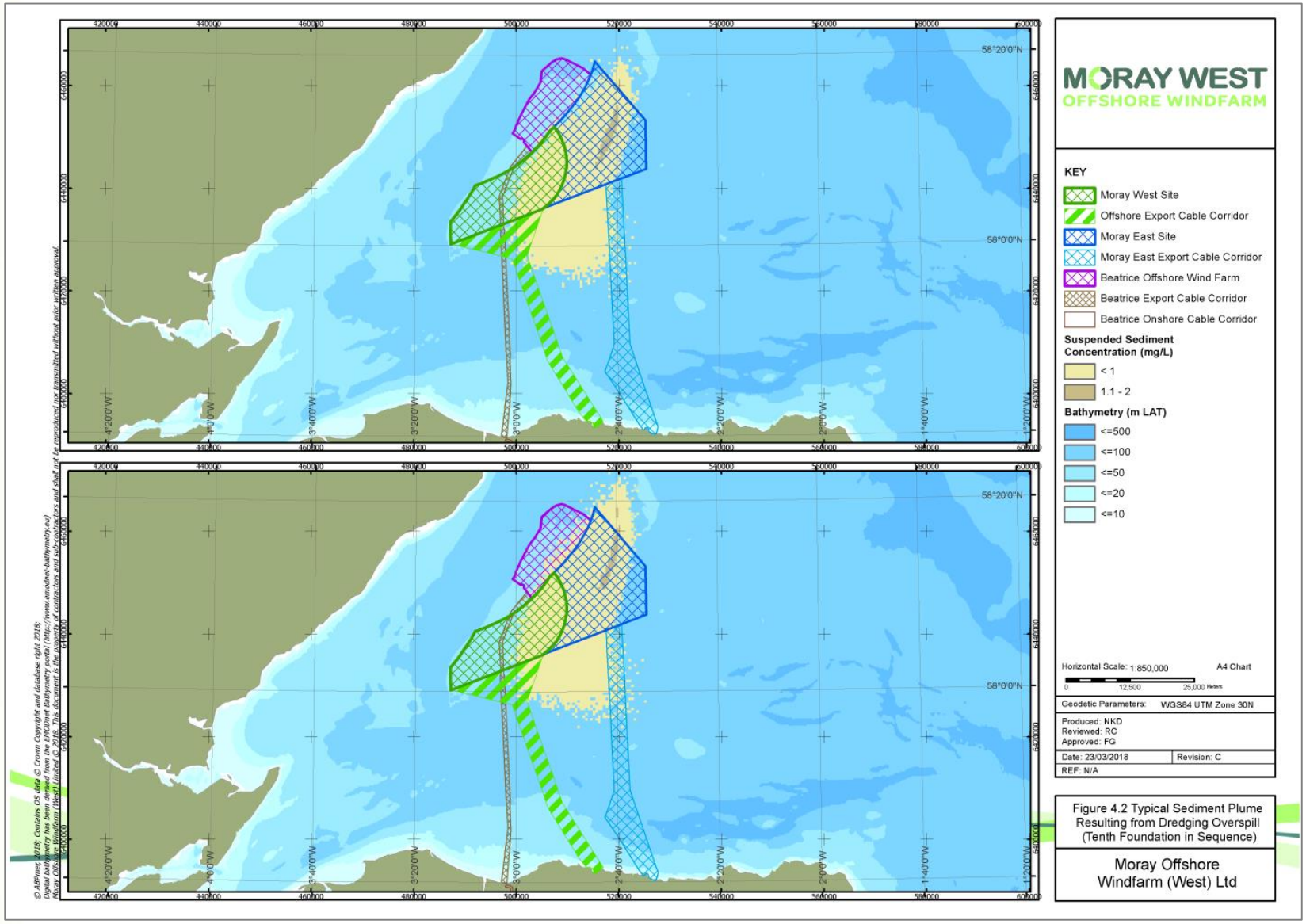


Figure 4.2: Typical sediment plume resulting from dredging overspill (following completion of ten consecutive foundations in the Moray East Site).

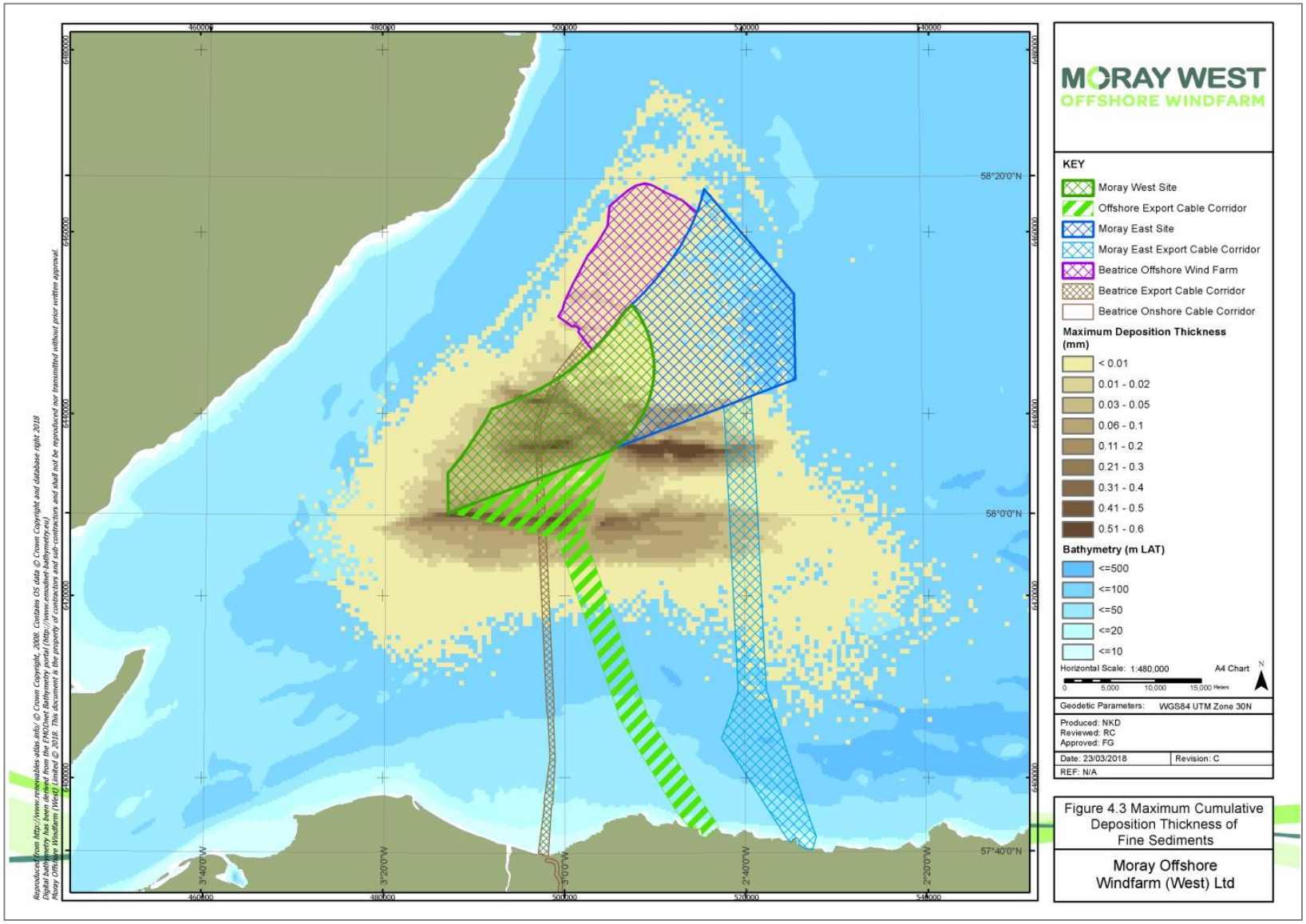


Figure 4.3: Distribution and thickness of fine sediment deposition from dredging overspill (following completion of 339 foundations in the Moray East Site).

The same scenario of ten consecutive foundation installations and a (theoretical) scenario testing cumulative overspill from all 339 WTG foundations in the Moray East Site was also modelled to assess the resulting extent and thickness of fine sediment deposits. The numerical modelling found that fine material was dispersed widely over time into the central Moray Firth. The extent of the dispersion meant that sediment did not accumulate in thicknesses more than 1.4 mm, which would not be measureable in practice. It was also noted that ongoing natural sediment transport processes might further reduce the potential for local accumulation of measureable thicknesses of fine sediment.

The wider evidence-base with regards to dredging and elevated levels of SSC is broad and well established through a variety of monitoring and numerical modelling studies. The following text from the UK Marine SAC Project (www.ukmarinesac.org.uk) is representative of the wider evidence base:

"Dredging activities often generate no more increased suspended sediments than commercial shipping operations, bottom fishing or generated during severe storms (Parr *et al*., 1998). Furthermore, natural events such as storms, floods and large tides can increase suspended sediments over much larger areas, for longer periods than dredging operations (Environment Canada, 1994). It is therefore often very difficult to distinguish the environmental effects of dredging from those resulting from natural processes or normal navigation activities (Pennekamp *et al*., 1996).

…In general, the effects of suspended sediments and turbidity are generally short term (<1 week after activity) and near-field (<1 km from activity). There generally only needs to be concern if sensitive species are located in the vicinity of the maintained channel."

Dredging for construction aggregates is a common marine activity in the UK. The total mass of aggregate recovered from each of the seven main license regions is reported annually by the British Marine Aggregate Producers Association (http://www.bmapa.org). It is reported that, in 2016, approximately 17.94 million tonnes (11.3 million m^3) of sand and gravel aggregate were dredged from 82.67 km^2 of seabed. The total licensed area for aggregate dredging in 2016 was 934 km^2. This corresponds to an average dredging intensity of approximately 217,000 tonnes/km^2/year or 136,500 m^3/km^2/year.

In comparison, the maximum total volume of sediment that could potentially be dredged in the Moray West Site (area 225 km^2) is 2,502,141 m^3 (85 smaller WTG GBS, plus one large OSP GBS foundation) over the whole duration of the construction period, which is expected to span up to two years. This corresponds to a comparatively much lower average dredging intensity of approximately 8,850 tonnes/km^2/year or 5,560 m^3/km^2/year.

It is also noted that sediment dredged as part of construction activities in the Moray West Site will all be returned to the seabed nearby to the dredging location, whereas sediment dredged as part of aggregate extraction is removed permanently from the seabed.

4.3.3.2 Assessment of change

The greatest volume of sediment disturbed locally by dredging (causing a potential increase in SSC and thickness of sediment deposition) would occur as a result of dredging for the largest diameter WTG GBS foundation (excavated pit dimensions 95 m diameter, 5 m depth) and for the largest diameter OSP GBS foundation (excavated pit dimensions 120 m diameter, 8 m depth).

The greatest volume of sediment disturbed in the whole Moray West Site would occur as a result of dredging for up to 85 of the smaller (Model 1) WTG GBS foundations (excavated pit dimensions 85 m diameter, 5 m depth) and the single largest diameter OSP GBS foundation (excavated pit dimensions 120 m diameter, 8 m depth). Foundations would have a minimum spacing of 1050 m crosswind and 1200 m downwind. Multiple dredgers may be working simultaneously.

The distribution of grain and clast sizes in the dredging over-spill and spoil release plumes is not known in advance, so results are provided separately for scenarios where 100% of the material is assumed to be either fines, (medium) sand or (coarse) gravel sized. In practice, depending on the actual ground conditions and dredging vessel used, the distribution of grain and clast size in the over-spill and spoil will

be some variable mixture of these with a corresponding intermediate duration, extent and magnitude of change.

It is noted that naturally occurring SSC normally refers to suspensions of sand and finer sediments. The nominal increase in SSC for gravels in suspension is reported but should be treated with caution if used to inform assessments of impacts on baseline conditions or other sensitive receptors.

The maximum adverse scenario for sediment spoil disposal by the dredger for all GBS foundation types is characterised in Table 2.3. The following operational details are also considered:

- The dredging will be undertaken by a Trailer Suction Hopper Dredger (TSHD) with a split bottom release (allowing the fastest possible release of all sediment in the hopper). It is assumed that the full representative hopper capacity of 5,000 m^3 is dredged (taking up to four hours) and then released during each dredging cycle;
- The rate of sediment release by over-spill during dredging is determined by the performance of the dredging vessel but is conservatively estimated to be 30 kg/s; and
- Spoil will be returned to the seabed at the end of each dredging cycle from the base of the dredging vessel at a nearby location within the Moray West Site.

During disposal, material will be released from the bottom of the vessel in a sudden event. The majority of the sediment load (up to 90% based on monitoring evidence from the aggregate industry) will descend to the seabed as a single unit, behaving as a density flow. This downward movement of material is termed the 'dynamic phase' of the plume. The rate of descent of the dynamic phase through the water column is rapid (in the order of several metres per second) relative to the normal settling rate for the individual grains that comprise it. The remaining 10% of the sediment volume released will form a more dispersed plume throughout the water column, termed the 'passive phase', that will settle at approximately the rate of the individual grains.

Levels of SSC resulting from dredging overspill assuming 100% of the overspill comprises fines are shown in Table 4.4 for the following range of dispersion scenarios:

- Source concentration at the point of release (total mass evenly dispersed in a volume of water 10 m wide, 10 m length, 1 m depth);
- Vertical diffusion to 5 m, 20 m lateral spread in footprint dimensions (1 to 2 minutes after release, 15 to 30 m downstream);
- Vertical diffusion to 20 m (from surface to approximately half the water depth), 50 m lateral spread in footprint dimensions (10 to 20 minutes after release, 150 m to 300 m downstream); and
- Vertical diffusion to 40 m (so affecting the seabed in shallower locations), 100 m lateral spread in footprint dimensions (1 hour after release, 900 m downstream).

The approximate timeframe and distance downstream from the point of release for each dispersion scenario is indicated, based on the representative rates of lateral dispersion and current speeds previously described in Section 4.3.1. Fines are dispersed widely and to such low concentrations prior to resettlement to the seabed that no locally measureable thickness of accumulation is realistically expected.

Table 4.4: Suspended sediment concentration as a result of over-spill during dredging for any foundation (100% over-spill as fines)

Parameter	Value
Rate of sediment release (kg/s)	30
Total mass released into receiving water (kg)	1,200

Table 4.4: Suspended sediment concentration as a result of over-spill during dredging for any foundation (100% over-spill as fines)

Parameter			Value
Representative current speed (m/s)			0.25
Plume Width (m)	**Plume Depth (m)**	**Plume Section Length (m)**	**Resulting SSC (mg/l)**
10	1	10	12,000
20	5		1,200
50	20		120
100	40		30
N.B. Results should be interpreted according to the corresponding order of magnitude (e.g. tens of metres or seconds, tens of thousands of milligrams per litre, etc.).			

Levels of SSC and the estimated area and average thickness of sediment deposition as a result of overspill during one dredging cycle, assuming 100% of the overspill is sands or gravels, is shown in Table 4.5. Up to eight dredging cycles may be required per WTG GBS foundation and up to 19 dredging cycles may be required per OSP GBS foundation. The estimated level of SSC applies equally during all dredging cycles for both foundation types. Areas of sediment deposition may overlap to some extent depending on the spatial pattern of dredging and ambient currents during the operation.

Table 4.5: Suspended sediment concentration and sediment deposition as a result of over-spill during one dredging cycle (100% over-spill as sands or gravels)

Sediment Type	Water Depth (m)	Settling Rate (m/s)	Duration of Settlement (s)	Distance Plume Advected by Peak Current (m)	Maximum Mass in Suspension (kg)	Area of Seabed Deposition (m²)	Average Thickness of Seabed Deposition (m)
100% Sand	35	0.05	700	350	21,000	83,973	0.02
	42		840	420	25,200	104,887	0.02
	48		960	480	28,800	123,905	0.02
	54		1,080	540	32,400	143,933	0.01
100% Gravel	35	0.5	70	35	2,100	7,224	0.27
	42		84	42	2,520	8,799	0.22
	48		96	48	2,880	10,183	0.19
	54		108	54	3,240	11,600	0.17
Sediment Type	**Water Depth (m)**	**Diameter of Midwater SSC Influence (m)**	**Area of Midwater SSC Influence (m²)**	**Midwater Average SSC (mg/l)**	**Diameter of Near-Bed SSC Influence (m)**	**Area of Near-Bed SSC Influence (m²)**	**Near-Bed Average SSC (mg/l)**
100% Sand	35	20	316	1,898	28	623	963
	42	24	451	1,329	34	892	673

	48	27	587	1,023	38	1,161	517
	54	31	739	811	43	1,465	410
100% Gravel	35	7	35	1,709	9	67	893
	42	8	49	1,217	11	95	632
	48	9	63	946	12	123	489
	54	10	79	757	14	154	390
N.B. Results should be interpreted according to the corresponding order of magnitude (e.g. tens of metres or seconds, tens of thousands of milligrams per litre, tens of centimetres thickness, etc.).							

Levels of SSC in the passive phase of the plume created during dredge spoil disposal during one dredging cycle for any foundation size assuming 100% of the material is fines are shown in Table 4.6.

Table 4.6: Suspended sediment concentration as a result of dredge spoil disposal (passive phase only) during one dredging cycle (100% over-spill as fines)

Plume Width (m)	Plume Depth (m)	Plume Section Length (m)	Resulting SSC (mg/l)
10	40	10	198,750
100	40	100	1,988
1000	40	1000	20
5000	40	5000	1

* Total mass fine sediment released into passive phase 795,000 kg (10% x 5,000 m3 x 2,650 kg/m^3 x 0.6 solidity); sediment released uniformly by the active phase during descent from surface to seabed; water depth 40 m.

N.B. Results should be interpreted according to the corresponding order of magnitude (e.g. tens of metres or seconds, tens of thousands of milligrams per litre, etc.).

Levels of SSC and the estimated area and average thickness of sediment deposition thickness related to the passive phase of the plume created during dredge spoil disposal during one dredging cycle for any size foundation assuming 100% of the material is sands or gravels are shown in Table 4.7.

Table 4.7: Suspended sediment concentration and sediment deposition as a result of dredge spoil disposal (passive phase only) during one dredging cycle (100% as sands or gravels)

Sediment Type	Water Depth (m)	Settling Rate (m/s)	Duration of Settlement (s)	Distance Plume Advected by Peak Current (m)	Maximum Mass in Suspension (kg)	Area of Seabed Deposition (m²)	Average Thickness of Seabed Deposition (m)
100% Sand	35	0.05	280	140	795,000	2,870	0.17
	42		500	250	795,000	8,978	0.06
	48		720	360	795,000	18,477	0.03
	54		940	470	795,000	31,366	0.02
100% Gravel	35	0.5	28	14	795,000	99	5.04
	42		50	25	795,000	299	1.67
	48		72	36	795,000	606	0.82

Table 4.7: Suspended sediment concentration and sediment deposition as a result of dredge spoil disposal (passive phase only) during one dredging cycle (100% as sands or gravels)

Sediment Type	Water Depth (m)	Settling Rate (m/s)	Duration of Settlement (s)	Distance Plume Advected by Peak Current (m)	Maximum Mass in Suspension (kg)	Area of Seabed Deposition (m^2)	Average Thickness of Seabed Deposition (m)
	54		94	47	795,000	1,020	0.49
100% Sand	35	8	54	1,043,204	12	105	540,449
	42	14	165	193,284	20	322	98,628
	48	21	334	66,119	29	659	33,534
	54	27	563	30,053	38	1,113	15,192
100% Gravel	35	3	7	8,171,772	4	13	4,520,003
	42	5	19	1,673,487	7	36	888,885
	48	7	37	596,954	9	71	311,635
	54	9	61	277,647	12	118	143,558

N.B. Results should be interpreted according to the corresponding order of magnitude (e.g. tens of metres or seconds, tens of thousands of milligrams per litre, tens of centimetres thickness, etc.).

Estimates of the area and average thickness of sediment deposition are provided in the preceding tables based on the approximate footprint of the plume and tidal advection factors. The extent, thickness and shape of sediment deposits on the seabed could be highly variable in practice.

However, given the maximum total volume of sediment released as overspill (272 m^3) and dredge spoil (5,000 m^3) per dredge cycle and considering all dredging requirements (up to 621 full dredging cycles based on the chosen representative hopper size), a range of potential alternative combinations can be more reliably calculated. A range of alternative possible value combinations are provided in Table 4.8 for dredging overspill and for the active and passive phases of the dredge spoil disposal plume. For more details about the basis of these tables, see the previous assessment for drilling (Section 4.3.2).

Table 4.8: Alternative potential extents and thicknesses of sediment deposition as a result of all dredging requirements for WTG and OSP GBS foundations (overspill and active and passive phases of the spoil disposal plume)

Foundation Type / Operation	Deposition Scenario	Nominal diameter of influence (m) as a result of one spoil disposal event (and the area of influence of all events as a proportion of the Moray West Site area, 225 km^2)	Thickness of Deposit (m)[a]
Dredging overspill from the dredger, 621 events for all foundations (272 m^3 overspill).	Uniform thickness	13 (0.15%) 19 (0.30%) 42 (1.50%)	0.50 0.25 0.05
Spoil disposal from the dredger, 621 events for all foundations	Cone	38 (0.31%) (steepest) 76 (1.25%) 114 (2.82%)	11.9 3.0 1.3

Table 4.8: Alternative potential extents and thicknesses of sediment deposition as a result of all dredging requirements for WTG and OSP GBS foundations (overspill and active and passive phases of the spoil disposal plume)

Foundation Type / Operation	Deposition Scenario	Nominal diameter of influence (m) as a result of one spoil disposal event (and the area of influence of all events as a proportion of the Moray West Site area, 225 km^2)	Thickness of Deposit (m)[a]
(4,500 m^3 in active phase, 90% of 5,000 m^3).	Uniform thickness	107 (2.48%) 151 (4.96%) 339 (24.82%)	0.50 0.25 0.05
Spoil disposal from the dredger, 621 events for all foundations (500 m^3 in passive phase, 10% of 5,000 m^3).	Uniform thickness	18 (0.28%) 25 (0.55%) 56 (2.76%)	0.50 0.25 0.05
All dredging overspill and spoil disposal, 621 events for all foundations.	Uniform thickness	Total (2.91%) Total (5.82%) Total (29.08%)	0.50 0.25 0.05

[a] Height of peak for cones and average uniform thickness. The dimensions of the steepest cone are provided here to indicate the smallest possible area that could be impacted. It is not realistically expected that cone deposits of greater thicknesses (e.g. >5 to 10 m) will be allowed to accumulate in practice. All value pairs are part of a continuous scale of possible outcomes.

N.B. Results should be interpreted according to the corresponding order of magnitude (e.g. tens of metres diameter, tens of centimetres thickness, etc.).

In summary, the influence of dredging overspill and spoil disposal on increasing SSC above ambient levels is characterised as follows:

- SSC levels would be highest (potentially tens to hundreds of thousands of mg/l) at the point of sediment release, which is at or near the water surface during dredging overspill and distributed through the whole water column during dredge spoil disposal. This feature would only be present during (the relatively longer) periods of active dredging or during (the relatively short) dredge spoil disposal events;
- For fine material in dredging overspill, SSC levels would decrease rapidly through vertical and horizontal dispersion to low tens of mg/l within the order of hundreds of metres from the point of release;
- For fine material released into the passive plume phase during dredge spoil disposal, SSC levels would be initially higher than for overspill (due to the sudden nature of the sediment release). SSC levels will decrease through horizontal dispersion to a few thousand mg/l within the order of low hundreds of metres and a few tens of mg/l within the order of one thousand metres distance from the source;
- For sand and gravel material in dredging overspill, local SSC levels would decrease to low thousands or hundreds of mg/l locally (low tens of mg/l in a depth mean sense) through horizontal dispersion whilst settling to the seabed;
- For sand and gravel material released into the passive plume phase during dredge spoil disposal, local SSC levels would remain relatively high whilst settling to the seabed but would reduce slightly from hundreds to tens of thousands of mg/l due to horizontal dispersion;

- Sands would deposit to the seabed within the order of hundreds of metres from the source (taking in the order of 5 to 15 minutes to settle from surface to seabed), and gravels likewise within tens of metres (0.5 to 1.5 minutes). The horizontal diameter of the main sand or gravel plume footprint within the water column and on the seabed is likely to be in the order of only tens of metres;
- Following cessation of dredging or spoil release, the influence of sands or gravels on SSC levels would reduce rapidly as described above and would end when the sediment is redeposited to the seabed (in the order of 0.5 to 15 minutes, depending on the grain size and water depth); and
- Once redeposited to the seabed, the locally dredged overspill and spoil material are essentially the same as the local sediment type. The dredged material would therefore immediately re-join the natural sedimentary environment and will not contribute further to elevated SSC above naturally occurring levels.

In summary, sediment deposition as a result of dredging for foundation installation is characterised as follows:

- Deposits of mainly gravel sized dredge overspill would be concentrated within a relatively small area in the order of tens of metres from the site of dredging, with an average thickness in the order of a few tens of centimetres;
- Deposits of mainly sand sized dredge overspill sediment would be concentrated within an area in the order of 150 to 500 m downstream/upstream and approximately tens to one hundred metres wide from individual foundations, with an average thickness in the order of less than a few centimetres;
- Spoil disposal would form more concentrated sediment deposits on the seabed. The main mass of sediment (90% of the total dredged volume, falling as the active phase of the plume) will initially result in discrete mounds or patches of sediment in the order of tens to hundreds of metres in diameter (depending on the pattern of settlement) and centimetres to a few metres in local thickness. An area equivalent to a circle of up to 340 m in diameter could be covered to an average depth of 0.05 m. Any larger area of change would correspond to a smaller average thickness. It is possible that consecutive disposal events could overlap on the seabed, resulting in a greater local thickness of sediment but a smaller overall area of influence;
- The smaller mass of material (10% of the total volume) falling as the passive phase of the spoil disposal plume would result in a narrow deposit downstream either hundreds of metres in length and a few centimetres or less thick (for sands), or, tens of metres in length and up to tens of centimetres to a few metres thick (for gravels); and
- Fine grained material released as overspill or as the passive phase of spoil disposal would be dispersed widely within the surrounding region and would not settle locally with measurable thickness. Fine grained material in the active phase of spoil disposal will remain bound in the main sediment mass and will not be differently dispersed to that described above.

The assessments undertaken and the summaries above describe the influence of conservatively marginal scenarios where the material being dredged or disposed is entirely fines, sands or gravels. Based on these marginal cases, the following summary describes the overall influence of the same activities assuming that a mixture of sediment grain sizes is present:

- SSC of low tens of mg/l will be present in a narrow plume (tens to a few hundreds of metres wide), up to one tidal excursion in length (up to ~3.5 to 4.2 km on spring tides, see Figure 2.1, and half that distance on neap tides) aligned to the tidal stream downstream from the source;

- If dredging occurs over more than one flood or ebb tidal period, the plume feature may be present in both downstream and upstream directions;
- Outside of the area up to one tidal excursion upstream and downstream of the foundation location, SSC less than 10 mg/l may occur more widely due to ongoing dispersion and dilution of material;
- The majority of gravel and sand sized sediment will be deposited to the seabed within tens to hundreds of metres from the source, respectively. A larger proportion of such material in the plume may result in SSC reducing more rapidly in this region and reducing the length or extent of the plume feature overall; and
- Sufficiently fine sediment may persist in suspension for hours to days or longer, but will become diluted to very low concentrations (indistinguishable from natural background levels and variability) within timescales of around one day.

If dredging, or any other activity causing sediment disturbance, is undertaken simultaneously at two or more locations that are aligned in relation to the ambient tidal streams, then there is potential for overlap between the areas of effect on SSC and sediment deposition. The potential for in-combination effects on SSC is discussed in Section 4.4.

4.3.4 Cable Burial

4.3.4.1 Summary

The impact of cable burial operations mainly relates to a localised and temporary re-suspension and subsequent settling of sediments (BERR, 2008). The exact nature of this disturbance will be determined by the soil conditions within the Moray West offshore windfarm area and export cable route, the length of installed cable, the burial depth and burial method. These changes are quantitatively characterised in this section for export, inter-array and interconnector cables using spreadsheet based numerical models.

4.3.4.2 Evidence base

The evidence base with respect to cable burial activities is broad and includes a range of theoretical, numerical modelling and monitoring studies considering a range of installation methodologies, sediment types, water depths and other environmental conditions. The evidence base is widely applicable as the dimensions of the cables, the installation techniques used and the target depths of burial do not vary significantly with the scale of the development (small or large wind farm arrays) or the type of cable being installed (wind farm export, array or inter-connector cables, or non-wind farm electrical and communications cables).

SSC monitoring during cable laying operations has been undertaken at Nysted Wind Farm (ABPmer *et al*., 2007; BERR, 2008). During the works, both jetting and trenching were used, where the latter method involves pre-trenching and back-filling using back-hoe dredgers. Superficial sediments within the site were predominantly medium sands, approximately 0.5 m to 3 m in thickness, underlain by clay. SSC was recorded at a distance of 200 m from jetting and trenching activities and the following values were observed:

- Trenching – mean (14 mg/l) and max (75 mg/l); and
- Jetting – mean (2 mg/l) and max (18 mg/l).

The higher sediment concentrations from the trenching activities were considered to be a result of the larger volume of seabed strata disturbed during operations and the fact that the material disturbed during trenching was lifted to the surface for inspection. This meant that the sediment was transported through the full water column before being placed alongside the trench (BERR, 2008).

Cable laying monitoring also took place at Kentish Flats where ploughing methods were used to install three export cables (EMU Limited, 2005). Cefas agreed pre-defined threshold limits against which SSC

monitoring would be compared. The monitoring 500 m down-tide, i.e. where the concentrations will be greatest, of the cable laying activities showed:

- Marginal, short-term increases in background levels (approximately nine times increase to the background concentrations); and
- Peak concentrations occasionally reaching 140 mg/l (equivalent to peaks in the naturally occurring background concentrations).

The observations at Nysted and Kentish Flats provide confidence that cable laying activities do not create a long-term, significant disruption to the background sediment concentrations. Furthermore, it also illustrates that there is little sediment dispersal, indicating that there is unlikely to be much deposition on the seabed other than immediately adjacent to the cable route.

Reach (2007) describes plume dispersion studies for a cable laying jetting operation in Hong Kong with an assumption that 20% of a trench cross-section of 1.75 m² would be disturbed by the jetting process and the speed of the jetting machine would be 300 m/hour (0.083 m/s). ASA (2005) describes similar studies for a cable laying operation near Cape Cod in the USA and assumed that 30% of a trench cross-section of 3 m² would be disturbed by the jetting process and the speed of the jetting machine would be 91 m/hour (0.025 m/s). This latter study also assumed that any sand particles would quickly return to the bed and only the fine sediment particles (particles with a diameter less than 63 µm) would form a plume in the water column.

SeaScape Energy (2008) describes cable installation plume dispersion monitoring studies carried out at the Burbo offshore wind farm in Liverpool Bay, UK:

- Three export cables were installed to a target depth of approximately 3 m by vertical injector ploughing while array cables were installed to a similar depth by jetting assisted ploughing;
- The monitoring demonstrated clearly that both cable installation techniques had only small scale impacts on localised SSC. Changes were measurable to a few hundreds of metres only and suspended sediment levels were not elevated more than five times background. Suspended sediment levels never approached the threshold level (3,000 mg/l) agreed with regulatory authorities beforehand, even in very close proximity to the works (< 50 m); and
- Local changes in SSC over a relatively fine sediment seabed area (most likely to lead to plume impacts) was in the region of 250 to 300 mg/l within 200 m of the operation, falling to the measured baseline level (100 mg/l) by 700 m downstream. It is assumed, therefore, that coarser sediments were associated with even lower levels.

The post-burial impacts of cable burial on sandy seabed morphology were also considered by BERR (2008) with reference to a wide range of desktop and monitoring studies. The report concludes that impacts will also be limited in terms of both the thickness of re-deposited sediments and the potential for affecting the surficial sediment type:

“The low levels of sediment that are mobilised during cable laying mean that there will be only low levels of deposition around the cable route. The finer material will generally remain in suspension for longer but will settle and remobilise on each tide with no measurable material left in place. Coarser sediments are expected to settle within a few metres of the cable route and following disturbance is likely to recover rapidly, given similar communities in the vicinity.” (BERR, 2008).

4.3.4.3 Assessment of change

Export and array cables would be installed by burial into the seabed. The Moray West OfTI export cable corridor runs approximately south from the southwestern margin of the Moray West Site to the Landfall Area between Findlater Castle and Redhythe Point in Sandend Bay on the Banffshire coast.

The maximum adverse scenario for sediment release caused by cable burial is characterised in Table 2.3. The potential effects of sediment release due to cable burial are typically localised to the cable route or

the active cable burial location. As such, the maximum adverse scenario information mainly considers the local trench dimensions and rates of sediment disturbance. The total volume of sediment disturbance is not relevant to the assessment and so is not presented here.

Jetting tools fluidises an area of sediment within the seabed through which the cable is inserted. By design, the process is intended to bury the cable and so only a minimal proportion of the fluidised sediment is expected to be actually ejected from the trench. The exact proportion ejected may vary. Values of 20% to 30% have been used in previous investigations of this type (ASA, 2005). For the purposes of this investigation, it is conservatively assumed that 100% of the disturbed material is ejected.

An assessment of potential changes to SSC and bed levels has been undertaken using the spreadsheet based numerical models introduced in 4.3.1. A conservative assumption has been made that sub-soil materials with a different grain size distribution to surficial sediments may also be re-suspended.

The seabed and sub-seabed sediment composition within the Moray West Site and along the offshore cable corridor is considered likely to be locally heterogeneous (similar with depth below the seabed surface). In most locations, the majority of disturbed material will be sand and gravels. However, some muddy sediment is also present in some locations in varying proportions.

It is impractical to capture the full detail of mixed sediment grainsize distributions in detail within the context of this assessment, which instead considers a series of maximum adverse scenario 'end-member' scenarios. These are:

- Jetting through 100% (coarse) gravel (15,000 µm);
- Jetting through 100% (medium) sand (375 µm); and
- Jetting through 100% (fine) silt (10 µm).

These three scenarios represent the full potential range of change both in terms of the duration, spatial extent of changes to SSC, and maximum thicknesses of sediment deposition. In practice, a release comprising entirely fines is very unlikely.

Cable burial through the underlying sub-soils may result in the release of a range of sediment grain sizes, depending on the local nature of sub-soil and cable burial method used. In practice, these soil types are unlikely to disaggregate entirely into the finest possible constituent particle sizes due to the cable burial methods being assessed. This is particularly true for non-jetting installation methods such as ploughing which, given the potential density of the sub seabed sediment units along parts of the export cable corridor, are more realistically expected to be used in these areas (DNV, 2014) (Figure 4.4). Also, even when fully disaggregated, the various sediment types that are present do not comprise 100% fine grained material. Ploughing will result in a much lower rate of sediment re-suspension, hence this method has not been explicitly assessed.

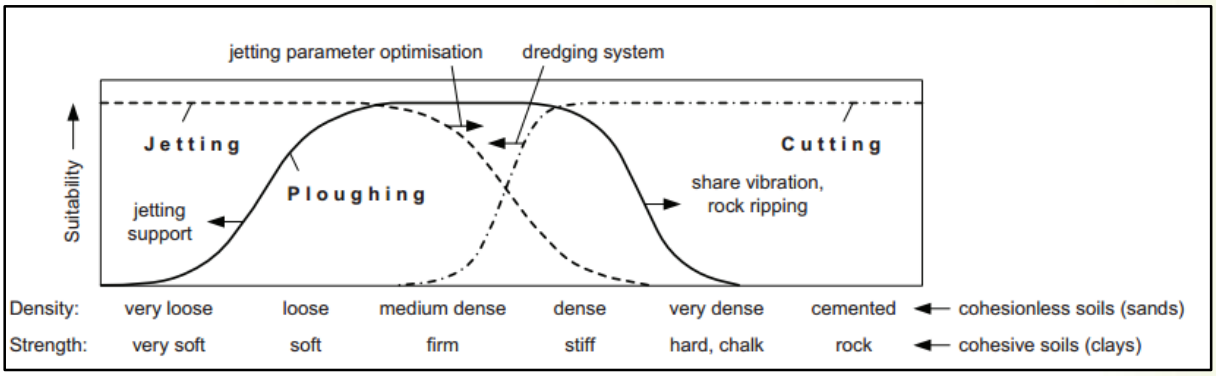


Figure 4.4: Indicative burial tool suitability in different ground conditions (DNV, 2014)

Results from the assessment scenarios outlined above are presented in Table 4.9 (for the gravel release scenario) and Table 4.10 (for the sand release scenario).

It is noted that naturally occurring SSC normally refers to suspensions of sand and finer sediments. The nominal increase in SSC for gravels in suspension is reported but should be treated with caution if used to inform assessments of impacts on baseline conditions or other sensitive receptors.

Results are presented for a range of representative current speeds, noting that cable burial activities will continue through all states of the tide, including current speeds lower than the highest locally possible (peak) value. Because of the uncertainty with regards to how high into the water column from the bed material may be ejected or re-suspended, results are provided for a realistic range of heights (1, 5 and 10 m). A greater height of ejection would lead to a potentially longer plume duration and a greater distance of influence, but also a corresponding reduction in SSC and deposition thickness. Because the cable burial tool moves relatively quickly (up to 1000 m/hr), any influence of the plume experienced immediately downstream will be similarly limited in duration, as little as 3.6 seconds (conservatively ten seconds or less), after which time, the plume will have been advected downstream past the location of the receptor, or will instead be affecting an area of seabed further along the cable route.

Table 4.9: Suspended sediment concentration and thickness of sediment deposition as a result of cable burial in 100% gravel (settling rate 0.5 m/s)

Representative Current Speed (m/s)	Height of Ejection (m)	Time for Resettlement (s)	Distance Plume Advected by Current (m)	Limited Length of Influence on SSC in Downstream Direction (m)	Limited Duration of Influence on SSC Locally (s)	Average SSC in the Limited Length / Duration of Influence (mg/l)	Average Thickness of Seabed Deposition * (m)
0.1	1	2	0.2	0.2	2.0	2,385,000	22.50
0.2	1	2	0.4	0.4	2.0	2,385,000	11.25
0.3	1	2	0.6	0.6	2.0	2,385,000	7.50
0.4	1	2	0.8	0.8	2.0	2,385,000	5.63
0.1	5	10	1.0	0.4	3.6	477,000	4.50
0.2	5	10	2.0	0.7	3.6	477,000	2.25
0.3	5	10	3.0	1.1	3.6	477,000	1.50
0.4	5	10	4.0	1.4	3.6	477,000	1.13
0.1	10	20	2.0	0.4	3.6	238,500	2.25
0.2	10	20	4.0	0.7	3.6	238,500	1.13
0.3	10	20	6.0	1.1	3.6	238,500	0.75
0.4	10	20	8.0	1.4	3.6	238,500	0.56

* Average thickness based on the total volume of sediment released and the distance the plume is advected by the current. Large deposit thicknesses (e.g. >5 to 10 m) in combination with relatively small footprints will more realistically correspond to a broader and less thick deposit with slopes at the angle of repose for the sediment. Each row of results is part of a continuous scale of possible outcomes.

N.B. Results should be interpreted according to the corresponding order of magnitude (e.g. tens of metres or seconds, tens of thousands of milligrams per litre, tens of centimetres thickness, etc.).

Table 4.10: Suspended sediment concentration and thickness of sediment deposition as a result of cable burial in 100% sand (settling rate 0.05 m/s)

Representative Current Speed (m/s)	Height of Ejection (m)	Time for Resettlement (s)	Distance Plume Advected by Current (m)	Limited Length of Influence on SSC in Downstream Direction (m)	Limited Duration of Influence on SSC Locally (s)	Average SSC in the Limited Length / Duration of Influence (mg/l)	Average Thickness of Seabed Deposition * (m)
0.1	1	20	2.0	0.4	3.6	2,385,000	2.25
0.2	1	20	4.0	0.7	3.6	2,385,000	1.13
0.3	1	20	6.0	1.1	3.6	2,385,000	0.75
0.4	1	20	8.0	1.4	3.6	2,385,000	0.56
0.1	5	100	10.0	0.4	3.6	477,000	0.45
0.2	5	100	20.0	0.7	3.6	477,000	0.23
0.3	5	100	30.0	1.1	3.6	477,000	0.15
0.4	5	100	40.0	1.4	3.6	477,000	0.11
0.1	10	200	20.0	0.4	3.6	238,500	0.23
0.2	10	200	40.0	0.7	3.6	238,500	0.11
0.3	10	200	60.0	1.1	3.6	238,500	0.08
0.4	10	200	80.0	1.4	3.6	238,500	0.06

* Average thickness based on the total volume of sediment released and the distance the plume is advected by the current. Large deposit thicknesses (e.g. >5 to 10 m) in combination with relatively small footprints will more realistically correspond to a broader and less thick deposit with slopes at the angle of repose for the sediment. Each row of results is part of a continuous scale of possible outcomes.

N.B. Results should be interpreted according to the corresponding order of magnitude (e.g. tens of metres or seconds, tens of thousands of milligrams per litre, tens of centimetres thickness, etc.).

Changes associated with cable burial into 100% fine grained sediment will be similar to that described for sand in Table 4.10 within the reported plume length in a downstream direction (2 to 80 m for the range of current speeds and ejection heights shown). In this area, the duration of change to SSC locally will also be in the order of seconds (<10 s) due to rapid progression of the tool and the correspondingly localised plume. The average level of SSC will be hundreds of thousands of mg/l in areas near to active cable burial. Beyond this relatively short distance downstream, fine sediment could persist in suspension for longer than sands (order of days) but the plume will be subject to significant dispersion in that time, reducing any change to SSC to tens of mg/l or less in the same timeframe. As a result of dispersion, no measurable thickness of accumulation of fine sediment is expected.

The main findings of the assessment can be summarised as follows:

- Medium to coarse sand and gravels are likely to result in a temporally and spatially limited plume affecting SSC levels (and settling out of suspension) in close proximity to the point of release. SSC will be locally elevated within the plume close to active cable burial up to hundreds of thousands to low millions of mg/l. However, the change will be highly localised and only be present for a very short time locally, in the order of seconds for sand or gravel, before the material is advected past any given location or resettles to the seabed. Depending on the height to which the material is ejected and the current speed at the time of release, changes in SSC and deposition will be spatially limited to within metres (up to 10 m) downstream of the cable for gravels and within tens of metres (up to one hundred metres) for sands;

- Finer material will be advected away from the release location by the prevailing tidal current. High initial concentrations (similar to sands and gravels) are to be expected but will be subject to rapid dispersion, both laterally and vertically, to near-background levels (tens of mg/l) within hundreds to a few thousands of metres of the point of release. In practice, only a small proportion of the material disturbed is expected to be fines, with a corresponding reduction in the expected levels of SSC; and
- Irrespective of sediment type, the volumes of sediment being displaced and deposited locally are relatively limited (up to 4.5 m^3 per metre of cable burial) which also limits the combinations of sediment deposition thickness and extent that might realistically occur. Fundamentally, the maximum distance from each metre of cable trench over which 4.5 m^3 of sediment can be spread to an average thickness of (for example) 0.05 m is 90 m; any larger distance would correspond to a smaller average thickness. The assessment suggests that the extent and so the area of deposition will normally be much smaller for sands and gravels (although leading to a greater average thickness of deposition in the order of tens of centimetres to a few metres) and that fine material will be distributed much more widely, becoming so dispersed that it is unlikely to settle in measurable thickness locally.

If cable burial, or any other activity causing sediment disturbance, is undertaken simultaneously at two or more locations that are aligned in relation to the ambient tidal streams, then there is potential for overlap between the areas of effect on SSC and sediment deposition. The potential for in-combination effects on SSC and sediment deposition are discussed in Section 4.3.2.

4.3.5 Seabed Indentations as a Result of Jack-Up Vessels and Large Anchors

4.3.5.1 Summary

The source of this potential impact is the vessels involved in installing WTG and OSP foundations, which may utilise jack-up legs or a number of anchors to hold station and to provide stability for the working platform. Where legs or anchors have been inserted into the seabed and then removed, an indentation proportional to the dimensions of the object may remain. The volume and dimensions of the depression may reduce over time due to natural movement of the soils and due to infilling in proportion to the rate of sediment transport through the area. Depending upon the nature of the seabed surface sediments, the presence of a depression does not necessarily imply a difference in sedimentary environment in the area of effect. As sediment is not being removed or added, a volume of sediment approximately equal to the volume of the depression will also be locally raised above the original seabed level.

4.3.5.2 Evidence base

Post construction surveys provide potential monitoring evidence for the persistence of jack up and anchor indentations. The available evidence-base does not presently include notable observations of persistent post-construction jack up vessel or anchor indentations in the seabed. In some cases, jack up vessels may simply not have been required. In cases where jack up vessels were used, it is certain that the process will have had some effect on the seabed at the point of completion; however, the recovery rate may have been rapid due to small depths of penetration and / or highly mobile seabed conditions.

Surveys for the monitoring of scour formation are commonly undertaken but tend to be localised to the foundation and may not include the locations previously affected by larger jack up vessels. More extensive post construction monitoring surveys do not typically observe indentations attributable to jack up vessels, i.e. such features are not commonly noted, expected or discussed in relation to UK windfarms.

4.3.5.3 Assessment of change

The use of jack-up legs or anchors may potentially affect the form and function of Smith Bank if the disturbance leads to a relatively large change (outside of the range of natural variability) in local or regional water depth, seabed sediment characteristics or sediment transport pathways.

The use of the jack-up legs would not impact on any physical environmental receptors beyond the range of natural variability. Any effects of jack-up legs would be localised to immediately around each leg and these would also be temporary on a medium-term time scale. The following assessment therefore applies:

- The lower end of each of the six jack-up legs will terminate in a 'spud can' foot with an area of up to 275 m^2, equivalent to a footprint of 16.5 m square or a circular footprint diameter of 18.7 m. Each leg will penetrate into the seabed between by up to a maximum of 11 m, depending on the local ground conditions;
- As the leg is inserted, the already partially consolidated seabed sediments will be firstly compressed downwards and then displaced laterally sideways, probably causing the seabed around the inserted leg to be raised in a series of concentric pressure ridges. The particular response of the seabed will depend upon the actual dimensions of the leg and the local geotechnical properties of the underlying soils;
- As the leg is subsequently retracted, the force holding sediments laterally will be reduced and some of the material previously pushed sideways will return to the hole via mass slumping under gravity. Additionally, loose sediment will avalanche back into the depression until a maximum stable slope angle (approximately 32° from horizontal in sands) is achieved. On this basis, for an approximately 19 m diameter depression, a stable slope angle would be achieved when the maximum depth in the centre is 5.8 m below the original seabed level. Where this is similar to the actual depth of penetration, initial refilling of the depression by avalanching of loose sediment would be minimal;
- The scale of the depression left by a single leg soon after extraction in loose soils is therefore characterised as a 19 m diameter conical pit, between 0.5 to 5.8 m deep from ambient bed level in the centre depending on the depth of penetration and soil conditions. The pit will possibly also be surrounded by a concentric raised area of seabed. The (positive) volume of sediment remaining above the original bed level will likely be similar to but slightly smaller than the (negative) volume of the pit (i.e. an overall lowering of the mean bed level) due to compaction of sediments in the base of the pit by the pressure exerted by the jack-up leg;
- The sedimentary texture of the pit surface is likely to be similar to that of the surrounding seabed because no sediment is introduced or removed by the jack-up leg and the sediment veneer is considered to be largely uniform (sand or gravely sand) within at least the upper 5 m of seabed over much of the area;
- Over the short to medium term, the pits will tend to become shallower and less distinct as storm events resuspended the mobile fractions of the raised sediment material around the edges of the pit and either redeposit it into the pit or move it elsewhere. There will be an initial tendency for some sediments being transported through the area to accumulate in the pits if they are sufficiently deep to reduce nearbed current speed and/or wave action locally, however, this tendency will decrease rapidly as the pits flatten; and
- Potential rates of sediment transport associated with a range of combined wave and current conditions normally present within the site on sub-annual time-scales were estimated using total load relationships in Soulsby (1997) to be in the range 10^{-6} to 10^{-5} $m^3/m/s$. At such relatively low but frequently occurring rates, the total volume of collapsed pits up to 19 m wide and 5.8 m deep (up to 536 m^3) could be refilled by ambient sediment transport in the order of $2.6x10^7$ to $2.6x10^6$ hours of active transport (approximately 30 to 300 days), assuming that all sediment passing through the footprint of the affected area is retained there. This timescale could be reduced by additional contributions from larger wave events (due to higher transport rates). Waves of 4 m height or greater are present for approximately 3 % of the year (263 hours). Overall, it is reasonable to estimate that such pits (if formed at all) are

likely to be filled by natural sediment transport on time scales in the order of 0.1 to 5 years following construction (depending on the frequency and intensity of storms).

An array of four to six anchors might be used by some work vessels to hold position and provide stability during operations on-site. Anchors used by such large ships are typically of smaller dimensions than the jack-up legs described above and exert their force differently on the seabed. The length-scale of the main body of one such anchor is assumed to be in the region of 3 m.

The use of anchors does not impact upon the identified sensitive physical environmental receptors beyond the range of natural variability. Any effects of anchors are of small magnitude, with only a localised effect that is temporary on medium term time-scales. The following assessment therefore applies:

- The specific design of the anchor stock, crown and flukes, and so the way in which the anchor interacts with the seabed, will vary depending upon the particular design used. Generically, the anchor will be initially deposited onto the seabed under its own weight, causing minimal impact disturbance in its own footprint. The anchor will then be pulled horizontally across the seabed for some distance to allow the flukes and crown to penetrate the seabed. Dragging the anchor may leave a short, shallow furrow. Once embedded in the seabed, a ridge of sediment will have been raised in front of the anchor in the direction of pull, partially accumulated from the furrow and partially pushed up by the horizontal pressure on the bed from the anchor pull;
- To release the anchor, the connecting wire or chain is tensioned vertically, levering the flukes out of the sediment. The anchor is then retrieved through the water column, either to the main vessel or by an anchor handing vessel for redeployment. The act of removing the anchor in this way will redistribute much of the sediment accumulated back to the seabed around or into any hole remaining;
- The footprint length scale of the disturbance remaining soon after removal of an anchor will be approximately similar to the size of the anchor (3 m). The character of the disturbance may be highly variable (chaotic ridges and depressions) within the footprint of effect. In the worst case, the maximum depth of a conical pit with these footprint dimensions (assuming a stable slope angle of 32°) is 0.94 m;
- The sedimentary texture of the disturbed surface is likely to be similar to that of the surrounding seabed because no sediment is introduced or removed by the anchor and the sediment veneer is considered to be largely uniform (sand or gravely sand) within the upper 5 m;
- In the short to medium term, the disturbed surface will be reworked and flattened to a baseline condition by waves and currents during storm events. No tendency to intercept regional sediment transport is expected because the sediment is essentially only locally redistributed in a small footprint; and
- The total volume of a 3 m diameter pit (2.2 m^3) would be refilled by ambient sediment transport in the order of 20 to 200 hours of active transport at the relatively low but frequently occurring typical sediment transport rates described in the previous section, This timescale would be further reduced (due to higher transport rates) during larger wave events. Therefore, such pits are likely to be entirely filled by natural sediment transport on time scales between a single storm event and 1 year.

4.4 Cumulative Changes

Drilling may occur simultaneously at up to two foundations and / or simultaneously with other construction activities (e.g. installation of inter-array cables, described in Section 4.3.4). Multiple dredgers may be working simultaneously and / or also simultaneously with other construction activities.

If two or more simultaneous activities disturbing sediment are aligned in relation to the ambient tidal streams and within one tidal excursion distance (see Figure 2.1), then there is potential for overlap between the areas of effect on SSC and sediment deposition. The length of tidal excursion in the Moray West Site is relatively small (up to ~3.5 to 4.2 km on spring tides and half that distance on neap tides) and therefore the potential for overlap and cumulative effects is limited both within the Moray West Site and even more so in relation to the nearby Moray East and Beatrice Offshore Wind Farms

The effect on SSC in areas of overlap will be additive if the downstream activity occurs within the area of effect from upstream (i.e. sediment is disturbed within the sediment plume from the upstream location). The effect on SSC will be non-additive (i.e. the effects will be as described for single occurrences only) if the areas of effect only meet or overlap downstream following advection or dispersion of the effects.

Effects on sediment deposition will only be additive where the footprints of the deposits overlap. Given that the minimum spacing between foundations is 1050 m, it is unlikely that sands or gravels put into suspension will be dispersed far enough (i.e. between adjacent foundation locations) to cause any overlapping effects before being redeposited to the seabed. Only relatively fine sediment is likely to be advected far enough to potentially cause overlapping effects on SCC.

5 Changes at the Landfall

5.1 Overview

The Moray West OfTI export cables will make landfall in the Landfall Area between Findlater Castle and Redhythe Point in Sandend Bay (see Figure 1.1), located to the south of the Moray West Site, on the southern coast of the Moray Firth.

The coastline at the Landfall Area is generally characterised as an exposed northwest facing embayment. The beach is backed by a mixture of coastal defences, managed ground and mature vegetated sandy dunes. The beach is constrained by rocky headlands and underpinned by a bedrock platform.

The cable will be installed via trenching in the approaches to the Landfall Area and potentially also across intertidal and shallow subtidal areas if possible. This could be achieved using several techniques including ploughing and jetting. In areas of engineering difficulty horizontal directional drilling (HDD) techniques would be used (most likely from a nearby onshore location, under the beach, in an offshore direction to a sub-tidal location in the order of hundreds of metres from the beach). Cables will not be surface laid (and covered with cable protection) in the Landfall Area. Cables would be buried to a depth of up to approximately 3 m below the seabed.

There are several source/pathways via which morphological receptors in the Landfall Area could potentially be impacted:

- Disturbance of sediments from cabling activities, resulting in localised elevations in SSC and associated changes to bed levels (construction);
- Changes to the nearshore wave regime/ longshore sediment transport due to the presence of cable protection measures and/or any ancillary structures associated with cable installation (construction/ operation);
- Changes to the nearshore wave regime due to the presence of cable protection measures and onward effects on recreational surfing venues (operation);
- Exposure of cables leading to morphological change (operation); and
- Coastal recession/ instability, leading to exposure of cable infrastructure within the intertidal (operation).

The various impact sources set out above are considered in turn, within the following section. In this assessment, the landward limit of the Landfall Area is defined as the HAT mark, whilst the seaward limit is defined by the -5 mLAT contour.

5.2 Baseline Conditions

A summary of the baseline characteristics in the Landfall Area are provided below. Full details are provided in a separate report (Technical Appendix 6.1 (Volume 3): Physical Processes Baseline).

- The beach material in the vicinity of the Landfall Area is predominantly sandy. It is likely that the main body of sediments immediately offshore is also predominantly of a similar type;
- Sandend is classified as a semi-independent beach unit (‘Cell 3a’) within which sediment circulates, but does not regularly exchange with or along the adjacent coastlines (Ramsay and Brampton, 2000). Therefore, regional net longshore sediment transport in this cell is considered to be minimal.
- There are areas of exposed bedrock in the nearshore, close to the Landfall Area. This suggests that, regionally, the nearshore and beach sediments are a veneer on a rocky platform. The thickness of the (predominantly) sand veneer is not known in detail but is likely to vary both spatially and temporally;

- At Sandend, little horizontal movement in the position of the MHWS contour has occurred since the start of the 20th Century (Scottish Government *et al*. 2017). The 'Future Look' provided in the same document suggests that by 2050, the position of the MHWS will not have appreciably altered from present.
- The Landfall Area is within the Cullen to Stake Ness Coast Site of Special Scientific Interest (SSSI). The SSSI occupies a coastline nearly 20 km long, bordered by the settlements of Cullen, Sandend and Portsoy. The majority of the site comprises a low, narrow coastal platform with extensive rocky shores, sand and shingle bays, and a low vegetated raised beach. This is backed by a vegetated raised cliffline, which includes cliff-top heath at two main locations. The site has both biological and geological interests, the latter of which are briefly summarised below. The rocks exposed in the SSSI are metamorphic (rocks which have been altered by heat and pressure), and belong to the Dalradian Supergroup, which makes up most of the Central Highlands.
- At the offshore onshore extents of the Moray West OfTI, near the Landfall Area, coarse grain sediments dominate, with sand and gravel sized material particularly prevalent in nearshore areas. In contrast, muddy and sandy mud deposits are widespread through middle sections of the route; and
- Owing to the presence of coarse sediment in the nearshore and the relatively weak tidal properties, the material is unlikely to be regularly re-suspended, as confirmed by measured SPM, which is typically very low (< ~5 mg/l) all year round.

5.3 Evidence Base

HDD is generally considered to cause minimal direct disturbance to the existing coastline and is an appropriate form of mitigation to avoid damage, particularly in the intertidal part of the Landfall Area where habitats may be more sensitive (BERR, 2008). This methodology has been successfully adopted at the export cable landfalls of a number of Round 1 and Round 2 offshore wind farm developments with minimal environmental impact.

Open trenching and ploughing through the intertidal zone are also commonly used techniques for cable installation in a range of intertidal environments. A wide range of different burial tools and techniques are described in BERR (2008), By design, tools and methods that are suitable for use in intertidal areas will achieve the required burial depth with a minimal footprint of disruption (to minimise the force and effort required to create the trench) and the majority of sediment will be retained in or returned to the trench (to maximise protection of the cable). When used above the water line, trenching techniques do not mix sediment with water and so result in minimal sediment resuspension impacts. The dynamic nature of beach processes will rapidly rework any locally disturbed or displaced sediment.

While there are few detailed case studies publicly available, cable landfall engineering is a common and mature concept that is commonly undertaken with minimal adverse impacts to the local environment geomorphology.

5.4 Assessment

5.4.1 Disturbance of Sediments, Resulting in Localised Elevations in SSC and Changes to Bed Levels (Construction)

Cable installation by open cut trenching is considered to represent the realistic worst case in terms of the potential to cause elevated levels of SSC and localised changes in bed level during the construction phase. A detailed cable installation plan is not yet available although it is reasonable to assume that an open cut channel may be created by either jetting, trenching by use of a tracked excavator or similar, or ploughing.

5.4.1.1 Changes in SSC

Where cable installation is carried out above the level of the water, there will be very limited potential for the disturbed material to enter into suspension. However, where cable installation is carried out below the water, jetting has the potential to cause the greatest volume of material to enter into suspension. Accordingly, this technique represents the maximum adverse scenario in terms of sediment dispersion.

Potential changes in SSC associated with jetting activities at the landward end of the export cable route have previously been considered in Section 4.3.4.

Based on the sediment grab samples from the Landfall Area, the seabed is characterised by sands and gravels in varying proportions, which will likely form the majority of the sediment being disturbed. These sediment types (if disturbed to the point of resuspension) will redeposit rapidly to the seabed (in a matter of seconds to minutes) and will cause only a very localised and temporary effect on SSC. Any fines that are present may persist in suspension for longer but only at relatively low concentrations due to the very low proportion of such sediment present.

In the shallow waters near the Landfall Area, the same sands and any fines present are likely to be resuspended naturally by occasional storm events, generating a similar or even higher magnitude of naturally occurring SSC than the cable installation activity, but over much larger areas and longer durations.

5.4.1.2 Changes in bed levels

Cables in the Landfall Area will not be surface laid and therefore no surface mounted cable protection will be required. Cable installation via trenching in nearshore and intertidal areas may result in the displacement of some sediment from the trench, forming a trough or depression. Some of the displaced material will enter into suspension, although, in practice and by design, the majority is expected to remain in or immediately adjacent to the trench, forming a raised mound. Once the cables have been laid it is anticipated that sidecast material would be returned to the trench as backfill, thereby accelerating the natural processes of recovery.

The dimensions of bed level changes associated with the cable trench near and in the Landfall Area will depend upon several factors including the cable installation method, trench width, cable burial depth and the nature of the excavated material. For immediate use, the maximum trench dimensions are depth 3 m, width 3 m, with a 'V' shape profile. If left open for longer, a wider trench (order of 10 m) may be required to accommodate stable side slope angles. The displaced sediment may form temporary side berms or a sidecast mound with comparable dimensions to the trench (above the bed level).

Given that the trenches and any sidecast mounds would only be present for a relatively short period of time (order of a few weeks), any resulting changes in the wider distribution of beach sediments would be localised, of limited magnitude, and would recover to a natural equilibrium state (through tidal inundation and wave action) rapidly following completion of the works.

The lateral margins of Sandend Bay are rocky and the beach sands overly a hard rock platform which are not sensitive to changes in the distribution of mobile sediment or to local patterns of waves and currents. Therefore, there would be no potential for long term change to the morphology of the Bay as a whole.

Cables will be buried below the seabed by trenching or HDD and cable protection measures will not be used near to the Landfall Area. Therefore, neither cables nor cable protection would interact with the naturally occurring patterns of waves or currents, affect the naturally occurring patterns of sediment transport, or cause morphological change in the Landfall Area during the construction or operational phases of the Development.

Where cable installation by open cut trenching is used, the depth of trenching would be limited by the presence of any underlying hard rock surfaces, i.e. only the overlying Quaternary (sand and gravel) sediments will be affected by trenching. Rock cutting would not be normally required. Rocks in the Landfall Area associated with the SSSI that are normally exposed will not be cut. Rocks that are normally buried

under beach sediments may be cut if required, subject to agreement as part of the post consent cable landfall design assessment. Trenching may temporarily and locally expose the underlying rocky surface during construction but this would not adversely affect the designated features.

5.4.2 Exposure of Cables Leading to Morphological Change (Operation)

Following burial, the only way in which the cables could influence hydrodynamics and seabed/ intertidal morphology during operation would be if they became exposed as a consequence of natural morphological change (bed level lowering to below the level of initial burial for trenched cables). Where HDD techniques are used, the cable will remain buried throughout the lifetime of the Development with no likelihood of exposure.

An understanding of the likely temporal variability in intertidal and shallow subtidal bed level elevation throughout the lifetime of the Development is therefore required to inform the appropriate routing of cables as well as determination of appropriate target burial depths.

The potential for future (natural) variability in the Landfall Area is assessed with consideration of the observed longer term morphological behaviour which has historically taken place. Available information from Scotland's National Coastal Change Assessment (Scottish Government *et al*. 2017) suggests that at Sandend, little horizontal movement in the position of the MHWS contour has occurred since the start of the 20th Century. The only exception to this general observation is in the west of the bay, associated with historic migration of Scattery Burn across the beach. The 'Future Look' provided in Scotland's National Coastal Change Assessment suggests that by 2050, the position of the MHWS will not have appreciably altered from present.

The natural processes controlling the historically low levels of morphological variability in the Landfall Area described above will continue to act in the same way following installation of the cables and irrespective of any temporary local disturbance caused.

It is anticipated that the information on morphological variability will feed into an engineering assessment of cable burial depth which will minimise the risk of exposure. Appropriate consideration will also need to be given to the potential effects of climate change which is expected to lead to mean sea level rise.

If the export cables are buried at a sufficient depth below the base of the mobile seabed material, the cables will have no potential to influence the hydrodynamics or seabed/ intertidal morphology.

Although highly unlikely to occur, in the event that a section of a cable does become exposed through natural seabed level change, it might then locally influence coastal processes and morphology (causing local scour) at a scale proportional to the diameter of the cable (order of a few tens of centimetres) and the length of the exposed section.

Where a cable does become exposed remedial action will be taken. Where sufficient sediment is present the exposed cable section may be mechanically reburied. In the unlikely scenario of cable exposure by significant beach erosion (which is possible but not expected), re-burial in sediment might not be possible and the exposed cable would need either a new rock-cut trench or armouring. This would be achieved using similar methods to that used for the initial installation, with similar potential impacts. Shorter sections of cable exposed by natural local erosion (e.g. during a storm event) may also become reburied through natural processes.

5.4.3 Coastal Recession, Leading to Exposure of Cable Infrastructure within the Intertidal (Operation)

The cable transition pits and landward HDD exit pits will be located onshore of the intertidal area (above MHWS) and, given the relatively high stability of the beach and coastline, are unlikely to be affected by coastline recession during the lifetime of the Development.

Following consent, a separate cable landfall assessment will be undertaken to inform engineering design. This will take into consideration factors including land elevation, soil conditions and the latest available information regarding any future management policy at the exact location of the landfall. Due

consideration will also be given to the potential influence of climate change (especially sea level rise) on coastal morphology.

5.5 Cumulative Changes

Provided the Moray West cables remain buried as intended, they have no potential to influence naturally occurring patterns of waves, currents, sediment transport, or seabed and intertidal morphology. In the unlikely event that a section of cable became exposed, the potential impacts will be of a small magnitude, localised (order of metres) and temporary (rapid recovery following natural or mechanical reburial). If both cables become exposed at the same time, the scale of the potential effect for each cable is too small to result in a combined or cumulative effect. There are no other known relevant activities that may act in combination with this potential effect.

6 Changes to the Tidal Regime

6.1 Overview

The interaction between the tidal regime and the foundations of the wind farm infrastructure could result in a reduction in current speed and an increase in levels of turbulence locally due to frictional drag. Resistance posed by the array (the sum of all foundation drag) to the passage of water at a large scale could potentially affect the progression of the tidal wave, and so the phase and height of tidal water levels.

Changes to the tidal regime may potentially influence sediment transport and seabed morphology in a number of ways. In particular, a causal relationship between flow speed and bedform type can be expected (Belderson *et al*., 1982) and thus any changes to flows have the potential to alter seabed morphology over the lifetime of the project. More generally, changes in flow may alter the balance between sediment erosion and deposition as well as the rate and direction of sediment transport. These potential changes to the sediment transport regime are discussed separately, in Section 8.4.

A quantitative review of the various foundation and related wind farm design options was carried out in order to calculate and identify the combination producing the greatest total blockage to tidal currents within the Moray West Site. A full description of all design options is provided in Chapter 4: Description of the Development. The review included the four general scheme layout 'models', corresponding to varying numbers of turbines (85 WTGs in Model 1, to 62 WTGs in Model 4), and the associated model specific dimensions of GBS, jacket and monopile foundations. A similar process was followed for the options for one or two OSPs. The review identified that 62 larger 'inverted T' GBS WTG foundations (Model 4) and two 'inverted T' GBS OSP foundations would result in the maximum total blockage to tidal currents within the Moray West Site.

For the assessment of cumulative effects, the Moray East Offshore Wind Farm is described according to the consented design parameters and the Beatrice Offshore Wind Farm is described according to the 'as built' design parameters (summarised in Table 2.2). The table shows that both the density of foundations and the dimensions of the individual foundations (and hence the overall blockage density) within these sites has reduced greatly from those assessed in their respective Environmental Statements (Moray East 2012, BOWL, 2012). There is therefore expected to be a corresponding reduction in the magnitude and extent of effect on the tidal regime due to these developments, in comparison to that previously assessed.

6.2 Baseline Conditions

A summary of the baseline water level and flow characteristics within and nearby to the area of the Moray West and OfTI Sites are provided below. Full details are provided in a separate report (Technical Appendix 6.1 (Volume 3): Physical Processes Baseline).

- The Moray West Site is within a meso-tidal setting with mean spring tidal range of approximately 3 m. There is only a small (~0.15 m) difference in spring tidal range over the length of the Moray West Site, with the largest tidal range experienced in the southwest. In the vicinity of the Landfall Area, the mean spring range is 3.4 m, indicating approximately 0.2 m variation in tidal range along the Moray West OfTI;
- Mean spring peak current speeds within the Moray West Site are in the approximate range 0.25 m/s to 0.3 m/s. Neap speeds are typically half of that observed on spring tides;
- Tidal currents are directed generally to the south or south-south-west during the flood tide and to the north or north-north-east during the ebb tide and there is little consistent asymmetry between flood and ebb in tidal current speeds and directions;
- Along most of the Moray West OfTI export cable corridor, mean spring peak current speeds are relatively uniform and less than ~0.3 m/s. There is some evidence of tidal asymmetry close to the Landfall Area where current speeds are relatively greater towards the east;

- Surge related influences are a frequent occurrence and may provide both positive and negative variations to the normal tidal elevation. The project-specific oceanographic data demonstrates that both water levels and current speed may be modified by surge processes. Estimates of total current speeds across the Moray West Site (based on the 1 in 50-year return period storm surge combined with the mean spring astronomical tidal current) are 0.39 m/s in the west and 1.17 m/s in the northeast, closer to the Pentland Firth. Current speeds associated with occasional surge events are considerably greater than observed peak spring tide only current speeds through the Moray West Site.

6.3 Evidence Base

On the basis of: (i) post construction monitoring of wake fields (e.g. at Burbo Bank offshore wind farm, ABPmer *et al*. (2010) and at the East China Sea Wind Farm, Li *et al*. (2014)); and (ii) numerical modelling results available from other offshore wind farm project Environmental Statements including Moray East and Beatrice Offshore Wind Farms, it is apparent that changes to flow speeds as a result of flow blockage are relatively small in both absolute and relative magnitude. Effects are relatively greatest in the immediate vicinity of the foundation structures, reducing quickly in magnitude with increased distance from the foundations. The greatest changes in flow speed are typically confined to within the order of hundreds of metres of individual WTG or OSP foundations and therefore also largely within the wind farm array area. Changes to tidal water levels are typically only very small in both absolute and relative magnitude and would not be measureable within the range of natural variability.

6.4 Assessment

The presence of the Moray West Offshore Wind Farm infrastructure during its operational phases has the potential to produce an impact on the tidal regime due to interaction between currents and the WTG and OSP foundations. Any changes to the tidal regime may have a resultant impact on the sediment regime which is considered separately in Section 8.4. The WTG and OSP foundations have the potential to impact on the following tidal characteristics:

- Water levels;
- Current speed; and
- Current direction.

To quantify the likely magnitude and extent of interaction between the operational scheme and the hydrodynamic regime, a numerical tidal model (described in Technical Appendix 6.2 (Volume 3): Physical Processes Numerical Modelling) was used to simulate representative spring and neap tidal conditions for both baseline and the 'with scheme' scenario. The effect of a particular development scenario is evaluated by finding the absolute and relative differences between the baseline and corresponding scheme scenario. Descriptions of the changes found are described below for tidal water level and currents.

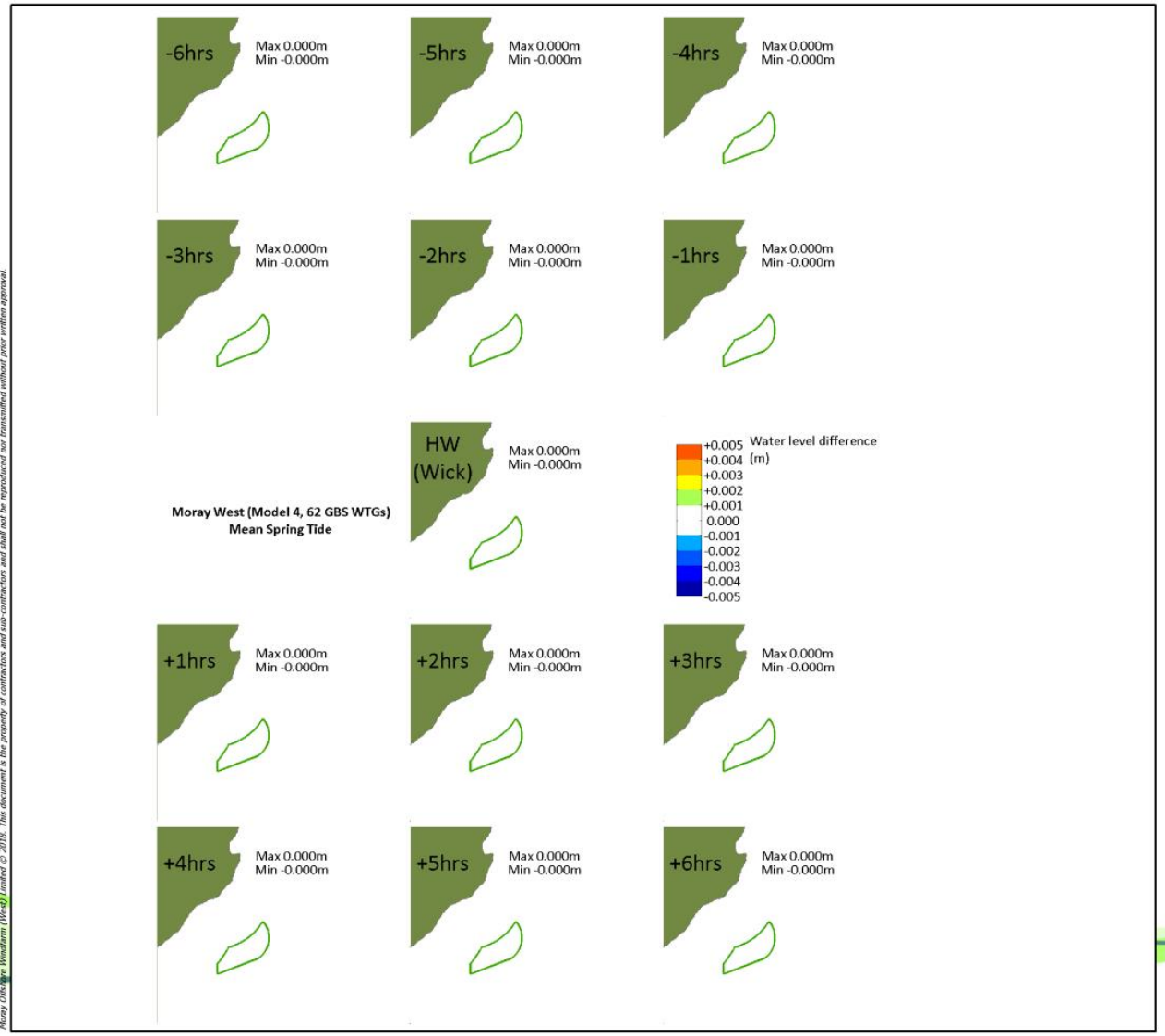
6.4.1 Changes to Water Levels

The potential effect of the Moray West Offshore Wind Farm alone on tidal water levels during a representative mean spring tidal cycle is shown in Figure 6.1. Results for neap tidal range conditions are proportionally smaller (around half) than that reported here for spring tides. The results show that:

- The maximum magnitude of effect on tidal water level in any location and at any time during a typical spring-neap tidal cycle is less than 0.001 m;
- Given the similarity in processes, a similar (low) order of effect on non-tidal (surge) water levels is inferred.

The magnitude of the effect of the array on water levels in both the near-field and the far-field is evidently very small when compared to the natural range of variability in tidal levels (2 to 4 m), non-tidal levels (1 m) and the potential effects of sea level rise (0.08 to 0.14 m), and would not be measurable in practice.

Any potential effects of the array on water levels will persist for the lifetime of the development but are of very small magnitude, would have only a local effect and do not impact upon any of the identified sensitive physical environmental receptors beyond the range of natural variability.



MORAY WEST
OFFSHORE WINDFARM

KEY

Moray West Site

A4 Chart

Geodetic Parameters:	N/A
Produced: DOL Reviewed: RC Approved: FG	
Date: 26/03/2018	Revision: C
REF: N/A	

Figure 6.1 Effect of the Development on Tidal Water Levels

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Figure 6.1: Effect of the Moray West Offshore Wind Farm on Tidal Water Levels during a Mean Spring Tide

6.4.2 Changes to Currents

The potential effect of the Moray West Development alone on tidal currents during a representative mean spring tidal cycle is shown in Figure 6.2. Results for neap tidal range conditions are proportionally smaller (around half) than that reported here for spring tides. The results show that:

- The maximum magnitude of effect on tidal current speed in any location and at any time during a typical spring-neap tidal cycle is less than 0.01 m/s;
- No consistent measureable effect on tidal current direction is expected in any location and at any time during a typical spring-neap tidal cycle; and
- Given the similarity in processes, a similar (low) order of effect on non-tidal (surge) current speeds and directions is inferred.

The magnitude of the effect of the array on current speed in both the near-field and the far-field is evidently very small when compared to the natural range of variability for tidal currents (0.25 to 0.3 m/s) and surge affected currents (0.39 to 1.17 m/s), and would not be measurable in practice.

Any potential effects of the array on water levels will persist for the lifetime of the development but are of very small magnitude, would have only a local effect and do not impact upon any of the identified sensitive physical environmental receptors beyond the range of natural variability.

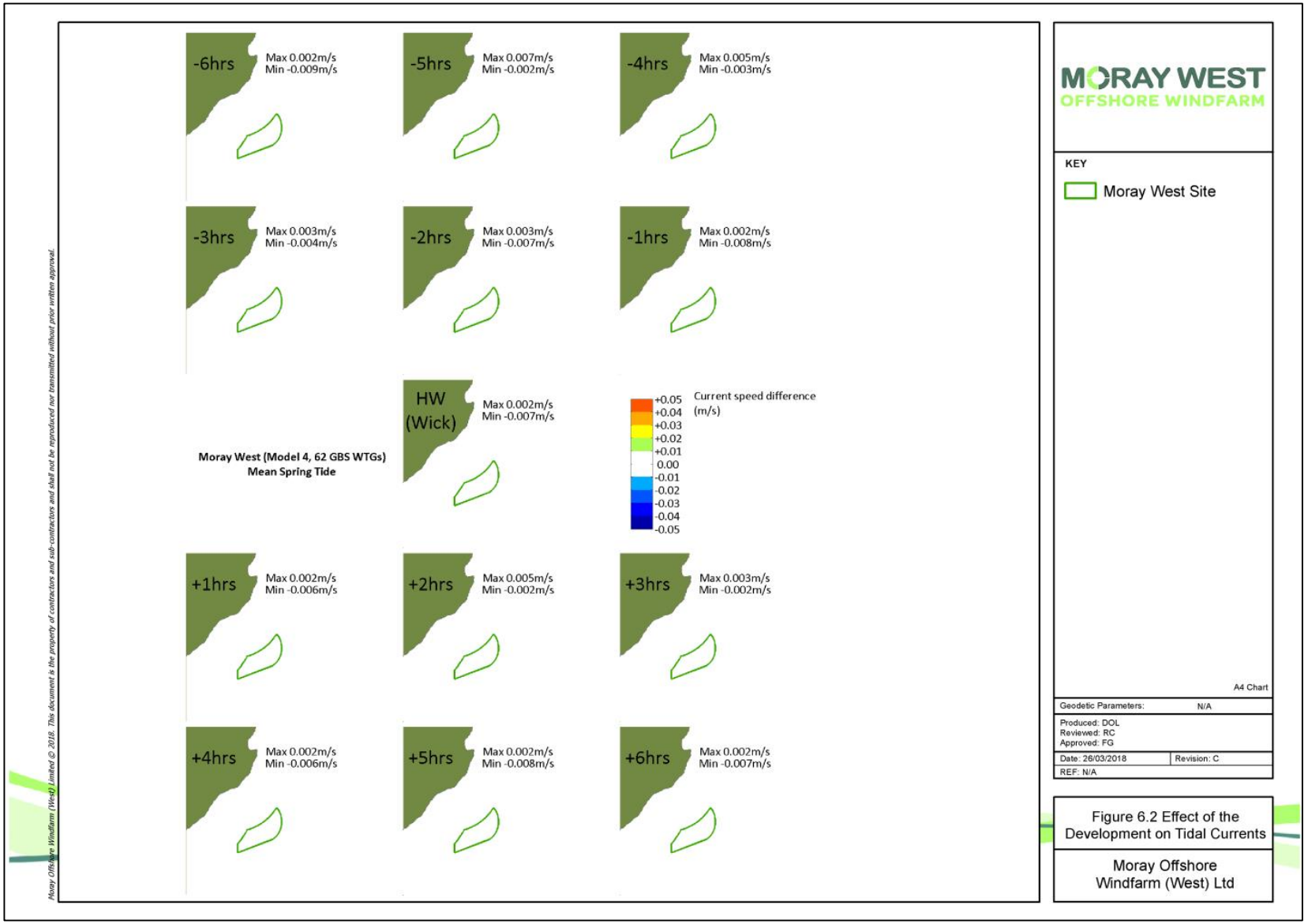

Figure 6.2: Effect of the Moray West Offshore Wind Farm on Tidal Currents Levels during a Mean Spring Tide

6.5 Cumulative Changes

The simultaneous presence of the Moray West, Moray East and Beatrice Offshore Wind Farms during their operational phases has the potential to produce a cumulative impact on the tidal regime as flows interact with the WTG and OSP foundations. Any changes to the tidal regime may have a resultant impact on the sediment regime which is considered separately in Section 8.5. The WTG and OSP foundations have the potential to impact on the following tidal characteristics:

- Water levels;
- Current speed; and
- Current direction.

To quantify the likely magnitude and extent of interaction between the operational scheme and the hydrodynamic regime, a numerical tidal model (described in Technical Appendix 6.2 (Volume 3): Physical Processes Numerical Modelling) was used to simulate representative spring and neap tidal conditions for both baseline and a number of 'with scheme' scenarios. The effect of a particular development scenario is evaluated by finding the absolute and relative differences between the baseline and corresponding scheme scenario. Descriptions of the changes found are described below for tidal water level and currents.

Interaction between wind farms only has the potential to occur if the extent of the turbulent wake features from one location overlaps with that from the other. Wind farms not aligned in relation to the ambient tidal streams, or located more than one spring tidal excursion distance from one another, are very unlikely to cause cumulative changes. The European Offshore Wind Deployment Centre wind farm foundations, Forth and Tay wind farm foundations and marine energy developments in the Pentland Firth and Orkney waters are all located outside of the Moray Firth, much more than one tidal excursion distance away (see Figure 2.1), and are too distant to realistically interact with the Moray West Offshore Wind Farm.

As shown in Figure 2.1, infrastructure associated with the Polly well in the Beatrice oil field and SHETL cable hub are within one tidal excursion distance of the Moray West Site and the other surrounding wind farms that are already included in the cumulative assessment. However, these are characterised as isolated, relatively small (dimensions in the order of 1 to 10 m), nearbed obstacles. Based on the likely cross-sectional area (approximately equivalent to a full water depth monopile <1 m in diameter), these pose a much lower potential to interact with currents than any one of the individual jacket (or GBS) foundations within the Moray East and Beatrice Offshore Wind Farms, i.e. contributing much less than 0.1 % to any cumulative effect.

6.5.1 Changes to Water Levels

The potential combined effect of the Moray West, Moray East and Beatrice Offshore Wind Farms on tidal water levels during a representative mean spring tidal cycle is shown in Figure 6.3. Results for neap tidal range conditions are proportionally smaller (around half) than that reported here for spring tides. The results show that:

- The maximum magnitude of effect on tidal water levels in any location and at any time during a typical spring-neap tidal cycle is less than 0.001 m; and
- Given the similarity in processes, a similar (low) order of effect on non-tidal (surge) water levels is inferred.

The magnitude of the effect of the array on water levels in both the near-field and the far-field is evidently very small when compared to the natural range of variability in tidal levels (2 to 4 m), non-tidal levels (surge effects up to 1 m, waves up to 4 to 6 m) and the potential effects of sea level rise (0.08 to 0.14 m), and would not be measurable in practice.

Any potential effects of the array on water levels will persist for the lifetime of the development but are of very small magnitude, would have only a local effect and do not impact upon any of the identified sensitive physical environmental receptors beyond the range of natural variability.

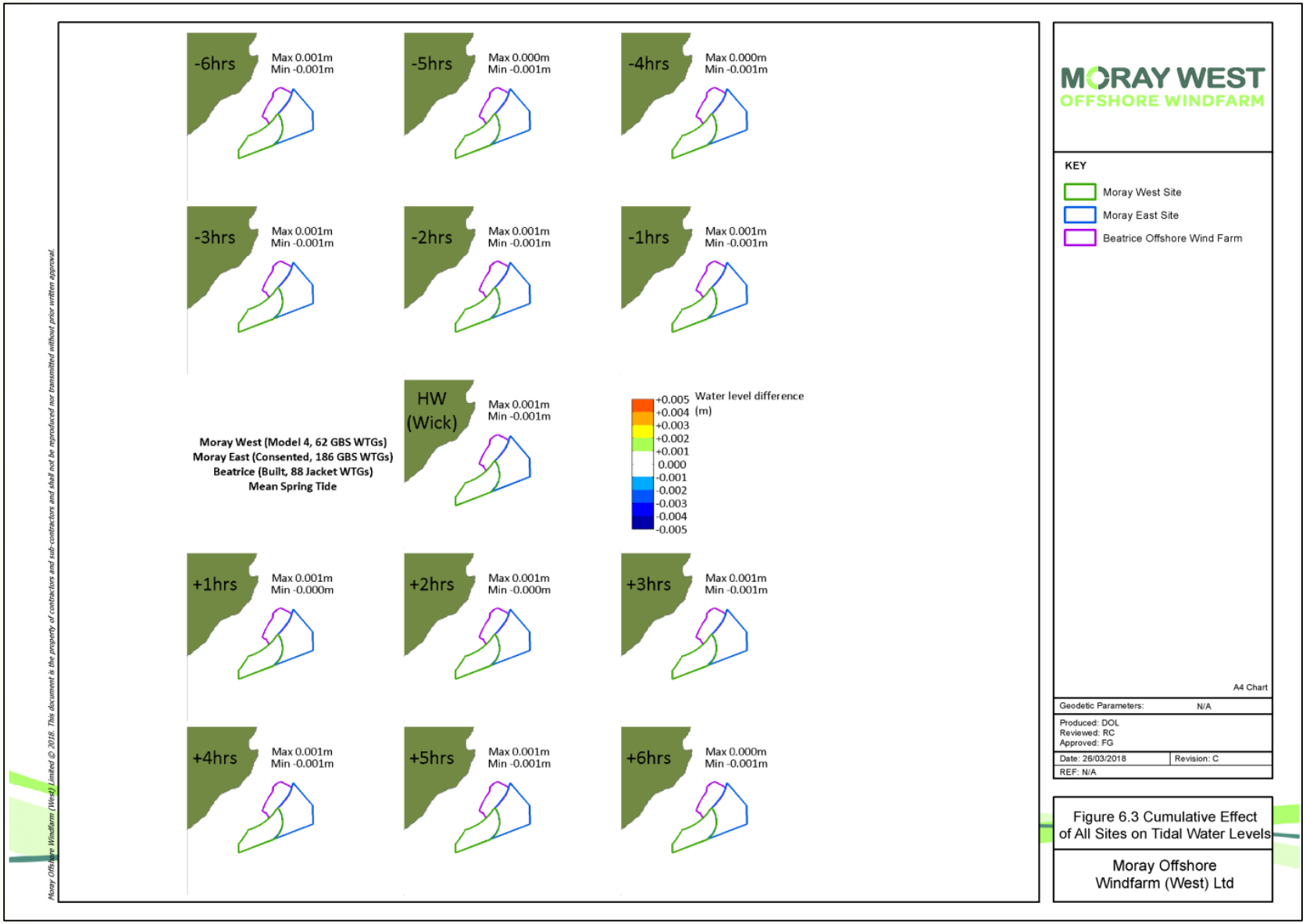

Figure 6.3: Cumulative Effect of the Moray West, Moray East and Beatrice Offshore Wind Farms on Tidal Water Levels during a Mean Spring Tide

6.5.2 Changes to Currents

The potential combined effect of the Moray West, Moray East and Beatrice Offshore Wind Farms on tidal currents during a representative mean spring tidal cycle is shown in Figure 6.4. Results for neap tidal range conditions are proportionally smaller (around half) than that reported here for spring tides. The results show that:

- The maximum magnitude of effect on tidal current speed in any location and at any time during a typical spring-neap tidal cycle is less than 0.02 m/s (in the Moray East Site) and less than 0.01 m/s in the Moray West Site;
- No consistent measureable effect on tidal current direction is expected in any location and at any time during a typical spring-neap tidal cycle;and
- Given the similarity in processes, a similar (low) order of effect on non-tidal (surge) current speeds and directions is inferred.

The magnitude of the effect of the array on current speed in both the near-field and the far-field is evidently very small when compared to the natural range of variability for tidal currents (0.25 to 0.3 m/s) and surge affected currents (0.39 to 1.17 m/s), and would not be measurable in practice.

Any potential effects of the array on water levels will persist for the lifetime of the development but are of very small magnitude, would have only a local effect and do not impact upon any of the identified sensitive physical environmental receptors beyond the range of natural variability.

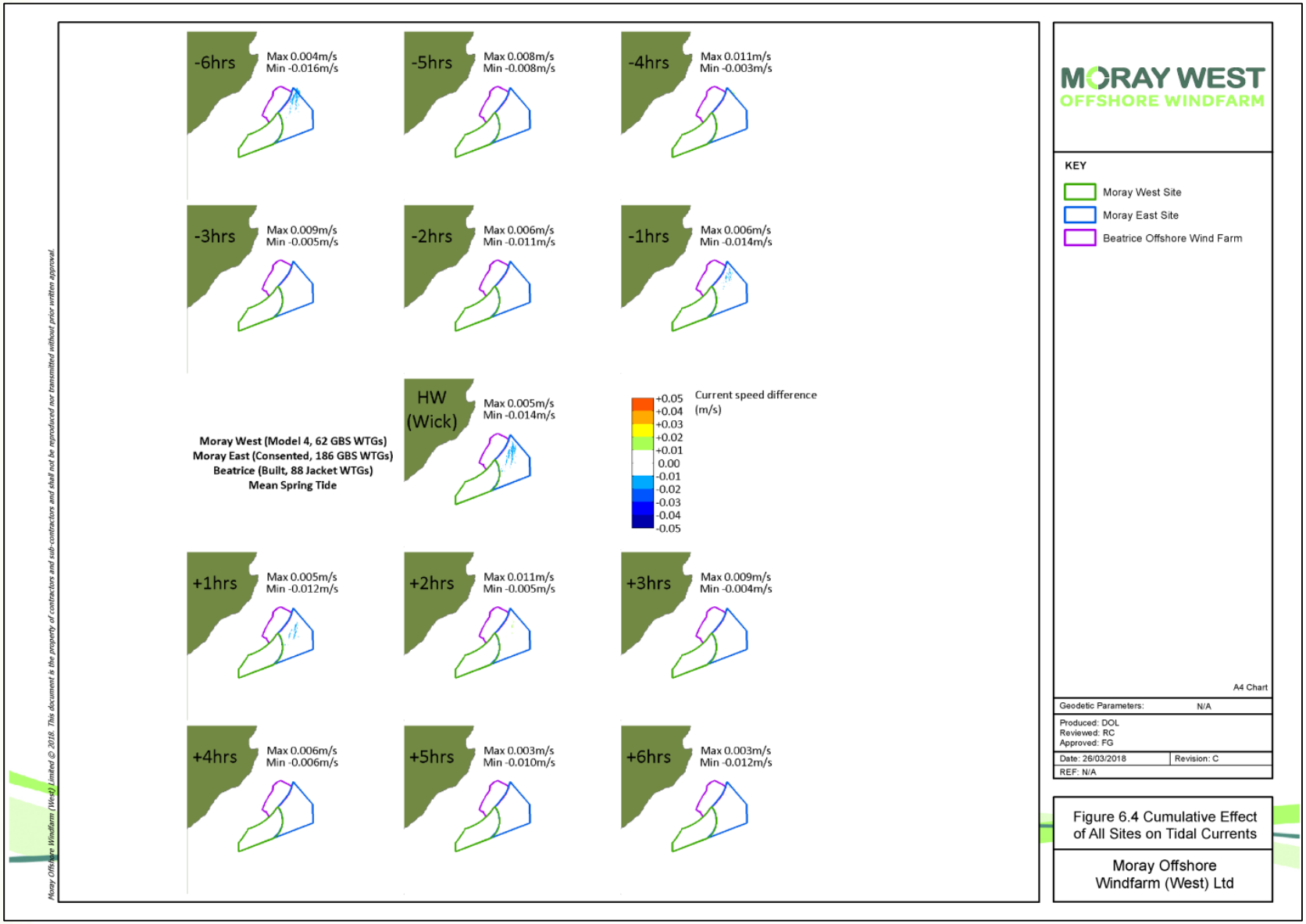

Figure 6.4: Cumulative Effect of the Moray West, Moray East and Beatrice Offshore Wind Farms on Tidal Currents during a Mean Spring Tide

7 Changes to the Wave Regime

7.1 Overview

The interaction between waves and foundation infrastructure may result in a local reduction in wave energy (height and / or period) potentially extending into the far-field. The influence of a single structure on individual waves is not easily measurable in practice but the cumulative change of many structures is generally accepted to be a slight reduction of wave energy downwind of the array that will recover with time and distance downwind.

Where the wave climate is persistently modified, these changes may potentially alter the frequency of sediment mobilisation and rates of transport and deposition (considered in Section 8.4).

A quantitative review of the various foundation and related wind farm design options was carried out in order to calculate and identify the combination producing the greatest total blockage to waves within the Moray West Site. A full description of all design options is provided in Chapter 4: Description of the Development. The review included the four general scheme layout 'models', corresponding to varying numbers of turbines (85 WTGs in Model 1, to 62 WTGs in Model 4), and the associated model specific dimensions of GBS, jacket and monopile foundations. A similar process was followed for the options for one or two OSPs. The review identified that 62 larger 'inverted T' GBS WTG foundations (Model 4) and 2 'inverted T' GBS OSP foundations would result in the maximum total blockage to waves within the Moray West Site.

For the assessment of cumulative effects, the Moray East Offshore Wind Farm is described according to the consented design parameters and the Beatrice Offshore Wind Farm is described according to the 'as built' design parameters (summarised in Table 2.2). The table shows that both the density of foundations and the dimensions of the individual foundations (and hence the overall blockage density) within these sites has reduced greatly from those assessed in their respective Environmental Statements (Moray East 2012, BOWL, 2012). There is therefore expected to be a corresponding reduction in the magnitude and extent of effect on waves due to these developments, in comparison to that previously assessed.

7.2 Baseline Conditions

Baseline characteristics of the wave regime are briefly summarised below. Full details are provided in a separate report (Technical Appendix 6.1 (Volume 3): Physical Processes Baseline).

- Due to the low tidal current energy characteristic to the Moray Firth, winds and waves are important energy inputs to the coastal system;
- The wave regime across the Moray West Offshore Wind Farm is typically characterised by locally generated wind waves, with some contribution from longer period swell waves generated elsewhere in the North Sea;
- The most frequent wave direction is from the north-east and east with around 75% of all waves originating from this direction;
- Even though water depths across the Moray West Site are no less than 35 m, storm waves sufficiently large to cause water motion at the seabed are not uncommon. Specific return period significant wave heights vary by the direction from which they come. Values characterising a range of storm conditions from common (annual) to decadal return periods are shown in Table 7.1;
- Most of the Moray West OfTI export cable corridor is likely to be exposed to waves of similar or smaller size than the Moray West Site, with wave heights generally decreasing with increased proximity to the coast. The large range of water depths along the route also mean that the ability of a given wave condition to penetrate to the seabed will also be variable; and

- Larger storm events are more likely to occur closer to winter.

Table 7.1: Extreme value analysis used to estimate the significant wave height (Hs, in metres) for given return periods for location 58.25° N 2.86° W

Sector	Directional Range (°N)	Return Period – Hs (m)			
		1	10	50	100
N	337.5 to 22.5	6.3	7.2	7.6	7.9
NE	22.5 to 67.5	6.7	8.0	8.9	9.2
E	67.5 to 112.5	6.7	7.5	8.0	8.2
SE	112.5 to 157.5	6.3	7.1	7.6	7.9
S	157.5 to 202.5	4.6	6.0	6.7	7.0
SW	202.5 to 247.5	4.9	5.8	6.4	6.6
S	247.5 to 292.5	4.7	5.6	6.2	6.4
NW	292.5 to 337.5	4.1	5.0	5.5	5.6
Any direction		6.7	8.0	8.9	9.2

7.3 Evidence Base

Previous wave effect modelling of the Moray East and Beatrice Offshore Wind Farms (Moray East, 2012 and BOWL, 2012) using realistic worst case parameters for the (pre-consent design) wind farms predicted:

- A maximum local reduction in the height of waves passing through the Moray East and Beatrice Sites between 0.40 and 1.52 m or 6 to 21 % of the incident wave height for all directions and return periods.
- The area of maximum effect on wave height in every case was relatively small (length scale of order 1 km) and is located where waves transitioned through the greatest width of the Moray East Site in that orientation. The effect gradually developed in proportion to the distance travelled through the Site then recovered towards ambient values at a non-linear rate (i.e. recovering quickly over small distances but smaller magnitude effects persisted over greater distances);
- The maximum effect on wave period was approximately 0.3 s (3 to 5 %). The spatial pattern of the effect was not well defined and the small magnitude of the effect would not be measurable in practice.
- No measurable effect on instantaneous wave direction (i.e. differences are < 1°) in the near- or far-field; and

The potential effect of both GBS and Jacket foundation options were separately tested and reported in Moray East (2012). The results for jacket foundations in the Moray East Site consistently showed a greatly reduced magnitude of impact (due to the smaller blockage presented by the individual foundations and the array as a whole).

The above description of the potential effects on waves determined by modelling is consistent with the results of similar studies for other wind farms. The magnitude and spatial extent of the effect for other wind farms will, however, vary with the shape and size of the wind farm array area and the number, dimensions and distribution of foundations (the blockage density).

The only presently available field evidence with respect to the effect of wind farm infrastructure on the wave regime is provided in Cefas (2005). The study considers Scroby Sands, a Round 1 development located at closer proximity (2.3 km) to the shoreline. The array consists of 30 monopiles of 4 m diameter, supporting WTGs rated at 2 MW. Field measurements of waves using radar concluded that the 'wave diffraction caused by monopiles in an [offshore wind farm] is not significant compared with variations due to other mechanisms' and 'Cumulative effect of WTG foundations upon wave conditions can be considered negligible'. It was also shown that concerns regarding impacts upon the sediment transport regime, through changes in the wave climate, should be eliminated.

7.4 Assessment

The potential effect of the Moray West Offshore Wind Farm alone on significant wave height during a 1:1, 1:10 and 1:50 year return period seastate is shown in Figure 7.1, Figure 7.2 and Figure 7.3, respectively. The results of the modelling show that:

- The main effect would be to reduce the height of waves passing through the Moray West Site;
- The maximum local reduction in wave height within the site boundary would vary between 0.25 and 0.68 m, or 6 to 9 % of the local baseline wave height, depending on the wave direction and return period (based on the 8 directions and 3 return periods tested). It should be noted that the largest proportional reduction is not necessarily associated with the largest absolute reduction in wave height. The greatest absolute effects would be on the largest waves that also pass through the long axis of the Moray West Site (i.e. from 45 and 90 °N). The highest proportional effects would be on largest waves from the southwest and west (215 and 270 °N) while the smallest proportional effects would be on waves from the southeast (125 °N);
- The area of maximum effect on wave height in every case would be relatively small (length scale of order 1 km^2) and would be located where waves have transitioned through the greatest width of the Moray West Site in that orientation;
- The effect would gradually develop from no effect at the upwind edge of the Moray West Site to the maximum value in proportion to the distance travelled through the Moray West Site, i.e. 50 % of the Moray West Site will experience less than 50 % of the maximum level of effect, and 25 %, less than 25 % of the maximum effect, etc;
- Behind the Moray West Site, any near-field reduction in wave height would recover towards ambient values at a non-linear rate (i.e. recovering quickly over small distances but smaller magnitude effects can persist over greater distances). These residual effects would extend in the direction of wave travel (with some lateral spreading);
- The maximum local reduction in wave height at any of the adjacent coastlines within the Moray Firth (including the various designated coastlines and surfing venues in the area) would be in the order of centimetres (less than 0.1 m) in comparison to a wave height in the order of several metres, i.e. only a small (not measurable) absolute and relative difference. Only a limited area of coastline downwind of the Moray West Site would be affected at any one time. The time that waves might come from any particular direction (and therefore the area of coastline potentially affected) is limited (details in Technical Appendix 6.1 (Volume 3): Physical Processes Baseline);
- The maximum local effect on wave period in all cases considered would be less than one second. The spatial pattern of the effect is not well defined, would recover with distance from the Moray West Site, and the small magnitude of the effect would not be measurable in practice; and
- There would be no measurable effect on instantaneous wave direction in the near- or far-field.

The magnitude of the effect of the Moray West Offshore Wind Farm on waves in the near-field and (especially in) the far-field is small in absolute and relative terms when compared to the natural range of variability for wave height (4 to 9 m) and period (>10 s), and would not be measurable in practice.

Any potential effects of the Moray West Offshore Wind Farm on waves will persist for the lifetime of the development but are of small magnitude, would have only a local effect and do not impact upon any of the identified sensitive physical environmental receptors beyond the range of natural variability.

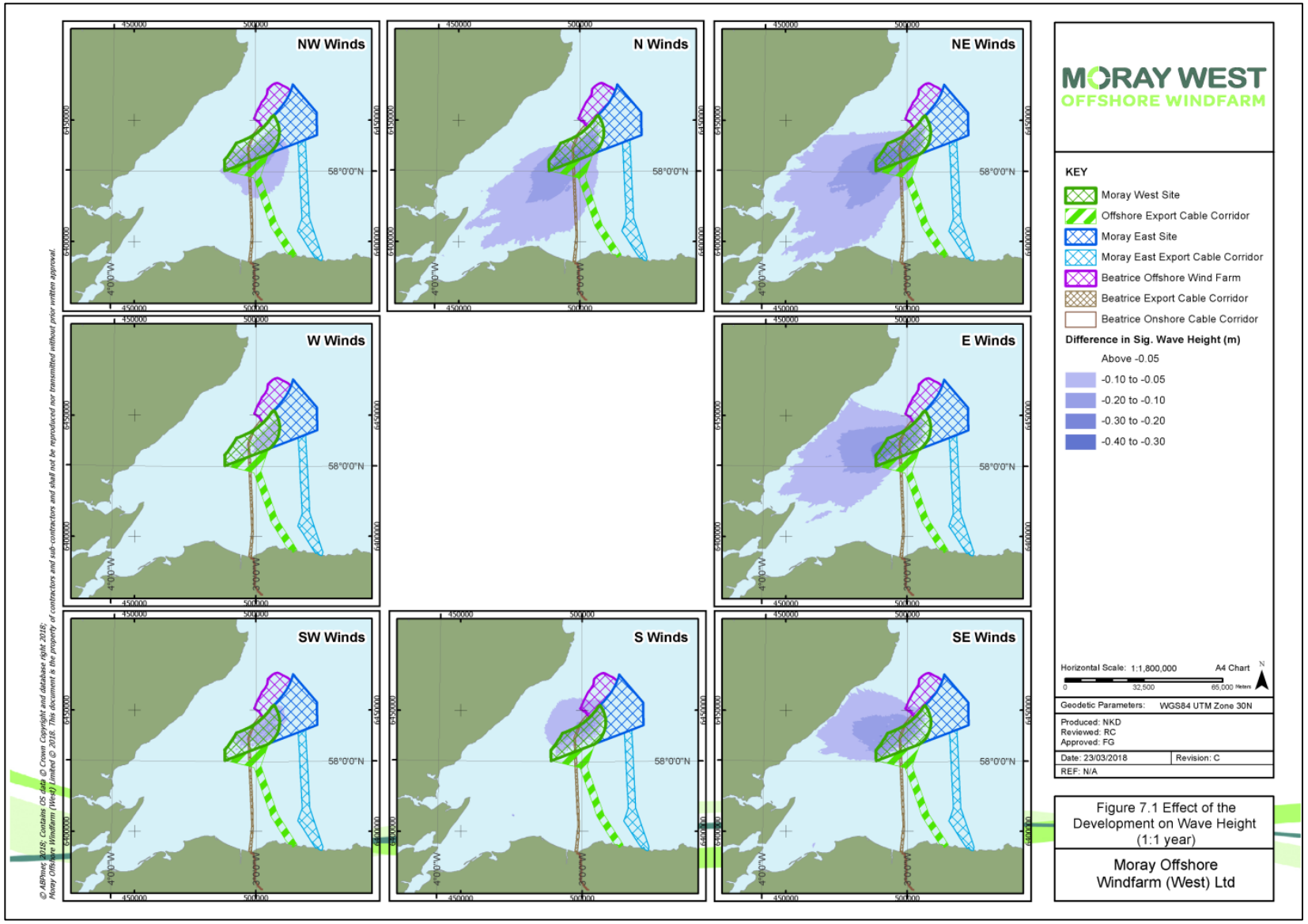

Figure 7.1: Effect of the Moray West Offshore Wind Farm on Significant Wave Height during the 1:1 year storm condition.

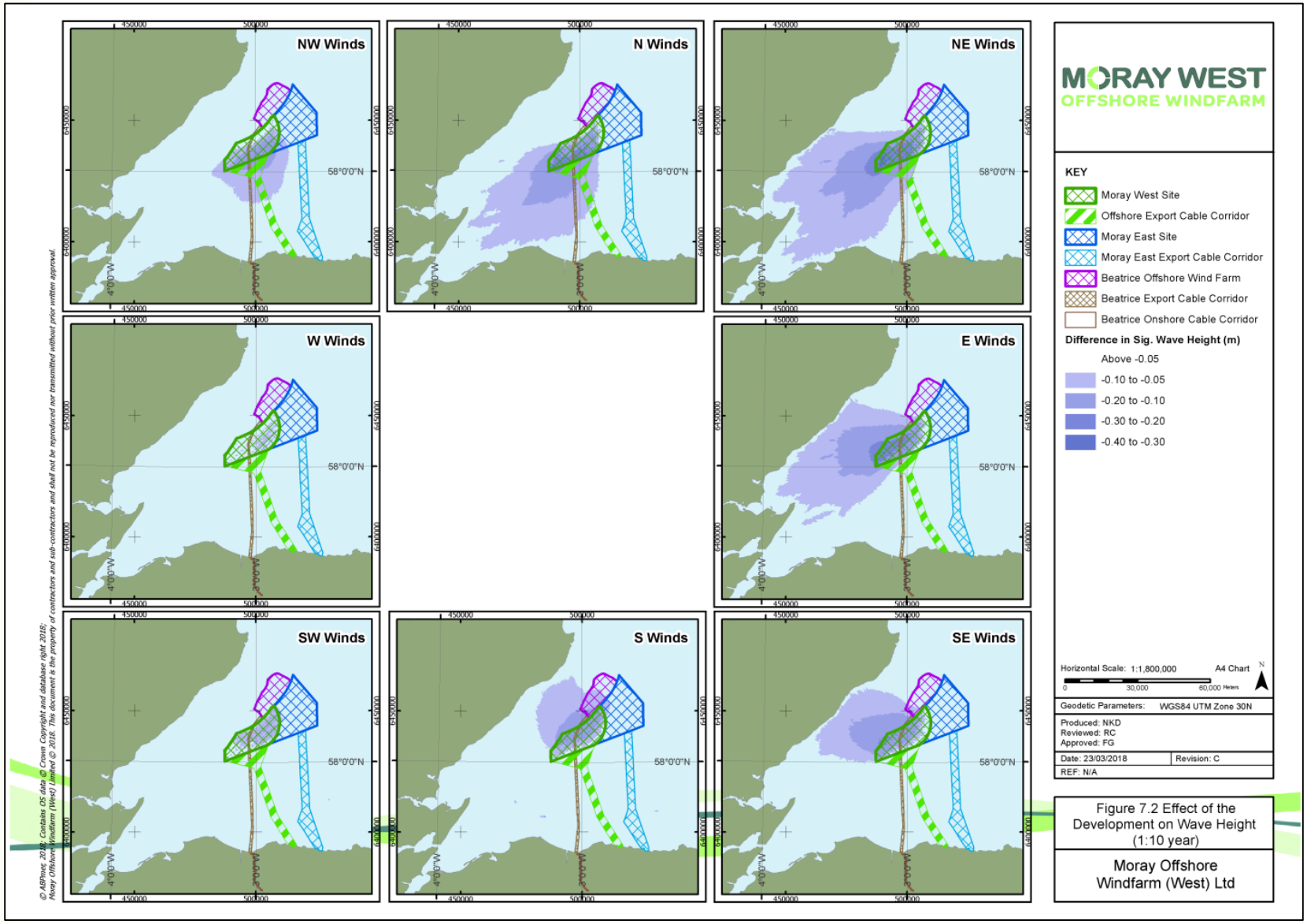

Figure 7.2: Effect of the Moray West Offshore Wind Farm on Significant Wave Height during the 1:10 year storm condition.

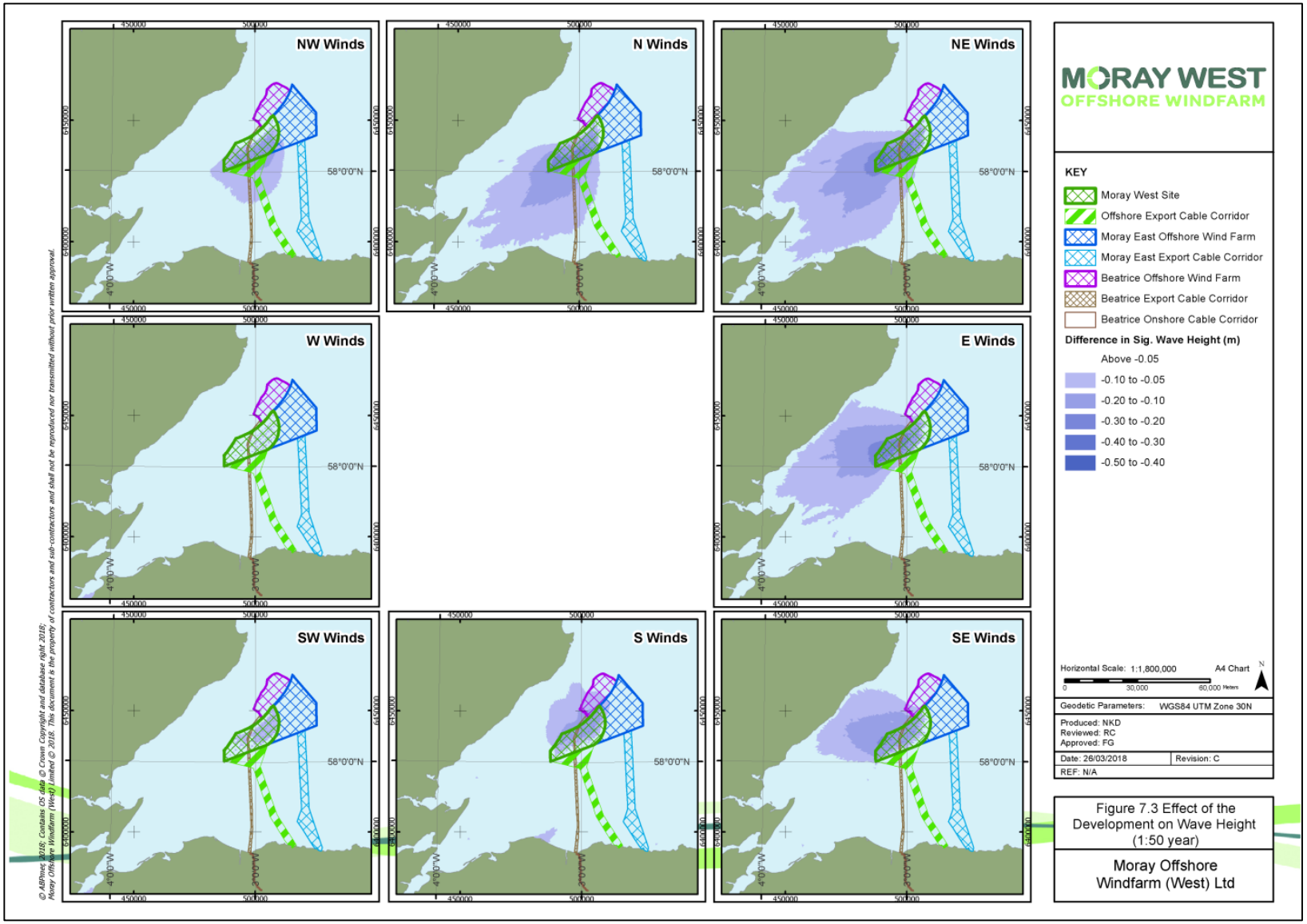

Figure 7.3: Effect of the Moray West Offshore Wind Farm on Significant Wave Height during the 1:50 year storm condition.

The model results described above consider a conservative description of blockage effects that equally affect the whole wave spectrum (which is a mixture of longer and shorter period waves superimposed upon each other at the same time and location). In practice, relatively shorter and relatively longer waves within the spectrum will interact differently with the obstacles posed by the wind farm foundations. In particular, longer period waves (important for coastal process and recreational surfing) will be even less affected by the wind farm than described above, as explained below.

Cylindrical structures or structures with cylindrical members, such as the foundations being considered in the present study, will only interact strongly with waves when the diameter of the structure (D) becomes large relative to the wavelength (L). Slender pile theory shows that wave scattering becomes important when the ratio D/L > 0.2 (e.g. Sumer and Fredsøe, 1997). Waves that are long compared to the size of the structure will more simply pass around it, losing little or no energy. Relatively shorter wavelengths are more likely to impact with the structure and are more likely to be affected by reflection, diffraction or wave breaking; however, such shorter waves are also more likely to be locally wind generated and so recover more rapidly with distance.

Foundations in the Moray West Offshore Wind Farm present a physical blockage or obstacle ranging from a few metres (for jackets) to 15 m (for monopiles and the upper sections of a GBS). Using the above ratio, waves that are 'small' in relation to these obstacles (and hence more susceptible to blockage) are in the order of 10 to 75 m long, corresponding to wave periods of approximately 2 to 5 s. Individual waves passing through the site that are longer than this are 'long' in comparison to the obstacle and will experience little or no blockage from the wind farm foundations. The reduction in significant wave height shown in the modelling results is therefore rather due to a local reduction and downstream recovery in the energy of relatively shorter period waves within the wave spectrum.

As such, it is important to note that longer period waves (important for coastal process and recreational surfing) will be even less affected by the wind farm (if at all) than reported above for the wave spectrum as a whole.

7.5 Cumulative Changes

The potential cumulative effect of the Moray West, Moray East and Beatrice Offshore Wind Farms on significant wave height during a 1:1, 1:10 and 1:50 year return period seastate is shown in Figure 7.4, Figure 7.5 and Figure 7.6, respectively. The results of the modelling show that:

- The main effect would be to reduce the height of waves passing through the Moray West, Moray East and Beatrice Sites;
- The maximum local reduction in wave height within the site boundaries of the three wind farms would vary between 0.35 and 0.85 m, or 7 to 12 % of the local baseline wave height, depending on the wave direction and return period (based on the 8 directions and 3 return periods tested). It should be noted that the largest proportional reduction is not necessarily associated with the largest absolute reduction in wave height. The greatest absolute effects would be on the largest waves that also pass through the long axis of the three proposed wind farm sites (i.e. from 45 and 90 °N). The highest proportional effects would be on largest waves from the southwest and west (215 and 270 °N) while the smallest proportional effects would be on waves from the southeast (125 °N);
- The area of maximum effect on wave height in every case would be relatively small (length scale of order 1 km) and would be located where waves have transitioned through the greatest width of the application site in that orientation;
- The effect would gradually develop from no effect at the upwind edge of the three wind farm sites to the maximum value in proportion to the distance travelled through them i.e. 50 % of the Site areas will experience less than 50 % of the maximum level of effect, and 25 %, less than 25 % of the maximum effect, etc;

- Behind the three wind farm sites, any near-field reduction in wave height would recover towards ambient values at a non-linear rate (i.e. recovering quickly over small distances but smaller magnitude effects can persist over greater distances). These residual effects would extend in the direction of wave travel (with some lateral spreading);
- The maximum local reduction in wave height at any of the adjacent coastlines within the Moray Firth (including the various designated coastlines and surfing venues in the area) would be in the order of centimetres (less than 0.1 m) in comparison to a wave height in the order of several metres, i.e. only a small (not measurable) absolute and relative difference. Only a limited area of coastline downwind of the array areas would be affected at any one time. The time that waves might come from any particular direction (and therefore the area of coastline potentially affected) is limited (details in Technical Appendix 6.1 (Volume 3): Physical Processes Baseline);
- The maximum local effect on the peak wave period in all cases considered would be less than 1 second. The spatial pattern of the effect is not well defined, would recover with distance from the three wind farm sites, and the small magnitude of the effect would not be measurable in practice; and
- There would be no measurable effect on instantaneous wave direction in the near- or far-field.

The magnitude of the effect of the Moray West, Moray East and Beatrice Offshore Wind Farms on waves in the near-field and (especially in) the far-field is small in both absolute and relative terms when compared to the natural range of variability for wave height (4 to 9 m) and period (>10 s), and would not be measurable in practice.

Any potential effects of the Moray West, Moray East and Beatrice Offshore Wind Farms on waves will persist for the lifetime of the developments but are of small magnitude, would have only a local effect and do not impact upon any of the identified sensitive physical environmental receptors beyond the range of natural variability.

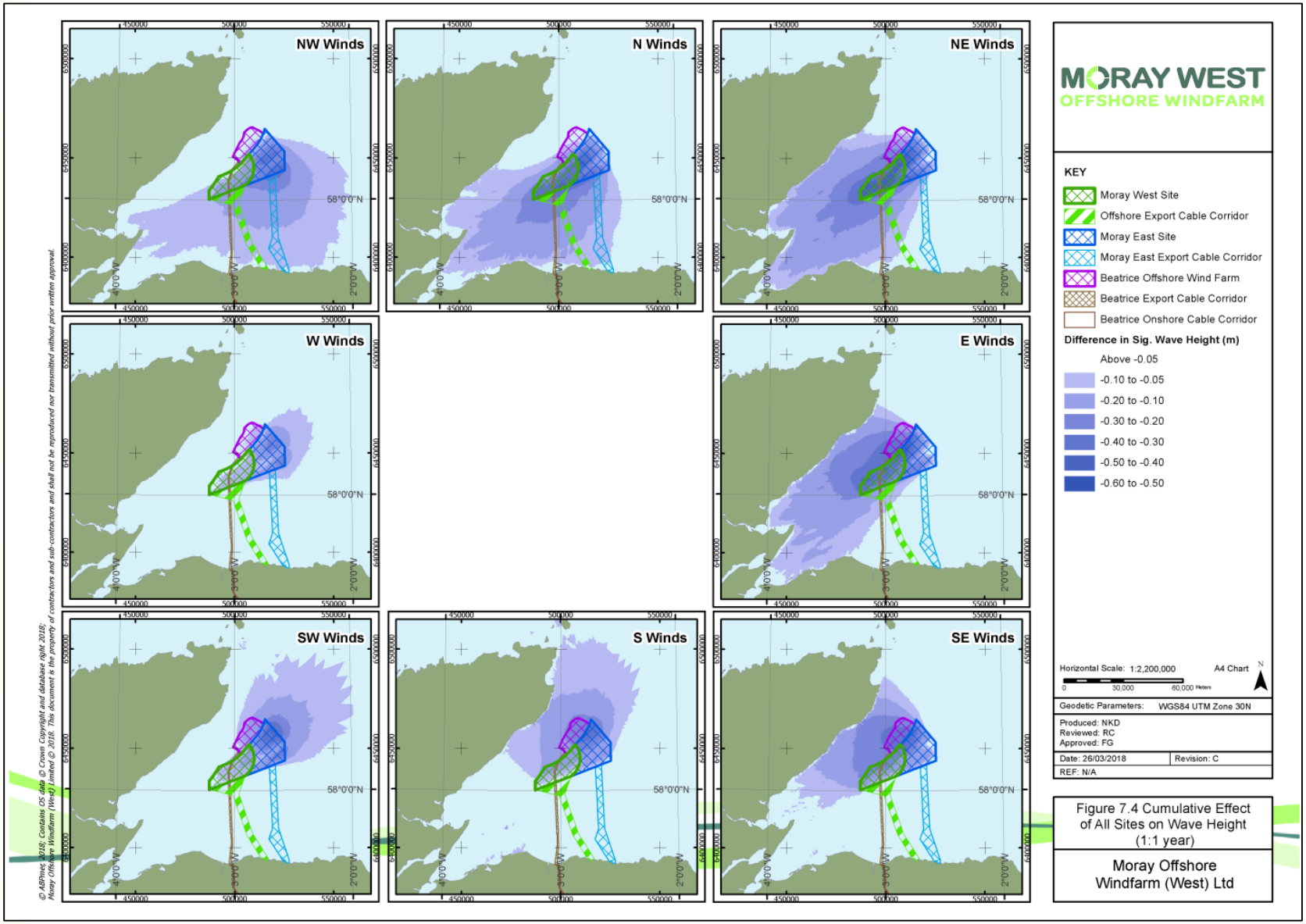

Figure 7.4: Cumulative Effect of the Moray West, Moray East and Beatrice Offshore Wind Farms on Significant Wave Height during the 1:1 year storm condition.

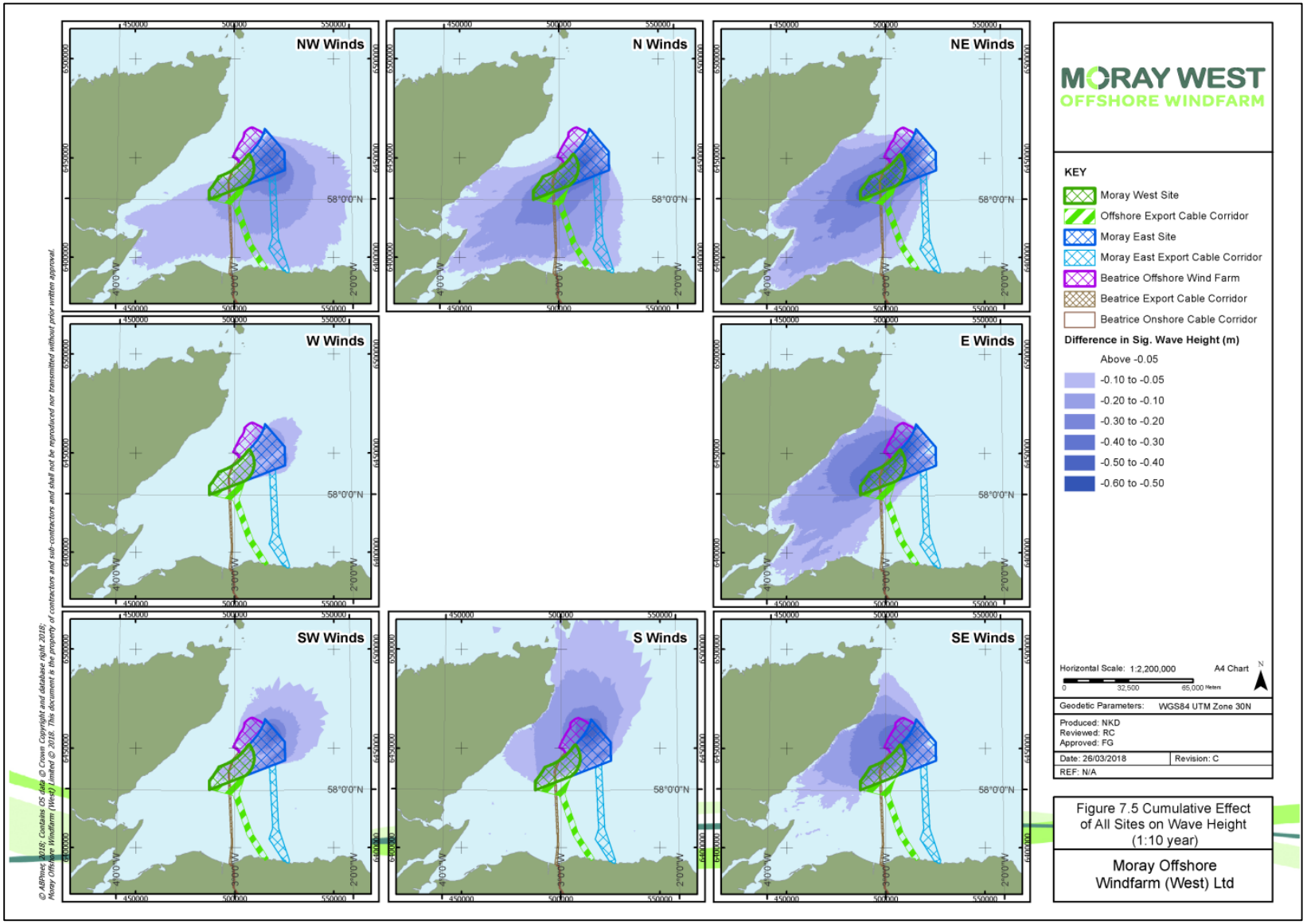

Figure 7.5: Cumulative Effect of the Moray West, Moray East and Beatrice Offshore Wind Farms on Significant Wave Height during the 1:10 year storm condition.

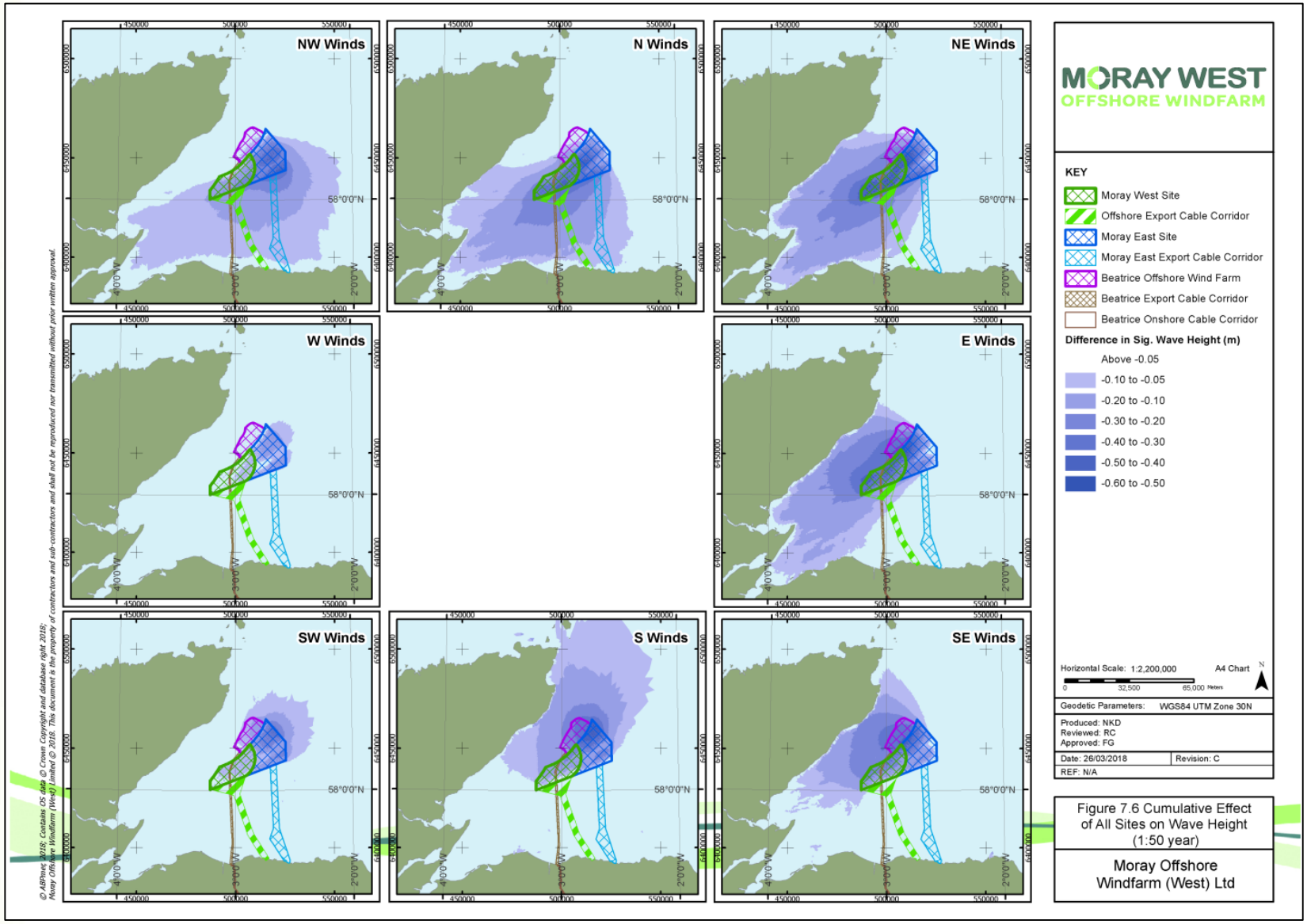

Figure 7.6: Cumulative Effect of the Moray West, Moray East and Beatrice Offshore Wind Farms on Significant Wave Height during the 1:50 year storm condition.

As discussed in Section 7.4, it is important to note that longer period waves (important for coastal process and recreational surfing) will be even less affected by the wind farm (if at all) than reported above for the wave spectrum as a whole.

8 Changes to the Sediment Transport Regime

8.1 Overview

Potential changes to the sediment transport regime could occur in response to the presence of:

- WTG and OSP foundations; and
- Cable protection measures.

Infrastructure installations may present a direct blockage to the transport of sediment. Interaction between the naturally present oceanographic regime (currents and waves) and the WTG and OSP foundations may also result in a reduction in current speed and wave energy, and locally an increase in levels of turbulence. Elevated turbulence may result in local scour (considered in Section 11) and will also enhance the carrying capacity of the flow (e.g. Butt *et al*., 2004, Gyr and Hoyer, 2006). Persistent changes to wave and currents over larger areas may cause changes, over time, to patterns of net sediment transport (rates and directions).

The sensitivity of morphological features to these patterns of change would depend upon the relative importance of currents and/or waves, the magnitude and extent of any change to them and the degree to which the system is presently in balance. The potential for such changes to occur is assessed in this section, with the influence of foundation infrastructure and cable protection measures considered separately.

8.2 Baseline Conditions

Baseline characteristics of the sediment transport regime are briefly summarised below. Full details are provided in a separate report (Technical Appendix 6.1 (Volume 3): Physical Processes Baseline).

- The primary mechanisms for sediment transport within the Moray West Site and Moray West OfTI export cable corridor are bed-load and suspended-load transport, which are controlled by different processes;
- The magnitude and direction of net bed-load transport is principally governed by patterns of tidal currents and storm surge effects. Waves may act to erode sediment locally, which may increase the rate of transport by currents. The broad bedload transport pattern therefore follow the coastline of the Moray Firth. Sediment enters the Moray Firth from the north, moving west along the Caithness coast and into the Inner Moray Firth. Sediment leaving the Moray Firth does so in an eastward direction along the southern coast of the Firth. Within the Moray Firth, sediments become dispersed along routes aligned to the tidal flow axis;
- Naturally low levels of SSC within the Moray West Site and Moray West OfTI export cable corridor suggest a low potential for sediment transport as suspended-load. Field observations within the Moray West Site indicate nearbed SSC is typically in the range 0 to 10 mg/l, interspersed with short periods of very high (> ~100 mg/l) concentrations during an immediately after larger storm events. It is likely that SSC values are normally low because:
    - There is a limited amount of fine sediment in the local surficial seabed sediments;
    - Tidal currents are of insufficient strength locally to mobilise surficial sediments; and
    - There are no large fluvial sources of fine sediment in suspension into the Outer Moray Firth.
- Measurements of Suspended Particulate Matter concentration (SPM, similar to SSC but also including solid organic matter contributions) in surface waters, are very low (< ~5 mg/l) throughout the year and are at their highest in winter months. Little spatial variation is observed across the Development; and

- Bedforms identified within the Moray West Site indicate a wave dominated environment, with both sand and gravel making up the ridge bedforms, which would primarily be transported by bed-load.

8.3 Evidence Base

Relatively little observational evidence is available with regard to the impacts of wind farm foundations on patterns of bedload sediment transport and potential associated changes to bathymetry. Where information is available, it is typically associated with the short to medium impacts of monopile foundations which are located in areas of sandy seabed, not directly analogous to the Moray West Site.

Cefas (2005) describe the results of post construction monitoring at Scroby Sands offshore wind farm which was undertaken to investigate the impacts of monopiles on coastal processes. It was found that at Scroby Sands, the impacts on sediment transport are probably limited to local scour pits and scour wakes. Any ensuing bathymetric impacts are probably limited to the order of 100 m around each monopile. It was further noted that, given the spacing between the foundations is greater than 300 m, such bathymetric/ sediment transport impacts are unlikely to be cumulative between foundations and across the array area.

8.4 Assessment

8.4.1 WTG and OSP Foundations

8.4.1.1 Sediment transport and morphology at adjacent coastlines

On the basis of the quantitative analysis of potential changes to the wave regime, it is found that there will be no measurable reduction in wave height at adjacent coastlines due to the presence of the WTG and OSP foundations in the Moray West Site. Differences in wave height will be very small (<1-2 %) and will occur only intermittently when the wave direction causes waves to pass through the Moray West Site and then on to the area of interest. Changes in wave height of this magnitude are small in both relative and absolute terms. Such small differences are not measurable in practice and would be indistinguishable from normal short term natural variability in wave height (both for individual wave heights and in terms of the overall seastate).

Accordingly, these changes are not predicted to have any measurable influence on short or long term nearshore sedimentary process, including long-shore and cross-shore sediment transport.

8.4.1.2 Sediment transport and morphology offshore

Patterns of net sediment transport are dominated by patterns of tidal currents and storm surge effects. Waves may act to erode sediment locally, which may naturally increase levels of SSC and the rate of sediment transport by the ambient currents.

Potential changes to currents due to the presence of the WTG and OSP foundations in the Moray West Site are described in Section 1.1.1. In summary, current speed would be reduced but turbulence increased in a narrow wake extending downstream for tens to a few hundreds of metres from each foundation. The wider effect is much more limited, with no measureable effect (<0.01 m/s) predicted within the Moray West Site, and no effects at all expected outside of the Moray West Site near-field area.

Potential changes to waves due to the presence of the WTG and OSP foundations in the Moray West Site are described in Section 7.4. In summary, the maximum local reduction in wave height on the downwind edge of the Moray West Site could be up to 0.25 to 0.68 m (7 to 12% of the baseline condition, noting that the largest proportional reduction is not necessarily associated with the largest absolute reduction in wave height), depending on the particular wave condition (return period and direction) being considered. Due to the gradual build-up of the effect within the Moray West Site, and subsequent recovery of wave height downwind, the potential reduction in wave height would be more typically much less than the maximum value elsewhere in the Moray West Site, less than 5% in offshore areas away from the Moray West Site, and, in the order of centimetres (less than 0.1 m) in comparison to a wave height in the order

of several metres, i.e. only a small (not measurable) absolute and relative difference, at any adjacent coastline. Any effect on wave height outside of the Moray West Site will only occur where and when waves have passed through the Moray West Site before reaching the area of interest. Potential effects at any particular location will therefore be spatially and temporally limited, the latter depending on the proportion of time that waves come from the relevant direction.

As the effect on waves and currents is limited in both magnitude and extent, in both absolute and relative terms, any resulting effects on patterns of sediment transport as bedload or as suspended load would be similarly limited, likely not measurable in practice, and in any case would be within the range of natural variability.

8.4.2 Cable Protection Measures

Installation of cable protection could result in a locally raised obstacle up to 1 m above the present-day seabed level. Cable protection would be placed onto the seabed surface above the cable and could therefore directly trap or block sediment in transport, locally impacting down-drift locations. The spatial extent and location of the cable protection is to be confirmed.

Following installation and under favourable conditions, an initial period of sediment accumulation would be expected to occur, filling any voids in the structure and creating a smooth slope against the cable protection. When the accumulated sediment slope reaches the top of the protection, sediment in transport would simply 'overtop' the obstacle and continue with limited or no interruption. This process of accumulation may take place over a period of a few weeks to months, depending on rates of sediment transport.

The presence of cable protection could potential influence sandy sediments which are being transported as bedload. Bedload transport occurs via 'saltation', 'rolling' and 'sliding':

- Saltation is the process by which sands are moved up into the water column. These suspended sands would be expected to move relatively freely over the top of the protection although to begin with would regularly be deposited upon it, filling any void spaces. Once any void spaces have been infilled, saltation is expected to be largely unaffected by the presence of the protection such that existing transport process (including bed form migration) will remain unaffected.

The process of void infilling is expected to occur relatively quickly (in the order of a few months). This is due to saltation as well as the anticipated high rates of transport in areas of mobile seabed (which is where much of the cable protection is anticipated).

- Rolling and sliding is the process by which sands move while still in contact with the seabed. Transport via these mechanisms will be temporarily affected up until such time that the protection is covered by sand and the slope gradient either side has been reduced in response to the accumulation of a sediment wedge with stable slope angles (approximately 30 degrees). Following this, bedload will continue because the slope angle presented by sections of protected cable would be within the natural range of bed slope angles associated with bed forms mapped within the corridor.

Accordingly, for all areas in which cable protection is used, it is not expected that the presence of the cable protection devices will continuously affect patterns of sediment transport following the initial period of accumulation. It follows that any changes on seabed morphology away from the cable protection will also be very small. The extent of the cable protection measures does not constitute a continuous blockage along the cable route corridor.

8.5 Cumulative Changes

The primary process mechanisms driving sediment transport within the study area are currents and waves. The potential changes to tides and waves presented in Section 6.4 and 7.4 for the Moray West Offshore Wind Farm alone, and in Sections 1.1 and 7.5 for the cumulative effect of Moray West, Moray East and Beatrice Offshore Wind Farms, respectively, show that the footprint of measurable change to these parameters is too small in both extent (and magnitude) to cumulatively interact with similar changes associated with other developments. It follows that any associated changes to sediment transport will also be similarly limited in extent and as such, no cumulative changes are expected.

9 Changes to Water Column Stratification

9.1 Overview

Stratification is a naturally occurring seasonal hydrodynamic feature related to the distribution of sea water temperature and salinity, which influences the availability of nutrients, and the distribution and growth rates of pelagic flora and fauna.

During the summer, increased heat input from solar radiation and higher air temperatures preferentially warms the upper part of the water column. Temperature differences of up to 10 °C between the warmer (and so more buoyant) surface waters and colder (denser) bottom waters can be established elsewhere in the North Sea, with a relatively steep vertical gradient in temperature between the two layers. In the Moray Firth, only much smaller temperature differences of up to 1 °C have been observed, corresponding to a much weaker degree of stratification. The gradient in temperature (sometimes enhanced by vertical gradients in salinity) corresponds to a gradient in water density (the pycnocline), which acts as a physical barrier to vertical mixing and diffusion processes within the water column. Where stratification is present, depending on the strength of the density gradient, the availability of nutrients can be enhanced or reduced in certain parts of the water column, affecting the distribution of pelagic flora and fauna and leading to complex cycles and patterns of ecosystem development.

The tendency for stratification to develop is balanced against the ambient rate of turbulent mixing across the density gradient. Turbulence is developed at the seabed by friction with currents, and at the water surface by friction with winds (and any wave breaking). As a result, stratification is more likely to develop in relatively deeper areas, but may also occur in shallower areas with sufficiently low current speeds and exposure to winds and waves.

Stratification (as described above) is a horizontally orientated feature, characterised by vertical gradients in temperature, salinity and/or density. Fronts are vertically orientated features that develop at the transition between areas of stratified and non-stratified water. Fronts are also associated with (typically relatively enhanced) local patterns of nutrient distribution and ecosystem development. Fronts are relatively widespread features within the North Sea and (at certain times during the year) may extend for a distance of several hundred kilometres (e.g. Hill *et al.*, 1993; 2005). The strength of a vertical front is also defined by the strength of the (horizontal) gradients in density (temperature and salinity). The position and strength of the vertical front may vary on timescales of weeks to months, and from year to year, due to differences in the factors controlling stratification, including: the rates of warming and fresh water input; the speed of tidal currents (neap vs spring); the short term wind and wave climate; and the balance of these factors in conjunction with the local water depth. The position of the vertical front is also variable on shorter timescales of hours to days as the water body containing the feature is advected back and forth by local (ebb and flood) currents.

As currents move water past the individual offshore wind farm foundations, a turbulent wake is formed. Within the turbulent wake, vertical mixing can be enhanced above ambient levels, which could potentially contribute to a local reduction in the strength of vertical stratification. This section considers the potential for foundations within the Moray West Site to influence regional-scale patterns of stratification and any resulting change in the location of fronts.

9.2 Baseline Conditions

A brief summary of the nature of water column stratification and frontal regions across the Development is summarised as follows. Full details are provided in a separate report (Technical Appendix 6.1 (Volume 3): Physical Processes Baseline).

- The wider North Sea is characterised by significant spatial and temporal variation in the vertical distribution of temperature and salinity. An assessment of intra-annual patterns of

stratification in the North Sea has been undertaken using a long term (51 year) regional scale hydrobiogeochemical model simulation by van Leeuwen *et al*. (2015);

- The majority of the Moray West Site (mainly the eastern half) is located in an area described by van Leeuwen *et al*., (2016) as being 'intermittently stratified', defined as <40 days in the year where the water column is stratified and between 120 to 250 days in the year where the water column is fully mixed. To the north of the Moray West Site (i.e. closer to the Pentland Firth), higher current speeds result in areas described as 'permanently mixed' (<20 days stratified and >345 days mixed in the year). In the western part of the Moray West Site and elsewhere in the Moray Firth are areas of deeper water and lower current speeds described as stratified or 'seasonally mixed' (>120 days stratified and >40 days mixed in the year);
- Solar heating causes the water temperature to vary unevenly with depth and season within the Moray Firth. In the summer, the water becomes seasonally stratified due to temperature-related density differences between warmer surface waters and cooler deeper waters, typically forming a weak thermocline (temperature differences of up to 1 °C) at 10 to 15 m depth in the vicinity of the Moray Firth Zone. The field data collected indicate that there is no significant fresh-water / salinity contribution to the observed stratification. The stratification breaks down at the end of summer and the water column remains well mixed during the winter months due to the increased frequency and severity of storms and a reduced rate of heat input;
- Temperature and salinity may fluctuate to a greater extent at the coast and in the Inner Moray Firth, due to more highly variable local river input; local temperature stratification in summer may also be associated with relatively warm, fresh river water overlying colder, more saline sea water; and
- Weak thermal fronts are also present in the Moray Firth and their locations have been deduced from infrared satellite images (OSPAR, 2000). The fronts represents the boundary between deeper, weakly seasonally stratified water offshore and an area of more intense mixing inshore due to a combination of shallower water depths and relatively stronger tidal currents. On this basis, the position of the fronts are likely to migrate in an onshore-offshore direction in response to the spring-neap cycle and its measurable signal may become weak or absent altogether in proportion to the strength of local (offshore) seasonal stratification.

9.3 Evidence Base

The potential for wind farm foundations to influence alter column stratification has previously been considered by Carpenter *et al*. (2016) and Cazenave *et al*. (2016), using numerical modelling analyses. These two studies are considered below in Section 9.4

9.4 Assessment

As described in Section 6.1 where an obstruction is introduced to a flow, complex three-dimensional interaction creates a wake with reduced time-mean current speed and increased turbulence intensity. The most pronounced changes to the flow regime occur immediately around but primarily downstream of the obstruction, within approximately three times the length scale of the obstacle. The wake effect recovers towards ambient levels of time-mean flow speed and turbulence with time and distance downstream. The potential for WTG foundation wakes to enhance vertical mixing and decrease stratification within the water column is discussed below.

Carpenter *et al*. (2016) use an idealised (conceptual) numerical model of structure induced turbulent mixing in conjunction with existing environmental hindcast data to consider the potential for large scale change to stratification of the German Bight region of the North Sea in response to planned wind farm developments. The study shows that stratification is only gradually broken down by interaction with the wind farm. A range of 'timescale for [complete] mixing' estimates are provided (in the order of 100 to 500 days) if the same body of initially stratified water is continually passed through the wind farm. In practice,

due to non-zero residual rates of tidal advection, the same body of water will not be repeatedly passed through the same wind farm for 100 to 500 days. As a result, mixing due to the foundations will only lead to some partial reduction in the strength of stratification in water that passes through the wind farm. They conclude that no large scale changes to stratification of the North Sea are expected at the current levels of offshore wind farm construction and extensive regions of the North Sea would need to be covered in offshore wind farms for a significant impact on stratification to occur. The study also found that the results are sensitive to the assumed type (shape and size) of foundation structure being assessed, and to the assumptions made about the evolution of the pycnocline thickness under enhanced mixing conditions.

Cazenave *et al*. (2016) use a regional scale 3D hydrodynamic model with a number of wind farm foundations represented as small islands in the mesh. The mesh has a variable resolution of 2.5 to 20 m in the vicinity of the obstacles. Patterns of depth and time mean flow speed reduction in the wake are consistent with that described in section 1.1.1. Patterns of slightly downwards and upwards inclined time mean flow, upstream and downstream of each WTG are presented as a possible mechanism for mixing across the pycnocline. The resulting vertical distributions of temperature and salinity are used to calculate the local energy anomaly (a measure of water column stratification stability). Maps of this parameter are compared for scenarios with and without the wind farms present showing a change equivalent to 5 to 15% of the strength of stratification. It is noted that the change is both positive and negative, and is localised to the wind farm array areas.

The general results of Cazenave *et al*., (2016) are that wind farm foundations may have some limited influence on the strength of stratification locally but it does not suggest that naturally present stratification would be completely mixed by this process. It is noted that the model used in this study only considers time mean flow at a typical spatial resolution of 10 to 20 m in the horizontal plane and more than several metres in the vertical plane. The elevation of turbulence intensity and turbulent mixing at smaller length scales in the narrow wake is important for the processes in question (as noted by Carpenter *et al*., 2016) but is only generally parameterised and not explicitly resolved by this model, which leads to some uncertainty in the results.

Based on the available evidence, weak vertical stratification (and so also the presence of any fronts) is only expected to occur in or near to the Moray West Site for less than 40 days per year on average. When stratification is present, it is possible that foundations in the Moray West Site may cause some minor decrease in the strength of water column stratification within the array area. Only a small proportion of water passing through the array area will actually interact with individual foundations, causing only partial and localised mixing of any stratification. Numerous repeat passes through the array area would be needed for an initially stratified body of water to become mixed; however, this is unlikely to happen due to displacement of the water body out of the array area over shorter time periods by residual tidal currents. It is therefore unlikely that water which is stratified entering the Moray West Site will become fully mixed. Regional scale patterns of stratification in the Moray Firth and wider North Sea will be unaffected and will continue to be subject to natural processes and variability. The location and physical characteristics of fronts in the Moray Firth are therefore unlikely to be measurably affected and will remain within the range of natural variability.

9.5 Cumulative Changes

Based on the available evidence (summarised above in Section 9.4), vertical stratification (and so also the presence of any fronts) is only expected to occur in or near to the Moray West, Moray East and Beatrice Offshore Wind Farms for less than 40 days in the year on average (van Leeuwen *et al*. 2015) (see Technical Appendix 6.1 (Volume 3): Physical Processes Baseline). When stratification is present, it is possible that the foundations in these three wind farms may locally cause some minor decrease in the strength of water column stratification; however, it is very unlikely that water which is stratified entering any one array area will become fully mixed. Based on the size and orientation of tidal excursion ellipses (Figure 2.1) water passing through the Moray West Site would not normally also then pass any large distance through the Moray East or Beatrice Sites. There is therefore limited potential for cumulative impacts on stratification.

As such, regional scale patterns of stratification in the Moray Firth and wider North Sea will be unaffected and will continue to be subject to natural processes and variability under a cumulative scenario considering these projects. The location and physical characteristics of any fronts in the Moray Firth are therefore also unlikely to be measurably affected and will remain within the range of natural variability.

All other proposed wind farms are located much more than one tidal excursion from the Moray West Site, and so present no further potential for cumulative impacts on stratification.

10 Scour and Seabed Alteration

10.1 Overview

The purpose of this section is to conservatively and quantifiably estimate the area of seabed that might potentially be altered during the operational phase of the wind farm as a result of sediment scour developing adjacent to WTG foundations (in the absence of any scour protection).

The term scour refers here to the development of pits, troughs or other depressions in the seabed sediments around the base of WTG and OSP foundations. Scour is the result of net sediment removal over time due to the complex three-dimensional interaction between the foundation and ambient flows (currents and/or waves). Such interactions result in locally accelerated time-mean flow and locally elevated turbulence levels that enhance sediment transport potential in the area of influence. The resulting dimensions of the scour features and their rate of development are, generally, dependent upon the characteristics of the:

- Obstacle (dimensions, shape and orientation);
- Ambient flow (depth, magnitude, orientation and variation including tidal currents, waves, or combined conditions); and
- Seabed sediment (geotextural and geotechnical properties).

Based on the existing literature and evidence base, an equilibrium depth and pattern of scour can be empirically approximated for given combinations of these parameters. Natural variability in the above parameters means that the predicted equilibrium scour condition may also vary over time on, for example, spring-neap, seasonal or annual time-scales. The time required for the equilibrium scour condition to initially develop is also dependant on these parameters and may vary from hours to years.

Scour assessment for EIA purposes is considered here for three foundation types: monopiles, piled jacket foundations (a four legged version) and GBS. Each foundation type may produce different scour patterns therefore monopiles, GBS and jacket foundations have all been considered. Suction caisson foundations (for monopods and jackets) have not been considered in the assessment below because these will fall within the envelope of change associated with the other three foundation types. Indeed, local scour around each suction bucket will be limited (largely owing to the fact that they will only have limited protrusion above the seabed), with the total spatial extent of local scour expected to be less than the extent of group scour for jacket foundations.

The concerns under consideration include the seabed area that may become modified from its natural state (potentially impacting sensitive receptors through habitat alteration) and the volume and rate of additional sediment resuspension, as a result of scour. The seabed area directly affected by scour may be modified from the baseline (pre-development) or ambient state in several ways, including:

- A different (coarser) surface sediment grain size distribution may develop due to winnowing of finer material by the more energetic flow within the scour pit;
- A different surface character will be present if scour protection (e.g. rock protection) is used;
- Seabed slopes may be locally steeper in the scour pit; and
- Flow speed and turbulence may be locally elevated.

The magnitude of any change will vary depending upon the foundation type, the local baseline oceanographic and sedimentary environments and the type of scour protection implemented (if needed). In some cases, the modified sediment character within a scour pit may not be so different from the surrounding seabed; however, changes relating to bed slope and elevated flow speed and turbulence close to the foundation are still likely to apply. No direct assessment is offered within this document as to the potential impact on sensitive ecological receptors.

The assessment presented here is not intended for use in detailed engineering design. However, methodologies similar to those recommended for the design of offshore wind foundations (DNV, 2016) have been used in some cases where they are applicable. The methods applied to assess scour are set out in Section 0 (Annex 6.3A).

10.2 Baseline Conditions

Key features of the baseline environment pertinent to the assessment of scour due to the presence of wind farm infrastructure are summarised below. Full details are provided in a separate report (Technical Appendix 6.1 (Volume 3): Physical Processes Baseline).

- The thickness of potentially mobile seabed sediment across the Development is highly variable, ranging from ~ 5 to 15 m in the west of the Moray West Site, up to 30 m in the east;
- The surficial seabed sediments are typically characterised by the presence of granular (fine to medium sand and gravel) sediments. Fine grained (muddy) material is only present in very low (<5%) quantities. Due to the relatively weak tidal currents, these sediments are not likely to be mobilised regularly accounting for the low sediment concentrations observed; and
- Defined sand patches and ridges are present across the site, governed by approach direction of large waves and generally stand between 0.3 to 2 m above surrounding seabed. The governing wave influences means these features are likely to be temporary in nature, with little migration properties.

10.3 Evidence Base

Even where man-made obstacles are not present on the seabed, normal sediment transport processes can cause spatial and temporal variations in seabed level and sediment character in the baseline environment. Scour is a similar but localised change resulting from particular local patterns of sediment transport. Scour may also occur in the baseline environment in response to natural obstacles such as rocky outcrops or boulders.

Whitehouse (1998) provides a synthesis of a range of research papers, industry reports, monitoring studies and other evidence available at that time, describing the patterns and dimensions of scour that result from a variety of obstacle shapes, sizes and environmental conditions. Building upon a theoretical understanding of the processes involved, the accepted methods for the prediction of scour mainly rely on stochastic relationships and approaches (i.e. relationships that are based on and describe the available evidence). As such, scour analysis is an evidence based science where suitable analogues provide the most robust basis for prediction.

Since the publication of Whitehouse (1998), evidence continues to be collected and other predictive relationships have been developed and reported by the research community. In general, more recent observations have confirmed the approaches (and associated ranges of uncertainty) presented in Whitehouse (1998). As the evidence base has grown, additional approaches and relationships have been developed to better predict scour for a wider range of more specific obstacle shapes, sizes and environmental conditions.

Monitoring evidence regarding scour development around unprotected wind farm monopile installations is provided by HR Wallingford *et al*. (2007) and ABPmer *et al*. (2010) in a series of monitoring data synthesis reports for the Department for Trade and Industry (DTI) and COWRIE. HR Wallingford *et al*. (2007) note that the available data support the view that scour is a progressive process that can occur where the seabed sediment is potentially erodible and there is an adequate thickness of that sediment for scouring to occur. Where the seabed comprises consolidated pre-Holocene sedimentary units (such as that encountered within many areas of the Moray West Site), the scour will be slower to develop and limited in depth. For instance, geotechnical surveys at Kentish Flats offshore wind farm (Outer Thames) show that the seabed consists of non-cohesive sands over more resistant London Clay. The post construction monitoring evidence generally indicates that maximum scour rates around the monopiles

(of diameter 4.3 m) occurred during the first year from installation and then rapidly slowed with near stability occurring by the third anniversary of the works. Scour depths ranged from 1.5 to 1.9 m at the monitoring locations and the results indicate that the scour depth is restricted by the cohesive underlying clay formation.

A research paper by Whitehouse *et al*., (2011) provides a summary of the field evidence for scour around GBS foundations in the North Sea used in oil and gas projects. This review emphasized the sensitivity of scour to foundation shape, with foundations in very close proximity sharing similar hydrodynamic/ sedimentary environments displaying markedly different scour characteristics. This review also described field evidence for scour around a rectangular GBS foundation (75 m by 80 m by 16 m high) located within the North Sea in 42 m water depth. Scour was measured as 2.5 to 3.5 m deep in 0.15 mm (i.e. fine) sand. It is noted that the GBS foundations to be used in the Moray West Site are likely to be circular, with an 'inverted T' shape.

Scour protection is evidently a mature engineering concept and by design will both prevent primary scour and minimise secondary scour. The evidence base supporting the design of scour protection is therefore strong but is not relevant to this assessment. The evidence base concerning the environmental impacts of scour protection is more limited. Although multi-layered gravel and rock scour protection is being successfully used at the Thornton Bank offshore wind farm in conjunction with six GBS foundations in a sandy environment with water depths (28 m, similar to depths in the shallower parts of the Moray West offshore wind farm) (ABPmer *et al*., 2010).

10.4 Assessment

10.4.1 Outline of Structures Considered in Assessment

The following foundation structures have been considered within the assessment presented in this section:

- Monopile foundations:
  - 15 m diameter (largest); and
  - 12 m diameter (smallest) ;
- Jacket foundations:
  - 40 m x 40 m base with four 4.0 m diameter leg piles (largest); and
  - 35 m x 35 m base with four 3.5 m diameter leg piles (smallest);
- GBS foundations:
  - 55 m diameter base (largest); and
  - 45 m diameter base (smallest).

For each foundation type, both the largest and smallest structures have been considered. This is because the former has the potential to cause the greatest extent of scour at the scale of individual foundations whereas the latter may potentially be associated with the greatest extent of scour at the array scale, owing to the larger number of structures.

10.4.2 Factors Affecting Equilibrium Scour Depth

As summarised in Whitehouse (1998), a number of factors are known to influence equilibrium scour depth for monopiles, contributing to the range of observed equilibrium scour depths. These factors include the:

- Frequency and magnitude of ambient sediment transport;
- Ratio of monopile diameter to water depth;
- Ratio of monopile diameter to peak flow speed;

- Ratio of monopile diameter to sediment grain size; and
- Sediment grain size, gradation and geotechnical soil properties.

The influence of these factors where they do apply is to generally reduce the depth, extent and volume of the predicted scour, hence providing a less conservative estimate. For example, a greater frequency and magnitude of sediment transport can actually reduce the equilibrium scour depth, as the scour hole is also simultaneously being (partially) in-filled by ambient sediment transport.

In relation to the geotechnical soil properties in the Moray West Site, most locations have a sufficient thickness of potentially mobile sediment to not limit the depth of scour development. However, in some limited areas, the presence of relatively erosion resistant till at a depth of 0.5 to 2 m under the relatively thin upper layers of sandy sediment would likely limit the depth of scour in these locations. The other factors listed above have been considered in the context of the Moray West Offshore Wind Farm area and were not found to significantly or consistently reduce the predicted values for the purposes of EIA.

The greatest influence on local scour depth would arise from the installation of scour protection. If correctly designed and installed, scour protection will essentially prevent the development of local primary scour as described in this section. The dimensions and nature of scour protection may vary between designs but, given its purpose, would likely cover an area of seabed approximately similar to the predicted extent of the scour.

Interaction between ambient currents and the scour protection may lead to the development of secondary scour at its edges. The local dimensions of secondary scour are highly dependent upon the specific shape, design and placement of the protection. These parameters are highly variable and so there is no clear quantitative method or evidence base for accurately predicting the dimensions of secondary scour. However, as for foundations, the approximate scale of the scour depth and extent is likely to be proportional to the much smaller size of the individual elements comprising the protection.

10.4.3 Time For Scour to Develop Around the Foundation Options

Scour depth can vary significantly under combined current and wave conditions through time (Harris *et al*., 2010). Monitoring of scour development around monopile foundations in UK offshore wind sites suggest that the time-scale to achieve equilibrium conditions can be of the order of 60 days in environments with a potentially mobile seabed (Harris *et al*., 2011). However, as previously stated in Section 10.3, equilibrium scour depths may not be reached for a period of several months or even a few years where erosion resistant sediments/ geology are present. These values account for tidal variations as well as the influence of waves. (Near) symmetrical scour will only develop following exposure to both flood and ebb tidal directions.

Under waves or combined waves and currents an equilibrium scour depth for the conditions existing at that time may be achieved over a period of minutes, whilst typically under tidal flows alone equilibrium scour conditions may take several months to develop.

10.4.4 Spatial Extent of Scour

At the Scroby Sands offshore wind farm, narrow, elongated scour features have been observed to extend over tens or hundreds of metres from individual foundations, leading to a more extensive impact than would normally be predicted. The development of elongate scour features at Scroby Sands is considered to have occurred due to the strongly rectilinear nature of the tidal currents (a very well defined tidal current axis with minimal deviation during each half tidal cycle) which allows the narrow turbulent wake behind each foundation to persist over the same areas of seabed for a greater proportion of the time, leading to net erosion in these areas. Due to a relatively higher rate of tidal rotation, especially in the western part of the Moray West Site, the development of elongate scour features is not considered likely to occur.

10.4.5 Results

Table 10.1 and Table 10.2 summarise the key results of the first-order scour assessment undertaken using the methodological approach set out in Annex 6.3A. Results conservatively assume maximum equilibrium scour depths are symmetrically present around the perimeter of the structure in a uniform and frequently mobile sedimentary environment with unlimited seabed thickness. Local scour extent is measured from the edge of the monopile or jacket pin pile; 'global scour' extent is measured from the centroid of the jacket foundation location. Global scour refers to a region of shallower but potentially more extensive scour associated with a multi-member foundation resulting from the change in flow velocity through the gaps between members of the structure and turbulence shed by the entire structure. Global scour does not imply scour at the scale of the wind farm array.

Scour footprints exclude the footprint of the structure. Scour pit volumes for monopiles and jacket foundation structures are calculated as the volume of an inverted truncated cone, minus the structure volume; scour pit volume for the jacket foundations are similarly calculated but as the sum of that predicted for each the corner piles.

Table 10.1: Summary of predicted maximum scour dimensions for largest individual WTG foundation structures

Parameter		Foundation Type		
		Monopile (15 m diameter)	**4 Legged Jacket (40 m x 40 m base, 3.5 m legs)**	**GBS (55 m base diameter)**
Equilibrium Scour Depth (m)	Steady current	19.5	4.6	1.1
	Waves	Insufficient for scour	Insufficient for scour	2.2
	Waves and current	19.5	4.6	3.5
	Global scour	N/A	1.4	N/A
Extent from foundation* (m)	Local scour	31.2	7.3	2.1
	Global scour	N/A	40.0	N/A
Footprint a (m^2)	Structure alone	177	50	2,376
	Local scour (exc. structure)	4,530	1,032	381
	Global scour (exc. structure)	N/A	4,976	N/A
Volume [a] (m^3)	Local scour (exc. structure)	34,224	1,739	250
	Global scour (exc. local scour and structure)	N/A	6,967	N/A
	Drill arisings or bed preparation	0	0	35,441

[a] Based upon the scour depth for steady currents. Footprint and volume values are per foundation.

Table 10.2: Total seabed footprint of the different WTG foundation types with and without scour

Parameter	Monopiles		4 Legged Jacket		GBS	
	(12 m diameter)	**(15 m diameter)**	**(35 m base length)**	**(40 m base length)**	**(45 m diameter)**	**(55 m diameter)**
Maximum number of foundations	85 (+2 OSP)	62 (+2 OSP)	85 (+1 or 2 OSP) [b]	62 (+1 or 2 OSP) [b]	85 (+1 or 2 OSP) [b]	62 (+1 or 2 OSP) [b]
Seabed footprint of all foundations (m²)	9,967	11,310	3,372	3,217	140,213	152,328
Proportion of Moray West Site area [a] (%)	0.00	0.01	0.00	0.00	0.06	0.07
Seabed footprint of all local scour (m²)	255,492	289,920	65,795	64,855	23,647	24,512
Proportion of Moray West Site area [a] (%)	0.11	0.13	0.03	0.03	0.01	0.01
Seabed footprint of all foundations + local scour (m²)	265,459	301,230	69,166	68,072	163,861	176,840
Proportion of Moray West Site area [a] (%)	0.12	0.13	0.03	0.03	0.07	0.08
Seabed footprint of all global scour (m²)	N/A	N/A	355,163	339,845	N/A	N/A
Proportion of Moray West Site area [a] (%)	N/A	N/A	0.16	0.15	N/A	N/A
Seabed footprint of all scour protection (m²)	73,737	68,526	58,149	42,046	356,571	301,593
Proportion of Moray West Site area [a] (%)	0.03	0.03	0.03	0.02	0.16	0.13
Seabed footprint of all foundations + scour protection (m²)	83,704	79,836	61,497	45,239	496,509	453,646
Proportion of Moray West Site area [a] (%)	0.04	0.04	0.03	0.02	0.22	0.20

All scour dimensions are based upon the scour depth for steady currents.

[a] Corresponding proportion of the Moray West Site area (225 km^2).

[b] The worst case result is provided for each parameter depending based on the choice of 1 (larger) or 2 (smaller) OSP foundations.

Key findings are summarised below:

- Scour development within the Moray West Site is expected to be dominated by the action of tidal currents;
- Of all of the WTG foundation options under consideration, a 15 m diameter monopile WTG and OSP foundation has the potential to cause the greatest equilibrium local scour depth (19.5 m), footprint (4,530 m^2) and volume (34,224 m^3), but only in areas where the seabed is potentially erodible by the action of scour to that depth;
- The greatest individual WTG foundation global scour footprint is associated with the larger (40 m base length) piled jacket WTG foundation (4,976 m^2), although with a relatively small average depth (1.4 m);
- For the Moray West Site as a whole, the greatest total foundation local scour footprint is associated with an array of 62 WTG and two monopile OSP larger (15 m diameter) monopile foundations (289,920 m^2, equivalent to only approximately 0.11% of the Moray West Site area);
- For the Moray West Site as a whole, the greatest total WTG foundation global scour footprint is associated with an array of 85 smaller (35 m base diameter) piled jacket WTG foundations and 1 larger piled jacket OSP foundation (355,163 m^2, equivalent to only approximately 0.16% of the Moray West Site area);
- In practice, a limited thickness of more easily erodible sediment of more erosion resistant subsoils (0.5 to 2 m below the seabed surface) will naturally limit the maximum scour depth in some areas. The corresponding footprint and volume of seabed affected by scour would also be reduced, both for individual foundations and for the array as a whole. The assessment of scour above conservatively assumes an unlimited depth of mobile sediment and is therefore likely to be an overestimate of what could actually occur; and
- Scour protection would be used to protect the stability of foundations if necessary. Where scour protection is used, primary scour is unlikely to occur, although a small amount of secondary scour may develop at the edges of the scour protection. For monopile and piled jacket foundation types the footprint area of scour protection is similar to (or smaller than) the predicted footprint of local scour. For GBS foundations, the footprint area of scour protection is larger than the predicted footprint of local scour for this foundation type (due to a relatively smaller predicted depth of scour) but more similar to that for monopiles. At most, the maximum footprint of scour protection is equivalent to only approximately 0.16% of the Moray West Site area (0.22% including the footprint of the foundations also).

10.5 Cumulative Changes

Scour around all structures will be confined to the Moray West Site. Accordingly, there is no potential for cumulative changes arising from interaction with other projects.

11 Decommissioning

The decommissioning phase could last in the order of two years. Specific details of the decommissioning phase are presently unknown. However, it is expected that on expiry of the lease the developer will remove all structures and return the seabed to a usable state, in accordance with Department of Energy and Climate Change decommissioning guidelines (DECC, 2011).

It is assumed that the decommissioning phase will involve the removal and/or burial of any structures related to the Development. Therefore, impacts upon tidal, wave and sedimentological regimes as a consequence of this phase will be comparable to those identified for the construction phase.

Post-decommissioning, the Moray West Site is expected to return to baseline conditions within the range of natural variability (allowing for some measure of climate change).

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13 Annex 6.3A - Scour

13.1 Overview

In order to quantify the area of seabed that might be affected by scour (either the footprint of scour or scour protection), estimates of the theoretical maximum depth and extent of scour are provided below. Estimates are made of the primary scour, i.e. the scour pit directly associated with the presence of the main obstacle. The equilibrium primary scour depth for each foundation type has been conservatively calculated assuming the absence of any scour protection, using empirical relationships described in Whitehouse (1998). This analysis considers scour resulting from the characteristic wave and current regime, both alone and in combination.

The project description (Chapter 4: Description of the Development) provides maximum design scenario extents of scour protection for each foundation type. Scour protection might be applied around the base of some or all foundations depending upon the seabed conditions and other engineering requirements. By design, scour protection will largely prevent the development of primary scour, but may itself cause smaller scale secondary scour due to turbulence at the edges of the scour protection area.

13.2 Assumptions

The following scour assessment for the Moray West Development reports the estimated equilibrium scour depth, which assumes that there are no limits to the depth or extent of scour development by time or the nature of the sedimentary or metocean environments. As such, the results of this study are considered to be conservative and provide an (over-) estimation of the maximum potential scour depth, footprint and volume. Several factors (discussed in Section 10.4.2) may naturally reduce or restrict the equilibrium scour depth locally, with a corresponding reduction in the area and volume of change.

This study makes the basic assumption that the seabed comprises an unlimited thickness of uniform non-cohesive and easily eroded sediment. The Moray West Site specific surveys indicate that whilst unconsolidated surficial sediment is present in many areas, this unit is typically thin (generally less than ~1 m thick) across much of the array. In practice, once exposed by initial scouring, the more erosion resistant subsoils are expected to either reduce or prevent further scour, limiting the depth, extent and volume of scour accordingly.

The foundation types, dimensions and numbers used in the assessment are consistent with the project design information provided in Volume 1, Chapter 3: Project Description.

Reported observations of scour under steady current conditions (e.g. in rivers) generally show that the upstream slope of the depression is typically equal to the angle of internal friction for the exposed sediment (typically 32° in loose medium sand; Hoffmans and Verheil, 1997) but the downstream slope is typically less steep. In reversing (tidal) current conditions, both slopes will develop under alternating upstream and downstream forcing and so will tend towards the less steep or an intermediate condition. For the purposes of the present study a representative angle of internal friction (32°) will be used as the characteristic slope angle for scour development.

13.3 Equilibrium scour depth

The maximum equilibrium scour depth (S_e) is defined as the depth of the scour pit adjacent to the structure, below the mean ambient or original seabed level. The value of S_e is typically proportional to the diameter of the structure and so is commonly expressed in units of structure diameter (D).

Scour depth decreases with distance from the edge of the foundation. The scour extent (S_{extent}) is defined as the radial distance from the edge of the structure (and the point of maximum scour depth) to the edge of the scour pit (where the bed level is again equal to the mean ambient or original seabed level). This is calculated on the basis of a linear slope at the angle of internal friction for the sediment, i.e.:

$$S_{extent} = \frac{S_e}{tan32°} \approx S_e \times 1.6$$

(Eq. 1)

The scour footprint ($S_{footprint}$) is defined as the seabed area affected by scour, excluding the foundation's footprint, i.e.:

$$S_{footprint} = \pi\left(\frac{D}{2} + S_{extent}\right)^2 - \pi\left(\frac{D}{2}\right)^2$$

(Eq. 2)

The scour pit volume is calculated as the volume of an inverted truncated cone described by Equations 1 and 2 above, accounting for the presence of the foundation but excluding its volume.

13.4 Scour assessment method: monopiles

The outline design of the proposed monopile structure is shown in Figure 13.1. Compared to other more complex foundation types, scour around upright slender monopile structures in steady currents is relatively well-understood in the literature and is supported by a relatively large empirical evidence base from the laboratory and from the field. The maximum equilibrium scour depth, adjacent to the structure, below the mean seabed level (S_c), is typically proportional to the diameter of the monopile and is therefore expressed in units of monopile diameter (D).

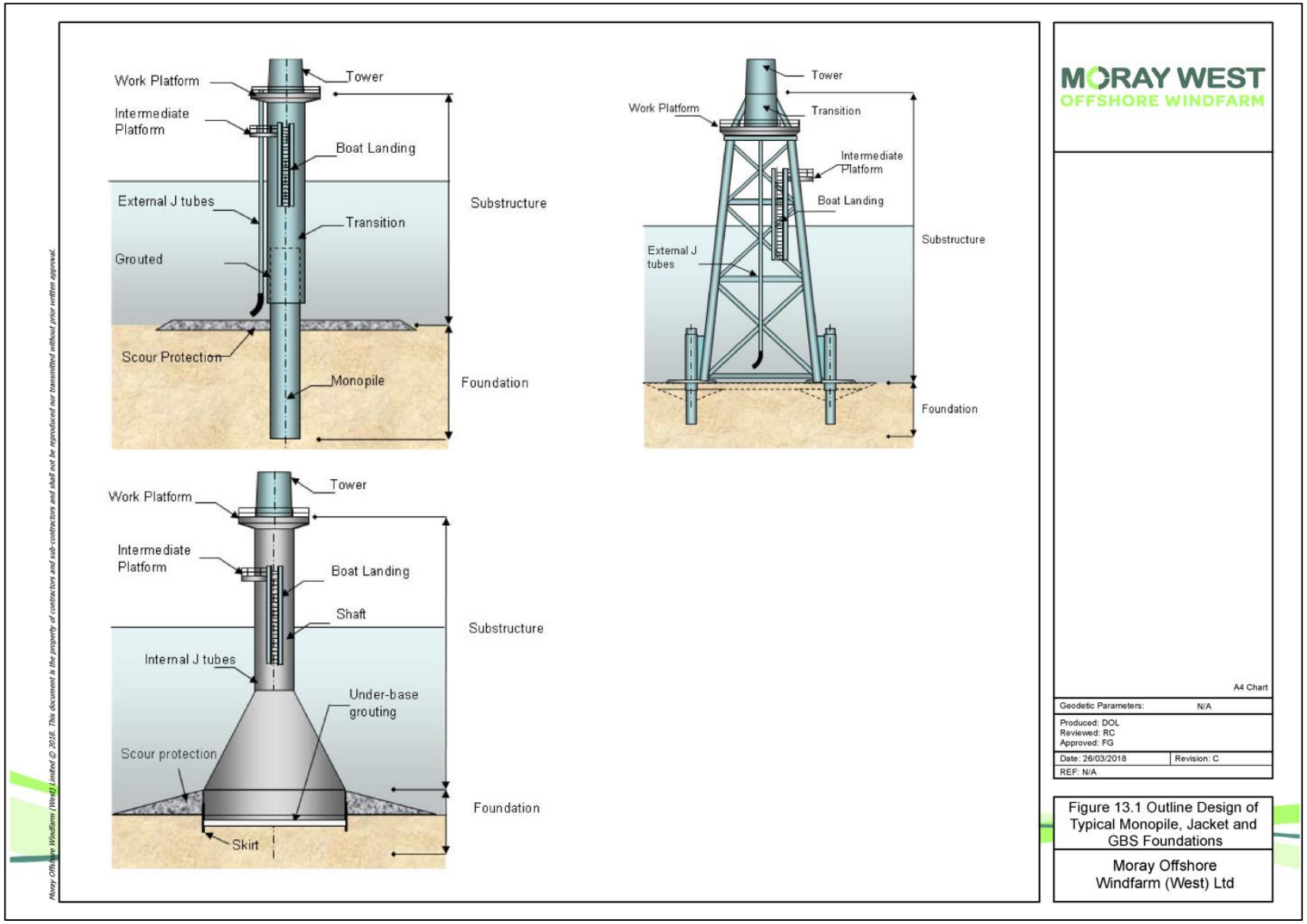

Figure 13.1: Outline design of typical monopile, jacket and GBS foundations

13.4.1 Under steady currents

Breusers *et al*. (1977) presented a simple expression for scour depth under live-bed scour (i.e. scour occurring in a dynamic sediment environment) which was extended by Sumer *et al*. (1992) who assessed the statistics of the original data to show that:

$$\frac{S_c}{D} = 1.3 \pm \sigma_{S_c/D}$$

(Eq. 3)

Where $\sigma_{Sc/D}$ is the standard deviation of observed ratio S_c /D. Based on the experimental data, $\sigma_{Sc/D}$ is approximately 0.7, hence, 95 % of observed scour falls within two standard deviations, i.e. in the range $0 < S_c/D < 2.7$. Based on the central value $S_c = 1.3$ D (as also recommended in DNV, 2016), the maximum equilibrium depth of scour for the largest diameter monopile (15 m) is estimated to be 19.5 m. The equivalent value for the smallest diameter monopile (12 m) is 15.6 m.

13.4.2 Under waves and combined wave-current forcing

The mechanisms of scour associated with wave action are limited when the oscillatory displacement of water at the seabed is less than the length or size of the structure around which it is flowing. This ratio is typically parameterised using the Keulegan-Carpenter (KC) number:

$$KC = \frac{U_{0m}T}{D}$$

(Eq. 4)

Where U_{0m} is the peak orbital velocity at the seabed (e.g. using methods presented in Soulsby, 1997) and T is the corresponding wave period. Sumer and Fredsøe (2001) found that for KC < 6, wave action is insufficient to cause significant scour in both wave alone and combined wave-current scenarios.

Values of KC are < 6 for monopiles in the Moray West Site, for a range of extreme wave conditions (Table 13.1) and for the full expected range of tidally affected water depths across the site (approximately -35 mLAT to -54 mLAT). Therefore, it is predicted that waves do not have the potential to contribute to scour development around monopiles in the Moray West Site.

Table 13.1: Extreme omni-directional wave conditions considered.

Return Period	Significant Wave Height (m)	Peak Wave Period (s)
1:1 year	6.7	9.6
1:10 year	8	10.1
1:50 year	8.9	10.3

The value of U_{0m} for given (offshore or deep water) wave conditions depends upon the local water depth, which varies between approximately -26.6 mLAT to -72.7 mLAT within the array due to variations in absolute bathymetry and relative water level; the influence of shoaling and wave breaking have been ignored in the present study (a conservative assumption).

13.5 Scour assessment method: jacket foundations

The outline design of the proposed four legged jacket foundation for WTGs is shown in Figure 13.1. Above the seabed jacket foundations comprise a lattice of vertical primary members and diagonal cross-member bracing, up to 3.5 m in diameter; it is assumed that either no near-bed horizontal cross-member bracing is required, or that it is sufficiently high above the bed to not induce significant local scour. The four legged

jacket foundation will have a nominally square plan view cross-section with base edge dimensions of between 35 m and 40 m (Chapter 4: Description of the Development).

The jacket foundation is anchored to the seabed at each corner by a pile driven into the seabed, between 3.5 and 4.0 m in diameter. A jacket foundation structure may result in the occurrence of both local and group or global scour. The local scour is the local response to individual structure members.

13.5.1 Under steady currents

Under steady currents alone, the equilibrium scour depth around the vertical members of the structure base can be assessed using the same methods as for monopiles, unless significant interaction between individual members occurs. The potential for such interaction is discussed below.

The main scour development will be in proportion to the size of the largest exposed member near to the seabed. In this case, the largest exposed member will be the top of the pin pile: for the largest jacket foundation this will have a diameter of 4.0 m. Using equation 3, the scour depth for the largest jacket foundation is therefore estimated as 5.2 m. The equivalent value for the smallest jacket foundation pin pile diameter or the primary member of a large jacket (3.5 m) is 4.6 m.

In the case of currents, inter-member interaction has been shown to be a factor when the gap to pile diameter ratio (G/D) is less than 3. In this case limited experiments by Gormsen and Larson (1984) have shown that the scour depth might increase by between 5 % and 15%. However, in the case of the present study the gap ratio for members at the base of the jacket foundation structure is much greater than 3, and so no significant in-combination change is expected.

Empirical relationships also presented in Sumer and Fredsøe (2002) indicate that the depth of group scour (measured from the initial sediment surface to the new sediment surface surrounding local scour holes) for an array of piles similar to a jacket foundation (2x2) can be approximated as 0.4D (i.e. approximately 1.6 m based on a 4.0 m diameter pin pile). On the basis of visual descriptions of group scour pits, their extent from the edge of the structure is estimated as half the width of the structure and following a broadly similar plan shape to that of the jacket foundation (i.e. square).

Together, the predicted maximum scour depth at the corner piles (5.2 m) and the group scour (1.6 m) is conservatively consistent with evidence from the field reported in Whitehouse (1998), summarising another report that scour depths of between 0.6 m and 3.6 m were observed below jacket structures in the Gulf of Mexico (although these could potentially be constrained from the maximum possible equilibrium scour depth by environmental factors and could also be subject to uncertainties in the seabed reference datum against which to measure the scour).

On the basis of the proposed jacket design, the diagonal bracing members are not predicted to induce seabed scouring due to the distance of separation from the seabed.

13.5.2 Under waves and combined wave-current forcing

Values of the KC parameter (Eq. 4) were calculated for a 4.0 m diameter jacket pin pile from the extreme wave conditions found at the site (Table 13.1)). Values of KC are less than 6 over the full expected range of tidally affected water depths across the site (approximately -35 mLAT to -54 mLAT) and so it is predicted that waves do not have the potential to contribute to scour development around the base of the jacket foundations.

The diagonal bracing members will have a smaller diameter and so a larger KC value. However, they are again not predicted to induce seabed scouring due to the distance of separation from the seabed. For moderate KC numbers a sufficient distance to avoid scour is approximately one diameter for a horizontal member, increasing to approximately three diameters under increasing KC numbers.

As such, little or no significant additional scour is predicted to result from waves, either alone or in combination with currents.

13.6 Scour assessment method: gravity base foundations

The outline design of a conical GBS foundation is shown in Figure 13.1. The GBS foundation to be used in the Moray West Site will have a vertical walled cylindrical base that does not taper with height. The base diameter would be 45 m (for the smallest option) and 55 m (for the largest).

The evidence base for scour associated with GBS foundation installations is relatively limited in comparison to that for monopiles and typically refers to oil and gas platforms which have a wide range of shapes and designs. Attempts to produce empirical relationships are complicated by this diversity of GBS foundation structures.

The pattern and extent of scouring and the location of the point of maximum scouring may also vary depending upon the GBS foundations relative size and shape. For the purposes of the present assessment, scour is assumed to be equally present at the predicted depth around the whole perimeter of the GBS foundation, decreasing in depth with distance from the base edge to the ambient bed level at the angle of internal friction for the sediment (32°).

13.6.1 Under steady currents

Hoffmans and Verheij (1997) presented the Khalfin (1983) current-only scour predictor for a GBS foundation with the following modified features:

- The pile diameter is replaced by a characteristic length, D_c, taken as the average of the length and breadth of the GBS foundation;
- The flow depth, h, in the water depth to diameter ratio h/D_c is replaced by the GBS foundation height, h_c; and
- The undisturbed depth-averaged flow velocity is multiplied by $\alpha_c/2$ with $\alpha_c = 2$ for a circular structure (or $\alpha_c = 2.3$ for a rectangular GBS foundation expressing the additional turbulence generated at the corners of the structure). The coefficient α_c is an influence factor that represents the flow enhancement near the structure caused by the structure.

The equilibrium scour depth, S, is then given by:

$$\frac{S}{D_c} = 8.96\left(2\frac{0.5a_cU}{U_{cr}} - 1\right)\left(\frac{h_c}{D_c}\right)^{1.43}\left(\frac{(0.5a_cU)^2}{gh}\right)^N$$

With $$U/U_{cr} = 1 \;\; for\; U > U_{cr}$$

And $$N = 0.83\left(\frac{h_c}{D_c}\right)^{0.34}$$

Where: U_{cr} is the value of depth-averaged flow velocity for initiation of sediment motion (m/s); and

g is the gravitational acceleration constant (9.81 m/s^2)

(Eq. 5)

Assuming $h_c = h = 40.8$ m and $U>U_{cr}$, the maximum equilibrium depth of scour for the largest diameter GBS foundation ($D_c = 55$ m) is estimated to be 1.32 m. The equivalent value for the smallest diameter GBS foundation ($D_c = 45$ m) is 1.14 m.

13.6.2 Under waves and combined wave-current forcing

The large scale of the GBS foundation structures in relation to both water depth and wave orbital excursion length mean that the processes governing structure-flow interaction and scour are different from that described in relation to monopile and jacket structures. As such, relationships for scour

associated with a shallow conical top GBS foundation for waves alone are also not readily available from the literature. However, Whitehouse (2004) provides a relationship for a 'girder top' GBS, predicting equilibrium scour depth in response to waves alone of:

$$S_e = 0.04D$$

(Eq. 6)

Yielding a value of between 1.8 m and 2.2 m for a 45 m and 55 m diameter GBS foundation, respectively. Empirical results from physical model testing by Whitehouse (2004) suggest that the maximum scour depth around a conical top GBS foundation (broadly similar to that proposed here) under combined wave-current conditions will be:

$$S_e = 0.064D$$

(Eq. 7)

Yielding a value of between 2.9 m and 3.5 m for a 45 m and 55 m diameter GBS foundation, respectively.

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MORAY WEST
OFFSHORE WINDFARM

Benthic Survey Report

Moray Offshore Windfarm (West) Limited

Technical Appendix 7.1

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1 Introduction

This document has been prepared by Precision Marine Survey Ltd. (PMSL) on behalf of Moray Offshore Windfarm (West) Limited ('Moray West'). It provides a summary of the results of survey work undertaken to characterise the benthic communities present in the Moray West Site and along the Offshore Export Cable Corridor. These results will in turn inform the understanding of baseline conditions relevant to assessment of the potential impacts of the proposed wind farm and associated offshore transmission infrastructure (OfTI) on benthic ecology as part of the Environmental Impact Assessment (EIA) process. It is expected that survey results will also inform refinements in project design as required.

2 Background

The proposed Wind Farm (Figure 2.1) is located approximately 22.5 km from the Scottish coast at its closest point and covers an area of 225 km^2. An Offshore Export Cable Corridor, which is approximately 3 km wide, runs from the southern Moray West Site boundary to the Moray and Aberdeenshire coast where cable landfall will be made.

In line with the Wind Farm and OfTI Scoping Reports (Moray West, 2017a; 2017b) the Development (i.e. the Wind Farm and the OfTI) will consist of an array of up to85 wind turbines linked by inter-array cables, up to two offshore substation platforms linked by interconnector cables, and export cables running from the OSPs to a landfall.

This technical report supplements the EIA for which the Development has been subject to. The outputs of the EIA process will be presented alongside an application for offshore consents within an Environmental Report.

2.1 Benthic Survey

The survey methods employed for the Moray West benthic baseline survey were comparable to those applied previously during the Moray East Offshore Wind Farm and Beatrice Offshore Wind Farm benthic characterisation surveys in order to fulfil perceived Marine Scotland and Scottish Natural Heritage (SNH) requirements and also ensure a consistent approach to survey across adjacent wind farm sites. Survey methods followed those outlined in the Moray West Benthic Scope of Works (Moray West, 2017c) submitted to the Marine Scotland Licensing Operations Team (MS LOT) for approval in April 2017 and subsequently approved.

As undertaken during previous surveys of the Moray East Site and Moray East Export Cable Corridor, the Moray West benthic survey utilised a programme of single benthic samples taken using a random stratified survey plan to cover the main seabed habitats/sedimentary features within the development area and also sampling locations just outside the wind farm boundary to cover any potential secondary impacts. The previous Moray East (and Beatrice Offshore Wind Farm) surveys have already sampled a number of reference sites outside of the primary/secondary impact zone to determine whether similar communities may occur there (with a view to possible future reference locations during subsequent monitoring campaigns) so it was not considered necessary to repeat these during the Moray West survey. Grab sampling for fauna and particle size distribution (PSD) analysis along with drop down video (DDV) survey were undertaken at a series of survey stations within and adjacent of the development area with a subset of stations sampled for contaminants. Beam trawling was also undertaken at a number of stations within the Moray West site to assess epifaunal/demersal fish communities. Along the Offshore Export Cable Corridor benthic survey was primarily undertaken using drop down video with grab sampling undertaken at a subset of sites PSD and contaminants analysis.

A summary of sampling effort is provided in Table 2.1 with the location of sampling stations and survey methodologies employed is given in (Figure 2.1).

Table 2.1: Moray West & Offshore Export Cable Corridor Benthic Sampling Effort

Survey Type	No. of Stations
DDV & Benthic Grabs (Fauna & PSD) in Moray West site	80 stations
DDV along the Offshore Export Cable Corridor	28 stations
Beam Trawls in Moray West site	15 stations
Contaminant Samples in Moray West site & Offshore Export Cable Corridor	10 stations
PSD Samples along the Offshore Export Cable Corridor	12 stations

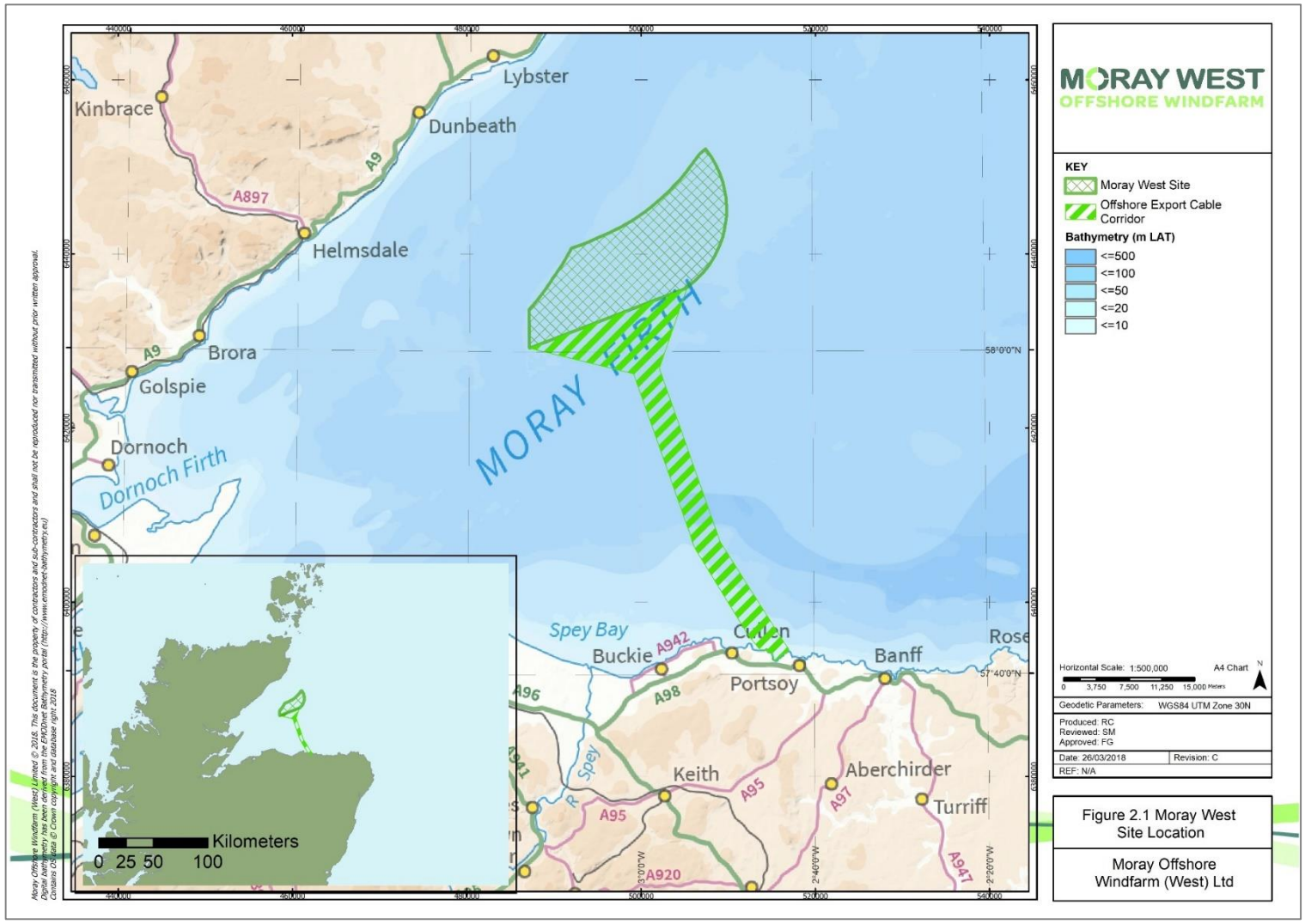


Figure 2.1 Moray West Wind Farm Sampling Layout

2.2 Field Methods

2.2.1 DDV Survey Methodology

Drop Down Video (DDV) methods followed standard procedures outlined in Coggan *et al*, 2007, Limpenny *et al*, 2010 and other appropriate guidance e.g. Marine Monitoring Handbook procedural guidance 3.5, MALSF Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites (Ware and Kenny, 2011). The survey utilised a camera system which included a modified Imenco DDV and digital stills camera (14 megapixels minimum with HD video recording) with appropriate lighting system and strobe flash. The drop down stills/video system was linked by umbilical to the surface to allow a real-time video feed to the surface for SD video recording. An additional feed of HD video to the surface using a supplementary HD-SDI video camera was also utilised at the DDV sites. A surface PC monitored linked to GPS allowed the vessel position to be overlain on relevant survey information (admiralty charts and survey positions).

The video system was set to allow an oblique view which could be adjusted as required along with camera height to allow optimum images to be obtained given that visibility in the survey area is often rather variable. Digital stills/HD frame grabs were taken at representative habitats at each site and the video system incorporated a laser scaling system (at approximately cobble size) to allow an assessment of scale for sedimentary/biological features. Video was recorded digitally using a DigitalEdge DVR system to provide GPS overlay and record and manage video data. This system allowed real time monitoring of HD and SD video, take full HD frame grabs (in addition to the stills taken using the stills camera) and also log survey data. The DigitalEdge system incorporated black box recording and multiple hard drives to provide redundancy and the video data was also archived on external hard drives for further analysis. GPS track files were also logged on the PC survey mapping software.

At each survey station the immediate survey area was checked for obstructions (e.g. static gear) before the camera was deployed. Survey positioning was undertaken using the vessel GPS in conjunction with an Ashtech Promark dGPS system. The drop down camera system was deployed at each benthic station and allowed to drift just above the sea bed for a minimum of five minutes (or 100m) and the camera was periodically allowed to rest on the seabed to allow still photographs to be extracted (tidal conditions permitting). The video camera was kept as close to the seabed as possible to allow for a clear representation of the sea bed (usually <1m) and faunal type to be recorded. A single drift was undertaken at each station although in some instance additional drifts were undertaken e.g. if conditions were poor or Annex I habitats were potentially present and the most representative video drift at each station subsequently analysed for habitat/species assessment. Notes were taken during survey (start end times, seabed habitats, dominant fauna/flora and potential Annex I habitats) and also logged using the DigitalEdge DVR software.

An assessment of video footage was made in-situ to assess the potential for Annex I habitats (e.g. Sabellaria reef or stony/cobble reef). These assessments were undertaken with reference to the currently available guidance notes i.e. Gubbay (2007) for potential Sabellaria reefs, and Irving (2009) for potential cobble reefs. At stony habitats inshore or offshore where there was potential for Annex I habitat several video transects were often employed to clarify habitat type and at one station within the wind farm where Annex I stony reef was identified additional transects either side of the target feature were surveyed to provide an assessment of the scale of the feature. The current survey aims to provide additional spatial information on any areas of identified Annex I reef, which will adequately inform EIA. Post-consent, and where any interaction with Annex I habitats may occur, a dedicated Annex I habitats survey could then be undertaken to inform detailed routing/installation plans. A summary of survey details for the DDV survey are provided in Annex 7.1A.

2.2.2 Benthic Grab Survey Methodology

The benthic grab survey was carried out following standard procedures e.g. Marine Monitoring Handbook procedural guideline 3-9, MALSF Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites (Ware and Kenny, 2011) and other standard guidelines (Limpenny et al 2010, DEFRA 2004a, Rees et al 1990, Proudfoot et al 2003, Cooper & Rees 2002, ICES/OSPAR 2000 & DEFRA 2004b). The survey utilised a 0.1m2 Mini-Hamon grab for sampling coarser marine sediments with sediment sieved in-situ through a 1mm sieve and an additional sub-sample taken at each site for PSD analysis. As outlined above, prior to grab sampling an inspection of seabed habitats was undertaken at each site using an underwater video camera to document the presence of any Annex I habitats at the sample sites and provide additional information on epibenthic communities in addition to highlighting any underwater hazards.

Following an assessment of the site by DDV the vessel was repositioned at each site upon which the vessel was taken out of gear and the 0.1m^2 Hamon grab lowered by winch into the water. The winch was then used to lower the grab to the seabed at a rate of approximately 1 m/s and the winch slowed as the length of warp indicated it was approaching the seabed. Once the grab had landed, as evident by the slackening of the winch wire, the winch was stopped and the position of the grab was taken from the GPS along with time and water depth and recorded on the grab logsheet. The winch was then used to raise the grab off the seabed and docked into the retrieval frame on board the survey vessel and slowly bought aboard and lowered onto a metal frame with a sample box placed beneath.

With the grab resting on the frame, the grab was inspected to assess whether it had deployed correctly and the winch cable was then slackened to allow the lifting arm to be raised and the sample deposited into the plastic box positioned beneath the frame with the grab scoop checked to ensure all sediment had been released. The grab arm was then cocked ready for the next deployment and the grab wire held under tension to avoid triggering the grab.

Once the sample box was removed from the grab frame, the volume of sediment was assessed to check whether it met minimum requirements (5 litres) and the sediment description was recorded on the grab logsheet. A minimum of three attempts were made at each station to collect an adequate sample if volumes were low. If required the vessel was repositioned slightly (within 50m) to allow additional attempts. In the instance that low sample volumes were collected then all samples were kept and the best/most representative one used for the faunal sample – expert judgement by the lead surveyor was used to determine whether sufficient material was present to warrant utilising the sample. Details of failed attempts were recorded on the grab logsheet. Once a valid sample had been collected then the sample details were entered onto the logsheet and the sample box transferred for processing with the sample label/container within the sample box. The grab was then washed out with water ready for the next deployment. The collected sample was transferred to the sieving area and excess water emptied into the 1mm sieve. The raw sample was then photographed with the labelled bucket lid visible and the sample volume measured using the graduated sample container.

The remainder of the sample was then transferred to a large sealable bucket to transport back to the laboratory for final sieving and processing. The sample was gently washed through a 1mm and 5mm sieve using a low-pressure hose. Care was taken not to allow sieves to overfill and if required sieves were puddled in seawater to allow finer sediments to pass through without damaging any fauna. The residue left after sieving was then photographed with a label and the residues kept in a sealable sample bucket. If there was a significant 5mm fraction this was put into a separate bucket labelled '>5mm fraction' otherwise the full residue (>1mm fraction) was transferred to a single bucket. In this process any larger or delicate animals were picked out using forceps and transferred to the sample bucket and the remaining residue gently transferred to the bucket with back-washing over a sample box (to collect any spillage) used to ensure all residue was collected. The sieves(s) were then checked and any animals caught in the sieve mesh extracted using forceps.

The sample buckets were then checked to make sure they had the correct labels which included the project title, date, survey reference and station number, sample type (PSA or Faunal) and sieve fraction as appropriate. Sample details were written on both the lid and the bucket side with an adhesive label also attached to the lid. A labelled tag was also placed inside the bucket which was then topped up with 4-5% buffered formalin solution with the volume of formalin equal or greater than the volume of sediment. The bucket lid was then secured onto the bucket and placed into storage for subsequent processing. The sample details for each sample were then entered onto the logsheet and sample tracking database. A PSD sample was also taken at each site whereby sediment was removed from the grab sample using a plastic scoop to extract a representative sub-sample of the sediment. A minimum of 500 ml was usually taken for PSD and the sediment sample was then transferred to a labelled plastic bag and then placed into a labelled plastic tub. Labels were checked against the logsheet and details entered as appropriate before the sample was transferred to a freezer for storage prior to analysis.

Additional samples for contaminants were undertaken at taken at 10 stations using a 0.1m^2 day grab with stainless steel jaws which allows an undisturbed surficial sediment sample to be taken. Contaminant samples were taken with the appropriate stainless steel or plastic scoop and transferred to appropriate containers for storage in a cool box/fridge prior to analysis.

2.2.3 Beam Trawl Methodology

At each trawl station, a 2m beam trawl with a minimum 10mm mesh and 5mm cod end liner was lowered to the seabed at a predetermined start point and towed for a duration of 10 minutes at 2 to 3 knots with a maximum tow length of 1000m. The start point for each trawl commenced from the point at which the winch is locked and upon completion of the time interval, or required distance, the trawl was then hauled to the surface and the sample recovered. The cod end will be opened over a large fish box or other suitable container to contain the whole catch, with the net then checked for any remaining epifauna and fish, before the cod end was fastened prior to redeployment at the next station.

The total volume of the catch was then sorted with the fish species separated from the epifaunal invertebrates. A survey log was maintained with digital images taken of the unsorted catch and sorted catch for each sampling station.

The epifaunal invertebrates were separated to species level where possible and enumerated with examples of each species retained for a reference collection. Where species could not be identified in the field (smaller fish, polychaetes, crustaceans, Bryozoa, Hydrozoa etc.) samples were retained for laboratory analysis. Small fish specimens and the unidentified epifauna was stored in tightly sealed 10 litre plastic buckets, containing a 4% seawater buffered formalin solution. Any notable observations from individual trawls was also recorded on the survey log (high amount of shell, rocks, cobbles, weed and other debris, including total catch volume). In addition to the enumeration and identification of epibenthic invertebrates, key commercial fish species were also measured with the sex of elasmobranchs and adult fish also identified where possible.

2.3 Laboratory Methodology for Benthic Samples

All laboratory methodologies were based on best practice and follow tried and tested method statements within the industry (Marine Monitoring Handbook procedural guideline 3-9; Ware and Kenny, 2011 and Worsfield et al 2010). Laboratory analysis was undertaken by experienced marine biologists/taxonomists and PMSL are members of the National Marine Biological and Analytical Quality Control scheme (NMBAQC). A standard sample tracking procedure was followed throughout the analysis period.

2.3.1 Sample Sorting

The sorting methodology followed standard procedures as follows:

Each sample was sieved in freshwater water and then rinsed with running tap water through a nest of 20cm, diameter 5mm and 1mm stainless steel sieves with larger sieves used as appropriate to separate cobbles etc. The sieve contents were then backwashed over a white tray (to catch any potential spillage) into pre-labelled 5 litre plastic storage buckets or other suitable containers.

Each sample was then re-washed through a nest of sieves, with the smallest mesh aperture of 1mm, to remove the preservative and partition the sample for ease of sorting. The residue from each sieve was then gently washed into separate white trays. Water was added to the trays and the contents agitated and immediately after agitation, the light fraction was decanted to another tray. This procedure was repeated up to three times, and each tray of light fraction was examined separately to the heavy fraction.

The trays were marked with the appropriate sample code (relating to the client, date, specific site, sample and replicate no.) and all fractions were then examined as a monolayer under water in white trays, both by eye under a fluorescent bench light and 1.5x illuminated magnifier to remove larger animals with the remaining residue from the light and heavy fractions decanted into petri dishes for further sorting by binocular microscope stereo microscope (6x to 10x magnification). The fauna and residue derived from this process were then retained and stored by group in appropriately labelled containers. Each fraction was decanted into separate 100mm petri dishes and examined under a stereoscopic microscope with 20x eyepieces giving a maximum magnification of up to 80x. The fauna derived were added to the retained containers, preserved and stored ready for identification. Each petri dish was checked for a final time by another member of staff.

2.3.2 Taxonomic Identification

Identification was carried out using binocular zoom microscopes with 10x and 20x eyepieces, giving a maximum magnification of up to 80x. An additional 2x objective were also used as appropriate to increase the potential magnification to 160x. Compound microscopes were also used for further magnification, up to 800x.

Identification of infaunal samples was undertaken to the lowest possible taxonomic level (i.e. species) and during identification, all individuals were initially separated into families, with part animals being assigned to families where possible. The macrofaunal animals were identified to species level using standard taxonomic keys, low and high power stereoscopic microscopes and dissection, when necessary, for identification. Incomplete animals without anterior ends were not recorded as individuals within the quantitative dataset but were identified where possible and recorded as present. Similarly, colonial sessile epibenthic taxa were recorded as present and not included within the infaunal quantitative data set.

Infauna were identified using standard taxonomic literature including the most up to date taxonomic keys and other more recent taxonomic publications or workshop (NMBAQC) proceedings and reporting nomenclature used the World Register of Marine Species (WoRMS) database (Appeltans, 2011).

Each sample residue was described textually and the residue retained for possible further analysis and Analytical Quality Control (AQC).

2.3.3 Biomass

Biomass analysis was performed by wet weight (tissue blotted) and carried out for each taxa. Each item to be weighed was placed on blotting paper for a minimum of 30 seconds to allow absorption of preservative into the blotting paper after which the individuals were placed on the microbalance and the reading taken. Animals with shells are weighed with shells attached and for bivalves any fluid were

drained off prior to weighing whilst echinoids were punctured and drained before weighing. The macrofaunal organisms were then placed back in their respective pots and stored. Biomass calculations included all identifiable fragments and calculated to ± 0.1mg and all biomass data was recorded in grams or fractions thereof.

2.3.4 Particle Size Determination

Particle Size Analysis (PSA) was compliant with the latest NMBAQC guidance (Mason, 2016). Prior to processing each of the sediment samples were visually assessed and the sample was mixed thoroughly until homogeneity is reached. PSA was undertaken using a combination of laser granulometry (Malvern Mastersizer 3000) and dry sieving. Any sample containing sediment greater than 1mm was processed using laser granulometry for the <1mm fraction and dry sieving for the >1mm fraction. Samples with no coarse fraction (>1mm) were processed by laser granulometry alone. A small sub-sample (approx. 100ml) was taken for laser granulometry and screened through a 1mm mesh sieve prior to analysis. If any evidence of coarser material was found then the remaining PSA sample was wet sieved through a 1mm sieve. The <1mm fraction was left to settle for 24 hours and the sediment then oven dried and weighed. The coarser sediment fraction (>1mm) was also oven dried and then dry sieved using an Endecotts sieve shaker for 20 minutes using a nest of sieves at 0.5phi intervals and each fraction weighed.

Data generated from these methods was analysed separately but for visualisation purposes the finer fractions were also merged to the coarse fraction (if present) to provide an overall grain size distribution for each sample following NMBAQC protocols. The combined data generated from the analysis of both the coarse and the fine fractions was subject to further analysis using the software programme Gradistat. Each sample was assigned a description based on the Folk and/or the Wentworth classification system. Statistics relating to particle size distribution (PSD) including mean/median grain size, skewness, kurtosis, sorting coefficient and bulk sediment classes (e.g. % silt, sand & gravel) were also calculated using the Gradistat software. These methods are consistent with the procedures identified at the recent NMBAQC PSA workshop on laboratory methods and those used for NMBAQC ring tests.

2.3.5 Loss on Ignition

Estimates of total organic carbon were determined by loss on ignition. Each sample was oven dried at 105ºC until the weight stabilised (± 0.01g). The weight of the sample was then recorded and the sample then placed into a kiln at 450ºC for 8 hours or until weights have stabilised. Once the sample had cooled sufficiently the sample was then re-weighed and the difference between the two weights expressed as the percentage loss on ignition (% LOI).

2.4 Data Analysis

2.4.1 Univariate Biological Parameters

A suite of standard biological parameters commonly utilised for benthic analysis were calculated using the Primer software package including the following:

- The total number of taxa at each station (per 0.1m^2)
- The total number of individuals at each station (per 0.1m^2)
- The total (wet weight) biomass (g) at each station (per 0.1m^2)
- Margalef's index of species richness (d)
- Shannon's diversity index (H')
- Pielou's evenness (J)

This index is a univariate measure of diversity which incorporates both the number of species and the distribution or equitability of individuals between species. High values of H' indicate a more diverse community whilst low values indicate low diversity.

This index is a univariate measure of evenness or equitability which describes the distribution of individuals between species. High values of J (approaching 1) indicate that the abundance of animals are evenly spread between species whilst low values of J (approaching 0) indicate that the majority of animals are comprised of a few species, a situation which often occurs in low diversity areas subject to disturbance or organic enrichment.

2.4.2 Multivariate Analysis

Cluster analysis is used to graphically display the similarity between samples based upon their species composition whereby the similarity between samples is calculated (in this case using the Bray-Curtis similarity coefficient) to produce a similarity matrix showing the percent similarity of sites (0% indicating no species in common and 100% indicating an identical community). Species data was square-root transformed prior to multivariate analysis.

These values are then used to plot a dendrogram or tree diagram in which sites are linked at their respective similarity to other sites and consequently it is possible to define groups of sites with similar species composition at a predefined level of similarity. Non-metric MDS is an ordination technique which graphically displays the (rank) similarity between sites as a 2-dimensional plot in which the distances between sites indicates the level of similarity between them. The stress value associated with an MDS plot indicates the how faithful the plot is in representing the similarity between sites. A measure of this stress on the two-dimensional representation is provided on the MDS plot. Stress values <0.2 correspond to a good ordination whilst stress values between 0.2 and 0.3 give a useful two-dimensional picture but one should not place too much reliance on the fine details of the plot. A stress value >0.3 indicates that the samples are close to being positioned in an arbitrary manner and should not be regarded as necessarily similar to one another. The station/sample groupings derived from cluster analysis have subsequently been superimposed onto the MDS plots and input into GIS and the characteristic species and mean environmental and biological parameters for each group calculated.

Station groupings were derived using the similarity profile permutation test (SIMPROF) within the PRIMER software package. The SIMPROF test looks for statistically significant evidence of genuine clusters in samples. Tests are performed at every node of a completed dendrogram, testing whether the group that has been subdivided has 'significant' internal structure. Characteristic taxa within each group were assessed using the SIMPER routine in PRIMER which identified taxa which contribute the most to similarity. The SIMPER routine allows comparisons between groups of stations to be made whereby following the comparison of similarities between groups the taxa responsible for the dissimilarities between stations are sub-listed in decreasing order of importance in order to facilitate the discrimination of the groups. This routine also provides information on the species responsible for within-site similarities and their contribution to the internal similarity of the group.

In order to assess the relationship between patterns in station groupings based on species data and the environmental parameters (water depth, sediment parameters) the BEST routine in Primer was utilised. This routine identifies correlations between individual environmental parameters and patterns in the infaunal assemblage and also identifies any combination of environmental parameters which gives the best overall correlation.

2.4.3 Biotope Classification

The results of data analysis in addition to information derived from DDV survey have been used to derive biotope codes for each station using shallow sea section of The Marine Habitat Classification for Britain and Ireland (Connor et al, 2004). This classification provides a tool to aid the management and conservation of marine habitats and uses a hierarchical classification which subdivides habitats into a series of levels each with a designated biotope code and accompanying descriptive text. Six levels exist within the shallow section of the classification as follows:

- Level 1 Environment (marine)
- Level 2 Broad habitat type
- Level 3 Habitat complex
- Level 4 Biotope complex
- Levels 5 & 6 Biotope or sub-biotope

For example, level 2 marine habitats include a number of broad habitats each with a corresponding code: Littoral Rock (**LR**), Littoral Sediment (**LS**), Infralittoral Rock (**IR**), Circalittoral Rock (**CR**) and Sublittoral Sediment (**SS**). Within each of these a series of habitat and biotope complexes are defined such as Sublittoral Sands (**SS.SSa**) within which are biotopes (or sub-biotopes) which provide the detailed description of habitat and assemblage for that community.

3 Results

3.1 Drop Down Video (DDV) Survey

In total 155 DDV deployments were undertaken at the 108 survey stations from the 13th May to the 27th May 2017 on the survey vessel 'Precision 1' and a summary of the video deployments is provided in Annex 7.1A. The video survey included repeat video deployments at a number of locations which was either due to poor visibility, strong tides, equipment malfunction which required repeat deployments, in areas with heterogeneous seabed habitat or at locations where there was the potential presence of Annex I habitat. A representative video deployment from each survey station has been analysed (Annex 7.1B) and representative stills/HD frame grabs collated (Annex 7.1C) with data from the other video deployments used for supplementary data where required. The DDV survey highlighted a range of different seabed habitats and in some areas several habitats were noted in the same video deployment. In some areas (e.g. the Offshore Export Cable Corridor) the differences between habitats were relatively obvious and quite clearly spatially separated whilst in other areas (e.g. the wind farm sites) more homogeneous habitats were often recorded which differed due to more subtle variations in mud or gravel content. For summary purposes, the seabed habitats have been broadly split into different sediment groupings and summarized in a series of tables with representative stills below. These tables include a summary of observed taxa within the habitats along with the % of stations/habitats in which they occurred and an indication of their abundance following the SACFOR scale (S=Super-abundant; A=Abundant; C=Common; F=Frequent; O=Occasional; R=Rare).

3.1.1 Offshore Export Cable Corridor

Inshore areas of relatively clean Sublittoral Sands (**SS.SSa**) often with a small proportion of shell grit or occasionally fine gravel were recorded at stations C13, C17 and C21. These had a relatively impoverished epifaunal community with *Asterias rubens* and sand eels (Ammodytidae) occasional recorded along with low numbers of crabs (Brachyura, *Necora puber* and *Pagurus bernhardus*) and rare observations of plaice (Table 3.1).

Table 3.1: Video Summary: Rippled Sand

Rippled Sand	
Biotope: SS.SSa	
3 stations (C13, C17, C21)	
Taxa in >25% of recorded habitats: *Asterias rubens* (75% O-F), Ammodytidae (75% R-F), Brachyura (33% R), Ctenophora# (33% R), *Necora puber* (33% O), *Pagurus bernhardus* (33% R), *Pleuronectes platessa* (33% R) # in water column/drifting on bed	

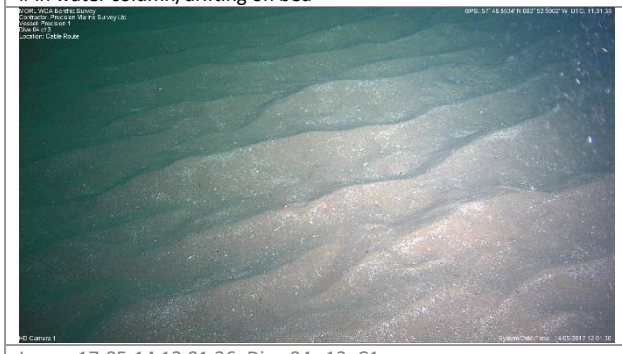
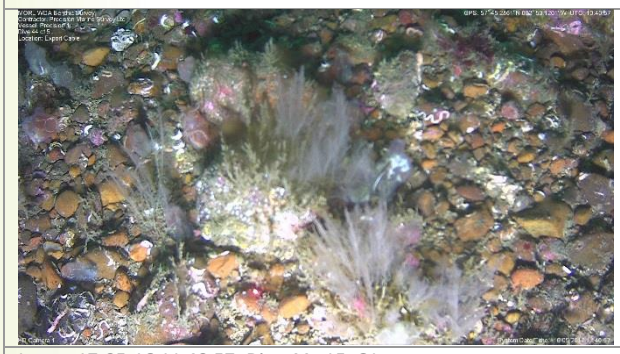
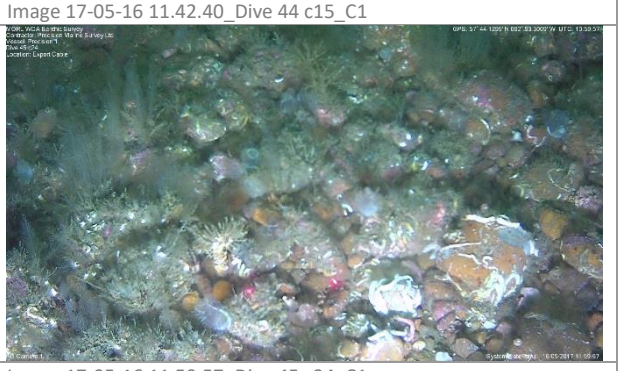



Image 17-05-14 12.01.36_Dive 04 c13_C1	Image 17-05-15 13.17.31_Dive 36 c17_C1

Extensive areas of inshore coarse mixed sediments were observed at stations C15, C16, C18 and C24 (Table 3.2) which comprised of heterogeneous areas of mixed gravel and stones, pebble and cobble and

occasional small boulder often on or embedded in sand/gravel. Such habitats were typically quite variable ranging from relatively impoverished flat embedded pebbles/cobble to more mixed pebble/shell and cobble or occasional boulder with faunal turf communities. Such habitats were characterised by a variable and often rather patchy hydroid/bryozoan turf (notably *Nemertesia antennina*), Serpulids (e.g. *Spirobranchus* spp.), echinoderms such as *Asterias rubens* and *Crossaster papposus* or brittlestars and a variety of other encrusting taxa such as ascidians and dead man's fingers and occasional patches of red algae.

Table 3.2: Video Summary: Coarse Mixed Sediments with Pebbles, Cobble or Boulders

Coarse mixed sediments with pebbles, cobble or boulders	
Biotopes: Mosaic of SS.SCS.CCS / SS.SMx.CMx biotopes & inshore sheltered variants of CR.HCR.XFa.SpNemAdia or other CR biotopes	
4 stations (C15, C16, C18, C24)	
Taxa in >25% of recorded habitats: *Asterias rubens* (100% O-C), *Corella parallelogramma* (100% F-A), *Crossaster papposus* (100% R-F), Hydrozoa/Bryozoa (100% A), *Lanice conchilega* (100% R-A), *Lithothamnion* spp. (100% C-A), *Nemertesia antennina* (100% F-A), Serpulidae (100% A), *Actiniaria* (75% O-R), *Antedon bifida* (75% O-F), *Ascidiella aspersa* (75% O-C), *Echinus esculentus* (75% O-C) , *Henricia* (75% R-O), Majoidea (75% R-O), *Munida rugosa* (75% O-A), *Ophiura* (75% O-C), Pectinidae (50% R-O), *Pholis gunnellus* (50% R), Rhodophyta - filamentous (50% O-F), Rhodophyta - foliose (50% F) **Other Taxa:** *Aequipecten opercularis*, *Alcyonium digitatum*, Asteroidea, *Brachyura*, Buccinidae, *Calliostoma zizyphinum*, *Delesseria sanguinea*, *Echinocardium cordatum*, *Eupolymnia nebulosa*, *Hyas coarctatus*, *Lithodes maja*, *Luidia ciliaris*, *Necora puber*, *Ophiocomina nigra*, *Ophiothrix fragilis*, *Pecten maximus*	
 Image 17-05-16 11.40.57_Dive 44 c15_C1	 Image 17-05-16 11.42.40_Dive 44 c15_C1
 Image 17-05-15 12.48.46_Dive 35 c16_C1	 Image 17-05-16 11.59.57_Dive 45 c24_C1
 Image 17-05-16 10.05.03_Dive 40 c18_C1	 Image 17-05-15 12.48.21_Dive 35 c16_C1

Such habitats were inherently patchy or heterogeneous and forms a mosaic of Circalittoral Coarse sediments (**SS.SCS.CCS**) or **SS.SMx.CMx** (Circalittoral mixed sediment) which show some correlation to a number of biotopes and more diverse areas resembled somewhat sheltered inshore variants of rocky biotopes such as **CR.HCR.XFa.SpNemAdia** (Sparse sponges, *Nemertesia* spp. and *Alcyonidium diaphanum* on circalittoral mixed substrata) or uncertain variants of **SS.SMx.CMx.FluHyd** (*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment) albeit lacking *Flustra foliacea*. Occasional patches of cobble/boulder in some areas also resembled an inshore variant of **CR.MCR.EcCr.FaAlCr.Pom** (Faunal and algal crusts with *Pomatoceros triqueter* and sparse *Alcyonium digitatum* on exposed to moderately wave-exposed circalittoral rock) or in very barren areas a more stable variant of **SS.SCS.CCS.PomB** (*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles). Some areas had small patches of more consolidated cobble/boulder which could be considered clast supported albeit rather small scale. Such habitats (often similar to the biotope **CR.HCR.XFa.SpNemAdia)** could potentially be lower grade stony reef although they tended to have limited elevation with limited extent (<25m^2) and interspersed with wider areas of pebbles, gravel and cobble.

One station at the inshore end of the Offshore Export Cable Corridor (C19) was characterised by sand/gravelly sand (**SS.SCS.CCS**) with patchy areas cobbles/pebbles (Table 3.3). This habitat was rather heterogenous/patchy but generally characterised by areas of brittlestar beds which included variable densities of *Ophiocomina nigra* and *Ophiothrix fragilis* often reaching Abundant or Super Abundant densities. Patches or brittlestars were also recorded in other adjacent stations but at this station a number of video deployments indicated a quite extensive brittlestar bed on mixed sediment **SS.SMx.CMx.OphMx** (*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment). A variety of other epifaunal/encrusting taxa were recorded including *Ascidiella aspersa*, *Lithothamnion* spp., *Ophiura* sp., Serpulidae (*Spirobranchus* spp.), *Alcyonium digitatum*, Ascidiacea, patchy Hydrozoa/Bryozoa turf, *Nemertesia antennina*, *Munida rugosa* and *Asterias rubens*.

Table 3.3: Video Summary: Coarse Sand/Gravelly Sand with Cobble & Brittlestars

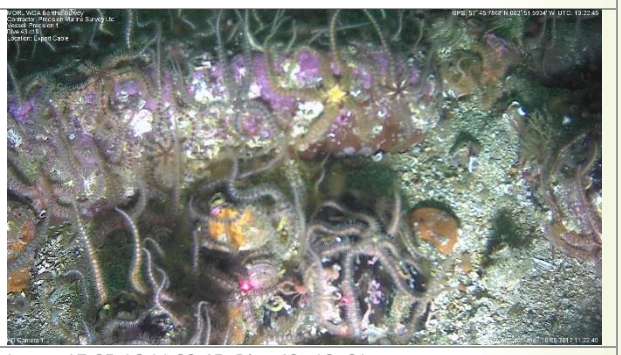
Coarse sand/gravelly sand with cobble & brittlestars	
Biotopes: SS.SCS.CCS & SS.SMx.CMx.OphMx	
1 station (C19)	
Taxa: *Ophiocomina nigra* (S-C), *Ophiothrix fragilis* (S-C), *Ascidiella aspersa* (A), Lithothamnion spp. (A), Ophiura (A), Serpulidae (A), *Alcyonium digitatum* (C), Ascidiacea (C), Hydrozoa/Bryozoa (C), *Munida rugosa* (F), *Nemertesia antennina* (F), *Asterias rubens* (O), *Corella parallelogramma* (O), *Echinus esculentus* (O), *Lanice conchilega* (O), Actiniaria (R), Brachyura (R), *Crossaster papposus* (R)	
	
Image 17-05-16 11.13.47_Dive 43 c19_C1	Image 17-05-16 11.22.45_Dive 43 c19_C1

Table 3.3: Video Summary: Coarse Sand/Gravelly Sand with Cobble & Brittlestars

Image 17-05-16 11.23.04_Dive 43 c19_C1	Image 17-05-16 11.23.11_Dive 43 c19_C1

Other stations toward the inshore end of the Offshore Export Cable Corridor (stations C14, C20, C21 and C22) and one station offshore closer to the wind farm (station C3) included habitats which were characterised by variable/mixed sand or gravelly sand, often with patchy areas of stones, gravel or cobble (Table 3.4). These habitats typically formed a mosaic of **SS.SSa** and/or **SS.SCS.CCS.** From an epifaunal perspective the cobble/stony areas at some stations could to be a variant of biotopes such as **SS.SSa.IFiSa.ScupHyd** (*Sertularia cupressina* and *Hydrallmania falcata* on tide-swept sublittoral sand with cobbles or pebbles) or even an impoverished **SS.SMx.CMx.FluHyd** (*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment) but were too variable/patchy to derive a definitive biotope. Taxa includes a rather sparse hydroid/bryozoan turf on stones/cobble with Serpulidae (*Spirobranchus* spp.), barnacles, *Lanice conchilega*, *Lithothamnion* spp. and *Asterias rubens*.

Table 3.4: Video Summary: Variable Coarse Sediment with Sand or Gravelly Sand with Stones, Gravel or Cobble

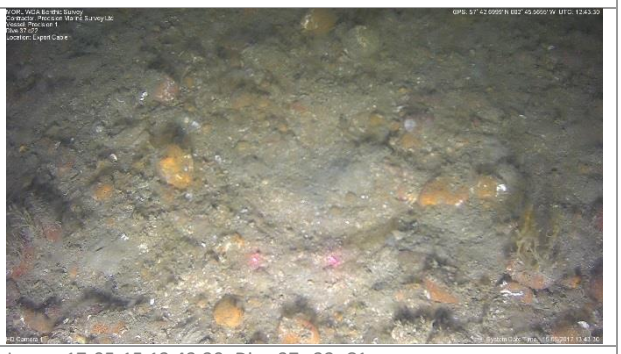
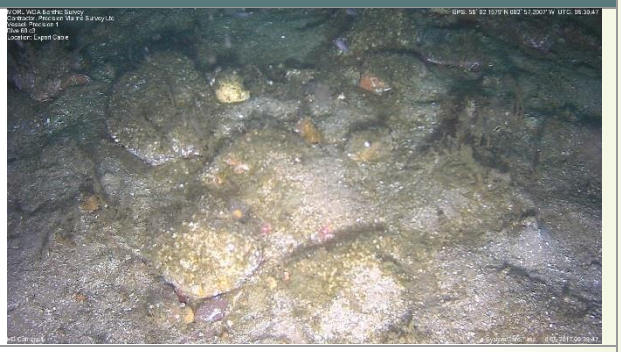
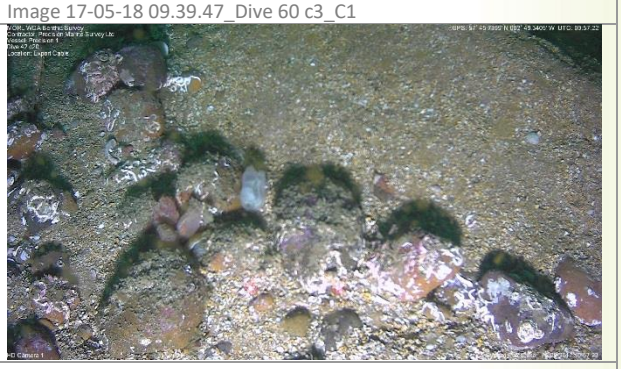
Variable mixed coarse sediment including sand or gravelly sand with stones, gravel or cobble	
Biotopes: SS.SSa / SS.SCS.CCS	
5 stations (C3, C14, C20, C21, C22)	
Taxa in >25% of recorded habitats: Hydrozoa/Bryozoa (100% R-A), Serpulidae (100% O-C), *Lithothamnion* spp. (100% R-C), *Lanice conchilega* (100% R-F), Pectinidae (66% R-O), *Asterias rubens* (50% O-C), *Corella parallelogramma* (50% R-O), *Munida rugosa* (50% R-C), *Securiflustra securifrons* (50% R-O), *Callionymus lyra* (33% R), Ctenophora (33% R-O), *Flustra foliacea* (33% R-O), *Henricia* (33% R), *Nemertesia antennina* (33% R), *Porania pulvillus* (33% R-F) **Other Taxa:** *Alcyonium digitatum*, Ammodytidae, *Ascidiacea, Ascidiella aspersa*, Asteroidea, Brachyura, Buccinidae, *Calliostoma zizyphinum, Crossaster papposus*, Galatheoidea, Gobiidae?, Nemertea, *Pagurus bernhardus, Turritella communis*	
	
Image 17-05-15 08.43.20_Dive 28 c14_C1	Image 17-05-15 13.43.30_Dive 37 c22_C1

Table 3.4: Video Summary: Variable Coarse Sediment with Sand or Gravelly Sand with Stones, Gravel or Cobble

	
Image 17-05-16 10.35.28_Dive 41 c21_C1	Image 17-05-18 09.39.47_Dive 60 c3_C1
	
Image 17-05-16 10.54.20_Dive 42 c20_C1	Image 17-05-16 10.57.23_Dive 42 c20_C1

Along the middle section of the Offshore Export Cable Corridor deep water stations such as C8, C9, C10, C11 and C12 were characterised by areas of sandy mud or very muddy sand with the sea pen *Pennatula phosphorea* (Table 3.5). The sea bed also had numerous pits, holes within the mud which may include megafauna burrows. Visibility was generally poor in this area due to the continued presence of *Nephrops* trawlers but other taxa included *Virgularia mirabilis*, sparse hydroid/bryozoa (presumably on occasional shell/stone within the mud), curled octopus (*Eledone cirrhosa*) and plaice (*Pleuronectes platessa*). These habitats fall under the biotope **SS.SMu.CFiMu.SpnMeg** (Seapens and burrowing megafauna in circalittoral fine mud) which is a Priority Marine Feature (PMF).

Table 3.5: Video Summary: Sandy Mud/Muddy Sand with Burrows/Pits

Sandy mud/muddy sand with burrows/pits
Biotope: SS.SMu.CFiMu.SpnMeg
5 sites (C8, C9, C10, C11, C12)
Taxa in >25% of recorded habitats: *Pennatula phosphorea* (80% R-A), Hydrozoa/Bryozoa (40% R), *Virgularia mirabilis* (50% R), *Eledone cirrhosa* (25% R), *Pleuronectes platessa* (25% R) Note: potential megafauna burrows & pits also numerous

Table 3.5: Video Summary: Sandy Mud/Muddy Sand with Burrows/Pits	
Image 17-05-24 11.32.24_Dive 142 c9_C1	Image 17-05-24 12.19.14_Dive 143 c8_C1

Adjacent to the deeper sandy mud habitats, in slightly shallower water, stations C6 and C7 appeared to have a muddy sand habitat (Table 3.6). This habitat had a fairly sparse fauna but included occasional or frequent *Pennatula phosphorea* along with occasional/frequent clumps of Hydrozoa/Bryozoa, and rare sightings of *Alcyonium digitatum*, *Callionymus lyra*, *Eledone cirrhosa*, *Antalis entalis*, *Astropecten irregularis* and *Pleuronectes platessa*. This habitat has been classified as a somewhat sandier and uncertain variant of **SS.SMu.CFiMu.SpnMeg** (Seapens and burrowing megafauna in circalittoral fine mud).

Table 3.6: Video Summary: Muddy Sand	
Muddy sand (often with shell fragments/debris)	
Biotope: uncertain variant of SS.SMu.CFiMu.SpnMeg?	
2 sites (C6, C7)	
Taxa in >25% of recorded habitats: *Pennatula phosphorea* (100% O-F), Hydrozoa/Bryozoa (100% F), *Alcyonium digitatum* (100% R), *Callionymus lyra* (100% R), *Eledone cirrhosa* (100% R), *Antalis entalis* (50% R), *Astropecten irregularis* (50% R), Pectinidae (50% R), *Pleuronectes platessa* (50% R)	

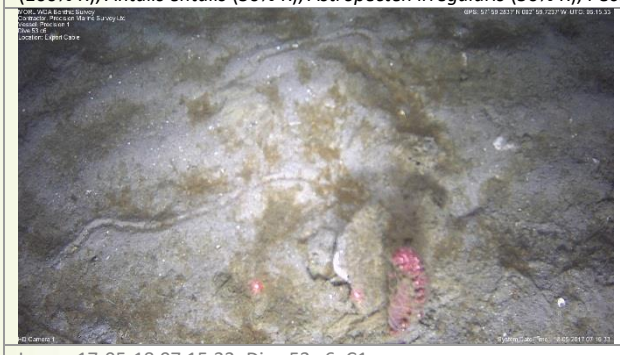



Image 17-05-18 07.15.33_Dive 53 c6_C1	Image 17-05-18 07.33.09_Dive 54 c7_C1
Image 17-05-18 07.35.34_Dive 54 c7_C1	Image 17-05-18 07.13.04_Dive 53 c6_C1

At the offshore end of the Offshore Export Cable Corridor adjacent to the wind farm were stations with rippled (slightly muddy) sand often with shell debris/grit or occasional small stones (Table 3.7). This habitat had a fairly sparse epifauna characterised by small clumps of hydroid/bryozoa (on shell or stones) patchy *Ophiura* sp. and occasional or rare *Pennatula phosphorea*, *Antalis entalis*, *Asterias rubens*,

Callionymus lyra and *Astropecten irregularis*. Densities of sea pens were not high enough to qualify as a sea pen biotope although may be an intermediate variant with **SS.SSa** (Sublittoral sands and muddy sands).

Table 3.7: Video Summary: Rippled (Slightly Muddy) Sand Often with Shell Debris/Grit	
Rippled (slightly muddy) sand often with shell debris/grit	
Biotope: SS.SSa	
9 stations (C1, C2, C4, C5, C23, C25, C26, C27, C28)	
Taxa in >25% of recorded habitats: Hydrozoa/Bryozoa (80% R-O), *Ophiura* (60% R-A), *Pennatula phosphorea* (50% R-O), *Antalis entalis* (40% R-O), *Asterias rubens* (40% R), *Callionymus lyra* (40% R), *Astropecten irregularis* (30% R) **Other Taxa:** *Eledone cirrhosa*, *Flustra foliacea*, Pleuronectidae, *Alcyonium digitatum*, *Buccinum undatum*, *Chelidonichthys cuculus*, Ctenophora, Gobiidae?, *Lanice conchilega*, Pectinidae, *Pleuronectes platessa*, *Porania pulvillus*, Scorpaeniformes	
Image 17-05-17 10.40.54_Dive 48 c27_C1	Image 17-05-18 05.33.00_Dive 49 c1_C1

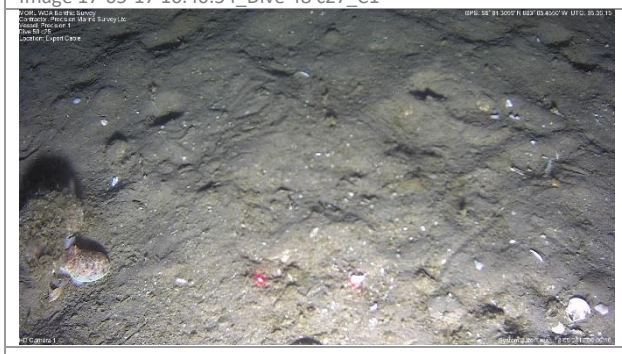
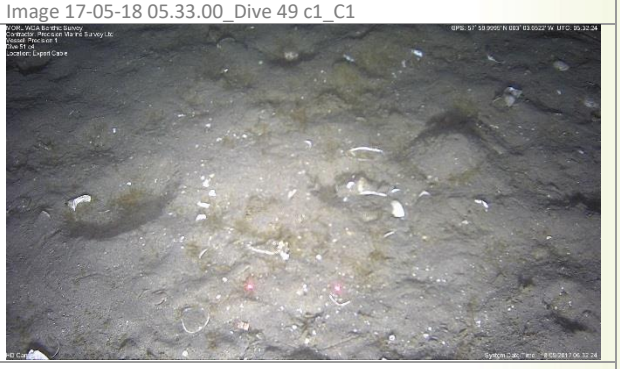

	

Image 17-05-18 06.06.16_Dive 50 c25_C1	Image 17-05-18 06.32.24_Dive 51 c4_C1

At station C26 adjacent to the Moray West site an area of mixed muddy shell gravel/muddy gravelly sand and shell debris/stones was present (Table 3.8). This habitat appeared to form part of an area of gravel waves running through adjacent sandy habitats. The mixed shell gravel had a rather sparse epifaunal community characterised by occasional hydroid/bryozoa with rare examples of *Antalis entalis*, Asteroidea, *Lanice conchilega* and *Microchirus variegatus*. This habitat has been classified as **SS.SMx.CMx (Circalittoral mixed sediment)**.

Table 3.8: Video Summary: Muddy Shell Gravel or Muddy Gravelly Sand with Shell Debris
Muddy shell gravel or muddy gravelly sand with shell debris
Biotope: SS.SMx.CMx
1 station (C26)
Taxa: Hydrozoa/Bryozoa (O), *Antalis entalis* (R), Asteroidea (R), *Lanice conchilega* (R), *Microchirus variegatus* (R)

Table 3.8: Video Summary: Muddy Shell Gravel or Muddy Gravelly Sand with Shell Debris

Image 17-05-18 10.09.46_Dive 61 c26_C1	Image 17-05-18 10.09.59_Dive 61 c26_C1

3.1.2 Moray West Site

Seabed habitats in the wind farm were quite variable (particularly to the east or north of the site) but also included large areas of relatively homogeneous sandy habitats which varied slightly in terms of mud (or gravel) content.

A large area covering much of the western side of the Moray West site were characterised by extensive areas of rippled (slightly muddy) sand (Table 3.9) which are broadly classified as **SS.SSa** (Sublittoral sands and muddy sands). Occasional stone or cobble may also be sporadically recorded in these habitats. Such areas tended to have a rather sparse epifauna with *Asterias rubens* the most commonly recorded taxa. Small clumps of hydroid/bryozoa were also recorded quite frequently presumably attached to shells or stones within the sand. Other taxa which were recorded at over 25% of these habitats included *Pagurus bernhardus*, *Astropecten irregularis*, *Ophiura* sp., and the dragonet *Callionymus lyra*. A wide variety of other taxa were occasionally recorded at a reduced number of stations usually in low densities including taxa such as *Alcyonium digitatum*, *Chelidonichthys cuculus*, *Pleuronectes platessa*, Pleuronectidae, Pectinidae, Asteroidea, Buccinidae, *Pagurus prideaux*, *Suberites carnosus*, *Adamsia palliata*, *Agonus cataphractus*, *Antalis entalis*, Brachyura, *Crossaster papposus*, *Eledone cirrhosa*, *Luidia sarsi*, Paguridae, *Turritella communis*, *Atelecyclus rotundatus*, Bivalvia sp. and *Buccinum undatum*.

Table 3.9: Video Summary: Rippled (Slightly Muddy) Sand Often with Shell Debris/Grit

Rippled (slightly muddy) sand often with shell debris/grit
Biotope: SS.SSa
36 stations (W1, W2, W8, W9, W10, W11, W12, W14, W15, W16, W17, W18, W19, W21, W22, W23, W24, W27, W29, W30, W31, W32, W33, W35, W36, W37, W38, W39, W42, W43, W46, W74, W75, W76, W77, W78)
Taxa in >25% of recorded habitats: *Asterias rubens* (73% R-F), Hydrozoa/Bryozoa (54% R-C), *Pagurus bernhardus* (32% R-F), *Astropecten irregularis* (27% R), *Ophiura* (27% R-O), *Callionymus lyra* (24% R) **Other Taxa:** *Alcyonium digitatum*, *Chelidonichthys cuculus*, *Pleuronectes platessa*, Pleuronectidae, Pectinidae, Asteroidea, Buccinidae, *Pagurus prideaux*, *Suberites carnosus*, *Adamsia palliata*, *Agonus cataphractus*, *Antalis entalis*, Brachyura, *Crossaster papposus*, *Eledone cirrhosa*, *Luidia sarsi*, Paguridae, *Turritella communis*, *Atelecyclus rotundatus*, Bivalvia, *Buccinum undatum*, *Buglossidium luteum*, *Neptunea antiqua*, *Flustra foliacea*, *Hyalinoecia tubicola*, *Lanice conchilega*, *Merlangius merlangus*, *Nemertesia antennina*, *Raja clavata*, Sabellidae, Serpulidae, *Suberites suberia*, *Zeus faber*

Table 3.9: Video Summary: Rippled (Slightly Muddy) Sand Often with Shell Debris/Grit

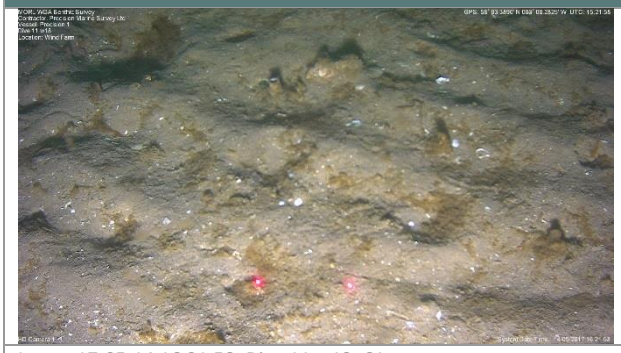
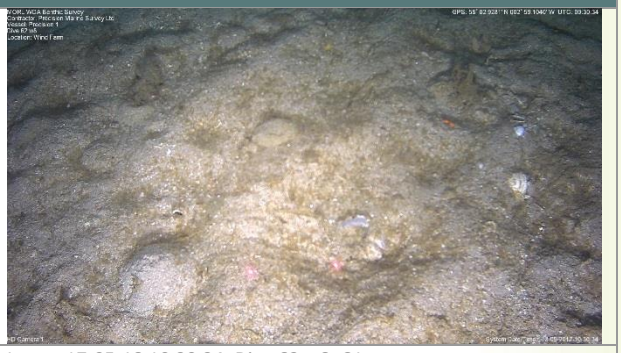
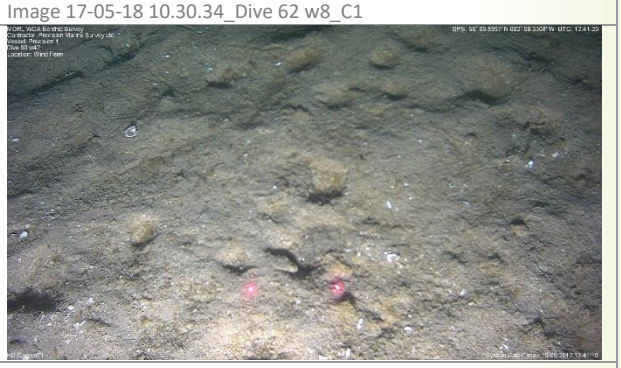
	

Image 17-05-14 16.21.58_Dive 11 w18_C1	Image 17-05-18 10.30.34_Dive 62 w8_C1
	
Image 17-05-18 12.46.45_Dive 67 w33_C1	Image 17-05-19 13.41.19_Dive 90 w42_C1

Further east of the habitats described above the sandy habitats in the eastern side Moray West site appeared to get progressively sandier with a lower mud content and comprised of rippled sand often with shell grit/debris or occasional stones **SS.SSa** (Sublittoral sands and muddy sands). In terms of epifauna such areas were fairly similar to the slightly muddier sands described above and were characterised by relatively low numbers of *Asterias rubens* along with sporadic *Pagurus bernhardus* and clumps of hydroids/Bryozoa and *Callionymus lyra* (Table 3.10). Other taxa recorded in few examples of this habitat included *Chelidonichthys cuculus*, *Astropecten irregularis, Neptunea antiqua*, Paguridae, *Pleuronectes platessa*, *Alcyonium digitatum*, Buccinidae, *Eledone cirrhosa*, *Myoxocephalus scorpius*, Serpulidae, *Agonus cataphractus*, Asteroidea, *Crossaster papposus* and *Gadus morhua*.

Table 3.10: Video Summary: Rippled Sand (often with Shell Grit/Debris)

Rippled Sand (often with shell grit/debris)
Biotope: SS.SSa
21 stations (W6, W8, W40, W41, W48, W49, W53, W54, W55, W56, W59, W61, W64, W65, W66, W67, W70, W71, W73, W79, W80)
Taxa in >25% of recorded habitats: *Asterias rubens* (83% R-C), *Pagurus bernhardus* (43% R-O), Hydrozoa/Bryozoa (35% R-O), *Callionymus lyra* (30% R) **Other Taxa:** *Chelidonichthys cuculus*, *Astropecten irregularis*, *Neptunea antiqua*, Paguridae, *Pleuronectes platessa*, *Alcyonium digitatum*, Buccinidae, *Eledone cirrhosa*, *Myoxocephalus scorpius*, Serpulidae, *Agonus cataphractus*, Asteroidea, *Crossaster papposus*, *Gadus morhua*, *Nemertesia antennina*, *Ophiura*, Pectinidae, Pleuronectidae, *Suberites carnosus*, *Suberites suberia*

Table 3.10: Video Summary: Rippled Sand (often with Shell Grit/Debris)

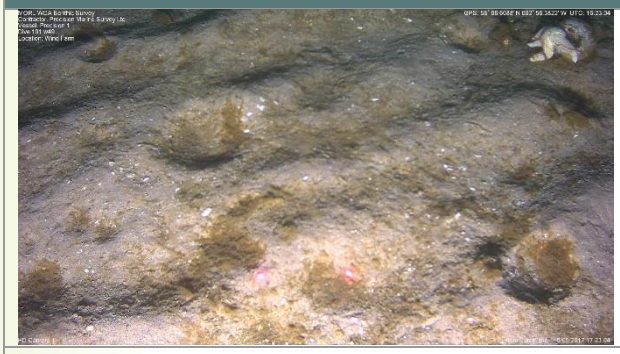


Image 17-05-19 17.23.05_Dive 101 w49_C1	Image 17-05-21 12.09.36_Dive 107 w80_C1

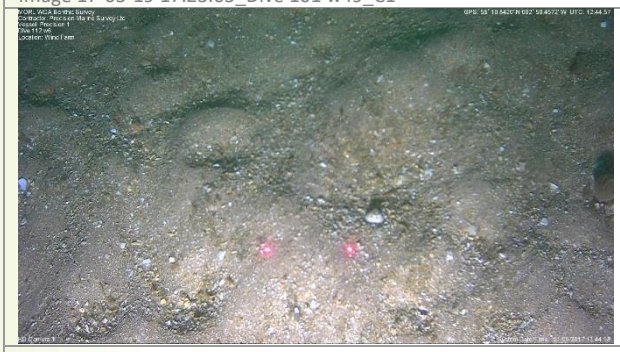



Image 17-05-21 13.44.58_Dive 112 w6_C1	Image 17-05-21 19.04.32_Dive 130 w56_C1

Five stations within the Moary West site appeared to have somewhat muddier sands with occasional shell debris or stones but can be generally classified as **SS.SSa** (Sublittoral sands and muddy sands). These stations also had a rather sparse epifauna with primarily *Asterias rubens*, which was recorded in most examples of this habitat along with occasional clumps of Hydroids/Bryozoa, Pagu*rus bernhar*dus and Pleuronectidae (Table 3.11). Other taxa less frequently recorded included *Adamsia palliata*, *Agonus cataphractus*, *Antalis entalis*, *Chelidonichthys cuculus*, *Nemertesia antennina*, *Ophiura*, *Pagurus prideaux*, Paguridae, Pectinidae and *Pleuronectes platessa*.

Table 3.11: Video Summary: Muddy Sand (Often With Shell Fragments/Debris)

Muddy sand (often with shell fragments/debris)	
Biotope: SS.SSa	
5 stations (W3, W13, W25, W26, W52)	
Taxa in >25% of recorded habitats: *Asterias rubens* (80% R-O), Hydrozoa/Bryozoa (80% R-F), *Pagurus bernhardus* (50% R), Pleuronectidae (50% R) **Other Taxa:** *Adamsia palliata*, *Agonus cataphractus*, *Antalis entalis*, *Chelidonichthys cuculus*, *Nemertesia antennina*, *Ophiura*, *Pagurus prideaux*, Paguridae, Pectinidae, *Pleuronectes platessa*, *Suberites suberia*	

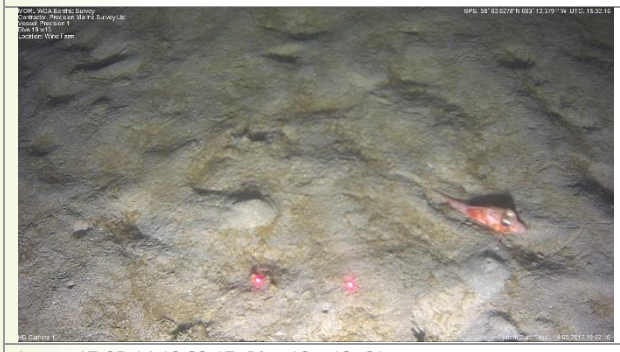



Image 17-05-14 19.02.17_Dive 19 w13_C1	Image 17-05-18 13.12.28_Dive 68 w25_C1

Table 3.11: Video Summary: Muddy Sand (Often With Shell Fragments/Debris)	

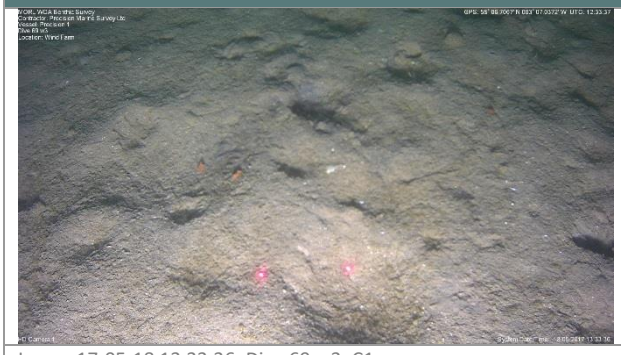
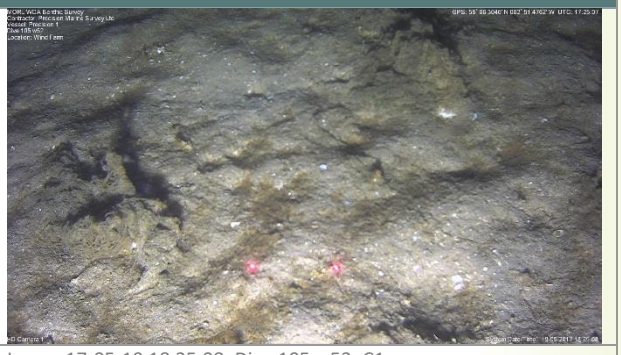

	

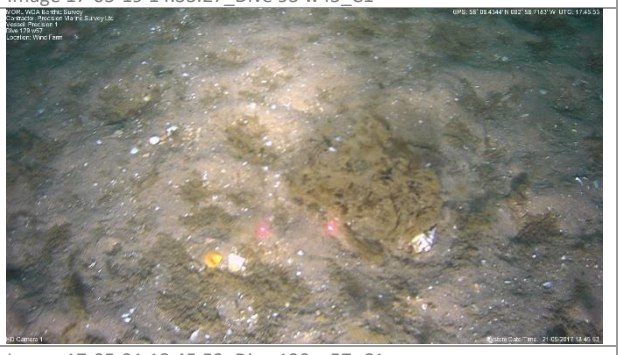
Image 17-05-18 13.33.36_Dive 69 w3_C1	Image 17-05-19 18.25.08_Dive 105 w52_C1

A number of stations included rather variable slightly muddy sands or gravelly sand often with some stones, pebbles or shell. These were generally similar to the habitats described above but were slightly more variable or with an increased gravel content (Table 3.12). These habitats would generally be classified as **SS.SSa** (Sublittoral sands and muddy sands) or possibly Circalittoral Coarse sediments (**SS.SCS.CCS**). As described for the other predominantly sandy habitats the main epifaunal recorded included *Asterias rubens* which was recorded at all examples of this habitat and other taxa included small clumps of hydroids/bryozoa, *Astropecten irregularis*, *Pagurus bernhardus*, *Alcyonium digitatum* (on occasional cobble), *Neptunea antiqua* and *Pleuronectes platessa*.

A variety of other taxa were less frequently recorded including Antalis entalis, Callionymus lyra, Myoxocephalus scorpius, Nemertesia antennina, Ophiura, Pleuronectidae, Suberites carnosus, Actiniaria, Adamsia palliata, Ascidiacea and Ascidiella aspersa. At some sites, particularly those with some stones/pebbles some tubes were present in the sediment or encrusting on small stones which could potentially be Sabellaria sp. but this is rather uncertain.

Table 3.12: Video Summary: Variable (Slightly Muddy) Sand or Gravelly Sand with Some Stones/Pebbles/Shell	
Variable (slightly muddy) sand or gravelly sand often with some stones/pebbles/shell	
Biotopes: SS.SSa &/or SS.SCS.CCS	
11 stations (W7, W34, W35, W44, W45, W47, W57, W58, W62, W68, W69)	
Taxa in >25% of recorded habitats: *Asterias rubens* (100% R-C), Hydrozoa/Bryozoa (82% R-F), *Astropecten irregularis* (45% R), *Pagurus bernhardus* (45% R-O), *Alcyonium digitatum* (27% R), *Neptunea antiqua* (27% R-O), *Pleuronectes platessa* (27% R) **Other Taxa:** *Antalis entalis*, *Callionymus lyra*, *Myoxocephalus scorpius*, *Nemertesia antennina*, *Ophiura*, Pleuronectidae, *Suberites carnosus*, Actiniaria, *Adamsia palliata*, Ascidiacea, *Ascidiella aspersa*, Asteroidea, Bivalvia, *Eledone cirrhosa*, *Pagurus prideaux*, Paguridae, Pectinidae, Serpulidae, *Turritella communis*. Also possible *Sabellaria* tubes on stones/in sediment?	
Image 17-05-18 13.56.36_Dive 70 w34_C1	Image 17-05-19 11.39.17_Dive 83 w7_C1

Table 3.12: Video Summary: Variable (Slightly Muddy) Sand or Gravelly Sand with Some Stones/Pebbles/Shell

Image 17-05-19 14.19.46_Dive 92 w44_C1	Image 17-05-19 14.33.27_Dive 93 w45_C1
	
Image 17-05-21 14.57.55_Dive 116 w69_C1	Image 17-05-21 18.45.53_Dive 129 w57_C1

In some areas of the Moray West site, primarily in the eastern half of the survey area, a habitat comprising of mixed gravelly sediment was recorded at a number of stations (Figure 2.1). These habitats comprised of coarse shell gravel and sand with some mud and were often present as areas of gravel 'waves' running through otherwise sandy habitats. In such areas the troughs of the waves often had muddier mixed sediment with stones and these habitats varied from Circalittoral Coarse sediments (**SS.SCS.CCS**) to muddier Circalittoral Mixed sediments (**SS.SMx.CMx**). Epifauna was relatively sparse in such areas and included patchy hydroids/bryozoa on stones/shell along with other taxa such as *Adamsia palliata*, *Asterias rubens*, *Pagurus prideaux*, *Pagurus bernhardus*, *Ophiura*, *Callionymus lyra* and occasionally Serpulidae (*Spirobranchus* spp.). A variety of other taxa was sporadically recorded in such habitats including *Alcyonium digitatum*, *Astropecten irregularis*, *Lanice conchilega*, Paguridae, *Atelecyclus rotundatus*, Brachyura, Buccinidae, *Buccinum undatum*, *Chelidonichthys cuculus*, *Echinus esculentus*, *Flustra foliacea*, *Luidia ciliaris*, Majoidea, *Munida rugosa*, Pectinidae (scallops) and *Pleuronectes platessa*.

Table 3.13: Video Summary: Mixed (Muddy) Shell Gravel or Muddy Gravelly Sand with Shells/Stones

Mixed (muddy) shell gravel or muddy gravelly sand with shells/stones
Biotopes: SS.SCS.CCS / SS.SMx.CMx
11 stations (W6, W8, W20, W28, W35, W39, W43, W50, W51, W72, W79)
Taxa in >25% of recorded habitats: Hydrozoa/Bryozoa (82% R-C), *Adamsia palliata* (73% R-C), *Asterias rubens* (73% R-C), *Pagurus prideaux* (73% R-C), *Pagurus bernhardus* (55% R-C), *Ophiura* (36% R-O), *Callionymus lyra* (27% R), Serpulidae (27% R-O) **Other Taxa:** *Alcyonium digitatum*, *Astropecten irregularis*, *Lanice conchilega*, Paguridae, *Atelecyclus rotundatus*, Brachyura, Buccinidae, *Buccinum undatum*, *Chelidonichthys cuculus, Echinus esculentus, Flustra foliacea, Luidia ciliaris*, Majoidea, *Munida rugosa*, Pectinidae, *Pleuronectes platessa*

Table 3.13: Video Summary: Mixed (Muddy) Shell Gravel or Muddy Gravelly Sand with Shells/Stones

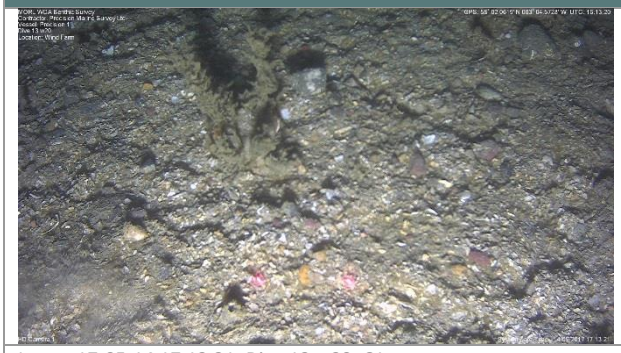
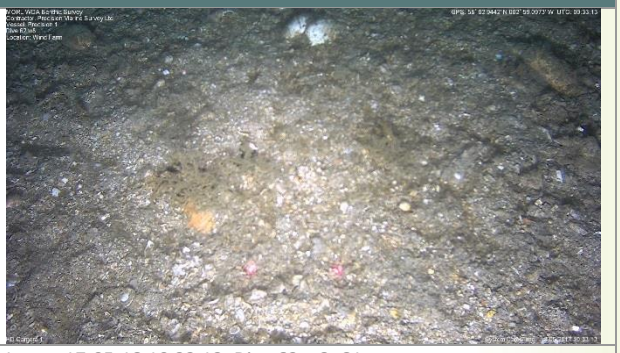
	

Image 17-05-14 17.13.21_Dive 13 w20_C1	Image 17-05-18 10.33.13_Dive 62 w8_C1

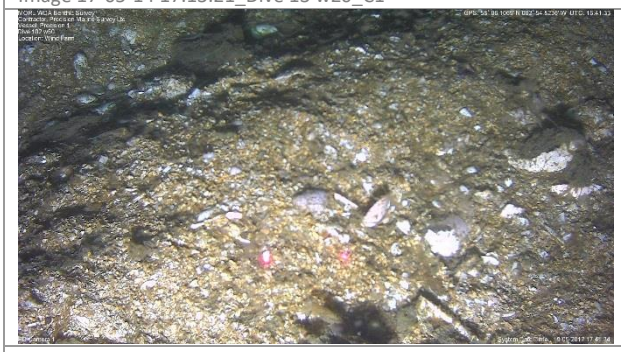
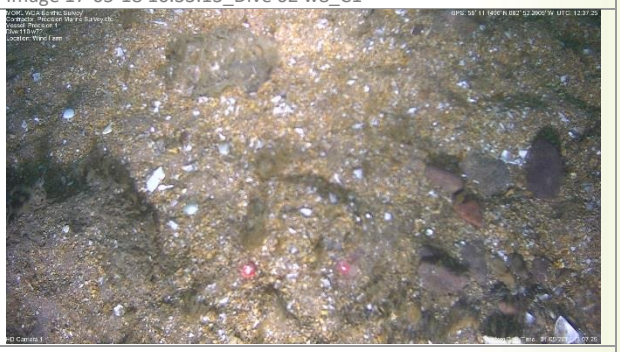

	

Image 17-05-19 17.41.34_Dive 102 w50_C1	Image 17-05-21 13.06.40_Dive 110 w72_C1

Other areas of variable somewhat mixed but heterogenous coarse sediments were also present – particular toward the eastern fringe of the Moray West site. These habitats tended to be inherently patchy and rather variable but tended to be characterised by mixed sands or sandy gravel with patches of surficial stones or cobble (Table 3.14) and were predominantly classified as Circalittoral Coarse sediments (**SS.SCS.CCS**). These habitats were predominantly characterised by *Asterias rubens* and clumps of Hydrozoa/Bryozoa on cobbles or stones along with other taxa such as *Pagurus bernhardus*, *Alcyonium digitatum*, Serpulidae, *Echinus esculentus*, *Callionymus lyra*, *Lithothamnion* spp., *Myoxocephalus scorpius*, *Nemertesia antennina*, Paguridae and Pleuronectidae.

Other taxa recorded less frequently included Adamsia palliata, Asteroidea, Buccinum undatum, Calliostoma zizyphinum, Cancer pagurus, Flustra foliacea, Munida rugosa, Pagurus prideaux, Pleuronectes platessa and Porifera sp. In some areas the presence of tubes encrusting some stones or in surface sediment were possibly formed by Sabellaria spinulosa although this was uncertain and were not present in particularly high densities.

Table 3.14: Video Summary: Variable Coarse/Mixed Sediments with Sand or Sandy Gravel and Patchy Stones/Cobble

Variable coarse/mixed sediments with sand or sandy gravel and patchy stones/cobble
Biotope: SS.SCS.CCS
7 stations (W4, W5, W6, W60, W63, W67, W72)
Taxa in >25% of recorded habitats: *Asterias rubens* (88% R-F), Hydrozoa/Bryozoa (75% O-A), *Pagurus bernhardus* (63% R), *Alcyonium digitatum* (50% R-C), Serpulidae (50% R-A), *Echinus esculentus* (38% R-C), *Callionymus lyra* (25% R), *Lithothamnion* spp. (25% R-F), *Myoxocephalus scorpius* (25% R), *Nemertesia antennina* (25% R), Paguridae (25% O), Pleuronectidae (25% R-O) **Other Taxa:** *Adamsia palliata*, Asteroidea, *Buccinum undatum*, *Calliostoma zizyphinum*, *Cancer pagurus*, *Flustra foliacea*, *Munida rugosa*, *Pagurus prideaux*, *Pleuronectes platessa*, Porifera and barnacles. Also possible *Sabellaria* tubes on stones/in sediment?

Table 3.14: Video Summary: Variable Coarse/Mixed Sediments with Sand or Sandy Gravel and Patchy Stones/Cobble

Image 17-05-21 11.50.44_Dive 106 w5_C1	Image 17-05-21 13.06.40_Dive 110 w72_C1

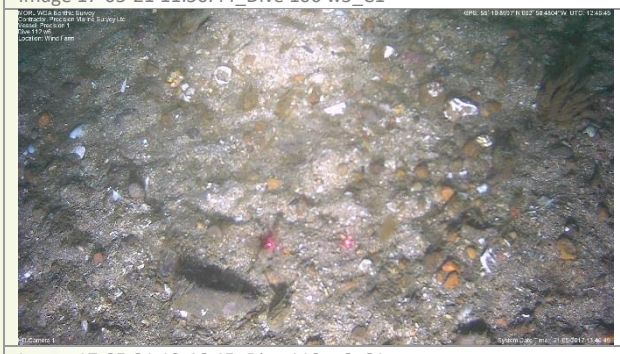
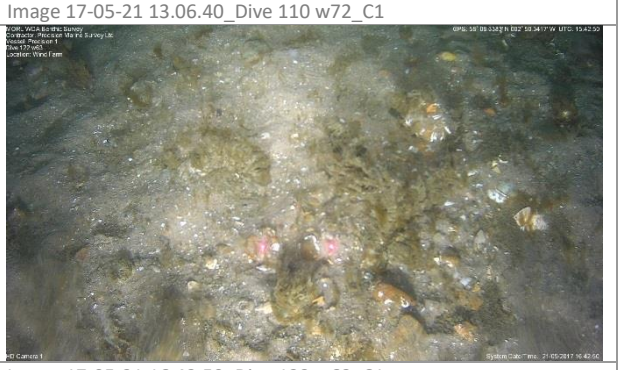
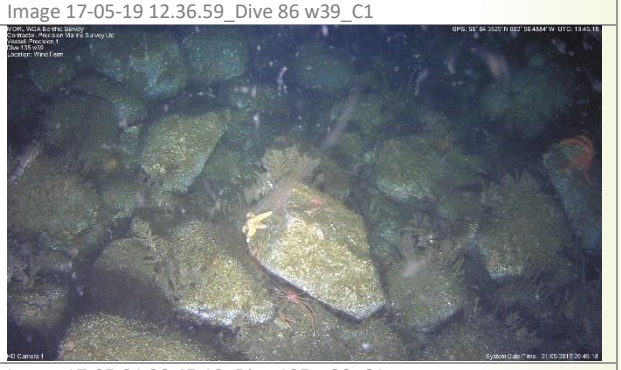

	

Image 17-05-21 13.46.45_Dive 112 w6_C1	Image 17-05-21 16.42.50_Dive 122 w63_C1

At one station within the wind farm (W39) an area of coarse mixed gravelly sediment was recorded approximately 150m NE of the station. This habitat comprised of somewhat muddy shell gravel with stones as described above in Table 3.14. Within this habitat the proportion of cobbles increased until an area approx. 20m wide was encountered which was predominantly composed of large cobble or small boulder (Table 3.15). As depicted in Figure 3.11,this habitat whilst not particularly large and somewhat patchy was composed of primarily clast supported cobble or boulder and had sufficient area/elevation and dominance by epifaunal taxa to be considered Annex I stony reef following guidance in Irving (2009). The cobbles boulder in this area were predominantly characterised by silted barnacles with a patchy hydroid/bryozoan turf and a variety of other epifauna including *Munida rugosa*, Hydrozoa sp., *Nemertesia antennina*, *Alcyonium digitatum*, *Asterias rubens*, *Lithothamnion* spp., *Ophiothrix fragilis* and Serpulidae (*Spirobranchus* sp.) with a number of other taxa also occasionally recorded such as *Antedon bifida*, Brachyura, *Cancer pagurus*, *Corella parallelogramma* and *Crossaster papposus*. The wider mixed/coarse sediment adjacent to this habitat have been classified as Circalittoral Mixed sediments (**SS.SMx.CMx**) whilst the smaller area with more consolidated cobbles/boulder is likely to be a transitional **SS.SMx.CMx/SS.SCS.CCS** habitat overlain with rather impoverished sediment influenced variants of circalittoral rock biotopes such as **CR.HCR.FaT** (Very tide-swept faunal communities), **CR.HCR.XFa** (Mixed faunal turf communities) or **CR.MCR.EcCr** (Echinoderms and crustose communities). Cobbly/stony circalittoral sediment biotopes such as **SS.SCS.CCS.PomB** (*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles) have some resemblance to this habitat although **SS.SCS.CCS.PomB** is generally reserved for unstable pebbles/cobbles rather then the more stable cobble feature recorded here. This feature also resembles barnacle dominated circalittoral rock biotopes such **CR.HCR.FaT.BalTub** (*Balanus crenatus* and *Tubularia indivisa* on extremely tide-swept circalittoral rock) but lacks the dense populations of *Tubularia* hydroids characteristic of this biotope. The boulder/cobble habitat could also include impoverished variants of **CR.HCR.XFa.SpNemAdia** (Sparse sponges, *Nemertesia* spp. and *Alcyonidium diaphanum* on circalittoral mixed substrata), **SS.SMx.CMx.FluHyd** (*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed

sediment) albeit lacking a significant *Flustra* component or **CR.MCR.EcCr.FaAlCr.Pom** (Faunal and algal crusts with *Pomatoceros triqueter* and sparse *Alcyonium digitatum* on exposed to moderately wave-exposed circalittoral rock). Overall this feature correlates rather poorly to the biotope classification but includes **SS.SCS.CCS** and **SS.SMx.CMx** overlain with sediment influenced, intermediate variants of **CR.HCR.XFa** or **CR.MCR.EcCr** biotopes as listed above.

Table 3.15: Video Summary: Mixed Coarse Sediment with Cobble/Boulder

Mixed coarse sediment with cobbles & small boulder	
Biotope: SS.SMx.CMx/SS.SCS.CCS with consolidated cobble/boulder (sediment influenced CR.HCR or CR.MCR biotopes)	
1 station (W39)	
Taxa: Barnacles (SA-C), *Munida rugosa* (A), Hydrozoa/Bryozoa (C), *Nemertesia antennina* (F), *Alcyonium digitatum* (O), *Asterias rubens* (O), *Lithothamnion* spp. (O), *Ophiothrix fragilis* (O), Serpulidae (C), *Antedon bifida* (R), *Brachyura* (R), *Cancer pagurus* (R), *Corella parallelogramma* (R), *Crossaster papposus* (R), *Eledone cirrhosa* (R), *Eupolymnia nebulosa* (R), *Luidia ciliaris* (R), *Ophiura* (R), Pectinidae (R), *Phrynorhombus norvegicus* (R), *Pleuronectes platessa* (R), Pleuronectidae (R)	
Image 17-05-19 12.36.40_Dive 86 w39_C1	Image 17-05-19 12.36.45_Dive 86 w39_C1
Image 17-05-19 12.36.50_Dive 86 w39_C1	Image 17-05-19 12.36.59_Dive 86 w39_C1
	
Image 17-05-19 12.37.22_Dive 86 w39_C1	Image 17-05-21 20.45.19_Dive 135 w39_C1

3.2 Benthic Grab Survey

The Moray West benthic survey was conducted in May and June 2017 using the Precision Marine Survey Ltd survey vessel 'Precision 1' a 12m survey catamaran built in 2012. The survey vessel was mobilised from Buckie on the Moray and Aberdeenshire coast and returned to port each day with survey undertaken in daylight hours only. The benthic grab sampling was undertaken from the 24th May to the 27th May 2017

with additional sampling for contaminant analysis and the remaining PSD samples from the Offshore Export Cable Corridor undertaken on the 3rd and 4th June 2017. Sampling was undertaken at all the specified survey stations, although due to the nature of the sediments it was not possible to obtain an adequate contaminant sample at station C18 so a contaminant sample was instead collected at the adjacent station C17. A summary of the grab sampling survey with sample positions is provided in Annex 7.1D and the positions of benthic samples collected in also shown in Figure 3.1.

3.2.1 Particle Size Distribution Analysis

The results of particle size distribution (PSD) analysis are provided in full in Annex 7.1E and Annex 7.1F along with a summary of key PSD parameters and the spatial distribution of sediment type, bulk sediment classes (% gravel, % sand and % mud) and median phi grain size shown in Figure 3.2 to Figure 3.4.

Along the export cable route sediments were highly variable including slightly gravelly sands (often with a small amount of mud), slightly gravelly muddy sands, sandy mud, sandy gravel and gravel. Mud content along the export cable ranged from 0% (C24) to 63% (C10) whilst gravel content ranged from 0% (stations C10 and C8) to 98% (c24). Median phi grain size ranged from -5.52 (station C24) to 4.44 at station C10 whilst sediment sorting was highly variable and ranged from poorly or very poorly sorted sediments (stations C2, C3, C6, C8, C10, C12 and C21) to moderately sorted (C1, C17 and C19) and well sorted (C24). The majority of stations exhibited finely skewed sediments with the exception of stations C13 and C17 (symmetrical distribution) and C21 (very coarse skewed). The inshore stations included clean sand or slightly gravelly sand with negligible mud content at stations C17 and C13, whilst stations C19, C21 and C24 had coarser sediments (gravelly sand, sandy gravel and gravel respectively) with sediment at these stations generally including stones and pebbles (particularly station C24). On the middle section of the Offshore Export Cable Corridor in deeper water sediments were sandy mud or slightly gravelly muddy sand with a quite high mud content (31% to 63% mud) recorded at the stations in the deepest water depths (stations C8, C10 and C12). Outer Offshore Export Cable Corridor sediments (stations C1, C2 and C3) tended to be slightly gravelly sand with a modest mud content (<10% mud) and very low quantities of gravel (<5%).

The wind farm sampling stations also included a variety sediment types including slightly gravelly sand or muddy sand, sandy gravel, gravelly sand and mixed gravelly muddy sand or muddy sandy gravel. Mud content ranged from 0% to 12.94% (at station W18) whilst gravel content ranged from 0% to > 50% (at stations W6 and W51). Median phi grain size ranged from -1.34 at station W6 to 2.89 at station W13. Sorting and skewness was highly variable with sediment sorting ranging from moderately well sorted to very poorly sorted whilst skewness varied from very coarse skewed to very fine skewed. A large proportion of stations were classified as (slightly gravelly) sand which tended to have a relatively small amount of gravel (<5%) typically shell fragment/grit or occasional small stones. These slightly gravelly sand sediments showed a degree of spatial variation with stations to the west of the site tending to have a modest mud content (up to 10%) whilst (slightly gravelly) sand sediments further east had very low mud contents (<1%). A number of stations with (slightly gravelly) muddy sand were recorded on the north-eastern corner of the Moray West site and in general the north and eastern end of the site tended to exhibit more variation in sediments with more mixed or coarser sediments often present which included areas of mixed muddy sandy gravel or sandy (shell) gravel and also patchy sand or gravelly sand with stones/pebbles and cobble.

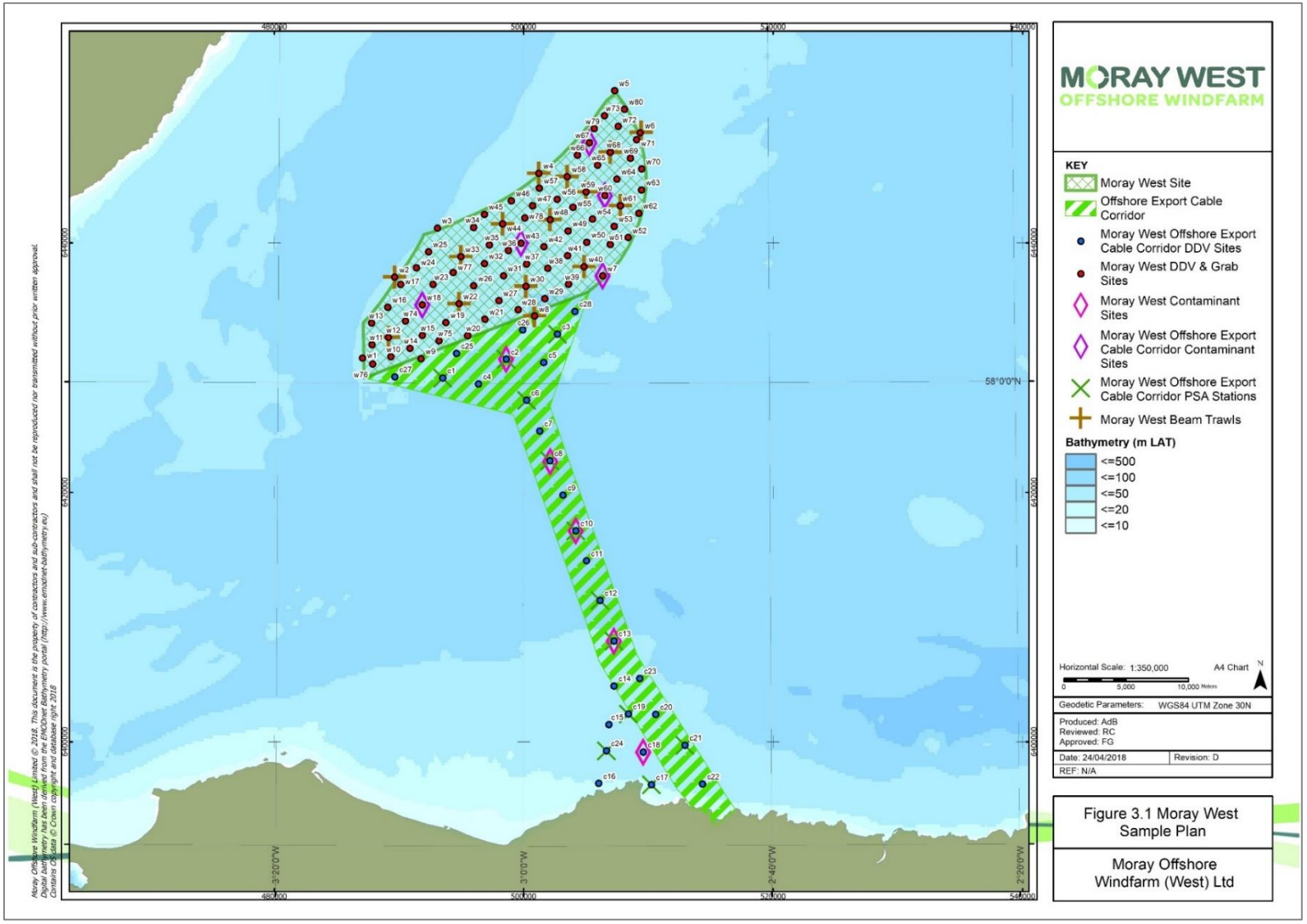


Figure 3.1: Moray West Site Benthic Sample Locations

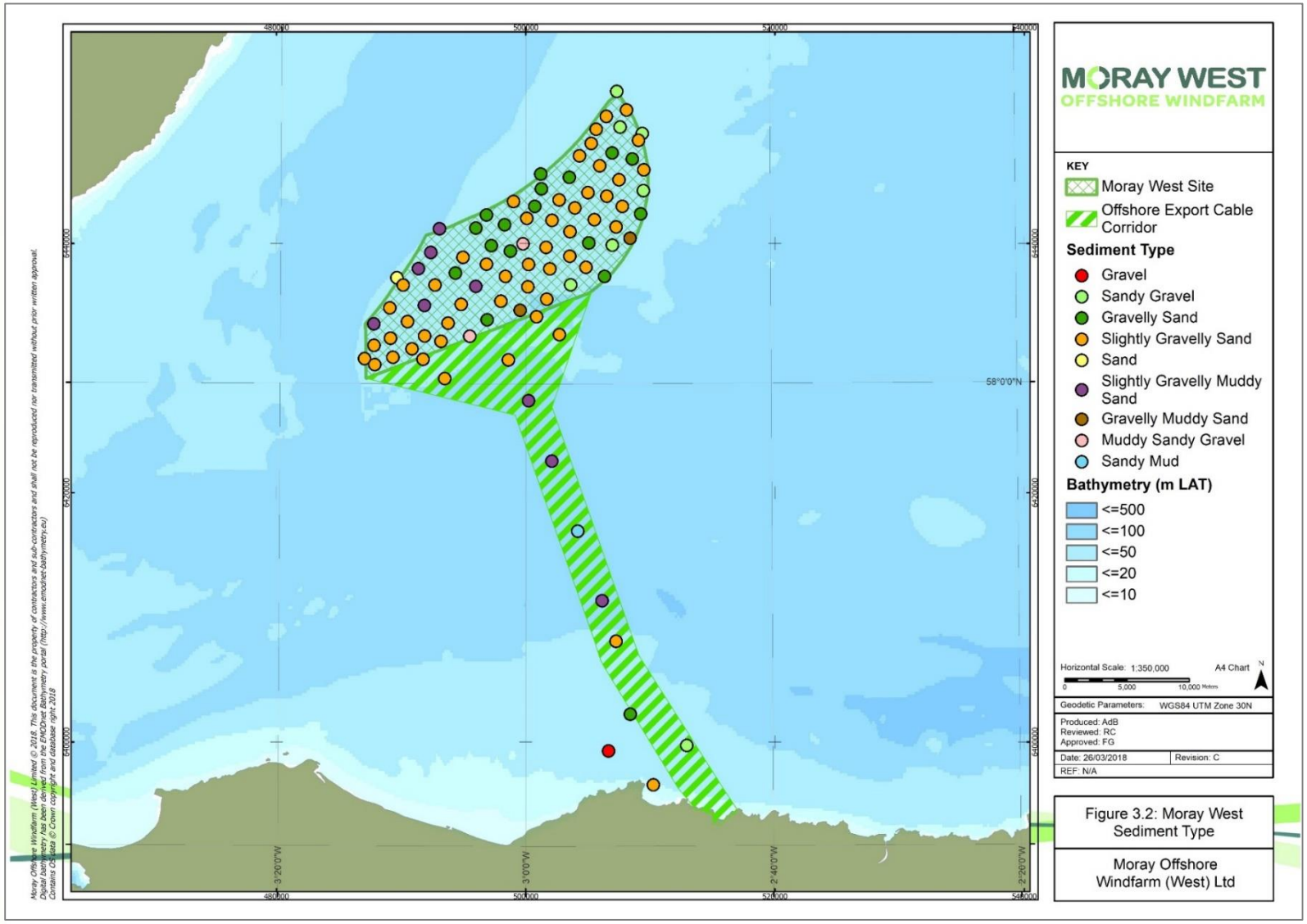


Figure 3.2: Moray West Site Sediment Type (Folk Classification)

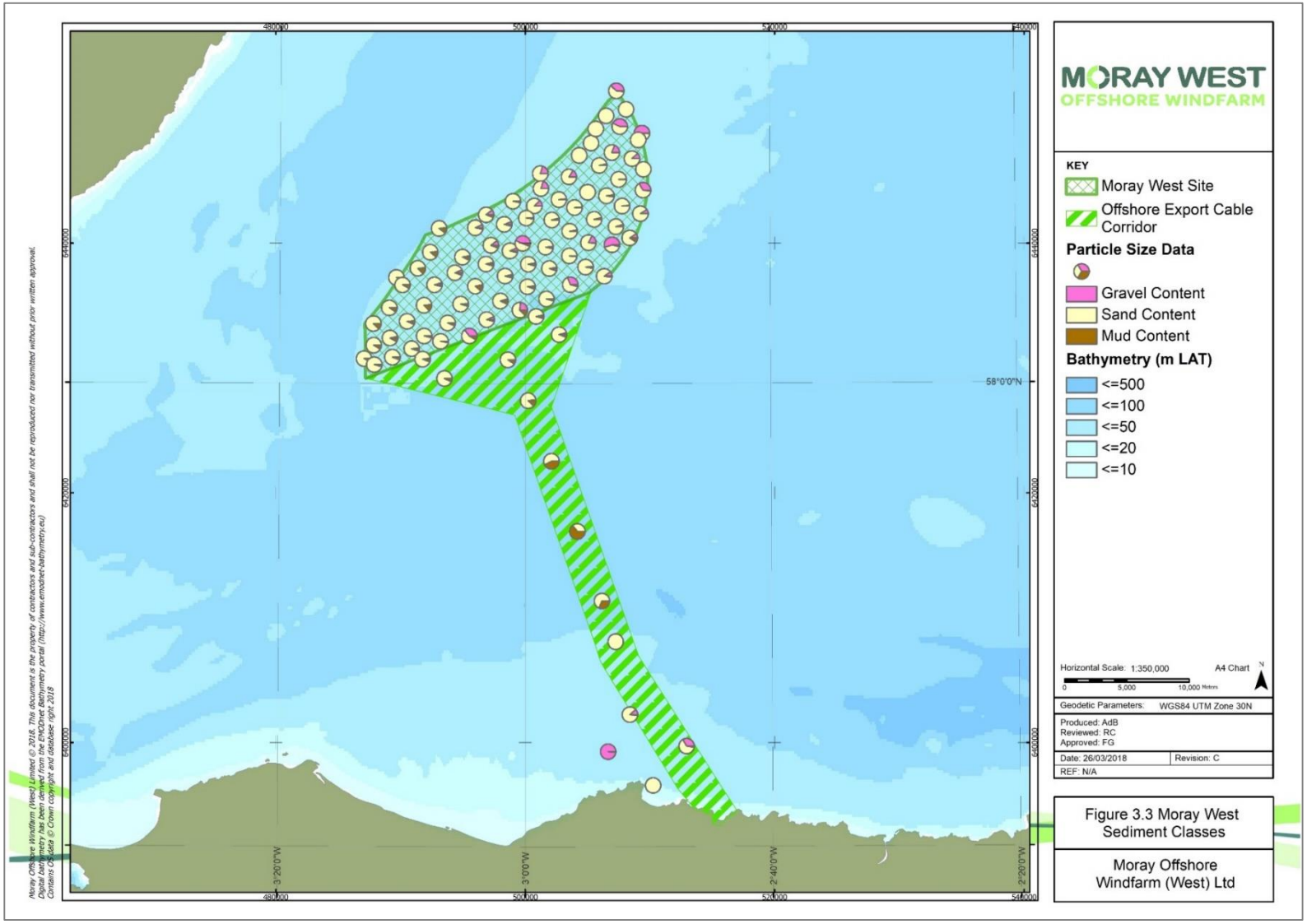


Figure 3.3: Moray West Site Bulk Sediment Class

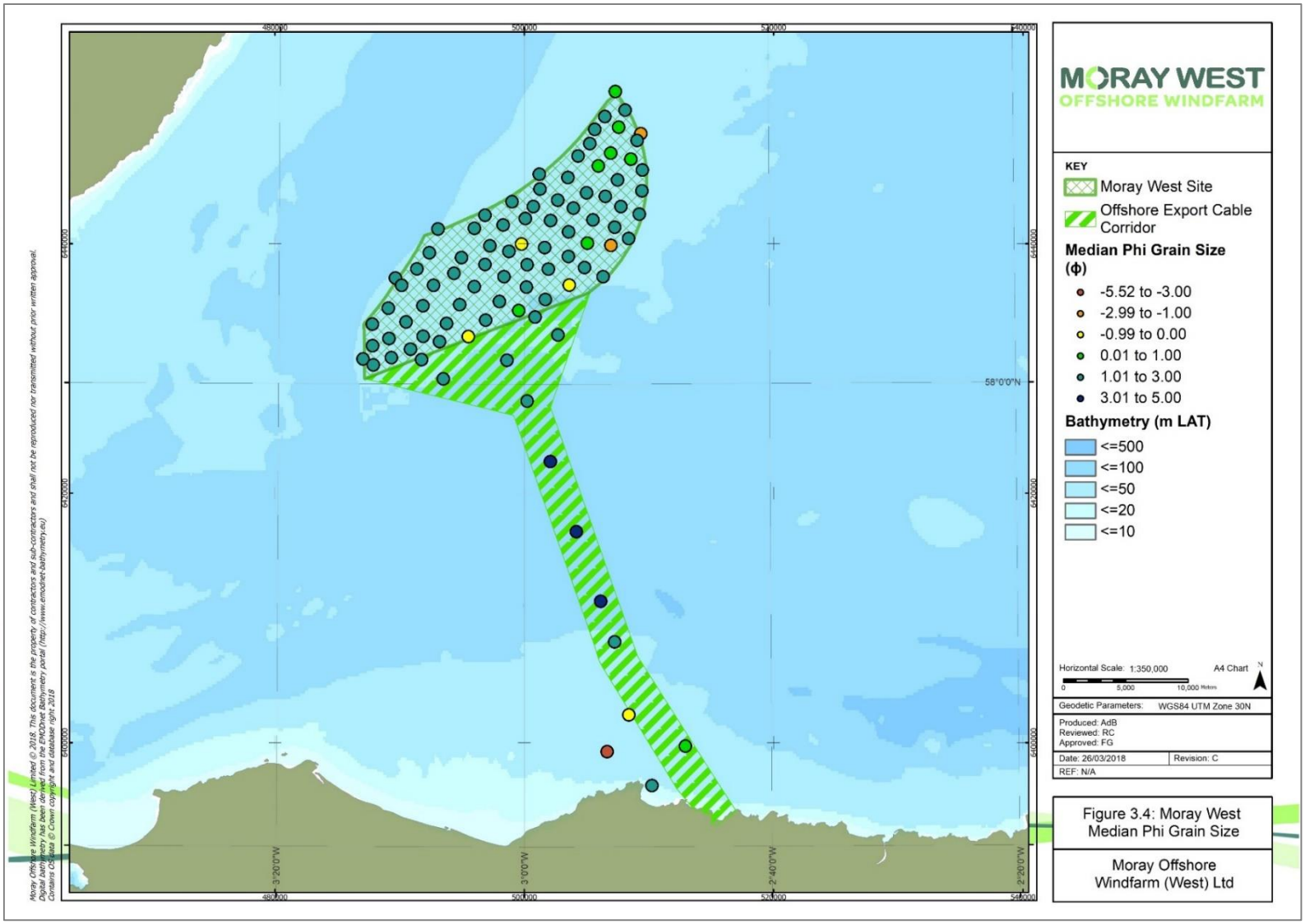


Figure 3.4: Moray West Site Median Phi Grain Size

3.2.2 Contaminant Analysis

Ten stations across the Moray West site and export cable route were sampled for contaminants including metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, barium, aluminum and tin) and polyaromatic hydrocarbons (PAHs). A summary of relevant statutory sediment quality guidelines/standards are provided in Table 3.16 whilst the results of contaminant analysis are provided in Table 3.17. All metals were found at concentrations below respective guidelines (where available) with no samples above UK limits or Dutch/Canadian standards. PAH concentrations were also low and generally below the limit of detection (LOD) for the analytical tests although LODs for Acenaphthene, Acenaphthylene, Dibenzo(ah)anthracene were slightly higher than the Canadian TEL values.

Table 3.16: Sediment Quality Guidelines for Chemical Contamination of Marine Sediments

Contaminant	UK Guidelines (CEFAS)		Dutch Standards		ZBT	Canadian Guidelines	
	AL1	AL2	TV	RV		TEL	PEL
Heavy Metals (mg/kg dry weight)							
Arsenic	20	100	29	55	29	7.24	41.6
Cadmium	0.4	5	0.8	7.5	4	0.676	4.21
Chromium	40	400	100	380	120	52.3	160
Copper	40	400	35	90	60	18.7	108
Lead	50	500	85	530	110	30.2	112
Mercury	0.3	3	0.3	1.3	1.2	0.13	0.7
Nickel	20	200	35	45	45	15.9	42.8
Zinc	130	800	140	720	365	124	271
Polyaromatic Hydrocarbons (mg/kg dry weight)							
Acenaphthene	-	-	-	-	-	0.007	0.089
Acenaphthylene	-	-	-	-	-	0.006	0.128
Anthracene	-	-	-	-	-	0.047	0.245
Benzo(a)anthracene	-	-	-	-	-	0.075	0.693
Benzo(a)pyrene	-	-	-	-	-	0.089	0.763
Chrysene	-	-	-	-	-	0.108	0.846
Dibenzo(ah)anthracene	-	-	-	-	-	0.006	0.135
Fluoranthene	-	-	-	-	-	0.113	1.497
Fluorene	-	-	-	-	-	0.021	0.144
2-Methylnaphthalene	-	-	-	-	-	0.020	0.201
Naphthalene	-	-	-	-	-	0.035	0.391
Phenanthrene	-	-	-	-	-	0.087	0.544
Pyrene	-	-	-	-	-	0.153	1.398
Total PAH	-	-	1	10	8	-	-

Table 3.17: Results of Contaminant Analysis

Test Description	Units	C2	C8	C10	C13	C17	W7	W18	W43	W60	W67
Arsenic	mg/kg	1.67	2.09	2.59	3.93	3.06	1.76	1.9	1.49	3.26	5.44
Cadmium	mg/kg	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
Chromium	mg/kg	8.28	10.4	13.8	4.09	7.15	5.71	10.8	8.52	4.09	3.44
Copper	mg/kg	<1.0	2.3	4.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Lead	mg/kg	2.6	4.7	6.7	2	2.8	3	3.2	3.3	1.2	1.7
Mercury	mg/kg	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Nickel	mg/kg	2.8	6.6	9.8	1.4	2	1.7	2.3	2.4	2.6	1.7
Barium	mg/kg	9.07	22.8	38.7	5.71	30.5	7.1	8.69	9.58	2.15	5.28
Aluminium	mg/kg	1450	3170	4770	716	1070	794	1050	917	488	693
Tin	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Naphthalene	mg/kg DW	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	mg/kg DW	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthene	mg/kg DW	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	mg/kg DW	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	mg/kg DW	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	mg/kg DW	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	mg/kg DW	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	mg/kg DW	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	mg/kg DW	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	mg/kg DW	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	mg/kg DW	<0.01	0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	mg/kg DW	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	mg/kg DW	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 3.17: Results of Contaminant Analysis

Test Description	Units	C2	C8	C10	C13	C17	W7	W18	W43	W60	W67
Indeno(1,2,3-c,d)pyrene	mg/kg DW	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	mg/kg DW	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(a,h)anthracene	mg/kg DW	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PAH, Sum of 16	mg/kg DW	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
TOC, NG Method	%	0.27	0.88	1.3	0.27	0.23	0.12	0.19	0.23	0.23	0.19

3.2.3 Primary and Derived Biological Parameters

A number of primary and derived biological parameters values were calculated from the species data tabulated and input into GIS.

A summary of biological parameters from the sampling stations within and adjacent to the Moray West site is provided in Annex 7.1G and spatial variation in numbers of taxa, abundance, biomass and Shannon's H' diversity is highlighted in Figure 3.5 to Figure 3.8 (full abundance and biomass results are presented in Annex 7.1 H and Annex 7.1I, respectively). As might be expected given the predominantly sandy habitats present in the study area numbers of taxa, infaunal abundance and diversity are moderate and rather variable. Numbers of taxa ranged from 10 taxa per 0.01m^2 at station W10 to 49 taxa per 0.01m^2 at station W50. Highest numbers of taxa tended to be recorded in areas of more mixed gravelly sediments usually in the centre or east of the site, although such habitats also tended to be rather in terms of number of taxa. Cleaner (less muddy) sands in the eastern half of the site generally tended to exhibit lower numbers of taxa.

Faunal abundance was also rather variable but generally low to moderate with values ranging from 12 individuals per 0.1m^2 at station W72 to 454 individuals per 0.1m^2 at station W50. There was no clear spatial trend in abundance although the highest abundances tended to occur in mixed gravelly sand or muddy sandy gravels. A similar pattern was evident with regard to faunal biomass which was highly variable and ranged from 0.028g per 0.1m^2 at station W72 to 140.47g per 0.1m2 at station W51. As described for abundance, highest biomass values tended to be recorded in mixed gravelly sand, sandy gravel or gravelly muddy sand and often reflected the presence of large bodied bivalves such as *Glycymeris glycymeris* or *Polititapes rhomboides* or echinoderms (e.g. *Echinocardium cordatum*) present in these habitats. The majority of stations had relatively high evenness values with values predominantly above 0.8 and ranging from 0.54 (station W50) to 0.99 at station W72. Shannon's diversity values were generally moderate to high with most stations having values between 3 and 5 and values ranged from 2.65 (station W56) to 4.86 (station W33)

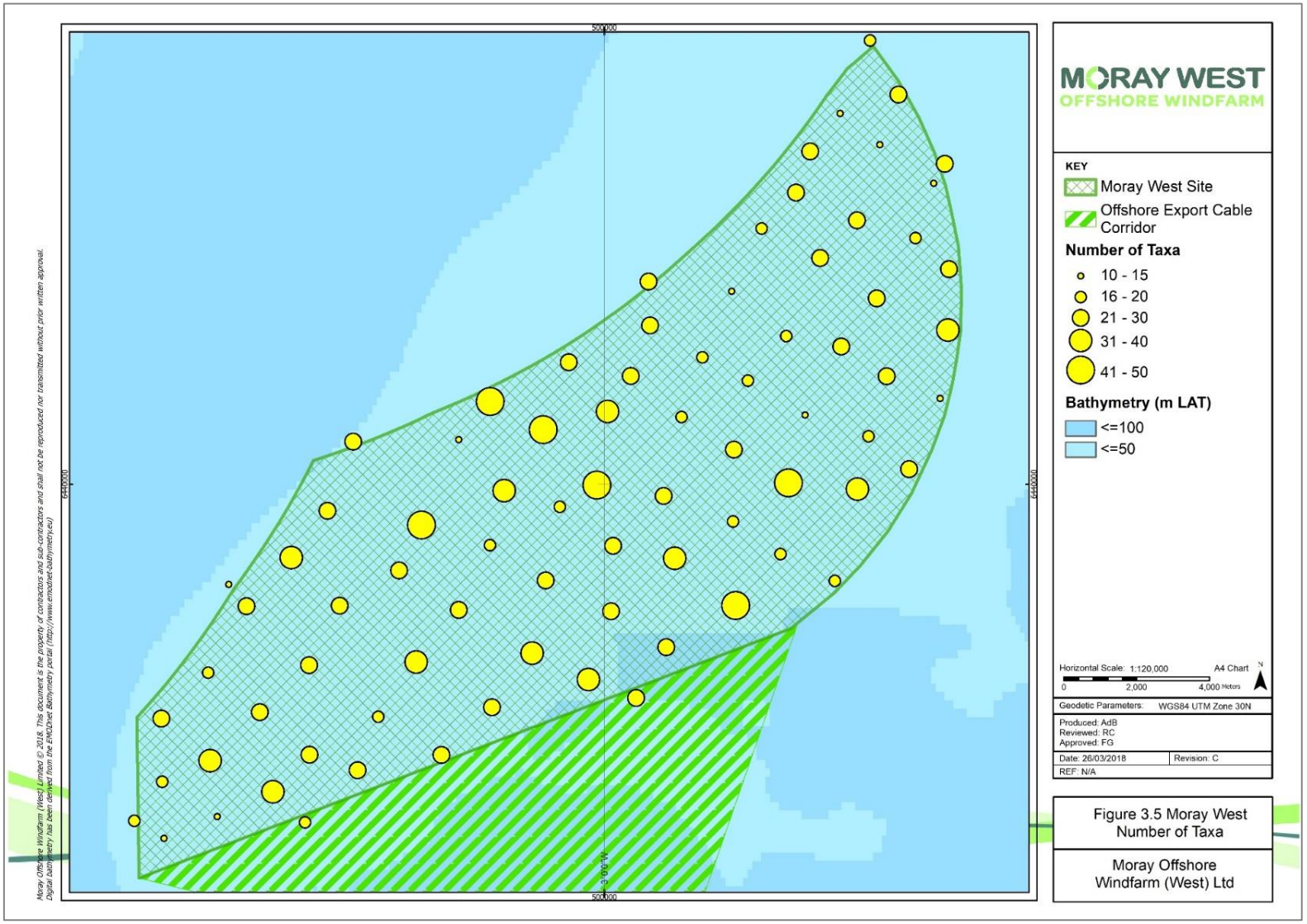


Figure 3.5: Moray West Site Number of Taxa per 0.1m²

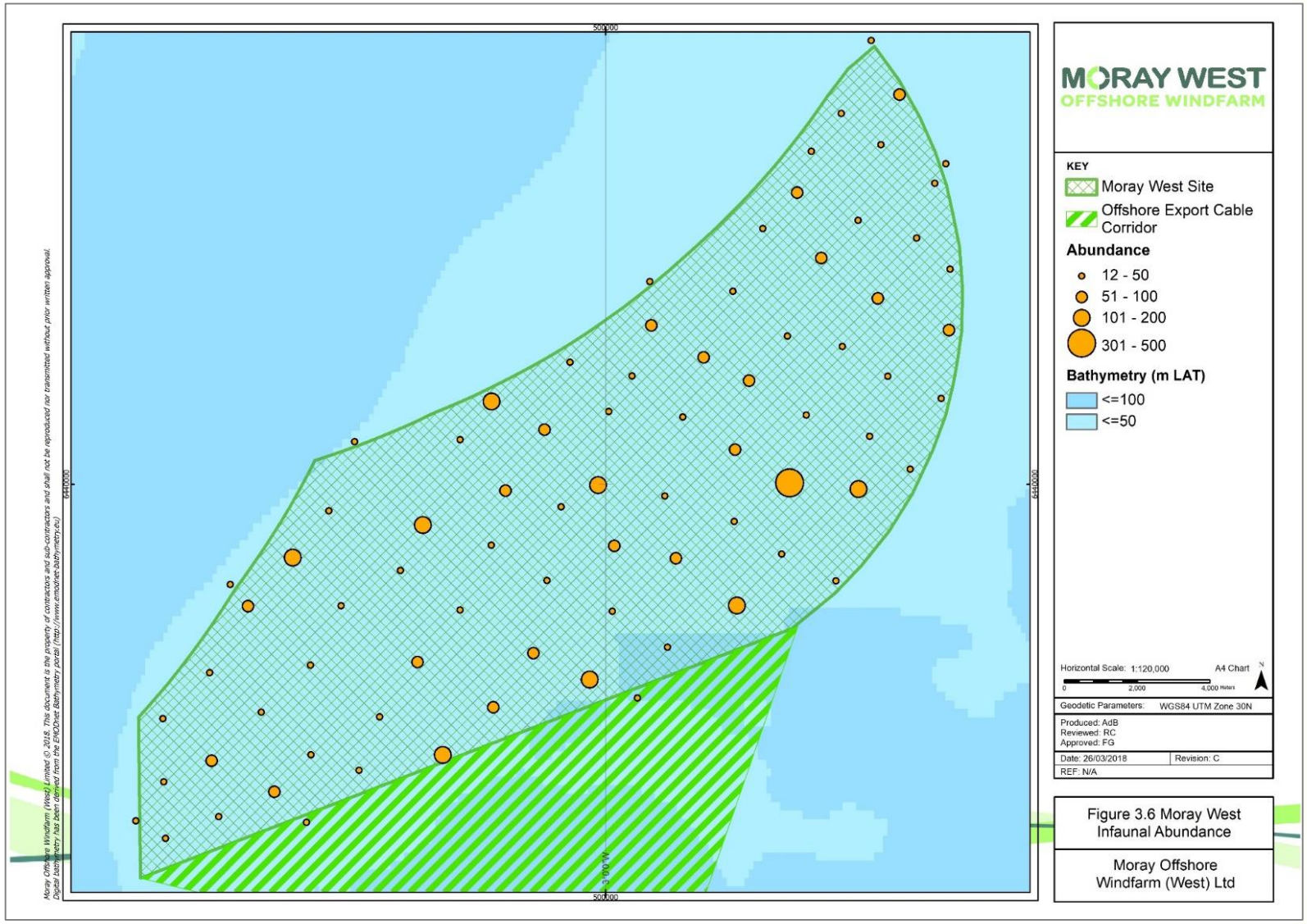


Figure 3.6: Moray West Site Total Abundance per 0.1m^2

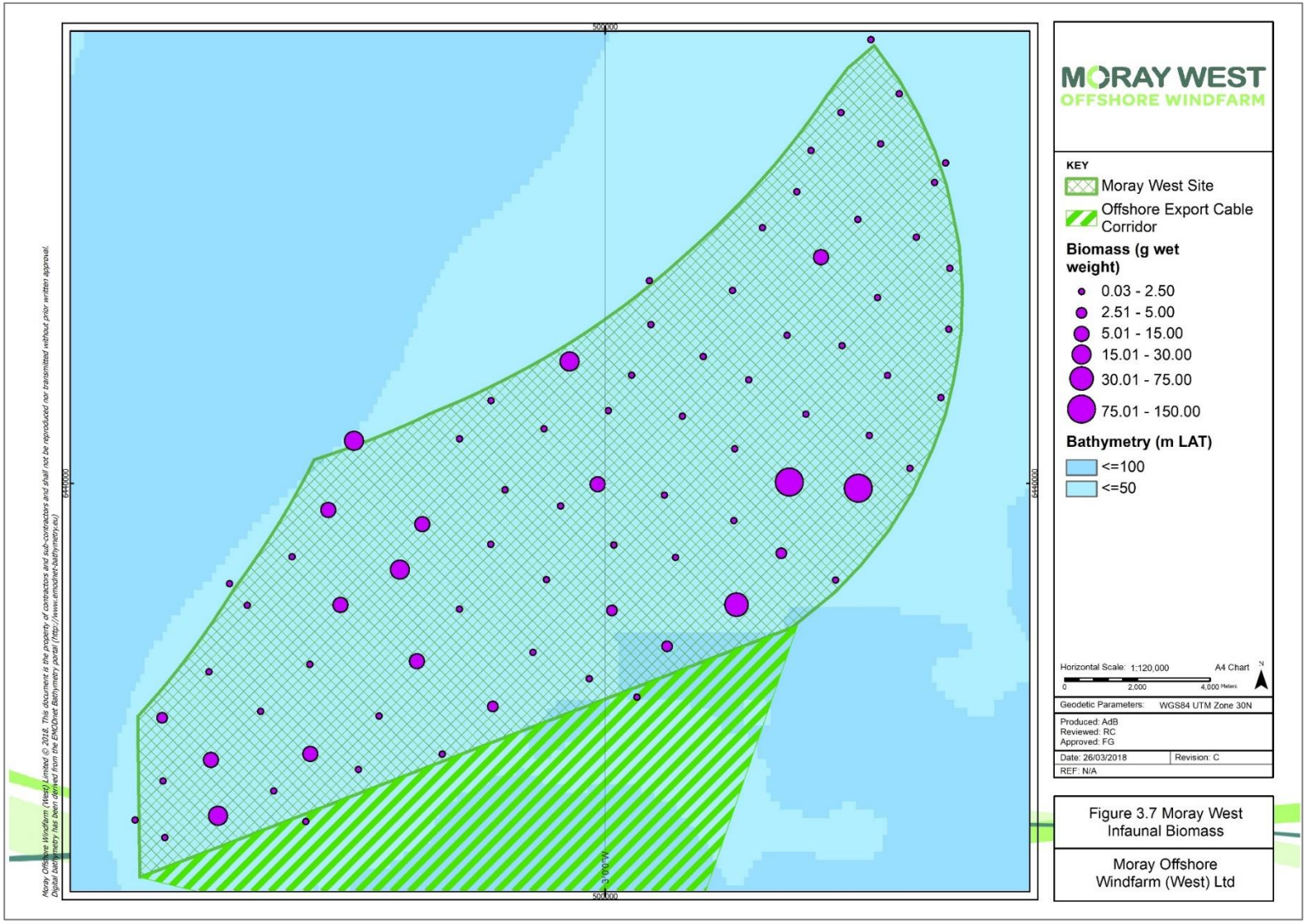


Figure 3.7: Moray West Site Total Wet Weight Biomass (g per 0.1m^2)

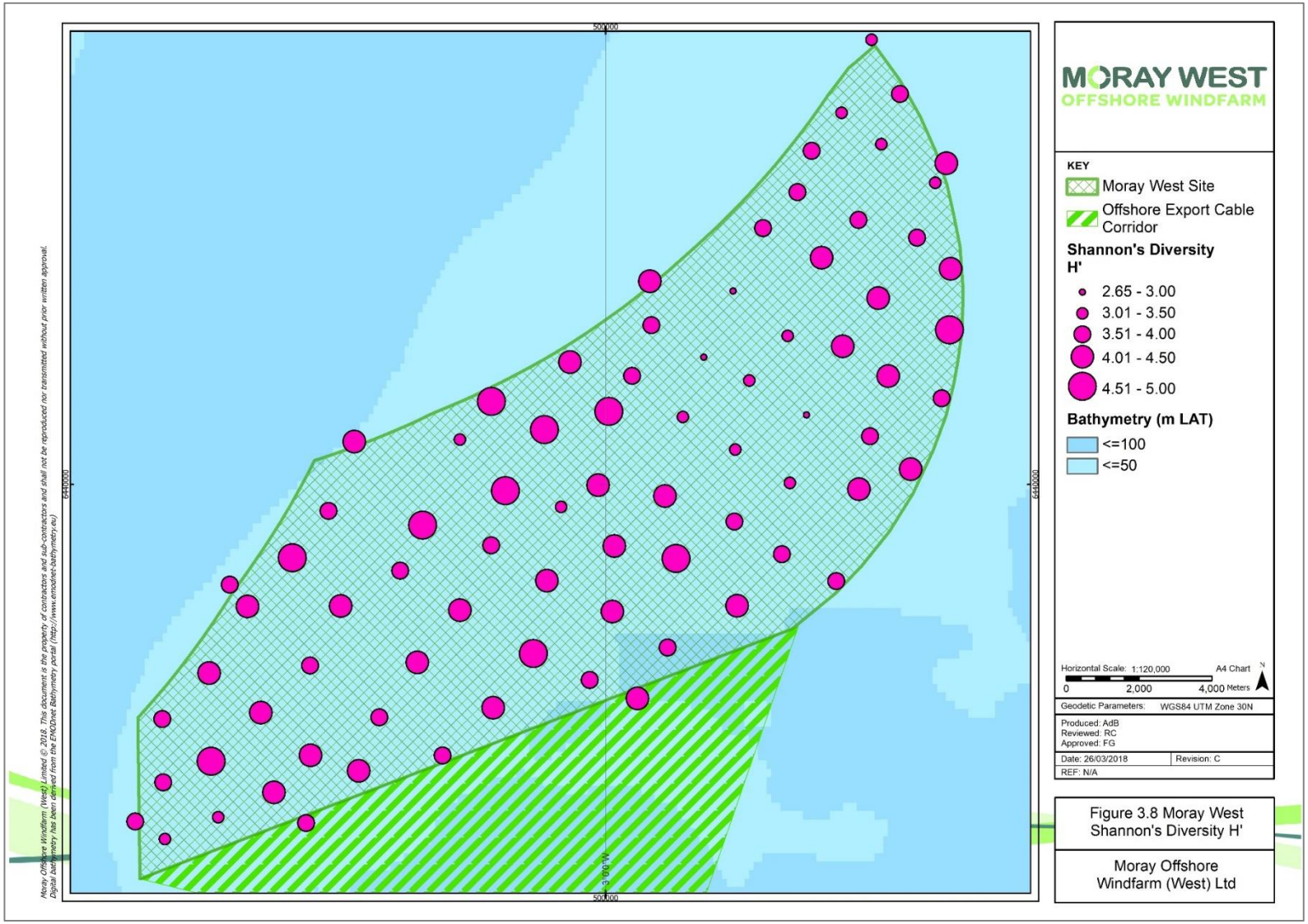


Figure 3.8: Moray West Site Shannon's Diversity H'

3.2.4 Species Composition

A wide variety of taxa were recorded from the benthic grab survey with 352 taxa recorded in total although many of these were present in low numbers and only recorded at a few stations (Annex 7.1G and Annex 7.1H). In terms of abundance annelid worms (predominantly polychaetes) were the most dominant phyla (Table 3.18) accounting for 35% of the total abundance followed by Mollusca (24.6% of total abundance) with Arthropoda, Echinodermata and other phyla accounting for 10.7%, 15% and 14% respectively. In terms of biomass molluscan taxa accounted for 63.65% of total biomass followed by echinoderms (31.94%) with other phyla accounting for the remaining biomass. Annelid polychaetes accounted for 42% of the total number of taxa with arthropods and molluscs accounting for around 21%.

Table 3.18: Composition by Phyla

Phyla	Abundance	% Abundance	Biomass (g)	% Biomass	No. of Taxa	% of Taxa
Annelida	1648	35.31	16.35	3.35	149	42.33
Arthropoda	500	10.71	1.98	0.41	74	21.02
Echinodermata	703	15.06	155.84	31.94	20	5.68
Mollusca	1149	24.62	310.56	63.65	73	20.74
Other	667	14.29	3.17	0.65	36	10.23

The most dominant taxa ranked by abundance and biomass are provided in Table 3.19 and Table 3.20. In terms of abundance the pea urchin *Echinocyamus pusillus* was the most abundant taxa and accounted for 9.88% of the total abundance and this species was also the most ubiquitous and was recorded at 65% of the survey stations. Other key taxa included nematode worms, *Spiophanes bombyx*, *Lumbrineris aniara*, juvenile Ophiuroidea spp., *Asbjornsenia pygmaea*, *Thracia villosiuscula*, *Abra prismatica*, *Venus casina*, *Spisula elliptica*, *Aonides paucibranchiata*, Phoronida sp., Nemertea, *Bathyporeia pelagica*, *Prionospio fallax* and *Fabulina fabula* which collectively accounted for 50% of the total abundance, although the majority of these with the exception of *Spiophanes bombyx* and *Lumbrineris aniara* were present at less than 40% of the survey stations. A wide variety of other taxa were recorded in lower numbers.

Table 3.19: Dominant Infaunal Taxa by Abundance

Taxa	Total Abundance	Mean Abundance	Cumulative % of Total Abundance	No. of Samples	% of Samples
Echinocyamus pusillus	461	5.76	9.88	65	81
Nematoda	388	4.85	18.19	10	13
Spiophanes bombyx	203	2.54	22.54	59	74
Lumbrineris aniara	174	2.18	26.27	46	58
Ophiuroidea spp. (juvenile)	138	1.73	29.23	35	44
Asbjornsenia pygmaea	118	1.48	31.75	24	30
Thracia villosiuscula	114	1.43	34.20	36	45
Abra prismatica	93	1.16	36.19	34	43
Venus casina	92	1.15	38.16	27	34

Table 3.19: Dominant Infaunal Taxa by Abundance					
Taxa	**Total Abundance**	**Mean Abundance**	**Cumulative % of Total Abundance**	**No. of Samples**	**% of Samples**
Spisula elliptica	90	1.13	40.09	30	38
Aonides paucibranchiata	90	1.13	42.02	12	15
Phoronida sp.	88	1.10	43.90	47	59
Nemertea	88	1.10	45.79	40	50
Bathyporeia pelagica	87	1.09	47.65	35	44
Prionospio fallax	77	0.96	49.30	28	35
Fabulina fabula	68	0.85	50.76	26	33

In terms of biomass, molluscs were the main contributor with the bivalves *Glycymeris glycymeris* and *Polititapes rhomboides* along with the sea potato *Echinocardium cordatum* accounting for 79% of total biomass although the bivalves listed above were recorded at very few stations but included some very large specimens. Other taxa such as *Clausinella fasciata*, Pharidae sp., *Chamelea striatula*, *Dosinia lupinus*, Echinoidea sp. and *Gari fervensis* collectively accounted for 90% of the biomass although most of these taxa with the exception of *Echinocardium cordatum* and *Clausinella fasciata* were present in less than 10% of the stations. Taxa which had moderate biomass contributions but were more widespread included *Antalis entalis*, *Spisula elliptica*, *Venus casina*, *Lanice conchilega*, *Cochlodesma praetenue*, *Lumbrineris aniara* and *Euspira nitida* which were present at 10% to 58% of the stations.

Table 3.20: Dominant Infaunal Taxa by Biomass					
Taxa	**Total Biomass**	**Mean Biomass**	**Cumulative % of Total Biomass**	**No. of Samples**	**% of Samples**
Glycymeris glycymeris	167.93	2.0991	34.42	2	3
Echinocardium cordatum	147.52	1.8439	64.65	15	19
Polititapes rhomboides	73.50	0.9188	79.72	4	5
Clausinella fasciata	17.37	0.2171	83.28	11	14
Pharidae sp.	7.77	0.0971	84.87	2	3
Chamelea striatula	6.92	0.0865	86.29	8	10
Dosinia lupinus	6.51	0.0813	87.62	4	5
Echinoidea sp. (damaged)	6.06	0.0757	88.86	2	3
Gari fervensis	5.75	0.0719	90.04	42	53
Antalis entalis	4.06	0.0507	90.87	16	20
Spisula elliptica	3.99	0.0498	91.69	30	38
Venus casina	2.50	0.0313	92.20	27	34
Lanice conchilega	2.07	0.0258	92.63	25	31

Table 3.20: Dominant Infaunal Taxa by Biomass					
Taxa	**Total Biomass**	**Mean Biomass**	**Cumulative % of Total Biomass**	**No. of Samples**	**% of Samples**
Cochlodesma praetenue	1.68	0.0209	92.97	9	11
Lumbrineris aniara	1.65	0.0206	93.31	46	58
Euspira nitida	1.44	0.0180	93.60	29	36
Gari tellinella	1.43	0.0179	93.90	2	3
Lucinoma borealis	1.40	0.0175	94.18	12	15
Abra prismatica	1.29	0.0162	94.45	34	43
Ammodytes sp.	1.27	0.0159	94.71	1	1
Lumbrineridae	1.15	0.0144	94.95	6	8
Phaxas pellucidus	1.15	0.0144	95.18	31	39

3.2.5 Multivariate Analysis

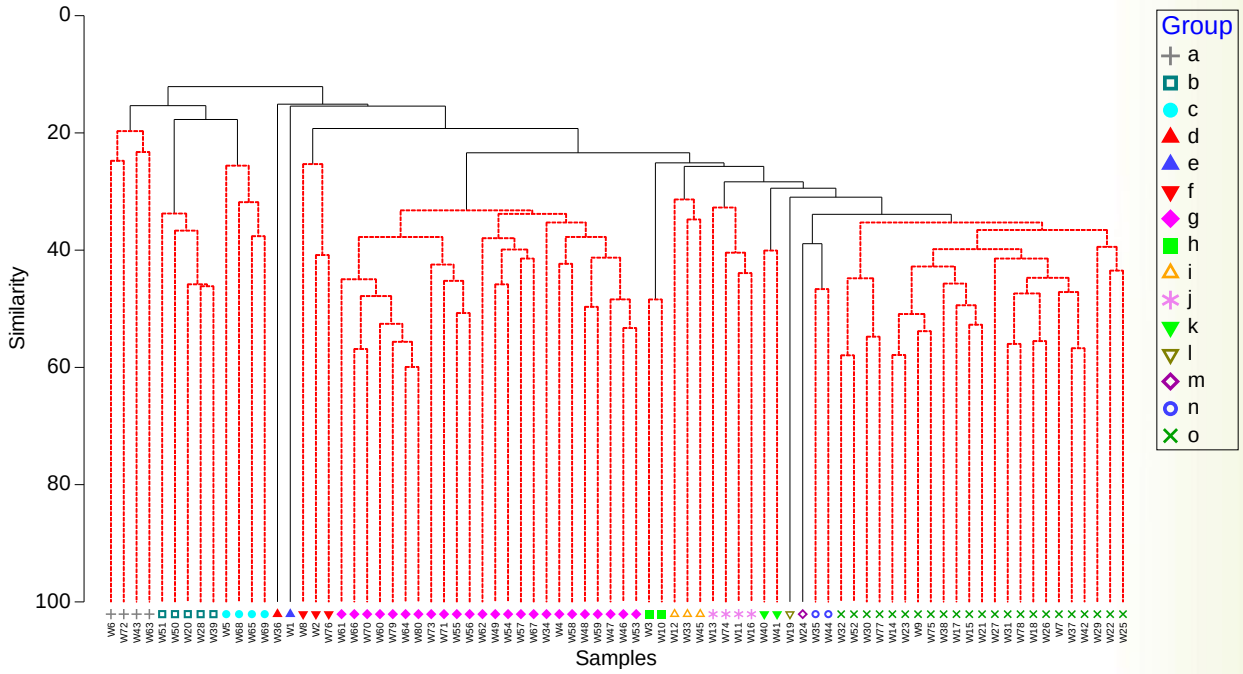
Multivariate analysis of the abundance data was carried out in order to describe the main patterns and assemblages within the area. Classification (cluster analysis) of the data was undertaken using the Bray-Curtis similarity coefficient and grouped average (UPGMA) clustering technique followed by a non-metric MDS (multi-dimensional scaling) ordination was undertaken using the PRIMER package.

The results of multivariate analysis are provided in Figure 3.9 which highlights quite a high degree of variability between samples with quite low similarities between many of the samples/groups as might be expected in sandy or gravelly samples with a wide variety of taxa often present in low numbers of in few samples. The SIMPROF routine identified 15 groups of samples although these included a number of small groups with few samples. A summary of the characteristics of the sample groups derived from SIMPER (including abundance of key taxa, contribution to similarity number of stations and key environmental parameters) is provided in Table 3.21 and correlations between environmental parameters and similarities between stations based on species data derived using the BEST routine in Primer are highlighted in Table 3.22. A more detailed summary from SIMPER for each of the groups derived by the SIMPROF routine is provided in Annex 7.1J.

The main separation between groups was between groups A, B and C and the remaining groups which are separated at 12% similarity. Group A included four stations with coarse or mixed sediments (sandy gravel, gravel or muddy sand gravel). These stations exhibited relatively low similarities and are primarily located on the eastern fringe of the site (Figure 3.10) and characteristic taxa include *Echinocyamus pusillus*, *Aponuphis bilineata*, *Lumbrineris aniara*, *Gnathia oxyuraea*, *Timoclea ovata*, Nemertea sp. and *Chaetozone zetlandica*. These samples are rather variable and don't exhibit communities which are clearly correlated to existing biotopes but are essentially variations of **SS.SCS.CCS** (Circalittoral coarse sediment) biotopes and given the presence of lumbrinerids and robust bivalves such as *Timoclea ovata* are most likely variants of **SS.SCS.CCS.MedLumVen** (*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel). Group B includes five rather variable mixed coarse sediment stations (muddy sandy gravels, sandy gravel or gravelly sands) with varying silt content characterised by taxa such as Nematoda, *Echinocyamus pusillus*, *Aonides paucibranchiata*, *Notomastus* spp., juvenile Ophiuroidea spp., Nemertea and *Pisione remota*. These stations are likely to be uncertain variants of **SS.SCS.CCS** (Circalittoral coarse sediment) or **SS.SMx** (Sublittoral mixed sediment) depending on mud content.

However, a number of these stations from cleaner sandy gravel/gravelly sand (shell gravel) include taxa such as *Echinocyamus pusillus*, *Aonides paucibranchiata* and *Pisione remota* and one of the stations also included a specimen of the European lancelet *Branchiostoma lanceolatum* and as such resemble the biotope **SS.SCS.CCS.Blan** (*Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel).

Group C includes four stations with cleaner gravelly sands or sandy gravel characterised by the bivalve *Asbjornsenia pygmaea* (previously *Moerella pygmaea*) along with *Spisula elliptica*, Nematoda, *Glycera lapidum* agg., *Ophelia borealis*, *Aonides paucibranchiata, Urothoe marina* and *Echinocyamus pusillus* and corresponds to the biotope **SS.SCS.ICS.MoeVen** (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) which is a Priority Marine Feature habitat. Groups D, E and F are three outlier groups loosely associated with groups G to O at around 18-20% similarity which include two groups with single stations (W36 in group D and W1 in group E) in gravelly sand or slightly gravelly sand whilst group contains three stations (W2, W8 and W76) in slightly gravelly sand. These stations are characterised by taxa such as *Bathyporeia pilosa*, *Thracia villosiuscula*, *Lumbrineris aniara* and *Nephtys kersivalensis* (group D), Amphiuridae sp. (juvenile), *Magelona alleni*, *Prionospio fallax*, *Spiophanes bombyx* and *Bathyporeia sarsi* (group E) or Copepoda sp., *Diplocirrus glaucus*, Phoronida sp., *Bathyporeia pelagica* and *Venus casina* (group F). These groups are not a particularly good match for any specific biotope and are considered rather transitional or intermediate communities within **SS.SSa** (Sublittoral sands and muddy sands).



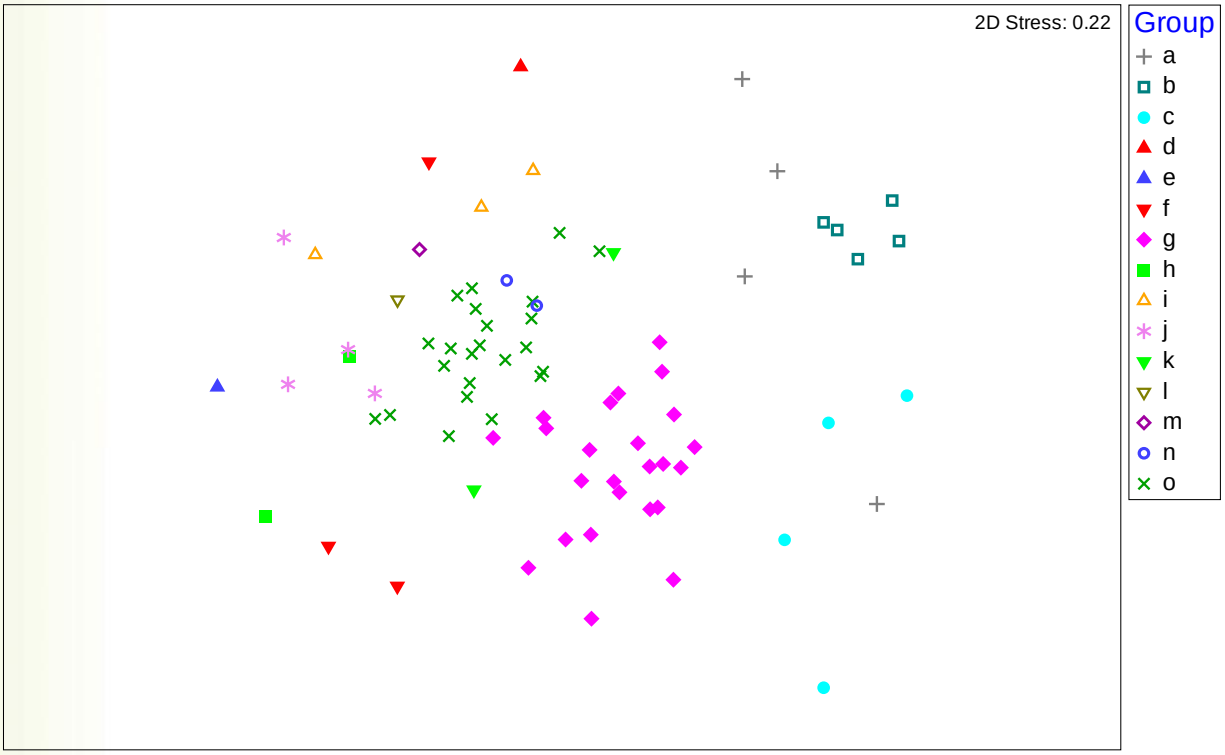


Figure 3.9: Results of multivariate analysis - cluster analysis (top) and nMDS ordination (bottom)

Group G is a relatively large group (24 stations) primarily to the west of the Moray West site characterised by gravelly sand or slightly gravelly sand and dominated by taxa such as *Echinocyamus pusillus*, *Spiophanes bombyx*, *Gari fervensis*, *Bathyporeia pelagica*, *Spisula elliptica*, *Asbjornsenia pygmaea*, *Crenella decussata* and *Abra prismatica*. As such this community is considered to be a variant of **SS.SSa.CFiSa.EpusOborApri** (*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand) although it lacks a significant population of *Ophelia borealis* and is perhaps transitional with **SS.SCS.ICS.MoeVen**. Groups H to O form a series of clusters separated from group G at around 25% similarity of which the largest is group O (with 23 sites) to which the remaining groups are loosely associated at around 25% to 35% similarity. Groups I to K are a series of small groups with stations characterised by slightly gravelly sand or slightly gravelly muddy sand with a modest mud component (<10%). These groups are rather variable and are characterised by a variety of taxa many of which are which are present in both group G and group O (the two main groups of stations). Group H is characterised by *Magelona alleni*, Edwardsiidae sp., *Venus casina*, *Thracia villosiuscula*, *Spiophanes bombyx*, *Echinocardium cordatum*, *Fabulina fabula* and is likely a variant of **SS.SSa.IMuSa.FfabMag** (*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand). Group I contains stations with a higher gravel content (station W45 in particular) and is characterised by taxa such as *Spiophanes bombyx*, *Clausinella fasciata*, *Lumbrineris aniara*, *Thracia villosiuscula, Diplocirrus glaucus, Ampelisca tenuicornis*, *Phaxas pellucidus* and the group does not form a good match with any specific biotope therefore stations in this group are classified as **SS.SSa** (Sublittoral sands and muddy sands) or **SS.SCS.CCS** (Circalittoral coarse sediment) although some of the stations within this group also include low densities of *Fabulina fabula* and *Magelona* sp. so are possibly transitional or intermediate variants of **SS.SSa.IMuSa.FfabMag**.

Groups J and K are characterised by Phaxas pellucidus, Antalis entalis, Diplocirrus glaucus, Prionospio fallax, Lumbrineris aniara and Chaetozone setosa or Echinocyamus pusillus, Copepoda sp., Thracia villosiuscula, Ophiuroidea spp. (juvenile), Fabulina fabula and Chamelea striatula respectively and are also rather transitional communities which belong to **SS.SSa** (Sublittoral sands and muddy sands) and possibly include variants of **SS.SSa.IMuSa.FfabMag** (Fabulina fabula and Magelona mirabilis with venerid bivalves

and amphipods in infralittoral compacted fine muddy sand) particularly group K which has modest numbers of Fabulina fabula.

Groups L and M include two single stations (W19 in group L and W24 in group M) in slightly gravelly sand or slightly gravelly muddy sand. These stations exhibit rather transitional communities characterised by *Echinocyamus pusillus*, *Magelona filiformis*, *Prionospio fallax*, *Diplocirrus glaucus*, *Phaxas pellucidus*, *Nothria conchylega* and *Owenia fusiformis* (group L) or *Prionospio fallax*, *Lumbrineris aniara*, *Diplocirrus glaucus*, *Thracia villosiuscula*, *Bathyporeia gracilis*, juvenile Amphiuridae sp. and *Venus casina* (group M). These stations are classified as **SS.SSa** (Sublittoral sands and muddy sands) but include low numbers of species which are characteristic of biotopes such as **SS.SSa.CFiSa.EpusOborApri** and **SS.SSa.IMuSa.FfabMag** but also include low numbers of Amphiuridae brittlestars and *Owenia fusiformis* so also have some correlation to **SS.SSa.OSa.OfusAfil** (*Owenia fusiformis and Amphiura filiformis* in offshore circalittoral sand or muddy sand) and are likely to be intermediate variants of these biotopes.

Group N comprises of two stations (W35 and W44) in gravelly sand with a modest mud content characterised by Lumbrineris aniara, Venus casina, Spiophanes bombyx, Bathyporeia pelagica, Urothoe elegans, Abra prismatica, Thracia villosiuscula and Echinocyamus pusillus and is likely to be an a rather uncertain variant of **SS.SSa.CFiSa.EpusOborApri** (Echinocyamus pusillus, Ophelia borealis and Abra prismatica in circalittoral fine sand) with elements of coarser sediment biotopes (e.g. **SS.SCS.CCS.MedLumVen)**. Group O comprises of 23 stations with gravelly sand, slightly gravelly sand or slightly gravelly muddy sand and is characterised by taxa such as Echinocyamus pusillus, Spiophanes bombyx, Phoronida sp., Lumbrineris aniara, Prionospio fallax, Diplocirrus glaucus, Urothoe elegans, Abra prismatica, Magelona alleni and Fabulina fabula. It is most closely associated with the biotope **SS.SSa.CFiSa.EpusOborApri** (Echinocyamus pusillus, Ophelia borealis and Abra prismatica in circalittoral fine sand) but is likely to be a deeper intermediate variant with **SS.SSa.IMuSa.FfabMag** (Fabulina fabula and Magelona mirabilis with venerid bivalves and amphipods in infralittoral compacted fine muddy sand). Both groups N and O and a number of the other small groups associated with these also include stations with low numbers of Owenia fusiformis and occasionally Amphiura spp. Along with taxa such as Diplocirrus glaucus which are characteristic of biotopes such as **SS.SSa.OSa.OfusAfil** (Owenia fusiformis and Amphiura filiformis in offshore circalittoral sand or muddy sand) although numbers of Owenia and Amphiura are generally too low to be considered a definitive match for this biotope.

Overall, the infaunal communities present within the wind farm area are variations of the Sublittoral Sand (**SSa**) and Circalittoral coarse (or mixed) sediment (**CCS** or **CMX**) habitat complexes with rather transitional biotopes which are often poorly aligned to existing biotopes. Many of these biotopes are currently being refined/revised as part of an ongoing project managed by JNCC which will hopefully clarify such communities in future surveys. A summary of the biotope distribution for the survey stations including biotope designations derived from DDV along the Offshore Export Cable Corridor route are provided in Figure 3.10.

Table 3.21: Summary of Groups Derived from Cluster Analysis

Group	No. of Stations	Sediment Types	Mean % Gravel	Mean % Sand	Mean % Mud	Mean Depth (m CD)	Characteristic Taxa
Group A (Average similarity: 21.14%)	4	Sandy Gravel, Muddy Sandy Gravel	43.30	54.42	2.27	39.8	*Echinocyamus pusillus, Aponuphis bilineata, Lumbrineris aniara, Gnathia oxyuraea, Timoclea ovata, Nemertea, Chaetozone zetlandica, Platyhelminthes sp., Scoloplos armiger, Polynoidae sp*.

Table 3.21: Summary of Groups Derived from Cluster Analysis

Group	No. of Stations	Sediment Types	Mean % Gravel	Mean % Sand	Mean % Mud	Mean Depth (m CD)	Characteristic Taxa
Group B (Average similarity: 38.29%)	5	Muddy Sandy Gravel, Gravelly Muddy Sand, Sandy Gravel, Gravelly Sand	32.48	61.45	6.07	43.4	Nematoda, *Echinocyamus pusillus, Aonides paucibranchiata, Notomastus spp., Ophiuroidea spp*. (juvenile), Nemertea, *Pisione remota, Lanice conchilega, Grania sp., Aponuphis bilineata*
Group C (Average similarity: 29.67%)	4	Sandy Gravel, Slightly Gravelly Sand, Gravelly Sand	18.14	81.19	0.67	37.3	*Asbjornsenia pygmaea, Spisula elliptica,* Nematoda, *Glycera lapidum agg., Ophelia borealis, Aonides paucibranchiata, Urothoe marina, Echinocyamus pusillus, Leptocheirus hirsutimanus, Golfingia sp.*
Group D	1	Gravelly Sand	6.61	89.48	3.91	43.8	*Bathyporeia pilosa, Thracia villosiuscula, Lumbrineris aniara, Nephtys kersivalensis, Eumida sanguinea, Polynoidae sp., Owenia fusiformis, Euclymene oerstedii, Cheirocratus sp., Ophiuroidea spp.* (juvenile)
Group E	1	Slightly Gravelly Sand	0.01	92.34	7.65	49.2	*Amphiuridae sp*. (juvenile), *Magelona alleni, Prionospio fallax, Spiophanes bombyx, Bathyporeia sarsi, Goniada maculata, Oxydromus flexuosus, Nephtys kersivalensis, Copepoda sp., Ampelisca tenuicornis*
Group F (Average similarity: 30.50%)	3	Sand, Slightly Gravelly Sand	1.21	93.12	5.67	48.7	*Copepoda sp., Diplocirrus glaucus, Phoronida sp., Bathyporeia pelagica, Venus casina, Glycinde nordmanni, Lanice conchilega, Phaxas pellucidus*
Group G (Average similarity: 36.16%)	24	Gravelly Sand, Slightly Gravelly Sand	4.69	94.82	0.49	38.5	*Echinocyamus pusillus, Spiophanes bombyx, Gari fervensis, Bathyporeia pelagica, Spisula elliptica, Asbjornsenia pygmaea, Crenella decussata, Abra prismatica, Thracia villosiuscula, Ophiuroidea spp*. (juvenile)
Group H (Average similarity: 48.41%)	2	Slightly Gravelly Muddy Sand, Slightly Gravelly Sand	1.21	90.82	7.97	47.6	*Magelona alleni, Edwardsiidae sp., Venus casina, Thracia villosiuscula, Spiophanes bombyx, Echinocardium cordatum, Fabulina fabula, Antalis entalis*

Table 3.21: Summary of Groups Derived from Cluster Analysis

Group	No. of Stations	Sediment Types	Mean % Gravel	Mean % Sand	Mean % Mud	Mean Depth (m CD)	Characteristic Taxa
Group I (Average similarity: 32.49%)	3	Slightly Gravelly Sand, Gravelly Sand	5.75	87.30	6.94	43.8	*Spiophanes bombyx, Clausinella fasciata, Lumbrineris aniara, Thracia villosiuscula, Diplocirrus glaucus, Ampelisca tenuicornis, Phaxas pellucidus, Nucula nitidosa, Bathyporeia gracilis, Edwardsia claparedii*
Group J (Average similarity: 37.16%)	4	Slightly Gravelly Sand, Slightly Gravelly Muddy Sand	0.50	90.20	9.30	46.9	*Phaxas pellucidus, Antalis entalis, Diplocirrus glaucus, Prionospio fallax, Lumbrineris aniara, Chaetozone setosa, Phoronida sp., Copepoda sp., Abra prismatica, Paguridae sp*. (juvenile/larvae)
Group K (Average similarity: 40.07%)	2	Slightly Gravelly Sand	1.23	96.52	2.25	42.4	*Echinocyamus pusillus, Copepoda sp., Thracia villosiuscula, Ophiuroidea spp*. (juvenile), *Fabulina fabula, Chamelea striatula, Euspira nitida*
Group L	1	Slightly Gravelly Sand	0.75	93.33	5.92	46.8	*Echinocyamus pusillus, Magelona filiformis, Prionospio fallax, Diplocirrus glaucus, Phaxas pellucidus, Nothria conchylega, Owenia fusiformis, Spiophanes bombyx, Ampharete lindstroemi, Lanice conchilega*
Group M	1	Slightly Gravelly Muddy Sand	1.21	86.25	12.55	46.0	*Prionospio fallax, Lumbrineris aniara, Diplocirrus glaucus, Thracia villosiuscula, Bathyporeia gracilis, Amphiuridae sp.* (juvenile), *Venus casina, Chaetozone setosa, Gari fervensis, Nephtys kersivalensis*
Group N (Average similarity: 46.65%)	2	Gravelly Sand	8.15	86.77	5.08	42.5	*Lumbrineris aniara, Venus casina, Spiophanes bombyx, Bathyporeia pelagica, Urothoe elegans, Abra prismatica, Thracia villosiuscula, Echinocyamus pusillus, Gari fervensis, Phoronida sp*.
Group O (Average similarity: 39.40%)	23	Gravelly Sand, Slightly Gravelly Sand, Slightly Gravelly Muddy Sand, Gravelly Muddy Sand	3.12	91.19	5.69	46.2	*Echinocyamus pusillus, Spiophanes bombyx, Phoronida sp., Lumbrineris aniara, Prionospio fallax, Diplocirrus glaucus, Urothoe elegans, Abra prismatica, Magelona alleni, Fabulina fabula*

The correlation between station similarities (based on species data) and environmental parameters including water depth and particle size summary statistics has been assessed using the BEST routine in Primer. The results of the BEST routine are provided in Table 3.22 which indicate that sediment parameters had good correlations to infaunal community structure and Median Phi Grain Size provided the best overall correlation (r=0.71) closely followed by Mean Phi Grain Size (r=0.661). Sand and gravel content have correlations of 0.466 and 0.44 respectively whilst sediment sorting (r=0.391), water depth (r=0.357) and mud content (r=0.262) exhibited slightly lower correlations. sediment skewness had a correlation of 0.198 whilst sediment kurtosis had a very low correlation of 0.047. No combination of parameters provided a better correlation than Median Phi Grain Size.

Table 3.22: Results of BEST Routine

Parameter	Correlation (r)	Best Combination (r=0.71)
Median Phi Grain Size	0.71	✓
Mean Phi Grain Size	0.661	
Sand Content	0.466	
Gravel Content	0.44	
Sediment Sorting	0.391	
Water Depth	0.357	
Mud Content	0.262	
Sediment Skewness	0.198	
Sediment Kurtosis	0.047	

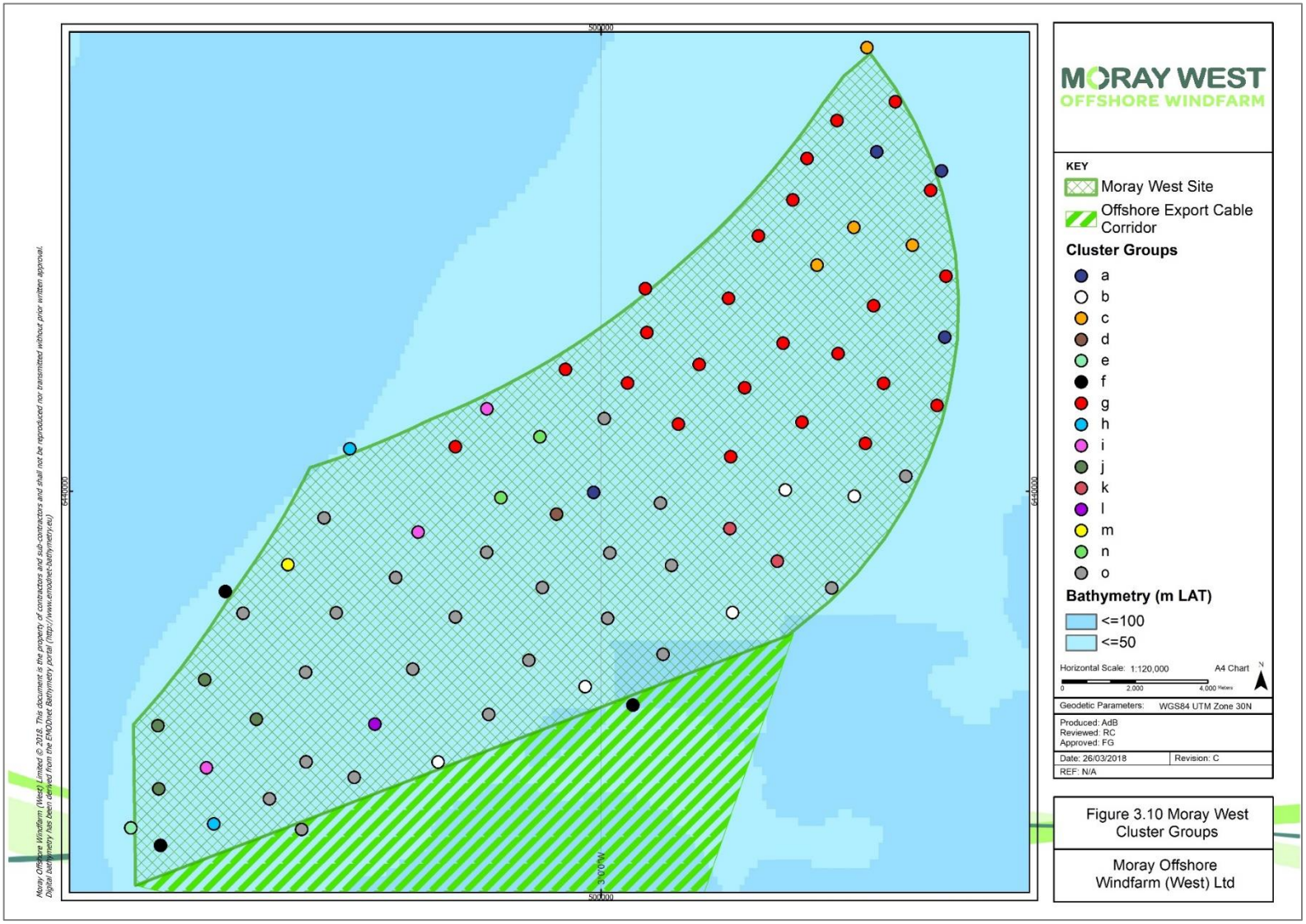


Figure 3.10: Moray West Site Faunal Cluster Groups Identified From Multivariate Analysis

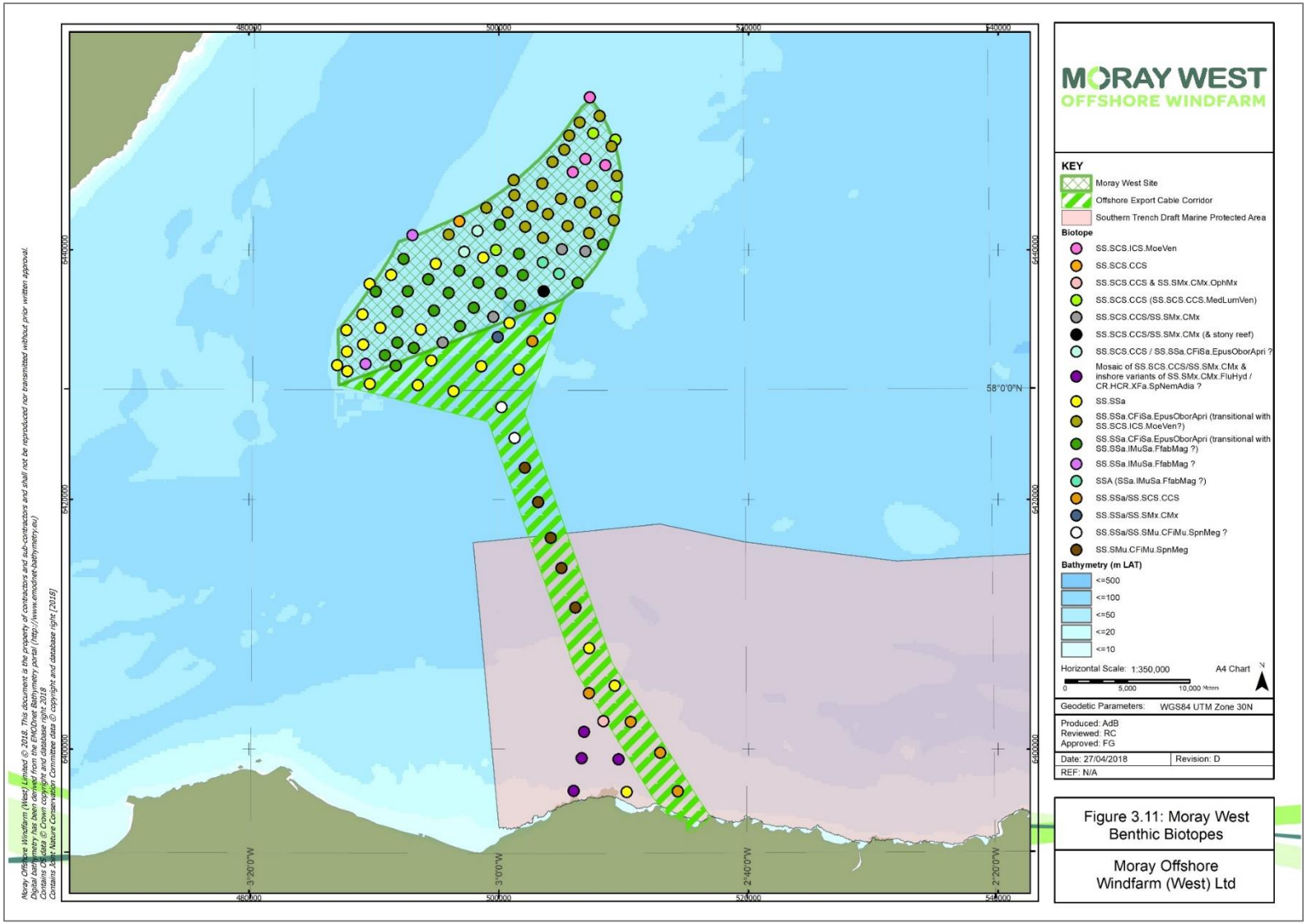


Figure 3.11: Moray West Site Biotopes

3.3 Epibenthic Trawl Survey

Fifteen 2m beam trawls were undertaken within the vicinity of the Moray West site (Figure 3.12). Full species data from the trawls are provided in Annex 7.1J and Annex 7.1K. The most dominant enumerated invertebrate taxa from the trawl survey were *Balanus crenatus* and *Asterias rubens* (Table 3.23) which accounted for 62% of the total abundance and were widely distributed. Other numerically important invertebrates were *Pagurus prideaux*, *Adamsia palliata*, *Ophiura ophiura*, *Echinus esculentus* and *Astropecten irregularis* which collectively accounted for 79% of the total abundance. A range of other taxa were also present including *Ophiothrix fragilis*, *Hyas coarctatus*, *Anomia ephippium*, *Ascidiella scabra*, *Echinocardium cordatum*, *Galathea intermedia*, *Psammechinus miliaris*, *Pagurus bernhardus*, *Spirobranchus triqueter*, *Luidia sarsii*, *Macropodia rostrata* and *Eunereis longissima*. Echinoderms and a variety of decapod crustacea (primarily crabs) were generally the most numerous species along with a variety of other polychaete, crustacean and mollusc taxa. Prawns and shrimps were present in relatively low numbers (notably Prawns such as *Pandalina brevirostris* and the Pink Shrimp *Pandalus montagui*). A wide variety of other taxa were also present in lower numbers and in total 121 invertebrate taxa were recorded from the trawl survey.

Table 3.23: Dominant Quantitative Invertebrate Taxa from Beam Trawls

Common name	Scientific Name	Total Abundance	Cum % Abundance	No. Sites	% Sites
Acorn Barnacle	*Balanus crenatus*	2408	38	12	80
Common Starfish	*Asterias rubens*	1554	62	15	100
Hermit Crab	*Pagurus prideaux*	315	67	13	87
Cloak Anemone	*Adamsia palliata*	288	71	13	87
Serpent Star	*Ophiura ophiura*	171	74	15	100
Edible Sea Urchin	*Echinus esculentus*	128	76	4	27
Sand Star	*Astropecten irregularis*	110	78	14	93
Common Brittlestar	*Ophiothrix fragilis*	99	79	3	20
Contracted Crab	*Hyas coarctatus*	96	81	13	87
Saddle Oyster	*Anomia ephippium*	92	82	12	80
Hairy Sea Squirt	*Ascidiella scabra*	91	84	11	73
Sea Potato	*Echinocardium cordatum*	69	85	7	47
Squat Lobster	*Galathea intermedia*	67	86	10	67
Green Sea Urchin	*Psammechinus miliaris*	62	87	9	60
Hermit Crab	*Pagurus bernhardus*	57	88	14	93
Keelworm	*Spirobranchus triqueter*	43	88	9	60
Starfish	*Luidia sarsii*	43	89	8	53
Long Legged Crab	*Macropodia rostrata*	42	90	11	73
Ragworm	*Eunereis longissima*	41	90	9	60

A variety of colonial or encrusting epifaunal taxa were also recorded across the study area, which were not enumerated (qualitative taxa). As highlighted in Table 3.24 these taxa included Dead Man's Fingers (*Alcyonium digitatum*), Hornwrack (*Flustra foliacea*) and the hydrozoan *Hydrallmania falcata,* which were

all present at over 80% of the trawl stations. A variety of other taxa including hydroids, bryozoans and sponges were also present including species such as *Suberites carnosus*, *Alcyonidium diaphanum*, *Alcyonidium parasiticum*, *Hydractinia echinata*, *Nemertesia*, Bougainvilliidae, *Tubulipora*, *Securiflustra securifrons*, Sertulariidae and *Sertularia cupressina*.

Table 3.24: Qualitative Invertebrate Taxa from Beam Trawls

Common name	Scientific Name	Total Abundance	No. Sites	% Sites
Dead Man's Fingers	*Alcyonium digitatum*	P	14	93
Hornwrack	*Flustra foliacea*	P	13	87
Hydrozoan	*Hydrallmania falcata*	P	12	80
Sponge	*Suberites carnosus*	P	11	73
Sea Chervil	*Alcyonidium diaphanum*	P	10	67
Parasitic Chervil	*Alcyonidium parasiticum*	P	10	67
Snail Fur	*Hydractinia echinata*	P	9	60
Hydrozoa	Nemertesia	P	6	40
Hydrozoan	Bougainvilliidae	P	5	33
Bryozoa	*Tubulipora*	P	5	33
Bryozoa	*Securiflustra securifrons*	P	5	33
Hydrozoan	Sertulariidae	P	4	27
White Weed	*Sertularia cupressina*	P	4	27
Hydrozoan	Campanulariidae	P	3	20
Sponge	Porifera	P	2	13
Bottlebrush Hydroid	*Thuiaria thuja*	P	2	13
Sponge	Suberitidae	P	1	7
Sea Beard	*Nemertesia antennina*	P	1	7
Hydrozoan	*Nemertesia ramosa*	P	1	7
Whelk Egg Mass	*Buccinum undatum*	P	1	7
Red Whelk Egg Mass	*Neptunea antiqua*	P	1	7
Bryozoa	*Eucratea loricata*	P	1	7
Bryozoa	*Bugulina flabellata*	P	1	7
Sea Squirts	Styelidae	P	1	7

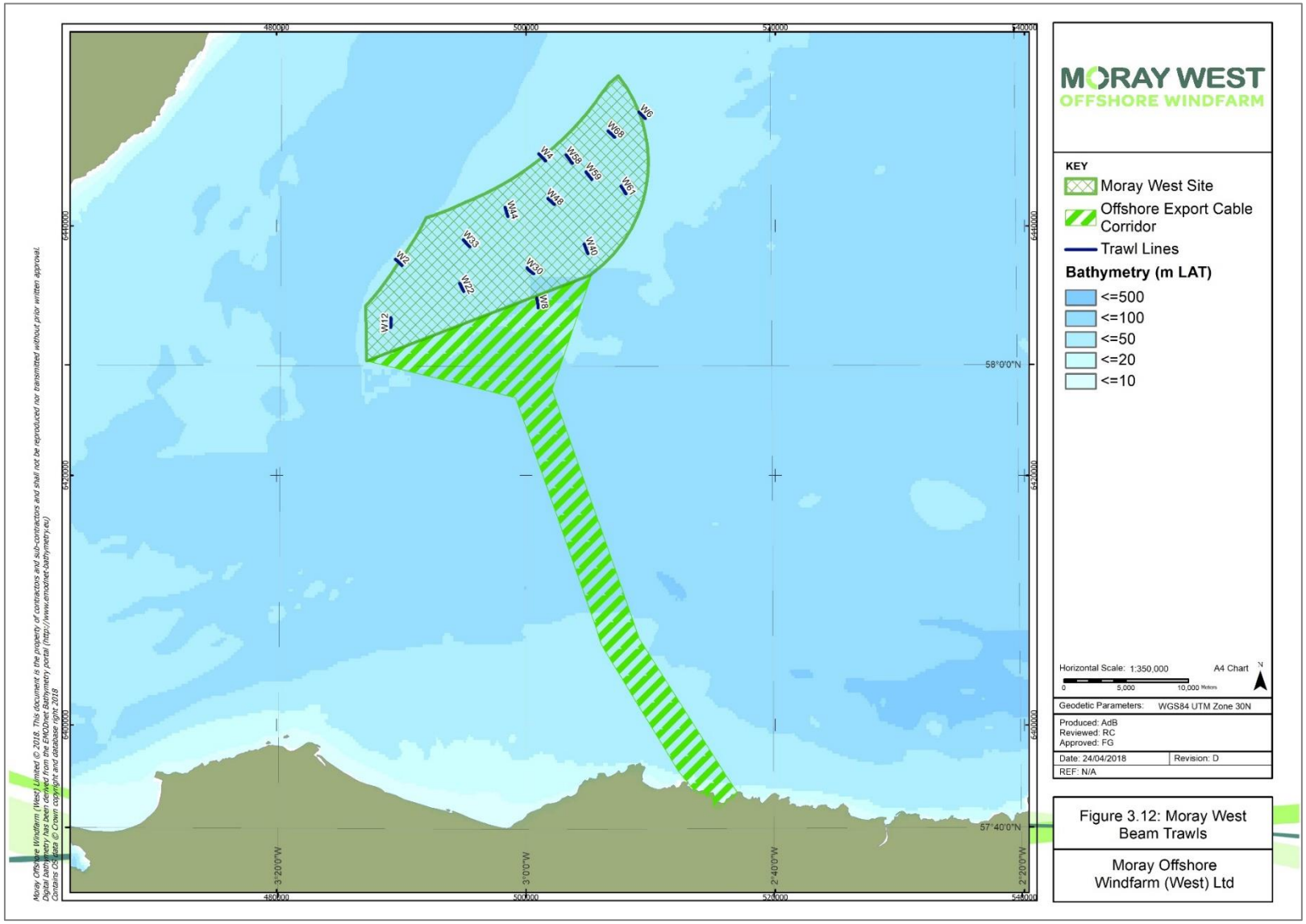


Figure 3.12: Moray West Site Beam Trawls

In terms of fish species, flatfish such as dab and plaice were most numerous followed by the dragonet *Callionymus lyra* and these taxa were recorded at all the trawl stations (Table 3.25). Other fish species recorded in moderate numbers included Pogge (*Agonus cataphractus*), Lemon Sole (*Microstomus kitt*) and Grey Gurnard (*Eutrigla gurnardus*) which were recorded at over 80% of the trawl stations. Other numerically important fish species included *Microchirus variegatus*, *Crystallogobius linearis*, juvenile Gadidae, *Buglossidium luteum*, *Myoxocephalus scorpius*, juvenile Pleuronectiformes and *Arnoglossus laterna* along with a variety of goby species. Other fish species were recorded in low numbers including angler fish, Norwegian topknot, and sand eel whilst elasmobranchs such as the cuckoo ray and lesser spotted dogfish were also occasionally recorded.

Table 3.25. Dominant Fish Taxa from Beam Trawls

Common name	Scientific Name	Notes	Sum	No. Sites	% Sites
Dab	*Limanda limanda*		183	15	100
Plaice	*Pleuronectes platessa*		127	15	100
Common Dragonet	*Callionymus lyra*		76	15	100
Pogge	*Agonus cataphractus*		60	14	93
Lemon Sole	*Microstomus kitt*		36	12	80
Grey Gurnard	*Eutrigla gurnardus*		34	12	80
Thickback Sole	*Microchirus variegatus*		20	10	67
Crystal Goby	*Crystallogobius linearis*		19	7	47
Gadoid	Gadidae	Juvenile	19	4	27
Solenette	*Buglossidium luteum*		14	10	67
Bull Rout	*Myoxocephalus scorpius*		12	4	27
Flatfish	Pleuronectiformes	Juvenile	11	3	20
Scaldfish	*Arnoglossus laterna*		10	7	47
Sand Goby	*Pomatoschistus minutus*		7	5	33
Goby	*Pomatoschistus*	Juvenile	7	3	20
Angler fish	*Lophius piscatorius*		6	5	33
Common Goby	*Pomatoschistus microps*		5	2	13
Reticulated Dragonet	*Callionymus reticulatus*		4	3	20
Norwegian Topknot	*Phrynorhombus norvegicus*		4	3	20
Raitt's Sand-eel	*Ammodytes marinus*		4	2	13
Cuckoo Ray	*Leucoraja naevus*		2	2	13
Three Bearded Rockling	*Gaidropsarus vulgaris*		2	2	13
John Dory	*Zeus faber*		2	2	13
Lesser Spotted Dogfish	*Scyliorhinus canicula*		1	1	7
Sand-eel	*Ammodytes*	Juvenile	1	1	7
Dragonet	*Callionymus*	Juvenile	1	1	7

Table 3.25. Dominant Fish Taxa from Beam Trawls					
Common name	**Scientific Name**	**Notes**	**Sum**	**No. Sites**	**% Sites**
Egg case	*Scyliorhinus*		P	1	7

The size class distribution of commercial fish species which were recorded in high numbers (dab, plaice and lemon sole) are provided in Figures Figure 3.13 to Figure 3.15. These indicate that the majority of these species are from a single cohort of sub-adult (young fish) although a possible second cohort of juveniles may be present, particularly for dab. Adult dab are generally between 25-30cm in length whilst adult plaice are generally around 30cm in length and peak abundances from the current survey were around 14cm for dab and 18-19cm for plaice with few if any individuals recorded at adult size. Lemon sole were also predominantly below adult size and whilst overall numbers were rather low they likely to be predominantly from a single cohort.

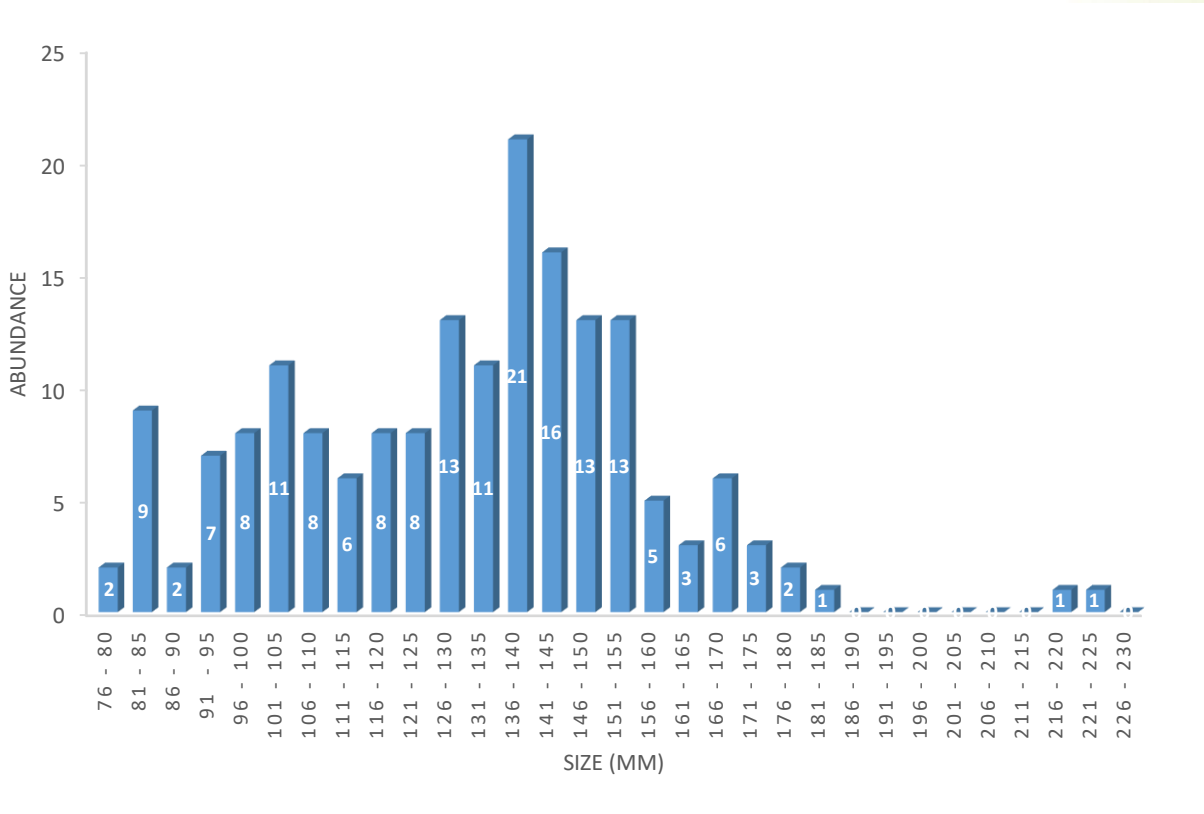


Figure 3.13: Size class of Dab (*Limanda limanda*)

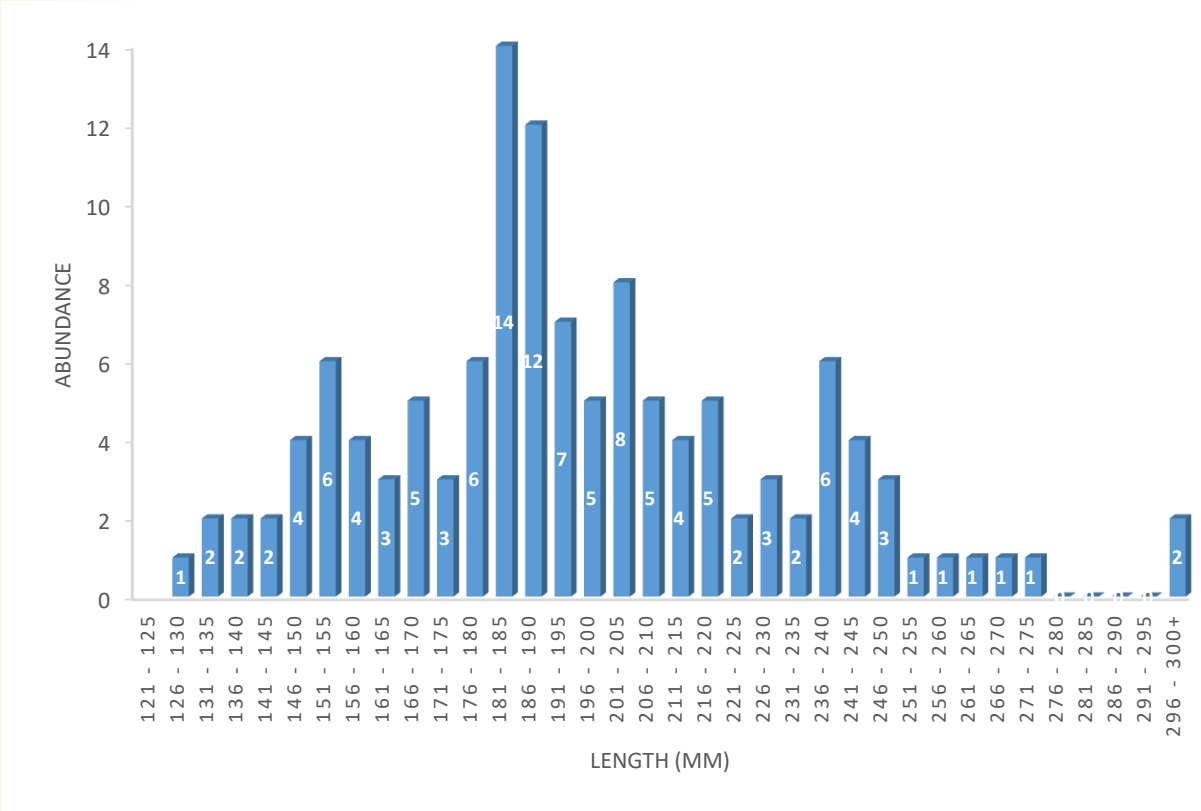


Figure 3.14: Size class of Plaice *(Pleuronectes platessa)*

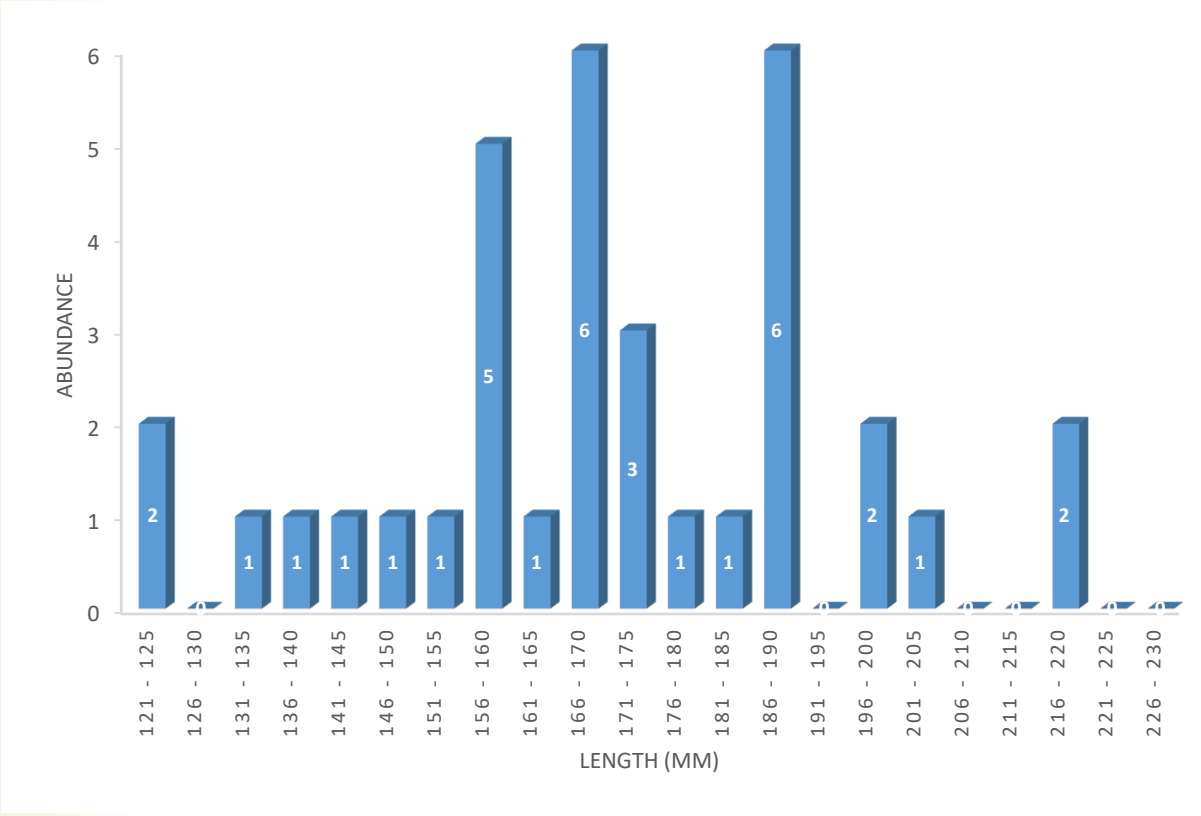


Figure 3.15: Size class of Lemon Sole (Microstomus kitt)

The total number of taxa and abundance (fish and invertebrates) from the trawls have been enumerated (Annex 7.1M, Figure 3.16 and Figure 3.17: Moray West Site Abundance of Epifauna per Trawl) and numbers of taxa per trawl range from 28 (trawl W2) to 70 (trawl W68), whilst total abundance ranged from 176 (trawl W2) to 1611 (trawl W44) per trawl. In general, the highest numbers of taxa and abundance tended to be recorded to the north or and east of the Moray West site, which is likely to reflect the more heterogenous seabed habitats present in these areas which are often characterized by patches of coarser mixed sediment, gravels and stones/cobble.

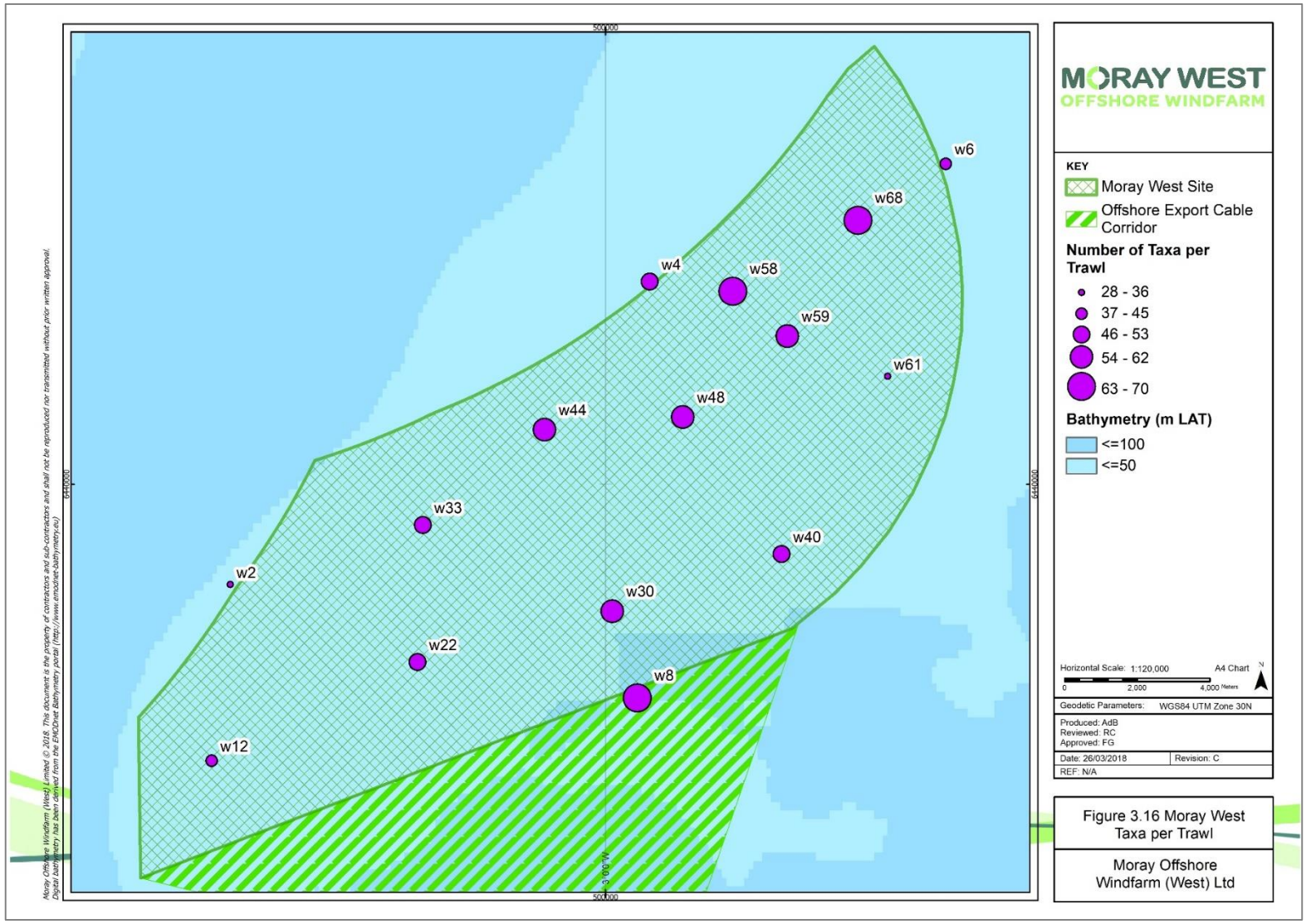


Figure 3.16: Moray West Site Number of Taxa Per Trawl

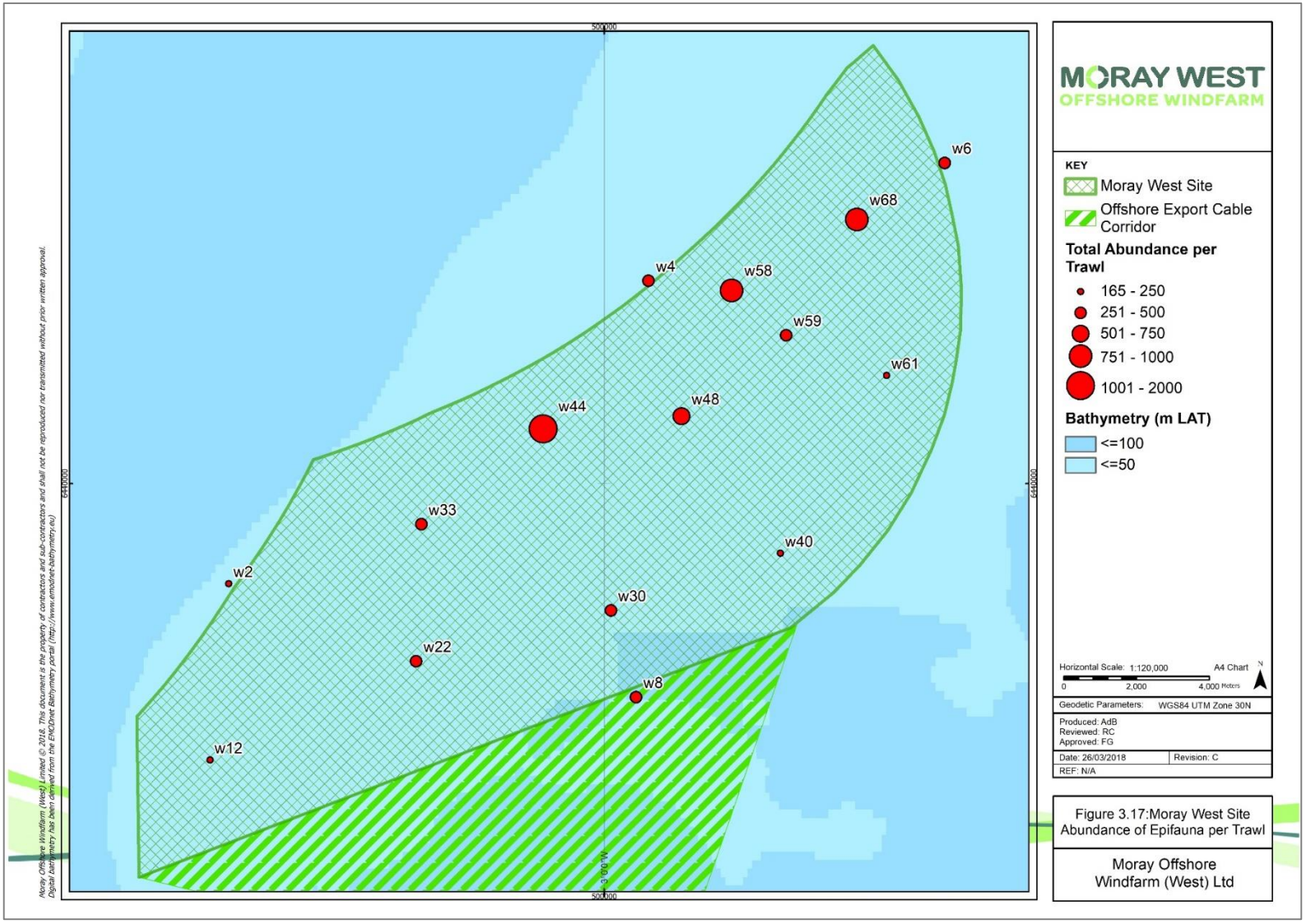


Figure 3.17: Moray West Site Abundance of Epifauna per Trawl

3.3.1 Multivariate Analysis of Trawl Data

Multivariate analysis has been undertaken on the quantitative trawl dataset (invertebrates and fish) with six groups of trawls stations derived from cluster analysis using the SIMPROF routine (**Figure 3.18**). The spatial distribution of these groups is provided in Figure 3.19, whilst a summary of characteristic taxa defined from the SIMPER routine is given for each cluster group in Annex 7.1M.

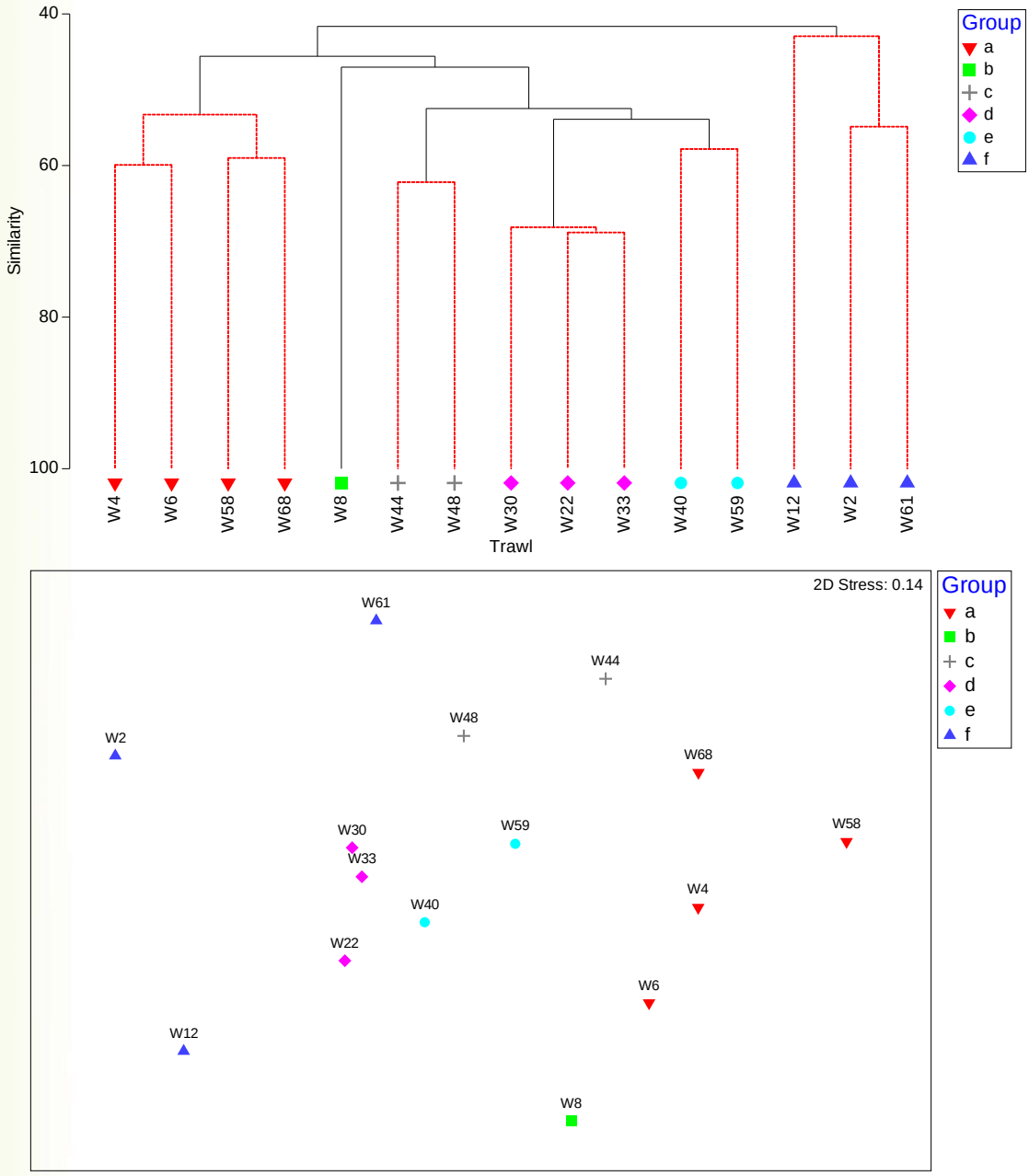


Figure 3.18: Results of Multivariate Analysis on Quantitative Trawl Data

Group A included four trawl stations (W4, W6, W58 and W68) located in the mixed coarser sediments to the north east of the wind farm and were characterised by a diverse number of invertebrates such as *Asterias rubens*, *Pagurus prideaux*, *Adamsia palliata*, *Psammechinus miliaris*, *Hyas coarctatus*, *Anomia ephippium* and *Ascidiella scabra* with relatively low numbers of fish such as dab (*Limanda limanda*), plaice (*Pleuronectes platessa*) and pogge (*Agonus cataphractus*).

Group B included a single trawl station (W8) to the south of the wind farm characterised by *Pagurus prideaux*, *Adamsia palliata*, *Ophiura ophiura*, *Pseudoprotella phasma*, *Balanus crenatus* and moderate numbers of juvenile Gadidae, dragonet (*Callionymus lyra*) and dab (*Limanda limanda*).

Groups C (W44 and W48) and D (W30, W22 and W33) were located in the middle and north of the Moray West site and were characterised by moderately high numbers of *Balanus crenatus* (particularly in group C) along with *Asterias rubens* and dab (*Limanda limanda*) with a variety of other fish and invertebrate taxa e.g. *Astropecten irregularis*, plaice (*Pleuronectes platessa*), *Eunereis longissima*, *Spirobranchus triqueter*, *Pagurus prideaux*, *Adamsia palliata* and *Galathea intermedia* in group C or *Ophiura ophiura*, *Echinocardium cordatum*, *Pagurus prideaux*, *Astropecten irregularis*, *Adamsia palliata*, dragonet (*Callionymus lyra*) and plaice (*Pleuronectes platessa*) in group D.

Group E was comprised two trawl stations (W40 and W59) to the east of the Moray West site and were characterised by moderate numbers of *Asterias rubens*, dab (*Limanda limanda*), Plaice (*Pleuronectes platessa*) and *Ophiura ophiura* with a variety of other taxa in relatively low numbers.

Group F included three stations (W2, W12 and W61) and was characterised by *Asterias rubens*, *Balanus crenatus* and dab (*Limanda limanda*), along with other taxa in lower densities such as *Ophiura ophiura*, plaice (*Pleuronectes platessa*), *Astropecten irregularis*, dragonet (*Callionymus lyra*), pogge (*Agonus cataphractus*) and solenette (*Buglossidium luteum*).

Overall the results of multivariate analysis on the epibenthic trawl data indicate a relatively high similarity between trawls (all trawls exhibiting >40% similarity), with many groups containing similar taxa and differences between groups primarily reflecting variation in rank dominance of invertebrates/fish rather than distinct changes in epifaunal assemblage which probably reflects (in part) variation in heterogeneity of the seabed habitats. As described for the infaunal dataset a degree of spatial separation in trawl groups was evident which correlated to variations in sediment type, namely sand or slightly muddier sand in the east and middle of the site and coarser or more heterogenous habitats to the north and extreme east of the site.

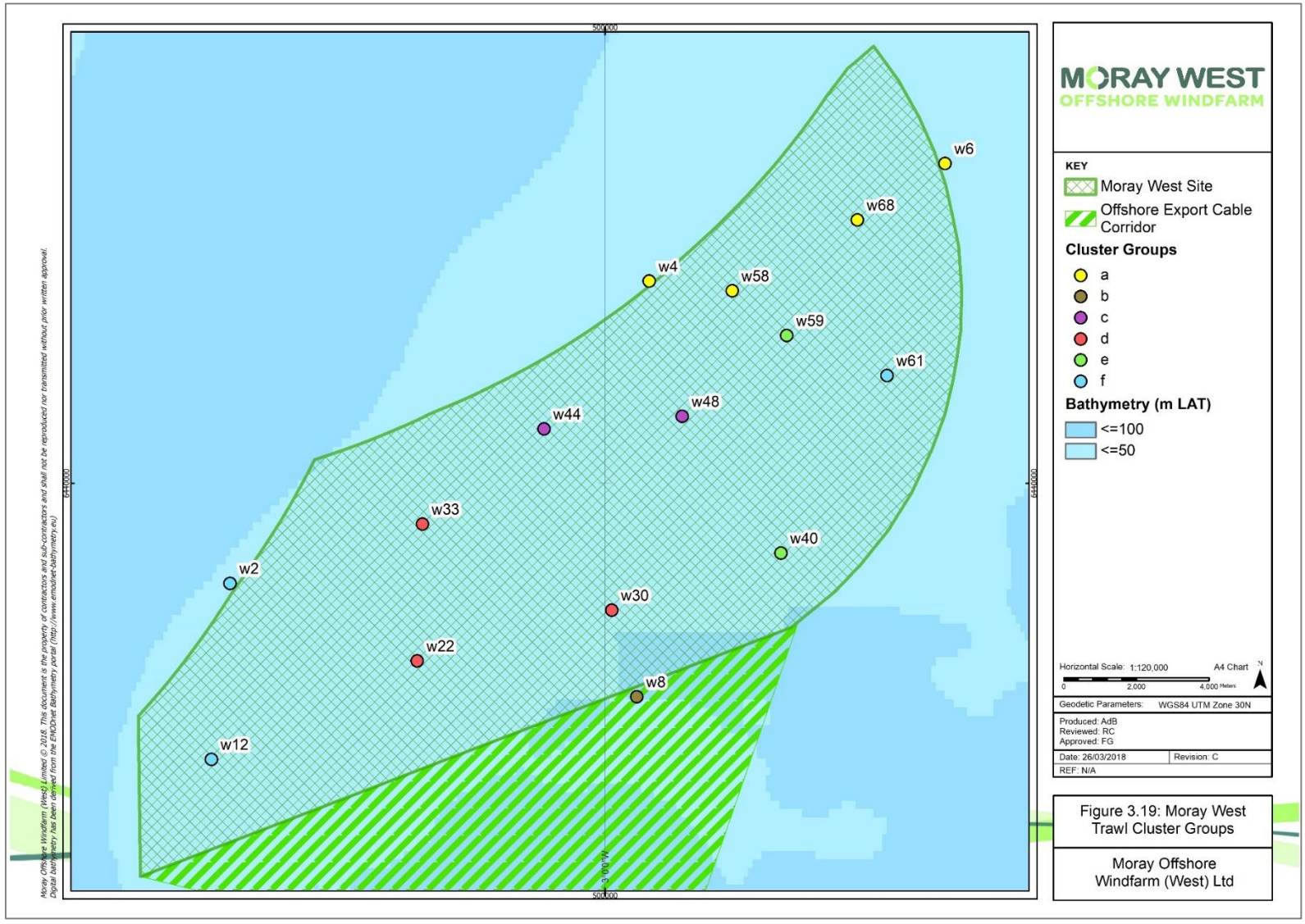


Figure 3.19: Moray West Site Cluster Groups From Trawl Survey

4 Conclusions

The Moray West benthic survey undertaken in May and June 2017 included drop down video (DDV) at 108 stations, benthic grab survey for fauna and/or PSD at 92 stations and epibenthic beam trawling at 15 stations. The DDV survey highlighted a variety of seabed habitats including inshore coarse mixed sediments (gravel, pebbles and cobble) with a varied epifaunal assemblage, clean or slightly gravelly sands, deeper sandy muds with sea pens and mixed coarse gravelly sediments or sands with surficial stones/gravel. Within the Moray West site boundary sediments tended to be more homogeneous with much of the area characterised by sands or slightly gravelly sands. Such habitats showed some spatial variation in mud content with cleaner, less muddy sediments to the eastern half of the site and slightly muddier sands (up to 10% mud) further west. Other sediment within the wind farm included muddy sands (primarily to the north), heterogeneous/patchy gravelly sand or sandy gravels often with patches of surface stones/cobble particularly at the eastern end of the Moray West site. Occasional areas of more consolidated surface cobble were recorded, particularly to the east of station W39 which included a small area likely to be considered stony reef. Other habitats included bands of (muddy) gravel wave forms which comprised of coarse shell gravel with sand and stones often with somewhat muddier gravelly sand or sandy gravel in the tough of the waves. Occasionally the DDV survey revealed shallow tracks or lines through the sediment which may be a result of trawling or other activities.

The range of seabed habitats observed appears broadly consistent with other surveys in the area e.g. the Beatrice Offshore Wind Farm survey and the Moray East wind farm surveys. The Beatrice Offshore Wind Farm surveys indicated predominantly sandy habitats with varying amounts of shell debris or gravel and occasional harder substrates (boulder/cobble). Similar sediments were also recorded within the Moray East site although a somewhat greater proportion of coarser gravelly or stony sediments appeared to be recorded in this survey which corresponds to the increase in coarser more heterogenous sediments toward the eastern side of the Moray West site in the current survey. Benthic studies for the Beatrice Offshore Wind Farm and Moray East wind farm export cables highlighted a similar range in seabed habitats to those recorded during the current survey with inshore coarse (mixed) stony or gravelly sediments, sands or somewhat gravelly sands (particularly further offshore) and deeper waters along the central section of Offshore Export Cable Corridor with muddy habitats. Sediments from 10 locations were investigated for a suite of heavy metal and organic contaminants (Polyclic Aromatic Hydrocarbons). Heavy metals were generally present at low concentrations and below Sediment Quality Guidelines and CEFAS and Marine Scotland Action levels where these exist whilst PAHs were present at very low levels or not detected (<0.01mg/kg).

The benthic survey highlighted a wide variety of infaunal species with 352 taxa recorded in total and the most dominant taxa in terms of abundance were annelid worms (predominantly polychaetes) which accounted for 35% of total abundance followed by molluscs (25% of total abundance). Molluscs accounted for the majority of biomass within the survey area (64%). The most abundant taxa was the pea urchin *Echinocyamus pusillus* which accounted for 9.88% of the total abundance and this species was also the most ubiquitous and recorded at 65% of the survey stations. Other nematode worms, *Spiophanes bombyx*, *Lumbrineris aniara*, juvenile Ophiuroidea spp., *Asbjornsenia pygmaea*, *Thracia villosiuscula*, *Abra prismatica*, *Venus casina*, *Spisula elliptica*, *Aonides paucibranchiata*, Phoronida sp., Nemertea, *Bathyporeia pelagica*, *Prionospio fallax* and *Fabulina fabula* which collectively accounted for 50% of the total abundance although many of these were recorded in under 40% of the survey stations. Many of these taxa were also commonly recorded in the Moray East and Beatrice Offshore Wind Farm benthic surveys although the Moray East survey for example had a higher proportion of taxa such as *Chone* sp. and encrusting polychaetes such as *Spirobranchus triqueter* and other Serpulidae along with *Hydroides norvegica* in addition to a higher proportion of sessile colonial epifauna which perhaps reflects the higher proportion of coarser substrata.

As might be expected to predominantly sandy or somewhat gravelly sediments species richness, density and diversity were low to moderately high and numbers of taxa ranged from 10 taxa per 0.1m^2 at station W10 to 49 taxa per 0.1m^2 at station W50 whilst faunal abundance was also rather variable but generally low to moderate with values ranging from 12 individuals per 0.1m^2 at station W72 to 454 individuals per 0.1m^2 at station W50. Shannon's diversity values were generally moderate to high with most stations having values between 3 and 5 and values ranged from 2.65 (station W56) to 4.86 (station W33). Typically, areas with higher diversity tended to be recorded in somewhat coarser more mixed sediments and a similar trend was evident at both the Moray East and Beatrice Offshore Wind Farm surveys. These results are typical for benthic communities around the UK as cleaner (and often somewhat mobile) well sorted sands tend to have a lower species richness and diversity whilst more gravelly or mixed sediments tend to be exhibit higher diversities which reflects the increased structural diversity of these habitats.

Trawl surveys within the Moray West site highlighted a variety of epifaunal and fish species with barnacles such as *Balanus crenatus* and asteroid echinoderms such as *Asterias rubens* dominating the epifauna along with Paguridae decapod crustacea and echinoderms such as *Ophiura ophiura*, *Echinus esculentus* and *Astropecten irregularis* whilst sessile colonial taxa were predominantly represented by Dead Man's Fingers (*Alcyonium digitatum*), Hornwrack (*Flustra foliacea*) and the hydrozoan *Hydrallmania falcata* along with a variety of other hydroids/bryozoans. Fish species were dominated by flatfish (predominantly dab and plaice) along with Pogge (*Agonus cataphractus*), Lemon Sole (*Microstomus kitt*) and Grey Gurnard (*Eutrigla gurnardus*). Prawns and shrimp were also present in the survey area but only recorded in low numbers. As shown for the infaunal benthic communities highest numbers of taxa and density tended to occur to the north/east end of the wind farm which is likely to reflect the more heterogenous seabed habitats often present in these areas which included patches of coarser mixed sediment, gravels and stones/cobble.

A variety of biotopes/communities were recorded from the benthic survey with cluster analysis identifying 15 groups of stations although many of these were represented by small cluster of a few stations. These communities included a number of biotopes including variants of **SS.SCS.CCS** (Circalittoral coarse sediment) or **SS.SMx** (Sublittoral mixed sediment) in coarser sediments notably biotopes such as **SS.SCS.CCS.MedLumVen** (*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel) which tended to be the most diverse communities with highest densities of animals. Some instances of these coarse/mixed sediment biotopes potentially included examples of biotope **SS.SCS.CCS.Blan** (*Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel). In some areas (particularly to the north/east side of the wid farm) these coarse or mixed sediment biotopes also had surface stones/cobbles which were generally characterised by a rather sparse epifauna including keelworms (Spirobranchus sp.), and in some cases barnacles such as *Balanus crenatus* along with a patchy hydroid/bryozoan turf. Closer inshore on the Offshore Export Cable Corridor stony habitats were more widely recorded with a varied epibiota which ranged from sparsely populated pebbles/stones to more consolidated cobble with a richer hydroid/bryozoan turf. The epifaunal component of these habitats bore some resemblance to a more stable and/or sediment influenced variant of biotopes such as **SS.SCS.CCS.PomB** (P*omatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles), **SS.SSa.IFiSa.ScupHyd** (*Sertularia cupressina* and *Hydrallmania falcata* on tide-swept sublittoral sand with cobbles or pebbles) or an impoverished variant of **SS.SMx.CMx.FluHyd** (*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment) overlaying **SS.SCS.CCS** biotopes. Richer stony habitats with a more diverse epifauna closer inshore are likely to include a sheltered inshore variant of rocky biotopes such as **CR.HCR.XFa.SpNemAdia** (Sparse sponges, *Nemertesia* spp. and *Alcyonidium diaphanum* on circalittoral mixed substrata) whilst patches of boulder/cobble with a reduced epifauna also resemble sheltered variants of **CR.MCR.EcCr.FaAlCr.Pom** (Faunal and algal crusts with *Pomatoceros triqueter* and sparse *Alcyonium digitatum* on exposed to moderately wave-exposed circalittoral rock).

Other biotopes on the export cable route included **SS.SMu.CFiMu.SpnMeg** (Seapens and burrowing megafauna in circalittoral fine mud in areas of deeper muddy sediment and **SS.SMx.CMx.OphMx**

(*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment). The inner and outer sections of the Offshore Export Cable Corridor, in addition to the majority of the Moray West site, also included sandy biotopes (**SS.SSa**) often with a small proportion of shell grit/fine gravel and a varying mud content. Offshore examples of these habitats included a somewhat deeper variant of **SS.SCS.ICS.MoeVen** (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) in slightly coarser sand or gravelly sand whilst the majority of sandy stations were variants of **SS.SSa.CFiSa.EpusOborApri** (*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand) which in cleaner sands included some elements of the **SS.SCS.ICS.MoeVen** biotope**.** Slightly muddier sands (up to 10% mud) included **SS.SSa.IMuSa.FfabMag** (*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand) and also wide areas of a rather transitional communities which appear to be intermediate variants of **SS.SSa.CFiSa.EpusOborApri** and **SS.SSa.IMuSa.FfabMag.**

Overall, the infaunal/epifauna communities present within the Moray West site are predominantly variations of the Sublittoral Sand (**SS.SSa**) and Circalittoral coarse (or mixed) sediment (**SS.CCS** or **SS.CMX**) habitat complexes which often exhibit somewhat transitional communities which are rather poorly aligned to existing biotopes. Biotopes recorded here such as **SS.SCS.CCS.MedLumVen** (*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel) are a component of what has previously been described as the 'Deep Venus Community' and the 'Boreal Off-Shore Gravel Association' by other workers (Ford 1923; Jones 1950) and is also likely to be part of the Venus community (Thorson, 1957) and in the infralittoral etage described by Glemarec (1973). It is likely that **SS.SCS.CCS.MedLumVen**, which is widespread around the UK (and previously recorded in Moray Firth) includes a number of variants or sub-biotopes and it is also closely related to a number of other gravelly sand biotopes recorded in this study e.g. **SS.SCS.ICS.MoeVen.** Such communities are likely form a continuum of closely related communities which grade into other biotopes as gravel content decreases including **SS.SSa.CFiSa.EpusOborApri** (or **SS.SSa.IMuSa.FfabMag**) which were present as rather transitional variants in the current study. Many of these biotopes are not particularly well defined or based on limited data (e.g. **SS.SSa.CFiSa.EpusOborApri**) and are currently in the process of being refined/revised as part of an ongoing project being undertaken by PMSL and managed by JNCC which aims to clarify the biotope descriptions for sublittoral soft sediments. The biotope **SS.SCS.ICS.MoeVen** recorded here for example appears to be in somewhat deeper water than outlined under the original biotope description although this was originally based on relatively little data and more recent surveys currently being analysed with JNCC and SNH indicate that it was a wider depth range than initially described. However, in the context of the survey area the benthic communities identified here are typical for circalittoral sands or gravels and the majority of the biotopes outlined above were also recorded in other benthic surveys around Smith Bank e.g. the Moray East and Beatrice Offshore Wind Farm benthic surveys.

4.1 Habitats or Species of Conservation Interest

A number of habitats/species of conservation interest were also noted during the survey. Biotopes such as **SS.SCS.ICS.MoeVen** are listed as Priority Marine Feature whilst the arctic quahog (*Arctica Islandica*) and the flame shell (*Limaria hians*) are Priority Marine Feature species although they were only recorded at single stations and in very low numbers. Sand eels (a Priority Marine Feature species) were also recorded during trawl and video surveys. In addition, the deeper muddy habitats along the Offshore Export Cable Corridor were classified as **SS.SMu.CFiMu.SpnMeg** which is also a Priority Marine Feature. Some areas of potential Annex I habitat were also recorded included a small area of stony reef approximately 25m wide just to the north west of station W39. Other areas of the Moray West site (particularly to the eastern edge of the site) also had sporadic individual boulders which may have implications from an engineering perspective. However, it is uncertain whether other areas of the wind farm outwith the areas covered by survey have consolidated, clast supported boulders/cobble which may be considered Annex I stony reef. Mixed coarse stony/cobble habitats inshore were widespread and

rather variable but also included patches of more consolidated cobble or small boulder which may be considered small scale examples of transitional or low grade stony reef although they tended to lack significant elevation or topographic distinctness and were relatively small scale (<5m^2).

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6 Annex 7.1A: Drop Down Video Positions

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 01 c24	c24	2017-05-13 16:42:57	Started Video	00:00:00	57˚ 44.1255' N 002˚ 53.2882' W UTC: 15:42:57	Export Cable	
Dive 01 c24	c24	2017-05-13 16:48:42	Stopped Video	00:05:45	57˚ 44.1385' N 002˚ 53.2429' W UTC: 15:48:43	Export Cable	
Dive 02 c24	c24	2017-05-14 10:57:33	Started Video	00:00:00	57˚ 44.1216' N 002˚ 53.3330' W UTC: 09:57:34	Export Cable	
Dive 02 c24	c24	2017-05-14 11:09:07	Stopped Video	00:11:34	57˚ 44.1063' N 002˚ 53.3273' W UTC: 10:09:07	Export Cable	
Dive 03 c13	c13	2017-05-14 11:48:16	Started Video	00:00:00	57˚ 48.8676' N 002˚ 52.6852' W UTC: 10:48:16	Export Cable	
Dive 03 c13	c13	2017-05-14 11:50:51	Stopped Video	00:02:35	57˚ 48.8621' N 002˚ 52.6488' W UTC: 10:50:52	Export Cable	
Dive 04 c13	c13	2017-05-14 11:55:50	Started Video	00:00:00	57˚ 48.8696' N 002˚ 52.6668' W UTC: 10:55:50	Export Cable	Y
Dive 04 c13	c13	2017-05-14 12:02:01	Stopped Video	00:06:10	57˚ 48.8523' N 002˚ 52.5838' W UTC: 11:02:01	Export Cable	Y
Dive 05 w21	w21	2017-05-14 14:35:35	Started Video	00:00:00	58˚ 02.7749' N 003˚ 03.1516' W UTC: 13:35:36	Wind Farm	Y
Dive 05 w21	w21	2017-05-14 14:41:55	Stopped Video	00:06:19	58˚ 02.7368' N 003˚ 03.1576' W UTC: 13:41:56	Wind Farm	Y
Dive 06 w22	w22	2017-05-14 14:55:20	Started Video	00:00:00	58˚ 03.4438' N 003˚ 05.2982' W UTC: 13:55:20	Wind Farm	
Dive 06 w22	w22	2017-05-14 15:00:49	Stopped Video	00:05:28	58˚ 03.4118' N 003˚ 05.3314' W UTC: 14:00:49	Wind Farm	
Dive 07 w23	w23	2017-05-14 15:12:08	Started Video	00:00:00	58˚ 04.2917' N 003˚ 07.4236' W UTC: 14:12:09	Wind Farm	
Dive 07 w23	w23	2017-05-14 15:17:22	Stopped Video	00:05:13	58˚ 04.2680' N 003˚ 07.4546' W UTC: 14:17:22	Wind Farm	
Dive 08 w24	w24	2017-05-14 15:26:43	Started Video	00:00:00	58˚ 05.0029' N 003˚ 08.7608' W UTC: 14:26:43	Wind Farm	
Dive 08 w24	w24	2017-05-14 15:32:29	Stopped Video	00:05:45	58˚ 04.9773' N 003˚ 08.7849' W UTC: 14:32:30	Wind Farm	
Dive 09 w2	w2	2017-05-14 15:45:59	Started Video	00:00:00	58˚ 04.5909' N 003˚ 10.5218' W UTC: 14:46:00	Wind Farm	Y
Dive 09 w2	w2	2017-05-14 15:51:18	Stopped Video	00:05:18	58˚ 04.5750' N 003˚ 10.5467' W UTC: 14:51:18	Wind Farm	Y
Dive 10 w17	w17	2017-05-14 16:02:33	Started Video	00:00:00	58˚ 04.2877' N 003˚ 10.0112' W UTC: 15:02:33	Wind Farm	
Dive 10 w17	w17	2017-05-14 16:07:23	Stopped Video	00:04:49	58˚ 04.2849' N 003˚ 10.0225' W UTC: 15:04:13	Wind Farm	
Dive 11 w18	w18	2017-05-14 16:20:52	Started Video	00:00:00	58˚ 03.3886' N 003˚ 08.2727' W UTC: 15:20:53	Wind Farm	Y
Dive 11 w18	w18	2017-05-14 16:26:25	Stopped Video	00:05:32	58˚ 03.3899' N 003˚ 08.3242' W UTC: 15:26:25	Wind Farm	Y
Dive 12 w19	w19	2017-05-14 16:40:47	Started Video	00:00:00	58˚ 02.6455' N 003˚ 06.3316' W UTC: 15:40:48	Wind Farm	Y
Dive 12 w19	w19	2017-05-14 16:46:17	Stopped Video	00:05:29	58˚ 02.6545' N 003˚ 06.3820' W UTC: 15:46:18	Wind Farm	Y

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 13 w20	w20	2017-05-14 17:12:58	Started Video	00:00:00	58˚ 02.0622' N 003˚ 04.5669' W UTC: 16:12:58	Wind Farm	Y
Dive 13 w20	w20	2017-05-14 17:18:22	Stopped Video	00:05:24	58˚ 02.0654' N 003˚ 04.6160' W UTC: 16:18:23	Wind Farm	Y
Dive 14 w25	w25	2017-05-14 17:29:36	Started Video	00:00:00	58˚ 01.2952' N 003˚ 05.4726' W UTC: 16:29:37	Wind Farm	
Dive 14 w25	w25	2017-05-14 17:35:09	Stopped Video	00:05:32	58˚ 01.3043' N 003˚ 05.5252' W UTC: 16:35:10	Wind Farm	
Dive 15 w75	w75	2017-05-14 17:47:53	Started Video	00:00:00	58˚ 01.8503' N 003˚ 06.9259' W UTC: 16:47:53	Wind Farm	Y
Dive 15 w75	w75	2017-05-14 17:53:05	Stopped Video	00:05:11	58˚ 01.8653' N 003˚ 06.9974' W UTC: 16:53:05	Wind Farm	Y
Dive 16 w15	w15	2017-05-14 18:04:22	Started Video	00:00:00	58˚ 02.0870' N 003˚ 08.2662' W UTC: 17:04:23	Wind Farm	Y
Dive 16 w15	w15	2017-05-14 18:10:07	Stopped Video	00:05:44	58˚ 02.1198' N 003˚ 08.3606' W UTC: 17:10:08	Wind Farm	Y
Dive 17 w74	w74	2017-05-14 18:21:45	Started Video	00:00:00	58˚ 02.7154' N 003˚ 09.6291' W UTC: 17:21:45	Wind Farm	
Dive 17 w74	w74	2017-05-14 18:27:35	Stopped Video	00:05:50	58˚ 02.7642' N 003˚ 09.7123' W UTC: 17:27:35	Wind Farm	
Dive 18 w16	w16	2017-05-14 18:37:24	Started Video	00:00:00	58˚ 03.3069' N 003˚ 11.0804' W UTC: 17:37:24	Wind Farm	Y
Dive 18 w16	w16	2017-05-14 18:43:47	Stopped Video	00:06:23	58˚ 03.3573' N 003˚ 11.1433' W UTC: 17:43:47	Wind Farm	Y
Dive 19 w13	w13	2017-05-14 18:58:08	Started Video	00:00:00	58˚ 02.6023' N 003˚ 12.3538' W UTC: 17:58:08	Wind Farm	Y
Dive 19 w13	w13	2017-05-14 19:03:36	Stopped Video	00:05:27	58˚ 02.6356' N 003˚ 12.3866' W UTC: 18:03:36	Wind Farm	Y
Dive 20 w12	w12	2017-05-14 19:16:00	Started Video	00:00:00	58˚ 01.9670' N 003˚ 11.0262' W UTC: 18:16:01	Wind Farm	Y
Dive 20 w12	w12	2017-05-14 19:21:10	Stopped Video	00:05:09	58˚ 01.9973' N 003˚ 11.0721' W UTC: 18:21:10	Wind Farm	Y
Dive 21 w14	w14	2017-05-14 19:41:54	Started Video	00:00:00	58˚ 01.5121' N 003˚ 09.2553' W UTC: 18:41:53	Export Cable	
Dive 21 w14	w14	2017-05-14 19:44:25	Stopped Video	00:02:30	58˚ 01.5354' N 003˚ 09.2846' W UTC: 18:44:25	Export Cable	
Dive 22 w14	w14	2017-05-14 19:54:11	Started Video	00:00:00	58˚ 01.5293' N 003˚ 09.2879' W UTC: 18:54:11	Export Cable	
Dive 22 w14	w14	2017-05-14 20:02:26	Stopped Video	00:08:15	58˚ 01.5965' N 003˚ 09.3643' W UTC: 19:02:26	Export Cable	
Dive 23 w9	w9	2017-05-14 20:16:49	Started Video	00:00:00	58˚ 01.0655' N 003˚ 08.3559' W UTC: 19:16:49	Wind Farm	Y
Dive 23 w9	w9	2017-05-14 20:22:17	Stopped Video	00:05:27	58˚ 01.1176' N 003˚ 08.4079' W UTC: 19:22:17	Wind Farm	Y
Dive 24 w10	w10	2017-05-14 20:33:10	Started Video	00:00:00	58˚ 01.1448' N 003˚ 10.8228' W UTC: 19:33:10	Wind Farm	Y
Dive 24 w10	w10	2017-05-14 20:38:33	Stopped Video	00:05:23	58˚ 01.1905' N 003˚ 10.8669' W UTC: 19:38:33	Wind Farm	Y
Dive 25 w11	w11	2017-05-14 20:47:49	Started Video	00:00:00	58˚ 01.6657' N 003˚ 12.3575' W UTC: 19:47:49	Wind Farm	Y

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 25 w11	w11	2017-05-14 20:53:22	Stopped Video	00:05:32	58˚ 01.7171' N 003˚ 12.4141' W UTC: 19:53:21	Wind Farm	Y
Dive 26 w1	w1	2017-05-14 21:03:39	Started Video	00:00:00	58˚ 01.0761' N 003˚ 13.1286' W UTC: 20:03:39	Wind Farm	Y
Dive 26 w1	w1	2017-05-14 21:08:52	Stopped Video	00:05:13	58˚ 01.1085' N 003˚ 13.1608' W UTC: 20:08:53	Wind Farm	Y
Dive 27 w76	w76	2017-05-14 21:19:30	Started Video	00:00:00	58˚ 00.8193' N 003˚ 12.2895' W UTC: 20:19:29	Wind Farm	Y
Dive 27 w76	w76	2017-05-14 21:26:24	Stopped Video	00:06:54	58˚ 00.8743' N 003˚ 12.3314' W UTC: 20:26:24	Wind Farm	Y
Dive 28 c14	c14	2017-05-15 8:38:59	Started Video	00:00:00	57˚ 46.9087' N 002˚ 52.6815' W UTC: 07:39:00	Export Cable	Y
Dive 28 c14	c14	2017-05-15 8:46:37	Stopped Video	00:07:37	57˚ 47.0069' N 002˚ 52.8365' W UTC: 07:46:37	Export Cable	Y
Dive 29 c23	c23	2017-05-15 9:07:49	Started Video	00:00:00	57˚ 47.2539' N 002˚ 50.5941' W UTC: 08:07:50	Export Cable	Y
Dive 29 c23	c23	2017-05-15 9:13:31	Stopped Video	00:05:41	57˚ 47.3307' N 002˚ 50.7160' W UTC: 08:13:32	Export Cable	Y
Dive 30 c20	c20	2017-05-15 9:43:29	Started Video	00:00:00	57˚ 45.6915' N 002˚ 49.3343' W UTC: 08:43:30	Export Cable	
Dive 30 c20	c20	2017-05-15 9:50:34	Stopped Video	00:07:05	57˚ 45.7661' N 002˚ 49.5135' W UTC: 08:50:35	Export Cable	
Dive 31 c19	c19	2017-05-15 10:05:52	Started Video	00:00:00	57˚ 45.7149' N 002˚ 51.5204' W UTC: 09:05:53	Export Cable	
Dive 31 c19	c19	2017-05-15 10:18:44	Stopped Video	00:12:52	57˚ 45.8427' N 002˚ 51.8997' W UTC: 09:18:45	Export Cable	
Dive 32 c15	c15	2017-05-15 10:34:41	Started Video	00:00:00	57˚ 45.2570' N 002˚ 53.1095' W UTC: 09:34:43	Export Cable	
Dive 32 c15	c15	2017-05-15 10:47:35	Stopped Video	00:12:53	57˚ 45.3994' N 002˚ 53.4040' W UTC: 09:47:36	Export Cable	
Dive 33 c18	c18	2017-05-15 11:14:45	Started Video	00:00:00	57˚ 44.0731' N 002˚ 50.3323' W UTC: 10:14:46	Export Cable	
Dive 33 c18	c18	2017-05-15 11:24:30	Stopped Video	00:09:44	57˚ 44.2157' N 002˚ 50.6366' W UTC: 10:24:30	Export Cable	
Dive 34 c21	c21	2017-05-15 11:57:53	Started Video	00:00:00	57˚ 44.3718' N 002˚ 46.9663' W UTC: 10:57:53	Export Cable	
Dive 34 c21	c21	2017-05-15 12:05:54	Stopped Video	00:08:01	57˚ 44.5392' N 002˚ 47.2150' W UTC: 11:05:55	Export Cable	
Dive 35 c16	c16	2017-05-15 12:43:33	Started Video	00:00:00	57˚ 42.7097' N 002˚ 53.9250' W UTC: 11:43:33	Export Cable	Y
Dive 35 c16	c16	2017-05-15 12:53:43	Stopped Video	00:10:10	57˚ 42.7654' N 002˚ 54.0821' W UTC: 11:53:44	Export Cable	Y
Dive 36 c17	c17	2017-05-15 13:15:24	Started Video	00:00:00	57˚ 42.6535' N 002˚ 49.6674' W UTC: 12:15:25	Export Cable	Y
Dive 36 c17	c17	2017-05-15 13:20:45	Stopped Video	00:05:20	57˚ 42.6971' N 002˚ 49.7524' W UTC: 12:20:45	Export Cable	Y
Dive 37 c22	c22	2017-05-15 13:41:46	Started Video	00:00:00	57˚ 42.6794' N 002˚ 45.5434' W UTC: 12:41:47	Export Cable	Y

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 37 c22	c22	2017-05-15 13:50:30	Stopped Video	00:08:44	57˚ 42.7794' N 002˚ 45.6571' W UTC: 12:50:31	Export Cable	Y
Dive 39 c24	c24	2017-05-16 9:35:36	Started Video	00:00:00	57˚ 44.1185' N 002˚ 53.3134' W UTC: 08:35:36	Export Cable	
Dive 39 c24	c24	2017-05-16 9:43:48	Stopped Video	00:08:11	57˚ 44.2351' N 002˚ 53.2804' W UTC: 08:43:48	Export Cable	
Dive 40 c18	c18	2017-05-16 10:02:24	Started Video	00:00:00	57˚ 44.0475' N 002˚ 50.3483' W UTC: 09:02:24	Export Cable	Y
Dive 40 c18	c18	2017-05-16 10:09:46	Stopped Video	00:07:21	57˚ 44.1236' N 002˚ 50.3413' W UTC: 09:09:46	Export Cable	Y
Dive 41 c21	c21	2017-05-16 10:31:23	Started Video	00:00:00	57˚ 44.3376' N 002˚ 46.9815' W UTC: 09:31:24	Export Cable	Y
Dive 41 c21	c21	2017-05-16 10:38:51	Stopped Video	00:07:27	57˚ 44.3949' N 002˚ 47.0141' W UTC: 09:38:51	Export Cable	Y
Dive 42 c20	c20	2017-05-16 10:52:22	Started Video	00:00:00	57˚ 45.6934' N 002˚ 49.3220' W UTC: 09:52:22	Export Cable	Y
Dive 42 c20	c20	2017-05-16 10:58:06	Stopped Video	00:05:43	57˚ 45.7460' N 002˚ 49.3408' W UTC: 09:58:06	Export Cable	Y
Dive 43 c19	c19	2017-05-16 11:13:35	Started Video	00:00:00	57˚ 45.7115' N 002˚ 51.5352' W UTC: 10:13:36	Export Cable	Y
Dive 43 c19	c19	2017-05-16 11:26:09	Stopped Video	00:12:33	57˚ 45.8114' N 002˚ 51.6142' W UTC: 10:26:09	Export Cable	Y
Dive 44 c15	c15	2017-05-16 11:36:44	Started Video	00:00:00	57˚ 45.2547' N 002˚ 53.1045' W UTC: 10:36:44	Export Cable	Y
Dive 44 c15	c15	2017-05-16 11:47:18	Stopped Video	00:10:34	57˚ 45.3418' N 002˚ 53.1354' W UTC: 10:47:18	Export Cable	Y
Dive 45 c24	c24	2017-05-16 11:59:45	Started Video	00:00:00	57˚ 44.1264' N 002˚ 53.3016' W UTC: 10:59:44	Export Cable	Y
Dive 45 c24	c24	2017-05-16 12:10:03	Stopped Video	00:10:18	57˚ 44.2418' N 002˚ 53.2674' W UTC: 11:10:03	Export Cable	Y
Dive 46 c16	c16	2017-05-16 12:28:46	Started Video	00:00:00	57˚ 42.7165' N 002˚ 53.9613' W UTC: 11:28:46	Export Cable	
Dive 46 c16	c16	2017-05-16 12:39:41	Stopped Video	00:10:54	57˚ 42.8554' N 002˚ 53.8620' W UTC: 11:39:41	Export Cable	
Dive 47 c27	c27	2017-05-17 10:28:01	Started Video	00:00:00	58˚ 00.2794' N 003˚ 10.4576' W UTC: 09:28:02	Export Cable	
Dive 47 c27	c27	2017-05-17 10:30:37	Stopped Video	00:02:35	58˚ 00.3061' N 003˚ 10.4474' W UTC: 09:30:38	Export Cable	
Dive 48 c27	c27	2017-05-17 10:40:33	Started Video	00:00:00	58˚ 00.2645' N 003˚ 10.4813' W UTC: 09:40:34	Export Cable	Y
Dive 48 c27	c27	2017-05-17 10:46:47	Stopped Video	00:06:14	58˚ 00.3030' N 003˚ 10.4821' W UTC: 09:46:47	Export Cable	Y
Dive 49 c1	c1	2017-05-18 5:28:06	Started Video	00:00:00	58˚ 00.2447' N 003˚ 06.5781' W UTC: 04:28:06	Export Cable	Y
Dive 49 c1	c1	2017-05-18 5:34:16	Stopped Video	00:06:10	58˚ 00.2187' N 003˚ 06.5294' W UTC: 04:34:17	Export Cable	Y
Dive 50 c25	c25	2017-05-18 6:05:10	Started Video	00:00:00	58˚ 01.3087' N 003˚ 05.4654' W UTC: 05:05:10	Export Cable	Y
Dive 50 c25	c25	2017-05-18 6:11:55	Stopped Video	00:06:45	58˚ 01.2953' N 003˚ 05.4051' W UTC: 05:11:55	Export Cable	Y

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 51 c4	c4	2017-05-18 6:29:56	Started Video	00:00:00	57˚ 59.9969' N 003˚ 03.6891' W UTC: 05:29:56	Export Cable	Y
Dive 51 c4	c4	2017-05-18 6:35:28	Stopped Video	00:05:32	58˚ 00.0028' N 003˚ 03.6098' W UTC: 05:35:28	Export Cable	Y
Dive 52 c6	c6	2017-05-18 7:00:39	Started Video	00:00:00	57˚ 59.2778' N 002˚ 59.7576' W UTC: 06:00:39	Export Cable	
Dive 52 c6	c6	2017-05-18 7:04:12	Stopped Video	00:03:33	57˚ 59.2809' N 002˚ 59.7048' W UTC: 06:04:12	Export Cable	
Dive 53 c6	c6	2017-05-18 7:10:59	Started Video	00:00:00	57˚ 59.2789' N 002˚ 59.7807' W UTC: 06:10:58	Export Cable	Y
Dive 53 c6	c6	2017-05-18 7:19:16	Stopped Video	00:08:17	57˚ 59.2862' N 002˚ 59.6755' W UTC: 06:19:16	Export Cable	Y
Dive 54 c7	c7	2017-05-18 7:32:59	Started Video	00:00:00	57˚ 57.9555' N 002˚ 58.6956' W UTC: 06:32:59	Export Cable	Y
Dive 54 c7	c7	2017-05-18 7:40:25	Stopped Video	00:07:26	57˚ 57.9511' N 002˚ 58.6062' W UTC: 06:40:26	Export Cable	Y
Dive 55 c2	c2	2017-05-18 8:13:05	Started Video	00:00:00	58˚ 01.0465' N 003˚ 01.4100' W UTC: 07:13:06	Export Cable	
Dive 55 c2	c2	2017-05-18 8:15:25	Stopped Video	00:02:19	58˚ 01.0527' N 003˚ 01.3803' W UTC: 07:15:25	Export Cable	
Dive 56 c2	c2	2017-05-18 8:22:03	Started Video	00:00:00	58˚ 01.0494' N 003˚ 01.4223' W UTC: 07:22:04	Export Cable	
Dive 56 c2	c2	2017-05-18 8:26:53	Stopped Video	00:04:49	58˚ 01.0650' N 003˚ 01.3694' W UTC: 07:26:53	Export Cable	
Dive 57 c2	c2	2017-05-18 8:35:45	Started Video	00:00:00	58˚ 01.0519' N 003˚ 01.4270' W UTC: 07:35:46	Export Cable	Y
Dive 57 c2	c2	2017-05-18 8:41:45	Stopped Video	00:05:59	58˚ 01.0715' N 003˚ 01.3633' W UTC: 07:41:45	Export Cable	Y
Dive 58 c5	c5	2017-05-18 8:59:03	Started Video	00:00:00	58˚ 00.9183' N 002˚ 58.3646' W UTC: 07:59:04	Export Cable	
Dive 58 c5	c5	2017-05-18 9:03:25	Stopped Video	00:04:22	58˚ 00.9307' N 002˚ 58.3390' W UTC: 08:03:25	Export Cable	
Dive 59 c5	c5	2017-05-18 9:10:17	Started Video	00:00:00	58˚ 00.9042' N 002˚ 58.3709' W UTC: 08:10:17	Export Cable	Y
Dive 59 c5	c5	2017-05-18 9:17:15	Stopped Video	00:06:57	58˚ 00.9350' N 002˚ 58.3433' W UTC: 08:17:15	Export Cable	Y
Dive 60 c3	c3	2017-05-18 9:32:31	Started Video	00:00:00	58˚ 02.1284' N 002˚ 57.2382' W UTC: 08:32:31	Export Cable	Y
Dive 60 c3	c3	2017-05-18 9:49:03	Stopped Video	00:16:32	58˚ 02.1925' N 002˚ 57.1555' W UTC: 08:49:03	Export Cable	Y
Dive 61 c26	c26	2017-05-18 10:05:29	Started Video	00:00:00	58˚ 02.3151' N 003˚ 00.0856' W UTC: 09:05:30	Export Cable	Y
Dive 61 c26	c26	2017-05-18 10:13:43	Stopped Video	00:08:13	58˚ 02.3722' N 003˚ 00.0717' W UTC: 09:13:43	Export Cable	Y
Dive 62 w8	w8	2017-05-18 10:28:23	Started Video	00:00:00	58˚ 02.9151' N 002˚ 59.1099' W UTC: 09:28:22	Wind Farm	Y
Dive 62 w8	w8	2017-05-18 10:38:49	Stopped Video	00:10:26	58˚ 02.9781' N 002˚ 59.0841' W UTC: 09:38:50	Wind Farm	Y

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 63 w28	w28	2017-05-18 11:05:35	Started Video	00:00:00	58˚ 03.1888' N 003˚ 00.4417' W UTC: 10:05:35	Wind Farm	Y
Dive 63 w28	w28	2017-05-18 11:17:08	Stopped Video	00:11:32	58˚ 03.2596' N 003˚ 00.4184' W UTC: 10:17:08	Wind Farm	Y
Dive 64 w27	w27	2017-05-18 11:30:59	Started Video	00:00:00	58˚ 03.5690' N 003˚ 01.9953' W UTC: 10:30:59	Wind Farm	Y
Dive 64 w27	w27	2017-05-18 11:36:46	Stopped Video	00:05:47	58˚ 03.6089' N 003˚ 01.9794' W UTC: 10:36:46	Wind Farm	Y
Dive 65 w26	w26	2017-05-18 11:53:33	Started Video	00:00:00	58˚ 04.2157' N 003˚ 04.0710' W UTC: 10:53:33	Wind Farm	Y
Dive 65 w26	w26	2017-05-18 11:59:18	Stopped Video	00:05:44	58˚ 04.2443' N 003˚ 04.0512' W UTC: 10:59:17	Wind Farm	Y
Dive 66 w77	w77	2017-05-18 12:16:20	Started Video	00:00:00	58˚ 04.7968' N 003˚ 05.7368' W UTC: 11:16:20	Wind Farm	Y
Dive 66 w77	w77	2017-05-18 12:24:26	Stopped Video	00:08:06	58˚ 04.8406' N 003˚ 05.7098' W UTC: 11:24:27	Wind Farm	Y
Dive 67 w33	w33	2017-05-18 12:45:19	Started Video	00:00:00	58˚ 05.4791' N 003˚ 05.1174' W UTC: 11:45:19	Wind Farm	Y
Dive 67 w33	w33	2017-05-18 12:52:27	Stopped Video	00:07:07	58˚ 05.5013' N 003˚ 05.1090' W UTC: 11:52:26	Wind Farm	Y
Dive 68 w25	w25	2017-05-18 13:11:09	Started Video	00:00:00	58˚ 05.6849' N 003˚ 07.7427' W UTC: 12:11:09	Wind Farm	Y
Dive 68 w25	w25	2017-05-18 13:20:09	Stopped Video	00:08:59	58˚ 05.6940' N 003˚ 07.7699' W UTC: 12:20:09	Wind Farm	Y
Dive 69 w3	w3	2017-05-18 13:32:15	Started Video	00:00:00	58˚ 06.7064' N 003˚ 07.0291' W UTC: 12:32:15	Wind Farm	Y
Dive 69 w3	w3	2017-05-18 13:38:53	Stopped Video	00:06:37	58˚ 06.7083' N 003˚ 07.0681' W UTC: 12:38:53	Wind Farm	Y
Dive 70 w34	w34	2017-05-18 13:52:51	Started Video	00:00:00	58˚ 06.7409' N 003˚ 04.0587' W UTC: 12:52:51	Wind Farm	Y
Dive 70 w34	w34	2017-05-18 13:58:37	Stopped Video	00:05:46	58˚ 06.7332' N 003˚ 04.1033' W UTC: 12:58:37	Wind Farm	Y
Dive 71 w35	w35	2017-05-18 14:10:18	Started Video	00:00:00	58˚ 05.9890' N 003˚ 02.8131' W UTC: 13:10:18	Wind Farm	Y
Dive 71 w35	w35	2017-05-18 14:16:31	Stopped Video	00:06:12	58˚ 05.9782' N 003˚ 02.9163' W UTC: 13:16:31	Wind Farm	Y
Dive 72 w32	w32	2017-05-18 14:25:28	Started Video	00:00:00	58˚ 05.1743' N 003˚ 03.2107' W UTC: 13:25:28	Wind Farm	Y
Dive 72 w32	w32	2017-05-18 14:30:56	Stopped Video	00:05:28	58˚ 05.1636' N 003˚ 03.3144' W UTC: 13:30:56	Wind Farm	Y
Dive 73 w36	w36	2017-05-18 14:40:47	Started Video	00:00:00	58˚ 05.7537' N 003˚ 01.2382' W UTC: 13:40:46	Wind Farm	
Dive 73 w36	w36	2017-05-18 14:46:34	Stopped Video	00:05:47	58˚ 05.7428' N 003˚ 01.3449' W UTC: 13:46:35	Wind Farm	
Dive 74 w31	w31	2017-05-18 14:55:43	Started Video	00:00:00	58˚ 04.6661' N 003˚ 01.6135' W UTC: 13:55:43	Wind Farm	
Dive 74 w31	w31	2017-05-18 15:01:06	Stopped Video	00:05:22	58˚ 04.6641' N 003˚ 01.7309' W UTC: 14:01:06	Wind Farm	
Dive 75 w37	w37	2017-05-18 15:11:45	Started Video	00:00:00	58˚ 05.1800' N 002˚ 59.7377' W UTC: 14:11:45	Wind Farm	Y

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 75 w37	w37	2017-05-18 15:17:44	Stopped Video	00:05:58	58˚ 05.1724' N 002˚ 59.8641' W UTC: 14:17:43	Wind Farm	Y
Dive 76 w30	w30	2017-05-18 15:31:11	Started Video	00:00:00	58˚ 04.2145' N 002˚ 59.7382' W UTC: 14:31:10	Wind Farm	Y
Dive 76 w30	w30	2017-05-18 15:37:29	Stopped Video	00:06:17	58˚ 04.2140' N 002˚ 59.8682' W UTC: 14:37:29	Wind Farm	Y
Dive 77 w38	w38	2017-05-18 15:49:08	Started Video	00:00:00	58˚ 04.9983' N 002˚ 58.0113' W UTC: 14:49:08	Wind Farm	Y
Dive 77 w38	w38	2017-05-18 15:56:43	Stopped Video	00:07:35	58˚ 05.0011' N 002˚ 58.1885' W UTC: 14:56:43	Wind Farm	Y
Dive 78 w29	w29	2017-05-18 16:09:02	Started Video	00:00:00	58˚ 03.6695' N 002˚ 58.2462' W UTC: 15:09:03	Wind Farm	
Dive 78 w29	w29	2017-05-18 16:12:09	Stopped Video	00:03:06	58˚ 03.6697' N 002˚ 58.3211' W UTC: 15:12:08	Wind Farm	
Dive 79 w29	w29	2017-05-18 16:21:21	Started Video	00:00:00	58˚ 03.6764' N 002˚ 58.2737' W UTC: 15:21:21	Wind Farm	
Dive 79 w29	w29	2017-05-18 16:27:56	Stopped Video	00:06:35	58˚ 03.6853' N 002˚ 58.4400' W UTC: 15:27:55	Wind Farm	
Dive 80 w39	w39	2017-05-18 16:38:38	Started Video	00:00:00	58˚ 04.2932' N 002˚ 56.3118' W UTC: 15:38:38	Wind Farm	
Dive 80 w39	w39	2017-05-18 16:46:30	Stopped Video	00:07:52	58˚ 04.3120' N 002˚ 56.5087' W UTC: 15:46:30	Wind Farm	
Dive 81 c28	c28	2017-05-18 17:08:51	Started Video	00:00:00	58˚ 03.1213' N 002˚ 55.8251' W UTC: 16:08:51	Export Cable	
Dive 81 c28	c28	2017-05-18 17:16:15	Stopped Video	00:07:23	58˚ 03.1239' N 002˚ 55.9917' W UTC: 16:16:14	Export Cable	
Dive 82 w7	w7	2017-05-19 11:23:09	Started Video	00:00:00	58˚ 04.6614' N 002˚ 53.5719' W UTC: 10:23:08	Wind Farm	
Dive 82 w7	w7	2017-05-19 11:25:34	Stopped Video	00:02:25	58˚ 04.6790' N 002˚ 53.6036' W UTC: 10:25:34	Wind Farm	
Dive 83 w7	w7	2017-05-19 11:35:52	Started Video	00:00:00	58˚ 04.6497' N 002˚ 53.5648' W UTC: 10:35:52	Wind Farm	Y
Dive 83 w7	w7	2017-05-19 11:41:44	Stopped Video	00:05:52	58˚ 04.6902' N 002˚ 53.6424' W UTC: 10:41:45	Wind Farm	Y
Dive 84 w39	w39	2017-05-19 11:57:18	Started Video	00:00:00	58˚ 04.2572' N 002˚ 56.3207' W UTC: 10:57:18	Wind Farm	
Dive 84 w39	w39	2017-05-19 12:08:27	Stopped Video	00:11:08	58˚ 04.3162' N 002˚ 56.4937' W UTC: 11:08:27	Wind Farm	
Dive 85 w39	w39	2017-05-19 12:16:52	Started Video	00:00:00	58˚ 04.2871' N 002˚ 56.3321' W UTC: 11:16:53	Wind Farm	
Dive 85 w39	w39	2017-05-19 12:19:15	Stopped Video	00:02:22	58˚ 04.3036' N 002˚ 56.3842' W UTC: 11:19:16	Wind Farm	
Dive 86 w39	w39	2017-05-19 12:26:31	Started Video	00:00:00	58˚ 04.2806' N 002˚ 56.2846' W UTC: 11:26:31	Wind Farm	Y
Dive 86 w39	w39	2017-05-19 12:39:07	Stopped Video	00:12:35	58˚ 04.3569' N 002˚ 56.5348' W UTC: 11:39:07	Wind Farm	Y
Dive 87 w40	w40	2017-05-19 12:55:36	Started Video	00:00:00	58˚ 05.0376' N 002˚ 55.0678' W UTC: 11:55:36	Wind Farm	

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 87 w40	w40	2017-05-19 12:57:29	Stopped Video	00:01:52	58˚ 05.0496' N 002˚ 55.1138' W UTC: 11:57:28	Wind Farm	
Dive 88 w40	w40	2017-05-19 13:04:17	Started Video	00:00:00	58˚ 05.0465' N 002˚ 55.0489' W UTC: 12:04:18	Wind Farm	Y
Dive 88 w40	w40	2017-05-19 13:12:12	Stopped Video	00:07:54	58˚ 05.1020' N 002˚ 55.2303' W UTC: 12:12:12	Wind Farm	Y
Dive 89 w41	w41	2017-05-19 13:24:26	Started Video	00:00:00	58˚ 05.5150' N 002˚ 56.3526' W UTC: 12:24:27	Wind Farm	Y
Dive 89 w41	w41	2017-05-19 13:30:01	Stopped Video	00:05:34	58˚ 05.5532' N 002˚ 56.4677' W UTC: 12:30:01	Wind Farm	Y
Dive 90 w42	w42	2017-05-19 13:40:59	Started Video	00:00:00	58˚ 05.8974' N 002˚ 58.3229' W UTC: 12:41:00	Wind Farm	Y
Dive 90 w42	w42	2017-05-19 13:46:21	Stopped Video	00:05:21	58˚ 05.9326' N 002˚ 58.4377' W UTC: 12:46:22	Wind Farm	Y
Dive 91 w43	w43	2017-05-19 13:56:32	Started Video	00:00:00	58˚ 06.0455' N 003˚ 00.1828' W UTC: 12:56:33	Wind Farm	Y
Dive 91 w43	w43	2017-05-19 14:02:22	Stopped Video	00:05:49	58˚ 06.0795' N 003˚ 00.3100' W UTC: 13:02:22	Wind Farm	Y
Dive 92 w44	w44	2017-05-19 14:14:44	Started Video	00:00:00	58˚ 06.9099' N 003˚ 01.7142' W UTC: 13:14:44	Wind Farm	Y
Dive 92 w44	w44	2017-05-19 14:22:40	Stopped Video	00:07:56	58˚ 06.9583' N 003˚ 01.8755' W UTC: 13:22:41	Wind Farm	Y
Dive 93 w45	w45	2017-05-19 14:32:23	Started Video	00:00:00	58˚ 07.3175' N 003˚ 03.2085' W UTC: 13:32:24	Wind Farm	Y
Dive 93 w45	w45	2017-05-19 14:39:25	Stopped Video	00:07:02	58˚ 07.3527' N 003˚ 03.3499' W UTC: 13:39:26	Wind Farm	Y
Dive 94 w46	w46	2017-05-19 15:00:14	Started Video	00:00:00	58˚ 07.8978' N 003˚ 00.9878' W UTC: 14:00:14	Wind Farm	
Dive 94 w46	w46	2017-05-19 15:03:30	Stopped Video	00:03:15	58˚ 07.9112' N 003˚ 01.0528' W UTC: 14:03:30	Wind Farm	
Dive 95 w46	w46	2017-05-19 15:11:04	Started Video	00:00:00	58˚ 07.8969' N 003˚ 00.9867' W UTC: 14:11:04	Wind Farm	
Dive 95 w46	w46	2017-05-19 15:16:09	Stopped Video	00:05:05	58˚ 07.9172' N 003˚ 01.0837' W UTC: 14:16:10	Wind Farm	
Dive 96 w46	w46	2017-05-19 15:27:40	Started Video	00:00:00	58˚ 07.8840' N 003˚ 00.9125' W UTC: 14:27:40	Wind Farm	
Dive 96 w46	w46	2017-05-19 15:32:51	Stopped Video	00:05:10	58˚ 07.9044' N 003˚ 01.0020' W UTC: 14:32:50	Wind Farm	
Dive 97 w46	w46	2017-05-19 15:56:52	Started Video	00:00:00	58˚ 07.8954' N 003˚ 00.9766' W UTC: 14:56:52	Wind Farm	Y
Dive 97 w46	w46	2017-05-19 16:03:13	Stopped Video	00:06:21	58˚ 07.9181' N 003˚ 01.1006' W UTC: 15:03:14	Wind Farm	Y
Dive 98 w47	w47	2017-05-19 16:24:21	Started Video	00:00:00	58˚ 07.6866' N 002˚ 59.1786' W UTC: 15:24:21	Wind Farm	Y
Dive 98 w47	w47	2017-05-19 16:30:42	Stopped Video	00:06:21	58˚ 07.7050' N 002˚ 59.3122' W UTC: 15:30:43	Wind Farm	Y
Dive 99 w78	w78	2017-05-19 16:41:18	Started Video	00:00:00	58˚ 07.1626' N 002˚ 59.8667' W UTC: 15:41:18	Wind Farm	Y
Dive 99 w78	w78	2017-05-19 16:47:31	Stopped Video	00:06:12	58˚ 07.1795' N 002˚ 59.9795' W UTC: 15:47:31	Wind Farm	Y

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 100 w48	w48	2017-05-19 17:01:41	Started Video	00:00:00	58˚ 07.0923' N 002˚ 57.8181' W UTC: 16:01:41	Wind Farm	Y
Dive 100 w48	w48	2017-05-19 17:07:29	Stopped Video	00:05:47	58˚ 07.1104' N 002˚ 57.9411' W UTC: 16:07:29	Wind Farm	Y
Dive 101 w49	w49	2017-05-19 17:21:34	Started Video	00:00:00	58˚ 06.6019' N 002˚ 56.3529' W UTC: 16:21:34	Wind Farm	Y
Dive 101 w49	w49	2017-05-19 17:27:11	Stopped Video	00:05:36	58˚ 06.6280' N 002˚ 56.4513' W UTC: 16:27:10	Wind Farm	Y
Dive 102 w50	w50	2017-05-19 17:41:10	Started Video	00:00:00	58˚ 06.1053' N 002˚ 54.8165' W UTC: 16:41:09	Wind Farm	Y
Dive 102 w50	w50	2017-05-19 17:48:03	Stopped Video	00:06:53	58˚ 06.1353' N 002˚ 54.9338' W UTC: 16:48:03	Wind Farm	Y
Dive 103 w51	w51	2017-05-19 18:02:18	Started Video	00:00:00	58˚ 05.9898' N 002˚ 52.9231' W UTC: 17:02:18	Wind Farm	
Dive 103 w51	w51	2017-05-19 18:04:44	Stopped Video	00:02:25	58˚ 05.9928' N 002˚ 52.9575' W UTC: 17:04:44	Wind Farm	
Dive 104 w51	w51	2017-05-19 18:08:44	Started Video	00:00:00	58˚ 06.0042' N 002˚ 52.9182' W UTC: 17:08:45	Wind Farm	Y
Dive 104 w51	w51	2017-05-19 18:14:49	Stopped Video	00:06:04	58˚ 06.0068' N 002˚ 52.9909' W UTC: 17:14:49	Wind Farm	Y
Dive 105 w52	w52	2017-05-19 18:23:26	Started Video	00:00:00	58˚ 06.3044' N 002˚ 51.4582' W UTC: 17:23:26	Wind Farm	Y
Dive 105 w52	w52	2017-05-19 18:30:21	Stopped Video	00:06:55	58˚ 06.3082' N 002˚ 51.5212' W UTC: 17:30:21	Wind Farm	Y
Dive 106 w5	w5	2017-05-21 11:40:53	Started Video	00:00:00	58˚ 12.6515' N 002˚ 52.5331' W UTC: 10:40:52	Wind Farm	Y
Dive 106 w5	w5	2017-05-21 11:54:47	Stopped Video	00:13:54	58˚ 12.7759' N 002˚ 52.5778' W UTC: 10:54:46	Wind Farm	Y
Dive 107 w80	w80	2017-05-21 12:09:11	Started Video	00:00:00	58˚ 11.8379' N 002˚ 51.7437' W UTC: 11:09:11	Wind Farm	Y
Dive 107 w80	w80	2017-05-21 12:15:37	Stopped Video	00:06:26	58˚ 11.9042' N 002˚ 51.7650' W UTC: 11:15:37	Wind Farm	Y
Dive 108 w73	w73	2017-05-21 12:28:19	Started Video	00:00:00	58˚ 11.5757' N 002˚ 53.3790' W UTC: 11:28:19	Wind Farm	Y
Dive 108 w73	w73	2017-05-21 12:33:43	Stopped Video	00:05:24	58˚ 11.6310' N 002˚ 53.4141' W UTC: 11:33:44	Wind Farm	Y
Dive 109 w72	w72	2017-05-21 12:47:49	Started Video	00:00:00	58˚ 11.0711' N 002˚ 52.2771' W UTC: 11:47:49	Wind Farm	
Dive 109 w72	w72	2017-05-21 12:57:01	Stopped Video	00:09:12	58˚ 11.1571' N 002˚ 52.3392' W UTC: 11:57:00	Wind Farm	
Dive 110 w72	w72	2017-05-21 13:03:34	Started Video	00:00:00	58˚ 11.1095' N 002˚ 52.2606' W UTC: 12:03:33	Wind Farm	Y
Dive 110 w72	w72	2017-05-21 13:09:28	Stopped Video	00:05:53	58˚ 11.1720' N 002˚ 52.3089' W UTC: 12:09:27	Wind Farm	Y
Dive 111 w79	w79	2017-05-21 13:21:54	Started Video	00:00:00	58˚ 11.0154' N 002˚ 54.2192' W UTC: 12:21:53	Wind Farm	Y
Dive 111 w79	w79	2017-05-21 13:29:45	Stopped Video	00:07:51	58˚ 11.1100' N 002˚ 54.3186' W UTC: 12:29:45	Wind Farm	Y

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 112 w6	w6	2017-05-21 13:44:07	Started Video	00:00:00	58˚ 10.8311' N 002˚ 50.4482' W UTC: 12:44:07	Wind Farm	Y
Dive 112 w6	w6	2017-05-21 13:49:43	Stopped Video	00:05:36	58˚ 10.8884' N 002˚ 50.5176' W UTC: 12:49:43	Wind Farm	Y
Dive 113 w6	w6	2017-05-21 13:56:37	Started Video	00:00:00	58˚ 10.8238' N 002˚ 50.4338' W UTC: 12:56:38	Wind Farm	
Dive 113 w6	w6	2017-05-21 14:02:53	Stopped Video	00:06:15	58˚ 10.8890' N 002˚ 50.5084' W UTC: 13:02:53	Wind Farm	
Dive 114 w71	w71	2017-05-21 14:11:55	Started Video	00:00:00	58˚ 10.5168' N 002˚ 50.7499' W UTC: 13:11:54	Wind Farm	Y
Dive 114 w71	w71	2017-05-21 14:18:12	Stopped Video	00:06:17	58˚ 10.5961' N 002˚ 50.8370' W UTC: 13:18:12	Wind Farm	Y
Dive 115 w70	w70	2017-05-21 14:41:03	Started Video	00:00:00	58˚ 09.2314' N 002˚ 50.3056' W UTC: 13:41:02	Wind Farm	Y
Dive 115 w70	w70	2017-05-21 14:47:12	Stopped Video	00:06:09	58˚ 09.2884' N 002˚ 50.3652' W UTC: 13:47:12	Wind Farm	Y
Dive 116 w69	w69	2017-05-21 14:55:47	Started Video	00:00:00	58˚ 09.7011' N 002˚ 51.2634' W UTC: 13:55:46	Wind Farm	Y
Dive 116 w69	w69	2017-05-21 15:03:55	Stopped Video	00:08:07	58˚ 09.7835' N 002˚ 51.3446' W UTC: 14:03:54	Wind Farm	Y
Dive 117 w68	w68	2017-05-21 15:14:00	Started Video	00:00:00	58˚ 09.9672' N 002˚ 52.9092' W UTC: 14:13:59	Wind Farm	Y
Dive 117 w68	w68	2017-05-21 15:20:18	Stopped Video	00:06:18	58˚ 10.0280' N 002˚ 52.9727' W UTC: 14:20:17	Wind Farm	Y
Dive 118 w67	w67	2017-05-21 15:28:07	Started Video	00:00:00	58˚ 10.3909' N 002˚ 54.6070' W UTC: 14:28:07	Wind Farm	Y
Dive 118 w67	w67	2017-05-21 15:35:11	Stopped Video	00:07:03	58˚ 10.4644' N 002˚ 54.6778' W UTC: 14:35:10	Wind Farm	Y
Dive 119 w66	w66	2017-05-21 15:51:01	Started Video	00:00:00	58˚ 09.8748' N 002˚ 55.5839' W UTC: 14:51:01	Wind Farm	Y
Dive 119 w66	w66	2017-05-21 15:56:24	Stopped Video	00:05:22	58˚ 09.9440' N 002˚ 55.6035' W UTC: 14:56:24	Wind Farm	Y
Dive 120 w65	w65	2017-05-21 16:06:59	Started Video	00:00:00	58˚ 09.4041' N 002˚ 53.9439' W UTC: 15:06:59	Wind Farm	Y
Dive 120 w65	w65	2017-05-21 16:12:44	Stopped Video	00:05:44	58˚ 09.4602' N 002˚ 53.9759' W UTC: 15:12:44	Wind Farm	Y
Dive 121 w64	w64	2017-05-21 16:24:07	Started Video	00:00:00	58˚ 08.7871' N 002˚ 52.3489' W UTC: 15:24:07	Wind Farm	Y
Dive 121 w64	w64	2017-05-21 16:31:57	Stopped Video	00:07:50	58˚ 08.8476' N 002˚ 52.4008' W UTC: 15:31:56	Wind Farm	Y
Dive 122 w63	w63	2017-05-21 16:42:46	Started Video	00:00:00	58˚ 08.3378' N 002˚ 50.3412' W UTC: 15:42:46	Wind Farm	Y
Dive 122 w63	w63	2017-05-21 16:50:33	Stopped Video	00:07:47	58˚ 08.3843' N 002˚ 50.3716' W UTC: 15:50:33	Wind Farm	Y
Dive 123 w62	w62	2017-05-21 17:05:06	Started Video	00:00:00	58˚ 07.3428' N 002˚ 50.5977' W UTC: 16:05:05	Wind Farm	Y
Dive 123 w62	w62	2017-05-21 17:12:37	Stopped Video	00:07:30	58˚ 07.3645' N 002˚ 50.6466' W UTC: 16:12:36	Wind Farm	Y
Dive 124 w61	w61	2017-05-21 17:20:50	Started Video	00:00:00	58˚ 07.6738' N 002˚ 52.0875' W UTC: 16:20:49	Wind Farm	Y

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 124 w61	w61	2017-05-21 17:27:03	Stopped Video	00:06:13	58˚ 07.6881' N 002˚ 52.1380' W UTC: 16:27:02	Wind Farm	Y
Dive 125 w60	w60	2017-05-21 17:34:31	Started Video	00:00:00	58˚ 08.1213' N 002˚ 53.3505' W UTC: 16:34:30	Wind Farm	Y
Dive 125 w60	w60	2017-05-21 17:46:54	Stopped Video	00:12:22	58˚ 08.1443' N 002˚ 53.4288' W UTC: 16:46:53	Wind Farm	Y
Dive 126 w59	w59	2017-05-21 17:55:41	Started Video	00:00:00	58˚ 08.2761' N 002˚ 54.8946' W UTC: 16:55:40	Wind Farm	Y
Dive 126 w59	w59	2017-05-21 18:03:51	Stopped Video	00:08:09	58˚ 08.2870' N 002˚ 54.9779' W UTC: 17:03:51	Wind Farm	Y
Dive 127 w58	w58	2017-05-21 18:12:16	Started Video	00:00:00	58˚ 08.9382' N 002˚ 56.4274' W UTC: 17:12:16	Wind Farm	Y
Dive 127 w58	w58	2017-05-21 18:19:01	Stopped Video	00:06:45	58˚ 08.9471' N 002˚ 56.5259' W UTC: 17:19:01	Wind Farm	Y
Dive 128 w4	w4	2017-05-21 18:29:03	Started Video	00:00:00	58˚ 09.0835' N 002˚ 58.7572' W UTC: 17:29:02	Wind Farm	Y
Dive 128 w4	w4	2017-05-21 18:34:52	Stopped Video	00:05:49	58˚ 09.0888' N 002˚ 58.8435' W UTC: 17:34:52	Wind Farm	Y
Dive 129 w57	w57	2017-05-21 18:45:17	Started Video	00:00:00	58˚ 08.4336' N 002˚ 58.7059' W UTC: 17:45:17	Wind Farm	Y
Dive 129 w57	w57	2017-05-21 18:52:19	Stopped Video	00:07:01	58˚ 08.4438' N 002˚ 58.8172' W UTC: 17:52:19	Wind Farm	Y
Dive 130 w56	w56	2017-05-21 19:03:39	Started Video	00:00:00	58˚ 07.9645' N 002˚ 57.2478' W UTC: 18:03:37	Wind Farm	Y
Dive 130 w56	w56	2017-05-21 19:09:25	Stopped Video	00:05:46	58˚ 07.9713' N 002˚ 57.3451' W UTC: 18:09:24	Wind Farm	Y
Dive 131 w55	w55	2017-05-21 19:19:28	Started Video	00:00:00	58˚ 07.6153' N 002˚ 55.9748' W UTC: 18:19:28	Wind Farm	Y
Dive 131 w55	w55	2017-05-21 19:26:42	Stopped Video	00:07:13	58˚ 07.6261' N 002˚ 56.0963' W UTC: 18:26:41	Wind Farm	Y
Dive 132 w54	w54	2017-05-21 19:38:00	Started Video	00:00:00	58˚ 07.1125' N 002˚ 54.3732' W UTC: 18:38:00	Wind Farm	Y
Dive 132 w54	w54	2017-05-21 19:44:15	Stopped Video	00:06:14	58˚ 07.1169' N 002˚ 54.4707' W UTC: 18:44:15	Wind Farm	Y
Dive 133 w53	w53	2017-05-21 19:55:45	Started Video	00:00:00	58˚ 06.7848' N 002˚ 52.6094' W UTC: 18:55:44	Wind Farm	Y
Dive 133 w53	w53	2017-05-21 20:04:48	Stopped Video	00:09:02	58˚ 06.8068' N 002˚ 52.7513' W UTC: 19:04:47	Wind Farm	Y
Dive 134 w39	w39	2017-05-21 20:31:21	Started Video	00:00:00	58˚ 04.3313' N 002˚ 56.4696' W UTC: 19:31:20	Wind Farm	
Dive 134 w39	w39	2017-05-21 20:35:13	Stopped Video	00:03:52	58˚ 04.3554' N 002˚ 56.5113' W UTC: 19:35:12	Wind Farm	
Dive 135 w39	w39	2017-05-21 20:42:30	Started Video	00:00:00	58˚ 04.3333' N 002˚ 56.4632' W UTC: 19:42:29	Wind Farm	
Dive 135 w39	w39	2017-05-21 20:47:20	Stopped Video	00:04:49	58˚ 04.3662' N 002˚ 56.5028' W UTC: 19:47:20	Wind Farm	
Dive 136 c28	c28	2017-05-21 21:05:35	Started Video	00:00:00	58˚ 03.1049' N 002˚ 55.8183' W UTC: 20:05:34	Export Cable	Y

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 136 c28	c28	2017-05-21 21:14:44	Stopped Video	00:09:08	58˚ 03.1490' N 002˚ 55.8904' W UTC: 20:14:44	Export Cable	Y
Dive 137 c24	c24	2017-05-23 10:48:23	Started Video	00:00:00	57˚ 44.1259' N 002˚ 53.3202' W UTC: 09:48:23	Export Cable	
Dive 137 c24	c24	2017-05-23 10:51:31	Stopped Video	00:03:08	57˚ 44.1333' N 002˚ 53.1697' W UTC: 09:51:32	Export Cable	
Dive 138 c24	c24	2017-05-23 10:58:37	Started Video	00:00:00	57˚ 44.1252' N 002˚ 53.3641' W UTC: 09:58:38	Export Cable	
Dive 138 c24	c24	2017-05-23 11:03:47	Stopped Video	00:05:10	57˚ 44.1313' N 002˚ 53.1250' W UTC: 10:03:47	Export Cable	
Dive 139 c12	c12	2017-05-24 10:06:42	Started Video	00:00:00	57˚ 50.6215' N 002˚ 53.8789' W UTC: 09:06:42	Export Cable	Y
Dive 139 c12	c12	2017-05-24 10:13:57	Stopped Video	00:07:15	57˚ 50.6237' N 002˚ 53.6530' W UTC: 09:13:57	Export Cable	Y
Dive 140 c11	c11	2017-05-24 10:31:41	Started Video	00:00:00	57˚ 52.3265' N 002˚ 54.9498' W UTC: 09:31:40	Export Cable	Y
Dive 140 c11	c11	2017-05-24 10:39:21	Stopped Video	00:07:40	57˚ 52.3258' N 002˚ 54.7715' W UTC: 09:39:21	Export Cable	Y
Dive 141 c10	c10	2017-05-24 10:56:49	Started Video	00:00:00	57˚ 53.6417' N 002˚ 55.7955' W UTC: 09:56:49	Export Cable	Y
Dive 141 c10	c10	2017-05-24 11:05:30	Stopped Video	00:08:40	57˚ 53.6351' N 002˚ 55.6242' W UTC: 10:05:30	Export Cable	Y
Dive 142 c9	c9	2017-05-24 11:26:56	Started Video	00:00:00	57˚ 55.1845' N 002˚ 56.8421' W UTC: 10:26:56	Export Cable	Y
Dive 142 c9	c9	2017-05-24 11:39:22	Stopped Video	00:12:25	57˚ 55.1366' N 002˚ 56.6286' W UTC: 10:39:22	Export Cable	Y
Dive 143 c8	c8	2017-05-24 12:07:26	Started Video	00:00:00	57˚ 56.6690' N 002˚ 57.8788' W UTC: 11:07:27	Export Cable	Y
Dive 143 c8	c8	2017-05-24 12:25:51	Stopped Video	00:18:24	57˚ 56.6515' N 002˚ 57.6273' W UTC: 11:25:52	Export Cable	Y
Dive 144 w22	w22	2017-05-24 13:09:11	Started Video	00:00:00	58˚ 03.4544' N 003˚ 05.2669' W UTC: 12:09:11	Wind Farm	Y
Dive 144 w22	w22	2017-05-24 13:16:34	Stopped Video	00:07:22	58˚ 03.4904' N 003˚ 05.2317' W UTC: 12:16:34	Wind Farm	Y
Dive 145 w23	w23	2017-05-24 13:28:40	Started Video	00:00:00	58˚ 04.2778' N 003˚ 07.3961' W UTC: 12:28:39	Wind Farm	Y
Dive 145 w23	w23	2017-05-24 13:34:34	Stopped Video	00:05:53	58˚ 04.3205' N 003˚ 07.3635' W UTC: 12:34:33	Wind Farm	Y
Dive 146 w24	w24	2017-05-24 13:46:10	Started Video	00:00:00	58˚ 04.9913' N 003˚ 08.7516' W UTC: 12:46:10	Wind Farm	Y
Dive 146 w24	w24	2017-05-24 13:51:44	Stopped Video	00:05:33	58˚ 05.0356' N 003˚ 08.7183' W UTC: 12:51:44	Wind Farm	Y
Dive 147 w17	w17	2017-05-24 14:03:33	Started Video	00:00:00	58˚ 04.2614' N 003˚ 10.0736' W UTC: 13:03:33	Wind Farm	Y
Dive 147 w17	w17	2017-05-24 14:09:03	Stopped Video	00:05:30	58˚ 04.2964' N 003˚ 10.0632' W UTC: 13:09:03	Wind Farm	Y
Dive 148 w74	w74	2017-05-24 14:22:41	Started Video	00:00:00	58˚ 02.7011' N 003˚ 09.6282' W UTC: 13:22:41	Wind Farm	Y
Dive 148 w74	w74	2017-05-24 14:28:38	Stopped Video	00:05:57	58˚ 02.7592' N 003˚ 09.5952' W UTC: 13:28:37	Wind Farm	Y

Dive	Site	Time (GMT)	Log Event	Video Time	GPS Data (WGS84)	Log	Analysis
Dive 149 w14	w14	2017-05-24 14:43:47	Started Video	00:00:00	58˚ 01.5187' N 003˚ 09.2789' W UTC: 13:43:47	Wind Farm	Y
Dive 149 w14	w14	2017-05-24 14:49:47	Stopped Video	00:06:00	58˚ 01.5651' N 003˚ 09.2290' W UTC: 13:49:48	Wind Farm	Y
Dive 150 w39	w39	2017-05-27 6:04:23	Started Video	00:00:00	58˚ 04.3082' N 002˚ 56.4208' W UTC: 05:04:23	Wind Farm	
Dive 150 w39	w39	2017-05-27 6:08:55	Stopped Video	00:04:32	58˚ 04.3647' N 002˚ 56.4911' W UTC: 05:08:56	Wind Farm	
Dive 151 w39	w39	2017-05-27 6:20:19	Started Video	00:00:00	58˚ 04.3184' N 002˚ 56.3943' W UTC: 05:20:19	Wind Farm	
Dive 151 w39	w39	2017-05-27 6:25:33	Stopped Video	00:05:14	58˚ 04.3833' N 002˚ 56.4667' W UTC: 05:25:33	Wind Farm	
Dive 152 w29	w29	2017-05-27 6:40:08	Started Video	00:00:00	58˚ 03.6615' N 002˚ 58.2634' W UTC: 05:40:08	Wind Farm	Y
Dive 152 w29	w29	2017-05-27 6:45:50	Stopped Video	00:05:41	58˚ 03.7221' N 002˚ 58.3521' W UTC: 05:45:50	Wind Farm	Y
Dive 153 w31	w31	2017-05-27 7:09:17	Started Video	00:00:00	58˚ 04.6708' N 003˚ 01.6171' W UTC: 06:09:18	Wind Farm	
Dive 153 w31	w31	2017-05-27 7:10:40	Stopped Video	00:01:22	58˚ 04.6868' N 003˚ 01.6411' W UTC: 06:10:41	Wind Farm	
Dive 154 w31	w31	2017-05-27 7:22:28	Started Video	00:00:00	58˚ 04.6605' N 003˚ 01.6427' W UTC: 06:22:29	Wind Farm	Y
Dive 154 w31	w31	2017-05-27 7:27:48	Stopped Video	00:05:20	58˚ 04.7170' N 003˚ 01.7294' W UTC: 06:27:49	Wind Farm	Y
Dive 155 w36	w36	2017-05-27 7:40:14	Started Video	00:00:00	58˚ 05.7388' N 003˚ 01.2364' W UTC: 06:40:14	Wind Farm	Y
Dive 155 w36	w36	2017-05-27 7:45:54	Stopped Video	00:05:40	58˚ 05.8004' N 003˚ 01.3182' W UTC: 06:45:55	Wind Farm	Y

7 Annex 7.1B: Video Analysis Summary

Site	**C13**	**W21**	**W2**	**W18**	**W19**	**W20**
Dive	Dive 4	Dive 5	Dive 9	Dive 11	Dive 12	Dive 13
Date	14/05/2017	14/05/2017	14/05/2017	14/05/2017	14/05/2017	14/05/2017
StartTime (hh:mm:ss)	11:55:50	14:35:35	15:45:59	16:20:52	16:40:47	17:12:58
EndTime (hh:mm:ss)	12:02:01	14:41:55	15:51:18	16:26:25	16:46:17	17:18:22
Duration (hh:mm:ss)	06:10	06:19	05:18	05:32	05:29	05:24
Start - Latitude	57˚ 48.8696' N	58˚ 02.7749' N	58˚ 04.5909' N	58˚ 03.3886' N	58˚ 02.6455' N	58˚ 02.0622' N
Start - Longitude	002˚ 52.6668' W	003˚ 03.1516' W	003˚ 10.5218' W	003˚ 08.2727' W	003˚ 06.3316' W	003˚ 04.5669' W
End - Latitude	57˚ 48.8523' N	58˚ 02.7368' N	58˚ 04.5750' N	58˚ 03.3899' N	58˚ 02.6545' N	58˚ 02.0654' N
End - Longitude	002˚ 52.5838' W	003˚ 03.1576' W	003˚ 10.5467' W	003˚ 08.3242' W	003˚ 06.3820' W	003˚ 04.6160' W
Habitat description	Sand & shell debris/grit (with occasional pebble or cobble)	(sl. Muddy) Sand with broken shells. Faunal trails present.	(sl. Muddy) Sand	Muddy sand with broken shells. Infaunal tubes present.	(sl. Muddy) Sand with broken shells. Infaunal tubes present.	Muddy sand/gravel with broken shells and occasional cobbles
Comments	Unidentified fish @ 3:14	Poor visibility	Poor visibility		Poor visibility in latter half of transect.	
Taxa						
Actiniaria						
Adamsia palliata			R			O

Aequipecten opercularis						
Agonus cataphractus						
Alcyonium digitatum						
Ammodytidae	F					
Antalis entalis						
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	O			R		R
Asteroidea						
Astropecten irregularis					R	
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura	R					
Buccinidae						
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra			R	R		
Calliostoma zizyphinum						
Cancer pagurus						

Chelidonichthys cuculus						R
Corella parallelogramma						
Crossaster papposus						
Ctenophora	R					
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa		R	R			O
Lanice conchilega						
Lithodes maja						
Lithothamnion						
Luidia ciliaris						R
Luidia sarsii						
Majoidea						

Merlangius merlangus						
Microchirus variegatus						
Munida rugosa						
Myoxocephalus scorpius						
Necora puber	O					
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura		R				
Pagurus bernhardus	R					
Pagurus prideaux			R			O
Paguridae			R			O
Pecten maximus						
Pectinidae						
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa						
Pleuronectidae						
Porania (Porania) pulvillus						
Porifera						

Raja clavata						
Rhodophyta						
Rhodophyta						
Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae						R
Suberites carnosus						
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**W75**	**W15**	**W16**	**W13**	**W12**	**W9**
Dive	Dive 15	Dive 16	Dive 18	Dive 19	Dive 20	Dive 23
Date	14/05/2017	14/05/2017	14/05/2017	14/05/2017	14/05/2017	14/05/2017
StartTime (hh:mm:ss)	17:47:53	18:04:22	18:37:24	18:58:08	19:16:00	20:16:49
EndTime (hh:mm:ss)	17:53:05	18:10:07	18:43:47	19:03:36	19:21:10	20:22:17
Duration (hh:mm:ss)	05:11	05:44	06:23	05:27	05:09	05:27
Start - Latitude	58˚ 01.8503' N	58˚ 02.0870' N	58˚ 03.3069' N	58˚ 02.6023' N	58˚ 01.9670' N	58˚ 01.0655' N
Start - Longitude	003˚ 06.9259' W	003˚ 08.2662' W	003˚ 11.0804' W	003˚ 12.3538' W	003˚ 11.0262' W	003˚ 08.3559' W
End - Latitude	58˚ 01.8653' N	58˚ 02.1198' N	58˚ 03.3573' N	58˚ 02.6356' N	58˚ 01.9973' N	58˚ 01.1176' N
End - Longitude	003˚ 06.9974' W	003˚ 08.3606' W	003˚ 11.1433' W	003˚ 12.3866' W	003˚ 11.0721' W	003˚ 08.4079' W
Habitat description	(sl. Muddy) Sand with broken shells. Infaunal tubes present.	(sl. Muddy) Sand with broken shells. Tubes and burrows present.	(sl. Muddy) Sand. Burrows, tubes and worm casts present. Lots of small fish in water column.	Muddy sand. Tubes, burrows and casts present.	(sl.muddy) Sand. Tubes, burrows and casts present.	(sl. Muddy) Sand with broken shells. Tubes, tracks, burrows present.
Comments		Arctica islandica @ 4:27?		Crustacean retreating into burrow @ 4:45?	Octopus @ 3:18?	
Taxa						
Actiniaria						
Adamsia palliata						

Aequipecten opercularis						
Agonus cataphractus						
Alcyonium digitatum		R				
Ammodytidae						
Antalis entalis						
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	R		R	R	R	O
Asteroidea						
Astropecten irregularis		R			R	R
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura						
Buccinidae						
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra						
Calliostoma zizyphinum						
Cancer pagurus						
Chelidonichthys cuculus		R		R		O

Corella parallelogramma						
Crossaster papposus						
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea			R			
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa					R	
Lanice conchilega						
Lithodes maja						
Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea						

Merlangius merlangus						
Microchirus variegatus						
Munida rugosa						
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura						
Pagurus bernhardus			R			R
Pagurus prideaux						
Paguridae						
Pecten maximus						
Pectinidae						
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa			O			
Pleuronectidae				R		R
Porania (Porania) pulvillus						
Porifera						
Raja clavata						

Rhodophyta						
Rhodophyta						
Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae						
Suberites carnosus						
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**W10**	**W11**	**W1**	**W76**	**C14**	**C23**
Dive	Dive 24	Dive 25	Dive 26	Dive 27	Dive 28	Dive 29
Date	14/05/2017	14/05/2017	14/05/2017	14/05/2017	15/05/2017	15/05/2017
StartTime (hh:mm:ss)	20:33:10	20:47:49	21:03:39	21:19:30	08:38:59	09:07:49
EndTime (hh:mm:ss)	20:38:33	20:53:22	21:08:52	21:26:24	08:46:37	09:13:31
Duration (hh:mm:ss)	05:23	05:32	05:13	06:54	07:37	05:41
Start - Latitude	58˚ 01.1448' N	58˚ 01.6657' N	58˚ 01.0761' N	58˚ 00.8193' N	57˚ 46.9087' N	57˚ 47.2539' N
Start - Longitude	003˚ 10.8228' W	003˚ 12.3575' W	003˚ 13.1286' W	003˚ 12.2895' W	002˚ 52.6815' W	002˚ 50.5941' W
End - Latitude	58˚ 01.1905' N	58˚ 01.7171' N	58˚ 01.1085' N	58˚ 00.8743' N	57˚ 47.0069' N	57˚ 47.3307' N
End - Longitude	003˚ 10.8669' W	003˚ 12.4141' W	003˚ 13.1608' W	003˚ 12.3314' W	002˚ 52.8365' W	002˚ 50.7160' W
Habitat description	(sl. Muddy) Sand. Tracks, casts and burrows present. Lots of fry in water column.	(sl. Muddy) Sand. Tubes and burrows present. Lots of fry in water column.	(sl. Muddy) Sand. Casts, burrows and tubes present.	(sl. Muddy) Sand. Burrows and tubes present.	Heterogeneous - shelly sand mixed with small patches of cobbles. Burrows and tubes present.	(sl. Muddy) Sand. Tracks, tubes, casts and burrows present.
Comments		Sand eel @ 3:58?		Poor visibility.	Poor visibility at times. Unidentified fish @ 4:58	Poor visibility at times.
Taxa						
Actiniaria						
Adamsia palliata						
Aequipecten opercularis						

Agonus cataphractus						
Alcyonium digitatum			R			
Ammodytidae					O	
Antalis entalis						
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	O	O			C	
Asteroidea				R	R	
Astropecten irregularis						R
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura						
Buccinidae						
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra	R					R
Calliostoma zizyphinum						
Cancer pagurus						
Chelidonichthys cuculus	R	R	R			

Corella parallelogramma						
Crossaster papposus					R	
Ctenophora					R	R
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea					O	
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa	R		R		C	R
Lanice conchilega					R	
Lithodes maja						
Lithothamnion					R	
Luidia ciliaris						
Luidia sarsii				R		
Majoidea						
Merlangius merlangus						

Microchirus variegatus						
Munida rugosa						
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina					R	
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura						
Pagurus bernhardus		R				
Pagurus prideaux						
Paguridae						
Pecten maximus						
Pectinidae					R	
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa						
Pleuronectidae	R		R			
Porania (Porania) pulvillus					F	R
Porifera						
Raja clavata						

Rhodophyta						
Rhodophyta						
Sabellidae						
Scorpaeniformes						
Securiflustra securifrons					O	
Serpulidae					O	
Suberites carnosus						
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**C16**	**C17**	**C22**	**C18**	**C21**	**C21**
Dive	Dive 35	Dive 36	Dive 37	Dive 40	Dive 41	Dive 41
Date	15/05/2017	15/05/2017	15/05/2017	16/05/2017	16/05/2017	16/05/2017
StartTime (hh:mm:ss)	12:43:33	13:15:24	13:41:46	10:02:24	10:31:23	10:35:32
EndTime (hh:mm:ss)	12:53:43	13:20:45	13:50:30	10:09:46	10:35:31	10:37:18
Duration (hh:mm:ss)	10:10	05:20	08:44	07:22	04:08	01:46
Start - Latitude	57˚ 42.7097' N	57˚ 42.6535' N	57˚ 42.6794' N	57˚ 44.0475' N	57˚ 44.3376' N	57˚ 44.3698' N
Start - Longitude	002˚ 53.9250' W	002˚ 49.6674' W	002˚ 45.5434' W	002˚ 50.3483' W	002˚ 46.9815' W	002˚ 46.9984' W
End - Latitude	57˚ 42.7654' N	57˚ 42.6971' N	57˚ 42.7794' N	57˚ 44.1236' N	57˚ 44.3698' N	57˚ 44.3824' N
End - Longitude	002˚ 54.0821' W	002˚ 49.7524' W	002˚ 45.6571' W	002˚ 50.3413' W	002˚ 46.9984' W	002˚ 47.0054' W
Habitat description	Boulders, cobbles & small stones with turf of hydroids, Lithothamnia, filamentous red algae & keel worms	Sand	(sl. Muddy) Sand with gravel and cobbles.	Boulders, cobbles & small stones with turf of hydroids. Lithothamnia & keel worms	(sl. Muddy) Sand and gravel with occasional cobbles.	Sand & shell debris/grit (with occasional patches of small stones)
Comments	Unidentified fauna: Taurulus bubalis? @ 3:19; Anemone? @ 6:11; blue sunstar @ 9:16 - Solaster endeca?	2 unidentifiable fish seen; infrequent burrows/worm casts	Poor visibility. Occasional worm tubes /burrows		Two parallel lines of small stones & broken shells at outset. Worm tubes seen at regular intervals.	Worm tubes at regular intervals.
Taxa						

Actiniaria				O		
Adamsia palliata						
Aequipecten opercularis				R		
Agonus cataphractus						
Alcyonium digitatum						
Ammodytidae		R				
Antalis entalis						
Antedon bifida				O		
Ascidiacea						
Ascidiella aspersa				C		
Asterias rubens	C	F		O		
Asteroidea	R					
Astropecten irregularis						
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura			R			
Buccinidae				R		
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra						
Calliostoma zizyphinum				R		

Cancer pagurus						
Chelidonichthys cuculus						
Corella parallelogramma	F			C	R	O
Crossaster papposus	R			O		
Ctenophora					O	
Delesseria sanguinea	O					
Echinocardium cordatum				R		
Echinus esculentus				C		
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea			R			
Gobiidae						
Henricia			R	R		
Hyalinoecia tubicola						
Hyas coarctatus	R					
Hydrozoa/Bryozoa	A		A	A	O	R
Lanice conchilega	R		R	A	F	R
Lithodes maja				R		
Lithothamnion	A		R	A	O	R
Luidia ciliaris				R		
Luidia sarsii						

Majoidea	R			R		
Merlangius merlangus						
Microchirus variegatus						
Munida rugosa	O			A	R	
Myoxocephalus scorpius						
Necora puber	R					
Nemertea					R	
Nemertesia antennina	C			A		
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura				C		
Pagurus bernhardus						
Pagurus prideaux						
Paguridae						
Pecten maximus				R		
Pectinidae					R	O
Pennatula phosphorea						
Pholis gunnellus	R					
Phrynorhombus norvegicus						
Pleuronectes platessa						
Pleuronectidae						
Porania (Porania) pulvillus						
Porifera						

Raja clavata						
Rhodophyta	F					
Rhodophyta	F					
Sabellidae						
Scorpaeniformes						
Securiflustra securifrons			R			
Serpulidae	A		O	A	F	O
Suberites carnosus						
Suberites suberia						
Turritella communis			O			
Virgularia mirabilis						
Zeus faber						

Site	**C21**	**C20**	**C19**	**C15**	**C24**	**C27**
Dive	Dive 41	Dive 42	Dive 43	Dive 44	Dive 45	Dive 48
Date	16/05/2017	16/05/2017	16/05/2017	16/05/2017	16/05/2017	17/05/2017
StartTime (hh:mm:ss)	10:37:18	10:52:22	11:13:35	11:36:44	11:59:45	10:40:33
EndTime (hh:mm:ss)	10:38:51	10:58:06	11:26:09	11:47:18	12:10:03	10:46:47
Duration (hh:mm:ss)	01:33	05:43	12:33	10:34	10:18	06:14
Start - Latitude	57˚ 44.3824' N	57˚ 45.6934' N	57˚ 45.7115' N	57˚ 45.2547' N	57˚ 44.1264' N	58˚ 00.2645' N
Start - Longitude	002˚ 47.0054' W	002˚ 49.3220' W	002˚ 51.5352' W	002˚ 53.1045' W	002˚ 53.3016' W	003˚ 10.4813' W
End - Latitude	57˚ 44.3949' N	57˚ 45.7460' N	57˚ 45.8114' N	57˚ 45.3418' N	57˚ 44.2418' N	58˚ 00.3030' N
End - Longitude	002˚ 47.0141' W	002˚ 49.3408' W	002˚ 51.6142' W	002˚ 53.1354' W	002˚ 53.2674' W	003˚ 10.4821' W
Habitat description	Sand & shell debris/grit	Mixed substrate - sand with patches of cobbles & pebbles	Brittle star meadow - Gravelly Sand with patchy cobbles and pebbles. Hydroids & sea squirts	Mixed - cobbles & pebbles alternating with sand/gravel & pebbles. Brittle stars, hydroids & sea squirts	Gravel, Cobbles and pebbles	(sl. Muddy) Sand with shell fragments. Tracks, burrows, tubes and casts.
Comments		Worm tubes evident.	Brittle star numbers drop off at 11.40 to be replaced by Ascidiacea, predominantly Ascidiella aspersa.	Possible sea lemon at 3.52. Patches of brittlestar beds.		Fish @ 2:27
Taxa						

Actiniaria			R	R	R	
Adamsia palliata						
Aequipecten opercularis						
Agonus cataphractus						
Alcyonium digitatum			C	F		
Ammodytidae						
Antalis entalis						
Antedon bifida				F	F	
Ascidiacea			C			
Ascidiella aspersa		F	A	O	O	
Asterias rubens		O	O	F	F	R
Asteroidea						
Astropecten irregularis						
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura			R		R	
Buccinidae		R				
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra		R				

Calliostoma zizyphinum		R				
Cancer pagurus						
Chelidonichthys cuculus						
Corella parallelogramma		O	O	C	A	
Crossaster papposus			R	O	F	
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus			O	O	F	
Eledone cirrhosa						
Eupolymnia nebulosa					R	
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia				O	R	
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa		F	C	A	A	
Lanice conchilega		R	O	O	C	
Lithodes maja						
Lithothamnion		C	A	C	A	
Luidia ciliaris						

Luidia sarsii						
Majoidea					O	
Merlangius merlangus						
Microchirus variegatus						
Munida rugosa		O	F		C	
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina			F	C	F	
Ophiocomina nigra			S	A		
Ophiothrix fragilis			S	A		
Ophiura			A	O	C	
Pagurus bernhardus						
Pagurus prideaux						
Paguridae						
Pecten maximus						
Pectinidae				O	R	
Pennatula phosphorea						
Pholis gunnellus					R	
Phrynorhombus norvegicus						
Pleuronectes platessa	R					
Pleuronectidae						

Porania (Porania) pulvillus		R				
Porifera						
Raja clavata						
Rhodophyta					O	
Rhodophyta					F	
Sabellidae						
Scorpaeniformes						R
Securiflustra securifrons		O				
Serpulidae		C	A	A	A	
Suberites carnosus						
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**C1**	**C25**	**C4**	**C6**	**C7**	**C2**
Dive	Dive 49	Dive 50	Dive 51	Dive 53	Dive 54	Dive 57
Date	18/05/2017	18/05/2017	18/05/2017	18/05/2017	18/05/2017	18/05/2017
StartTime (hh:mm:ss)	05:28:06	06:05:10	06:29:56	2017-05-18 7:10:59	2017-05-18 7:32:59	2017-05-18 8:35:45
EndTime (hh:mm:ss)	05:34:16	06:11:55	06:35:28	2017-05-18 7:19:16	2017-05-18 7:40:25	2017-05-18 8:41:45
Duration (hh:mm:ss)	06:10	06:45	05:32	08:17	07:26	05:59
Start - Latitude	58˚ 00.2447' N	58˚ 01.3087' N	57˚ 59.9969' N	57˚ 59.2789' N	57˚ 57.9555' N	58˚ 01.0519' N
Start - Longitude	003˚ 06.5781' W	003˚ 05.4654' W	003˚ 03.6891' W	002˚ 59.7807' W	002˚ 58.6956' W	003˚ 01.4270' W
End - Latitude	58˚ 00.2187' N	58˚ 01.2953' N	58˚ 00.0028' N	57˚ 59.2862' N	57˚ 57.9511' N	58˚ 01.0715' N
End - Longitude	003˚ 06.5294' W	003˚ 05.4051' W	003˚ 03.6098' W	002˚ 59.6755' W	002˚ 58.6062' W	003˚ 01.3633' W
Habitat description	(sl. Muddy) Sand with shell fragments. Tracks, tubes and burrows.	(sl. Muddy) Sand & shell fragments with tracks and burrows	(sl. Muddy) Sand & shell fragments with tracks, burrows and tubes.	Muddy Sand with shell fragments (& occasional stone or cobble). Tracks, burrows, tubes and casts.	Muddy sand with burrows, tubes, tracks and worm casts	(sl. Muddy) Sand with shell fragments. Tracks, worm casts, burrows and tubes.
Comments	Fish @ 5:37 - red gurnard?			Poor visibility from 3:00. Indet. Bivalve closing @ 4:05.		
Taxa						
Actiniaria						
Adamsia palliata						

Aequipecten opercularis						
Agonus cataphractus						
Alcyonium digitatum				R	R	
Ammodytidae						
Antalis entalis			O	R		R
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens			R			R
Asteroidea						
Astropecten irregularis					R	
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura						
Buccinidae						
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra		R	R	R	R	R
Calliostoma zizyphinum						
Cancer pagurus						
Chelidonichthys cuculus						

Corella parallelogramma						
Crossaster papposus						
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa		R		R	R	
Eupolymnia nebulosa						
Flustra foliacea	R					
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa	O	O	R	F	F	O
Lanice conchilega						
Lithodes maja						
Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea						
Merlangius merlangus						

Microchirus variegatus						
Munida rugosa						
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura	R	R				R
Pagurus bernhardus						
Pagurus prideaux						
Paguridae						
Pecten maximus						
Pectinidae				R		
Pennatula phosphorea	O	O	R	O	F	O
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa	R				R	
Pleuronectidae	R					
Porania (Porania) pulvillus						
Porifera						
Raja clavata						
Rhodophyta						

Rhodophyta						
Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae						
Suberites carnosus						
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**C5**	**C3**	**C26**	**C26**	**C26**
Dive	Dive 59	Dive 60	Dive 61	Dive 61	Dive 61
Date	18/05/2017	18/05/2017	18/05/2017	18/05/2017	18/05/2017
StartTime (hh:mm:ss)	09:10:17	09:32:31	10:05:29	10:09:19	10:10:39
EndTime (hh:mm:ss)	09:17:15	09:49:03	10:09:19	10:10:39	10:13:43
Duration (hh:mm:ss)	06:57	16:32	03:50	01:20	03:04
Start - Latitude	58˚ 00.9042' N	58˚ 02.1284' N	58˚ 02.3151' N	58˚ 02.3431' N	58˚ 02.3528' N
Start - Longitude	002˚ 58.3709' W	002˚ 57.2382' W	003˚ 00.0856' W	003˚ 00.0740' W	003˚ 00.0744' W
End - Latitude	58˚ 00.9350' N	58˚ 02.1925' N	58˚ 02.3431' N	58˚ 02.3528' N	58˚ 02.3722' N
End - Longitude	002˚ 58.3433' W	002˚ 57.1555' W	003˚ 00.0740' W	003˚ 00.0744' W	003˚ 00.0717' W
Habitat description	(sl. Muddy) Sand with shell fragments. Worm casts, tracks, tubes and burrows.	Heterogeneous. Sand and gravel with patches of pebbles and cobbles	(sl. Muddy) Sand with shell fragments. Tubes, tracks and burrows	(sl. Muddy) Sandy Gravel & shells/stones	Sand or (sl. Muddy) Sand with tracks, burrows and tubes
Comments	Poor visibility at times.	Possible hermit crab in Calliostoma and Actiniaria @ 10:14		1	
Taxa					
Actiniaria					
Adamsia palliata					
Aequipecten opercularis					

Agonus cataphractus					
Alcyonium digitatum		A	R		
Ammodytidae					
Antalis entalis	R		R	R	
Antedon bifida					
Ascidiacea		R			
Ascidiella aspersa					
Asterias rubens		O			R
Asteroidea				R	
Astropecten irregularis	R				R
Atelecyclus rotundatus					
Barnacles		O			
Bivalvia					
Brachyura					
Buccinidae					
Buccinum undatum					
Buglossidium luteum					
Neptunea antiqua					
Callionymus lyra		R			
Calliostoma zizyphinum					
Cancer pagurus					
Chelidonichthys cuculus					

Corella parallelogramma					
Crossaster papposus					
Ctenophora					
Delesseria sanguinea					
Echinocardium cordatum					
Echinus esculentus					
Eledone cirrhosa	R				
Eupolymnia nebulosa					
Flustra foliacea	R	R			
Gadus morhua					
Galatheoidea					
Gobiidae		R			
Henricia		R			
Hyalinoecia tubicola					
Hyas coarctatus					
Hydrozoa/Bryozoa	R	A	R	O	O
Lanice conchilega		F	O	R	
Lithodes maja					
Lithothamnion		C			
Luidia ciliaris					
Luidia sarsii					
Majoidea					
Merlangius merlangus					

Microchirus variegatus				R	
Munida rugosa		C			
Myoxocephalus scorpius					
Necora puber					
Nemertea					
Nemertesia antennina		R			
Ophiocomina nigra					
Ophiothrix fragilis					
Ophiura			R		R
Pagurus bernhardus		R			
Pagurus prideaux					
Paguridae					
Pecten maximus					
Pectinidae		R			
Pennatula phosphorea	R				
Pholis gunnellus					
Phrynorhombus norvegicus					
Pleuronectes platessa					
Pleuronectidae	R				
Porania (Porania) pulvillus					
Porifera					
Raja clavata					

Rhodophyta					
Rhodophyta					
Sabellidae					
Scorpaeniformes					
Securiflustra securifrons					
Serpulidae		C			
Suberites carnosus					
Suberites suberia					
Turritella communis					
Virgularia mirabilis					
Zeus faber					

Site	**W8**	**W8**	**W8**	**W28**	**W27**	**W26**
Dive	Dive 62	Dive 62	Dive 62	Dive 63	Dive 64	Dive 65
Date	18/05/2017	18/05/2017	18/05/2017	18/05/2017	18/05/2017	18/05/2017
StartTime (hh:mm:ss)	10:28:23	10:31:51	10:38:20	11:05:35	11:30:59	11:53:33
EndTime (hh:mm:ss)	10:31:51	10:34:50	10:38:49	11:17:08	11:36:46	11:59:18
Duration (hh:mm:ss)	03:28	06:29	00:30	11:32	05:47	05:44
Start - Latitude	58˚ 02.9151' N	58˚ 02.9359' N	58˚ 02.9540' N	58˚ 03.1888' N	58˚ 03.5690' N	58˚ 04.2157' N
Start - Longitude	002˚ 59.1099' W	002˚ 59.1003' W	002˚ 59.0931' W	003˚ 00.4417' W	003˚ 01.9953' W	003˚ 04.0710' W
End - Latitude	58˚ 02.9359' N	58˚ 02.9540' N	58˚ 02.9781' N	58˚ 03.2596' N	58˚ 03.6089' N	58˚ 04.2443' N
End - Longitude	002˚ 59.1003' W	002˚ 59.0931' W	002˚ 59.0841' W	003˚ 00.4184' W	003˚ 01.9794' W	003˚ 04.0512' W
Habitat description	(sl. Muddy) Sand and gravel	(sl. Muddy) Sandy Gravel & shell	Sand	Sand and gravel initially grading into gravelly muddy sand with broken shell at 00:54. No fauna before gravel.	(sl. Muddy) Sand & shells with tracks and burrows.	Shelly Muddy Sand and gravel with tracks, burrows and worm casts.
Comments						
Taxa						
Actiniaria						
Adamsia palliata				C		R
Aequipecten opercularis						

Agonus cataphractus						
Alcyonium digitatum		R				
Ammodytidae						
Antalis entalis						
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens				O	O	R
Asteroidea						
Astropecten irregularis						
Atelecyclus rotundatus				R		
Barnacles						
Bivalvia						
Brachyura						
Buccinidae		R				
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua			R			
Callionymus lyra		R		R		
Calliostoma zizyphinum						
Cancer pagurus						
Chelidonichthys cuculus						
Corella parallelogramma						

Crossaster papposus						
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa	F	C	R	C	R	O
Lanice conchilega		R		C		
Lithodes maja						
Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea				R		
Merlangius merlangus						
Microchirus variegatus						

Munida rugosa		R				
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura		R		O		R
Pagurus bernhardus	R	O		C	R	
Pagurus prideaux				C		R
Paguridae						R
Pecten maximus						
Pectinidae		O				
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa					R	
Pleuronectidae						
Porania (Porania) pulvillus						
Porifera						
Raja clavata						
Rhodophyta						
Rhodophyta						

Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae				O		
Suberites carnosus						
Suberites suberia						R
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**W77**	**W33**	**W25**	**W3**	**W34**	**W35**
Dive	Dive 66	Dive 67	Dive 68	Dive 69	Dive 70	Dive 71
Date	18/05/2017	18/05/2017	18/05/2017	18/05/2017	18/05/2017	18/05/2017
StartTime (hh:mm:ss)	12:16:20	12:45:19	13:11:09	13:32:15	13:52:51	14:10:18
EndTime (hh:mm:ss)	12:24:26	12:52:27	13:20:09	13:38:53	13:58:37	14:12:32
Duration (hh:mm:ss)	08:06	07:07	08:59	06:37	05:46	02:14
Start - Latitude	58˚ 04.7968' N	58˚ 05.4791' N	58˚ 05.6849' N	58˚ 06.7064' N	58˚ 06.7409' N	58˚ 05.9890' N
Start - Longitude	003˚ 05.7368' W	003˚ 05.1174' W	003˚ 07.7427' W	003˚ 07.0291' W	003˚ 04.0587' W	003˚ 02.8131' W
End - Latitude	58˚ 04.8406' N	58˚ 05.5013' N	58˚ 05.6940' N	58˚ 06.7083' N	58˚ 06.7332' N	58˚ 05.9847' N
End - Longitude	003˚ 05.7098' W	003˚ 05.1090' W	003˚ 07.7699' W	003˚ 07.0681' W	003˚ 04.1033' W	003˚ 02.8499' W
Habitat description	(sl. Muddy) Sand and gravel with tracks and worms casts.	Shelly sand or (sl. Muddy) sand and gravel with tracks, worm tubes and burrows.	Muddy Sand and gravel with burrows, tubes and tracks.	Muddy Sand and gravel with burrows and tracks.	Sand and gravel with burrows, tracks and tubes.	Sand and gravel with burrows, tracks and tubes.
Comments	Two unidentified fish: flatfish @ 1:11 & possible dragonet @ 4:59					
Taxa						
Actiniaria						
Adamsia palliata						

Aequipecten opercularis						
Agonus cataphractus						
Alcyonium digitatum						
Ammodytidae						
Antalis entalis			R			
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	F	R	R		O	O
Asteroidea						
Astropecten irregularis		R			R	R
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura						
Buccinidae						
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua					R	R
Callionymus lyra	R					
Calliostoma zizyphinum						
Cancer pagurus						

Chelidonichthys cuculus						
Corella parallelogramma						
Crossaster papposus						
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa	O	R	R	R	F	F
Lanice conchilega						
Lithodes maja						
Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea						

Merlangius merlangus						
Microchirus variegatus						
Munida rugosa						
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura		R			R	
Pagurus bernhardus	R		R	R		
Pagurus prideaux						
Paguridae	R					
Pecten maximus						
Pectinidae	R	R	R			
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa		R			R	
Pleuronectidae		R	R			
Porania (Porania) pulvillus						
Porifera						

Raja clavata						
Rhodophyta						
Rhodophyta						
Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae						
Suberites carnosus						
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	W35	W35	W32	W37	W30	W38
Dive	Dive 71	Dive 71	Dive 72	Dive 75	Dive 76	Dive 77
Date	18/05/2017	18/05/2017	18/05/2017	18/05/2017	18/05/2017	18/05/2017
StartTime (hh:mm:ss)	14:12:32	14:13:10	14:25:28	15:11:45	15:31:11	15:49:08
EndTime (hh:mm:ss)	14:13:10	14:16:31	14:30:56	15:17:44	15:37:29	15:56:43
Duration (hh:mm:ss)	00:38	03:21	05:28	05:58	06:17	07:35
Start - Latitude	58˚ 05.9847' N	58˚ 05.9836' N	58˚ 05.1743' N	58˚ 05.1800' N	58˚ 04.2145' N	58˚ 04.9983' N
Start - Longitude	003˚ 02.8499' W	003˚ 02.8602' W	003˚ 03.2107' W	002˚ 59.7377' W	002˚ 59.7382' W	002˚ 58.0113' W
End - Latitude	58˚ 05.9836' N	58˚ 05.9782' N	58˚ 05.1636' N	58˚ 05.1724' N	58˚ 04.2140' N	58˚ 05.0011' N
End - Longitude	003˚ 02.8602' W	003˚ 02.9163' W	003˚ 03.3144' W	002˚ 59.8641' W	002˚ 59.8682' W	002˚ 58.1885' W
Habitat description	Sand or (sl. Muddy) Sand and shell gravel	Sand or (sl. Muddy) Sand with tubes and burrows.	Sand or (sl. Muddy) Sand with tubes and burrows.	Sand or (sl. Muddy) Sand	Sand or (sl. Muddy) Sand and some gravel with tracks, casts and burrows.	Shelly sand with occasional cobbles. Burrows evident. Hydroids, Asteroidea (starfish) & hermit crabs.
Comments				Poor visibility at times.		
Taxa						
Actiniaria						
Adamsia palliata	R	R				
Aequipecten opercularis						

Agonus cataphractus				R		
Alcyonium digitatum						R
Ammodytidae						
Antalis entalis						
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	R	R	O	O	O	R
Asteroidea				R		
Astropecten irregularis			R			R
Atelecyclus rotundatus		R				
Barnacles						
Bivalvia						
Brachyura						
Buccinidae						
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra		R				
Calliostoma zizyphinum						
Cancer pagurus						
Chelidonichthys cuculus						
Corella parallelogramma						

Crossaster papposus						
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa		R				
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa	O	F	R	R	F	C
Lanice conchilega						
Lithodes maja						
Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea						
Merlangius merlangus						
Microchirus variegatus						

Munida rugosa						
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura	O					R
Pagurus bernhardus				R	R	O
Pagurus prideaux	R	R				O
Paguridae						
Pecten maximus						
Pectinidae						
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa						
Pleuronectidae			O			
Porania (Porania) pulvillus						
Porifera						
Raja clavata						
Rhodophyta						
Rhodophyta						

Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae		R				
Suberites carnosus						
Suberites suberia						
Turritella communis		R				R
Virgularia mirabilis						
Zeus faber						R

Site	**W7**	**W39**	**W39**	**W39**	**W39**	**W40**
Dive	Dive 83	Dive 86	Dive 86	Dive 86	Dive 86	Dive 88
Date	19/05/2017	19/05/2017	19/05/2017	19/05/2017	19/05/2017	19/05/2017
StartTime (hh:mm:ss)	11:35:52	12:26:31	12:29:43	12:35:18	12:37:33	13:04:17
EndTime (hh:mm:ss)	11:41:44	12:29:43	12:35:18	12:37:33	12:39:07	13:12:12
Duration (hh:mm:ss)	05:52	03:12	05:35	02:15	01:34	07:54
Start - Latitude	58˚ 04.6497' N	58˚ 04.2806' N	58˚ 04.3005' N	58˚ 04.3341' N	58˚ 04.3474' N	58˚ 05.0465' N
Start - Longitude	002˚ 53.5648' W	002˚ 56.2846' W	002˚ 56.3556 W	002˚ 56.4615' W	002˚ 56.5043' W	002˚ 55.0489' W
End - Latitude	58˚ 04.6902' N	58˚ 04.3005' N	58˚ 04.3341' N	58˚ 04.3474' N	58˚ 04.3569' N	58˚ 05.1020' N
End - Longitude	002˚ 53.6424' W	002˚ 56.3556 W	002˚ 56.4615' W	002˚ 56.5043' W	002˚ 56.5348' W	002˚ 55.2303' W
Habitat description	Shelly sand with occasional cobbles. Burrows, tracks & tubes evident.	Slighlty muddy Sand, broken shells, pebbles & gravel. Hermit crabs.	Sand with burrows, tracks and tubes.	Muddy Sand, broken shells, pebbles & gravel and cobbles. Grades into Stony Reef with cobble/boulder.	Shelly sand or sl. muddy Sand with burrows and tracks.	Sand with burrows & tracks in evidence. Hydroids & Asteroidea (starfish).
Comments		Camera moving rather fast. Lots of juvenile fish (fry) in water column.	Lots of juvenile fish (fry)	Patch of Stony Reef. Lots of juvenile fish (fry)	Lots of juvenile fish (fry)	Poor/no visibility 4:01-5:25.
Taxa						
Actiniaria						

Adamsia palliata		R				
Aequipecten opercularis						
Agonus cataphractus						
Alcyonium digitatum	O	R	R	O	R	R
Ammodytidae						
Antalis entalis	R		R			
Antedon bifida				R		
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	R			O		F
Asteroidea						
Astropecten irregularis						
Atelecyclus rotundatus						
Barnacles				SA-C		
Bivalvia	R					
Brachyura			R	R		
Buccinidae						
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua	R					
Callionymus lyra						
Calliostoma zizyphinum						

Cancer pagurus				R		
Chelidonichthys cuculus						R
Corella parallelogramma				R		
Crossaster papposus				R		
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa				R		
Eupolymnia nebulosa				R		
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa	F		O	C	R	O
Lanice conchilega			O			
Lithodes maja						
Lithothamnion				O		
Luidia ciliaris				R		
Luidia sarsii						

Majoidea						
Merlangius merlangus						
Microchirus variegatus						
Munida rugosa				A		
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina	R		R	F		R
Ophiocomina nigra						
Ophiothrix fragilis				O		
Ophiura		R		R	R	R
Pagurus bernhardus	R	O				
Pagurus prideaux		R				
Paguridae						
Pecten maximus						
Pectinidae				R		
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus				R		
Pleuronectes platessa				R	R	R
Pleuronectidae				R		
Porania (Porania) pulvillus						

Porifera						
Raja clavata						
Rhodophyta						
Rhodophyta						
Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae	O			C		
Suberites carnosus						
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**W41**	**W42**	**W43**	**W43**	**W44**	**W45**
Dive	Dive 89	Dive 90	Dive 91	Dive 91	Dive 92	Dive 93
Date	19/05/2017	19/05/2017	19/05/2017	19/05/2017	19/05/2017	19/05/2017
StartTime (hh:mm:ss)	13:24:26	13:40:59	13:56:32	13:59:17	14:14:44	14:32:23
EndTime (hh:mm:ss)	13:30:01	13:46:21	13:59:17	14:02:22	14:22:40	14:39:25
Duration (hh:mm:ss)	05:34	05:21	02:45	03:04	07:56	07:02
Start - Latitude	58˚ 05.5150' N	58˚ 05.8974' N	58˚ 06.0455' N	58˚ 06.0618' N	58˚ 06.9099' N	58˚ 07.3175' N
Start - Longitude	002˚ 56.3526' W	002˚ 58.3229' W	003˚ 00.1828' W	003˚ 00.2435' W	003˚ 01.7142' W	003˚ 03.2085' W
End - Latitude	58˚ 05.5532' N	58˚ 05.9326' N	58˚ 06.0618' N	58˚ 06.0795' N	58˚ 06.9583' N	58˚ 07.3527' N
End - Longitude	002˚ 56.4677' W	002˚ 58.4377' W	003˚ 00.2435' W	003˚ 00.3100' W	003˚ 01.8755' W	003˚ 03.3499' W
Habitat description	Sand with burrows & tracks. Asteroidea (starfish) & hermit crabs.	(sl. Muddy) Sand with burrows, tracks & tubes. Asteroidea (starfish).	(sl. Muddy) Sand with burrows & tubes. Hydroids & hermit crabs.	Sl. Muddy Shelly sand & gravel.	Sl. Muddy sand with shell fragments and occasional cobbles. Burrows, tracks, worn casts & tubes in evidence. Hydroids & Asteroidea (starfish).	Shelly sand or (sl. Muddy) Sand with gravel. Burrows, casts and tracks. Hydrozoa, Asteroidea (starfish) and hermit crabs.
Comments						
Taxa						
Actiniaria						

Adamsia palliata				R	R	
Aequipecten opercularis						
Agonus cataphractus						
Alcyonium digitatum			R		R	
Ammodytidae						
Antalis entalis					O	
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	C	F	R	R	O	F
Asteroidea						
Astropecten irregularis	R	R			R	
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura						
Buccinidae						
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra		R			R	
Calliostoma zizyphinum						
Cancer pagurus						

Chelidonichthys cuculus	R					
Corella parallelogramma						
Crossaster papposus						
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa		O	C	R	F	F
Lanice conchilega						
Lithodes maja						
Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea						

Merlangius merlangus						
Microchirus variegatus						
Munida rugosa						
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura						O
Pagurus bernhardus	O		O			O
Pagurus prideaux				R	R	
Paguridae						
Pecten maximus						
Pectinidae						
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa		R			R	
Pleuronectidae					R	
Porania (Porania) pulvillus						
Porifera						
Raja clavata						

Rhodophyta						
Rhodophyta						
Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae						
Suberites carnosus						
Suberites suberia						
Turritella communis					R	
Virgularia mirabilis						
Zeus faber						

Site	**W46**	**W47**	**W78**	**W48**	**W49**	**W50**
Dive	Dive 97	Dive 98	Dive 99	Dive 100	Dive 101	Dive 102
Date	19/05/2017	19/05/2017	19/05/2017	19/05/2017	19/05/2017	19/05/2017
StartTime (hh:mm:ss)	15:56:52	16:24:21	16:41:18	17:01:41	17:21:34	17:41:10
EndTime (hh:mm:ss)	16:03:13	16:30:42	16:47:31	17:07:29	17:27:11	17:48:03
Duration (hh:mm:ss)	06:21	06:21	06:12	05:47	05:36	06:53
Start - Latitude	58˚ 07.8954' N	58˚ 07.6866' N	58˚ 07.1626' N	58˚ 07.0923' N	58˚ 06.6019' N	58˚ 06.1053' N
Start - Longitude	003˚ 00.9766' W	002˚ 59.1786' W	002˚ 59.8667' W	002˚ 57.8181' W	002˚ 56.3529' W	002˚ 54.8165' W
End - Latitude	58˚ 07.9181' N	58˚ 07.7050' N	58˚ 07.1795' N	58˚ 07.1104' N	58˚ 06.6280' N	58˚ 06.1353' N
End - Longitude	UTC: 15:03:14	002˚ 59.3122' W	002˚ 59.9795' W	002˚ 57.9411' W	002˚ 56.4513' W	002˚ 54.9338' W
Habitat description	Sand with burrows, casts and tracks. Hydrozoa, Asteroidea (starfish) and hermit crabs.	Shelly/gravelly sand with burrows, tubes, casts and tracks. Hydrozoa and Asteroidea (starfish).	(sl. Muddy) shelly sand with tracks and casts. Hydrozoa, Asteroidea (starfish) and hermit crabs.	Shelly sand with burrows, casts and tracks. Hydrozoa and Asteroidea (starfish).	Sand with burrows and tracks. Asteroidea (starfish).	Mixed sand, gravel & shell
Comments		Probable hermit crab @ 0:28 but uncertain	Possible dragonet @ 2:07 but uncertain		Possible flat fish present @ 1:18	
Taxa						
Actiniaria						
Adamsia palliata						

Aequipecten opercularis						
Agonus cataphractus	R					
Alcyonium digitatum			R			
Ammodytidae						
Antalis entalis	R					
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	O	O	R	F	R	C
Asteroidea						
Astropecten irregularis	R	R	R		R	
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura						
Buccinidae						
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra				R		R
Calliostoma zizyphinum						
Cancer pagurus						

Chelidonichthys cuculus						
Corella parallelogramma						
Crossaster papposus						
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa	O	O	O	F		F
Lanice conchilega						
Lithodes maja						
Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea						

Merlangius merlangus						
Microchirus variegatus						
Munida rugosa						
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura	R					
Pagurus bernhardus	O	R		R	R	R
Pagurus prideaux						
Paguridae						
Pecten maximus						
Pectinidae			R			
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa						R
Pleuronectidae						
Porania (Porania) pulvillus						
Porifera						

Raja clavata						
Rhodophyta						
Rhodophyta						
Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae						
Suberites carnosus						
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**W51**	**W52**	**W5**	**W80**	**W73**	**W72**
Dive	Dive 104	Dive 105	Dive 106	Dive 107	Dive 108	Dive 110
Date	19/05/2017	21/05/2017	21/05/2017	21/05/2017	21/05/2017	21/05/2017
StartTime (hh:mm:ss)	18:08:44	18:23:26	11:40:53	12:09:11	12:28:19	13:03:34
EndTime (hh:mm:ss)	18:14:49	18:30:21	11:54:47	12:15:37	12:33:43	13:06:34
Duration (hh:mm:ss)	06:04	06:55	13:54	06:26	05:24	03:00
Start - Latitude	58˚ 06.0042' N	58˚ 06.3044' N	58˚ 12.6515' N	58˚ 11.8379' N	58˚ 11.5757' N	58˚ 11.1095' N
Start - Longitude	002˚ 52.9182' W	002˚ 51.4582' W	002˚ 52.5331' W	002˚ 51.7437' W	002˚ 53.3790' W	002˚ 52.2606' W
End - Latitude	58˚ 06.0068' N	58˚ 06.3082' N	58˚ 12.7759' N	58˚ 11.9042' N	58˚ 11.6310' N	58˚ 11.1414' N
End - Longitude	002˚ 52.9909' W	002˚ 51.5212' W	002˚ 52.5778' W	002˚ 51.7650' W	002˚ 53.4141' W	002˚ 52.2835' W
Habitat description	Mixed sl. Muddy sand, gravel & shell	Muddy sand with burrows and tracks. Hydrozoa and Asteroidea (starfish).	Mixed - shell/gravel & sand with pebbles and cobbles. Worm tubes and tracks present.	Sand. Asterias rubens.	Sand. Asterias rubens.	Shelly sand or sandy gravel with patchy stones & occasional cobbles
Comments	Fish @ 6:00. Hooknose?		Yellow sponges @ 1:10, 9:38 & 12:26			
Taxa						
Actiniaria						
Adamsia palliata	R					
Aequipecten opercularis						

Agonus cataphractus		R			R	
Alcyonium digitatum			F			R
Ammodytidae						
Antalis entalis						
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	O	O	F	C	C	O
Asteroidea						
Astropecten irregularis						
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura	R					
Buccinidae						
Buccinum undatum	R		R			
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra						
Calliostoma zizyphinum			R			
Cancer pagurus						
Chelidonichthys cuculus						
Corella parallelogramma						

Crossaster papposus						
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus			C			R
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa	O	F	A			O
Lanice conchilega						
Lithodes maja						
Lithothamnion			F			R
Luidia ciliaris						
Luidia sarsii						
Majoidea						
Merlangius merlangus						
Microchirus variegatus						

Munida rugosa						
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina		R				
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura						
Pagurus bernhardus	F		R	O		R
Pagurus prideaux	R					
Paguridae			O			
Pecten maximus						
Pectinidae						
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa		R				R
Pleuronectidae			R			
Porania (Porania) pulvillus						
Porifera			O			
Raja clavata						
Rhodophyta						
Rhodophyta						

Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae			A			R
Suberites carnosus						
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**W72**	**W79**	**W79**	**W6**	**W6**	**W6**
Dive	Dive 110	Dive 111	Dive 111	Dive 112	Dive 112	Dive 112
Date	21/05/2017	21/05/2017	21/05/2017	21/05/2017	21/05/2017	21/05/2017
StartTime (hh:mm:ss)	13:06:34	13:21:54	13:25:12	13:44:41 PM	13:44:57 PM	13:45:15 PM
EndTime (hh:mm:ss)	13:09:28	13:25:12	13:29:45	13:44:57 PM	13:45:15 PM	13:45:57 PM
Duration (hh:mm:ss)	02:54	03:18	04:33	00:16	00:18	00:42
Start - Latitude	58˚ 11.1414' N	58˚ 11.0154' N	58˚ 11.0558' N	58˚ 10.8385' N	58˚ 10.8420' N	58˚ 10.8459' N
Start - Longitude	002˚ 52.2835' W	002˚ 54.2192' W	002˚ 52.2640' W	002˚ 50.4543' W	002˚ 50.4572' W	002˚ 50.4609' W
End - Latitude	58˚ 11.1720' N	58˚ 11.0558' N	58˚ 11.1100' N	58˚ 10.8420' N	58˚ 10.8459' N	58˚ 10.8527' N
End - Longitude	002˚ 52.3089' W	002˚ 52.2640' W	002˚ 54.3186' W	002˚ 50.4572' W	002˚ 50.4609' W	002˚ 50.4700' W
Habitat description	Shelly gravelly sand with pebbles	Sand	Sandy gravel/shell	Coarse sand/gravel/ shell/few stones	Coarse sand/shell	Coarse sand
Comments		Pink sponge @ 1:54? Unidentified fish @ 2:14			No fauna	
Taxa						
Actiniaria						
Adamsia palliata	R		O			
Aequipecten opercularis						
Agonus cataphractus						
Alcyonium digitatum						

Ammodytidae						
Antalis entalis						
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	O	F	F			R
Asteroidea						
Astropecten irregularis	R		R			
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura						
Buccinidae						
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra						
Calliostoma zizyphinum						
Cancer pagurus						
Chelidonichthys cuculus						
Corella parallelogramma						
Crossaster papposus						

Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus	R					
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea	R					
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa	R		O			
Lanice conchilega						
Lithodes maja						
Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea						
Merlangius merlangus						
Microchirus variegatus						
Munida rugosa						

Myoxocephalus scorpius				R		R
Necora puber						
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura						
Pagurus bernhardus			O			
Pagurus prideaux	R		O			
Paguridae			O			R
Pecten maximus						
Pectinidae						
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa						
Pleuronectidae						
Porania (Porania) pulvillus						
Porifera						
Raja clavata						
Rhodophyta						
Rhodophyta						

Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae	R					
Suberites carnosus						R
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**W6**	**W6**	**W6**	**W71**	**W70**	**W69**
Dive	Dive 112	Dive 112	Dive 112	Dive 114	Dive 115	Dive 116
Date	21/05/2017	21/05/2017	21/05/2017	21/05/2017	21/05/2017	21/05/2017
StartTime (hh:mm:ss)	13:45:57 PM	13:48:23 PM	13:48:49 PM	14:11:55	14:41:03	14:55:47
EndTime (hh:mm:ss)	13:48:23 PM	13:48:49 PM	13:49:43	14:18:12	14:47:12	15:03:55
Duration (hh:mm:ss)	02:26	00:26	00:54	06:17	06:09	08:07
Start - Latitude	58˚ 10.8527' N	58˚ 10.8756' N	58˚ 10.8798' N	58˚ 10.5168' N	58˚ 09.2314' N	58˚ 09.7011' N
Start - Longitude	002˚ 50.4700' W	002˚ 50.5015' W	002˚ 50.5069' W	002˚ 50.7499' W	002˚ 50.3056' W	002˚ 51.2634' W
End - Latitude	58˚ 10.8756' N	58˚ 10.8798' N	58˚ 10.8884' N	58˚ 10.5961' N	58˚ 09.2884' N	58˚ 09.7835' N
End - Longitude	002˚ 50.5015' W	002˚ 50.5069' W	002˚ 50.5176' W	002˚ 50.8370' W	002˚ 50.3652' W	002˚ 51.3446' W
Habitat description	Coarse sand, small pebbles	Coarse sand/shell	Coarse sand	Sand (diatoms on surface?)	Sand (diatoms on surface?)	Coarse sand or gravelly sand (diatoms on surface?)
Comments	Occasional Pomatoceros. Unidentified Fish at 4.11	No fauna	No fauna		Fast current	Fast current
Taxa						
Actiniaria						F
Adamsia palliata						
Aequipecten opercularis						

Agonus cataphractus						
Alcyonium digitatum						R
Ammodytidae						
Antalis entalis						
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	R			F	F	R
Asteroidea	O					
Astropecten irregularis						
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura						
Buccinidae				R		
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra						
Calliostoma zizyphinum						
Cancer pagurus						
Chelidonichthys cuculus					R	
Corella parallelogramma						

Crossaster papposus						
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa						
Lanice conchilega						
Lithodes maja						
Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea						
Merlangius merlangus						
Microchirus variegatus						

Munida rugosa						
Myoxocephalus scorpius	R			R		R
Necora puber						
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura						
Pagurus bernhardus						
Pagurus prideaux						
Paguridae	O			R	R	R
Pecten maximus						
Pectinidae						
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa						
Pleuronectidae						R
Porania (Porania) pulvillus						
Porifera						
Raja clavata						
Rhodophyta						
Rhodophyta						

Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae						
Suberites carnosus						R
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**W68**	**W67**	**W67**	**W66**	**W65**	**W64**
Dive	Dive 117	Dive 118	Dive 118	Dive 119	Dive 120	Dive 121
Date	21/05/2017	21/05/2017	21/05/2017	21/05/2017	21/05/2017	21/05/2017
StartTime (hh:mm:ss)	15:14:00	15:28:07	15:30:31	15:51:01	16:06:59	16:24:07
EndTime (hh:mm:ss)	15:20:18	15:30:30	15:35:11	15:56:24	16:12:44	21/05/2017
Duration (hh:mm:ss)	06:18	02:23	04:40	05:22	05:44	07:50
Start - Latitude	58˚ 09.9672' N	58˚ 10.3909' N	58˚ 10.4191' N	58˚ 09.8748' N	58˚ 09.4041' N	58˚ 08.7871' N
Start - Longitude	002˚ 52.9092' W	002˚ 54.6070' W	002˚ 54.6364' W	002˚ 55.5839' W	002˚ 53.9439' W	002˚ 52.3489' W
End - Latitude	58˚ 10.0280' N	58˚ 10.4191' N	58˚ 10.4644' N	58˚ 09.9440' N	58˚ 09.4602' N	58˚ 08.8476' N
End - Longitude	002˚ 52.9727' W	002˚ 54.6364' W	002˚ 54.6778' W	002˚ 55.6035' W	002˚ 53.9759' W	002˚ 52.4008' W
Habitat description	Coarse sand with gravel/ broken shell	Sand (& some gravel)	Mixed - sand & gravel with pebbles and some cobbles	Sand	Sand	Sand with more pebbles evident towards end of transect
Comments	Diatom encrusted hydrozoa, Flustra on large rocks					
Taxa						
Actiniaria						
Adamsia palliata						
Aequipecten opercularis						

Agonus cataphractus						
Alcyonium digitatum			R			
Ammodytidae						
Antalis entalis						
Antedon bifida						
Ascidiacea						
Ascidiella aspersa	R					
Asterias rubens	C		R	C	C	F
Asteroidea		R				
Astropecten irregularis						
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura						
Buccinidae						
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua		R				
Callionymus lyra		R				
Calliostoma zizyphinum						
Cancer pagurus						
Chelidonichthys cuculus					R	

Corella parallelogramma						
Crossaster papposus						
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus			R			
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa		F	O			F
Lanice conchilega						
Lithodes maja						
Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea						
Merlangius merlangus						

Microchirus variegatus						
Munida rugosa						
Myoxocephalus scorpius	R					
Necora puber						
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura						
Pagurus bernhardus			R			R
Pagurus prideaux						
Paguridae						
Pecten maximus						
Pectinidae						
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa				R		
Pleuronectidae						R
Porania (Porania) pulvillus						
Porifera						
Raja clavata						

Rhodophyta						
Rhodophyta						
Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae						R
Suberites carnosus						
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**W63**	**W62**	**W61**	**W60**	**W59**	**W58**
Dive	Dive 122	Dive 123	Dive 124	Dive 125	Dive 126	Dive 127
Date	21/05/2017	21/05/2017	21/05/2017	21/05/2017	21/05/2017	21/05/2017
StartTime (hh:mm:ss)	16:42:46	17:05:06	17:20:50	17:34:31	17:55:41	18:12:16
EndTime (hh:mm:ss)	16:50:33	17:12:37	17:27:03	17:46:54	18:03:51	18:19:01
Duration (hh:mm:ss)	07:47	07:30	06:13	12:22	08:09	06:45
Start - Latitude	58˚ 08.3378' N	58˚ 07.3428' N	58˚ 07.6738' N	58˚ 08.1213' N	58˚ 08.2761' N	58˚ 08.9382' N
Start - Longitude	002˚ 50.3412' W	002˚ 50.5977' W	002˚ 52.0875' W	002˚ 53.3505' W	002˚ 54.8946' W	002˚ 56.4274' W
End - Latitude	58˚ 08.3843' N	58˚ 07.3645' N	58˚ 07.6881' N	58˚ 08.1443' N	58˚ 08.2870' N	58˚ 08.9471' N
End - Longitude	002˚ 50.3716' W	002˚ 50.6466' W	002˚ 52.1380' W	002˚ 53.4288' W	002˚ 54.9779' W	002˚ 56.5259' W
Habitat description	Mixed - sand and gravel with pebbles and some cobbles	Shelly sand with occasional cobbles. Evidence of animal tracks.	Sand	Sand, broken shells and pebbles becoming more sandy towards end of transect	Sand	Shelly/gravelly sand with occasional cobbles
Comments	Unidentified fish at 2.57?					
Taxa						
Actiniaria						
Adamsia palliata						
Aequipecten opercularis						

Agonus cataphractus						
Alcyonium digitatum	C					
Ammodytidae						
Antalis entalis						
Antedon bifida						
Ascidiacea		R				
Ascidiella aspersa						
Asterias rubens	O	O	O	F	F	O
Asteroidea						R
Astropecten irregularis						R
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura						
Buccinidae						
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra	R		R		R	R
Calliostoma zizyphinum						
Cancer pagurus				R		
Chelidonichthys cuculus					R	
Corella parallelogramma						

Crossaster papposus					R	
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa						
Eupolymnia nebulosa						
Flustra foliacea	R					
Gadus morhua					R	
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa	A	F		F		O
Lanice conchilega						
Lithodes maja						
Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea						
Merlangius merlangus						
Microchirus variegatus						

Munida rugosa	R					
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina	R	R				
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura						
Pagurus bernhardus	R				R	R
Pagurus prideaux						
Paguridae						
Pecten maximus						
Pectinidae						R
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa		O				
Pleuronectidae				O		
Porania (Porania) pulvillus						
Porifera						
Raja clavata						
Rhodophyta						
Rhodophyta						

Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae	F				R	
Suberites carnosus		R				
Suberites suberia						
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**W4**	**W57**	**W56**	**W55**	**W54**	**W53**
Dive	Dive 128	Dive 129	Dive 130	Dive 131	Dive 132	Dive 133
Date	21/05/2017	21/05/2017	21/05/2017	21/05/2017	21/05/2017	21/05/2017
StartTime (hh:mm:ss)	18:29:03	18:45:17	19:03:39	19:19:28	19:38:00	19:55:45
EndTime (hh:mm:ss)	18:34:52	18:52:19	19:09:25	19:26:42	19:44:15	20:04:48
Duration (hh:mm:ss)	05:49	07:01	05:46	07:13	06:14	09:02
Start - Latitude	58˚ 09.0835' N	58˚ 08.4336' N	58˚ 07.9645' N	58˚ 07.6153' N	58˚ 07.1125' N	58˚ 06.7848' N
Start - Longitude	002˚ 58.7572' W	002˚ 58.7059' W	002˚ 57.2478' W	002˚ 55.9748' W	002˚ 54.3732' W	002˚ 52.6094' W
End - Latitude	58˚ 09.0888' N	58˚ 08.4438' N	58˚ 07.9713' N	58˚ 07.6261' N	58˚ 07.1169' N	58˚ 06.8068' N
End - Longitude	002˚ 58.8435' W	002˚ 58.8172' W	002˚ 57.3451' W	002˚ 56.0963' W	002˚ 54.4707' W	002˚ 52.7513' W
Habitat description	Heterogeneous - shelly sand with patches of cobbles and pebbles	Sand or gravelly sand with occasional cobbles	Sand & shell fragments	Sand & shell fragments	Sand & shell fragments	Sand & shell fragments
Comments	Possible Sabellaria tubes on stones	Octopus @ 02:10				Diatoms both on surface and suspended in the water column. Fast current.
Taxa						
Actiniaria						
Adamsia palliata	R					

Aequipecten opercularis						
Agonus cataphractus						
Alcyonium digitatum						R
Ammodytidae						
Antalis entalis						
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	O	R	O	F	F	C
Asteroidea						
Astropecten irregularis					R	
Atelecyclus rotundatus						
Barnacles	R					
Bivalvia						
Brachyura						
Buccinidae						R
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua					R	
Callionymus lyra	R			R	R	R
Calliostoma zizyphinum						
Cancer pagurus						

Chelidonichthys cuculus						
Corella parallelogramma						
Crossaster papposus						
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa		R			R	O
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa	C	R	R	R	O	
Lanice conchilega						
Lithodes maja						
Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea						

Merlangius merlangus						
Microchirus variegatus						
Munida rugosa						
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina	R					
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura						
Pagurus bernhardus	R	R	R	R	R	R
Pagurus prideaux	R					
Paguridae						
Pecten maximus						
Pectinidae			R			
Pennatula phosphorea						
Pholis gunnellus						
Phrynorhombus norvegicus						
Pleuronectes platessa					R	
Pleuronectidae						
Porania (Porania) pulvillus						
Porifera						

Raja clavata						
Rhodophyta						
Rhodophyta						
Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae	O					
Suberites carnosus						
Suberites suberia						R
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**C28**	**C12**	**C11**	**C10**	**C9**	**C8**
Dive	Dive 136	Dive 139	Dive 140	Dive 141	Dive 142	Dive 143
Date	21/05/2017	24/05/2017	24/05/2017	24/05/2017	24/05/2017	24/05/2017
StartTime (hh:mm:ss)	21:05:35	10:06:42	10:31:41	10:56:49	11:26:56	12:07:26
EndTime (hh:mm:ss)	21:14:44	24/05/2017	10:39:21	11:05:30	11:39:22	12:25:51
Duration (hh:mm:ss)	09:08	07:15	07:40	08:40	12:25	18:24
Start - Latitude	58˚ 03.1049' N	57˚ 50.6215' N	57˚ 52.3265' N	57˚ 53.6417' N	57˚ 55.1845' N	57˚ 56.6690' N
Start - Longitude	002˚ 55.8183' W	002˚ 53.8789' W	002˚ 54.9498' W	002˚ 55.7955' W	002˚ 56.8421' W	002˚ 57.8788' W
End - Latitude	58˚ 03.1490' N	57˚ 50.6237' N	57˚ 52.3258' N	57˚ 53.6351' N	57˚ 55.1366' N	57˚ 56.6515' N
End - Longitude	002˚ 55.8904' W	002˚ 53.6530' W	002˚ 54.7715' W	002˚ 55.6242' W	002˚ 56.6286' W	002˚ 57.6273' W
Habitat description	(sl. Muddy) Sand with some shell (with diatoms on surface?)	Muddy sand/Sandy Mud. Megafauna burrows?	Sandy Mud. Megafauna burrows	Sandy Mud. Seapens & megafauna burrows	Sandy Mud. Seapens & megafauna burrows	Muddy sand/Sandy Mud
Comments	Fast moving current. Burrows, tubes & worms casts evident. Unidentified juvenile fish (fry).	Burrows, tubes & worms casts evident. Poor visibility throughout.	Burrows, tubes & tracks evident. Poor visibility throughout. No fauna except for jellyfish @ 1:56	Burrows & tracks evident. Poor visibility throughout.	Burrows evident. Poor visibility throughout.	Burrows & tubes evident. Reduced visibility at times. 2 unidentified fish @ 1:59 & 17:52. First one might be dead.
Taxa						
Actiniaria						
Adamsia palliata						

Aequipecten opercularis						
Agonus cataphractus						
Alcyonium digitatum						
Ammodytidae						
Antalis entalis						
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens						
Asteroidea						
Astropecten irregularis						
Atelecyclus rotundatus						
Barnacles						
Bivalvia						
Brachyura						
Buccinidae						
Buccinum undatum	O					
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra						
Calliostoma zizyphinum						

Cancer pagurus						
Chelidonichthys cuculus	R					
Corella parallelogramma						
Crossaster papposus						
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa						R
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae	R					
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa		R				R
Lanice conchilega						
Lithodes maja						
Lithothamnion						

Luidia ciliaris						
Luidia sarsii						
Majoidea						
Merlangius merlangus						
Microchirus variegatus						
Munida rugosa						
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura	A					
Pagurus bernhardus						
Pagurus prideaux						
Paguridae						
Pecten maximus						
Pectinidae	R					
Pennatula phosphorea		F		R	C	A
Pholis gunnellus						

Phrynorhombus norvegicus						
Pleuronectes platessa						R
Pleuronectidae						
Porania (Porania) pulvillus						
Porifera						
Raja clavata						
Rhodophyta						
Rhodophyta						
Sabellidae						
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae						
Suberites carnosus						
Suberites suberia						
Turritella communis						
Virgularia mirabilis				R	R	
Zeus faber						

Site	**W22**	**W23**	**W24**	**W17**	**W74**	**W14**
Dive	Dive 144	Dive 145	Dive 146	Dive 147	Dive 148	Dive 149
Date	24/05/2017	24/05/2017	24/05/2017	24/05/2017	24/05/2017	24/05/2017
StartTime (hh:mm:ss)	13:09:11	13:28:40	13:46:10	14:03:33	14:22:41	14:43:47
EndTime (hh:mm:ss)	13:16:34	13:34:34	13:51:44	14:09:03	14:28:38	14:49:47
Duration (hh:mm:ss)	07:22	05:53	05:33	05:30	05:57	06:00
Start - Latitude	58˚ 03.4544' N	58˚ 04.2778' N	58˚ 04.9913' N	58˚ 04.2614' N	58˚ 02.7011' N	58˚ 01.5187' N
Start - Longitude	003˚ 05.2669' W	003˚ 07.3961' W	003˚ 08.7516' W	003˚ 10.0736' W	003˚ 09.6282' W	003˚ 09.2789' W
End - Latitude	58˚ 03.4904' N	58˚ 04.3205' N	58˚ 05.0356' N	58˚ 04.2964' N	58˚ 02.7592' N	58˚ 01.5651' N
End - Longitude	003˚ 05.2317' W	003˚ 07.3635' W	003˚ 08.7183' W	003˚ 10.0632' W	003˚ 09.5952' W	003˚ 09.2290' W
Habitat description	(sl. Muddy) Sand with some shell (with diatoms on surface?)	(sl. Muddy) Sand with some shell/gravel (with diatoms on surface?)	Muddy Sand with some shell (with diatoms on surface?)	(sl. Muddy) Sand (with diatoms on surface?)	(sl. Muddy) Sand with some shell (with diatoms on surface?)	(sl. Muddy) Sand with some shell (with diatoms on surface?)
Comments	Fast moving current. Burrows, tubes & worms casts evident. Reduced visibility occasionally.	Fast moving current. Burrows, tubes & worms casts evident.	Worm burrows evident. Hydrozoa covered in diatoms			
Taxa						
Actiniaria						
Adamsia palliata						

Aequipecten opercularis						
Agonus cataphractus						
Alcyonium digitatum						
Ammodytidae						
Antalis entalis						
Antedon bifida						
Ascidiacea						
Ascidiella aspersa						
Asterias rubens	F	O		O	F	R
Asteroidea			R			
Astropecten irregularis						
Atelecyclus rotundatus						
Barnacles						
Bivalvia			R			
Brachyura			R			
Buccinidae					R	R
Buccinum undatum						
Buglossidium luteum						
Neptunea antiqua						
Callionymus lyra				R	R	R

Calliostoma zizyphinum						
Cancer pagurus						
Chelidonichthys cuculus		O				R
Corella parallelogramma						
Crossaster papposus				R	R	
Ctenophora						
Delesseria sanguinea						
Echinocardium cordatum						
Echinus esculentus						
Eledone cirrhosa		R				
Eupolymnia nebulosa						
Flustra foliacea						
Gadus morhua						
Galatheoidea						
Gobiidae						
Henricia						
Hyalinoecia tubicola						
Hyas coarctatus						
Hydrozoa/Bryozoa						
Lanice conchilega						
Lithodes maja						

Lithothamnion						
Luidia ciliaris						
Luidia sarsii						
Majoidea						
Merlangius merlangus						
Microchirus variegatus						
Munida rugosa						
Myoxocephalus scorpius						
Necora puber						
Nemertea						
Nemertesia antennina						
Ophiocomina nigra						
Ophiothrix fragilis						
Ophiura	O	R			R	R
Pagurus bernhardus	F					
Pagurus prideaux						
Paguridae						
Pecten maximus						
Pectinidae		R				R
Pennatula phosphorea						
Pholis gunnellus						

Phrynorhombus norvegicus						
Pleuronectes platessa					R	
Pleuronectidae	R					
Porania (Porania) pulvillus						
Porifera						
Raja clavata				R		
Rhodophyta						
Rhodophyta						
Sabellidae						R
Scorpaeniformes						
Securiflustra securifrons						
Serpulidae						
Suberites carnosus						
Suberites suberia					R	
Turritella communis						
Virgularia mirabilis						
Zeus faber						

Site	**W29**	**W31**	**W36**
Dive	Dive 152	Dive 154	Dive 155
Date	27/05/2017	27/05/2017	27/05/2017
StartTime (hh:mm:ss)	06:40:08	07:22:28	07:40:14
EndTime (hh:mm:ss)	06:45:50	07:27:48	07:45:54
Duration (hh:mm:ss)	05:41	05:20	05:40
Start - Latitude	58˚ 03.6615' N	58˚ 04.6605' N	58˚ 05.7388' N
Start - Longitude	002˚ 58.2634' W	003˚ 01.6427' W	003˚ 01.2364' W
End - Latitude	58˚ 03.7221' N	58˚ 04.7170' N	58˚ 05.8004' N
End - Longitude	002˚ 58.3521' W	003˚ 01.7294' W	003˚ 01.3182' W
Habitat description	(sl. Muddy) Sand with some shell (with diatoms on surface?)	(sl. Muddy) Sand with some shell (with diatoms on surface?)	(sl. Muddy) Sand with some shell (with diatoms on surface?)
Comments	Occasional hydrozoa and tracks evident	Ocassional hydrozoa	Occasional hydrozoa, worm tubes and juvenile fish (fry).
Taxa			
Actiniaria			
Adamsia palliata			
Aequipecten opercularis			
Agonus cataphractus			
Alcyonium digitatum			R

Ammodytidae			
Antalis entalis			
Antedon bifida			
Ascidiacea			
Ascidiella aspersa			
Asterias rubens	O	F	F
Asteroidea			
Astropecten irregularis			
Atelecyclus rotundatus			
Barnacles			
Bivalvia			
Brachyura			
Buccinidae			R
Buccinum undatum		R	
Buglossidium luteum	R		
Neptunea antiqua			R
Callionymus lyra			
Calliostoma zizyphinum			
Cancer pagurus			
Chelidonichthys cuculus		R	
Corella parallelogramma			
Crossaster papposus			
Ctenophora			

Delesseria sanguinea			
Echinocardium cordatum			
Echinus esculentus			
Eledone cirrhosa			
Eupolymnia nebulosa			
Flustra foliacea			
Gadus morhua			
Galatheoidea			
Gobiidae			
Henricia			
Hyalinoecia tubicola	R		
Hyas coarctatus			
Hydrozoa/Bryozoa			
Lanice conchilega			
Lithodes maja			
Lithothamnion			
Luidia ciliaris			
Luidia sarsii	R		
Majoidea			
Merlangius merlangus			R
Microchirus variegatus			
Munida rugosa			
Myoxocephalus scorpius			

Necora puber			
Nemertea			
Nemertesia antennina			
Ophiocomina nigra			
Ophiothrix fragilis			
Ophiura	R		
Pagurus bernhardus			
Pagurus prideaux			
Paguridae			
Pecten maximus			
Pectinidae			
Pennatula phosphorea			
Pholis gunnellus			
Phrynorhombus norvegicus			
Pleuronectes platessa			
Pleuronectidae			
Porania (Porania) pulvillus			
Porifera			
Raja clavata			
Rhodophyta			
Rhodophyta			
Sabellidae			
Scorpaeniformes			

Securiflustra securifrons			
Serpulidae			
Suberites carnosus	R	R	R
Suberites suberia			
Turritella communis			
Virgularia mirabilis			
Zeus faber			

8 Annex 7.1C: Stills from HD video

Image: 17-05-18 05.28.26_Dive 49 c1_C1
Station C1

Image: 17-05-18 05.29.42_Dive 49 c1_C1
Station C1

Image: 17-05-18 05.30.09_Dive 49 c1_C1
Station C1

Image: 17-05-18 05.31.17_Dive 49 c1_C1
Station C1

Image: 17-05-18 05.32.13_Dive 49 c1_C1
Station C1

Image: 17-05-18 05.32.25_Dive 49 c1_C1
Station C1

Image: 17-05-18 05.33.00_Dive 49 c1_C1
Station C1

Image: 17-05-18 08.35.48_Dive 57 c2_C1
Station C2

Image: 17-05-18 08.36.59_Dive 57 c2_C1
Station C2

Image: 17-05-18 08.37.05_Dive 57 c2_C1
Station C2

Image: 17-05-18 08.37.24_Dive 57 c2_C1
Station C2

Image: 17-05-18 08.38.26_Dive 57 c2_C1
Station C2

Image: 17-05-18 08.41.06_Dive 57 c2_C1
Station C2

Image: 17-05-18 09.32.43_Dive 60 c3_C1
Station C3

Image: 17-05-18 09.34.12_Dive 60 c3_C1
Station C3

Image: 17-05-18 09.35.32_Dive 60 c3_C1
Station C3

Image: 17-05-18 09.35.53_Dive 60 c3_C1
Station C3

Image: 17-05-18 09.39.47_Dive 60 c3_C1
Station C3

Image: 17-05-18 09.40.25_Dive 60 c3_C1
Station C3

Image: 17-05-18 09.43.39_Dive 60 c3_C1
Station C3

Image: 17-05-18 09.45.44_Dive 60 c3_C1
Station C3

Image: 17-05-18 09.46.14_Dive 60 c3_C1
Station C3

Image: 17-05-18 06.30.30_Dive 51 c4_C1
Station C4

Image: 17-05-18 06.31.12_Dive 51 c4_C1
Station C4

Image: 17-05-18 06.31.47_Dive 51 c4_C1
Station C4

Image: 17-05-18 06.32.16_Dive 51 c4_C1
Station C4

Image: 17-05-18 06.32.46_Dive 51 c4_C1
Station C4

Image: 17-05-18 06.33.56_Dive 51 c4_C1
Station C4

Image: 17-05-18 06.34.56_Dive 51 c4_C1
Station C4

Image: 17-05-18 09.11.12_Dive 59 c5_C1
Station C5

Image: 17-05-18 09.13.09_Dive 59 c5_C1
Station C5

Image: 17-05-18 09.14.28_Dive 59 c5_C1
Station C5

Image: 17-05-18 09.15.16_Dive 59 c5_C1
Station C5

Image: 17-05-18 09.16.21_Dive 59 c5_C1
Station C5

Image: 17-05-18 09.16.48_Dive 59 c5_C1
Station C5

Image: 17-05-18 07.11.02_Dive 53 c6_C1
Station C6

Image: 17-05-18 07.13.35_Dive 53 c6_C1
Station C6

Image: 17-05-18 07.15.33_Dive 53 c6_C1
Station C6

Image: 17-05-18 07.17.00_Dive 53 c6_C1
Station C6

Image: 17-05-18 07.18.21_Dive 53 c6_C1
Station C6

Image: 17-05-18 07.19.11_Dive 53 c6_C1
Station C6

Image: 17-05-18 07.33.09_Dive 54 c7_C1
Station C7

Image: 17-05-18 07.34.21_Dive 54 c7_C1
Station C7

Image: 17-05-18 07.35.18_Dive 54 c7_C1
Station C7

Image: 17-05-18 07.36.33_Dive 54 c7_C1
Station C7

Image: 17-05-18 07.37.15_Dive 54 c7_C1
Station C7

Image: 17-05-18 07.39.55_Dive 54 c7_C1
Station C7

Image: 17-05-24 12.08.33_Dive 143 c8_C1
Station C8

Image: 17-05-24 12.09.11_Dive 143 c8_C1
Station C8

Image: 17-05-24 12.11.09_Dive 143 c8_C1
Station C8

Image: 17-05-24 12.11.51_Dive 143 c8_C1
Station C8

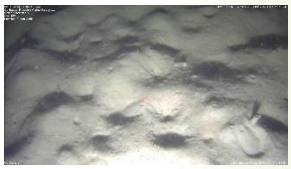


Image: 17-05-24 12.13.24_Dive 143 c8_C1
Station C8

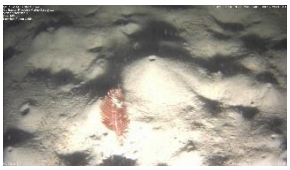
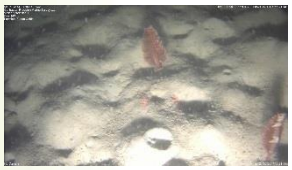


Image: 17-05-24 12.13.59_Dive 143 c8_C1
Station C8

Image: 17-05-24 12.16.24_Dive 143 c8_C1
Station C8

Image: 17-05-24 12.17.39_Dive 143 c8_C1
Station C8

Image: 17-05-24 12.19.14_Dive 143 c8_C1
Station C8



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Station C8

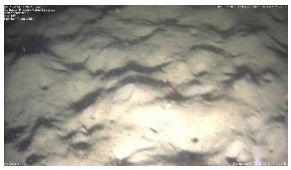

Image: 17-05-24 12.22.32_Dive 143 c8_C1
Station C8

Image: 17-05-24 12.23.46_Dive 143 c8_C1
Station C8

Image: 17-05-24 12.24.36_Dive 143 c8_C1
Station C8

Image: 17-05-24 12.25.40_Dive 143 c8_C1
Station C8

Image: 17-05-24 11.28.05_Dive 142 c9_C1
Station C9

Image: 17-05-24 11.29.31_Dive 142 c9_C1
Station C9

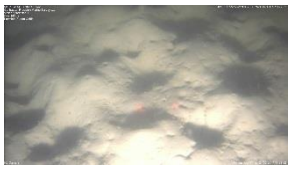

Image: 17-05-24 11.29.52_Dive 142 c9_C1
Station C9

Image: 17-05-24 11.30.00_Dive 142 c9_C1
Station C9

Image: 17-05-24 11.31.59_Dive 142 c9_C1
Station C9

Image: 17-05-24 11.32.04_Dive 142 c9_C1
Station C9

Image: 17-05-24 11.32.24_Dive 142 c9_C1
Station C9

Image: 17-05-24 11.33.18_Dive 142 c9_C1
Station C9

Image: 17-05-24 11.33.35_Dive 142 c9_C1
Station C9

Image: 17-05-24 11.34.25_Dive 142 c9_C1
Station C9

Image: 17-05-24 11.36.30_Dive 142 c9_C1
Station C9

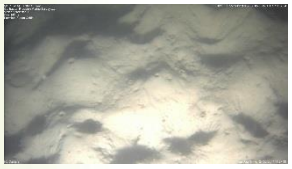

Image: 17-05-24 11.37.34_Dive 142 c9_C1
Station C9

Image: 17-05-24 11.38.33_Dive 142 c9_C1
Station C9

Image: 17-05-24 10.57.55_Dive 141 c10_C1
Station C10

Image: 17-05-24 10.58.44_Dive 141 c10_C1
Station C10

Image: 17-05-24 11.00.14_Dive 141 c10_C1
Station C10

Image: 17-05-24 11.01.40_Dive 141 c10_C1
Station C10

Image: 17-05-24 11.02.32_Dive 141 c10_C1
Station C10

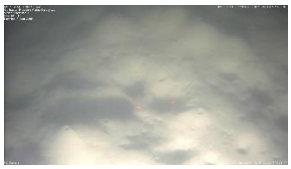

Image: 17-05-24 11.03.17_Dive 141 c10_C1
Station C10

Image: 17-05-24 11.04.15_Dive 141 c10_C1
Station C10

Image: 17-05-24 11.04.57_Dive 141 c10_C1
Station C10

Image: 17-05-24 10.32.52_Dive 140 c11_C1
Station C11

Image: 17-05-24 10.34.36_Dive 140 c11_C1
Station C11

Image: 17-05-24 10.34.59_Dive 140 c11_C1
Station C11

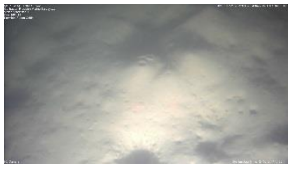

Image: 17-05-24 10.36.11_Dive 140 c11_C1
Station C11

Image: 17-05-24 10.38.08_Dive 140 c11_C1
Station C11

Image: 17-05-24 10.38.51_Dive 140 c11_C1
Station C11

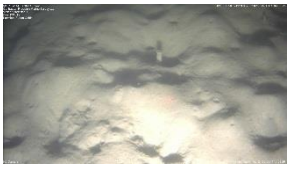

Image: 17-05-24 10.08.29_Dive 139 c12_C1
Station C12

Image: 17-05-24 10.09.01_Dive 139 c12_C1
Station C12

Image: 17-05-24 10.09.37_Dive 139 c12_C1
Station C12

Image: 17-05-24 10.09.59_Dive 139 c12_C1
Station C12

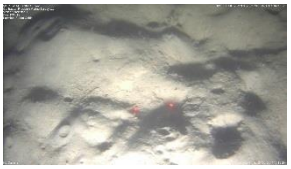

Image: 17-05-24 10.10.25_Dive 139 c12_C1
Station C12

Image: 17-05-24 10.10.52_Dive 139 c12_C1
Station C12

Image: 17-05-24 10.11.10_Dive 139 c12_C1
Station C12

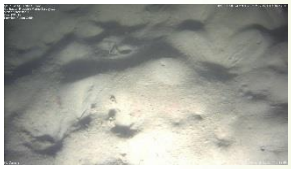

Image: 17-05-24 10.12.00_Dive 139 c12_C1
Station C12

Image: 17-05-24 10.12.20_Dive 139 c12_C1
Station C12

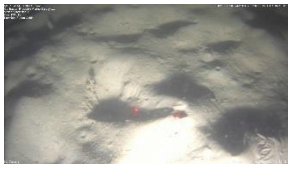

Image: 17-05-24 10.13.12_Dive 139 c12_C1
Station C12

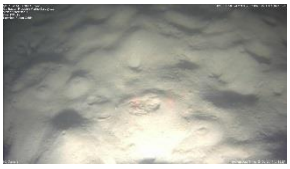

Image: 17-05-24 10.13.27_Dive 139 c12_C1
Station C12

Image: 17-05-14 11.56.13_Dive 04 c13_C1
Station C13

Image: 17-05-14 11.57.26_Dive 04 c13_C1
Station C13

Image: 17-05-14 11.58.00_Dive 04 c13_C1
Station C13

Image: 17-05-14 11.59.55_Dive 04 c13_C1
Station C13

Image: 17-05-14 12.01.16_Dive 04 c13_C1
Station C13

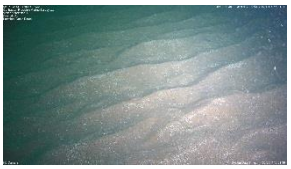

Image: 17-05-14 12.01.36_Dive 04 c13_C1
Station C13

Image: 17-05-15 08.39.37_Dive 28 c14_C1
Station C14

Image: 17-05-15 08.40.17_Dive 28 c14_C1
Station C14

Image: 17-05-15 08.41.54_Dive 28 c14_C1
Station C14

Image: 17-05-15 08.43.20_Dive 28 c14_C1
Station C14

Image: 17-05-15 08.43.47_Dive 28 c14_C1
Station C14

Image: 17-05-15 08.44.02_Dive 28 c14_C1
Station C14

Image: 17-05-15 08.44.13_Dive 28 c14_C1
Station C14

Image: 17-05-15 08.44.54_Dive 28 c14_C1
Station C14

Image: 17-05-15 08.45.39_Dive 28 c14_C1
Station C14

Image: 17-05-15 08.45.44_Dive 28 c14_C1
Station C14

Image: 17-05-15 08.46.04_Dive 28 c14_C1
Station C14

Image: 17-05-15 08.46.09_Dive 28 c14_C1
Station C14

Image: 17-05-15 08.46.28_Dive 28 c14_C1
Station C14

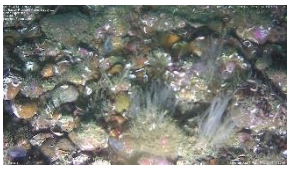

Image: 17-05-16 11.36.58_Dive 44 c15_C1
Station C15

Image: 17-05-16 11.38.50_Dive 44 c15_C1
Station C15

Image: 17-05-16 11.40.00_Dive 44 c15_C1
Station C15

Image: 17-05-16 11.40.57_Dive 44 c15_C1
Station C15

Image: 17-05-16 11.42.08_Dive 44 c15_C1
Station C15

Image: 17-05-16 11.43.09_Dive 44 c15_C1
Station C15

Image: 17-05-16 12.29.52_Dive 46 c16_C1
Station C16

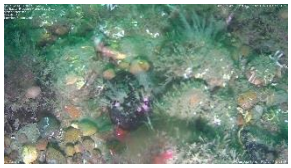

Image: 17-05-16 12.31.59_Dive 46 c16_C1
Station C16

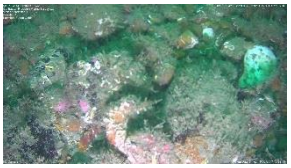

Image: 17-05-16 12.32.15_Dive 46 c16_C1
Station C16

Image: 17-05-16 12.33.33_Dive 46 c16_C1
Station C16

Image: 17-05-16 12.33.53_Dive 46 c16_C1
Station C16

Image: 17-05-16 12.34.22_Dive 46 c16_C1
Station C16

Image: 17-05-16 12.35.08_Dive 46 c16_C1
Station C16

Image: 17-05-16 12.37.41_Dive 46 c16_C1
Station C16

Image: 17-05-16 12.39.20_Dive 46 c16_C1
Station C16

Image: 17-05-15 12.43.39_Dive 35 c16_C1
Station C16

Image: 17-05-15 12.45.43_Dive 35 c16_C1
Station C16

Image: 17-05-15 12.46.08_Dive 35 c16_C1
Station C16

Image: 17-05-15 12.46.37_Dive 35 c16_C1
Station C16

Image: 17-05-15 12.47.07_Dive 35 c16_C1
Station C16

Image: 17-05-15 12.48.03_Dive 35 c16_C1
Station C16

Image: 17-05-15 12.48.46_Dive 35 c16_C1
Station C16

Image: 17-05-15 12.48.58_Dive 35 c16_C1
Station C16

Image: 17-05-15 12.49.21_Dive 35 c16_C1
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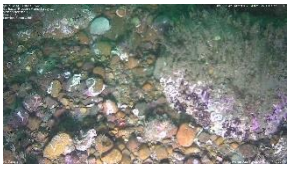

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Station C16

Image: 17-05-15 12.50.25_Dive 35 c16_C1
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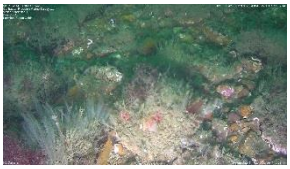
Station C16

Image: 17-05-15 12.51.08_Dive 35 c16_C1
Station C16



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Station C16

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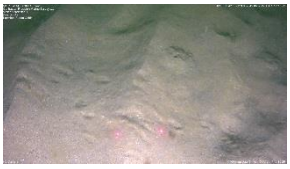
Station C17



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Station C17

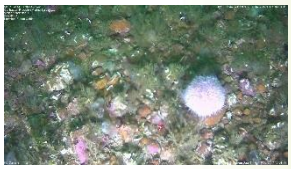
Image: 17-05-15 13.17.48_Dive 36 c17_C1
Station C17

Image: 17-05-15 13.18.31_Dive 36 c17_C1
Station C17

Image: 17-05-15 13.19.05_Dive 36 c17_C1
Station C17

Image: 17-05-15 13.20.35_Dive 36 c17_C1
Station C17

Image: 17-05-16 10.03.16_Dive 40 c18_C1
Station C18



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Station C18

Image: 17-05-16 10.04.41_Dive 40 c18_C1
Station C18

Image: 17-05-16 10.05.23_Dive 40 c18_C1
Station C18

Image: 17-05-16 10.06.00_Dive 40 c18_C1
Station C18

Image: 17-05-16 10.06.31_Dive 40 c18_C1
Station C18

Image: 17-05-16 10.06.44_Dive 40 c18_C1
Station C18

Image: 17-05-16 10.07.00_Dive 40 c18_C1
Station C18

Image: 17-05-16 10.07.36_Dive 40 c18_C1
Station C18

Image: 17-05-16 10.08.03_Dive 40 c18_C1
Station C18

Image: 17-05-16 10.08.23_Dive 40 c18_C1
Station C18

Image: 17-05-16 10.08.39_Dive 40 c18_C1
Station C18

Image: 17-05-16 10.08.59_Dive 40 c18_C1
Station C18

Image: 17-05-16 10.09.13_Dive 40 c18_C1
Station C18

Image: 17-05-16 10.09.32_Dive 40 c18_C1
Station C18

Image: 17-05-16 11.13.39_Dive 43 c19_C1
Station C19

Image: 17-05-16 11.16.50_Dive 43 c19_C1
Station C19

Image: 17-05-16 11.20.13_Dive 43 c19_C1
Station C19

Image: 17-05-16 11.21.33_Dive 43 c19_C1
Station C19

Image: 17-05-16 11.22.11_Dive 43 c19_C1
Station C19

Image: 17-05-16 11.23.11_Dive 43 c19_C1
Station C19

Image: 17-05-16 11.23.32_Dive 43 c19_C1
Station C19

Image: 17-05-16 11.24.50_Dive 43 c19_C1
Station C19

Image: 17-05-16 11.25.26_Dive 43 c19_C1
Station C19

Image: 17-05-16 10.53.01_Dive 42 c20_C1
Station C20

Image: 17-05-16 10.53.54_Dive 42 c20_C1
Station C20

Image: 17-05-16 10.54.37_Dive 42 c20_C1
Station C20

Image: 17-05-16 10.55.13_Dive 42 c20_C1
Station C20

Image: 17-05-16 10.56.54_Dive 42 c20_C1
Station C20

Image: 17-05-16 10.57.23_Dive 42 c20_C1
Station C20

Image: 17-05-16 10.32.38_Dive 41 c21_C1
Station C21

Image: 17-05-16 10.33.38_Dive 41 c21_C1
Station C21

Image: 17-05-16 10.35.13_Dive 41 c21_C1
Station C21

Image: 17-05-16 10.35.43_Dive 41 c21_C1
Station C21

Image: 17-05-16 10.36.09_Dive 41 c21_C1
Station C21

Image: 17-05-16 10.36.38_Dive 41 c21_C1
Station C21

Image: 17-05-15 13.42.28_Dive 37 c22_C1
Station C22

Image: 17-05-15 13.43.14_Dive 37 c22_C1
Station C22

Image: 17-05-15 13.44.00_Dive 37 c22_C1
Station C22

Image: 17-05-15 13.44.12_Dive 37 c22_C1
Station C22

Image: 17-05-15 13.44.37_Dive 37 c22_C1
Station C22

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Station C22

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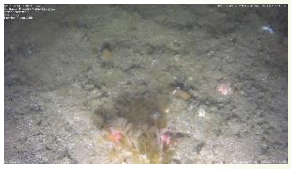
Station C22



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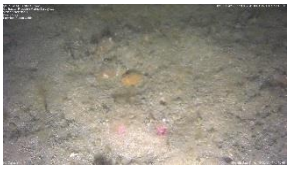

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Station C22

Image: 17-05-15 13.48.13_Dive 37 c22_C1
Station C22

Image: 17-05-15 13.48.48_Dive 37 c22_C1
Station C22

Image: 17-05-15 13.49.44_Dive 37 c22_C1
Station C22

Image: 17-05-15 13.50.07_Dive 37 c22_C1
Station C22

Image: 17-05-15 13.50.26_Dive 37 c22_C1
Station C22

Image: 17-05-15 09.08.22_Dive 29 c23_C1
Station C23

Image: 17-05-15 09.09.03_Dive 29 c23_C1
Station C23

Image: 17-05-15 09.09.18_Dive 29 c23_C1
Station C23

Image: 17-05-15 09.10.31_Dive 29 c23_C1
Station C23

Image: 17-05-15 09.11.19_Dive 29 c23_C1
Station C23

Image: 17-05-15 09.11.54_Dive 29 c23_C1
Station C23

Image: 17-05-15 09.12.35_Dive 29 c23_C1
Station C23

Image: 17-05-15 09.12.39_Dive 29 c23_C1
Station C23

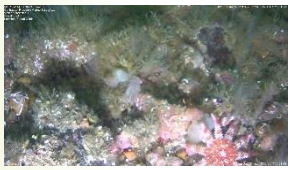
Image: 17-05-15 09.13.17_Dive 29 c23_C1
Station C23

Image: 17-05-15 09.13.27_Dive 29 c23_C1
Station C23

Image: 17-05-16 11.59.57_Dive 45 c24_C1
Station C24

Image: 17-05-16 12.00.16_Dive 45 c24_C1
Station C24

Image: 17-05-16 12.00.58_Dive 45 c24_C1
Station C24



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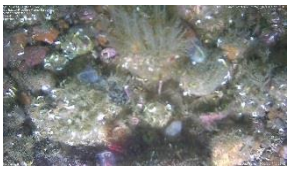
Station C24



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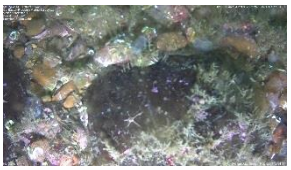
Station C24



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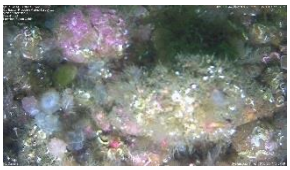

Image: 17-05-16 12.07.59_Dive 45 c24_C1
Station C24

Image: 17-05-16 12.08.06_Dive 45 c24_C1
Station C24

Image: 17-05-16 12.09.41_Dive 45 c24_C1
Station C24

Image: 17-05-18 06.05.40_Dive 50 c25_C1
Station C25

Image: 17-05-18 06.06.16_Dive 50 c25_C1
Station C25

Image: 17-05-18 06.07.33_Dive 50 c25_C1
Station C25

Image: 17-05-18 06.09.19_Dive 50 c25_C1
Station C25

Image: 17-05-18 06.10.45_Dive 50 c25_C1
Station C25

Image: 17-05-18 06.11.47_Dive 50 c25_C1
Station C25

Image: 17-05-18 10.05.58_Dive 61 c26_C1
Station C26

Image: 17-05-18 10.07.23_Dive 61 c26_C1
Station C26

Image: 17-05-18 10.08.08_Dive 61 c26_C1
Station C26

Image: 17-05-18 10.09.25_Dive 61 c26_C1
Station C26

Image: 17-05-18 10.09.46_Dive 61 c26_C1
Station C26

Image: 17-05-18 10.10.23_Dive 61 c26_C1
Station C26

Image: 17-05-18 10.10.52_Dive 61 c26_C1
Station C26

Image: 17-05-18 10.11.50_Dive 61 c26_C1
Station C26

Image: 17-05-18 10.13.17_Dive 61 c26_C1
Station C26

Image: 17-05-17 10.40.54_Dive 48 c27_C1
Station C27

Image: 17-05-17 10.41.40_Dive 48 c27_C1
Station C27

Image: 17-05-17 10.42.27_Dive 48 c27_C1
Station C27

Image: 17-05-17 10.44.26_Dive 48 c27_C1
Station C27

Image: 17-05-17 10.45.45_Dive 48 c27_C1
Station C27

Image: 17-05-17 10.46.16_Dive 48 c27_C1
Station C27

Image: 17-05-21 21.05.56_Dive 136 c28_C1
Station C28

Image: 17-05-21 21.07.07_Dive 136 c28_C1
Station C28

Image: 17-05-21 21.07.44_Dive 136 c28_C1
Station C28

Image: 17-05-21 21.08.06_Dive 136 c28_C1
Station C28

Image: 17-05-21 21.09.21_Dive 136 c28_C1
Station C28

Image: 17-05-21 21.10.03_Dive 136 c28_C1
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Image: 17-05-21 21.10.50_Dive 136 c28_C1
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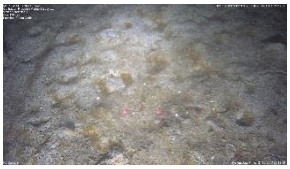

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Station C28

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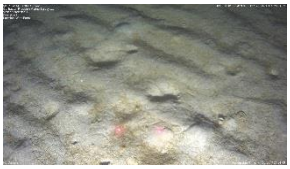
Station C28



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Station W1

Image: 17-05-14 21.05.07_Dive 26 w1_C1
Station W1

Image: 17-05-14 21.05.41_Dive 26 w1_C1
Station W1

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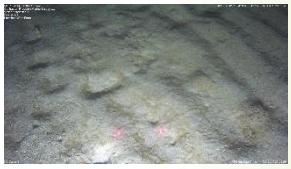
Station W1

Image: 17-05-14 21.07.43_Dive 26 w1_C1
Station W1



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Station W1

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Station W2

Image: 17-05-14 15.47.02_Dive 09 w2_C1
Station W2

Image: 17-05-14 15.48.03_Dive 09 w2_C1
Station W2

Image: 17-05-14 15.48.49_Dive 09 w2_C1
Station W2

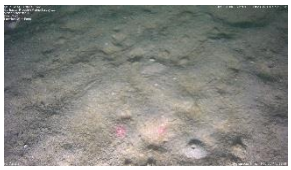
Image: 17-05-14 15.49.40_Dive 09 w2_C1
Station W2

Image: 17-05-14 15.50.43_Dive 09 w2_C1
Station W2

Image: 17-05-14 15.50.57_Dive 09 w2_C1
Station W2

Image: 17-05-18 13.32.40_Dive 69 w3_C1
Station W3

Image: 17-05-18 13.34.28_Dive 69 w3_C1
Station W3



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Station W3

Image: 17-05-18 13.37.00_Dive 69 w3_C1
Station W3

Image: 17-05-18 13.37.16_Dive 69 w3_C1
Station W3

Image: 17-05-18 13.38.49_Dive 69 w3_C1
Station W3

Image: 17-05-21 18.29.47_Dive 128 w4_C1
Station W4

Image: 17-05-21 18.30.17_Dive 128 w4_C1
Station W4

Image: 17-05-21 18.30.55_Dive 128 w4_C1
Station W4

Image: 17-05-21 18.31.21_Dive 128 w4_C1
Station W4

Image: 17-05-21 18.31.44_Dive 128 w4_C1
Station W4

Image: 17-05-21 18.32.28_Dive 128 w4_C1
Station W4

Image: 17-05-21 18.32.50_Dive 128 w4_C1
Station W4

Image: 17-05-21 18.33.39_Dive 128 w4_C1
Station W4

Image: 17-05-21 18.34.12_Dive 128 w4_C1
Station W4

Image: 17-05-21 18.34.38_Dive 128 w4_C1
Station W4

Image: 17-05-21 11.41.38_Dive 106 w5_C1
Station W5

Image: 17-05-21 11.42.03_Dive 106 w5_C1
Station W5

Image: 17-05-21 11.42.57_Dive 106 w5_C1
Station W5

Image: 17-05-21 11.43.27_Dive 106 w5_C1
Station W5

Image: 17-05-21 11.44.54_Dive 106 w5_C1
Station W5

Image: 17-05-21 11.46.27_Dive 106 w5_C1
Station W5

Image: 17-05-21 11.47.40_Dive 106 w5_C1
Station W5

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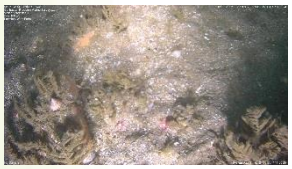
Station W5

Image: 17-05-21 11.49.38_Dive 106 w5_C1
Station W5



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Station W5

Image: 17-05-21 11.51.15_Dive 106 w5_C1
Station W5

Image: 17-05-21 11.51.47_Dive 106 w5_C1
Station W5

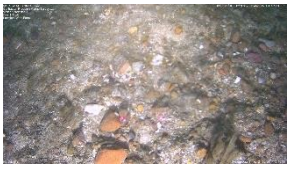
Image: 17-05-21 11.53.56_Dive 106 w5_C1
Station W5

Image: 17-05-21 11.54.43_Dive 106 w5_C1
Station W5

Image: 17-05-21 13.44.50_Dive 112 w6_C1
Station W6

Image: 17-05-21 13.45.19_Dive 112 w6_C1
Station W6

Image: 17-05-21 13.46.17_Dive 112 w6_C1
Station W6



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Station W6

Image: 17-05-21 13.48.21_Dive 112 w6_C1
Station W6

Image: 17-05-21 13.49.02_Dive 112 w6_C1
Station W6

Image: 17-05-21 13.49.30_Dive 112 w6_C1
Station W6

Image: 17-05-19 11.35.59_Dive 83 w7_C1
Station W7

Image: 17-05-19 11.37.03_Dive 83 w7_C1
Station W7

Image: 17-05-19 11.37.38_Dive 83 w7_C1
Station W7

Image: 17-05-19 11.38.06_Dive 83 w7_C1
Station W7

Image: 17-05-19 11.39.17_Dive 83 w7_C1
Station W7

Image: 17-05-19 11.40.13_Dive 83 w7_C1
Station W7

Image: 17-05-19 11.41.05_Dive 83 w7_C1
Station W7

Image: 17-05-18 10.29.15_Dive 62 w8_C1
Station W8

Image: 17-05-18 10.29.49_Dive 62 w8_C1
Station W8

Image: 17-05-18 10.30.34_Dive 62 w8_C1
Station W8

Image: 17-05-18 10.32.39_Dive 62 w8_C1
Station W8

Image: 17-05-18 10.33.13_Dive 62 w8_C1
Station W8

Image: 17-05-18 10.33.49_Dive 62 w8_C1
Station W8

Image: 17-05-18 10.35.44_Dive 62 w8_C1
Station W8

Image: 17-05-18 10.36.32_Dive 62 w8_C1
Station W8

Image: 17-05-18 10.38.36_Dive 62 w8_C1
Station W8

Image: 17-05-14 20.16.58_Dive 23 w9_C1
Station W9

Image: 17-05-14 20.17.03_Dive 23 w9_C1
Station W9

Image: 17-05-14 20.17.42_Dive 23 w9_C1
Station W9

Image: 17-05-14 20.18.30_Dive 23 w9_C1
Station W9

Image: 17-05-14 20.19.24_Dive 23 w9_C1
Station W9

Image: 17-05-14 20.19.53_Dive 23 w9_C1
Station W9

Image: 17-05-14 20.20.37_Dive 23 w9_C1
Station W9

Image: 17-05-14 20.20.56_Dive 23 w9_C1
Station W9

Image: 17-05-14 20.21.19_Dive 23 w9_C1
Station W9

Image: 17-05-14 20.21.50_Dive 23 w9_C1
Station W9

Image: 17-05-14 20.33.38_Dive 24 w10_C1
Station W10

Image: 17-05-14 20.33.48_Dive 24 w10_C1
Station W10

Image: 17-05-14 20.34.17_Dive 24 w10_C1
Station W10

Image: 17-05-14 20.34.42_Dive 24 w10_C1
Station W10

Image: 17-05-14 20.34.51_Dive 24 w10_C1
Station W10

Image: 17-05-14 20.35.19_Dive 24 w10_C1
Station W10

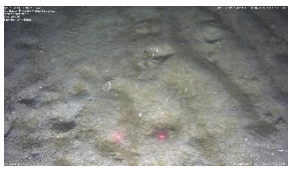

Image: 17-05-14 20.35.41_Dive 24 w10_C1
Station W10

Image: 17-05-14 20.37.28_Dive 24 w10_C1
Station W10

Image: 17-05-14 20.37.33_Dive 24 w10_C1
Station W10

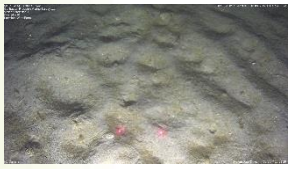

Image: 17-05-14 20.38.29_Dive 24 w10_C1
Station W10

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Station W11

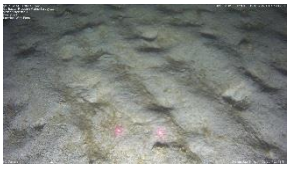


Image: 17-05-14 20.49.31_Dive 25 w11_C1
Station W11

Image: 17-05-14 20.50.53_Dive 25 w11_C1
Station W11

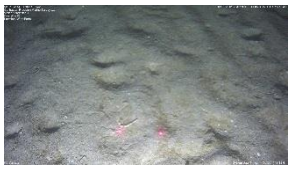
Image: 17-05-14 20.51.13_Dive 25 w11_C1
Station W11

Image: 17-05-14 20.51.20_Dive 25 w11_C1
Station W11

Image: 17-05-14 20.52.51_Dive 25 w11_C1
Station W11

Image: 17-05-14 19.16.36_Dive 20 w12_C1
Station W12

Image: 17-05-14 19.16.57_Dive 20 w12_C1
Station W12



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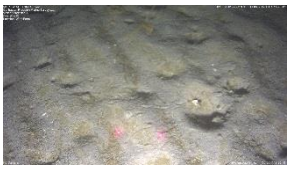

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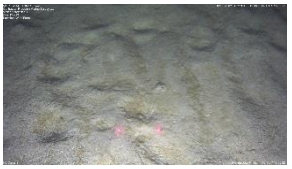
Station W12

Image: 17-05-14 19.20.49_Dive 20 w12_C1
Station W12

Image: 17-05-14 18.58.25_Dive 19 w13_C1
Station W13

Image: 17-05-14 18.59.38_Dive 19 w13_C1
Station W13



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Station W13

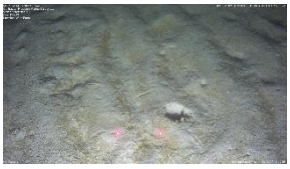

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Image: 17-05-14 19.02.17_Dive 19 w13_C1
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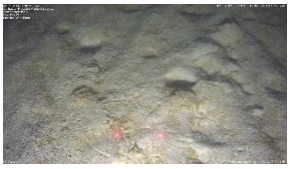

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Image: 17-05-14 19.03.05_Dive 19 w13_C1
Station W13

Image: 17-05-24 14.43.56_Dive 149 w14_C1
Station W14

Image: 17-05-24 14.45.07_Dive 149 w14_C1
Station W14

Image: 17-05-24 14.46.11_Dive 149 w14_C1
Station W14

Image: 17-05-24 14.47.37_Dive 149 w14_C1
Station W14

Image: 17-05-24 14.48.17_Dive 149 w14_C1
Station W14

Image: 17-05-24 14.49.09_Dive 149 w14_C1
Station W14

Image: 17-05-24 14.49.36_Dive 149 w14_C1
Station W14

Image: 17-05-14 18.04.37_Dive 16 w15_C1
Station W15

Image: 17-05-14 18.05.16_Dive 16 w15_C1
Station W15

Image: 17-05-14 18.06.10_Dive 16 w15_C1
Station W15

Image: 17-05-14 18.06.19_Dive 16 w15_C1
Station W15

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Station W15

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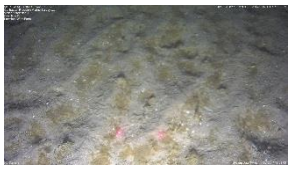
Station W15



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Station W15

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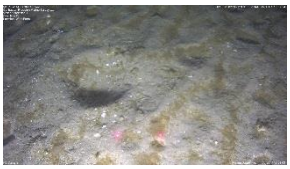
Station W15



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Station W15

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Station W15

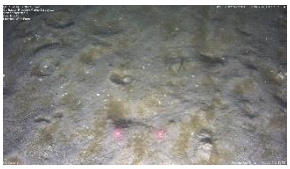

Image: 17-05-14 18.10.03_Dive 16 w15_C1
Station W15

Image: 17-05-14 18.37.25_Dive 18 w16_C1
Station W16

Image: 17-05-14 18.38.13_Dive 18 w16_C1
Station W16

Image: 17-05-14 18.40.36_Dive 18 w16_C1
Station W16

Image: 17-05-14 18.41.21_Dive 18 w16_C1
Station W16

Image: 17-05-14 18.42.08_Dive 18 w16_C1
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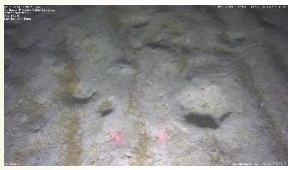

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Station W16

Image: 17-05-24 14.04.08_Dive 147 w17_C1
Station W17

Image: 17-05-24 14.04.54_Dive 147 w17_C1
Station W17

Image: 17-05-24 14.05.27_Dive 147 w17_C1
Station W17

Image: 17-05-24 14.06.17_Dive 147 w17_C1
Station W17

Image: 17-05-24 14.07.25_Dive 147 w17_C1
Station W17

Image: 17-05-24 14.07.36_Dive 147 w17_C1
Station W17

Image: 17-05-24 14.08.30_Dive 147 w17_C1
Station W17

Image: 17-05-14 16.21.58_Dive 11 w18_C1
Station W18

Image: 17-05-14 16.22.23_Dive 11 w18_C1
Station W18

Image: 17-05-14 16.23.06_Dive 11 w18_C1
Station W18

Image: 17-05-14 16.23.33_Dive 11 w18_C1
Station W18

Image: 17-05-14 16.23.40_Dive 11 w18_C1
Station W18

Image: 17-05-14 16.24.38_Dive 11 w18_C1
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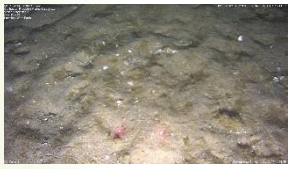
Station W18

Image: 17-05-14 16.26.11_Dive 11 w18_C1
Station W18



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Station W19

Image: 17-05-14 16.42.13_Dive 12 w19_C1
Station W19

Image: 17-05-14 16.43.02_Dive 12 w19_C1
Station W19

Image: 17-05-14 16.44.28_Dive 12 w19_C1
Station W19

Image: 17-05-14 16.45.13_Dive 12 w19_C1
Station W19

Image: 17-05-14 16.45.46_Dive 12 w19_C1
Station W19

Image: 17-05-14 17.13.00_Dive 13 w20_C1
Station W20

Image: 17-05-14 17.13.21_Dive 13 w20_C1
Station W20

Image: 17-05-14 17.13.36_Dive 13 w20_C1
Station W20

Image: 17-05-14 17.13.58_Dive 13 w20_C1
Station W20

Image: 17-05-14 17.14.36_Dive 13 w20_C1
Station W20

Image: 17-05-14 17.15.09_Dive 13 w20_C1
Station W20

Image: 17-05-14 17.16.03_Dive 13 w20_C1
Station W20

Image: 17-05-14 17.16.26_Dive 13 w20_C1
Station W20

Image: 17-05-14 17.16.41_Dive 13 w20_C1
Station W20

Image: 17-05-14 17.17.20_Dive 13 w20_C1
Station W20

Image: 17-05-14 17.17.50_Dive 13 w20_C1
Station W20

Image: 17-05-14 17.18.14_Dive 13 w20_C1
Station W20

Image: 17-05-14 14.36.22_Dive 05 w21_C1
Station W21

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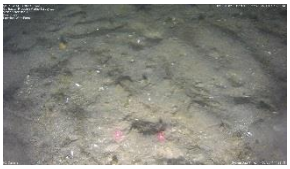

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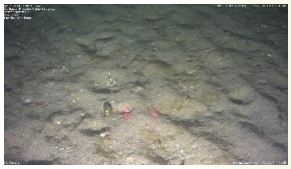
Station W21



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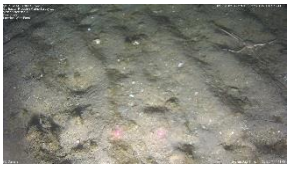

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Station W21

Image: 17-05-14 14.41.49_Dive 05 w21_C1
Station W21

Image: 17-05-24 13.09.25_Dive 144 w22_C1
Station W22

Image: 17-05-24 13.11.09_Dive 144 w22_C1
Station W22

Image: 17-05-24 13.12.21_Dive 144 w22_C1
Station W22

Image: 17-05-24 13.13.58_Dive 144 w22_C1
Station W22

Image: 17-05-24 13.14.17_Dive 144 w22_C1
Station W22

Image: 17-05-24 13.15.22_Dive 144 w22_C1
Station W22

Image: 17-05-24 13.29.21_Dive 145 w23_C1
Station W23

Image: 17-05-24 13.30.34_Dive 145 w23_C1
Station W23

Image: 17-05-24 13.31.31_Dive 145 w23_C1
Station W23

Image: 17-05-24 13.32.53_Dive 145 w23_C1
Station W23

Image: 17-05-24 13.34.19_Dive 145 w23_C1
Station W23

Image: 17-05-24 13.46.35_Dive 146 w24_C1
Station W24

Image: 17-05-24 13.47.54_Dive 146 w24_C1
Station W24

Image: 17-05-24 13.48.38_Dive 146 w24_C1
Station W24

Image: 17-05-24 13.49.50_Dive 146 w24_C1
Station W24

Image: 17-05-24 13.50.21_Dive 146 w24_C1
Station W24

Image: 17-05-24 13.51.39_Dive 146 w24_C1
Station W24

Image: 17-05-18 13.12.28_Dive 68 w25_C1
Station W25

Image: 17-05-18 13.12.55_Dive 68 w25_C1
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Station W25

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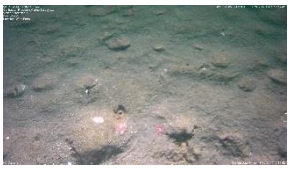
Station W25



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Station W25

Image: 17-05-18 13.18.07_Dive 68 w25_C1
Station W25

Image: 17-05-18 13.19.23_Dive 68 w25_C1
Station W25

Image: 17-05-18 11.53.51_Dive 65 w26_C1
Station W26

Image: 17-05-18 11.54.35_Dive 65 w26_C1
Station W26

Image: 17-05-18 11.55.10_Dive 65 w26_C1
Station W26

Image: 17-05-18 11.56.10_Dive 65 w26_C1
Station W26

Image: 17-05-18 11.56.50_Dive 65 w26_C1
Station W26

Image: 17-05-18 11.57.28_Dive 65 w26_C1
Station W26

Image: 17-05-18 11.58.42_Dive 65 w26_C1
Station W26

Image: 17-05-18 11.59.14_Dive 65 w26_C1
Station W26

Image: 17-05-18 11.32.29_Dive 64 w27_C1
Station W27

Image: 17-05-18 11.33.48_Dive 64 w27_C1
Station W27

Image: 17-05-18 11.34.12_Dive 64 w27_C1
Station W27

Image: 17-05-18 11.34.36_Dive 64 w27_C1
Station W27

Image: 17-05-18 11.35.08_Dive 64 w27_C1
Station W27

Image: 17-05-18 11.36.25_Dive 64 w27_C1
Station W27

Image: 17-05-18 11.06.44_Dive 63 w28_C1
Station W28

Image: 17-05-18 11.07.37_Dive 63 w28_C1
Station W28

Image: 17-05-18 11.08.51_Dive 63 w28_C1
Station W28

Image: 17-05-18 11.11.48_Dive 63 w28_C1
Station W28

Image: 17-05-18 11.13.53_Dive 63 w28_C1
Station W28

Image: 17-05-18 11.14.41_Dive 63 w28_C1
Station W28

Image: 17-05-18 11.16.45_Dive 63 w28_C1
Station W28

Image: 17-05-27 06.40.19_Dive 152 w29_C1
Station W29

Image: 17-05-27 06.40.55_Dive 152 w29_C1
Station W29

Image: 17-05-27 06.41.28_Dive 152 w29_C1
Station W29

Image: 17-05-27 06.43.08_Dive 152 w29_C1
Station W29

Image: 17-05-27 06.43.47_Dive 152 w29_C1
Station W29

Image: 17-05-27 06.44.47_Dive 152 w29_C1
Station W29

Image: 17-05-27 06.45.31_Dive 152 w29_C1
Station W29

Image: 17-05-18 15.31.53_Dive 76 w30_C1
Station W30

Image: 17-05-18 15.33.17_Dive 76 w30_C1
Station W30

Image: 17-05-18 15.34.24_Dive 76 w30_C1
Station W30

Image: 17-05-18 15.35.27_Dive 76 w30_C1
Station W30

Image: 17-05-18 15.36.13_Dive 76 w30_C1
Station W30

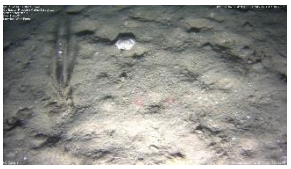
Image: 17-05-18 15.37.24_Dive 76 w30_C1
Station W30

Image: 17-05-27 07.22.50_Dive 154 w31_C1
Station W31

Image: 17-05-27 07.23.50_Dive 154 w31_C1
Station W31

Image: 17-05-27 07.24.44_Dive 154 w31_C1
Station W31

Image: 17-05-27 07.25.06_Dive 154 w31_C1
Station W31



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Station W31

Image: 17-05-27 07.27.34_Dive 154 w31_C1
Station W31

Image: 17-05-18 14.25.35_Dive 72 w32_C1
Station W32

Image: 17-05-18 14.25.46_Dive 72 w32_C1
Station W32

Image: 17-05-18 14.26.20_Dive 72 w32_C1
Station W32

Image: 17-05-18 14.27.04_Dive 72 w32_C1
Station W32

Image: 17-05-18 14.27.49_Dive 72 w32_C1
Station W32

Image: 17-05-18 14.30.17_Dive 72 w32_C1
Station W32

Image: 17-05-18 12.46.08_Dive 67 w33_C1
Station W33

Image: 17-05-18 12.46.45_Dive 67 w33_C1
Station W33

Image: 17-05-18 12.49.22_Dive 67 w33_C1
Station W33

Image: 17-05-18 12.50.28_Dive 67 w33_C1
Station W33

Image: 17-05-18 12.51.38_Dive 67 w33_C1
Station W33

Image: 17-05-18 12.52.22_Dive 67 w33_C1
Station W33

Image: 17-05-18 13.53.23_Dive 70 w34_C1
Station W34

Image: 17-05-18 13.55.09_Dive 70 w34_C1
Station W34

Image: 17-05-18 13.56.00_Dive 70 w34_C1
Station W34

Image: 17-05-18 13.56.36_Dive 70 w34_C1
Station W34

Image: 17-05-18 13.57.10_Dive 70 w34_C1
Station W34

Image: 17-05-18 13.58.02_Dive 70 w34_C1
Station W34

Image: 17-05-18 14.10.31_Dive 71 w35_C1
Station W35

Image: 17-05-18 14.10.53_Dive 71 w35_C1
Station W35

Image: 17-05-18 14.11.52_Dive 71 w35_C1
Station W35

Image: 17-05-18 14.12.33_Dive 71 w35_C1
Station W35

Image: 17-05-18 14.12.47_Dive 71 w35_C1
Station W35

Image: 17-05-18 14.13.00_Dive 71 w35_C1
Station W35

Image: 17-05-18 14.13.37_Dive 71 w35_C1
Station W35

Image: 17-05-18 14.14.35_Dive 71 w35_C1
Station W35

Image: 17-05-18 14.15.50_Dive 71 w35_C1
Station W35

Image: 17-05-27 07.40.28_Dive 155 w36_C1
Station W36

Image: 17-05-27 07.41.07_Dive 155 w36_C1
Station W36

Image: 17-05-27 07.43.06_Dive 155 w36_C1
Station W36

Image: 17-05-27 07.43.56_Dive 155 w36_C1
Station W36

Image: 17-05-27 07.44.22_Dive 155 w36_C1
Station W36

Image: 17-05-27 07.45.05_Dive 155 w36_C1
Station W36

Image: 17-05-27 07.45.39_Dive 155 w36_C1
Station W36

Image: 17-05-18 15.13.27_Dive 75 w37_C1
Station W37

Image: 17-05-18 15.14.20_Dive 75 w37_C1
Station W37

Image: 17-05-18 15.15.12_Dive 75 w37_C1
Station W37

Image: 17-05-18 15.15.53_Dive 75 w37_C1
Station W37

Image: 17-05-18 15.16.33_Dive 75 w37_C1
Station W37

Image: 17-05-18 15.17.14_Dive 75 w37_C1
Station W37

Image: 17-05-18 15.51.10_Dive 77 w38_C1
Station W38

Image: 17-05-18 15.52.08_Dive 77 w38_C1
Station W38

Image: 17-05-18 15.52.34_Dive 77 w38_C1
Station W38

Image: 17-05-18 15.54.51_Dive 77 w38_C1
Station W38

Image: 17-05-18 15.55.56_Dive 77 w38_C1
Station W38

Image: 17-05-18 15.56.21_Dive 77 w38_C1
Station W38

Image: 17-05-18 15.56.39_Dive 77 w38_C1
Station W38

Image: 17-05-19 12.26.38_Dive 86 w39_C1
Station W39

Image: 17-05-19 12.28.02_Dive 86 w39_C1
Station W39

Image: 17-05-19 12.29.20_Dive 86 w39_C1
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Image: 17-05-19 12.29.56_Dive 86 w39_C1
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Image: 17-05-19 12.30.36_Dive 86 w39_C1
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Image: 17-05-19 12.31.17_Dive 86 w39_C1
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Image: 17-05-19 12.32.29_Dive 86 w39_C1
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Image: 17-05-19 12.33.16_Dive 86 w39_C1
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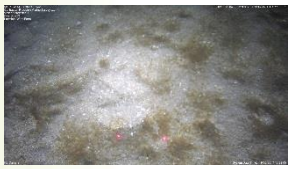

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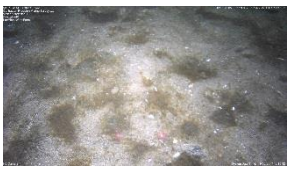

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Station W45

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Station W45

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Station W46

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Image: 17-05-19 16.25.16_Dive 98 w47_C1
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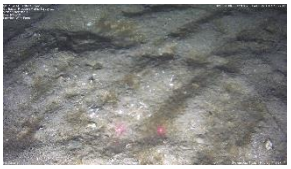

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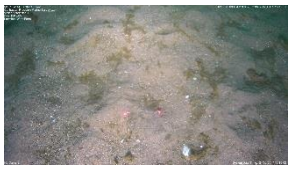

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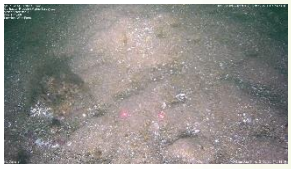

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Image: 17-05-21 14.55.56_Dive 116 w69_C1
Station W69

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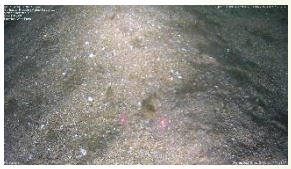

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Station W70

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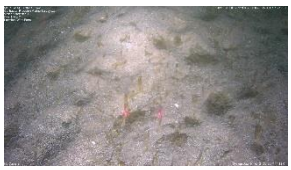

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Image: 17-05-21 13.08.59_Dive 110 w72_C1
Station W72

Image: 17-05-21 12.29.21_Dive 108 w73_C1
Station W73

Image: 17-05-21 12.29.38_Dive 108 w73_C1
Station W73

Image: 17-05-21 12.30.00_Dive 108 w73_C1
Station W73

Image: 17-05-21 12.30.45_Dive 108 w73_C1
Station W73

Image: 17-05-21 12.32.00_Dive 108 w73_C1
Station W73

Image: 17-05-21 12.33.23_Dive 108 w73_C1
Station W73

Image: 17-05-24 14.23.51_Dive 148 w74_C1
Station W74

Image: 17-05-24 14.25.33_Dive 148 w74_C1
Station W74

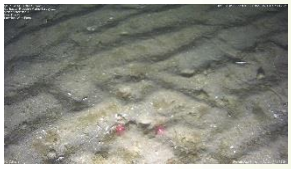
Image: 17-05-24 14.26.03_Dive 148 w74_C1
Station W74

Image: 17-05-24 14.27.28_Dive 148 w74_C1
Station W74

Image: 17-05-24 14.27.54_Dive 148 w74_C1
Station W74

Image: 17-05-24 14.28.33_Dive 148 w74_C1
Station W74

Image: 17-05-14 17.48.48_Dive 15 w75_C1
Station W75



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Station W75

Image: 17-05-14 17.49.54_Dive 15 w75_C1
Station W75

Image: 17-05-14 17.50.15_Dive 15 w75_C1
Station W75

Image: 17-05-14 17.51.01_Dive 15 w75_C1
Station W75

Image: 17-05-14 17.51.41_Dive 15 w75_C1
Station W75

Image: 17-05-14 17.52.23_Dive 15 w75_C1
Station W75

Image: 17-05-14 17.52.28_Dive 15 w75_C1
Station W75

Image: 17-05-14 17.53.02_Dive 15 w75_C1
Station W75

Image: 17-05-14 21.19.42_Dive 27 w76_C1
Station W76

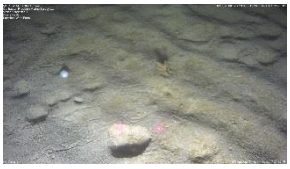

Image: 17-05-14 21.20.19_Dive 27 w76_C1
Station W76

Image: 17-05-14 21.20.59_Dive 27 w76_C1
Station W76

Image: 17-05-14 21.21.23_Dive 27 w76_C1
Station W76

Image: 17-05-14 21.22.37_Dive 27 w76_C1
Station W76

Image: 17-05-14 21.23.30_Dive 27 w76_C1
Station W76

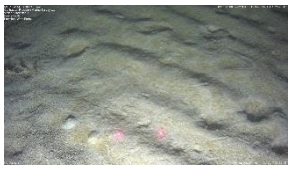

Image: 17-05-14 21.26.12_Dive 27 w76_C1
Station W76

Image: 17-05-18 12.18.07_Dive 66 w77_C1
Station W77

Image: 17-05-18 12.19.31_Dive 66 w77_C1
Station W77

Image: 17-05-18 12.19.57_Dive 66 w77_C1
Station W77

Image: 17-05-18 12.21.26_Dive 66 w77_C1
Station W77

Image: 17-05-18 12.22.02_Dive 66 w77_C1
Station W77

Image: 17-05-18 12.22.43_Dive 66 w77_C1
Station W77

Image: 17-05-19 16.41.23_Dive 99 w78_C1
Station W78

Image: 17-05-19 16.43.12_Dive 99 w78_C1
Station W78

Image: 17-05-19 16.44.55_Dive 99 w78_C1
Station W78

Image: 17-05-19 16.45.29_Dive 99 w78_C1
Station W78

Image: 17-05-19 16.45.47_Dive 99 w78_C1
Station W78

Image: 17-05-19 16.46.26_Dive 99 w78_C1
Station W78

Image: 17-05-19 16.46.42_Dive 99 w78_C1
Station W78

Image: 17-05-19 16.47.11_Dive 99 w78_C1
Station W78

Image: 17-05-21 13.22.15_Dive 111 w79_C1
Station W79

Image: 17-05-21 13.23.40_Dive 111 w79_C1
Station W79

Image: 17-05-21 13.24.37_Dive 111 w79_C1
Station W79

Image: 17-05-21 13.25.32_Dive 111 w79_C1
Station W79

Image: 17-05-21 13.26.11_Dive 111 w79_C1
Station W79

Image: 17-05-21 13.27.32_Dive 111 w79_C1
Station W79

Image: 17-05-21 13.28.08_Dive 111 w79_C1
Station W79

Image: 17-05-21 13.29.05_Dive 111 w79_C1
Station W79

Image: 17-05-21 13.29.42_Dive 111 w79_C1
Station W79

Image: 17-05-21 12.09.17_Dive 107 w80_C1
Station W80

Image: 17-05-21 12.10.27_Dive 107 w80_C1
Station W80

Image: 17-05-21 12.11.50_Dive 107 w80_C1
Station W80

Image: 17-05-21 12.12.56_Dive 107 w80_C1
Station W80

Image: 17-05-21 12.13.28_Dive 107 w80_C1
Station W80

Image: 17-05-21 12.14.06_Dive 107 w80_C1
Station W80

Image: 17-05-21 12.15.15_Dive 107 w80_C1
Station W80

9 Annex 7.1D: Benthic Grab Sampling Positions

Station	X (WGS84 UTM Zone 30N)	Y (WGS84 UTM Zone 30N)	Date/Time	Depth (mCD)	No. of Attempts
C1	493520	6429153	03/06/2017 10:12	49.1	5
C2	498608	6430651	03/06/2017 10:43	51.5	2
C3	502711	6432671	03/06/2017 11:34	44.7	7
C6	500236	6427380	03/06/2017 09:18	53.9	1
C8	502104	6422524	03/06/2017 08:52	79.6	1
C10	504182	6416905	03/06/2017 08:27	84.5	1
C12	506146	6411327	03/06/2017 08:01	93.2	1
C13	507252	6408068	03/06/2017 07:36	34.0	1
C17	510253	6396548	04/06/2017 19:31	20.0	1
C19	508400	6402224	04/06/2017 16:52	28.1	1
C21	512939	6399703	04/06/2017 18:35	33.0	2
C24	506648	6399260	04/06/2017 19:10	23.8	2
W1	487078	6430749	24/05/2017 15:48	49.2	1
W2	489674	6437245	24/05/2017 19:49	48.5	1
W3	493093	6441172	26/05/2017 12:50	48.0	1
W4	501217	6445571	25/05/2017 16:33	35.8	1
W5	507307	6452198	25/05/2017 10:03	37.7	4
W6	509358	6448813	25/05/2017 12:00	38.3	1
W7	506337	6437344	26/05/2017 09:26	44.8	1
W8	500874	6434125	26/05/2017 11:05	49.5	1*
W9	491770	6430706	27/05/2017 12:36	48.3	2
W10	489356	6430859	24/05/2017 16:21	47.2	1
W11	487848	6431821	24/05/2017 16:36	48.1	1
W12	489160	6432399	24/05/2017 18:41	46.2	4
W13	487823	6433556	24/05/2017 16:50	47.8	1
W14	490891	6431543	27/05/2017 11:50	46.9	1
W15	491897	6432563	27/05/2017 12:55	46.7	1
W16	489107	6434820	24/05/2017 19:07	46.7	2
W17	490163	6436650	24/05/2017 19:32	46.6	2
W18	491883	6435026	27/05/2017 11:12	44.5	1
W19	493782	6433603	27/05/2017 13:25	46.8	1
W20	495522	6432559	27/05/2017 13:56	47.8	1
W21	496913	6433868	27/05/2017 14:12	48.5	1

Station	X (WGS84 UTM Zone 30N)	Y (WGS84 UTM Zone 30N)	Date/Time	Depth (mCD)	No. of Attempts
W22	494829	6435110	27/05/2017 13:39	46.5	1
W23	492724	6436663	27/05/2017 10:49	43.6	1
W24	491393	6437983	24/05/2017 20:14	46.0	2
W25	492386	6439269	26/05/2017 12:32	46.1	1
W26	495997	6436545	26/05/2017 11:59	45.6	1
W27	498015	6435357	26/05/2017 11:39	48.0	1
W28	499566	6434629	26/05/2017 11:23	47.7	1
W29	501702	6435518	26/05/2017 14:02	51.1	1
W30	500182	6436509	26/05/2017 13:50	49.4	1
W31	498389	6437357	26/05/2017 13:39	46.4	1
W32	496860	6438325	26/05/2017 13:25	43.1	1
W33	494971	6438879	26/05/2017 13:09	43.3	1
W34	495999	6441225	27/05/2017 09:23	41.1	1
W35	497246	6439824	27/05/2017 09:47	41.8	1
W36	498779	6439377	27/05/2017 10:03	43.8	1
W37	500243	6438304	27/05/2017 10:22	47.1	1
W38	501935	6437965	26/05/2017 09:59	46.0	1
W39	503611	6436668	26/05/2017 09:41	45.3	1
W40	504844	6438079	26/05/2017 09:11	42.9	1
W41	503538	6438978	26/05/2017 08:48	41.9	1
W42	501632	6439679	26/05/2017 08:30	47.1	1
W43	499796	6439973	27/05/2017 08:23	44.6	1
W44	498318	6441501	27/05/2017 08:48	43.2	2
W45	496861	6442272	27/05/2017 09:06	41.8	1
W46	499021	6443356	26/05/2017 07:50	44.3	1
W47	500730	6442977	26/05/2017 07:36	37.2	1
W48	502126	6441849	26/05/2017 07:09	36.8	1
W49	503564	6440950	26/05/2017 06:56	37.4	1
W50	505065	6440035	26/05/2017 06:41	37.7	1
W51	506956	6439866	25/05/2017 18:07	38.6	2
W52	508376	6440416	26/05/2017 06:21	41.4	1
W53	507263	6441316	25/05/2017 17:50	40.6	2
W54	505522	6441901	25/05/2017 17:32	37.0	1
W55	503949	6442850	25/05/2017 17:21	38.0	1

Station	X (WGS84 UTM Zone 30N)	Y (WGS84 UTM Zone 30N)	Date/Time	Depth (mCD)	No. of Attempts
W56	502696	6443488	25/05/2017 17:04	37.7	1
W57	501261	6444369	25/05/2017 16:48	36.7	1
W58	503499	6445308	25/05/2017 16:13	38.4	2*
W59	505004	6444074	25/05/2017 15:53	39.2	2
W60	506516	6443786	25/05/2017 15:32	37.6	1
W61	507765	6442972	25/05/2017 15:15	39.0	1
W62	509234	6442362	25/05/2017 15:01	40.1	1
W63	509444	6444239	25/05/2017 14:46	40.3	2
W64	507487	6445107	25/05/2017 14:16	37.9	1
W65	505936	6446219	25/05/2017 13:57	36.2	1
W66	504324	6447027	25/05/2017 13:40	38.9	1
W67	505271	6448015	25/05/2017 13:22	38.2	1
W68	506947	6447256	25/05/2017 13:07	36.8	1
W69	508557	6446769	25/05/2017 12:51	38.4	1
W70	509474	6445912	25/05/2017 12:36	39.9	1
W71	509053	6448272	25/05/2017 12:18	37.3	1
W72	507577	6449334	25/05/2017 11:28	35.9	3
W73	506482	6450196	25/05/2017 10:44	37.0	1
W74	490529	6433732	27/05/2017 11:33	45.2	2
W75	493215	6432138	27/05/2017 13:09	47.2	1
W76	487897	6430268	24/05/2017 16:05	48.2	1
W77	494359	6437627	26/05/2017 12:16	43.3	1
W78	500085	6442003	26/05/2017 08:08	45.0	1
W79	505662	6449151	25/05/2017 11:03	40.0	1
W80	508089	6450711	25/05/2017 10:25	38.1	1

* Denotes slightly lower volume sample taken

10 Annex 7.1E: Particle Size Distribution Summary

Station	Sediment Type	Median phi	Mean phi	Sediment Sorting		% Gravel	% Sand	% Mud
C1	Slightly Gravelly Sand	2.76	2.77	0.93	Moderately Sorted	0.64	92.42	6.94
C2	Slightly Gravelly Sand	2.67	2.70	1.07	Poorly Sorted	0.92	90.07	9.01
C3	Slightly Gravelly Sand	1.08	1.11	1.36	Poorly Sorted	4.35	89.71	5.94
C6	Slightly Gravelly Muddy Sand	2.59	2.67	1.27	Poorly Sorted	2.16	85.65	12.18
C8	Slightly Gravelly Muddy Sand	3.81	4.33	1.59	Poorly Sorted	0.00	57.68	42.32
C10	Sandy Mud	4.44	4.88	1.64	Poorly Sorted	0.00	36.20	63.80
C12	Slightly Gravelly Muddy Sand	3.33	3.98	1.77	Poorly Sorted	0.03	68.89	31.09
C13	Slightly Gravelly Sand	1.58	1.57	0.49	Well Sorted	0.18	99.82	0.00
C17	Slightly Gravelly Sand	1.79	1.80	0.52	Moderately Well Sorted	0.07	99.44	0.50
C19	Gravelly Sand	-0.13	-0.06	0.87	Moderately Sorted	12.01	86.49	1.51
C21	Sandy Gravel	0.93	0.20	2.11	Very Poorly Sorted	33.18	64.10	2.72
C24	Gravel	-5.52	-5.46	0.50	Well Sorted	97.99	1.93	0.08
W1	Slightly Gravelly Sand	2.87	2.90	0.92	Moderately Sorted	0.01	92.34	7.65
W2	Sand	2.80	2.82	0.98	Moderately Sorted	0.00	92.15	7.85
W3	Slightly Gravelly Muddy Sand	2.60	2.64	1.12	Poorly Sorted	1.57	88.04	10.39
W4	Gravelly Sand	1.62	0.40	2.21	Very Poorly Sorted	20.38	79.62	0.00
W5	Sandy Gravel	0.46	-0.61	2.39	Very Poorly Sorted	38.07	60.12	1.81
W6	Sandy Gravel	-1.34	-1.18	2.54	Very Poorly Sorted	52.73	45.90	1.37
W7	Gravelly Sand	2.17	2.05	1.31	Poorly Sorted	10.04	87.88	2.08
W8	Slightly Gravelly Sand	2.33	2.20	1.20	Poorly Sorted	3.51	91.95	4.54
W9	Slightly Gravelly Sand	2.70	2.72	0.88	Moderately Sorted	2.28	91.72	6.00
W10	Slightly Gravelly Sand	2.73	2.75	0.81	Moderately Sorted	0.85	93.60	5.55
W11	Slightly Gravelly Sand	2.84	2.87	0.95	Moderately Sorted	0.04	91.25	8.72
W12	Slightly Gravelly Sand	2.71	2.73	0.97	Moderately Sorted	3.32	88.57	8.11
W13	Slightly Gravelly Muddy Sand	2.89	2.96	1.11	Poorly Sorted	0.01	87.68	12.31
W14	Slightly Gravelly Sand	2.68	2.69	0.80	Moderately Sorted	1.17	93.49	5.34
W15	Slightly Gravelly Sand	2.62	2.63	0.57	Moderately Well Sorted	0.74	95.34	3.92
W16	Slightly Gravelly Sand	2.76	2.79	1.01	Poorly Sorted	0.62	90.21	9.17
W17	Slightly Gravelly Sand	2.68	2.71	0.97	Moderately Sorted	0.98	91.12	7.89
W18	Slightly Gravelly Muddy Sand	2.57	2.65	1.10	Poorly Sorted	1.27	85.80	12.94
W19	Slightly Gravelly Sand	2.61	2.63	0.85	Moderately Sorted	0.75	93.33	5.92
W20	Muddy Sandy Gravel	-0.58	-0.13	2.22	Very Poorly Sorted	35.61	55.96	8.43
W21	Gravelly Sand	2.56	2.54	1.61	Poorly Sorted	6.76	89.44	3.80
W22	Slightly Gravelly Sand	2.51	2.53	0.79	Moderately Sorted	1.21	93.59	5.20
W23	Slightly Gravelly Sand	2.35	2.34	0.93	Moderately Sorted	4.77	91.48	3.75
W24	Slightly Gravelly Muddy Sand	2.67	2.76	1.16	Poorly Sorted	1.21	86.25	12.55
W25	Slightly Gravelly Muddy Sand	2.57	2.62	1.11	Poorly Sorted	1.66	87.56	10.79
W26	Slightly Gravelly Muddy Sand	2.47	2.54	1.07	Poorly Sorted	2.90	85.67	11.42

Station	Sediment Type	Median phi	Mean phi	Sediment Sorting		% Gravel	% Sand	% Mud
W27	Slightly Gravelly Sand	2.55	2.56	1.23	Poorly Sorted	4.51	88.45	7.04
W28	Gravelly Muddy Sand	0.07	0.65	2.54	Very Poorly Sorted	23.19	64.70	12.11
W29	Slightly Gravelly Sand	2.60	2.61	0.69	Moderately Well Sorted	0.36	95.56	4.08
W30	Slightly Gravelly Sand	2.54	2.55	0.91	Moderately Sorted	1.63	93.02	5.35
W31	Slightly Gravelly Sand	2.40	2.38	0.64	Moderately Well Sorted	3.35	92.90	3.75
W32	Slightly Gravelly Sand	2.31	2.30	0.92	Moderately Sorted	3.90	91.72	4.38
W33	Slightly Gravelly Sand	2.28	2.29	0.93	Moderately Sorted	3.29	89.84	6.87
W34	Gravelly Sand	2.13	2.13	1.07	Poorly Sorted	7.01	89.75	3.24
W35	Gravelly Sand	2.21	2.14	1.69	Poorly Sorted	10.56	83.29	6.15
W36	Gravelly Sand	2.25	2.23	1.10	Poorly Sorted	6.61	89.48	3.91
W37	Slightly Gravelly Sand	2.38	2.37	0.65	Moderately Well Sorted	3.13	93.04	3.83
W38	Slightly Gravelly Sand	2.44	2.43	0.91	Moderately Sorted	2.54	92.06	5.41
W39	Sandy Gravel	-0.38	0.07	2.28	Very Poorly Sorted	30.88	65.00	4.12
W40	Slightly Gravelly Sand	2.28	2.27	0.66	Moderately Well Sorted	1.60	95.57	2.83
W41	Slightly Gravelly Sand	2.23	2.23	0.60	Moderately Well Sorted	0.86	97.47	1.67
W42	Slightly Gravelly Sand	2.27	2.26	0.67	Moderately Well Sorted	1.03	95.43	3.54
W43	Muddy Sandy Gravel	-0.66	-0.17	2.71	Very Poorly Sorted	43.75	50.03	6.22
W44	Gravelly Sand	2.15	2.15	1.04	Poorly Sorted	5.74	90.25	4.01
W45	Gravelly Sand	2.09	2.03	1.48	Poorly Sorted	10.65	83.50	5.84
W46	Slightly Gravelly Sand	2.04	2.07	0.56	Moderately Well Sorted	0.93	95.49	3.58
W47	Gravelly Sand	1.89	1.79	1.18	Poorly Sorted	12.80	87.20	0.00
W48	Slightly Gravelly Sand	2.06	2.04	0.78	Moderately Sorted	4.24	95.76	0.00
W49	Slightly Gravelly Sand	2.11	2.10	0.53	Moderately Well Sorted	2.94	97.06	0.00
W50	Gravelly Sand	0.10	0.09	1.26	Poorly Sorted	17.45	80.70	1.85
W51	Sandy Gravel	-1.19	-0.68	2.29	Very Poorly Sorted	55.25	40.89	3.86
W52	Gravelly Muddy Sand	2.23	2.19	1.83	Poorly Sorted	9.23	81.58	9.19
W53	Slightly Gravelly Sand	2.02	1.99	0.92	Moderately Sorted	4.79	94.22	0.99
W54	Slightly Gravelly Sand	2.06	2.05	0.73	Moderately Sorted	3.65	96.35	0.00
W55	Slightly Gravelly Sand	1.92	1.93	0.49	Well Sorted	1.38	98.62	0.00
W56	Slightly Gravelly Sand	1.82	1.82	0.50	Moderately Well Sorted	1.74	98.26	0.00
W57	Gravelly Sand	1.56	0.45	2.09	Very Poorly Sorted	20.31	79.69	0.00
W58	Gravelly Sand	1.40	0.77	1.77	Poorly Sorted	16.21	83.79	0.00
W59	Slightly Gravelly Sand	1.62	1.62	0.52	Moderately Well Sorted	0.61	99.39	0.00
W60	Slightly Gravelly Sand	1.48	1.46	0.65	Moderately Well Sorted	2.17	95.83	2.00
W61	Slightly Gravelly Sand	1.68	1.67	0.53	Moderately Well Sorted	1.20	98.80	0.00
W62	Gravelly Sand	1.80	1.75	1.20	Poorly Sorted	9.03	90.97	0.00
W63	Sandy Gravel	1.15	-0.29	2.59	Very Poorly Sorted	33.84	64.82	1.34
W64	Slightly Gravelly Sand	1.42	1.40	0.66	Moderately Well Sorted	1.04	98.88	0.07

Station	Sediment Type	Median phi	Mean phi	Sediment Sorting		% Gravel	% Sand	% Mud
W65	Slightly Gravelly Sand	0.79	0.79	0.74	Moderately Sorted	3.51	96.00	0.49
W66	Slightly Gravelly Sand	1.64	1.64	0.54	Moderately Well Sorted	0.40	99.60	0.00
W67	Slightly Gravelly Sand	1.47	1.45	0.66	Moderately Well Sorted	0.53	99.42	0.05
W68	Gravelly Sand	0.79	-0.13	2.03	Very Poorly Sorted	19.30	80.36	0.34
W69	Gravelly Sand	0.73	0.60	1.38	Poorly Sorted	11.68	88.30	0.03
W70	Slightly Gravelly Sand	1.38	1.36	0.65	Moderately Well Sorted	0.16	99.25	0.58
W71	Slightly Gravelly Sand	1.70	1.70	0.56	Moderately Well Sorted	0.20	99.80	0.00
W72	Sandy Gravel	0.04	-1.21	2.84	Very Poorly Sorted	42.89	56.94	0.17
W73	Slightly Gravelly Sand	1.68	1.67	0.54	Moderately Well Sorted	0.19	99.81	0.00
W74	Slightly Gravelly Sand	2.59	2.63	0.89	Moderately Sorted	1.33	91.67	7.00
W75	Slightly Gravelly Sand	2.58	2.59	0.60	Moderately Well Sorted	0.97	96.02	3.01
W76	Slightly Gravelly Sand	2.82	2.83	0.58	Moderately Well Sorted	0.13	95.26	4.61
W77	Gravelly Sand	2.31	2.30	1.37	Poorly Sorted	6.13	87.87	6.00
W78	Slightly Gravelly Sand	2.08	2.09	0.55	Moderately Well Sorted	1.27	96.59	2.14
W79	Slightly Gravelly Sand	1.69	1.69	0.59	Moderately Well Sorted	0.49	98.97	0.53
W80	Slightly Gravelly Sand	1.72	1.71	0.66	Moderately Well Sorted	0.13	99.13	0.74

11 Annex 7.1F: Particle Size Data

Grain Size (Phi)	Sediment Type	C1	C2	C3	C6	C8	C10
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.5	Coarse Gravel	0.0000	0.0000	0.0000	0.9341	0.0000	0.0000
-4.0		0.0000	0.3463	0.0000	0.0000	0.0000	0.0000
-3.5	Medium Gravel	0.0000	0.0000	0.7474	0.7944	0.0000	0.0000
-3.0		0.3256	0.1318	0.7474	0.0419	0.0000	0.0000
-2.5	Fine Gravel	0.0389	0.1296	0.2410	0.1769	0.0000	0.0000
-2.0		0.0796	0.0961	0.5473	0.0962	0.0000	0.0000
-1.5	Very Fine Gravel	0.0991	0.1206	0.7351	0.0667	0.0000	0.0000
-1.0		0.1009	0.0938	1.3314	0.0528	0.0021	0.0000
-0.5	Very Coarse Sand	0.1292	0.1050	3.5328	0.0652	0.0042	0.0000
0.0		0.1398	0.1564	7.0043	0.0667	0.0064	0.0000
0.5	Coarse Sand	0.0358	0.0357	13.4642	0.0000	0.0000	0.0000
1.0		0.0363	0.2022	18.5325	0.0787	0.0000	0.0000
1.5	Medium Sand	0.4414	2.5692	18.9301	4.5088	0.0000	0.0170
2.0		7.9566	12.2269	14.8045	15.5886	0.0617	0.2855
2.5	Fine Sand	22.3381	22.8926	7.8649	22.1507	3.0330	1.2865
3.0		34.0572	29.0783	3.4386	23.9997	13.2654	5.6400
3.5	Very Fine Sand	20.8152	16.9888	1.1505	13.6944	19.8446	11.5268
4.0		6.4690	5.8188	0.9838	5.5006	21.4641	17.4443
4.5	Very Coarse Silt	0.2852	0.3650	0.9269	0.8110	12.6684	14.7457
5.0		0.0725	0.3078	0.9845	0.8246	6.4027	11.1371
5.5	Coarse Silt	0.8215	1.2158	0.8769	1.6629	2.9555	6.5481
6.0		1.3903	1.5160	0.8159	1.8173	2.9182	5.4669
6.5	Medium Silt	1.3300	1.3190	0.7195	1.6080	3.4390	5.7482
7.0		1.0282	1.1676	0.6160	1.5275	3.7172	5.9905
7.5	Fine Silt	0.8428	1.1741	0.5165	1.5449	3.7307	5.6033
8.0		0.7058	1.0798	0.3791	1.3631	3.3209	4.5535
8.5	Very Fine Silt	0.4193	0.6890	0.1091	0.8228	2.1924	2.8144
9.0		0.0418	0.1735	0.0000	0.2011	0.8377	1.0297
9.5	Clay	0.0000	0.0002	0.0000	0.0003	0.1356	0.1625

10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		C1	C2	C3	C6	C8	C10
SAMPLE TYPE:		Unimodal, Moderately Sorted	Unimodal, Poorly Sorted	Unimodal, Poorly Sorted	Unimodal, Poorly Sorted	Bimodal, Poorly Sorted	Bimodal, Poorly Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Muddy Sand	Slightly Gravelly Muddy Sand	Sandy Mud
SEDIMENT NAME:		Slightly Medium Gravelly Fine Sand	Slightly Coarse Gravelly Fine Sand	Slightly Very Fine Gravelly Medium Sand	Slightly Coarse Gravelly Coarse Silty Fine Sand	Slightly Very Fine Gravelly Very Coarse Silty Very Fine Sand	Very Fine Sandy Very Coarse Silt
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	148.1	157.10	472.91	165.9	71.2	45.958
	MEAN GRAIN SIZE (µm)	146.6	153.86	463.9	156.9	49.7	33.9
	SORTING	1.909	2.105	2.56	2.418	3.007	3.1
	SKEWNESS	-0.262	-0.289	-0.151	-0.322	-0.498	-0.365
	KURTOSIS	1.891	1.908	1.538	1.884	1.286	0.865
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	2.755	2.670	1.080	2.591	3.812	4.4
	MEAN GRAIN SIZE (phi):	2.770	2.700	1.108	2.672	4.331	4.9
	SORTING	0.933	1.074	1.357	1.274	1.588	1.6
	SKEWNESS	0.262	0.289	0.151	0.322	0.498	0.365
	KURTOSIS	1.891	1.908	1.538	1.884	1.286	0.865
FOLK AND WARD METHOD (Description)	MEAN:	Fine Sand	Fine Sand	Medium Sand	Fine Sand	Very Coarse Silt	Very Coarse Silt
	SORTING:	Moderately Sorted	Poorly Sorted	Poorly Sorted	Poorly Sorted	Poorly Sorted	Poorly Sorted
	SKEWNESS:	Fine Skewed	Fine Skewed	Fine Skewed	Very Fine Skewed	Very Fine Skewed	Very Fine Skewed

	KURTOSIS:	Very Leptokurtic	Very Leptokurtic	Very Leptokurtic	Very Leptokurtic	Leptokurtic	Platykurtic
BULK GRAIN SIZE	% GRAVEL:	0.644	0.918	4.350	2.163	0.002	0.000
	% SAND:	92.418	90.074	89.706	85.654	57.679	36.200
	% MUD:	6.937	9.008	5.944	12.183	42.318	63.800
	% V COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.000
	% COARSE GRAVEL:	0.000	0.346	0.000	0.934	0.000	0.000
	% MEDIUM GRAVEL:	0.326	0.132	1.495	0.836	0.000	0.000
	% FINE GRAVEL:	0.119	0.226	0.788	0.273	0.000	0.000
	% V FINE GRAVEL:	0.200	0.214	2.067	0.119	0.002	0.000
	% V COARSE SAND:	0.269	0.261	10.537	0.132	0.011	0.000
	% COARSE SAND:	0.073	0.244	32.041	0.089	0.000	0.000
	% MEDIUM SAND:	8.470	14.865	33.716	20.159	0.072	0.307
	% FINE SAND:	56.407	51.965	11.282	46.134	16.370	6.969
	% V FINE SAND:	27.199	22.738	2.130	19.139	41.227	28.924
	% V COARSE SILT:	0.362	0.679	1.916	1.645	19.087	25.919
	% COARSE SILT:	2.209	2.726	1.689	3.473	5.861	11.985
	% MEDIUM SILT:	2.356	2.484	1.334	3.133	7.150	11.728
	% FINE SILT:	1.551	2.257	0.896	2.912	7.061	10.170
	% V FINE SILT:	0.460	0.860	0.109	1.021	3.020	3.832
	% CLAY:	0.000	0.001	0.000	0.001	0.139	0.167
% LOI @ 450°C		1.06	1.13	1.22	1.11	2.72	4.33

Grain Size (Phi)	Sediment Type	C12	C13	C17	C19	C21	C24
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	53.1905
-5.0		0.0000	0.0000	0.0000	0.0000	0.0000	33.3019

-4.5	Coarse Gravel	0.0000	0.0000	0.0000	0.0000	2.4863	0.0000
-4.0		0.0000	0.0000	0.0000	0.0000	0.0000	8.5952
-3.5	Medium Gravel	0.0000	0.0000	0.0000	0.0000	1.8800	0.9861
-3.0		0.0000	0.0000	0.0000	0.2094	4.0427	0.5509
-2.5	Fine Gravel	0.0000	0.0000	0.0000	0.4237	7.5655	0.4139
-2.0		0.0084	0.0021	0.0260	0.9570	6.7072	0.4733
-1.5	Very Fine Gravel	0.0000	0.0574	0.0230	2.2082	5.8808	0.2176
-1.0		0.0189	0.1190	0.0184	8.2096	4.6195	0.2602
-0.5	Very Coarse Sand	0.0042	0.4513	0.0184	20.9301	3.3252	0.3607
0.0		0.0168	0.9846	0.0337	23.2081	1.5463	0.3302
0.5	Coarse Sand	0.2950	0.1603	0.0000	17.5553	3.7623	0.2324
1.0		0.3363	8.1188	3.1441	14.6510	9.4831	0.3155
1.5	Medium Sand	0.4815	33.0181	23.6448	7.5032	14.0002	0.2978
2.0		3.9569	39.7212	38.9723	2.0780	15.0868	0.2124
2.5	Fine Sand	11.2385	15.7725	25.5584	0.1788	10.5947	0.1069
3.0		20.6691	1.5944	7.7487	0.0410	5.3628	0.0473
3.5	Very Fine Sand	18.8460	0.0003	0.2825	0.1462	0.9111	0.0160
4.0		13.0423	0.0000	0.0340	0.1955	0.0236	0.0107
4.5	Very Coarse Silt	4.9710	0.0000	0.2024	0.1654	0.0905	0.0084
5.0		2.5638	0.0000	0.2297	0.2069	0.3027	0.0090
5.5	Coarse Silt	2.7906	0.0000	0.0635	0.2300	0.3352	0.0096
6.0		3.5947	0.0000	0.0001	0.2265	0.3368	0.0108
6.5	Medium Silt	3.9061	0.0000	0.0000	0.2054	0.3650	0.0111
7.0		3.9157	0.0000	0.0000	0.2016	0.4102	0.0106
7.5	Fine Silt	3.7226	0.0000	0.0000	0.1839	0.4147	0.0097
8.0		3.1143	0.0000	0.0000	0.0804	0.3343	0.0078
8.5	Very Fine Silt	1.8882	0.0000	0.0000	0.0049	0.1320	0.0034
9.0		0.5890	0.0000	0.0000	0.0000	0.0004	0.0000
9.5	Clay	0.0300	0.0000	0.0000	0.0000	0.0000	0.0000
10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		C12	C13	C17	C19	C21	C24
SAMPLE TYPE:		Bimodal, Poorly Sorted	Unimodal, Well Sorted	Unimodal, Moderatel	Unimodal ,	Trimodal, Very	Bimodal, Well Sorted

				y Well Sorted	Moderate ly Sorted	Poorly Sorted	
TEXTURAL GROUP:		Slightly Gravelly Muddy Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Gravelly Sand	Sandy Gravel	Gravel
SEDIMENT NAME:		Slightly Very Fine Gravelly Medium Silty Fine Sand	Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand	Very Fine Gravelly Very Coarse Sand	Sandy Fine Gravel	Very Coarse Gravel
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	99.7	333.5	288.6	1093.2	524.97	45917.4
	MEAN GRAIN SIZE (µm)	63.469	336.482	287.567	1042.83	869.193	43895.69
	SORTING	3.419	1.406	1.436	1.827	4.323	1.410
	SKEWNESS	-0.526	0.051	-0.056	-0.107	0.426	-0.406
	KURTOSIS	1.146	1.016	0.964	0.959	0.711	1.329
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	3.326	1.584	1.793	-0.129	0.930	-5.521
	MEAN GRAIN SIZE (phi):	3.978	1.571	1.798	-0.061	0.202	-5.456
	SORTING	1.774	0.491	0.522	0.870	2.112	0.496
	SKEWNESS	0.526	-0.051	0.056	0.107	-0.426	0.406
	KURTOSIS	1.146	1.016	0.964	0.959	0.711	1.329
FOLK AND WARD METHOD (Description)	MEAN:	Very Fine Sand	Medium Sand	Medium Sand	Very Coarse Sand	Coarse Sand	Very Coarse Gravel
	SORTING:	Poorly Sorted	Well Sorted	Moderatel y Well Sorted	Moderate ly Sorted	Very Poorly Sorted	Well Sorted
	SKEWNESS:	Very Fine Skewed	Symmetric al	Symmetric al	Fine Skewed	Very Coarse Skewed	Very Fine Skewed
	KURTOSIS:	Leptokurt ic	Mesokurti c	Mesokurti c	Mesokurt ic	Platykurti c	Leptokurt ic
BULK GRAIN SIZE	% GRAVEL:	0.027	0.178	0.067	12.008	33.182	97.990
	% SAND:	68.887	99.822	99.437	86.487	64.096	1.930
	% MUD:	31.086	0.000	0.496	1.505	2.722	0.080

	% V COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	85.022
	% COARSE GRAVEL:	0.000	0.000	0.000	0.000	2.486	10.066
	% MEDIUM GRAVEL:	0.000	0.000	0.000	0.209	5.923	1.537
	% FINE GRAVEL:	0.008	0.002	0.026	1.381	14.273	0.887
	% V FINE GRAVEL:	0.019	0.176	0.041	10.418	10.500	0.478
	% V COARSE SAND:	0.021	1.436	0.052	44.138	4.871	0.691
	% COARSE SAND:	0.632	8.357	3.200	32.224	13.279	0.549
	% MEDIUM SAND:	4.474	72.713	62.645	9.564	29.089	0.510
	% FINE SAND:	31.948	17.315	33.224	0.220	15.927	0.154
	% V FINE SAND:	31.811	0.000	0.315	0.341	0.931	0.027
	% V COARSE SILT:	7.550	0.000	0.432	0.374	0.395	0.017
	% COARSE SILT:	6.374	0.000	0.063	0.455	0.670	0.020
	% MEDIUM SILT:	7.815	0.000	0.000	0.407	0.774	0.022
	% FINE SILT:	6.846	0.000	0.000	0.264	0.750	0.018
	% V FINE SILT:	2.469	0.000	0.000	0.005	0.132	0.003
	% CLAY:	0.033	0.000	0.000	0.000	0.000	0.000
% LOI @ 450°C		2.09	0.71	0.52	3.46	1.40	2.06

Grain Size (Phi)	Sediment Type	W1	W2	W3	W4	W5	W6
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.5	Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	8.7069
-4.0		0.0000	0.0000	0.0000	0.0000	15.0374	7.2482
-3.5	Medium Gravel	0.0000	0.0000	0.0000	14.8744	8.7752	4.0307
-3.0		0.0000	0.0000	0.3113	0.0000	5.6677	9.2135
-2.5	Fine Gravel	0.0000	0.0000	0.8789	1.9061	2.3895	7.9517
-2.0		0.0051	0.0000	0.1221	0.7602	2.0893	6.8125

-1.5	Very Fine Gravel	0.0000	0.0000	0.1648	1.5535	2.1806	4.8956
-1.0		0.0051	0.0000	0.0916	1.2891	1.9275	3.8694
-0.5	Very Coarse Sand	0.0255	0.0154	0.2380	1.8070	2.5749	3.5951
0.0		0.0459	0.0770	0.1282	1.6968	3.3165	2.4268
0.5	Coarse Sand	0.1103	0.0293	0.1258	0.0407	6.4521	3.0780
1.0		0.0544	0.0919	0.2107	2.5233	13.6671	6.1505
1.5	Medium Sand	0.4335	1.6264	4.0955	15.8834	16.5002	9.4382
2.0		6.1322	9.4782	14.7883	29.7852	12.1648	10.4747
2.5	Fine Sand	18.6681	20.3480	22.7193	21.3437	4.6188	7.0283
3.0		32.2720	29.7491	25.3478	6.3931	0.7194	3.1933
3.5	Very Fine Sand	24.0431	20.9915	14.4409	0.1435	0.0005	0.4626
4.0		10.5596	9.7459	5.9423	0.0000	0.1084	0.0552
4.5	Very Coarse Silt	1.1545	1.3428	1.1399	0.0000	0.2267	0.2317
5.0		0.0706	0.0894	1.0617	0.0000	0.2516	0.3011
5.5	Coarse Silt	0.8565	0.8642	1.7100	0.0000	0.2095	0.1859
6.0		1.4416	1.3037	1.7284	0.0000	0.2126	0.1318
6.5	Medium Silt	1.3182	1.1398	1.3879	0.0000	0.2298	0.1418
7.0		0.9755	0.9127	1.1489	0.0000	0.2451	0.1630
7.5	Fine Silt	0.7906	0.8618	1.0294	0.0000	0.2362	0.1476
8.0		0.6586	0.7862	0.8119	0.0000	0.1704	0.0656
8.5	Very Fine Silt	0.3701	0.4757	0.3735	0.0000	0.0281	0.0001
9.0		0.0089	0.0710	0.0028	0.0000	0.0000	0.0000
9.5	Clay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W1	W2	W3	W4	W5	W6
SAMPLE TYPE:		Unimodal, Moderately Sorted	Unimodal, Moderately Sorted	Unimodal, Poorly Sorted	Bimodal, Very Poorly Sorted	Bimodal, Very Poorly Sorted	Trimodal, Very Poorly Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Sand	Slightly Gravelly Muddy Sand	Gravelly Sand	Sandy Gravel	Sandy Gravel

SEDIMENT NAME:		Slightly Fine Gravelly Fine Sand	Moderately Sorted Fine Sand	Slightly Fine Gravelly Coarse Silty Fine Sand	Medium Gravelly Medium Sand	Sandy Coarse Gravel	Sandy Coarse Gravel
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	136.6	143.89	164.9	324.46	725.65	2535.57
	MEAN GRAIN SIZE (µm)	134.33	141.46	160.2	759.5	1531.528	2258.199
	SORTING	1.892	1.967	2.169	4.64	5.234	5.814
	SKEWNESS	-0.261	-0.245	-0.261	0.719	0.520	-0.076
	KURTOSIS	1.795	1.679	1.699	1.945	0.570	0.641
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	2.872	2.797	2.601	1.624	0.463	-1.342
	MEAN GRAIN SIZE (phi):	2.896	2.822	2.642	0.397	-0.615	-1.175
	SORTING	0.920	0.976	1.117	2.214	2.388	2.539
	SKEWNESS	0.261	0.245	0.261	-0.719	-0.520	0.076
	KURTOSIS	1.795	1.679	1.699	1.945	0.570	0.641
FOLK AND WARD METHOD (Description)	MEAN:	Fine Sand	Fine Sand	Fine Sand	Coarse Sand	Very Coarse Sand	Very Fine Gravel
	SORTING:	Moderately Sorted	Moderately Sorted	Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted
	SKEWNESS:	Fine Skewed	Fine Skewed	Fine Skewed	Very Coarse Skewed	Very Coarse Skewed	Symmetrical
	KURTOSIS:	Very Leptokurtic	Very Leptokurtic	Very Leptokurtic	Very Leptokurtic	Very Platykurtic	Very Platykurtic
BULK GRAIN SIZE	% GRAVEL:	0.010	0.000	1.569	20.383	38.067	52.729
	% SAND:	92.345	92.153	88.037	79.617	60.123	45.903
	% MUD:	7.645	7.847	10.395	0.000	1.810	1.369
	% V COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.000
	% COARSE GRAVEL:	0.000	0.000	0.000	0.000	15.037	15.955
	% MEDIUM GRAVEL:	0.000	0.000	0.311	14.874	14.443	13.244

	% FINE GRAVEL:	0.005	0.000	1.001	2.666	4.479	14.764
	% V FINE GRAVEL:	0.005	0.000	0.256	2.843	4.108	8.765
	% V COARSE SAND:	0.071	0.092	0.366	3.504	5.891	6.022
	% COARSE SAND:	0.166	0.125	0.346	2.602	20.158	9.251
	% MEDIUM SAND:	6.626	11.167	18.949	45.701	28.641	19.914
	% FINE SAND:	50.977	50.116	48.052	27.667	5.323	10.200
	% V FINE SAND:	34.504	30.651	20.324	0.143	0.109	0.516
	% V COARSE SILT:	1.230	1.437	2.211	0.000	0.479	0.534
	% COARSE SILT:	2.295	2.164	3.430	0.000	0.421	0.317
	% MEDIUM SILT:	2.292	2.051	2.535	0.000	0.474	0.305
	% FINE SILT:	1.451	1.650	1.843	0.000	0.407	0.213
	% V FINE SILT:	0.378	0.545	0.375	0.000	0.028	0.000
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.000
% LOI @ 450°C		0.85	1.14	1.48	0.69	0.85	0.88

Grain Size (Phi)	Sediment Type	W7	W8	W9	W10	W11	W12
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.5	Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	3.1286
-4.0		2.0691	1.0879	0.0000	0.0000	0.0000	0.0000
-3.5	Medium Gravel	1.2465	0.0000	0.8373	0.0000	0.0000	0.0000
-3.0		0.8144	0.6450	0.2226	0.5425	0.0000	0.0000
-2.5	Fine Gravel	0.8227	0.4895	0.4875	0.0941	0.0000	0.0596
-2.0		1.5706	0.2720	0.4134	0.0664	0.0000	0.0341
-1.5	Very Fine Gravel	1.6121	0.3730	0.2226	0.0830	0.0302	0.0511
-1.0		1.9029	0.6450	0.0954	0.0664	0.0060	0.0468
-0.5	Very Coarse Sand	1.7118	0.9402	0.3180	0.0498	0.0060	0.0426
0.0		1.0886	1.1734	0.2120	0.1052	0.0060	0.0638
0.5	Coarse Sand	0.3652	4.0726	0.3792	0.0000	0.0000	0.0000

1.0		0.9363	6.2484	0.0982	0.0000	0.0001	0.0004
1.5	Medium Sand	6.4866	8.5011	0.2617	0.1218	0.1503	0.5644
2.0		19.8465	13.1265	7.0382	6.6674	5.5485	8.5176
2.5	Fine Sand	26.8666	17.6588	23.5610	23.6971	20.4992	22.7889
3.0		22.8798	21.3484	36.2204	37.2286	34.0505	32.6288
3.5	Very Fine Sand	7.0348	13.4796	19.2728	20.6077	22.7111	18.5364
4.0		0.6645	5.3967	4.3562	5.1217	8.2761	5.4281
4.5	Very Coarse Silt	0.0000	0.4373	0.0774	0.1303	0.5538	0.2359
5.0		0.0196	0.0604	0.1627	0.1386	0.1977	0.4141
5.5	Coarse Silt	0.2671	0.5395	1.0643	0.9120	1.1547	1.5626
6.0		0.4978	0.8388	1.5060	1.3017	1.5993	1.8211
6.5	Medium Silt	0.4592	0.7867	1.2140	1.0656	1.4064	1.3774
7.0		0.3385	0.6377	0.7869	0.7321	1.1467	0.9669
7.5	Fine Silt	0.2744	0.5654	0.5752	0.5866	1.0599	0.8008
8.0		0.2053	0.4763	0.4400	0.4762	0.9348	0.6398
8.5	Very Fine Silt	0.0191	0.1993	0.1767	0.2042	0.5656	0.2884
9.0		0.0000	0.0006	0.0007	0.0010	0.0971	0.0019
9.5	Clay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W7	W8	W9	W10	W11	W12
SAMPLE TYPE:		Unimodal, Poorly Sorted	Unimodal, Poorly Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Sorted
TEXTURAL GROUP:		Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:		Very Fine Gravelly Fine Sand	Slightly Coarse Gravelly Fine Sand	Slightly Medium Gravelly Fine Sand	Slightly Medium Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand	Slightly Coarse Gravelly Fine Sand
FOLK AND WARD METHOD	MEDIAN GRAIN SIZE D_{50} (µm)	222.7	198.5	153.54	150.26	139.7	152.82
	MEAN GRAIN SIZE (µm)	240.734	217.895	152.277	148.707	136.698	150.654
	SORTING	2.473	2.302	1.835	1.749	1.936	1.959

(µm)	SKEWNESS	0.399	0.205	-0.220	-0.237	-0.317	-0.247
	KURTOSIS	2.273	1.196	1.871	1.724	1.972	1.866
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	2.167	2.333	2.703	2.734	2.840	2.710
	MEAN GRAIN SIZE (phi):	2.054	2.198	2.715	2.749	2.871	2.731
	SORTING	1.306	1.203	0.876	0.807	0.953	0.970
	SKEWNESS	-0.399	-0.205	0.220	0.237	0.317	0.247
	KURTOSIS	2.273	1.196	1.871	1.724	1.972	1.866
FOLK AND WARD METHOD (Description)	MEAN:	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand
	SORTING:	Poorly Sorted	Poorly Sorted	Moderately Sorted	Moderately Sorted	Moderately Sorted	Moderately Sorted
	SKEWNESS:	Very Coarse Skewed	Coarse Skewed	Fine Skewed	Fine Skewed	Very Fine Skewed	Fine Skewed
	KURTOSIS:	Very Leptokurtic	Leptokurtic	Very Leptokurtic	Very Leptokurtic	Very Leptokurtic	Very Leptokurtic
BULK GRAIN SIZE	% GRAVEL:	10.038	3.512	2.279	0.852	0.036	3.320
	% SAND:	87.881	91.946	91.718	93.599	91.248	88.571
	% MUD:	2.081	4.542	6.004	5.548	8.716	8.109
	% V COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.000
	% COARSE GRAVEL:	2.069	1.088	0.000	0.000	0.000	3.129
	% MEDIUM GRAVEL:	2.061	0.645	1.060	0.542	0.000	0.000
	% FINE GRAVEL:	2.393	0.762	0.901	0.161	0.000	0.094
	% V FINE GRAVEL:	3.515	1.018	0.318	0.149	0.036	0.098
	% V COARSE SAND:	2.800	2.114	0.530	0.155	0.012	0.106
	% COARSE SAND:	1.317	10.341	0.478	0.000	0.000	0.002
	% MEDIUM SAND:	26.406	21.665	7.377	6.867	5.766	9.155
	% FINE SAND:	49.687	39.005	59.783	60.932	54.575	55.419
	% V FINE SAND:	7.670	18.821	23.550	25.645	30.894	23.889
	% V COARSE SILT:	0.021	0.501	0.246	0.274	0.758	0.658
	% COARSE SILT:	0.764	1.376	2.566	2.210	2.749	3.376

	% MEDIUM SILT:	0.797	1.423	1.999	1.796	2.551	2.342
	% FINE SILT:	0.480	1.043	1.016	1.064	1.997	1.442
	% V FINE SILT:	0.019	0.199	0.177	0.205	0.661	0.290
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.000
% LOI @ 450°C		0.95	1.16	1.14	0.71	0.70	1.17

Grain Size (Phi)	Sediment Type	W13	W14	W15	W16	W17	W18
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.5	Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-3.5	Medium Gravel	0.0000	0.0000	0.0000	0.6037	0.4136	0.0000
-3.0		0.0000	0.7407	0.0000	0.0000	0.1959	0.0000
-2.5	Fine Gravel	0.0000	0.1975	0.0000	0.0000	0.1088	0.3009
-2.0		0.0000	0.0395	0.2472	0.0000	0.0054	0.3869
-1.5	Very Fine Gravel	0.0056	0.1383	0.3635	0.0058	0.1524	0.1935
-1.0		0.0056	0.0494	0.1309	0.0116	0.1088	0.3869
-0.5	Very Coarse Sand	0.0056	0.1284	0.1890	0.0058	0.0326	0.5267
0.0		0.0338	0.1383	0.2472	0.0058	0.0381	0.4192
0.5	Coarse Sand	0.1927	0.0846	0.0000	0.0000	0.0000	0.0000
1.0		0.2035	0.0002	0.0000	0.0172	0.0359	0.0022
1.5	Medium Sand	1.5576	0.0763	0.0956	1.3526	1.6630	1.2212
2.0		8.2821	7.2351	8.2756	9.7455	11.6892	13.4745
2.5	Fine Sand	17.8420	26.1547	29.0536	21.6521	23.8234	27.9132
3.0		27.2644	38.6272	39.7201	30.4353	30.4159	29.3804
3.5	Very Fine Sand	20.9580	17.9232	15.7429	19.4433	17.4370	10.8079
4.0		11.3355	3.1224	2.0134	7.5559	5.9884	2.0510
4.5	Very Coarse Silt	2.2892	0.0259	0.0040	0.6344	0.4414	0.5617
5.0		0.4801	0.1197	0.0441	0.3852	0.3965	1.5068
5.5	Coarse Silt	1.5749	0.9656	0.6031	1.5262	1.3865	2.2912
6.0		2.1522	1.4103	1.0658	1.8250	1.5839	2.2344
6.5	Medium Silt	1.8090	1.1310	0.9138	1.4457	1.2434	1.7892

7.0		1.3422	0.7164	0.5686	1.0973	0.9691	1.4859
7.5	Fine Silt	1.1351	0.4997	0.3763	0.9702	0.8664	1.3342
8.0		0.9532	0.3570	0.2711	0.8162	0.7010	1.0785
8.5	Very Fine Silt	0.5274	0.1186	0.0741	0.4428	0.3017	0.5581
9.0		0.0501	0.0000	0.0000	0.0224	0.0016	0.0954
9.5	Clay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W13	W14	W15	W16	W17	W18
SAMPLE TYPE:		Unimodal, Poorly Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Well Sorted	Unimodal, Poorly Sorted	Unimodal, Moderately Sorted	Unimodal, Poorly Sorted
TEXTURAL GROUP:		Slightly Gravelly Muddy Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Muddy Sand
SEDIMENT NAME:		Slightly Very Fine Gravelly Coarse Silty Fine Sand	Slightly Medium Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand	Slightly Medium Gravelly Fine Sand	Slightly Medium Gravelly Fine Sand	Slightly Fine Gravelly Coarse Silty Fine Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	134.49	156.29	162.18	147.65	156.46	168.84
	MEAN GRAIN SIZE (µm)	128.693	154.591	161.246	144.394	153.124	158.958
	SORTING	2.157	1.737	1.483	2.012	1.960	2.139
	SKEWNESS	-0.289	-0.240	-0.059	-0.275	-0.270	-0.379
	KURTOSIS	1.771	1.859	1.164	1.792	1.755	2.204
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	2.894	2.678	2.624	2.760	2.676	2.566
	MEAN GRAIN SIZE (phi):	2.958	2.693	2.633	2.792	2.707	2.653
	SORTING	1.109	0.797	0.569	1.009	0.971	1.097
	SKEWNESS	0.289	0.240	0.059	0.275	0.270	0.379
	KURTOSIS	1.771	1.859	1.164	1.792	1.755	2.204

FOLK AND WARD METHOD (Description)	MEAN:	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand
	SORTING:	Poorly Sorted	Moderately Sorted	Moderately Well Sorted	Poorly Sorted	Moderately Sorted	Poorly Sorted
	SKEWNESS:	Fine Skewed	Fine Skewed	Symmetrical	Fine Skewed	Fine Skewed	Very Fine Skewed
	KURTOSIS:	Very Leptokurtic	Very Leptokurtic	Leptokurtic	Very Leptokurtic	Very Leptokurtic	Very Leptokurtic
BULK GRAIN SIZE	% GRAVEL:	0.011	1.165	0.742	0.621	0.985	1.268
	% SAND:	87.675	93.490	95.338	90.213	91.124	85.796
	% MUD:	12.313	5.344	3.921	9.165	7.892	12.936
	% V COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.000
	% COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.000
	% MEDIUM GRAVEL:	0.000	0.741	0.000	0.604	0.609	0.000
	% FINE GRAVEL:	0.000	0.237	0.247	0.000	0.114	0.688
	% V FINE GRAVEL:	0.011	0.188	0.494	0.017	0.261	0.580
	% V COARSE SAND:	0.039	0.267	0.436	0.012	0.071	0.946
	% COARSE SAND:	0.400	0.085	0.000	0.020	0.040	0.005
	% MEDIUM SAND:	9.895	7.397	8.466	11.166	13.427	14.784
	% FINE SAND:	45.134	64.770	68.743	52.096	54.233	57.246
	% V FINE SAND:	32.208	20.972	17.692	26.919	23.354	12.815
	% V COARSE SILT:	2.778	0.151	0.051	1.028	0.845	2.081
	% COARSE SILT:	3.720	2.372	1.666	3.344	2.964	4.515
	% MEDIUM SILT:	3.148	1.846	1.481	2.541	2.210	3.272
	% FINE SILT:	2.091	0.858	0.648	1.789	1.569	2.416
	% V FINE SILT:	0.576	0.118	0.074	0.464	0.303	0.651
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.001
% LOI @ 450°C		2.00	1.08	1.04	1.34	1.43	1.09

Grain Size (Phi)	**Sediment Type**	**W19**	**W20**	**W21**	**W22**	**W23**	**W24**

-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.5	Coarse Gravel	0.0000	0.0000	5.6916	0.0000	0.0000	0.0000
-4.0		0.0000	1.4399	0.0000	0.0000	0.0000	0.0000
-3.5	Medium Gravel	0.0000	2.0896	0.0000	0.5845	2.8534	0.2422
-3.0		0.0000	2.6021	0.0000	0.0000	0.0000	0.2328
-2.5	Fine Gravel	0.0000	0.6803	0.5516	0.0000	0.5651	0.2422
-2.0		0.0416	4.0389	0.0084	0.1570	0.4725	0.1630
-1.5	Very Fine Gravel	0.3496	10.1187	0.2842	0.2530	0.3150	0.1723
-1.0		0.3579	14.6396	0.2257	0.2181	0.5651	0.1537
-0.5	Very Coarse Sand	0.4828	17.7420	0.3092	0.3228	0.5373	0.1816
0.0		0.3496	15.3992	0.3845	0.3228	0.5188	0.1583
0.5	Coarse Sand	0.2010	5.3921	0.2045	0.0000	0.0000	0.1987
1.0		0.0234	4.9093	0.0531	0.0048	0.0054	0.0861
1.5	Medium Sand	0.6761	3.1984	0.9636	1.2039	1.2189	2.9158
2.0		10.5213	2.0334	10.6487	13.6272	17.4751	13.3683
2.5	Fine Sand	27.8772	1.7832	25.2857	30.8348	34.3600	22.3303
3.0		35.4638	2.1967	32.5933	33.8542	29.9798	25.9900
3.5	Very Fine Sand	15.2150	1.8164	15.7185	11.9656	7.0036	14.9669
4.0		2.5193	1.4893	3.2812	1.4492	0.3822	6.0512
4.5	Very Coarse Silt	0.0173	1.0726	0.0418	0.0022	0.0038	1.2111
5.0		0.2917	1.2449	0.0283	0.2436	0.2893	1.4094
5.5	Coarse Silt	1.1874	1.3362	0.4909	1.0186	0.8972	2.1629
6.0		1.4599	1.3254	0.8703	1.2235	0.9397	2.1033
6.5	Medium Silt	1.1093	1.1349	0.7944	0.9284	0.6241	1.6399
7.0		0.7292	0.8931	0.5722	0.6419	0.3879	1.3313
7.5	Fine Silt	0.5573	0.6876	0.4621	0.5396	0.3112	1.1978
8.0		0.4235	0.4903	0.3838	0.4424	0.2373	0.9722
8.5	Very Fine Silt	0.1457	0.2354	0.1523	0.1619	0.0571	0.5002
9.0		0.0000	0.0105	0.0003	0.0000	0.0000	0.0186
9.5	Clay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W19	W20	W21	W22	W23	W24
SAMPLE TYPE:		Unimodal, Moderately Sorted	Bimodal, Very Poorly Sorted	Bimodal, Poorly Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Sorted	Unimodal, Poorly Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Muddy Sandy Gravel	Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Muddy Sand
SEDIMENT NAME:		Slightly Very Fine Gravelly Fine Sand	Coarse Silty Sandy Very Fine Gravel	Coarse Gravelly Fine Sand	Slightly Medium Gravelly Fine Sand	Slightly Medium Gravelly Fine Sand	Slightly Medium Gravelly Coarse Silty Fine Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	163.95	1497.56	169.5	175.29	196.02	157.5
	MEAN GRAIN SIZE (µm)	161.329	1094.949	172.525	173.256	197.680	147.452
	SORTING	1.801	4.670	3.044	1.727	1.900	2.230
	SKEWNESS	-0.256	-0.380	0.379	-0.239	0.262	-0.332
	KURTOSIS	1.925	1.828	3.992	1.770	2.291	1.711
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	2.609	-0.583	2.561	2.512	2.351	2.667
	MEAN GRAIN SIZE (phi):	2.632	-0.131	2.535	2.529	2.339	2.762
	SORTING	0.849	2.223	1.606	0.788	0.926	1.157
	SKEWNESS	0.256	0.380	-0.379	0.239	-0.262	0.332
	KURTOSIS	1.925	1.828	3.992	1.770	2.291	1.711
FOLK AND WARD METHOD (Description)	MEAN:	Fine Sand	Very Coarse Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand
	SORTING:	Moderately Sorted	Very Poorly Sorted	Poorly Sorted	Moderately Sorted	Moderately Sorted	Poorly Sorted
	SKEWNESS:	Fine Skewed	Very Fine Skewed	Very Coarse Skewed	Fine Skewed	Coarse Skewed	Very Fine Skewed
	KURTOSIS:	Very Leptokurtic	Very Leptokurtic	Extremely Leptokurtic	Very Leptokurtic	Very Leptokurtic	Very Leptokurtic

BULK GRAIN SIZE	% GRAVEL:	0.749	35.609	6.761	1.213	4.771	1.206
	% SAND:	93.329	55.960	89.442	93.585	91.481	86.247
	% MUD:	5.921	8.431	3.796	5.202	3.748	12.547
	% V COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.000
	% COARSE GRAVEL:	0.000	1.440	5.692	0.000	0.000	0.000
	% MEDIUM GRAVEL:	0.000	4.692	0.000	0.585	2.853	0.475
	% FINE GRAVEL:	0.042	4.719	0.560	0.157	1.038	0.405
	% V FINE GRAVEL:	0.708	24.758	0.510	0.471	0.880	0.326
	% V COARSE SAND:	0.832	33.141	0.694	0.646	1.056	0.340
	% COARSE SAND:	0.226	10.309	0.260	0.008	0.008	0.292
	% MEDIUM SAND:	11.287	5.230	11.693	14.929	18.804	16.350
	% FINE SAND:	63.312	3.981	57.860	64.637	64.256	48.308
	% V FINE SAND:	17.672	3.298	18.935	13.366	7.357	20.957
	% V COARSE SILT:	0.315	2.325	0.073	0.251	0.298	2.632
	% COARSE SILT:	2.642	2.655	1.359	2.237	1.833	4.256
	% MEDIUM SILT:	1.837	2.026	1.365	1.569	1.011	2.968
	% FINE SILT:	0.982	1.179	0.847	0.983	0.549	2.173
	% V FINE SILT:	0.145	0.245	0.152	0.161	0.057	0.517
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.000
% LOI @ 450°C		1.18	1.78	1.03	1.22	0.98	1.22

Grain Size (Phi)	Sediment Type	W25	W26	W27	W28	W29	W30
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		0.0000	0.0000	0.0000	3.2564	0.0000	0.0000
-4.5	Coarse Gravel	0.0000	0.0000	3.4192	0.0000	0.0000	0.0000
-4.0		0.0000	0.8108	0.0000	0.4272	0.0000	0.0000

-3.5	Medium Gravel	0.0000	0.9971	0.0000	0.5783	0.0000	0.0000
-3.0		0.6305	0.4766	0.0754	0.7229	0.0000	0.0000
-2.5	Fine Gravel	0.1925	0.1808	0.1320	1.0910	0.0096	0.0669
-2.0		0.3129	0.0329	0.1446	3.0067	0.0096	0.3677
-1.5	Very Fine Gravel	0.2840	0.2137	0.4023	5.4186	0.1830	0.4680
-1.0		0.2358	0.1917	0.3394	8.6882	0.1541	0.7243
-0.5	Very Coarse Sand	0.3129	0.2301	0.3080	11.7935	0.2311	1.1478
0.0		0.2599	0.2246	0.4023	13.8604	0.2889	1.1589
0.5	Coarse Sand	0.0000	0.0000	0.2185	8.7044	0.1936	0.3023
1.0		0.0535	0.0040	0.0539	7.4382	0.1768	0.0582
1.5	Medium Sand	3.1917	0.9238	1.4603	4.9227	2.5825	2.0162
2.0		15.4008	15.2919	12.2524	3.7066	13.1916	13.2175
2.5	Fine Sand	24.3773	30.5040	26.3213	3.7086	25.3736	26.3232
3.0		26.1444	29.0526	31.1298	4.4771	31.5931	31.0089
3.5	Very Fine Sand	13.3665	8.6054	13.7089	3.4674	17.0813	14.5736
4.0		4.4484	0.8371	2.5903	2.6249	4.8498	3.2120
4.5	Very Coarse Silt	0.6143	0.1058	0.0321	1.6989	0.1516	0.0523
5.0		1.1788	1.2169	0.4759	1.7967	0.0573	0.3317
5.5	Coarse Silt	1.8823	2.0616	1.3413	1.8408	0.5808	1.0297
6.0		1.7864	2.0267	1.5190	1.8047	0.8633	1.1907
6.5	Medium Silt	1.4436	1.6683	1.1896	1.5679	0.7482	0.9109
7.0		1.2750	1.4465	0.8825	1.2803	0.5659	0.6519
7.5	Fine Silt	1.1876	1.3086	0.7410	1.0200	0.5046	0.5598
8.0		0.9439	1.0241	0.5833	0.7330	0.4398	0.4602
8.5	Very Fine Silt	0.4651	0.5029	0.2570	0.3457	0.1695	0.1673
9.0		0.0118	0.0614	0.0197	0.0188	0.0000	0.0000
9.5	Clay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W25	W26	W27	W28	W29	W30
SAMPLE TYPE:		Unimodal, Poorly Sorted	Unimodal, Poorly Sorted	Unimodal, Poorly Sorted	Trimodal, Very Poorly Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Sorted

TEXTURAL GROUP:		Slightly Gravelly Muddy Sand	Slightly Gravelly Muddy Sand	Slightly Gravelly Sand	Gravelly Muddy Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:		Slightly Medium Gravelly Coarse Silty Fine Sand	Slightly Medium Gravelly Coarse Silty Fine Sand	Slightly Coarse Gravelly Fine Sand	Very Fine Gravelly Coarse Silty Very Coarse Sand	Slightly Very Fine Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	168.51	180.16	170.85	955.51	164.93	171.46
	MEAN GRAIN SIZE (µm)	162.867	171.935	170.029	635.246	163.554	171.186
	SORTING	2.163	2.102	2.346	5.802	1.610	1.885
	SKEWNESS	-0.301	-0.373	-0.024	-0.347	-0.064	-0.139
	KURTOSIS	1.836	2.333	2.756	1.189	1.102	1.781
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	2.569	2.473	2.549	0.066	2.600	2.544
	MEAN GRAIN SIZE (phi):	2.618	2.540	2.556	0.655	2.612	2.546
	SORTING	1.113	1.072	1.230	2.536	0.687	0.914
	SKEWNESS	0.301	0.373	0.024	0.347	0.064	0.139
	KURTOSIS	1.836	2.333	2.756	1.189	1.102	1.781
FOLK AND WARD METHOD (Description)	MEAN:	Fine Sand	Fine Sand	Fine Sand	Coarse Sand	Fine Sand	Fine Sand
	SORTING:	Poorly Sorted	Poorly Sorted	Poorly Sorted	Very Poorly Sorted	Moderately Well Sorted	Moderately Sorted
	SKEWNESS:	Very Fine Skewed	Very Fine Skewed	Symmetrical	Very Fine Skewed	Symmetrical	Fine Skewed
	KURTOSIS:	Very Leptokurtic	Very Leptokurtic	Very Leptokurtic	Leptokurtic	Mesokurtic	Very Leptokurtic
BULK GRAIN SIZE	% GRAVEL:	1.656	2.904	4.513	23.189	0.356	1.627
	% SAND:	87.555	85.674	88.446	64.704	95.563	93.019
	% MUD:	10.789	11.423	7.041	12.107	4.081	5.355
	% V COARSE GRAVEL:	0.000	0.000	0.000	3.113	0.000	0.000
	% COARSE GRAVEL:	0.000	0.811	3.419	0.571	0.000	0.000

	% MEDIUM GRAVEL:	0.631	1.474	0.075	1.301	0.000	0.000
	% FINE GRAVEL:	0.505	0.214	0.277	4.098	0.019	0.435
	% V FINE GRAVEL:	0.520	0.405	0.742	14.107	0.337	1.192
	% V COARSE SAND:	0.573	0.455	0.710	25.654	0.520	2.307
	% COARSE SAND:	0.061	0.006	0.276	16.154	0.377	0.365
	% MEDIUM SAND:	18.665	16.314	13.796	8.630	15.851	15.315
	% FINE SAND:	50.496	59.492	57.421	8.188	56.954	57.306
	% V FINE SAND:	17.760	9.407	16.243	6.078	21.861	17.726
	% V COARSE SILT:	1.803	1.334	0.515	3.506	0.212	0.390
	% COARSE SILT:	3.660	4.079	2.854	3.637	1.442	2.216
	% MEDIUM SILT:	2.716	3.112	2.070	2.846	1.313	1.561
	% FINE SILT:	2.134	2.335	1.326	1.755	0.945	1.021
	% V FINE SILT:	0.476	0.563	0.276	0.363	0.169	0.167
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.000
% LOI @ 450°C		1.36	1.05	0.99	2.56	1.53	1.57

Grain Size (Phi)	Sediment Type	W31	W32	W33	W34	W35	W36
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.5	Coarse Gravel	0.0000	0.0000	0.0000	3.2475	0.9717	0.0000
-4.0		0.0000	0.0000	0.8034	0.0000	2.1360	0.7416
-3.5	Medium Gravel	1.1293	0.7421	0.6717	0.0000	1.7055	1.2094
-3.0		1.0136	0.0000	0.1910	0.4012	0.6601	0.2282
-2.5	Fine Gravel	0.0000	0.3828	0.3358	0.1211	0.7134	0.7872
-2.0		0.3810	0.5537	0.3293	0.5148	1.3079	0.9584
-1.5	Very Fine Gravel	0.4286	1.2310	0.5202	1.2869	1.7506	1.3120
-1.0		0.3946	0.9895	0.4346	1.4383	1.3161	1.3691
-0.5	Very Coarse Sand	0.6599	1.2428	0.3753	1.3248	1.1685	1.3234

0.0		0.5578	0.9071	0.3095	1.0522	1.0004	1.2664
0.5	Coarse Sand	0.0000	0.0585	0.0000	0.0452	0.0596	0.0706
1.0		0.0146	0.0470	0.0142	0.1326	0.2419	0.1925
1.5	Medium Sand	1.3068	2.9464	3.4119	6.4108	4.9997	4.6204
2.0		16.5496	19.6739	22.5006	25.3071	19.7129	20.3760
2.5	Fine Sand	32.9629	32.5624	33.7062	31.4888	27.3807	29.7479
3.0		31.1770	27.0901	24.4790	20.3001	21.9878	24.5112
3.5	Very Fine Sand	8.9062	6.7383	4.8344	3.5627	6.1477	6.7906
4.0		0.7691	0.4568	0.2087	0.1242	0.5861	0.5818
4.5	Very Coarse Silt	0.0022	0.0048	0.1291	0.0345	0.0563	0.0048
5.0		0.2340	0.3808	0.9237	0.4214	0.7862	0.3578
5.5	Coarse Silt	0.8197	0.9390	1.3717	0.7497	1.1939	0.8019
6.0		0.9287	0.9753	1.2132	0.6420	1.0787	0.7923
6.5	Medium Silt	0.6579	0.7034	0.9032	0.4268	0.8417	0.5769
7.0		0.4263	0.5020	0.7583	0.3376	0.7324	0.4546
7.5	Fine Silt	0.3440	0.4285	0.7101	0.3229	0.6827	0.4336
8.0		0.2675	0.3353	0.5754	0.2506	0.5410	0.3640
8.5	Very Fine Silt	0.0688	0.1084	0.2675	0.0563	0.2339	0.1272
9.0		0.0000	0.0000	0.0221	0.0000	0.0067	0.0000
9.5	Clay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W31	W32	W33	W34	W35	W36
SAMPLE TYPE:		Unimodal, Moderately Well Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Sorted	Unimodal, Poorly Sorted	Unimodal, Poorly Sorted	Unimodal, Poorly Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Gravelly Sand	Gravelly Sand	Gravelly Sand
SEDIMENT NAME:		Slightly Medium Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand	Coarse Gravelly Fine Sand	Coarse Gravelly Fine Sand	Very Fine Gravelly Fine Sand
	MEDIAN GRAIN SIZE D_{50} (µm)	189.98	201.89	205.61	228.45	215.94	210.68

FOLK AND WARD METHOD (µm)	MEAN GRAIN SIZE (µm)	191.527	203.451	204.022	228.536	226.460	213.366
	SORTING	1.553	1.889	1.912	2.100	3.231	2.142
	SKEWNESS	0.056	0.225	-0.240	0.274	0.219	0.283
	KURTOSIS	1.222	1.963	2.051	2.375	3.350	2.186
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	2.396	2.308	2.282	2.130	2.211	2.247
	MEAN GRAIN SIZE (phi):	2.384	2.297	2.293	2.130	2.143	2.229
	SORTING	0.635	0.917	0.935	1.070	1.692	1.099
	SKEWNESS	-0.056	-0.225	0.240	-0.274	-0.219	-0.283
	KURTOSIS	1.222	1.963	2.051	2.375	3.350	2.186
FOLK AND WARD METHOD (Description)	MEAN:	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand
	SORTING:	Moderately Well Sorted	Moderately Sorted	Moderately Sorted	Poorly Sorted	Poorly Sorted	Poorly Sorted
	SKEWNESS:	Symmetrical	Coarse Skewed	Fine Skewed	Coarse Skewed	Coarse Skewed	Coarse Skewed
	KURTOSIS:	Leptokurtic	Very Leptokurtic	Very Leptokurtic	Very Leptokurtic	Extremely Leptokurtic	Very Leptokurtic
BULK GRAIN SIZE	% GRAVEL:	3.347	3.899	3.286	7.010	10.561	6.606
	% SAND:	92.904	91.723	89.840	89.748	83.285	89.481
	% MUD:	3.749	4.378	6.874	3.242	6.153	3.913
	% V COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.000
	% COARSE GRAVEL:	0.000	0.000	0.803	3.248	3.108	0.742
	% MEDIUM GRAVEL:	2.143	0.742	0.863	0.401	2.366	1.438
	% FINE GRAVEL:	0.381	0.937	0.665	0.636	2.021	1.746
	% V FINE GRAVEL:	0.823	2.221	0.955	2.725	3.067	2.681
	% V COARSE SAND:	1.218	2.150	0.685	2.377	2.169	2.590
	% COARSE SAND:	0.018	0.112	0.022	0.193	0.313	0.274
	% MEDIUM SAND:	17.961	22.720	26.015	31.806	24.791	25.083
	% FINE SAND:	64.068	59.573	58.094	51.700	49.304	54.189

	% V FINE SAND:	9.639	7.167	5.023	3.672	6.709	7.345
	% V COARSE SILT:	0.241	0.391	1.060	0.460	0.849	0.367
	% COARSE SILT:	1.745	1.910	2.578	1.388	2.267	1.590
	% MEDIUM SILT:	1.083	1.204	1.660	0.764	1.573	1.031
	% FINE SILT:	0.612	0.765	1.287	0.574	1.225	0.798
	% V FINE SILT:	0.069	0.108	0.289	0.056	0.240	0.127
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.000
% LOI @ 450°C		0.92	1.07	1.12	0.82	1.16	0.96

Grain Size (Phi)	Sediment Type	W37	W38	W39	W40	W41	W42
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		0.0000	0.0000	5.2038	0.0000	0.0000	0.0000
-4.5	Coarse Gravel	1.8655	0.0000	0.0000	0.0000	0.0000	0.0000
-4.0		0.0000	0.0000	0.5482	0.0000	0.0000	0.0000
-3.5	Medium Gravel	0.4601	0.0000	1.3718	0.0000	0.0000	0.0000
-3.0		0.0000	0.0000	0.7733	0.3742	0.0000	0.1949
-2.5	Fine Gravel	0.0000	0.1728	0.7839	0.2462	0.1137	0.1157
-2.0		0.3346	0.7602	2.2881	0.2659	0.0731	0.0913
-1.5	Very Fine Gravel	0.1924	0.7809	7.2615	0.3053	0.3330	0.1949
-1.0		0.2761	0.8224	12.6453	0.4038	0.3412	0.4324
-0.5	Very Coarse Sand	0.4350	0.8431	16.1225	0.5318	0.4630	0.6516
0.0		0.4350	0.8362	13.5749	0.6500	0.5036	0.7917
0.5	Coarse Sand	0.0000	0.0727	4.7730	0.1100	0.0610	0.5890
1.0		0.0409	0.0876	5.2925	0.6557	0.4494	0.6377
1.5	Medium Sand	2.6353	2.4099	5.3338	6.5050	6.3607	6.4963
2.0		17.7995	16.0472	5.5912	21.8718	24.5259	22.4129
2.5	Fine Sand	31.6092	29.4456	5.2506	30.4939	33.9790	30.7398
3.0		29.7776	29.9020	4.9158	26.0924	25.4526	25.2413
3.5	Very Fine Sand	9.3349	10.8891	2.7875	7.9228	5.4371	7.2375

4.0		0.9699	1.5246	1.3619	0.7400	0.2368	0.6369
4.5	Very Coarse Silt	0.0025	0.0056	0.4979	0.0011	0.0000	0.0013
5.0		0.2623	0.3599	0.5075	0.1045	0.0000	0.2396
5.5	Coarse Silt	0.8399	1.0739	0.6174	0.5038	0.0910	0.7513
6.0		0.9230	1.2041	0.6295	0.6854	0.3852	0.8130
6.5	Medium Silt	0.6525	0.9217	0.5470	0.5586	0.4550	0.5934
7.0		0.4329	0.6739	0.4607	0.4014	0.3587	0.4251
7.5	Fine Silt	0.3605	0.5689	0.3940	0.3287	0.2587	0.3667
8.0		0.2879	0.4435	0.3071	0.2276	0.1207	0.2839
8.5	Very Fine Silt	0.0725	0.1541	0.1582	0.0201	0.0003	0.0618
9.0		0.0000	0.0000	0.0015	0.0000	0.0000	0.0000
9.5	Clay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W37	W38	W39	W40	W41	W42
SAMPLE TYPE:		Unimodal, Moderately Well Sorted	Unimodal, Moderately Sorted	Trimodal, Very Poorly Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Slightly Gravelly Sand	Sandy Gravel	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:		Slightly Coarse Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand	Sandy Very Fine Gravel	Slightly Very Fine Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	191.79	184.65	1299.62	205.85	212.69	207.70
	MEAN GRAIN SIZE (µm)	193.623	185.206	955.392	206.887	212.803	208.053
	SORTING	1.567	1.883	4.848	1.585	1.512	1.592
	SKEWNESS	0.044	-0.158	-0.139	0.022	0.015	0.007
	KURTOSIS	1.170	1.900	1.349	1.052	1.017	1.071
FOLK AND	MEDIAN GRAIN SIZE D_{50} (phi):	2.382	2.437	-0.378	2.280	2.233	2.267
	MEAN GRAIN SIZE (phi):	2.369	2.433	0.066	2.273	2.232	2.265

WARD METHOD (phi)	SORTING	0.648	0.913	2.277	0.664	0.596	0.671
	SKEWNESS	-0.044	0.158	0.139	-0.022	-0.015	-0.007
	KURTOSIS	1.170	1.900	1.349	1.052	1.017	1.071
FOLK AND WARD METHOD (Description)	MEAN:	Fine Sand	Fine Sand	Coarse Sand	Fine Sand	Fine Sand	Fine Sand
	SORTING:	Moderately Well Sorted	Moderately Sorted	Very Poorly Sorted	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted
	SKEWNESS:	Symmetrical	Fine Skewed	Fine Skewed	Symmetrical	Symmetrical	Symmetrical
	KURTOSIS:	Leptokurtic	Very Leptokurtic	Leptokurtic	Mesokurtic	Mesokurtic	Mesokurtic
BULK GRAIN SIZE	% GRAVEL:	3.129	2.536	30.876	1.595	0.861	1.029
	% SAND:	93.037	92.058	65.004	95.573	97.469	95.435
	% MUD:	3.834	5.406	4.121	2.831	1.670	3.536
	% V COARSE GRAVEL:	0.000	0.000	4.974	0.000	0.000	0.000
	% COARSE GRAVEL:	1.865	0.000	0.778	0.000	0.000	0.000
	% MEDIUM GRAVEL:	0.460	0.000	2.145	0.374	0.000	0.195
	% FINE GRAVEL:	0.335	0.933	3.072	0.512	0.187	0.207
	% V FINE GRAVEL:	0.468	1.603	19.907	0.709	0.674	0.627
	% V COARSE SAND:	0.870	1.679	29.697	1.182	0.967	1.443
	% COARSE SAND:	0.047	0.166	10.078	0.781	0.525	1.242
	% MEDIUM SAND:	20.532	18.548	10.930	28.462	30.983	28.995
	% FINE SAND:	61.321	59.296	10.161	56.519	59.342	55.910
	% V FINE SAND:	10.267	12.369	4.138	8.630	5.652	7.845
	% V COARSE SILT:	0.269	0.371	1.009	0.108	0.000	0.245
	% COARSE SILT:	1.759	2.273	1.244	1.187	0.476	1.561
	% MEDIUM SILT:	1.084	1.594	1.007	0.959	0.813	1.018
	% FINE SILT:	0.649	1.014	0.702	0.557	0.380	0.651
	% V FINE SILT:	0.072	0.154	0.159	0.020	0.000	0.062
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.000

% LOI @ 450°C		0.96	1.15	2.26	0.87	0.74	0.79

Grain Size (Phi)	Sediment Type	W43	W44	W45	W46	W47	W48
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		2.7084	0.0000	0.0000	0.0000	0.0000	0.0000
-4.5	Coarse Gravel	2.3280	0.0000	0.0000	0.0000	0.0000	0.0000
-4.0		1.5392	0.0000	2.0881	0.0000	3.5563	0.0000
-3.5	Medium Gravel	2.4761	1.3960	0.2139	0.0000	0.0000	0.0000
-3.0		2.1161	0.4689	0.8278	0.3379	0.9389	0.2471
-2.5	Fine Gravel	5.2202	1.1616	1.2882	0.0255	0.8553	0.5539
-2.0		7.5227	0.7460	2.1625	0.0446	2.4373	1.2697
-1.5	Very Fine Gravel	9.3912	1.0976	2.3299	0.2168	3.1511	0.8266
-1.0		10.4505	0.8685	1.7439	0.3061	1.8650	1.3464
-0.5	Very Coarse Sand	9.3708	0.8046	1.4370	0.2040	1.3698	1.1589
0.0		5.8890	0.7779	0.8603	0.1977	0.8232	0.8607
0.5	Coarse Sand	1.4909	0.0000	0.0000	0.0002	0.0001	0.0000
1.0		2.2946	0.2568	0.2864	0.6468	0.2233	0.0786
1.5	Medium Sand	3.9416	6.9400	7.3717	11.4986	9.7143	6.7863
2.0		6.6681	25.6424	23.9975	33.3251	31.6566	32.1462
2.5	Fine Sand	7.6788	31.5630	27.7948	32.7004	30.4045	37.3136
3.0		7.2527	20.4588	17.9167	15.4659	12.3289	16.4776
3.5	Very Fine Sand	3.7569	3.6766	3.6120	1.4428	0.6750	0.9335
4.0		1.6884	0.1342	0.2278	0.0104	0.0005	0.0009
4.5	Very Coarse Silt	0.7135	0.0350	0.2918	0.0273	0.0000	0.0000
5.0		0.8607	0.4768	1.1261	0.5011	0.0000	0.0000
5.5	Coarse Silt	0.9651	0.8612	1.2289	0.8625	0.0000	0.0000
6.0		0.9167	0.7826	0.9292	0.7615	0.0000	0.0000
6.5	Medium Silt	0.7820	0.5502	0.6732	0.5068	0.0000	0.0000
7.0		0.6714	0.4350	0.5826	0.3677	0.0000	0.0000
7.5	Fine Silt	0.5844	0.4115	0.5201	0.3160	0.0000	0.0000
8.0		0.4565	0.3358	0.3738	0.2071	0.0000	0.0000
8.5	Very Fine Silt	0.2399	0.1191	0.1158	0.0271	0.0000	0.0000
9.0		0.0256	0.0000	0.0000	0.0000	0.0000	0.0000
9.5	Clay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W43	W44	W45	W46	W47	W48
SAMPLE TYPE:		Polymodal, Very Poorly Sorted	Unimodal, Poorly Sorted	Unimodal, Poorly Sorted	Unimodal, Moderately Well Sorted	Unimodal, Poorly Sorted	Unimodal, Moderately Sorted
TEXTURAL GROUP:		Muddy Sandy Gravel	Gravelly Sand	Gravelly Sand	Slightly Gravelly Sand	Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:		Coarse Silty Sandy Very Fine Gravel	Very Fine Gravelly Fine Sand	Very Fine Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand	Very Fine Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	1576.72	225.83	234.77	242.34	269.17	240.04
	MEAN GRAIN SIZE (µm)	1121.450	224.877	244.951	238.518	289.901	243.351
	SORTING	6.530	2.056	2.791	1.472	2.269	1.717
	SKEWNESS	-0.228	0.238	0.184	-0.044	0.449	0.301
	KURTOSIS	0.941	2.282	3.013	1.041	2.854	2.078
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	-0.657	2.147	2.091	2.045	1.893	2.059
	MEAN GRAIN SIZE (phi):	-0.165	2.153	2.029	2.068	1.786	2.039
	SORTING	2.707	1.040	1.481	0.558	1.182	0.780
	SKEWNESS	0.228	-0.238	-0.184	0.044	-0.449	-0.301
	KURTOSIS	0.941	2.282	3.013	1.041	2.854	2.078
FOLK AND WARD METHOD (Description)	MEAN:	Very Coarse Sand	Fine Sand	Fine Sand	Fine Sand	Medium Sand	Fine Sand
	SORTING:	Very Poorly Sorted	Poorly Sorted	Poorly Sorted	Moderately Well Sorted	Poorly Sorted	Moderately Sorted
	SKEWNESS:	Fine Skewed	Coarse Skewed	Coarse Skewed	Symmetrical	Very Coarse Skewed	Very Coarse Skewed

	KURTOSIS:	Mesokurtic	Very Leptokurtic	Extremely Leptokurtic	Mesokurtic	Very Leptokurtic	Very Leptokurtic
BULK GRAIN SIZE	% GRAVEL:	43.752	5.738	10.654	0.931	12.804	4.244
	% SAND:	50.032	90.254	83.504	95.492	87.196	95.756
	% MUD:	6.216	4.007	5.842	3.577	0.000	0.000
	% V COARSE GRAVEL:	2.589	0.000	0.000	0.000	0.000	0.000
	% COARSE GRAVEL:	3.987	0.000	2.088	0.000	3.556	0.000
	% MEDIUM GRAVEL:	4.592	1.865	1.042	0.338	0.939	0.247
	% FINE GRAVEL:	12.743	1.908	3.451	0.070	3.293	1.824
	% V FINE GRAVEL:	19.842	1.966	4.074	0.523	5.016	2.173
	% V COARSE SAND:	15.260	1.582	2.297	0.402	2.193	2.020
	% COARSE SAND:	3.795	0.273	0.304	0.674	0.246	0.095
	% MEDIUM SAND:	10.626	32.669	31.443	44.904	41.448	39.039
	% FINE SAND:	14.922	51.933	45.635	48.065	42.636	53.673
	% V FINE SAND:	5.430	3.796	3.825	1.447	0.673	0.931
	% V COARSE SILT:	1.579	0.516	1.425	0.533	0.000	0.000
	% COARSE SILT:	1.877	1.640	2.152	1.620	0.000	0.000
	% MEDIUM SILT:	1.452	0.984	1.255	0.874	0.000	0.000
	% FINE SILT:	1.042	0.748	0.895	0.523	0.000	0.000
	% V FINE SILT:	0.265	0.119	0.115	0.027	0.000	0.000
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.000
% LOI @ 450°C		2.29	0.91	0.98	0.80	0.68	0.58

Grain Size (Phi)	Sediment Type	W49	W50	W51	W52	W53	W54
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

-5.0	Very Coarse Gravel	0.0000	0.0000	5.1701	0.0000	0.0000	0.0000
-4.5	Coarse Gravel	0.0000	1.9791	2.0530	0.0000	0.0000	0.0000
-4.0		1.0346	0.0000	0.4353	3.9405	0.0000	0.0000
-3.5	Medium Gravel	0.0000	0.1434	2.2330	0.6545	0.0000	0.0000
-3.0		0.1676	0.0000	2.4695	0.4409	1.4468	0.2974
-2.5	Fine Gravel	0.3784	1.2742	3.4664	0.5167	0.4459	0.6444
-2.0		0.1820	1.9910	10.3966	1.2676	0.6292	0.7790
-1.5	Very Fine Gravel	0.5652	3.9860	15.2523	1.0678	1.2833	0.9773
-1.0		0.6083	8.0755	13.7771	1.3433	0.9860	0.9489
-0.5	Very Coarse Sand	0.6706	13.3437	11.7698	1.2951	1.0603	0.9985
0.0		0.5796	15.7448	8.7413	0.8887	1.1297	0.8073
0.5	Coarse Sand	0.0609	17.2860	2.3753	0.0023	0.2260	0.0001
1.0		0.0751	15.5766	2.4771	0.3735	1.7334	0.1410
1.5	Medium Sand	5.6002	9.2627	2.5740	5.8948	11.5369	7.4122
2.0		30.7557	4.3858	3.3797	19.8105	28.0799	32.0494
2.5	Fine Sand	38.9642	2.3260	3.6681	26.0263	29.5908	36.1560
3.0		19.0147	1.7640	3.4068	20.7554	17.8914	17.4186
3.5	Very Fine Sand	1.3387	0.8119	1.7268	5.9489	2.9129	1.3650
4.0		0.0041	0.1962	0.7727	0.5856	0.0593	0.0049
4.5	Very Coarse Silt	0.0000	0.0266	0.3955	0.0418	0.0000	0.0000
5.0		0.0000	0.2739	0.5586	0.6782	0.0002	0.0000
5.5	Coarse Silt	0.0000	0.3842	0.6362	1.2274	0.0973	0.0000
6.0		0.0000	0.3473	0.6078	1.3314	0.2511	0.0000
6.5	Medium Silt	0.0000	0.2736	0.5185	1.2857	0.2592	0.0000
7.0		0.0000	0.2471	0.4314	1.3156	0.2137	0.0000
7.5	Fine Silt	0.0000	0.2192	0.3497	1.3258	0.1405	0.0000
8.0		0.0000	0.0811	0.2472	1.1330	0.0264	0.0000
8.5	Very Fine Silt	0.0000	0.0002	0.1093	0.6755	0.0000	0.0000
9.0		0.0000	0.0000	0.0009	0.1729	0.0000	0.0000
9.5	Clay	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W49	W50	W51	W52	W53	W54

SAMPLE TYPE:		Unimodal, Moderately Well Sorted	Unimodal, Poorly Sorted	Trimodal, Very Poorly Sorted	Unimodal, Poorly Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Gravelly Sand	Sandy Gravel	Gravelly Muddy Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:		Slightly Very Fine Gravelly Fine Sand	Very Fine Gravelly Coarse Sand	Sandy Very Fine Gravel	Coarse Gravelly Medium Silty Fine Sand	Slightly Very Fine Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	231.29	933.70	2273.79	213.62	246.28	239.24
	MEAN GRAIN SIZE (µm)	233.258	942.427	1604.963	219.131	251.805	240.787
	SORTING	1.443	2.401	4.892	3.562	1.894	1.662
	SKEWNESS	0.091	-0.003	-0.229	0.094	0.291	0.253
	KURTOSIS	1.115	1.176	1.702	3.553	1.869	1.826
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	2.112	0.099	-1.185	2.227	2.022	2.063
	MEAN GRAIN SIZE (phi):	2.100	0.086	-0.683	2.190	1.990	2.054
	SORTING	0.529	1.264	2.291	1.833	0.922	0.733
	SKEWNESS	-0.091	0.003	0.229	-0.094	-0.291	-0.253
	KURTOSIS	1.115	1.176	1.702	3.553	1.869	1.826
FOLK AND WARD METHOD (Description)	MEAN:	Fine Sand	Coarse Sand	Very Coarse Sand	Fine Sand	Medium Sand	Fine Sand
	SORTING:	Moderately Well Sorted	Poorly Sorted	Very Poorly Sorted	Poorly Sorted	Moderately Sorted	Moderately Sorted
	SKEWNESS:	Symmetrical	Symmetrical	Fine Skewed	Symmetrical	Coarse Skewed	Coarse Skewed
	KURTOSIS:	Leptokurtic	Leptokurtic	Very Leptokurtic	Extremely Leptokurtic	Very Leptokurtic	Very Leptokurtic
BULK GRAIN SIZE	% GRAVEL:	2.936	17.449	55.253	9.231	4.791	3.647
	% SAND:	97.064	80.698	40.892	81.581	94.221	96.353
	% MUD:	0.000	1.853	3.855	9.188	0.988	0.000

	% V COARSE GRAVEL:	0.000	0.000	4.942	0.000	0.000	0.000
	% COARSE GRAVEL:	1.035	1.979	2.717	3.940	0.000	0.000
	% MEDIUM GRAVEL:	0.168	0.143	4.703	1.095	1.447	0.297
	% FINE GRAVEL:	0.560	3.265	13.863	1.784	1.075	1.423
	% V FINE GRAVEL:	1.174	12.061	29.029	2.411	2.269	1.926
	% V COARSE SAND:	1.250	29.089	20.511	2.184	2.190	1.806
	% COARSE SAND:	0.149	32.884	4.858	0.390	1.987	0.159
	% MEDIUM SAND:	36.471	13.634	5.960	25.777	39.687	39.563
	% FINE SAND:	57.857	4.086	7.070	46.721	47.397	53.462
	% V FINE SAND:	1.337	1.005	2.492	6.510	2.960	1.364
	% V COARSE SILT:	0.000	0.303	0.958	0.727	0.001	0.000
	% COARSE SILT:	0.000	0.730	1.241	2.553	0.348	0.000
	% MEDIUM SILT:	0.000	0.520	0.949	2.599	0.472	0.000
	% FINE SILT:	0.000	0.301	0.598	2.462	0.167	0.000
	% V FINE SILT:	0.000	0.000	0.110	0.846	0.000	0.000
	% CLAY:	0.000	0.000	0.000	0.001	0.000	0.000
% LOI @ 450°C		0.65	1.72	1.92	1.28	4.53	0.51

Grain Size (Phi)	Sediment Type	W55	W56	W57	W58	W59	W60
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.5	Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.0		0.0000	0.0000	0.0000	9.4629	0.0000	0.0000
-3.5	Medium Gravel	0.0000	0.0000	10.0867	0.0000	0.0000	0.0000
-3.0		0.1970	0.2930	3.9043	4.0000	0.0000	0.0000
-2.5	Fine Gravel	0.2758	0.3786	1.7706	0.3200	0.0000	0.5274
-2.0		0.2364	0.3110	1.2520	0.5029	0.1422	0.3840
-1.5	Very Fine Gravel	0.2414	0.3922	1.9114	0.9143	0.2294	0.5320

-1.0		0.4286	0.3606	1.3891	1.0057	0.2386	0.7217
-0.5	Very Coarse Sand	0.2808	0.4012	1.3632	1.5657	0.2845	1.0825
0.0		0.2660	0.3471	1.0557	1.4629	0.3763	1.3370
0.5	Coarse Sand	0.0000	0.0000	0.0009	0.4414	0.0060	1.7030
1.0		0.5692	1.5434	3.7410	9.3898	8.2866	13.6394
1.5	Medium Sand	14.6685	19.3261	19.4518	25.8545	30.6134	30.7550
2.0		38.9643	40.6684	30.6092	29.3119	38.1985	31.6083
2.5	Fine Sand	32.5772	28.4587	18.7875	13.6100	18.5016	13.6780
3.0		10.9173	7.4085	4.6121	2.1564	3.1165	2.0272
3.5	Very Fine Sand	0.3773	0.1112	0.0646	0.0017	0.0062	0.0005
4.0		0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
4.5	Very Coarse Silt	0.0000	0.0000	0.0000	0.0000	0.0000	0.0518
5.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.3091
5.5	Coarse Silt	0.0000	0.0000	0.0000	0.0000	0.0000	0.4385
6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.3819
6.5	Medium Silt	0.0000	0.0000	0.0000	0.0000	0.0000	0.2963
7.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.2773
7.5	Fine Silt	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000
8.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0490
8.5	Very Fine Silt	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
9.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9.5	Clay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W55	W56	W57	W58	W59	W60
SAMPLE TYPE:		Unimodal, Well Sorted	Unimodal, Moderatel y Well Sorted	Bimodal, Very Poorly Sorted	Bimodal, Poorly Sorted	Unimodal, Moderatel y Well Sorted	Unimodal , Moderate ly Well Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Slightly Gravelly Sand	Gravelly Sand	Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:		Slightly Very Fine Gravelly	Slightly Very Fine Gravelly	Medium Gravelly	Coarse Gravelly	Slightly Very Fine Gravelly	Slightly Very Fine Gravelly

		Medium Sand	Medium Sand	Medium Sand	Medium Sand	Medium Sand	Medium Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	264.42	282.33	338.86	378.97	324.48	357.71
	MEAN GRAIN SIZE (µm)	263.085	283.060	731.100	588.451	324.604	362.276
	SORTING	1.408	1.418	4.246	3.420	1.432	1.572
	SKEWNESS	-0.018	-0.003	0.718	0.660	0.030	0.110
	KURTOSIS	1.023	1.000	2.169	2.555	0.991	1.186
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	1.919	1.825	1.561	1.400	1.624	1.483
	MEAN GRAIN SIZE (phi):	1.926	1.821	0.452	0.765	1.623	1.465
	SORTING	0.494	0.503	2.086	1.774	0.518	0.653
	SKEWNESS	0.018	0.003	-0.718	-0.660	-0.030	-0.110
	KURTOSIS	1.023	1.000	2.169	2.555	0.991	1.186
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand	Medium Sand	Coarse Sand	Coarse Sand	Medium Sand	Medium Sand
	SORTING:	Well Sorted	Moderately Well Sorted	Very Poorly Sorted	Poorly Sorted	Moderately Well Sorted	Moderately Well Sorted
	SKEWNESS:	Symmetrical	Symmetrical	Very Coarse Skewed	Very Coarse Skewed	Symmetrical	Coarse Skewed
	KURTOSIS:	Mesokurtic	Mesokurtic	Very Leptokurtic	Very Leptokurtic	Mesokurtic	Leptokurtic
BULK GRAIN SIZE	% GRAVEL:	1.379	1.735	20.314	16.206	0.610	2.165
	% SAND:	98.621	98.265	79.686	83.794	99.390	95.831
	% MUD:	0.000	0.000	0.000	0.000	0.000	2.004
	% V COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.000
	% COARSE GRAVEL:	0.000	0.000	0.000	9.463	0.000	0.000
	% MEDIUM GRAVEL:	0.197	0.293	13.991	4.000	0.000	0.000
	% FINE GRAVEL:	0.512	0.690	3.023	0.823	0.142	0.911
	% V FINE GRAVEL:	0.670	0.753	3.300	1.920	0.468	1.254
	% V COARSE SAND:	0.547	0.748	2.419	3.029	0.661	2.420

	% COARSE SAND:	0.604	1.589	3.788	9.892	8.365	15.415
	% MEDIUM SAND:	53.705	60.042	50.077	55.150	68.800	62.336
	% FINE SAND:	43.389	35.774	23.338	15.722	21.557	15.660
	% V FINE SAND:	0.376	0.111	0.064	0.002	0.006	0.001
	% V COARSE SILT:	0.000	0.000	0.000	0.000	0.000	0.363
	% COARSE SILT:	0.000	0.000	0.000	0.000	0.000	0.818
	% MEDIUM SILT:	0.000	0.000	0.000	0.000	0.000	0.573
	% FINE SILT:	0.000	0.000	0.000	0.000	0.000	0.249
	% V FINE SILT:	0.000	0.000	0.000	0.000	0.000	0.000
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.000
% LOI @ 450°C		0.56	0.66	0.73	0.65	0.45	0.50

Grain Size (Phi)	Sediment Type	W61	W62	W63	W64	W65	W66
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.5	Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.0		0.0000	2.3735	19.6968	0.0000	0.7333	0.0000
-3.5	Medium Gravel	0.0000	1.6007	2.6902	0.0000	0.2489	0.0000
-3.0		0.1713	1.1525	3.1688	0.1605	0.2330	0.0000
-2.5	Fine Gravel	0.3235	0.5259	2.5743	0.1081	0.2594	0.1278
-2.0		0.1570	0.8598	1.5844	0.1291	0.1112	0.0746
-1.5	Very Fine Gravel	0.2902	1.2302	2.2265	0.2267	0.8551	0.1119
-1.0		0.2616	1.2897	1.9025	0.4186	1.0669	0.0852
-0.5	Very Coarse Sand	0.3282	1.3125	2.1046	0.6070	2.1920	0.3303
0.0		0.3330	0.9787	1.9114	1.0186	6.3299	0.2344
0.5	Coarse Sand	0.1838	0.0355	0.9537	5.3717	21.2806	0.5771
1.0		6.6127	2.0077	6.2952	17.2089	28.0627	9.1250
1.5	Medium Sand	27.5153	16.1191	16.0835	28.9925	23.3654	28.8857

2.0		38.3106	33.6378	20.6722	28.5344	11.9395	37.0152
2.5	Fine Sand	21.0208	26.7403	12.7065	14.1157	2.7082	19.5341
3.0		4.4520	9.6799	3.9345	3.0303	0.0889	3.8843
3.5	Very Fine Sand	0.0400	0.4560	0.1585	0.0047	0.0001	0.0145
4.0		0.0000	0.0002	0.0001	0.0000	0.0339	0.0000
4.5	Very Coarse Silt	0.0000	0.0000	0.0332	0.0000	0.0553	0.0000
5.0		0.0000	0.0000	0.1897	0.0001	0.0825	0.0000
5.5	Coarse Silt	0.0000	0.0000	0.2653	0.0208	0.0416	0.0000
6.0		0.0000	0.0000	0.2311	0.0204	0.0305	0.0000
6.5	Medium Silt	0.0000	0.0000	0.1790	0.0187	0.1571	0.0000
7.0		0.0000	0.0000	0.1721	0.0131	0.1109	0.0000
7.5	Fine Silt	0.0000	0.0000	0.1719	0.0000	0.0130	0.0000
8.0		0.0000	0.0000	0.0936	0.0000	0.0000	0.0000
8.5	Very Fine Silt	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000
9.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9.5	Clay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W61	W62	W63	W64	W65	W66
SAMPLE TYPE:		Unimodal, Moderately Well Sorted	Unimodal, Poorly Sorted	Trimodal, Very Poorly Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Well Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Gravelly Sand	Sandy Gravel	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:		Slightly Very Fine Gravelly Medium Sand	Medium Gravelly Medium Sand	Sandy Coarse Gravel	Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Coarse Sand	Slightly Fine Gravelly Medium Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	312.93	286.84	450.79	373.29	576.63	321.64
	MEAN GRAIN SIZE (µm)	313.482	297.228	1220.745	379.904	579.023	321.887
	SORTING	1.449	2.301	6.008	1.581	1.667	1.453
	SKEWNESS	0.052	0.396	0.649	0.079	0.067	0.041

	KURTOSIS	0.996	2.788	0.575	1.035	1.071	0.986
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	1.676	1.802	1.149	1.422	0.794	1.636
	MEAN GRAIN SIZE (phi):	1.674	1.750	-0.288	1.396	0.788	1.635
	SORTING	0.535	1.202	2.587	0.661	0.737	0.539
	SKEWNESS	-0.052	-0.396	-0.649	-0.079	-0.067	-0.041
	KURTOSIS	0.996	2.788	0.575	1.035	1.071	0.986
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand	Medium Sand	Very Coarse Sand	Medium Sand	Coarse Sand	Medium Sand
	SORTING:	Moderately Well Sorted	Poorly Sorted	Very Poorly Sorted	Moderately Well Sorted	Moderately Sorted	Moderately Well Sorted
	SKEWNESS:	Symmetrical	Very Coarse Skewed	Very Coarse Skewed	Symmetrical	Symmetrical	Symmetrical
	KURTOSIS:	Mesokurtic	Very Leptokurtic	Very Platykurtic	Mesokurtic	Mesokurtic	Mesokurtic
BULK GRAIN SIZE	% GRAVEL:	1.204	9.032	33.844	1.043	3.508	0.400
	% SAND:	98.796	90.968	64.820	98.884	96.001	99.600
	% MUD:	0.000	0.000	1.336	0.073	0.491	0.000
	% V COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.000
	% COARSE GRAVEL:	0.000	2.374	19.697	0.000	0.733	0.000
	% MEDIUM GRAVEL:	0.171	2.753	5.859	0.160	0.482	0.000
	% FINE GRAVEL:	0.480	1.386	4.159	0.237	0.371	0.202
	% V FINE GRAVEL:	0.552	2.520	4.129	0.645	1.922	0.197
	% V COARSE SAND:	0.661	2.291	4.016	1.626	8.522	0.565
	% COARSE SAND:	6.861	2.081	7.287	22.649	49.398	9.770
	% MEDIUM SAND:	65.830	49.807	36.759	57.505	35.259	65.897
	% FINE SAND:	25.404	36.334	16.600	17.100	2.788	23.354
	% V FINE SAND:	0.040	0.454	0.158	0.005	0.034	0.014
	% V COARSE SILT:	0.000	0.000	0.224	0.000	0.138	0.000

	% COARSE SILT:	0.000	0.000	0.495	0.041	0.072	0.000
	% MEDIUM SILT:	0.000	0.000	0.351	0.032	0.268	0.000
	% FINE SILT:	0.000	0.000	0.266	0.000	0.013	0.000
	% V FINE SILT:	0.000	0.000	0.000	0.000	0.000	0.000
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.000
% LOI @ 450°C		0.72	0.79	0.86	0.69	0.59	0.53

Grain Size (Phi)	Sediment Type	W67	W68	W69	W70	W71	W72
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		0.0000	0.0000	0.0000	0.0000	0.0000	31.8236
-4.5	Coarse Gravel	0.0000	0.0000	3.1904	0.0000	0.0000	0.0000
-4.0		0.0000	11.3780	3.0284	0.0000	0.0000	0.0000
-3.5	Medium Gravel	0.0000	1.7985	1.1815	0.0000	0.0000	6.8129
-3.0		0.0000	2.4842	0.8573	0.0000	0.0000	1.6223
-2.5	Fine Gravel	0.0384	0.7555	1.3137	0.0000	0.0000	0.3473
-2.0		0.0769	0.5666	0.7635	0.0720	0.0000	0.4948
-1.5	Very Fine Gravel	0.1495	1.0963	0.4607	0.0336	0.0222	0.6661
-1.0		0.2648	1.2236	0.8829	0.0576	0.1775	1.1228
-0.5	Very Coarse Sand	0.4485	2.3692	2.9601	0.3265	0.2130	2.4787
0.0		0.6663	3.9706	6.3809	0.9123	0.2484	4.1867
0.5	Coarse Sand	5.3888	11.7357	17.0982	6.9718	0.6153	5.7783
1.0		16.5807	21.3686	25.3746	18.9181	7.6457	11.4016
1.5	Medium Sand	27.8041	22.8252	22.8963	29.4681	25.7561	15.1462
2.0		28.5295	14.1156	11.4845	27.2622	36.8539	12.4315
2.5	Fine Sand	15.6256	3.7839	2.0859	12.7774	22.4914	4.8886
3.0		4.2890	0.1905	0.0158	2.6142	5.8760	0.6268
3.5	Very Fine Sand	0.0860	0.0000	0.0000	0.0023	0.1005	0.0001
4.0		0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
4.5	Very Coarse Silt	0.0000	0.0083	0.0000	0.0452	0.0000	0.0000
5.0		0.0159	0.1263	0.0000	0.1965	0.0000	0.0176
5.5	Coarse Silt	0.0255	0.1113	0.0001	0.2034	0.0000	0.0537
6.0		0.0104	0.0196	0.0150	0.0604	0.0000	0.0425
6.5	Medium Silt	0.0000	0.0160	0.0102	0.0388	0.0000	0.0249
7.0		0.0000	0.0476	0.0000	0.0373	0.0000	0.0196
7.5	Fine Silt	0.0000	0.0088	0.0000	0.0021	0.0000	0.0118
8.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0017
8.5	Very Fine Silt	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9.5	Clay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W67	W68	W69	W70	W71	W72
SAMPLE TYPE:		Unimodal, Moderately Well Sorted	Bimodal, Very Poorly Sorted	Unimodal, Poorly Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Trimodal, Very Poorly Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Gravelly Sand	Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Sandy Gravel
SEDIMENT NAME:		Slightly Very Fine Gravelly Medium Sand	Coarse Gravelly Medium Sand	Coarse Gravelly Coarse Sand	Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand	Sandy Very Coarse Gravel
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	361.27	577.45	602.71	384.09	306.98	973.98
	MEAN GRAIN SIZE (µm)	365.374	1095.763	661.120	389.935	307.733	2305.393
	SORTING	1.585	4.095	2.594	1.570	1.472	7.141
	SKEWNESS	0.058	0.630	0.422	0.048	0.034	0.503
	KURTOSIS	0.992	1.790	2.195	0.987	0.977	0.482
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	1.469	0.792	0.730	1.380	1.704	0.038
	MEAN GRAIN SIZE (phi):	1.453	-0.132	0.597	1.359	1.700	-1.205
	SORTING	0.664	2.034	1.375	0.651	0.558	2.836
	SKEWNESS	-0.058	-0.630	-0.422	-0.048	-0.034	-0.503
	KURTOSIS	0.992	1.790	2.195	0.987	0.977	0.482
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand	Very Coarse Sand	Coarse Sand	Medium Sand	Medium Sand	Very Fine Gravel
	SORTING:	Moderately Well Sorted	Very Poorly Sorted	Poorly Sorted	Moderately Well Sorted	Moderately Well Sorted	Very Poorly Sorted
	SKEWNESS:	Symmetrical	Very Coarse Skewed	Very Coarse Skewed	Symmetrical	Symmetrical	Very Coarse Skewed

	KURTOSIS:	Mesokurtic	Very Leptokurtic	Very Leptokurtic	Mesokurtic	Mesokurtic	Very Platykurtic
BULK GRAIN SIZE	% GRAVEL:	0.530	19.303	11.678	0.163	0.200	42.890
	% SAND:	99.419	80.359	88.296	99.253	99.800	56.938
	% MUD:	0.052	0.338	0.025	0.584	0.000	0.172
	% V COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	30.418
	% COARSE GRAVEL:	0.000	11.378	6.219	0.000	0.000	1.405
	% MEDIUM GRAVEL:	0.000	4.283	2.039	0.000	0.000	8.435
	% FINE GRAVEL:	0.115	1.322	2.077	0.072	0.000	0.842
	% V FINE GRAVEL:	0.414	2.320	1.344	0.091	0.200	1.789
	% V COARSE SAND:	1.115	6.340	9.341	1.239	0.461	6.665
	% COARSE SAND:	22.035	33.158	42.527	25.960	8.322	17.216
	% MEDIUM SAND:	56.319	36.899	34.334	56.703	62.623	27.558
	% FINE SAND:	19.864	3.962	2.095	15.350	28.294	5.499
	% V FINE SAND:	0.086	0.000	0.000	0.002	0.100	0.000
	% V COARSE SILT:	0.016	0.135	0.000	0.243	0.000	0.018
	% COARSE SILT:	0.036	0.130	0.015	0.263	0.000	0.096
	% MEDIUM SILT:	0.000	0.063	0.010	0.076	0.000	0.044
	% FINE SILT:	0.000	0.009	0.000	0.002	0.000	0.014
	% V FINE SILT:	0.000	0.000	0.000	0.000	0.000	0.000
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.000
% LOI @ 450°C		0.57	0.74	0.75	0.84	0.72	0.89

Grain Size (Phi)	Sediment Type	W73	W74	W75	W76	W77	W78
-6.5	Cobble	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-6.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-5.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

-4.5	Coarse Gravel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-4.0		0.0000	0.0000	0.0000	0.0000	1.2164	0.0000
-3.5	Medium Gravel	0.0000	0.0000	0.0000	0.0000	2.3987	0.4023
-3.0		0.0000	0.4936	0.0000	0.0000	0.3349	0.0000
-2.5	Fine Gravel	0.0000	0.0123	0.0089	0.0000	0.5057	0.0050
-2.0		0.0354	0.2468	0.2322	0.0000	0.4989	0.1838
-1.5	Very Fine Gravel	0.0455	0.2962	0.2857	0.1259	0.6014	0.2036
-1.0		0.1061	0.2838	0.4465	0.0000	0.5740	0.4768
-0.5	Very Coarse Sand	0.1617	0.0864	0.6608	0.0599	0.6629	0.5562
0.0		0.3285	0.1234	0.6072	0.1259	0.4852	0.6208
0.5	Coarse Sand	0.6404	0.0000	0.1137	0.0000	0.0000	0.0001
1.0		8.1910	0.0006	0.0358	0.0000	0.0135	0.3295
1.5	Medium Sand	27.0984	0.6279	1.0686	0.0481	1.9723	9.3759
2.0		37.1222	11.6188	11.3229	4.1433	18.9932	32.2780
2.5	Fine Sand	21.2792	28.4593	27.7046	20.2267	32.8890	34.5179
3.0		4.9355	34.1527	35.5508	37.7636	26.5677	17.2241
3.5	Very Fine Sand	0.0560	14.1746	16.1060	24.9994	5.9567	1.6778
4.0		0.0000	2.4265	2.8449	7.8931	0.3332	0.0134
4.5	Very Coarse Silt	0.0000	0.0305	0.0195	0.3526	0.0535	0.0000
5.0		0.0000	0.5953	0.0003	0.0103	0.8692	0.0575
5.5	Coarse Silt	0.0000	1.4649	0.2425	0.5227	1.4099	0.4367
6.0		0.0000	1.5069	0.7007	1.0580	1.2145	0.5568
6.5	Medium Silt	0.0000	1.0930	0.7621	1.0107	0.8132	0.4223
7.0		0.0000	0.8015	0.5537	0.6954	0.6005	0.2924
7.5	Fine Silt	0.0000	0.7045	0.3851	0.4888	0.5200	0.2375
8.0		0.0000	0.5656	0.2833	0.3588	0.3882	0.1220
8.5	Very Fine Silt	0.0000	0.2338	0.0642	0.1168	0.1274	0.0098
9.0		0.0000	0.0011	0.0000	0.0000	0.0000	0.0000
9.5	Clay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10.5		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11.0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Parameter		W73	W74	W75	W76	W77	W78
SAMPLE TYPE:		Unimodal, Moderatel	Unimodal , Moderat	Unimodal, Moderatel	Unimodal, Moderatel	Unimoda l, Poorly Sorted	Unimodal, Moderatel

		y Well Sorted	ely Sorted	y Well Sorted	y Well Sorted		y Well Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:		Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand	Medium Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	312.94	165.75	166.70	141.15	201.27	237.31
	MEAN GRAIN SIZE (µm)	313.421	161.866	165.769	140.282	202.569	235.590
	SORTING	1.457	1.850	1.518	1.497	2.587	1.462
	SKEWNESS	0.048	-0.289	-0.017	-0.097	0.123	0.005
	KURTOSIS	0.964	1.994	1.088	1.061	3.427	1.044
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	1.676	2.593	2.585	2.825	2.313	2.075
	MEAN GRAIN SIZE (phi):	1.674	2.627	2.593	2.834	2.304	2.086
	SORTING	0.543	0.888	0.602	0.582	1.371	0.548
	SKEWNESS	-0.048	0.289	0.017	0.097	-0.123	-0.005
	KURTOSIS	0.964	1.994	1.088	1.061	3.427	1.044
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand	Fine Sand
	SORTING:	Moderatel y Well Sorted	Moderat ely Sorted	Moderatel y Well Sorted	Moderatel y Well Sorted	Poorly Sorted	Moderatel y Well Sorted
	SKEWNESS:	Symmetri cal	Fine Skewed	Symmetri cal	Symmetri cal	Coarse Skewed	Symmetri cal
	KURTOSIS:	Mesokurti c	Very Leptokurt ic	Mesokurti c	Mesokurti c	Extremel y Leptokur tic	Mesokurti c
BULK GRAIN SIZE	% GRAVEL:	0.187	1.333	0.973	0.126	6.130	1.271
	% SAND:	99.813	91.670	96.015	95.260	87.874	96.594
	% MUD:	0.000	6.997	3.011	4.614	5.996	2.135
	% V COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.000

	% COARSE GRAVEL:	0.000	0.000	0.000	0.000	1.216	0.000
	% MEDIUM GRAVEL:	0.000	0.494	0.000	0.000	2.734	0.402
	% FINE GRAVEL:	0.035	0.259	0.241	0.000	1.005	0.189
	% V FINE GRAVEL:	0.152	0.580	0.732	0.126	1.175	0.680
	% V COARSE SAND:	0.490	0.210	1.268	0.186	1.148	1.177
	% COARSE SAND:	8.895	0.002	0.152	0.000	0.018	0.352
	% MEDIUM SAND:	64.226	12.339	12.480	4.258	21.069	41.745
	% FINE SAND:	26.145	62.577	63.230	58.026	59.373	51.636
	% V FINE SAND:	0.056	16.543	18.885	32.790	6.265	1.684
	% V COARSE SILT:	0.000	0.634	0.021	0.366	0.930	0.060
	% COARSE SILT:	0.000	2.965	0.943	1.579	2.617	0.992
	% MEDIUM SILT:	0.000	1.893	1.315	1.705	1.412	0.714
	% FINE SILT:	0.000	1.272	0.669	0.848	0.909	0.360
	% V FINE SILT:	0.000	0.234	0.064	0.117	0.127	0.010
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.000
% LOI @ 450°C		0.98	1.14	1.03	1.33	0.97	0.76

Grain Size (Phi)	Sediment Type	W79	W80
-6.5	Cobble	0.0000	0.0000
-6.0		0.0000	0.0000
-5.5	Very Coarse Gravel	0.0000	0.0000
-5.0		0.0000	0.0000
-4.5	Coarse Gravel	0.0000	0.0000
-4.0		0.0000	0.0000
-3.5	Medium Gravel	0.0000	0.0000
-3.0		0.0000	0.0000
-2.5	Fine Gravel	0.0584	0.0000
-2.0		0.2663	0.0376
-1.5	Very Fine Gravel	0.1350	0.0031
-1.0		0.0328	0.0909
-0.5	Very Coarse Sand	0.1167	0.3071

0.0		0.2517	0.7802
0.5	Coarse Sand	0.7484	2.3390
1.0		8.7912	9.7043
1.5	Medium Sand	25.8091	22.8040
2.0		35.1093	31.3011
2.5	Fine Sand	21.7330	22.2850
3.0		6.2639	8.9500
3.5	Very Fine Sand	0.1509	0.6603
4.0		0.0000	0.0004
4.5	Very Coarse Silt	0.0008	0.0257
5.0		0.0577	0.1148
5.5	Coarse Silt	0.1511	0.2048
6.0		0.1368	0.1783
6.5	Medium Silt	0.1142	0.1114
7.0		0.0713	0.0905
7.5	Fine Silt	0.0014	0.0117
8.0		0.0000	0.0000
8.5	Very Fine Silt	0.0000	0.0000
9.0		0.0000	0.0000
9.5	Clay	0.0000	0.0000
10.0		0.0000	0.0000
10.5		0.0000	0.0000
11.0		0.0000	0.0000
Parameter		W79	W80
SAMPLE TYPE:		Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:		Slightly Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	309.45	303.84
	MEAN GRAIN SIZE (µm)	309.614	305.643
	SORTING	1.503	1.580
	SKEWNESS	0.016	0.028

	KURTOSIS	0.998	1.002
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	1.692	1.719
	MEAN GRAIN SIZE (phi):	1.691	1.710
	SORTING	0.588	0.660
	SKEWNESS	-0.016	-0.028
	KURTOSIS	0.998	1.002
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand	Medium Sand
	SORTING:	Moderately Well Sorted	Moderately Well Sorted
	SKEWNESS:	Symmetrical	Symmetrical
	KURTOSIS:	Mesokurtic	Mesokurtic
BULK GRAIN SIZE	% GRAVEL:	0.493	0.132
	% SAND:	98.974	99.131
	% MUD:	0.533	0.737
	% V COARSE GRAVEL:	0.000	0.000
	% COARSE GRAVEL:	0.000	0.000
	% MEDIUM GRAVEL:	0.000	0.000
	% FINE GRAVEL:	0.325	0.038
	% V FINE GRAVEL:	0.168	0.094
	% V COARSE SAND:	0.368	1.087
	% COARSE SAND:	9.601	12.097
	% MEDIUM SAND:	60.929	54.124
	% FINE SAND:	27.926	31.165
	% V FINE SAND:	0.150	0.658
	% V COARSE SILT:	0.059	0.142
	% COARSE SILT:	0.287	0.382
	% MEDIUM SILT:	0.185	0.202
	% FINE SILT:	0.001	0.012
	% V FINE SILT:	0.000	0.000
	% CLAY:	0.000	0.000
% LOI @ 450°C		0.58	0.74

12 Annex 7.1G: Biological Parameters

Station	Number of Taxa	Total Abundance	Total Biomass (g wet weight)	Margalef's d	Pielou's Evenness J	Shannon's Diversity H'
W1	19	21	0.2002	4.27	0.95	3.63
W2	14	15	0.1004	4.43	0.98	3.64
W3	26	37	20.5851	6.09	0.95	4.31
W4	24	37	0.1824	6.09	0.94	4.26
W5	19	19	0.0989	4.08	0.94	3.47
W6	24	40	0.5741	5.96	0.94	4.25
W7	18	33	0.2377	4.58	0.92	3.76
W8	23	31	0.2378	5.82	0.95	4.16
W9	19	30	0.1502	4.70	0.94	3.85
W10	10	16	17.5752	2.89	0.96	3.03
W11	18	23	0.2574	3.83	0.95	3.50
W12	34	54	9.7926	8.02	0.95	4.80
W13	21	36	4.0744	5.30	0.90	3.88
W14	31	69	1.672	6.85	0.90	4.44
W15	28	46	6.6602	6.27	0.95	4.41
W16	20	34	0.3672	5.39	0.94	4.05
W17	29	63	1.7665	6.52	0.93	4.47
W18	21	34	0.8492	4.54	0.94	3.83
W19	18	22	0.1413	4.85	0.97	3.88
W20	27	152	0.588	4.98	0.82	3.84
W21	28	53	2.6358	5.79	0.93	4.27
W22	32	83	10.52021	6.34	0.92	4.48
W23	27	48	11.1397	6.46	0.94	4.40
W24	40	126	1.3545	7.24	0.91	4.71
W25	21	39	14.3549	4.91	0.93	3.95
W26	24	42	0.3992	5.62	0.93	4.14
W27	33	62	2.3172	7.03	0.94	4.59
W28	40	191	1.5658	6.85	0.74	3.88
W29	23	30	3.3404	5.59	0.92	3.99
W30	22	40	3.0716	5.42	0.94	4.13
W31	29	48	0.5595	6.46	0.90	4.23
W32	17	33	1.112	4.00	0.91	3.54
W33	42	120	8.77706	8.56	0.90	4.86
W34	15	25	0.1268	4.04	0.89	3.40
W35	38	81	0.7408	7.05	0.92	4.58
W36	16	19	0.1395	4.08	0.90	3.33
W37	26	58	0.2056	5.91	0.89	4.12
W38	35	77	0.3457	7.60	0.91	4.64
W39	41	158	48.2465	6.72	0.81	4.16
W40	18	36	4.4659	4.46	0.92	3.75
W41	16	34	0.3116	4.25	0.91	3.63
W42	25	50	0.4318	5.88	0.93	4.28
W43	42	146	5.1437	7.42	0.85	4.46
W44	42	99	1.1352	8.49	0.90	4.81

Station	Number of Taxa	Total Abundance	Total Biomass (g wet weight)	Margalef's d	Pielou's Evenness J	Shannon's Diversity H'
W45	42	118	0.7556	8.59	0.89	4.81
W46	22	40	22.273	5.42	0.93	4.07
W47	22	35	1.4159	5.06	0.92	3.91
W48	16	33	1.2768	4.29	0.85	3.38
W49	22	58	0.7042	5.17	0.74	3.30
W50	49	454	77.1222	7.68	0.54	3.03
W51	35	168	140.4683	6.64	0.87	4.47
W52	22	31	0.6119	4.95	0.96	4.00
W53	20	30	1.0359	4.70	0.93	3.80
W54	11	38	0.0782	2.75	0.84	2.91
W55	19	51	0.3262	4.07	0.83	3.40
W56	16	67	0.2769	3.33	0.68	2.65
W57	27	64	0.8731	4.81	0.90	3.97
W58	11	19	0.0722	3.06	0.88	2.92
W59	17	29	2.1297	4.16	0.88	3.43
W60	23	46	0.2852	5.75	0.92	4.14
W61	22	39	0.1392	5.46	0.92	4.06
W62	15	24	0.2246	4.09	0.94	3.57
W63	35	54	1.3113	7.52	0.94	4.66
W64	28	74	0.5918	5.81	0.91	4.26
W65	30	85	10.8862	6.08	0.88	4.21
W66	19	34	0.5652	4.82	0.94	3.91
W67	21	61	1.8903	4.87	0.82	3.61
W68	21	45	0.2626	4.47	0.89	3.73
W69	19	37	0.1597	4.71	0.90	3.75
W70	21	39	0.4421	5.19	0.93	4.02
W71	12	38	0.2681	3.02	0.90	3.22
W72	12	12	0.0284	4.02	0.99	3.42
W73	11	22	0.0652	3.24	0.91	3.14
W74	24	36	0.49	5.58	0.93	4.10
W75	24	42	0.5534	5.35	0.92	4.03
W76	10	13	0.0451	3.12	0.97	3.09
W77	22	45	27.6711	4.99	0.91	3.95
W78	33	50	1.3936	7.41	0.93	4.58
W79	23	41	1.0046	5.12	0.91	3.94
W80	28	85	1.6533	5.63	0.84	3.96

13 Annex 7.1H: Benthic Species Data (abundance per 0.1m^2)

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Grania sp.															
Protodorvillea kefersteini															
Schistomeringos neglecta															
Lumbrineris aniara			1	3		2	1	4				1	8	3	
Lumbrineridae															p
Aponuphis bilineata				3		2									
Nothria conchylega															
Onuphidae sp. (damaged)					p										
Chrysopetalum debile															
Glycera alba				1											
Glycera capitata													1		
Glycera lapidum agg.					1	1									
Glycera oxycephala															
Glycera rouxii								1							
Glycera sp. (damaged)															
Glyceridae sp. (juvenile)															
Glycinde nordmanni		1						1							
Goniada maculata	1												1		
Goniadidae sp.															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Oxydromus flexuosus	1														
Podarkeopsis capensis												1			
Psamathe fusca															
Hesionidae sp. (damaged)															
Psamathinae (Hesiospina/Psamathe sp. damaged)															
Aglaophamus agilis															
Nephtys assimilis															
Nephtys caeca															
Nephtys cirrosa															
Nephtys hombergii													2		
Nephtys kersivalensis	1	1													
Nephtys spp. (juvenile/damaged)														1	
Nephtyidae spp.									p		1				
Nereis zonata								1							
Nereididae spp. (juvenile)															
Pholoe baltica								1							
Pholoe inornata			1												
Pholoe spp.	p				p										
Eteone flava/longa agg.					3										
Eteone sp. (damaged)															
Eulalia viridis												1			
Eumida sanguinea															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Phyllodoce groenlandica															
Phyllodoce maculata															
Phyllodoce rosea															
Phyllodoce sp. (juvenile)															
Phyllodocidae sp.															
Gattyana cirrhosa															
Malmgrenia castanea												1			
Malmgrenia ljungmani															
Malmgrenia sp.															
Polynoidae sp.						1								1	1
Polynoinae sp. (indet.)															
Neoleanira tetragona															
Pisione remota															
Sigalion mathildae												1			
Sigalion squamosus															
Sphaerodoridium minutum															
Sphaerodorum gracilis															
Exogone verugera								1							
Prosphaerosyllis sp.															
Syllis amica															
Trypanosyllis (Trypanosyllis) coeliaca															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Syllidae sp. (damaged)															
Aphroditoidea sp. (indet.)															
Galathowenia oculata												2		1	
Owenia fusiformis				1		1	1	2							
Owenia spp.															
Oweniidae sp.	p										p				
Jasmineira elegans						3									
Jasmineira sp. (damaged)															
Sabellidae															
Hydroides elegans															
Spirobranchus lamarcki															
Serpulidae sp.					p										
Magelona alleni	2		3	1					1	2		2	1	2	3
Magelona filiformis			1										1	1	
Magelona johnstoni															
Poecilochaetus serpens			1												
Aonides paucibranchiata						4									
Dipolydora caulleryi															
Dipolydora coeca agg.															
Laonice bahusiensis															
Laonice cirrata/bahusiensis															
Laonice sp. (damaged)															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Microspio mecznikowianus															
Polydora ciliata agg.								1							
Prionospio cirrifera															
Prionospio ehlersi															
Prionospio fallax	2				1		1		2		3		2	3	1
Pygospio elegans				1											
Scolelepis bonnieri				1											
Scolelepis (Scolelepis) foliosa															
Spio armata agg.															
Spio decorata								1							
Spiophanes bombyx	2		2	2			4		2	1		6		3	3
Spiophanes kroyeri			2					1				1	1		
Spionidae sp.		p			p										
Macrochaeta sp.															
Ampharete falcata															
Ampharete lindstroemi		1	1												
Ampharete sp. (juvenile)						1									
Aphelochaeta sp. (type 1)															
Chaetozone setosa				1					1			1	5	3	
Chaetozone zetlandica				1		3									
Cirratulus sp. (juvenile)															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Tharyx killariensis								1							1
Cirratulidae sp.					p										
Diplocirrus glaucus		1						1	2		1	1	1	2	5
Diplocirrus spp.	p														
Flabelligeridae															
Lagis koreni				1											
Pectinaria (Amphictene) auricoma									1					3	1
Pectinaria sp.															
Amphitrite cirrata															
Lanice conchilega		1				2		4							1
Pista cristata						6									
Pista elongata															
Axionice flexuosa															
Pista mirabilis															
Polycirrus sp.						1	1								
Terebellidae sp.															
Terebellides stroemii															
Capitella sp.			1		1										
Mediomastus fragilis								1					1		
Notomastus spp.						2									
Chaetopteridae sp.															
Leiochone johnstoni															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Clymenura sp.															
Euclymene lombricoides															
Euclymene oerstedii															
Euclymene sp. A															
Praxillura longissima															
Maldanidae			p			p					0				
Ophelia borealis					1										
Ophelia celtica															
Ophelia neglecta															
Orbinia sp.															
Scoloplos armiger				2		2									
Scoloplos sp. (indet.)															
Orbiniidae spp. (damaged)															
Aricidea (Acmira) cerrutii															
Aricidea (Acmira) laubieri															
Paraonides sp.															
Paraonidae sp.															
Polygordius spp.															
Scalibregma celticum															
Scalibregma inflatum					1										
Scalibregmatidae															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Travisia forbesii															
Acari															
Verruca stroemia															
Cirripedia sp. (Cyprid larvae)															
Copepoda sp.	1	1	2					3			3	2			1
Ampelisca brevicornis															
Ampelisca diadema															
Ampelisca tenuicornis	1											1			
Ampelisca typica															
Ampelisca sp.															
Atylus vedlomensis							2								
Atylus sp. (damaged)															
Bathyporeia gracilis												3			
Bathyporeia pelagica		1							1		2				
Bathyporeia pilosa															
Bathyporeia sarsi	2														2
Bathyporeia sp.															
Pariambus typicus			1						2				1	2	
Phtisica marina															
Pseudoprotella phasma															
Cheirocratus sp.															
Crassicorophium crassicorne															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Leptocheirus hirsutimanus					1										
Leptocheirus pectinatus															
Isaeidae sp. (damaged)															
Siphonoecetes (Centraloecetes) kroyeranus															
Siphonoecetes (Centraloecetes) striatus															
Leucothoe lilljeborgi														1	
Lepidepecreum longicornis															
Tryphosites longipes			1											2	
Othomaera othonis															
Maerella tenuimana															
Megaluropus agilis															
Melita palmata															
Perioculodes longimanus															
Westwoodilla caecula															
Gammaropsis sp. (damaged)															
Megamphopus cornutus															
Harpinia antennaria															
Harpinia serrata															
Paraphoxus oculatus											1				
Menigrates obtusifrons															
Urothoe elegans							2								

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Urothoe marina					1										
Urothoe sp.															
Amphipoda															
Iphinoe serrata															
Diastylis lucifera															1
Eudorellopsis deformis			1				1		1		1		1	1	1
Campylaspis undata															
Petalosarsia declivis															
Cumacea sp.											p				
Atelecyclus rotundatus															
Galathea intermedia															
Galathea sp.															
Ebalia cranchii									1						
Ebalia sp. (juvenile)															
Eurynome sp.															
Hyas coarctatus															
Paguridae sp. (juvenile/larvae)											1			1	
Liocarcinus pusillus															
Liocarcinus sp. (juvenile)															
Caridea zoea larvae												1			
Decapoda sp. (damaged)															
Decapoda sp. (larvae)				1			1	1							

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Astacilla damnoniensis				1											
Astacilla dilatata												1		1	1
Astacilla longicornis				1											
Gnathia oxyuraea															
Gnathia oxyuraea Praniza larvae															
Nebalia bipes															
Tanaopsis graciloides															1
Typhlotanais tenuicornis															
Tanaidacea sp. (juvenile)															
Ostracoda sp.															
Hippoporina pertusa															
Chaetognatha sp.													1		
Lotidae sp. (juvenile)															
Ammodytes sp.															
Microchirus variegatus															
Ascidiacea sp.															
Branchiostoma lanceolatum															
Actinopterygii sp. (damaged)															
Edwardsia claparedii	1			1								2			
Edwardsia spp. (indet.)															
Edwardsiidae sp.			2		1		4	1		3	p				p

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Halcampa chrysanthellum									1					1	
Actiniaria															
Alcyonium digitatum															
Cerianthus lloydii															
Cerianthus sp.															
Bougainvilliidae															
Campanulariidae sp.								p							
Calycella sp.															p
Sertulariidae sp.															
Hydrozoa sp. (damaged)												p			
Antedonidae sp. (damaged)															
Strongylocentrotus droebachiensis															
Strongylocentrotus sp.															
Echinocyamus pusillus				6		1	6	1	5					4	2
Echinocardium cordatum			1							1		1		1	1
Echinoidea sp. (damaged)	p												p		
Leptosynapta decaria															
Leptosynapta sp.												1			
Amphiura (Ophiopeltis) securigera															
Amphiura filiformis		2											2		
Amphiura (Amphiura) incana															
Amphiura sp. (juvenile)				2											

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Amphiuridae sp. (juvenile)	4														
Ophiura albida															
Ophiura ophiura															
Ophiura sarsii															
Ophiura sp. (juvenile)												1			
Ophiuridae sp. (juvenile)															
Ophiuroidea spp. (fragments)	p		p				p	p		p	p			p	
Ophiuroidea spp. (juvenile)							3		4					13	3
Hiatella arctica								1							
Ensis ensis						1									
Phaxas pellucidus	1	1	2				1	2	2		4	2	1		2
Pharidae sp.															
Glycymeris glycymeris															
Parvicardium pinnulatum															
Cardiidae sp. (damaged)															
Gari costulata															
Gari fervensis				1			1							1	
Gari tellinella															
Psammobiidae sp. (juvenile)															
Abra nitida												2			
Abra prismatica		1							1			1		2	

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Abra sp. (juvenile)												1			
Asbjornsenia pygmaea		1		2	4										
Fabulina fabula			2							1				1	
Limecola balthica															
Moerella sp. (juvenile)						1						3			
Astarte sulcata															
Goodallia triangularis															
Astartidae sp. (juvenile)															
Limaria hians															
Limatula subauriculata															
Lucinoma borealis	1													1	1
Parathyasira equalis															
Thyasira flexuosa												3	1		1
Thyasira sp. (juvenile)															
Crenella decussata															
Modiolus modiolus															
Mytilidae sp. (juvenile)															
Nucula hanleyi														1	
Nucula nitidosa												2			
Nucula nucleus															
Anomia ephippium															
Arctica islandica															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Chamelea gallina															
Chamelea striatula															
Clausinella fasciata			1			1						1			
Dosinia exoleta													3		
Dosinia lupinus															
Dosinia sp. (juvenile)															
Gouldia minima				1							1				
Polititapes rhomboides															
Timoclea ovata						1									
Venus casina		2	5				1		2	2				5	2
Spisula elliptica				2	2	1									
Kurtiella bidentata					1										
Kurtiella sp.															
Tellimya ferruginosa										3					
Cochlodesma praetenue							1								
Thracia villosiuscula			3	1						2		1			3
Thracia sp. (damaged)															
Chaetoderma nitidulum	1														
Cylichna cylindracea												1			1
Philine sp.			1												
Retusa obtusa															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Volvulella acuminata															
Eulima bilineata															
Euspira nitida									1					1	
Rissoidae sp. (juvenile)															
Turrisipho moebii															
Mangelia sp. (damaged)															
Turridae sp. (juvenile)												1			
Okenia sp.															
Nudibranchia eggs				p											
Pyrgiscus crenatus															
Pyramidellidae sp. (juvenile)															
Gibbula cineraria															
Gibbula tumida															
Gastropoda sp. (damaged)															
Leptochiton asellus															
Antalis entalis			1							1	2	4	1	2	
Antalis spp.															
Nematoda															
Nemertea			p		p	1					1	1			4
Phoronis muelleri															
Phoronis sp.															
Phoronida sp.		1	1				2	1			2		1	5	3

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Platyhelminthes sp.															
Cliona celata															
Suberitidae sp.															
Porifera sp.									p						
Golfingia (Golfingia) elongata						1									
Golfingia (Golfingia) vulgaris															
Golfingia sp.					1										
Phascolion (Phascolion) strombus															
Sipuncula sp. (juvenile)						1									
Astrorhiza															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Grania sp.					19								7		
Protodorvillea kefersteini															
Schistomeringos neglecta													2		
Lumbrineris aniara	2	5	1			1	2	2	9	1	1	3	3		1
Lumbrineridae															
Aponuphis bilineata													2		
Nothria conchylega				1											
Onuphidae sp. (damaged)															
Chrysopetalum debile															
Glycera alba															
Glycera capitata															
Glycera lapidum agg.					10										
Glycera oxycephala															
Glycera rouxii															
Glycera sp. (damaged)							p								
Glyceridae sp. (juvenile)															
Glycinde nordmanni															
Goniada maculata												1			
Goniadidae sp.				p											
Oxydromus flexuosus															
Podarkeopsis capensis															
Psamathe fusca															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Hesionidae sp. (damaged)									1						
Psamathinae (Hesiospina/Psamathe sp. damaged)													1		
Aglaophamus agilis					1								7		
Nephtys assimilis			1				4				1			1	
Nephtys caeca															
Nephtys cirrosa															
Nephtys hombergii															
Nephtys kersivalensis									4						
Nephtys spp. (juvenile/damaged)					p										
Nephtyidae spp.		p				2								1	
Nereis zonata															
Nereididae spp. (juvenile)												1			
Pholoe baltica							1								
Pholoe inornata										1					
Pholoe spp.															
Eteone flava/longa agg.					2										
Eteone sp. (damaged)															
Eulalia viridis															
Eumida sanguinea						3									

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Phyllodoce groenlandica															
Phyllodoce maculata															
Phyllodoce rosea								1							
Phyllodoce sp. (juvenile)															
Phyllodocidae sp.															
Gattyana cirrhosa															
Malmgrenia castanea															
Malmgrenia ljungmani													6		
Malmgrenia sp.															
Polynoidae sp.															
Polynoinae sp. (indet.)															
Neoleanira tetragona															
Pisione remota					7										
Sigalion mathildae															
Sigalion squamosus												1			
Sphaerodoridium minutum					1										
Sphaerodorum gracilis															
Exogone verugera															
Prosphaerosyllis sp.															
Syllis amica															
Trypanosyllis (Trypanosyllis) coeliaca															
Syllidae sp. (damaged)															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Aphroditoidea sp. (indet.)															
Galathowenia oculata		3					3		3			2			
Owenia fusiformis				1		2	p				1	2		1	2
Owenia spp.									p						
Oweniidae sp.															
Jasmineira elegans													13		
Jasmineira sp. (damaged)					8										
Sabellidae															
Hydroides elegans					1										
Spirobranchus lamarcki															
Serpulidae sp.															
Magelona alleni		1				5		1		1				1	4
Magelona filiformis		2		2			4	1			2	2			
Magelona johnstoni															
Poecilochaetus serpens															
Aonides paucibranchiata					17								10		
Dipolydora caulleryi													1		
Dipolydora coeca agg.														1	
Laonice bahusiensis															
Laonice cirrata/bahusiensis													2		
Laonice sp. (damaged)					1										

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Microspio mecznikowianus															
Polydora ciliata agg.															
Prionospio cirrifera															
Prionospio ehlersi															
Prionospio fallax	3	4	2	2		2	5	1	14	2	3			7	
Pygospio elegans															
Scolelepis bonnieri							1				1				
Scolelepis (Scolelepis) foliosa															
Spio armata agg.						1									
Spio decorata															
Spiophanes bombyx	1	4	3	1		4	1		3	1	5	4		2	2
Spiophanes kroyeri	1								1						
Spionidae sp.															
Macrochaeta sp.															
Ampharete falcata															
Ampharete lindstroemi				1		3						1			
Ampharete sp. (juvenile)									2						
Aphelochaeta sp. (type 1)															
Chaetozone setosa	1		2					3	5		1			1	
Chaetozone zetlandica													3		
Cirratulus sp. (juvenile)															
Tharyx killariensis							11								

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Cirratulidae sp.						p						p			
Diplocirrus glaucus	4	7	5	2		3	4		9	2	1	2		1	2
Diplocirrus spp.															
Flabelligeridae															
Lagis koreni															
Pectinaria (Amphictene) auricoma								1	1	1					
Pectinaria sp.															
Amphitrite cirrata					1										
Lanice conchilega		1		1	1	1	2		3				1		
Pista cristata															
Pista elongata															
Axionice flexuosa															
Pista mirabilis															
Polycirrus sp.		1													
Terebellidae sp.															
Terebellides stroemii															
Capitella sp.															
Mediomastus fragilis												1			
Notomastus spp.					9								12		
Chaetopteridae sp.															
Leiochone johnstoni															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Clymenura sp.								1							
Euclymene lombricoides															
Euclymene oerstedii	1	1							2		1				
Euclymene sp. A															
Praxillura longissima															
Maldanidae			p									p			
Ophelia borealis															
Ophelia celtica															
Ophelia neglecta															
Orbinia sp.															
Scoloplos armiger															
Scoloplos sp. (indet.)															
Orbiniidae spp. (damaged)															
Aricidea (Acmira) cerrutii															
Aricidea (Acmira) laubieri									1						
Paraonides sp.															
Paraonidae sp.															
Polygordius spp.					4								1		
Scalibregma celticum					1								2		
Scalibregma inflatum													1		
Scalibregmatidae			p												
Travisia forbesii															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Acari													1		
Verruca stroemia															
Cirripedia sp. (Cyprid larvae)															
Copepoda sp.	1		1		1				2				1	1	
Ampelisca brevicornis															
Ampelisca diadema															
Ampelisca tenuicornis									1						2
Ampelisca typica															
Ampelisca sp.															
Atylus vedlomensis															
Atylus sp. (damaged)															
Bathyporeia gracilis									7						
Bathyporeia pelagica		5	3					5							
Bathyporeia pilosa															
Bathyporeia sarsi															
Bathyporeia sp.															
Pariambus typicus		1				1		1	2						
Phtisica marina							1								
Pseudoprotella phasma					2										
Cheirocratus sp.															
Crassicorophium crassicorne															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Leptocheirus hirsutimanus													1		
Leptocheirus pectinatus															
Isaeidae sp. (damaged)															
Siphonoecetes (Centraloecetes) kroyeranus															
Siphonoecetes (Centraloecetes) striatus															
Leucothoe lilljeborgi	1														
Lepidepecreum longicornis															
Tryphosites longipes															
Othomaera othonis															
Maerella tenuimana															
Megaluropus agilis															
Melita palmata															
Perioculodes longimanus									2						
Westwoodilla caecula													2		
Gammaropsis sp. (damaged)															
Megamphopus cornutus															
Harpinia antennaria															
Harpinia serrata												1			
Paraphoxus oculatus															
Menigrates obtusifrons															
Urothoe elegans			1				2	1			2	1			2

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Urothoe marina															
Urothoe sp.				1											
Amphipoda															
Iphinoe serrata															
Diastylis lucifera															
Eudorellopsis deformis		2		1					1			1			
Campylaspis undata															
Petalosarsia declivis											1				
Cumacea sp.					1								p		
Atelecyclus rotundatus													1		
Galathea intermedia															
Galathea sp.												1			
Ebalia cranchii															
Ebalia sp. (juvenile)								p							
Eurynome sp.															
Hyas coarctatus															
Paguridae sp. (juvenile/larvae)	1			1											
Liocarcinus pusillus															
Liocarcinus sp. (juvenile)															
Caridea zoea larvae															
Decapoda sp. (damaged)														p	

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Decapoda sp. (larvae)									2	1	3				
Astacilla damnoniensis						1						3			
Astacilla dilatata							1		1	3	2			1	1
Astacilla longicornis															
Gnathia oxyuraea								1					1		
Gnathia oxyuraea Praniza larvae								1					1		
Nebalia bipes													1		
Tanaopsis graciloides	1	1				1						2			
Typhlotanais tenuicornis									1						
Tanaidacea sp. (juvenile)															
Ostracoda sp.									1						
Hippoporina pertusa															
Chaetognatha sp.							1								
Lotidae sp. (juvenile)															
Ammodytes sp.															
Microchirus variegatus															
Ascidiacea sp.															
Branchiostoma lanceolatum															
Actinopterygii sp. (damaged)															
Edwardsia claparedii															
Edwardsia spp. (indet.)									p	p					
Edwardsiidae sp.	1	3				p					p	3			

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Halcampa chrysanthellum															1
Actiniaria															
Alcyonium digitatum															
Cerianthus lloydii													1		
Cerianthus sp.															
Bougainvilliidae									p						
Campanulariidae sp.															
Calycella sp.															
Sertulariidae sp.															
Hydrozoa sp. (damaged)															
Antedonidae sp. (damaged)															
Strongylocentrotus droebachiensis															
Strongylocentrotus sp.					1										
Echinocyamus pusillus		1	2	3	17	8	5	4	3		7	9	29	2	6
Echinocardium cordatum							1	1		1				1	1
Echinoidea sp. (damaged)						p									
Leptosynapta decaria						1									
Leptosynapta sp.													2		
Amphiura (Ophiopeltis) securigera															
Amphiura filiformis															1

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Amphiura (Amphiura) incana				1											
Amphiura sp. (juvenile)	2														
Amphiuridae sp. (juvenile)									7						
Ophiura albida															
Ophiura ophiura															
Ophiura sarsii															
Ophiura sp. (juvenile)														1	
Ophiuridae sp. (juvenile)															
Ophiuroidea spp. (fragments)			p			p				p	p	p	p	p	
Ophiuroidea spp. (juvenile)		3			7		1	5					3		
Hiatella arctica															
Ensis ensis															
Phaxas pellucidus	5	4		2		2	4		4	2	1	1			
Pharidae sp.															
Glycymeris glycymeris															
Parvicardium pinnulatum															
Cardiidae sp. (damaged)															
Gari costulata															
Gari fervensis			1				2		5	1		1			
Gari tellinella															
Psammobiidae sp. (juvenile)															
Abra nitida									4						

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Abra prismatica	3		2				3	2		3	2	2		1	1
Abra sp. (juvenile)															
Asbjornsenia pygmaea													1		
Fabulina fabula	1	1	2			2	8	4	1		2				3
Limecola balthica													1		
Moerella sp. (juvenile)															
Astarte sulcata															
Goodallia triangularis															
Astartidae sp. (juvenile)															
Limaria hians															
Limatula subauriculata															
Lucinoma borealis	1	1				1	2	1		1					
Parathyasira equalis									1	3					
Thyasira flexuosa		1						1							
Thyasira sp. (juvenile)															
Crenella decussata													1		
Modiolus modiolus															
Mytilidae sp. (juvenile)															
Nucula hanleyi															
Nucula nitidosa			1				1								
Nucula nucleus															1

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Anomia ephippium															
Arctica islandica												1			
Chamelea gallina															
Chamelea striatula											1	3			1
Clausinella fasciata							2								
Dosinia exoleta									2	2					1
Dosinia lupinus															
Dosinia sp. (juvenile)															
Gouldia minima															
Polititapes rhomboides					1										
Timoclea ovata															
Venus casina		4		1				3	7	4					
Spisula elliptica		1	1								2	1			
Kurtiella bidentata															
Kurtiella sp.															
Tellimya ferruginosa															
Cochlodesma praetenue			5												
Thracia villosiuscula	1					1	5		9	7		2		1	1
Thracia sp. (damaged)															
Chaetoderma nitidulum															
Cylichna cylindracea						1			1						
Philine sp.															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Retusa obtusa															
Volvulella acuminata														1	
Eulima bilineata															
Euspira nitida						1		2			1		2		
Rissoidae sp. (juvenile)															
Turrisipho moebii														1	
Mangelia sp. (damaged)													1		
Turridae sp. (juvenile)		1													
Okenia sp.												1			
Nudibranchia eggs															
Pyrgiscus crenatus															
Pyramidellidae sp. (juvenile)								1							
Gibbula cineraria															
Gibbula tumida															
Gastropoda sp. (damaged)															
Leptochiton asellus					1										
Antalis entalis	2	1						2							1
Antalis spp.							2					4		2	
Nematoda					27								57		
Nemertea		2		1	10	3		1	4			2	8		3
Phoronis muelleri															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Phoronis sp.															
Phoronida sp.	1	1	1	p		3	3	1	p	2	1	3		2	3
Platyhelminthes sp.		1													
Cliona celata							p						p		p
Suberitidae sp.														p	
Porifera sp.															
Golfingia (Golfingia) elongata					1										
Golfingia (Golfingia) vulgaris															
Golfingia sp.							1								
Phascolion (Phascolion) strombus													2		
Sipuncula sp. (juvenile)															
Astrorhiza			p												

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Grania sp.									3						
Protodorvillea kefersteini									1				1		
Schistomeringos neglecta															
Lumbrineris aniara	2	7	6	5	12	1	1	7					32	7	8
Lumbrineridae															
Aponuphis bilineata									2				3		2
Nothria conchylega			1												
Onuphidae sp. (damaged)														p	
Chrysopetalum debile															
Glycera alba				1	2			1	11						
Glycera capitata														1	
Glycera lapidum agg.															
Glycera oxycephala													8		
Glycera rouxii															
Glycera sp. (damaged)															
Glyceridae sp. (juvenile)															
Glycinde nordmanni															1
Goniada maculata								2							
Goniadidae sp.									p			1			
Oxydromus flexuosus															
Podarkeopsis capensis			1		1										

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Psamathe fusca												1	3		
Hesionidae sp. (damaged)															
Psamathinae (Hesiospina/Psamathe sp. damaged)															
Aglaophamus agilis															
Nephtys assimilis	1													1	
Nephtys caeca															
Nephtys cirrosa			2												
Nephtys hombergii															
Nephtys kersivalensis						1			1						
Nephtys spp. (juvenile/damaged)										p					
Nephtyidae spp.							p	p	p						
Nereis zonata									1				1		
Nereididae spp. (juvenile)															
Pholoe baltica															
Pholoe inornata					1										
Pholoe spp.															
Eteone flava/longa agg.															
Eteone sp. (damaged)															
Eulalia viridis															
Eumida sanguinea					1	1							1		1
Phyllodoce groenlandica															
Phyllodoce maculata			1												

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Phyllodoce rosea									1						
Phyllodoce sp. (juvenile)			1												
Phyllodocidae sp.															
Gattyana cirrhosa	1	1			1										1
Malmgrenia castanea									5						
Malmgrenia ljungmani															
Malmgrenia sp.															1
Polynoidae sp.			2	1		1		1							
Polynoinae sp. (indet.)														1	
Neoleanira tetragona															
Pisione remota									13	1					
Sigalion mathildae															
Sigalion squamosus															
Sphaerodoridium minutum									1						
Sphaerodorum gracilis									1						
Exogone verugera															
Prosphaerosyllis sp.															
Syllis amica															
Trypanosyllis (Trypanosyllis) coeliaca															
Syllidae sp. (damaged)															
Aphroditoidea sp. (indet.)									p						

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Galathowenia oculata			2												
Owenia fusiformis	1	3	1		2	1	1	1	4	1		3		1	1
Owenia spp.															
Oweniidae sp.															
Jasmineira elegans									4						
Jasmineira sp. (damaged)															
Sabellidae													7		
Hydroides elegans													p		
Spirobranchus lamarcki													2		
Serpulidae sp.															
Magelona alleni	1	2	4									1			
Magelona filiformis	1						2				1	4		2	
Magelona johnstoni														1	
Poecilochaetus serpens															
Aonides paucibranchiata									26				2		
Dipolydora caulleryi									1						
Dipolydora coeca agg.			1		4									1	
Laonice bahusiensis															
Laonice cirrata/bahusiensis															
Laonice sp. (damaged)															
Microspio mecznikowianus											1				
Polydora ciliata agg.															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Prionospio cirrifera															
Prionospio ehlersi			3												
Prionospio fallax	3				1		1	4				2		1	2
Pygospio elegans										4					
Scolelepis bonnieri			1												
Scolelepis (Scolelepis) foliosa															
Spio armata agg.															
Spio decorata															
Spiophanes bombyx	3	1	13	5	3		4	10			1	1		13	14
Spiophanes kroyeri					1									4	
Spionidae sp.															
Macrochaeta sp.									1						
Ampharete falcata														1	
Ampharete lindstroemi															1
Ampharete sp. (juvenile)														1	1
Aphelochaeta sp. (type 1)							1	2							
Chaetozone setosa								2						1	2
Chaetozone zetlandica													4		
Cirratulus sp. (juvenile)															
Tharyx killariensis	1	1													
Cirratulidae sp.															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Diplocirrus glaucus	2		2				1					1			1
Diplocirrus spp.															
Flabelligeridae															
Lagis koreni	1			1											
Pectinaria (Amphictene) auricoma	1						1	1				1			
Pectinaria sp.															
Amphitrite cirrata															
Lanice conchilega								6	2	3				2	
Pista cristata															
Pista elongata															
Axionice flexuosa															
Pista mirabilis													2		
Polycirrus sp.					2			1							
Terebellidae sp.									p						
Terebellides stroemii															
Capitella sp.					2										
Mediomastus fragilis								1							
Notomastus spp.									6					1	
Chaetopteridae sp.												p			
Leiochone johnstoni															
Clymenura sp.															
Euclymene lombricoides			1												

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Euclymene oerstedii						1									
Euclymene sp. A										1					
Praxillura longissima															
Maldanidae	p		1		p						1			1	
Ophelia borealis															
Ophelia celtica															
Ophelia neglecta															
Orbinia sp.															
Scoloplos armiger													1		3
Scoloplos sp. (indet.)															
Orbiniidae spp. (damaged)															
Aricidea (Acmira) cerrutii															
Aricidea (Acmira) laubieri													1		
Paraonides sp.														1	
Paraonidae sp.															
Polygordius spp.									p						
Scalibregma celticum															
Scalibregma inflatum		3	1		2			1					3	1	
Scalibregmatidae															
Travisia forbesii															
Acari															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Verruca stroemia													1		
Cirripedia sp. (Cyprid larvae)															
Copepoda sp.	1						2	3		2	2	2			
Ampelisca brevicornis															
Ampelisca diadema															1
Ampelisca tenuicornis			1					1					3		1
Ampelisca typica															
Ampelisca sp.					1										
Atylus vedlomensis									2				9		
Atylus sp. (damaged)															
Bathyporeia gracilis															5
Bathyporeia pelagica			2	1	3		1	3						3	
Bathyporeia pilosa						6									
Bathyporeia sarsi															
Bathyporeia sp.			3												2
Pariambus typicus			1		1			1				1			
Phtisica marina															
Pseudoprotella phasma															
Cheirocratus sp.						1									
Crassicorophium crassicorne															
Leptocheirus hirsutimanus									2						
Leptocheirus pectinatus													1		

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Isaeidae sp. (damaged)													3		
Siphonoecetes (Centraloecetes) kroyeranus			1												3
Siphonoecetes (Centraloecetes) striatus														3	
Leucothoe lilljeborgi														1	
Lepidepecreum longicornis							2								
Tryphosites longipes												1			2
Othomaera othonis													1		
Maerella tenuimana							1								
Megaluropus agilis															
Melita palmata														1	
Perioculodes longimanus														1	
Westwoodilla caecula															
Gammaropsis sp. (damaged)															
Megamphopus cornutus			1												
Harpinia antennaria			2												
Harpinia serrata															
Paraphoxus oculatus													1		
Menigrates obtusifrons															
Urothoe elegans	1	3			3		1			4		1		3	7
Urothoe marina															
Urothoe sp.															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Amphipoda															
Iphinoe serrata															
Diastylis lucifera															
Eudorellopsis deformis			3		1		1				2	1			
Campylaspis undata									1						
Petalosarsia declivis															
Cumacea sp.															
Atelecyclus rotundatus															
Galathea intermedia													2		
Galathea sp.															
Ebalia cranchii								1							
Ebalia sp. (juvenile)															
Eurynome sp.															
Hyas coarctatus													3		
Paguridae sp. (juvenile/larvae)					1										
Liocarcinus pusillus									1						
Liocarcinus sp. (juvenile)															
Caridea zoea larvae															
Decapoda sp. (damaged)															
Decapoda sp. (larvae)	1														
Astacilla damnoniensis									1						
Astacilla dilatata		1						1						1	

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Astacilla longicornis			1												
Gnathia oxyuraea											1		11		
Gnathia oxyuraea Praniza larvae							1		1				5		
Nebalia bipes													1		
Tanaopsis graciloides					3			1							3
Typhlotanais tenuicornis														1	
Tanaidacea sp. (juvenile)															
Ostracoda sp.															
Hippoporina pertusa													p		
Chaetognatha sp.															
Lotidae sp. (juvenile)															
Ammodytes sp.															
Microchirus variegatus															
Ascidiacea sp.															
Branchiostoma lanceolatum															
Actinopterygii sp. (damaged)															
Edwardsia claparedii														3	4
Edwardsia spp. (indet.)			3												
Edwardsiidae sp.				4	p			1				3			
Halcampa chrysanthellum		2					3	2							
Actiniaria															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Alcyonium digitatum															
Cerianthus lloydii										1					
Cerianthus sp.															
Bougainvilliidae															
Campanulariidae sp.															
Calycella sp.															
Sertulariidae sp.					p										
Hydrozoa sp. (damaged)															
Antedonidae sp. (damaged)															1
Strongylocentrotus droebachiensis															
Strongylocentrotus sp.															
Echinocyamus pusillus	11	1	5	1	6		9	3	29	7	5	5	10	2	2
Echinocardium cordatum			1												
Echinoidea sp. (damaged)															
Leptosynapta decaria															
Leptosynapta sp.															
Amphiura (Ophiopeltis) securigera															
Amphiura filiformis															
Amphiura (Amphiura) incana										1					
Amphiura sp. (juvenile)															
Amphiuridae sp. (juvenile)														6	
Ophiura albida					6								3		

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Ophiura ophiura															
Ophiura sarsii															
Ophiura sp. (juvenile)	1		6												
Ophiuridae sp. (juvenile)													6		
Ophiuroidea spp. (fragments)	p				p										
Ophiuroidea spp. (juvenile)						1	9	6	7	2	1	1			8
Hiatella arctica															
Ensis ensis															
Phaxas pellucidus			1	1				2						1	1
Pharidae sp.															
Glycymeris glycymeris															
Parvicardium pinnulatum								1							
Cardiidae sp. (damaged)						1									
Gari costulata															8
Gari fervensis	2	1	2	1	2	1	1	1	1			1		2	
Gari tellinella															
Psammobiidae sp. (juvenile)															
Abra nitida															
Abra prismatica				1	3		3				3	2		4	
Abra sp. (juvenile)															3
Asbjornsenia pygmaea							1								

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Fabulina fabula	2		5	1	1	1	3			1	5	5		5	2
Limecola balthica															
Moerella sp. (juvenile)															
Astarte sulcata															
Goodallia triangularis															
Astartidae sp. (juvenile)															
Limaria hians															
Limatula subauriculata															
Lucinoma borealis															1
Parathyasira equalis															
Thyasira flexuosa	1							1							
Thyasira sp. (juvenile)															1
Crenella decussata									2						1
Modiolus modiolus															
Mytilidae sp. (juvenile)													1		
Nucula hanleyi					1										
Nucula nitidosa			1												1
Nucula nucleus	1														
Anomia ephippium															
Arctica islandica															
Chamelea gallina			4												
Chamelea striatula										1	2				

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Clausinella fasciata			14										1		11
Dosinia exoleta					1									4	
Dosinia lupinus									1						
Dosinia sp. (juvenile)															3
Gouldia minima											1				
Polititapes rhomboides									1						
Timoclea ovata													1		
Venus casina					4			1						4	
Spisula elliptica															
Kurtiella bidentata															
Kurtiella sp.															
Tellimya ferruginosa															
Cochlodesma praetenue							6		1						
Thracia villosiuscula	3		7	1	3	2		2		2	6	5		8	3
Thracia sp. (damaged)					p										
Chaetoderma nitidulum															
Cylichna cylindracea	1														1
Philine sp.														1	
Retusa obtusa															
Volvulella acuminata															1
Eulima bilineata															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Euspira nitida	1	1	2		1			2	6	1	1				1
Rissoidae sp. (juvenile)															
Turrisipho moebii															
Mangelia sp. (damaged)															
Turridae sp. (juvenile)															
Okenia sp.															
Nudibranchia eggs															
Pyrgiscus crenatus											1				
Pyramidellidae sp. (juvenile)															
Gibbula cineraria															
Gibbula tumida															
Gastropoda sp. (damaged)															
Leptochiton asellus													1		
Antalis entalis	1		1									1			
Antalis spp.															
Nematoda									12				1		1
Nemertea		5	5			p	1	1	5	1		2	3	1	
Phoronis muelleri			4												
Phoronis sp.															1
Phoronida sp.	3	1		1	5		1	3		3		4	5	2	
Platyhelminthes sp.													2		
Cliona celata		p		p	p	p			p				p	p	

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Suberitidae sp.															
Porifera sp.															
Golfingia (Golfingia) elongata															
Golfingia (Golfingia) vulgaris									1						
Golfingia sp.															
Phascolion (Phascolion) strombus															
Sipuncula sp. (juvenile)															
Astrorhiza	p	p				p							p		

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Grania sp.															
Protodorvillea kefersteini					8										
Schistomeringos neglecta															
Lumbrineris aniara	1	3	1	1		1	2	3							1
Lumbrineridae												p		p	
Aponuphis bilineata		3			1	1						2			1
Nothria conchylega															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Onuphidae sp. (damaged)															
Chrysopetalum debile						3									
Glycera alba															
Glycera capitata												1			
Glycera lapidum agg.					7										
Glycera oxycephala															
Glycera rouxii															
Glycera sp. (damaged)															
Glyceridae sp. (juvenile)															
Glycinde nordmanni					3										
Goniada maculata	1	1					1								
Goniadidae sp.															
Oxydromus flexuosus															
Podarkeopsis capensis					2										
Psamathe fusca															
Hesionidae sp. (damaged)															
Psamathinae (Hesiospina/Psamathe sp. damaged)															
Aglaophamus agilis															
Nephtys assimilis		2													
Nephtys caeca			1											1	
Nephtys cirrosa															
Nephtys hombergii															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Nephtys kersivalensis								1		1					
Nephtys spp. (juvenile/damaged)															
Nephtyidae spp.	1										1				
Nereis zonata															
Nereididae spp. (juvenile)							1								
Pholoe baltica						4									
Pholoe inornata															
Pholoe spp.															
Eteone flava/longa agg.					5										
Eteone sp. (damaged)					1										
Eulalia viridis															
Eumida sanguinea															
Phyllodoce groenlandica															
Phyllodoce maculata															
Phyllodoce rosea				2	3										1
Phyllodoce sp. (juvenile)															
Phyllodocidae sp.															
Gattyana cirrhosa					3										
Malmgrenia castanea															
Malmgrenia ljungmani			1												
Malmgrenia sp.															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Polynoidae sp.					5										1
Polynoinae sp. (indet.)												1			
Neoleanira tetragona	1			1											
Pisione remota				1	25										
Sigalion mathildae															
Sigalion squamosus														2	
Sphaerodoridium minutum															
Sphaerodorum gracilis															
Exogone verugera					4										
Prosphaerosyllis sp.															
Syllis amica					12										
Trypanosyllis (Trypanosyllis) coeliaca					2										
Syllidae sp. (damaged)												p			
Aphroditoidea sp. (indet.)															
Galathowenia oculata															
Owenia fusiformis	p		1				2							1	
Owenia spp.															
Oweniidae sp.		p						p							
Jasmineira elegans					4										
Jasmineira sp. (damaged)															
Sabellidae						5									
Hydroides elegans															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Spirobranchus lamarcki															
Serpulidae sp.															
Magelona alleni															
Magelona filiformis		1				1		1							
Magelona johnstoni															
Poecilochaetus serpens															
Aonides paucibranchiata					15	3					1				
Dipolydora caulleryi															
Dipolydora coeca agg.															
Laonice bahusiensis					1										
Laonice cirrata/bahusiensis															
Laonice sp. (damaged)															
Microspio mecznikowianus															
Polydora ciliata agg.															
Prionospio cirrifera															
Prionospio ehlersi															
Prionospio fallax					1										
Pygospio elegans															
Scolelepis bonnieri															
Scolelepis (Scolelepis) foliosa															
Spio armata agg.															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Spio decorata					3										
Spiophanes bombyx	2	1	3	1			2	2	6	1	4	7			1
Spiophanes kroyeri		1													
Spionidae sp.														p	
Macrochaeta sp.															
Ampharete falcata															
Ampharete lindstroemi															
Ampharete sp. (juvenile)															
Aphelochaeta sp. (type 1)															
Chaetozone setosa		1						1				1			
Chaetozone zetlandica															
Cirratulus sp. (juvenile)						1									
Tharyx killariensis				3					1	1					
Cirratulidae sp.															
Diplocirrus glaucus															
Diplocirrus spp.															
Flabelligeridae							p								
Lagis koreni															
Pectinaria (Amphictene) auricoma	1														
Pectinaria sp.															
Amphitrite cirrata															
Lanice conchilega				1		2	3					2		1	

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Pista cristata															
Pista elongata															
Axionice flexuosa												3			
Pista mirabilis															
Polycirrus sp.							1								1
Terebellidae sp.															
Terebellides stroemii															
Capitella sp.							1								
Mediomastus fragilis															
Notomastus spp.					7	6						2			
Chaetopteridae sp.										p					
Leiochone johnstoni															
Clymenura sp.															
Euclymene lombricoides															
Euclymene oerstedii															
Euclymene sp. A															
Praxillura longissima															
Maldanidae					p					p					
Ophelia borealis											1	4			
Ophelia celtica															
Ophelia neglecta				1											

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Orbinia sp.															
Scoloplos armiger	2												1		1
Scoloplos sp. (indet.)												1			
Orbiniidae spp. (damaged)												p			
Aricidea (Acmira) cerrutii										1					
Aricidea (Acmira) laubieri															
Paraonides sp.															
Paraonidae sp.					1										
Polygordius spp.				1	5										
Scalibregma celticum															
Scalibregma inflatum							4								
Scalibregmatidae															
Travisia forbesii				1						1	2				3
Acari															
Verruca stroemia															
Cirripedia sp. (Cyprid larvae)															
Copepoda sp.	1			1				1						1	
Ampelisca brevicornis															1
Ampelisca diadema															
Ampelisca tenuicornis										2					
Ampelisca typica															
Ampelisca sp.															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Atylus vedlomensis						6									
Atylus sp. (damaged)					1										
Bathyporeia gracilis															
Bathyporeia pelagica	3	3	2	5				1	3	2		9	1	1	2
Bathyporeia pilosa															
Bathyporeia sarsi															
Bathyporeia sp.															
Pariambus typicus		1													
Phtisica marina			1												
Pseudoprotella phasma															
Cheirocratus sp.															
Crassicorophium crassicorne															
Leptocheirus hirsutimanus															
Leptocheirus pectinatus					2										
Isaeidae sp. (damaged)															
Siphonoecetes (Centraloecetes) kroyeranus															
Siphonoecetes (Centraloecetes) striatus															
Leucothoe lilljeborgi															
Lepidepecreum longicornis															
Tryphosites longipes															
Othomaera othonis						5									

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Maerella tenuimana															
Megaluropus agilis															
Melita palmata															
Perioculodes longimanus															
Westwoodilla caecula															
Gammaropsis sp. (damaged)															
Megamphopus cornutus															
Harpinia antennaria															
Harpinia serrata															
Paraphoxus oculatus															
Menigrates obtusifrons															
Urothoe elegans							3								
Urothoe marina															
Urothoe sp.															1
Amphipoda															
Iphinoe serrata															
Diastylis lucifera															
Eudorellopsis deformis	2							1	1						
Campylaspis undata												1			
Petalosarsia declivis															
Cumacea sp.															
Atelecyclus rotundatus					1										

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Galathea intermedia					2										
Galathea sp.						1									
Ebalia cranchii															
Ebalia sp. (juvenile)															
Eurynome sp.										1					
Hyas coarctatus															
Paguridae sp. (juvenile/larvae)															
Liocarcinus pusillus															
Liocarcinus sp. (juvenile)															
Caridea zoea larvae															
Decapoda sp. (damaged)													p		
Decapoda sp. (larvae)	1	1	1				p						1		
Astacilla damnoniensis															
Astacilla dilatata															
Astacilla longicornis															
Gnathia oxyuraea						5									
Gnathia oxyuraea Praniza larvae															
Nebalia bipes															
Tanaopsis graciloides															
Typhlotanais tenuicornis															
Tanaidacea sp. (juvenile)															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Ostracoda sp.															
Hippoporina pertusa															
Chaetognatha sp.															1
Lotidae sp. (juvenile)															
Ammodytes sp.															
Microchirus variegatus					1										
Ascidiacea sp.															
Branchiostoma lanceolatum															
Actinopterygii sp. (damaged)											1				
Edwardsia claparedii					1										
Edwardsia spp. (indet.)															
Edwardsiidae sp.	2		1		1			1							2
Halcampa chrysanthellum				1			1								
Actiniaria															
Alcyonium digitatum															
Cerianthus lloydii															
Cerianthus sp.															
Bougainvilliidae												p			
Campanulariidae sp.															
Calycella sp.															
Sertulariidae sp.															
Hydrozoa sp. (damaged)															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Antedonidae sp. (damaged)															
Strongylocentrotus droebachiensis					1										
Strongylocentrotus sp.						5									
Echinocyamus pusillus	8	7	11	26	17	20	2	5	13	17	35	10	5	9	4
Echinocardium cordatum	2									1					
Echinoidea sp. (damaged)															
Leptosynapta decaria															
Leptosynapta sp.															
Amphiura (Ophiopeltis) securigera				1											
Amphiura filiformis															
Amphiura (Amphiura) incana			2												
Amphiura sp. (juvenile)										4					
Amphiuridae sp. (juvenile)												5	5		
Ophiura albida															
Ophiura ophiura	1														
Ophiura sarsii															
Ophiura sp. (juvenile)															
Ophiuridae sp. (juvenile)											1				
Ophiuroidea spp. (fragments)		p					p	p							
Ophiuroidea spp. (juvenile)		1			13	8			2						3
Hiatella arctica															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Ensis ensis															
Phaxas pellucidus										1					
Pharidae sp.															
Glycymeris glycymeris					3	2									
Parvicardium pinnulatum															
Cardiidae sp. (damaged)															
Gari costulata															
Gari fervensis	2	2	1	2			1	4		2	2	3	1	2	
Gari tellinella					4	7									
Psammobiidae sp. (juvenile)															
Abra nitida				1											
Abra prismatica	3							1		5	7				2
Abra sp. (juvenile)															
Asbjornsenia pygmaea				1					1			3	2	1	4
Fabulina fabula															
Limecola balthica															
Moerella sp. (juvenile)					5										
Astarte sulcata						2									
Goodallia triangularis					1	4									1
Astartidae sp. (juvenile)															
Limaria hians						3									
Limatula subauriculata						1									

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Lucinoma borealis															
Parathyasira equalis															
Thyasira flexuosa															
Thyasira sp. (juvenile)															
Crenella decussata		3				2		2	3	4			1	1	8
Modiolus modiolus						4									
Mytilidae sp. (juvenile)															
Nucula hanleyi															
Nucula nitidosa															
Nucula nucleus															
Anomia ephippium															
Arctica islandica															
Chamelea gallina															
Chamelea striatula					7		1								
Clausinella fasciata			4			7									
Dosinia exoleta					1		1				1				1
Dosinia lupinus				2	1			1							
Dosinia sp. (juvenile)															
Gouldia minima			1										1	2	
Polititapes rhomboides					1	1									
Timoclea ovata															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Venus casina										3	3			3	
Spisula elliptica	1	1	1		2	5		1		4	3	3		2	4
Kurtiella bidentata							1								
Kurtiella sp.					1										
Tellimya ferruginosa															
Cochlodesma praetenue		1													
Thracia villosiuscula	1			2				3	5		4	2	1		
Thracia sp. (damaged)															
Chaetoderma nitidulum															
Cylichna cylindracea															
Philine sp.											1				
Retusa obtusa						1									
Volvulella acuminata															
Eulima bilineata															
Euspira nitida				2	1	1		1	2					1	1
Rissoidae sp. (juvenile)					1										
Turrisipho moebii															
Mangelia sp. (damaged)															
Turridae sp. (juvenile)															
Okenia sp.															
Nudibranchia eggs												p			
Pyrgiscus crenatus															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Pyramidellidae sp. (juvenile)					1										
Gibbula cineraria						3									
Gibbula tumida						1									
Gastropoda sp. (damaged)															
Leptochiton asellus						25									
Antalis entalis															
Antalis spp.															
Nematoda					261	19									
Nemertea	1			1	5	3	2				p	1			
Phoronis muelleri															
Phoronis sp.															
Phoronida sp.	3	1	1				2		1			2		1	1
Platyhelminthes sp.		1			1							1			
Cliona celata		p					p	p				p			
Suberitidae sp.															
Porifera sp.															
Golfingia (Golfingia) elongata															
Golfingia (Golfingia) vulgaris															
Golfingia sp.															
Phascolion (Phascolion) strombus															
Sipuncula sp. (juvenile)															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Astrorhiza															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Grania sp.	1								3	2					
Protodorvillea kefersteini															
Schistomeringos neglecta															
Lumbrineris aniara			3			1		1						4	2
Lumbrineridae	p	p							p						
Aponuphis bilineata			1	1	2	1				1		1			
Nothria conchylega															
Onuphidae sp. (damaged)															
Chrysopetalum debile															
Glycera alba			1												
Glycera capitata	1														
Glycera lapidum agg.					6			5							
Glycera oxycephala															
Glycera rouxii															
Glycera sp. (damaged)															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Glyceridae sp. (juvenile)							1								
Glycinde nordmanni				1											
Goniada maculata															
Goniadidae sp.								1							
Oxydromus flexuosus															
Podarkeopsis capensis															
Psamathe fusca															
Hesionidae sp. (damaged)			p												
Psamathinae (Hesiospina/Psamathe sp. damaged)															
Aglaophamus agilis			1		3				2						
Nephtys assimilis		1													
Nephtys caeca															
Nephtys cirrosa															
Nephtys hombergii															
Nephtys kersivalensis													1		
Nephtys spp. (juvenile/damaged)															
Nephtyidae spp.	1			1										1	1
Nereis zonata															
Nereididae spp. (juvenile)															
Pholoe baltica														1	
Pholoe inornata															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Pholoe spp.															
Eteone flava/longa agg.															
Eteone sp. (damaged)															
Eulalia viridis															
Eumida sanguinea						1									
Phyllodoce groenlandica					1										
Phyllodoce maculata															1
Phyllodoce rosea															
Phyllodoce sp. (juvenile)															
Phyllodocidae sp.			p					1							
Gattyana cirrhosa								2							
Malmgrenia castanea															
Malmgrenia ljungmani							2								
Malmgrenia sp.															
Polynoidae sp.				1								1			
Polynoinae sp. (indet.)															
Neoleanira tetragona															
Pisione remota					5				1						
Sigalion mathildae															
Sigalion squamosus										2					
Sphaerodoridium minutum															
Sphaerodorum gracilis															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Exogone verugera															
Prosphaerosyllis sp.								1							
Syllis amica					1							1			
Trypanosyllis (Trypanosyllis) coeliaca				1											
Syllidae sp. (damaged)															
Aphroditoidea sp. (indet.)					p										
Galathowenia oculata															
Owenia fusiformis						1				1					
Owenia spp.															
Oweniidae sp.															
Jasmineira elegans															
Jasmineira sp. (damaged)															
Sabellidae															
Hydroides elegans															
Spirobranchus lamarcki			2												
Serpulidae sp.															
Magelona alleni														2	3
Magelona filiformis															1
Magelona johnstoni															
Poecilochaetus serpens					1										
Aonides paucibranchiata					8			1	2						

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Dipolydora caulleryi															
Dipolydora coeca agg.															
Laonice bahusiensis															
Laonice cirrata/bahusiensis															
Laonice sp. (damaged)															
Microspio mecznikowianus															
Polydora ciliata agg.															
Prionospio cirrifera															
Prionospio ehlersi															
Prionospio fallax															
Pygospio elegans															
Scolelepis bonnieri															
Scolelepis (Scolelepis) foliosa			1												
Spio armata agg.											1				
Spio decorata					4										
Spiophanes bombyx	2	5	5	4		1	3		1	3	3		3	2	4
Spiophanes kroyeri															
Spionidae sp.								p							
Macrochaeta sp.															
Ampharete falcata															
Ampharete lindstroemi															
Ampharete sp. (juvenile)															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Aphelochaeta sp. (type 1)															
Chaetozone setosa				2									1	5	
Chaetozone zetlandica			1												
Cirratulus sp. (juvenile)															
Tharyx killariensis															
Cirratulidae sp.															
Diplocirrus glaucus														1	1
Diplocirrus spp.															
Flabelligeridae															
Lagis koreni															
Pectinaria (Amphictene) auricoma															1
Pectinaria sp.															
Amphitrite cirrata															
Lanice conchilega		1				1	1								
Pista cristata															
Pista elongata									1						
Axionice flexuosa															
Pista mirabilis															
Polycirrus sp.			4	1											
Terebellidae sp.															
Terebellides stroemii														1	

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Capitella sp.															
Mediomastus fragilis															
Notomastus spp.	1	2		3	1										
Chaetopteridae sp.															
Leiochone johnstoni												P			
Clymenura sp.															
Euclymene lombricoides															1
Euclymene oerstedii															
Euclymene sp. A															
Praxillura longissima															
Maldanidae						p				p				p	p
Ophelia borealis	1			1	1				1						
Ophelia celtica										1					
Ophelia neglecta							1								
Orbinia sp.		1													
Scoloplos armiger			4	7		2				1			1		
Scoloplos sp. (indet.)															
Orbiniidae spp. (damaged)								p							
Aricidea (Acmira) cerrutii				1				1							
Aricidea (Acmira) laubieri															
Paraonides sp.															
Paraonidae sp.															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Polygordius spp.					8										
Scalibregma celticum															
Scalibregma inflatum			1												
Scalibregmatidae															
Travisia forbesii		2		3		4	1				2				
Acari															
Verruca stroemia															
Cirripedia sp. (Cyprid larvae)			1												
Copepoda sp.	2											1		1	2
Ampelisca brevicornis			1												
Ampelisca diadema															
Ampelisca tenuicornis	1														
Ampelisca typica					1										
Ampelisca sp.															
Atylus vedlomensis															
Atylus sp. (damaged)															
Bathyporeia gracilis															
Bathyporeia pelagica	1	1				2	3		1	3	1			1	3
Bathyporeia pilosa															
Bathyporeia sarsi															
Bathyporeia sp.			1										1		

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Pariambus typicus															
Phtisica marina															
Pseudoprotella phasma															
Cheirocratus sp.															
Crassicorophium crassicorne		2													
Leptocheirus hirsutimanus								1							
Leptocheirus pectinatus															
Isaeidae sp. (damaged)															
Siphonoecetes (Centraloecetes) kroyeranus															
Siphonoecetes (Centraloecetes) striatus															
Leucothoe lilljeborgi								2							
Lepidepecreum longicornis															
Tryphosites longipes															
Othomaera othonis															
Maerella tenuimana															
Megaluropus agilis							1								
Melita palmata															
Perioculodes longimanus	2		1												
Westwoodilla caecula															
Gammaropsis sp. (damaged)			1						1						
Megamphopus cornutus															
Harpinia antennaria															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Harpinia serrata															
Paraphoxus oculatus															
Menigrates obtusifrons															
Urothoe elegans			1				3	3							1
Urothoe marina									1						
Urothoe sp.															
Amphipoda				p											
Iphinoe serrata														1	
Diastylis lucifera															
Eudorellopsis deformis															1
Campylaspis undata															
Petalosarsia declivis	1														
Cumacea sp.															
Atelecyclus rotundatus															
Galathea intermedia															
Galathea sp.			1												
Ebalia cranchii			1												
Ebalia sp. (juvenile)															
Eurynome sp.															
Hyas coarctatus															
Paguridae sp. (juvenile/larvae)	1						1								

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Liocarcinus pusillus															
Liocarcinus sp. (juvenile)															1
Caridea zoea larvae															
Decapoda sp. (damaged)															
Decapoda sp. (larvae)										1	1				
Astacilla damnoniensis			1												
Astacilla dilatata															
Astacilla longicornis															
Gnathia oxyuraea			4									1			
Gnathia oxyuraea Praniza larvae															
Nebalia bipes															
Tanaopsis graciloides			1												
Typhlotanais tenuicornis															
Tanaidacea sp. (juvenile)														1	
Ostracoda sp.															
Hippoporina pertusa															
Chaetognatha sp.															
Lotidae sp. (juvenile)					1										
Ammodytes sp.							1								
Microchirus variegatus															
Ascidiacea sp.				1											
Branchiostoma lanceolatum					1										

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Actinopterygii sp. (damaged)															
Edwardsia claparedii															
Edwardsia spp. (indet.)															
Edwardsiidae sp.															
Halcampa chrysanthellum			1											1	
Actiniaria				p											
Alcyonium digitatum			p												
Cerianthus lloydii															
Cerianthus sp.			1												
Bougainvilliidae															
Campanulariidae sp.															
Calycella sp.															
Sertulariidae sp.															
Hydrozoa sp. (damaged)															
Antedonidae sp. (damaged)															
Strongylocentrotus droebachiensis															
Strongylocentrotus sp.															
Echinocyamus pusillus	3	3	4	7	3	1	5	4		1		1	1		8
Echinocardium cordatum															
Echinoidea sp. (damaged)															
Leptosynapta decaria															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Leptosynapta sp.															
Amphiura (Ophiopeltis) securigera															
Amphiura filiformis															
Amphiura (Amphiura) incana															
Amphiura sp. (juvenile)									2						
Amphiuridae sp. (juvenile)					3										
Ophiura albida															
Ophiura ophiura															
Ophiura sarsii															
Ophiura sp. (juvenile)															
Ophiuridae sp. (juvenile)															
Ophiuroidea spp. (fragments)														p	p
Ophiuroidea spp. (juvenile)	2	2	2	4		5	1	2		2			1		3
Hiatella arctica			2												
Ensis ensis											1				
Phaxas pellucidus									1	1				4	1
Pharidae sp.					1										
Glycymeris glycymeris															
Parvicardium pinnulatum															
Cardiidae sp. (damaged)															
Gari costulata															
Gari fervensis	1	1		2		2	1			1	1		2		

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Gari tellinella															
Psammobiidae sp. (juvenile)					1										
Abra nitida															
Abra prismatica	1			3						2	5		6	3	1
Abra sp. (juvenile)															
Asbjornsenia pygmaea	6		1	10	8	3	19	10	9	7	6	2			
Fabulina fabula														2	
Limecola balthica															
Moerella sp. (juvenile)															
Astarte sulcata															
Goodallia triangularis				2	1		1								
Astartidae sp. (juvenile)					1										
Limaria hians															
Limatula subauriculata				1											
Lucinoma borealis															1
Parathyasira equalis															
Thyasira flexuosa															
Thyasira sp. (juvenile)															
Crenella decussata	6			2						2			2		
Modiolus modiolus															
Mytilidae sp. (juvenile)															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Nucula hanleyi															
Nucula nitidosa															
Nucula nucleus															
Anomia ephippium			3												
Arctica islandica															
Chamelea gallina															
Chamelea striatula										1					
Clausinella fasciata					1			2							
Dosinia exoleta							1				4				
Dosinia lupinus															
Dosinia sp. (juvenile)															
Gouldia minima					1	1									
Polititapes rhomboides															
Timoclea ovata												1			
Venus casina		1				3				1	7		3	1	
Spisula elliptica	2			7	14	3	5	5	3	4	6				
Kurtiella bidentata															
Kurtiella sp.															
Tellimya ferruginosa															
Cochlodesma praetenue				5										1	
Thracia villosiuscula						1	7			2					
Thracia sp. (damaged)															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Chaetoderma nitidulum															
Cylichna cylindracea															
Philine sp.			1												
Retusa obtusa															
Volvulella acuminata															
Eulima bilineata									1						
Euspira nitida	2				1	1								1	2
Rissoidae sp. (juvenile)															
Turrisipho moebii															
Mangelia sp. (damaged)															
Turridae sp. (juvenile)															
Okenia sp.															
Nudibranchia eggs															
Pyrgiscus crenatus															
Pyramidellidae sp. (juvenile)															
Gibbula cineraria															
Gibbula tumida															
Gastropoda sp. (damaged)												1			
Leptochiton asellus															
Antalis entalis														1	3
Antalis spp.															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Nematoda					4			2	4						
Nemertea		1		1	2				2			1		1	
Phoronis muelleri															
Phoronis sp.															
Phoronida sp.		1		2			1		1					p	
Platyhelminthes sp.	1		1									1			
Cliona celata			p		p			p							
Suberitidae sp.															
Porifera sp.															
Golfingia (Golfingia) elongata															
Golfingia (Golfingia) vulgaris							2								
Golfingia sp.								1							
Phascolion (Phascolion) strombus															
Sipuncula sp. (juvenile)															
Astrorhiza															p

Taxa	W76	W77	W78	W79	W80
Grania sp.					

Taxa	W76	W77	W78	W79	W80
Protodorvillea kefersteini					
Schistomeringos neglecta					
Lumbrineris aniara		7	1		
Lumbrineridae					
Aponuphis bilineata				1	2
Nothria conchylega					
Onuphidae sp. (damaged)					
Chrysopetalum debile					
Glycera alba					
Glycera capitata					
Glycera lapidum agg.					
Glycera oxycephala					
Glycera rouxii					
Glycera sp. (damaged)					
Glyceridae sp. (juvenile)					
Glycinde nordmanni					
Goniada maculata					
Goniadidae sp.					
Oxydromus flexuosus					
Podarkeopsis capensis					
Psamathe fusca					
Hesionidae sp. (damaged)					p

Taxa	W76	W77	W78	W79	W80
Psamathinae (Hesiospina/Psamathe sp. damaged)					
Aglaophamus agilis					
Nephtys assimilis					
Nephtys caeca					
Nephtys cirrosa					
Nephtys hombergii					
Nephtys kersivalensis					
Nephtys spp. (juvenile/damaged)					
Nephtyidae spp.				p	p
Nereis zonata					
Nereididae spp. (juvenile)			1		
Pholoe baltica					
Pholoe inornata					
Pholoe spp.					
Eteone flava/longa agg.					
Eteone sp. (damaged)					
Eulalia viridis					
Eumida sanguinea					
Phyllodoce groenlandica					
Phyllodoce maculata					

Taxa	W76	W77	W78	W79	W80
Phyllodoce rosea					
Phyllodoce sp. (juvenile)					
Phyllodocidae sp.			p		
Gattyana cirrhosa					
Malmgrenia castanea					
Malmgrenia ljungmani					
Malmgrenia sp.					
Polynoidae sp.					
Polynoinae sp. (indet.)					
Neoleanira tetragona					
Pisione remota					
Sigalion mathildae					
Sigalion squamosus				1	
Sphaerodoridium minutum					
Sphaerodorum gracilis					
Exogone verugera					
Prosphaerosyllis sp.					
Syllis amica					
Trypanosyllis (Trypanosyllis) coeliaca					
Syllidae sp. (damaged)					
Aphroditoidea sp. (indet.)					

Taxa	W76	W77	W78	W79	W80
Galathowenia oculata		1			
Owenia fusiformis		1			2
Owenia spp.					
Oweniidae sp.					
Jasmineira elegans					
Jasmineira sp. (damaged)					
Sabellidae					
Hydroides elegans					
Spirobranchus lamarcki					
Serpulidae sp.					
Magelona alleni	2	3			
Magelona filiformis			1		
Magelona johnstoni					
Poecilochaetus serpens					
Aonides paucibranchiata				1	
Dipolydora caulleryi					
Dipolydora coeca agg.					
Laonice bahusiensis					
Laonice cirrata/bahusiensis					
Laonice sp. (damaged)					
Microspio mecznikowianus					
Polydora ciliata agg.					

Taxa	W76	W77	W78	W79	W80
Prionospio cirrifera	1				
Prionospio ehlersi					
Prionospio fallax			2		
Pygospio elegans					
Scolelepis bonnieri					
Scolelepis (Scolelepis) foliosa					1
Spio armata agg.					
Spio decorata					
Spiophanes bombyx		2	2	1	8
Spiophanes kroyeri					
Spionidae sp.					
Macrochaeta sp.					
Ampharete falcata					
Ampharete lindstroemi					
Ampharete sp. (juvenile)					
Aphelochaeta sp. (type 1)					
Chaetozone setosa					1
Chaetozone zetlandica					
Cirratulus sp. (juvenile)					
Tharyx killariensis			1		
Cirratulidae sp.					
Diplocirrus glaucus	1				

Taxa	W76	W77	W78	W79	W80
Diplocirrus spp.					
Flabelligeridae					
Lagis koreni					
Pectinaria (Amphictene) auricoma		1	2		
Pectinaria sp.	p				
Amphitrite cirrata					
Lanice conchilega			2	1	
Pista cristata					
Pista elongata					
Axionice flexuosa					
Pista mirabilis					
Polycirrus sp.					1
Terebellidae sp.					
Terebellides stroemii					
Capitella sp.					
Mediomastus fragilis					
Notomastus spp.					
Chaetopteridae sp.					
Leiochone johnstoni					1
Clymenura sp.					
Euclymene lombricoides					

Taxa	W76	W77	W78	W79	W80
Euclymene oerstedii					
Euclymene sp. A					
Praxillura longissima			1		
Maldanidae		1		p	
Ophelia borealis				1	1
Ophelia celtica					
Ophelia neglecta					
Orbinia sp.					
Scoloplos armiger			1	4	1
Scoloplos sp. (indet.)					
Orbiniidae spp. (damaged)					
Aricidea (Acmira) cerrutii					1
Aricidea (Acmira) laubieri					
Paraonides sp.					
Paraonidae sp.					
Polygordius spp.					
Scalibregma celticum					
Scalibregma inflatum					
Scalibregmatidae					
Travisia forbesii					5
Acari					
Verruca stroemia					

Taxa	W76	W77	W78	W79	W80
Cirripedia sp. (Cyprid larvae)					
Copepoda sp.	2		1		
Ampelisca brevicornis					
Ampelisca diadema					
Ampelisca tenuicornis					
Ampelisca typica					
Ampelisca sp.					
Atylus vedlomensis					
Atylus sp. (damaged)					
Bathyporeia gracilis					
Bathyporeia pelagica	1		7		1
Bathyporeia pilosa					
Bathyporeia sarsi		1			
Bathyporeia sp.					
Pariambus typicus			1		
Phtisica marina					
Pseudoprotella phasma					
Cheirocratus sp.					
Crassicorophium crassicorne					
Leptocheirus hirsutimanus					
Leptocheirus pectinatus					
Isaeidae sp. (damaged)					

Taxa	W76	W77	W78	W79	W80
Siphonoecetes (Centraloecetes) kroyeranus					
Siphonoecetes (Centraloecetes) striatus					
Leucothoe lilljeborgi					
Lepidepecreum longicornis					
Tryphosites longipes					
Othomaera othonis					
Maerella tenuimana					
Megaluropus agilis					
Melita palmata					
Perioculodes longimanus					1
Westwoodilla caecula			1		
Gammaropsis sp. (damaged)					
Megamphopus cornutus					
Harpinia antennaria					
Harpinia serrata					
Paraphoxus oculatus					
Menigrates obtusifrons				1	
Urothoe elegans		2	1		
Urothoe marina					
Urothoe sp.					
Amphipoda					

Taxa	W76	W77	W78	W79	W80
Iphinoe serrata					
Diastylis lucifera					
Eudorellopsis deformis					
Campylaspis undata					
Petalosarsia declivis					
Cumacea sp.					
Atelecyclus rotundatus			1		
Galathea intermedia					
Galathea sp.					
Ebalia cranchii					
Ebalia sp. (juvenile)					
Eurynome sp.					
Hyas coarctatus					
Paguridae sp. (juvenile/larvae)					1
Liocarcinus pusillus					
Liocarcinus sp. (juvenile)					
Caridea zoea larvae					
Decapoda sp. (damaged)					
Decapoda sp. (larvae)				1	
Astacilla damnoniensis					
Astacilla dilatata		1	1		
Astacilla longicornis					

Taxa	W76	W77	W78	W79	W80
Gnathia oxyuraea					
Gnathia oxyuraea Praniza larvae					
Nebalia bipes					
Tanaopsis graciloides			2		
Typhlotanais tenuicornis					
Tanaidacea sp. (juvenile)					
Ostracoda sp.					
Hippoporina pertusa					
Chaetognatha sp.					
Lotidae sp. (juvenile)					
Ammodytes sp.					
Microchirus variegatus					
Ascidiacea sp.					
Branchiostoma lanceolatum					
Actinopterygii sp. (damaged)					
Edwardsia claparedii					
Edwardsia spp. (indet.)					
Edwardsiidae sp.		p		1	1
Halcampa chrysanthellum					
Actiniaria					
Alcyonium digitatum					

Taxa	W76	W77	W78	W79	W80
Cerianthus lloydii			1		
Cerianthus sp.					
Bougainvilliidae					
Campanulariidae sp.					
Calycella sp.					
Sertulariidae sp.					
Hydrozoa sp. (damaged)					
Antedonidae sp. (damaged)					
Strongylocentrotus droebachiensis					
Strongylocentrotus sp.					
Echinocyamus pusillus		4	6	2	2
Echinocardium cordatum		1	p		
Echinoidea sp. (damaged)					
Leptosynapta decaria					
Leptosynapta sp.					
Amphiura (Ophiopeltis) securigera					
Amphiura filiformis					
Amphiura (Amphiura) incana					
Amphiura sp. (juvenile)					
Amphiuridae sp. (juvenile)					
Ophiura albida					

Taxa	W76	W77	W78	W79	W80
Ophiura ophiura					
Ophiura sarsii			1		
Ophiura sp. (juvenile)					
Ophiuridae sp. (juvenile)					
Ophiuroidea spp. (fragments)		p			
Ophiuroidea spp. (juvenile)	2			2	6
Hiatella arctica					
Ensis ensis					
Phaxas pellucidus		1	1		
Pharidae sp.				p	
Glycymeris glycymeris					
Parvicardium pinnulatum					
Cardiidae sp. (damaged)					
Gari costulata					
Gari fervensis		2	2	1	1
Gari tellinella					
Psammobiidae sp. (juvenile)					
Abra nitida					
Abra prismatica		2		4	8
Abra sp. (juvenile)					
Asbjornsenia pygmaea				7	9
Fabulina fabula		6	1		

Taxa	W76	W77	W78	W79	W80
Limecola balthica					
Moerella sp. (juvenile)					
Astarte sulcata					
Goodallia triangularis					1
Astartidae sp. (juvenile)					
Limaria hians					
Limatula subauriculata					
Lucinoma borealis	1				
Parathyasira equalis					
Thyasira flexuosa					
Thyasira sp. (juvenile)					
Crenella decussata				5	3
Modiolus modiolus					
Mytilidae sp. (juvenile)					
Nucula hanleyi					
Nucula nitidosa					
Nucula nucleus					
Anomia ephippium					
Arctica islandica					
Chamelea gallina					
Chamelea striatula					
Clausinella fasciata					

Taxa	W76	W77	W78	W79	W80
Dosinia exoleta					
Dosinia lupinus					
Dosinia sp. (juvenile)					
Gouldia minima					
Polititapes rhomboides					
Timoclea ovata					
Venus casina	1	2			17
Spisula elliptica			2	1	1
Kurtiella bidentata					
Kurtiella sp.					
Tellimya ferruginosa					
Cochlodesma praetenue				3	8
Thracia villosiuscula		5	2		
Thracia sp. (damaged)					
Chaetoderma nitidulum					
Cylichna cylindracea			1		
Philine sp.					
Retusa obtusa					
Volvulella acuminata					
Eulima bilineata					
Euspira nitida			1		1
Rissoidae sp. (juvenile)					

Taxa	W76	W77	W78	W79	W80
Turrisipho moebii					
Mangelia sp. (damaged)					
Turridae sp. (juvenile)					
Okenia sp.					
Nudibranchia eggs					
Pyrgiscus crenatus					
Pyramidellidae sp. (juvenile)					
Gibbula cineraria					
Gibbula tumida					
Gastropoda sp. (damaged)					
Leptochiton asellus					
Antalis entalis			1		
Antalis spp.					
Nematoda					
Nemertea		1		1	
Phoronis muelleri					
Phoronis sp.					
Phoronida sp.	2		2	2	
Platyhelminthes sp.					
Cliona celata					
Suberitidae sp.					
Porifera sp.					

Taxa	W76	W77	W78	W79	W80
Golfingia (Golfingia) elongata					
Golfingia (Golfingia) vulgaris					
Golfingia sp.		1			
Phascolion (Phascolion) strombus					
Sipuncula sp. (juvenile)					
Astrorhiza			p		

14 Annex 7.1I: Benthic Species Data (biomass g wet weight per 0.1m^2)

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Grania sp.															
Protodorvillea kefersteini															
Schistomeringos neglecta															
Lumbrineris aniara			0.0001	0.0048		0.0296	0.0195	0.0367				0.0011	0.0088	0.0081	
Lumbrineridae															0.016
Aponuphis bilineata				0.0034		0.023									
Nothria conchylega															
Onuphidae sp. (damaged)					0.0032										
Chrysopetalum debile															
Glycera alba				0.0001											
Glycera capitata													0.0064		
Glycera lapidum agg.					0.001	0.0008									
Glycera oxycephala															
Glycera rouxii								0.0041							
Glycera sp. (damaged)															
Glyceridae sp. (juvenile)															
Glycinde nordmanni		0.0044						0.0242							

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Goniada maculata	0.0046												0.0056		
Goniadidae sp.															
Oxydromus flexuosus	0.0147														
Podarkeopsis capensis												0.0008			
Psamathe fusca															
Hesionidae sp. (damaged)															
Psamathinae (Hesiospina/Psamathe sp. damaged)															
Aglaophamus agilis															
Nephtys assimilis															
Nephtys caeca															
Nephtys cirrosa															
Nephtys hombergii													0.1763		
Nephtys kersivalensis	0.022	0.0044													
Nephtys spp. (juvenile/damaged)														0.0001	
Nephtyidae spp.									0.0001		0.0078				
Nereis zonata								0.0001							
Nereididae spp. (juvenile)															
Pholoe baltica								0.0009							

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Pholoe inornata			0.001												
Pholoe spp.	0.0001				0.001										
Eteone flava/longa agg.					0.0015										
Eteone sp. (damaged)															
Eulalia viridis												0.0013			
Eumida sanguinea															
Phyllodoce groenlandica															
Phyllodoce maculata															
Phyllodoce rosea															
Phyllodoce sp. (juvenile)															
Phyllodocidae sp.															
Gattyana cirrhosa															
Malmgrenia castanea												0.0018			
Malmgrenia ljungmani															
Malmgrenia sp.															
Polynoidae sp.						0.0001								0.0123	0.0001
Polynoinae sp. (indet.)															
Neoleanira tetragona															
Pisione remota															
Sigalion mathildae												0.0293			
Sigalion squamosus															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Sphaerodoridium minutum															
Sphaerodorum gracilis															
Exogone verugera								0.0001							
Prosphaerosyllis sp.															
Syllis amica															
Trypanosyllis (Trypanosyllis) coeliaca															
Syllidae sp. (damaged)															
Aphroditoidea sp. (indet.)															
Galathowenia oculata												0.0009		0.0001	
Owenia fusiformis				0.0009		0.0193	0.0046	0.0987							
Owenia spp.															
Oweniidae sp.	0.0001										0.0042				
Jasmineira elegans						0.0045									
Jasmineira sp. (damaged)															
Sabellidae															
Hydroides elegans															
Spirobranchus lamarcki															
Serpulidae sp.					0.0079										

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Magelona alleni	0.0273		0.048	0.0022					0.0086	0.0241		0.0635	0.0246	0.0119	0.0396
Magelona filiformis			0.0001										0.0001	0.0001	
Magelona johnstoni															
Poecilochaetus serpens			0.002												
Aonides paucibranchiata						0.0037									
Dipolydora caulleryi															
Dipolydora coeca agg.															
Laonice bahusiensis															
Laonice cirrata/bahusiensis															
Laonice sp. (damaged)															
Microspio mecznikowianus															
Polydora ciliata agg.								0.0016							
Prionospio cirrifera															
Prionospio ehlersi															
Prionospio fallax	0.0001				0.0001		0.0001		0.001		0.0015		0.0038	0.0011	0.0001
Pygospio elegans				0.0001											
Scolelepis bonnieri				0.0022											
Scolelepis (Scolelepis) foliosa															
Spio armata agg.															
Spio decorata								0.0019							

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Spiophanes bombyx	0.018		0.0048	0.0041			0.0035		0.019	0.0008		0.0111		0.0161	0.01
Spiophanes kroyeri			0.0075					0.0001				0.0036	0.0077		
Spionidae sp.		0.0001			0.001										
Macrochaeta sp.															
Ampharete falcata															
Ampharete lindstroemi		0.0157	0.0036												
Ampharete sp. (juvenile)						0.0002									
Aphelochaeta sp. (type 1)															
Chaetozone setosa				0.002					0.0004			0.0011	0.0053	0.0007	
Chaetozone zetlandica				0.0044		0.0142									
Cirratulus sp. (juvenile)															
Tharyx killariensis								0.0032							0.0001
Cirratulidae sp.					0.0001										
Diplocirrus glaucus		0.0291						0.0127	0.0081		0.0214	0.0149	0.0134	0.0068	0.0864
Diplocirrus spp.	0.0186														
Flabelligeridae															
Lagis koreni				0.0553											
Pectinaria (Amphictene) auricoma									0.0025					0.0067	0.0065
Pectinaria sp.															
Amphitrite cirrata															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Lanice conchilega		0.0019				0.0112		0.0134							0.0001
Pista cristata						0.0183									
Pista elongata															
Axionice flexuosa															
Pista mirabilis															
Polycirrus sp.						0.0059	0.0023								
Terebellidae sp.															
Terebellides stroemii															
Capitella sp.			0.0009		0.0001										
Mediomastus fragilis								0.0022					0.0001		
Notomastus spp.						0.0715									
Chaetopteridae sp.															
Leiochone johnstoni															
Clymenura sp.															
Euclymene lombricoides															
Euclymene oerstedii															
Euclymene sp. A															
Praxillura longissima															
Maldanidae			0.0001			0.0106					0.0068				
Ophelia borealis					0.0252										
Ophelia celtica															
Ophelia neglecta															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Orbinia sp.															
Scoloplos armiger				0.0103		0.0122									
Scoloplos sp. (indet.)															
Orbiniidae spp. (damaged)															
Aricidea (Acmira) cerrutii															
Aricidea (Acmira) laubieri															
Paraonides sp.															
Paraonidae sp.															
Polygordius spp.															
Scalibregma celticum															
Scalibregma inflatum					0.0349										
Scalibregmatidae															
Travisia forbesii															
Acari															
Verruca stroemia															
Cirripedia sp. (Cyprid larvae)															
Copepoda sp.	0.0001	0.0008	0.0001					0.0019			0.0028	0.0003			0.0009
Ampelisca brevicornis															
Ampelisca diadema															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Ampelisca tenuicornis	0.0034											0.0044			
Ampelisca typica															
Ampelisca sp.															
Atylus vedlomensis							0.0062								
Atylus sp. (damaged)															
Bathyporeia gracilis												0.0029			
Bathyporeia pelagica		0.0015							0.0001		0.0026				
Bathyporeia pilosa															
Bathyporeia sarsi	0.0016														0.0021
Bathyporeia sp.															
Pariambus typicus			0.0001						0.0001				0.0001	0.0001	
Phtisica marina															
Pseudoprotella phasma															
Cheirocratus sp.															
Crassicorophium crassicorne															
Leptocheirus hirsutimanus					0.0001										
Leptocheirus pectinatus															
Isaeidae sp. (damaged)															
Siphonoecetes (Centraloecetes) kroyeranus															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Siphonoecetes (Centraloecetes) striatus															
Leucothoe lilljeborgi														0.0016	
Lepidepecreum longicornis															
Tryphosites longipes			0.0032											0.0051	
Othomaera othonis															
Maerella tenuimana															
Megaluropus agilis															
Melita palmata															
Perioculodes longimanus															
Westwoodilla caecula															
Gammaropsis sp. (damaged)															
Megamphopus cornutus															
Harpinia antennaria															
Harpinia serrata															
Paraphoxus oculatus											0.0014				
Menigrates obtusifrons															
Urothoe elegans							0.0016								
Urothoe marina					0.0032										
Urothoe sp.															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Amphipoda															
Iphinoe serrata															
Diastylis lucifera															0.0001
Eudorellopsis deformis			0.0001				0.0001		0.0001		0.0001		0.0001	0.0001	0.0018
Campylaspis undata															
Petalosarsia declivis															
Cumacea sp.											0.0001				
Atelecyclus rotundatus															
Galathea intermedia															
Galathea sp.															
Ebalia cranchii									0.006						
Ebalia sp. (juvenile)															
Eurynome sp.															
Hyas coarctatus															
Paguridae sp. (juvenile/larvae)											0.0001			0.0013	
Liocarcinus pusillus															
Liocarcinus sp. (juvenile)															
Caridea zoea larvae												0.0002			
Decapoda sp. (damaged)															
Decapoda sp. (larvae)				0.0001			0.003	0.0012							
Astacilla damnoniensis				0.0014											

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Astacilla dilatata												0.0004		0.0001	0.0025
Astacilla longicornis				0.0008											
Gnathia oxyuraea															
Gnathia oxyuraea Praniza larvae															
Nebalia bipes															
Tanaopsis graciloides															0.0001
Typhlotanais tenuicornis															
Tanaidacea sp. (juvenile)															
Ostracoda sp.															
Hippoporina pertusa															
Chaetognatha sp.													0.0025		
Lotidae sp. (juvenile)															
Ammodytes sp.															
Microchirus variegatus															
Ascidiacea sp.															
Branchiostoma lanceolatum															
Actinopterygii sp. (damaged)															
Edwardsia claparedii	0.0061			0.0127								0.0025			
Edwardsia spp. (indet.)															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Edwardsiidae sp.			0.0226		0.0005		0.0124	0.0019		0.009	0.0191				0.0026
Halcampa chrysanthellum									0.002					0.0082	
Actiniaria															
Alcyonium digitatum															
Cerianthus lloydii															
Cerianthus sp.															
Bougainvilliidae															
Campanulariidae sp.															
Calycella sp.															
Sertulariidae sp.															
Hydrozoa sp. (damaged)															
Antedonidae sp. (damaged)															
Strongylocentrotus droebachiensis															
Strongylocentrotus sp.															
Echinocyamus pusillus				0.0243		0.0456	0.0093	0.0001	0.0053					0.0035	0.0027
Echinocardium cordatum			19.4623							16.3354		8.7162		0.1234	6.4417
Echinoidea sp. (damaged)													3.625		
Leptosynapta decaria															
Leptosynapta sp.												0.0022			

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Amphiura (Ophiopeltis) securigera															
Amphiura filiformis		0.0236											0.1812		
Amphiura (Amphiura) incana															
Amphiura sp. (juvenile)				0.0022											
Amphiuridae sp. (juvenile)	0.0038														
Ophiura albida															
Ophiura ophiura															
Ophiura sarsii															
Ophiura sp. (juvenile)												0.0001			
Ophiuridae sp. (juvenile)															
Ophiuroidea spp. (fragments)	0.0503		0.0169				0.0037	0.0065		0.0048	0.0181			0.0293	
Ophiuroidea spp. (juvenile)							0.0001		0.0004					0.0064	0.0001
Hiatella arctica								0.0025							
Ensis ensis						0.1658									
Phaxas pellucidus	0.0264	0.0044	0.0231				0.0171	0.0225	0.0051		0.1366	0.0067	0.0018		0.0073
Pharidae sp.															
Glycymeris glycymeris															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Parvicardium pinnulatum															
Cardiidae sp. (damaged)															
Gari costulata															
Gari fervensis				0.0122			0.0094							0.0078	
Gari tellinella															
Psammobiidae sp. (juvenile)															
Abra nitida												0.0151			
Abra prismatica		0.0048							0.0465			0.1386		0.0818	
Abra sp. (juvenile)												0.0001			
Asbjornsenia pygmaea		0.0032		0.0191	0.0066										
Fabulina fabula			0.0037							0.0018				0.0024	
Limecola balthica															
Moerella sp. (juvenile)						0.0009						0.0064			
Astarte sulcata															
Goodallia triangularis															
Astartidae sp. (juvenile)															
Limaria hians															
Limatula subauriculata															
Lucinoma borealis	0.0001													0.0001	0.0001
Parathyasira equalis															
Thyasira flexuosa												0.0082	0.004		0.0001

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Thyasira sp. (juvenile)															
Crenella decussata															
Modiolus modiolus															
Mytilidae sp. (juvenile)															
Nucula hanleyi														0.0653	
Nucula nitidosa												0.0075			
Nucula nucleus															
Anomia ephippium															
Arctica islandica															
Chamelea gallina															
Chamelea striatula															
Clausinella fasciata			0.7506			0.0019						0.0016			
Dosinia exoleta													0.0052		
Dosinia lupinus															
Dosinia sp. (juvenile)															
Gouldia minima				0.0001							0.0014				
Polititapes rhomboides															
Timoclea ovata						0.0022									
Venus casina		0.0064	0.0124				0.142		0.0409	0.8184				0.0312	0.0029
Spisula elliptica				0.0055	0.0038	0.0064									
Kurtiella bidentata					0.0008										

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Kurtiella sp.															
Tellimya ferruginosa										0.0254					
Cochlodesma praetenue							0.0011								
Thracia villosiuscula			0.0123	0.0142						0.0098		0.0019			0.0072
Thracia sp. (damaged)															
Chaetoderma nitidulum	0.0029														
Cylichna cylindracea												0.0301			0.0232
Philine sp.			0.0022												
Retusa obtusa															
Volvulella acuminata															
Eulima bilineata															
Euspira nitida									0.004					0.002	
Rissoidae sp. (juvenile)															
Turrisipho moebii															
Mangelia sp. (damaged)															
Turridae sp. (juvenile)												0.0177			
Okenia sp.															
Nudibranchia eggs															
Pyrgiscus crenatus															
Pyramidellidae sp. (juvenile)															
Gibbula cineraria															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Gibbula tumida															
Gastropoda sp. (damaged)															
Leptochiton asellus															
Antalis entalis			0.1989							0.3457	0.0248	0.6974	0.0013	1.2351	
Antalis spp.															
Nematoda															
Nemertea			0.0081		0.0069	0.1221					0.004	0.0027			0.0044
Phoronis muelleri															
Phoronis sp.															
Phoronida sp.		0.0001	0.0004				0.0017	0.0013			0.0046		0.0011	0.0032	0.0015
Platyhelminthes sp.															
Cliona celata															
Suberitidae sp.															
Porifera sp.															
Golfingia (Golfingia) elongata						0.004									
Golfingia (Golfingia) vulgaris															
Golfingia sp.					0.001										
Phascolion (Phascolion) strombus															

Taxa	W1	W2	W3	W4	W5	W6	W7	W8	W9B	W10	W11	W12	W13	W14	W15
Sipuncula sp. (juvenile)						0.0001									
Astrorhiza															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Grania sp.					0.0063								0.0001		
Protodorvillea kefersteini															
Schistomeringos neglecta													0.0199		
Lumbrineris aniara	0.0024	0.0034	0.0001			0.0068	0.0237	0.004	0.0285	0.0001	0.0042	0.0076	0.0023		0.0041
Lumbrineridae															
Aponuphis bilineata													0.0288		
Nothria conchylega				0.0015											
Onuphidae sp. (damaged)															
Chrysopetalum debile															
Glycera alba															
Glycera capitata															
Glycera lapidum agg.					0.0264										
Glycera oxycephala															
Glycera rouxii															
Glycera sp. (damaged)							0.0016								
Glyceridae sp. (juvenile)															
Glycinde nordmanni															
Goniada maculata												0.0022			
Goniadidae sp.				0.0001											
Oxydromus flexuosus															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Podarkeopsis capensis															
Psamathe fusca															
Hesionidae sp. (damaged)									0.0041						
Psamathinae (Hesiospina/Psamathe sp. damaged)													0.001		
Aglaophamus agilis					0.0034								0.253		
Nephtys assimilis			0.079				0.066				0.037			0.3178	
Nephtys caeca															
Nephtys cirrosa															
Nephtys hombergii															
Nephtys kersivalensis									0.042						
Nephtys spp. (juvenile/damaged)					0.1074										
Nephtyidae spp.		0.0134				0.0037								0.0001	
Nereis zonata															
Nereididae spp. (juvenile)												0.0001			
Pholoe baltica							0.001								
Pholoe inornata										0.0017					
Pholoe spp.															
Eteone flava/longa agg.					0.0001										
Eteone sp. (damaged)															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Eulalia viridis															
Eumida sanguinea						0.0038									
Phyllodoce groenlandica															
Phyllodoce maculata															
Phyllodoce rosea								0.0079							
Phyllodoce sp. (juvenile)															
Phyllodocidae sp.															
Gattyana cirrhosa															
Malmgrenia castanea															
Malmgrenia ljungmani													0.0008		
Malmgrenia sp.															
Polynoidae sp.															
Polynoinae sp. (indet.)															
Neoleanira tetragona															
Pisione remota					0.001										
Sigalion mathildae															
Sigalion squamosus												0.0001			
Sphaerodoridium minutum					0.0001										
Sphaerodorum gracilis															
Exogone verugera															
Prosphaerosyllis sp.															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Syllis amica															
Trypanosyllis (Trypanosyllis) coeliaca															
Syllidae sp. (damaged)															
Aphroditoidea sp. (indet.)															
Galathowenia oculata		0.0001					0.0009		0.0001			0.001			
Owenia fusiformis				0.0254		0.0424	0.0046				0.0268	0.0137		0.025	0.0102
Owenia spp.									0.0115						
Oweniidae sp.															
Jasmineira elegans													0.0148		
Jasmineira sp. (damaged)					0.0105										
Sabellidae															
Hydroides elegans					0.0019										
Spirobranchus lamarcki															
Serpulidae sp.															
Magelona alleni		0.0077				0.0231		0.012		0.0151				0.0085	0.027
Magelona filiformis		0.0001		0.0014			0.0031	0.0002			0.001	0.0016			
Magelona johnstoni															
Poecilochaetus serpens															
Aonides paucibranchiata					0.02								0.0091		
Dipolydora caulleryi													0.0001		

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Dipolydora coeca agg.														0.0001	
Laonice bahusiensis															
Laonice cirrata/bahusiensis													0.0283		
Laonice sp. (damaged)					0.0041										
Microspio mecznikowianus															
Polydora ciliata agg.															
Prionospio cirrifera															
Prionospio ehlersi															
Prionospio fallax	0.0022	0.0034	0.002	0.0004		0.0014	0.0015	0.0001	0.0157	0.001	0.0024			0.0041	
Pygospio elegans															
Scolelepis bonnieri							0.0027				0.0025				
Scolelepis (Scolelepis) foliosa															
Spio armata agg.						0.0028									
Spio decorata															
Spiophanes bombyx	0.0018	0.0054	0.0224	0.0026		0.0169	0.0056		0.0032	0.0001	0.0092	0.0044		0.0033	0.0061
Spiophanes kroyeri	0.0018								0.0035						
Spionidae sp.															
Macrochaeta sp.															
Ampharete falcata															
Ampharete lindstroemi				0.0084		0.0064						0.0074			

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Ampharete sp. (juvenile)									0.0043						
Aphelochaeta sp. (type 1)															
Chaetozone setosa	0.0037		0.0054					0.0016	0.0078		0.0031			0.0001	
Chaetozone zetlandica													0.005		
Cirratulus sp. (juvenile)															
Tharyx killariensis							0.0059								
Cirratulidae sp.						0.0001						0.0013			
Diplocirrus glaucus	0.0485	0.0551	0.0438	0.0424		0.0204	0.0542		0.059	0.0146	0.014	0.0166		0.007	0.0301
Diplocirrus spp.															
Flabelligeridae															
Lagis koreni															
Pectinaria (Amphictene) auricoma								0.0029	0.0137	0.0604					
Pectinaria sp.															
Amphitrite cirrata					0.01										
Lanice conchilega		0.001		0.0021	0.0001	0.0001	0.0017		0.0037				0.1068		
Pista cristata															
Pista elongata															
Axionice flexuosa															
Pista mirabilis															
Polycirrus sp.		0.0046													
Terebellidae sp.															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Terebellides stroemii															
Capitella sp.															
Mediomastus fragilis												0.0001			
Notomastus spp.					0.1289								0.1769		
Chaetopteridae sp.															
Leiochone johnstoni															
Clymenura sp.								0.0018							
Euclymene lombricoides															
Euclymene oerstedii	0.0058	0.0054							0.0186		0.0026				
Euclymene sp. A															
Praxillura longissima															
Maldanidae			0.0041									0.0028			
Ophelia borealis															
Ophelia celtica															
Ophelia neglecta															
Orbinia sp.															
Scoloplos armiger															
Scoloplos sp. (indet.)															
Orbiniidae spp. (damaged)															
Aricidea (Acmira) cerrutii															
Aricidea (Acmira) laubieri									0.0001						

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Paraonides sp.															
Paraonidae sp.															
Polygordius spp.					0.0163								0.0001		
Scalibregma celticum					0.0097								0.0024		
Scalibregma inflatum													0.0056		
Scalibregmatidae			0.0005												
Travisia forbesii															
Acari													0.0001		
Verruca stroemia															
Cirripedia sp. (Cyprid larvae)															
Copepoda sp.	0.0014		0.0001		0.0001				0.0001				0.0001	0.0001	
Ampelisca brevicornis															
Ampelisca diadema															
Ampelisca tenuicornis									0.0003						0.0057
Ampelisca typica															
Ampelisca sp.															
Atylus vedlomensis															
Atylus sp. (damaged)															
Bathyporeia gracilis									0.0105						
Bathyporeia pelagica		0.0037	0.0026					0.0093							
Bathyporeia pilosa															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Bathyporeia sarsi															
Bathyporeia sp.															
Pariambus typicus		0.0001				0.0001		0.0001	0.0013						
Phtisica marina							0.0006								
Pseudoprotella phasma					0.0118										
Cheirocratus sp.															
Crassicorophium crassicorne															
Leptocheirus hirsutimanus													0.0023		
Leptocheirus pectinatus															
Isaeidae sp. (damaged)															
Siphonoecetes (Centraloecetes) kroyeranus															
Siphonoecetes (Centraloecetes) striatus															
Leucothoe lilljeborgi	0.0001														
Lepidepecreum longicornis															
Tryphosites longipes															
Othomaera othonis															
Maerella tenuimana															
Megaluropus agilis															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Melita palmata															
Perioculodes longimanus									0.001						
Westwoodilla caecula													0.0062		
Gammaropsis sp. (damaged)															
Megamphopus cornutus															
Harpinia antennaria															
Harpinia serrata												0.0011			
Paraphoxus oculatus															
Menigrates obtusifrons															
Urothoe elegans			0.0015				0.0012	0.0014			0.0024	0.0015			0.0031
Urothoe marina															
Urothoe sp.				0.0001											
Amphipoda															
Iphinoe serrata															
Diastylis lucifera															
Eudorellopsis deformis		0.0001		0.0001					0.001			0.0001			
Campylaspis undata															
Petalosarsia declivis											0.0001				
Cumacea sp.					0.0001								0.0001		
Atelecyclus rotundatus													0.0392		
Galathea intermedia															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Galathea sp.												0.0007			
Ebalia cranchii															
Ebalia sp. (juvenile)								0.0233							
Eurynome sp.															
Hyas coarctatus															
Paguridae sp. (juvenile/larvae)	0.0037			0.0057											
Liocarcinus pusillus															
Liocarcinus sp. (juvenile)															
Caridea zoea larvae															
Decapoda sp. (damaged)														0.0012	
Decapoda sp. (larvae)									0.0063	0.0014	0.0044				
Astacilla damnoniensis						0.0001						0.0011			
Astacilla dilatata							0.0016		0.001	0.005	0.0018			0.0021	0.0012
Astacilla longicornis															
Gnathia oxyuraea								0.0008					0.0004		
Gnathia oxyuraea Praniza larvae								0.0002					0.001		
Nebalia bipes													0.0032		
Tanaopsis graciloides	0.0001	0.0001				0.0001						0.0008			
Typhlotanais tenuicornis									0.0001						
Tanaidacea sp. (juvenile)															
Ostracoda sp.									0.0001						

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Hippoporina pertusa															
Chaetognatha sp.							0.0021								
Lotidae sp. (juvenile)															
Ammodytes sp.															
Microchirus variegatus															
Ascidiacea sp.															
Branchiostoma lanceolatum															
Actinopterygii sp. (damaged)															
Edwardsia claparedii															
Edwardsia spp. (indet.)									0.0123	0.0102					
Edwardsiidae sp.	0.0208	0.006				0.0056					0.0061	0.015			
Halcampa chrysanthellum															0.0096
Actiniaria															
Alcyonium digitatum															
Cerianthus lloydii													0.0001		
Cerianthus sp.															
Bougainvilliidae															
Campanulariidae sp.															
Calycella sp.															
Sertulariidae sp.															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Hydrozoa sp. (damaged)															
Antedonidae sp. (damaged)															
Strongylocentrotus droebachiensis															
Strongylocentrotus sp.					0.004										
Echinocyamus pusillus		0.0019	0.001	0.0023	0.0805	0.0119	0.0062	0.0066	0.0058		0.0071	0.0116	0.0536	0.0029	0.0083
Echinocardium cordatum							9.661	10.8607		14.0476				2.8867	2.7477
Echinoidea sp. (damaged)						2.431									
Leptosynapta decaria						0.0012									
Leptosynapta sp.													0.0286		
Amphiura (Ophiopeltis) securigera															
Amphiura filiformis															0.0165
Amphiura (Amphiura) incana				0.0196											
Amphiura sp. (juvenile)	0.0016														
Amphiuridae sp. (juvenile)									0.007						
Ophiura albida															
Ophiura ophiura															
Ophiura sarsii															
Ophiura sp. (juvenile)														0.0001	

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Ophiuridae sp. (juvenile)															
Ophiuroidea spp. (fragments)			0.0193			0.0139				0.0011	0.0278	0.0139	0.2396	0.026	
Ophiuroidea spp. (juvenile)		0.0011			0.0025		0.0001	0.0015					0.0004		
Hiatella arctica															
Ensis ensis															
Phaxas pellucidus	0.0418	0.0338		0.0201		0.0067	0.2585		0.0262	0.0038	0.0251	0.0233			
Pharidae sp.															
Glycymeris glycymeris															
Parvicardium pinnulatum															
Cardiidae sp. (damaged)															
Gari costulata															
Gari fervensis			0.4338				0.0166		0.0154	0.0001		0.1624			
Gari tellinella															
Psammobiidae sp. (juvenile)															
Abra nitida									0.0183						
Abra prismatica	0.0638		0.0001				0.01201	0.0203		0.04	0.0345	0.0767		0.0304	0.0126
Abra sp. (juvenile)															
Asbjornsenia pygmaea													0.0009		
Fabulina fabula	0.0029	0.0001	0.0045			0.0192	0.1831	0.0146	0.0026		0.0134				0.0238

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Limecola balthica													0.2104		
Moerella sp. (juvenile)															
Astarte sulcata															
Goodallia triangularis															
Astartidae sp. (juvenile)															
Limaria hians															
Limatula subauriculata															
Lucinoma borealis	0.0001	1.3905				0.0008	0.0019	0.0001		0.0001					
Parathyasira equalis									0.0028	0.0053					
Thyasira flexuosa		0.001						0.0018							
Thyasira sp. (juvenile)															
Crenella decussata													0.0022		
Modiolus modiolus															
Mytilidae sp. (juvenile)															
Nucula hanleyi															
Nucula nitidosa			0.1979				0.1585								
Nucula nucleus															0.0051
Anomia ephippium															
Arctica islandica												0.0007			
Chamelea gallina															
Chamelea striatula											0.0975	1.7263			0.036
Clausinella fasciata							0.004								

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Dosinia exoleta									0.0026	0.094					0.0449
Dosinia lupinus															
Dosinia sp. (juvenile)															
Gouldia minima															
Polititapes rhomboides					0.1232										
Timoclea ovata															
Venus casina		0.068		0.0024				0.0037	0.95	0.0071					
Spisula elliptica		0.0014	0.0014								0.0052	0.1153			
Kurtiella bidentata															
Kurtiella sp.															
Tellimya ferruginosa															
Cochlodesma praetenue			0.0206												
Thracia villosiuscula	0.0215					0.002	0.0065		0.0139	0.0056		0.0115		0.0017	0.0001
Thracia sp. (damaged)															
Chaetoderma nitidulum															
Cylichna cylindracea						0.001			0.0484						
Philine sp.															
Retusa obtusa															
Volvulella acuminata														0.0016	
Eulima bilineata															
Euspira nitida						0.0001		0.0159			0.0709		0.0036		
Rissoidae sp. (juvenile)															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Turrisipho moebii														0.0029	
Mangelia sp. (damaged)													0.0001		
Turridae sp. (juvenile)		0.0051													
Okenia sp.												0.0013			
Nudibranchia eggs															
Pyrgiscus crenatus															
Pyramidellidae sp. (juvenile)								0.0001							
Gibbula cineraria															
Gibbula tumida															
Gastropoda sp. (damaged)															
Leptochiton asellus					0.0001										
Antalis entalis	0.1271	0.1415						0.1403							0.0017
Antalis spp.							0.0308					0.049		0.0168	
Nematoda					0.0095								0.0091		
Nemertea		0.0091		0.0023	0.0099	0.0055		0.0075	0.0041			0.0393	0.0114		0.0751
Phoronis muelleri															
Phoronis sp.															
Phoronida sp.	0.0161	0.0019	0.0091	0.0044		0.0087	0.0029	0.001	0.0076	0.0406	0.0001	0.0067		0.0019	0.0027
Platyhelminthes sp.		0.0015													
Cliona celata															
Suberitidae sp.															

Taxa	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Porifera sp.															
Golfingia (Golfingia) elongata					0.0001										
Golfingia (Golfingia) vulgaris															
Golfingia sp.							0.0001								
Phascolion (Phascolion) strombus													0.2982		
Sipuncula sp. (juvenile)															
Astrorhiza															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Grania sp.									0.0001						
Protodorvillea kefersteini									0.0024				0.0001		
Schistomeringos neglecta															
Lumbrineris aniara	0.026	0.0742	0.1867	0.0246	0.1556	0.0452	0.0001	0.0611					0.2278	0.1096	0.1553
Lumbrineridae															
Aponuphis bilineata									0.0598				0.0688		0.0026
Nothria conchylega			0.0784												
Onuphidae sp. (damaged)														0.0224	

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Chrysopetalum debile															
Glycera alba				0.0018	0.0324			0.0043	0.0178						
Glycera capitata														0.0001	
Glycera lapidum agg.															
Glycera oxycephala													0.025		
Glycera rouxii															
Glycera sp. (damaged)															
Glyceridae sp. (juvenile)															
Glycinde nordmanni															0.0261
Goniada maculata								0.0067							
Goniadidae sp.									0.0012			0.0014			
Oxydromus flexuosus															
Podarkeopsis capensis			0.0067		0.0014										
Psamathe fusca												0.0007	0.0016		
Hesionidae sp. (damaged)															
Psamathinae (Hesiospina/Psamathe sp. damaged)															
Aglaophamus agilis															
Nephtys assimilis	0.0346													0.0741	
Nephtys caeca															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Nephtys cirrosa			0.027												
Nephtys hombergii															
Nephtys kersivalensis						0.0426			0.0035						
Nephtys spp. (juvenile/damaged)										0.0254					
Nephtyidae spp.							0.0014	0.0001	0.4607						
Nereis zonata									0.0109				0.0017		
Nereididae spp. (juvenile)															
Pholoe baltica															
Pholoe inornata					0.0001										
Pholoe spp.															
Eteone flava/longa agg.															
Eteone sp. (damaged)															
Eulalia viridis															
Eumida sanguinea					0.0135	0.003							0.0001		0.0004
Phyllodoce groenlandica															
Phyllodoce maculata			0.0013												
Phyllodoce rosea									0.0002						
Phyllodoce sp. (juvenile)			0.0003												
Phyllodocidae sp.															
Gattyana cirrhosa	0.0009	0.001			0.0045										0.0002
Malmgrenia castanea									0.0046						

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Malmgrenia ljungmani															
Malmgrenia sp.															0.0009
Polynoidae sp.			0.0011	0.0001		0.0001		0.0001							
Polynoinae sp. (indet.)														0.0024	
Neoleanira tetragona															
Pisione remota									0.0052	0.0001					
Sigalion mathildae															
Sigalion squamosus															
Sphaerodoridium minutum									0.0001						
Sphaerodorum gracilis									0.0001						
Exogone verugera															
Prosphaerosyllis sp.															
Syllis amica															
Trypanosyllis (Trypanosyllis) coeliaca															
Syllidae sp. (damaged)															
Aphroditoidea sp. (indet.)									0.0092						
Galathowenia oculata			0.0003												
Owenia fusiformis	0.0317	0.026	0.0164		0.035	0.0136	0.001	0.0066	0.308	0.0187		0.0498		0.0765	0.0222
Owenia spp.															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Oweniidae sp.															
Jasmineira elegans									0.0155						
Jasmineira sp. (damaged)															
Sabellidae													0.0137		
Hydroides elegans													0.0001		
Spirobranchus lamarcki													0.0016		
Serpulidae sp.															
Magelona alleni	0.003	0.0391	0.0304									0.0047			
Magelona filiformis	0.0001						0.0005				0.0017	0.0019		0.0012	
Magelona johnstoni														0.002	
Poecilochaetus serpens															
Aonides paucibranchiata									0.0424				0.0014		
Dipolydora caulleryi									0.0001						
Dipolydora coeca agg.			0.0004		0.0052									0.0001	
Laonice bahusiensis															
Laonice cirrata/bahusiensis															
Laonice sp. (damaged)															
Microspio mecznikowianus											0.0374				
Polydora ciliata agg.															
Prionospio cirrifera															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Prionospio ehlersi			0.0016												
Prionospio fallax	0.0004				0.0001		0.0001	0.0021				0.0001		0.0001	0.0008
Pygospio elegans										0.0054					
Scolelepis bonnieri			0.0013												
Scolelepis (Scolelepis) foliosa															
Spio armata agg.															
Spio decorata															
Spiophanes bombyx	0.0049	0.0029	0.03	0.0047	0.003		0.0057	0.0422			0.0001	0.0001		0.0213	0.0342
Spiophanes kroyeri					0.0029									0.0195	
Spionidae sp.															
Macrochaeta sp.									0.0009						
Ampharete falcata														0.0052	
Ampharete lindstroemi															0.0088
Ampharete sp. (juvenile)														0.0001	0.0002
Aphelochaeta sp. (type 1)							0.0001	0.0016							
Chaetozone setosa								0.0009						0.0018	0.0003
Chaetozone zetlandica													0.0077		
Cirratulus sp. (juvenile)															
Tharyx killariensis	0.0013	0.0001													
Cirratulidae sp.															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Diplocirrus glaucus	0.0142		0.055				0.022					0.02			0.0001
Diplocirrus spp.															
Flabelligeridae															
Lagis koreni	0.0298			0.0238											
Pectinaria (Amphictene) auricoma	0.002						0.0004	0.0041				0.0001			
Pectinaria sp.															
Amphitrite cirrata															
Lanice conchilega								0.0069	0.4034	0.0626				0.1456	
Pista cristata															
Pista elongata															
Axionice flexuosa															
Pista mirabilis													0.1341		
Polycirrus sp.					0.0567			0.02							
Terebellidae sp.									0.0862						
Terebellides stroemii															
Capitella sp.					0.0017										
Mediomastus fragilis								0.0001							
Notomastus spp.									0.2003					0.0039	
Chaetopteridae sp.												0.0153			
Leiochone johnstoni															
Clymenura sp.															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Euclymene lombricoides			0.03986												
Euclymene oerstedii						0.0069									
Euclymene sp. A										0.0012					
Praxillura longissima															
Maldanidae	0.0005		0.128		0.0792						0.0193			0.0409	
Ophelia borealis															
Ophelia celtica															
Ophelia neglecta															
Orbinia sp.															
Scoloplos armiger													0.0105		0.0166
Scoloplos sp. (indet.)															
Orbiniidae spp. (damaged)															
Aricidea (Acmira) cerrutii															
Aricidea (Acmira) laubieri													0.0008		
Paraonides sp.														0.0001	
Paraonidae sp.															
Polygordius spp.									0.0016						
Scalibregma celticum															
Scalibregma inflatum		0.0265	0.0233		0.0243			0.0128					0.018	0.0167	
Scalibregmatidae															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Travisia forbesii															
Acari															
Verruca stroemia															
Cirripedia sp. (Cyprid larvae)															
Copepoda sp.	0.0005						0.0011	0.0015		0.0012	0.0007	0.0017			
Ampelisca brevicornis															
Ampelisca diadema															0.0018
Ampelisca tenuicornis			0.0039					0.0054					0.0154		0.0007
Ampelisca typica															
Ampelisca sp.					0.0014										
Atylus vedlomensis									0.0041				0.0237		
Atylus sp. (damaged)															
Bathyporeia gracilis															0.0062
Bathyporeia pelagica			0.001	0.0015	0.0041		0.0028	0.0058						0.006	
Bathyporeia pilosa						0.0038									
Bathyporeia sarsi															
Bathyporeia sp.			0.0005												0.0003
Pariambus typicus			0.0001		0.0008			0.0001				0.0007			
Phtisica marina															
Pseudoprotella phasma															
Cheirocratus sp.						0.0045									

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Crassicorophium crassicorne															
Leptocheirus hirsutimanus									0.0113						
Leptocheirus pectinatus													0.0001		
Isaeidae sp. (damaged)													0.0018		
Siphonoecetes (Centraloecetes) kroyeranus			0.0009												0.0028
Siphonoecetes (Centraloecetes) striatus														0.0026	
Leucothoe lilljeborgi														0.0001	
Lepidepecreum longicornis							0.0034								
Tryphosites longipes												0.0043			0.0058
Othomaera othonis													0.0078		
Maerella tenuimana							0.0027								
Megaluropus agilis															
Melita palmata														0.0001	
Perioculodes longimanus														0.0001	
Westwoodilla caecula															
Gammaropsis sp. (damaged)															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Megamphopus cornutus			0.0003												
Harpinia antennaria			0.0013												
Harpinia serrata															
Paraphoxus oculatus													0.0001		
Menigrates obtusifrons															
Urothoe elegans	0.0014	0.0036			0.0029		0.0018			0.0039		0.0012		0.0011	0.0089
Urothoe marina															
Urothoe sp.															
Amphipoda															
Iphinoe serrata															
Diastylis lucifera															
Eudorellopsis deformis			0.0019		0.0001		0.0001				0.001	0.0001			
Campylaspis undata									0.0001						
Petalosarsia declivis															
Cumacea sp.															
Atelecyclus rotundatus															
Galathea intermedia													0.0089		
Galathea sp.															
Ebalia cranchii								0.0053							
Ebalia sp. (juvenile)															
Eurynome sp.															
Hyas coarctatus													0.0054		

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Paguridae sp. (juvenile/larvae)					0.0019										
Liocarcinus pusillus									0.0063						
Liocarcinus sp. (juvenile)															
Caridea zoea larvae															
Decapoda sp. (damaged)															
Decapoda sp. (larvae)	0.0001														
Astacilla damnoniensis									0.002						
Astacilla dilatata		0.0022						0.0012						0.0013	
Astacilla longicornis			0.0005												
Gnathia oxyuraea											0.0005		0.009		
Gnathia oxyuraea Praniza larvae							0.0001		0.0001				0.0023		
Nebalia bipes													0.0044		
Tanaopsis graciloides					0.0011			0.0001							0.0009
Typhlotanais tenuicornis														0.0001	
Tanaidacea sp. (juvenile)															
Ostracoda sp.															
Hippoporina pertusa															
Chaetognatha sp.															
Lotidae sp. (juvenile)															
Ammodytes sp.															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Microchirus variegatus															
Ascidiacea sp.															
Branchiostoma lanceolatum															
Actinopterygii sp. (damaged)															
Edwardsia claparedii														0.0695	0.0234
Edwardsia spp. (indet.)			0.0081												
Edwardsiidae sp.				0.0089	0.0149			0.0094				0.018			
Halcampa chrysanthellum		0.0205					0.0107	0.0051							
Actiniaria															
Alcyonium digitatum															
Cerianthus lloydii										0.0026					
Cerianthus sp.															
Bougainvilliidae															
Campanulariidae sp.															
Calycella sp.															
Sertulariidae sp.															
Hydrozoa sp. (damaged)															
Antedonidae sp. (damaged)															0.0009
Strongylocentrotus droebachiensis															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Strongylocentrotus sp.															
Echinocyamus pusillus	0.011	0.001	0.01	0.002	0.0219		0.0018	0.0044	0.0743	0.0089	0.004	0.0075	0.0997	0.0051	0.0094
Echinocardium cordatum			7.032												
Echinoidea sp. (damaged)															
Leptosynapta decaria															
Leptosynapta sp.															
Amphiura (Ophiopeltis) securigera															
Amphiura filiformis															
Amphiura (Amphiura) incana										0.0049					
Amphiura sp. (juvenile)															
Amphiuridae sp. (juvenile)														0.0164	
Ophiura albida					0.0138								0.0328		
Ophiura ophiura															
Ophiura sarsii															
Ophiura sp. (juvenile)	0.007		0.0011												
Ophiuridae sp. (juvenile)													0.0019		
Ophiuroidea spp. (fragments)	0.0086				0.0223										

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Ophiuroidea spp. (juvenile)						0.0001	0.0042	0.0021	0.0023	0.0001	0.0001	0.0029			0.0022
Hiatella arctica															
Ensis ensis															
Phaxas pellucidus			0.0011	0.0106				0.0046						0.0617	0.014
Pharidae sp.															
Glycymeris glycymeris															
Parvicardium pinnulatum								0.0276							
Cardiidae sp. (damaged)						0.0001									
Gari costulata															0.0603
Gari fervensis	0.0135	0.8748	0.0029	0.0041	0.1369	0.0163	0.0057	0.0118	0.0011			0.0028		0.011	
Gari tellinella															
Psammobiidae sp. (juvenile)															
Abra nitida															
Abra prismatica				0.038	0.0048		0.0925				0.0721	0.1465		0.0044	
Abra sp. (juvenile)															0.0006
Asbjornsenia pygmaea							0.0001								
Fabulina fabula	0.0348		0.0484	0.0021	0.0024	0.0001	0.005			0.0096	0.03	0.0571		0.0457	0.0926
Limecola balthica															
Moerella sp. (juvenile)															
Astarte sulcata															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Goodallia triangularis															
Astartidae sp. (juvenile)															
Limaria hians															
Limatula subauriculata															
Lucinoma borealis															0.0014
Parathyasira equalis															
Thyasira flexuosa	0.0015							0.0001							
Thyasira sp. (juvenile)															0.0006
Crenella decussata									0.0049						0.0002
Modiolus modiolus															
Mytilidae sp. (juvenile)													0.0001		
Nucula hanleyi					0.0314										
Nucula nitidosa			0.037												0.0009
Nucula nucleus	0.002														
Anomia ephippium															
Arctica islandica															
Chamelea gallina			0.004												
Chamelea striatula										4.2961	0.1109				
Clausinella fasciata			0.0303										4.2887		0.0176
Dosinia exoleta					0.0009									0.0456	
Dosinia lupinus									5.9534						

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Dosinia sp. (juvenile)															0.0009
Gouldia minima											0.0001				
Polititapes rhomboides									40.1946						
Timoclea ovata													0.0719		
Venus casina					0.0088			0.0001						0.3003	
Spisula elliptica															
Kurtiella bidentata															
Kurtiella sp.															
Tellimya ferruginosa															
Cochlodesma praetenue							0.0241		0.3189						
Thracia villosiuscula	0.0074		0.021	0.0021	0.0118	0.0021		0.0738		0.0184	0.0137	0.0063		0.0079	0.0017
Thracia sp. (damaged)					0.0299										
Chaetoderma nitidulum															
Cylichna cylindracea	0.0018														0.0013
Philine sp.														0.0019	
Retusa obtusa															
Volvulella acuminata															0.0026
Eulima bilineata															
Euspira nitida	0.0095	0.0106	0.5379		0.0001			0.0107	0.0261	0.0015	0.0024				0.2285
Rissoidae sp. (juvenile)															
Turrisipho moebii															
Mangelia sp. (damaged)															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Turridae sp. (juvenile)															
Okenia sp.															
Nudibranchia eggs															
Pyrgiscus crenatus											0.0176				
Pyramidellidae sp. (juvenile)															
Gibbula cineraria															
Gibbula tumida															
Gastropoda sp. (damaged)															
Leptochiton asellus													0.0277		
Antalis entalis	0.3084		0.35									0.0774			
Antalis spp.															
Nematoda									0.0026				0.0001		0.0001
Nemertea		0.024	0.0499			0.0011	0.0037	0.0016	0.0079	0.0015		0.0073	0.0105	0.0069	
Phoronis muelleri			0.0049												
Phoronis sp.															0.0003
Phoronida sp.	0.0026	0.0055		0.0025	0.013		0.0145	0.0054		0.0038		0.0039	0.0143	0.0038	
Platyhelminthes sp.													0.0041		
Cliona celata															
Suberitidae sp.															
Porifera sp.															

Taxa	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Golfingia (Golfingia) elongata															
Golfingia (Golfingia) vulgaris									0.0023						
Golfingia sp.															
Phascolion (Phascolion) strombus															
Sipuncula sp. (juvenile)															
Astrorhiza															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Grania sp.															
Protodorvillea kefersteini					0.0148										
Schistomeringos neglecta															
Lumbrineris aniara	0.0104	0.0244	0.0163	0.0033		0.0048	0.0559	0.0115							0.0032
Lumbrineridae												0.0024		1.1133	
Aponuphis bilineata		0.0178			0.0086	0.0139						0.017			0.002
Nothria conchylega															
Onuphidae sp. (damaged)															
Chrysopetalum debile						0.0024									
Glycera alba															
Glycera capitata												0.0001			
Glycera lapidum agg.					0.139										
Glycera oxycephala															
Glycera rouxii															
Glycera sp. (damaged)															
Glyceridae sp. (juvenile)															
Glycinde nordmanni					0.0011										
Goniada maculata	0.0028	0.0037					0.0024								
Goniadidae sp.															
Oxydromus flexuosus															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Podarkeopsis capensis					0.0044										
Psamathe fusca															
Hesionidae sp. (damaged)															
Psamathinae (Hesiospina/Psamathe sp. damaged)															
Aglaophamus agilis															
Nephtys assimilis		0.2024													
Nephtys caeca			0.1172											0.7128	
Nephtys cirrosa															
Nephtys hombergii															
Nephtys kersivalensis								0.0083		0.0969					
Nephtys spp. (juvenile/damaged)															
Nephtyidae spp.	0.0001										0.0001				
Nereis zonata															
Nereididae spp. (juvenile)							0.001								
Pholoe baltica						0.0053									
Pholoe inornata															
Pholoe spp.															
Eteone flava/longa agg.					0.0012										
Eteone sp. (damaged)					0.0006										

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Eulalia viridis															
Eumida sanguinea															
Phyllodoce groenlandica															
Phyllodoce maculata															
Phyllodoce rosea				0.002	0.0011										0.004
Phyllodoce sp. (juvenile)															
Phyllodocidae sp.															
Gattyana cirrhosa					0.0043										
Malmgrenia castanea															
Malmgrenia ljungmani			0.0026												
Malmgrenia sp.															
Polynoidae sp.					0.0021										0.0001
Polynoinae sp. (indet.)												0.0001			
Neoleanira tetragona	0.0008			0.0001											
Pisione remota				0.0006	0.0054										
Sigalion mathildae															
Sigalion squamosus														0.1498	
Sphaerodoridium minutum															
Sphaerodorum gracilis															
Exogone verugera					0.0007										
Prosphaerosyllis sp.															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Syllis amica					0.0089										
Trypanosyllis (Trypanosyllis) coeliaca					0.0015										
Syllidae sp. (damaged)												0.0001			
Aphroditoidea sp. (indet.)															
Galathowenia oculata															
Owenia fusiformis	0.0265		0.0016				0.0204							0.0055	
Owenia spp.															
Oweniidae sp.		0.0055						0.0249							
Jasmineira elegans					0.0071										
Jasmineira sp. (damaged)															
Sabellidae						0.0078									
Hydroides elegans															
Spirobranchus lamarcki															
Serpulidae sp.															
Magelona alleni															
Magelona filiformis		0.0002				0.0001		0.0004							
Magelona johnstoni															
Poecilochaetus serpens															
Aonides paucibranchiata					0.0196	0.0008					0.0004				
Dipolydora caulleryi															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Dipolydora coeca agg.															
Laonice bahusiensis					0.0098										
Laonice cirrata/bahusiensis															
Laonice sp. (damaged)															
Microspio mecznikowianus															
Polydora ciliata agg.															
Prionospio cirrifera															
Prionospio ehlersi															
Prionospio fallax					0.0003										
Pygospio elegans															
Scolelepis bonnieri															
Scolelepis (Scolelepis) foliosa															
Spio armata agg.															
Spio decorata					0.0101										
Spiophanes bombyx	0.0008	0.0031	0.0014	0.0017			0.0015	0.0035	0.0051	0.0004	0.0224	0.009			0.0015
Spiophanes kroyeri		0.0164													
Spionidae sp.														0.0001	
Macrochaeta sp.															
Ampharete falcata															
Ampharete lindstroemi															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Ampharete sp. (juvenile)															
Aphelochaeta sp. (type 1)															
Chaetozone setosa		0.0003						0.0014				0.0054			
Chaetozone zetlandica															
Cirratulus sp. (juvenile)						0.0001									
Tharyx killariensis				0.004					0.0008	0.0001					
Cirratulidae sp.															
Diplocirrus glaucus															
Diplocirrus spp.															
Flabelligeridae							0.0038								
Lagis koreni															
Pectinaria (Amphictene) auricoma	0.0286														
Pectinaria sp.															
Amphitrite cirrata															
Lanice conchilega				0.0202		0.4305	0.0076					0.5147		0.0001	
Pista cristata															
Pista elongata															
Axionice flexuosa												0.0046			
Pista mirabilis															
Polycirrus sp.							0.0069								0.0001
Terebellidae sp.															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Terebellides stroemii															
Capitella sp.							0.0001								
Mediomastus fragilis															
Notomastus spp.					0.1712	0.0937						0.0153			
Chaetopteridae sp.										0.0218					
Leiochone johnstoni															
Clymenura sp.															
Euclymene lombricoides															
Euclymene oerstedii															
Euclymene sp. A															
Praxillura longissima															
Maldanidae					0.0203					0.0188					
Ophelia borealis											0.0214	0.1095			
Ophelia celtica															
Ophelia neglecta				0.0042											
Orbinia sp.															
Scoloplos armiger	0.0056												0.0009		0.0079
Scoloplos sp. (indet.)												0.0103			
Orbiniidae spp. (damaged)												0.0058			
Aricidea (Acmira) cerrutii										0.0016					
Aricidea (Acmira) laubieri															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Paraonides sp.															
Paraonidae sp.					0.0001										
Polygordius spp.				0.0001	0.0019										
Scalibregma celticum															
Scalibregma inflatum							0.0422								
Scalibregmatidae															
Travisia forbesii				0.0296						0.0134	0.0261				0.0158
Acari															
Verruca stroemia															
Cirripedia sp. (Cyprid larvae)															
Copepoda sp.	0.0001			0.0004				0.0001						0.0001	
Ampelisca brevicornis															0.0158
Ampelisca diadema															
Ampelisca tenuicornis										0.0059					
Ampelisca typica															
Ampelisca sp.															
Atylus vedlomensis						0.0246									
Atylus sp. (damaged)					0.002										
Bathyporeia gracilis															
Bathyporeia pelagica	0.0021	0.0021	0.0023	0.005				0.0016	0.0021	0.0039		0.0105	0.0015	0.0015	0.0042
Bathyporeia pilosa															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Bathyporeia sarsi															
Bathyporeia sp.															
Pariambus typicus		0.0001													
Phtisica marina			0.0001												
Pseudoprotella phasma															
Cheirocratus sp.															
Crassicorophium crassicorne															
Leptocheirus hirsutimanus															
Leptocheirus pectinatus					0.0002										
Isaeidae sp. (damaged)															
Siphonoecetes (Centraloecetes) kroyeranus															
Siphonoecetes (Centraloecetes) striatus															
Leucothoe lilljeborgi															
Lepidepecreum longicornis															
Tryphosites longipes															
Othomaera othonis						0.0381									
Maerella tenuimana															
Megaluropus agilis															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Melita palmata															
Perioculodes longimanus															
Westwoodilla caecula															
Gammaropsis sp. (damaged)															
Megamphopus cornutus															
Harpinia antennaria															
Harpinia serrata															
Paraphoxus oculatus															
Menigrates obtusifrons															
Urothoe elegans							0.0021								
Urothoe marina															
Urothoe sp.															0.001
Amphipoda															
Iphinoe serrata															
Diastylis lucifera															
Eudorellopsis deformis	0.0014							0.0001	0.0001						
Campylaspis undata												0.0001			
Petalosarsia declivis															
Cumacea sp.															
Atelecyclus rotundatus					0.0882										
Galathea intermedia					0.0012										

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Galathea sp.						0.0013									
Ebalia cranchii															
Ebalia sp. (juvenile)															
Eurynome sp.										0.0025					
Hyas coarctatus															
Paguridae sp. (juvenile/larvae)															
Liocarcinus pusillus															
Liocarcinus sp. (juvenile)															
Caridea zoea larvae															
Decapoda sp. (damaged)													0.0001		
Decapoda sp. (larvae)	0.0001	0.0016	0.0008				0.001						0.0001		
Astacilla damnoniensis															
Astacilla dilatata															
Astacilla longicornis															
Gnathia oxyuraea						0.0045									
Gnathia oxyuraea Praniza larvae															
Nebalia bipes															
Tanaopsis graciloides															
Typhlotanais tenuicornis															
Tanaidacea sp. (juvenile)															
Ostracoda sp.															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Hippoporina pertusa															
Chaetognatha sp.															0.0036
Lotidae sp. (juvenile)															
Ammodytes sp.															
Microchirus variegatus					0.0203										
Ascidiacea sp.															
Branchiostoma lanceolatum															
Actinopterygii sp. (damaged)											0.0096				
Edwardsia claparedii					0.0082										
Edwardsia spp. (indet.)															
Edwardsiidae sp.	0.0069		0.0029		0.0071			0.0024							0.0196
Halcampa chrysanthellum				0.0066			0.0049								
Actiniaria															
Alcyonium digitatum															
Cerianthus lloydii															
Cerianthus sp.															
Bougainvilliidae															
Campanulariidae sp.															
Calycella sp.															
Sertulariidae sp.															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Hydrozoa sp. (damaged)															
Antedonidae sp. (damaged)															
Strongylocentrotus droebachiensis					0.0096										
Strongylocentrotus sp.						0.0065									
Echinocyamus pusillus	0.0274	0.007	0.0136	0.0304	0.0264	0.1043	0.0016	0.0087	0.0217	0.0256	0.0426	0.0229	0.0245	0.033	0.0078
Echinocardium cordatum	21.3587									0.0131					
Echinoidea sp. (damaged)															
Leptosynapta decaria															
Leptosynapta sp.															
Amphiura (Ophiopeltis) securigera				0.0001											
Amphiura filiformis															
Amphiura (Amphiura) incana			0.0016												
Amphiura sp. (juvenile)										0.0014					
Amphiuridae sp. (juvenile)												0.0004	0.0032		
Ophiura albida															
Ophiura ophiura	0.0023														
Ophiura sarsii															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Ophiura sp. (juvenile)															
Ophiuridae sp. (juvenile)											0.0001				
Ophiuroidea spp. (fragments)		0.0058					0.0141	0.0555							
Ophiuroidea spp. (juvenile)		0.0001			0.0082	0.0033			0.0001						0.0025
Hiatella arctica															
Ensis ensis															
Phaxas pellucidus										0.0845					
Pharidae sp.															
Glycymeris glycymeris					75.069	92.859									
Parvicardium pinnulatum															
Cardiidae sp. (damaged)															
Gari costulata															
Gari fervensis	0.6267	1.0906	0.5505	0.0125			0.0068	0.803		0.0103	0.0244	0.0702	0.007	0.0273	
Gari tellinella					1.169	0.2639									
Psammobiidae sp. (juvenile)															
Abra nitida				0.0082											
Abra prismatica	0.1399							0.0564		0.0118	0.0072				0.0562
Abra sp. (juvenile)															
Asbjornsenia pygmaea				0.0065					0.0023			0.0526	0.0316	0.0039	0.0655

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Fabulina fabula															
Limecola balthica															
Moerella sp. (juvenile)					0.0103										
Astarte sulcata						1.1371									
Goodallia triangularis					0.0048	0.0163									0.0018
Astartidae sp. (juvenile)															
Limaria hians						0.0056									
Limatula subauriculata						0.0001									
Lucinoma borealis															
Parathyasira equalis															
Thyasira flexuosa															
Thyasira sp. (juvenile)															
Crenella decussata		0.0042				0.0063		0.0048	0.0056	0.0059			0.0012	0.0024	0.0135
Modiolus modiolus						0.0081									
Mytilidae sp. (juvenile)															
Nucula hanleyi															
Nucula nitidosa															
Nucula nucleus															
Anomia ephippium															
Arctica islandica															
Chamelea gallina															
Chamelea striatula					0.0938		0.3906								

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Clausinella fasciata			0.5598			11.7078									
Dosinia exoleta					0.0637		0.0017				0.0021				0.0115
Dosinia lupinus				0.496	0.0165			0.0403							
Dosinia sp. (juvenile)															
Gouldia minima			0.0001										0.0008	0.0016	
Polititapes rhomboides					0.0213	33.1651									
Timoclea ovata															
Venus casina										0.0028	0.031			0.0097	
Spisula elliptica	0.0044	0.0001	0.0017		0.0056	0.0234		0.0001		0.0055	0.0036	0.0021		0.0019	0.0395
Kurtiella bidentata							0.0022								
Kurtiella sp.					0.0028										
Tellimya ferruginosa															
Cochlodesma praetenue		0.0222													
Thracia villosiuscula	0.0043		0.0042	0.063				0.0128	0.029		0.0138	0.01	0.0013		
Thracia sp. (damaged)															
Chaetoderma nitidulum															
Cylichna cylindracea															
Philine sp.											0.003				
Retusa obtusa						0.0024									
Volvulella acuminata															
Eulima bilineata															

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Euspira nitida				0.0045	0.0025	0.386		0.0001	0.0104					0.0645	0.008
Rissoidae sp. (juvenile)					0.0004										
Turrisipho moebii															
Mangelia sp. (damaged)															
Turridae sp. (juvenile)															
Okenia sp.															
Nudibranchia eggs															
Pyrgiscus crenatus															
Pyramidellidae sp. (juvenile)					0.001										
Gibbula cineraria						0.0093									
Gibbula tumida						0.0038									
Gastropoda sp. (damaged)															
Leptochiton asellus						0.0986									
Antalis entalis															
Antalis spp.															
Nematoda					0.0529	0.0065									
Nemertea	0.0008			0.0052	0.0028	0.027	0.0428				0.0691	0.0007			
Phoronis muelleri															
Phoronis sp.															
Phoronida sp.	0.0223	0.0018	0.0001				0.0023		0.001			0.008		0.0022	0.0001
Platyhelminthes sp.		0.0065			0.0003							0.0013			

Taxa	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60
Cliona celata															
Suberitidae sp.															
Porifera sp.															
Golfingia (Golfingia) elongata															
Golfingia (Golfingia) vulgaris															
Golfingia sp.															
Phascolion (Phascolion) strombus															
Sipuncula sp. (juvenile)															
Astrorhiza															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Grania sp.	0.0001								0.0001	0.0001					
Protodorvillea kefersteini															
Schistomeringos neglecta															
Lumbrineris aniara			0.0895			0.003		0.0001						0.0287	0.0214
Lumbrineridae	0.0039	0.0152							0.001						
Aponuphis bilineata			0.002	0.0008	0.0001	0.0001				0.0382		0.0019			
Nothria conchylega															
Onuphidae sp. (damaged)															
Chrysopetalum debile															
Glycera alba			0.0014												
Glycera capitata	0.0216														
Glycera lapidum agg.					0.0095			0.0085							
Glycera oxycephala															
Glycera rouxii															
Glycera sp. (damaged)															
Glyceridae sp. (juvenile)							0.001								

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Glycinde nordmanni				0.1723											
Goniada maculata															
Goniadidae sp.								0.0001							
Oxydromus flexuosus															
Podarkeopsis capensis															
Psamathe fusca															
Hesionidae sp. (damaged)			0.0029												
Psamathinae (Hesiospina/Psamathe sp. damaged)															
Aglaophamus agilis			0.0047		0.0229				0.0166						
Nephtys assimilis		0.0857													
Nephtys caeca															
Nephtys cirrosa															
Nephtys hombergii															
Nephtys kersivalensis													0.0268		
Nephtys spp. (juvenile/damaged)															
Nephtyidae spp.	0.0001			0.0023										0.003	0.0019
Nereis zonata															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Nereididae spp. (juvenile)															
Pholoe baltica														0.0001	
Pholoe inornata															
Pholoe spp.															
Eteone flava/longa agg.															
Eteone sp. (damaged)															
Eulalia viridis															
Eumida sanguinea						0.0033									
Phyllodoce groenlandica					0.0007										
Phyllodoce maculata															0.0004
Phyllodoce rosea															
Phyllodoce sp. (juvenile)															
Phyllodocidae sp.			0.0002					0.0001							
Gattyana cirrhosa								0.0023							
Malmgrenia castanea															
Malmgrenia ljungmani							0.0781								

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Malmgrenia sp.															
Polynoidae sp.				0.0008								0.0009			
Polynoinae sp. (indet.)															
Neoleanira tetragona															
Pisione remota					0.0012				0.0005						
Sigalion mathildae															
Sigalion squamosus										0.0445					
Sphaerodoridium minutum															
Sphaerodorum gracilis															
Exogone verugera															
Prosphaerosyllis sp.								0.0001							
Syllis amica					0.0001							0.001			
Trypanosyllis (Trypanosyllis) coeliaca				0.0001											
Syllidae sp. (damaged)															
Aphroditoidea sp. (indet.)					0.003										
Galathowenia oculata															
Owenia fusiformis						0.0155				0.0001					

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Owenia spp.															
Oweniidae sp.															
Jasmineira elegans															
Jasmineira sp. (damaged)															
Sabellidae															
Hydroides elegans															
Spirobranchus lamarcki			0.0028												
Serpulidae sp.															
Magelona alleni														0.0513	0.0297
Magelona filiformis															0.0009
Magelona johnstoni															
Poecilochaetus serpens					0.0049										
Aonides paucibranchiata					0.0049			0.0001	0.0014						
Dipolydora caulleryi															
Dipolydora coeca agg.															
Laonice bahusiensis															
Laonice cirrata/bahusiensis															
Laonice sp. (damaged)															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Microspio mecznikowianus															
Polydora ciliata agg.															
Prionospio cirrifera															
Prionospio ehlersi															
Prionospio fallax															
Pygospio elegans															
Scolelepis bonnieri															
Scolelepis (Scolelepis) foliosa			0.0031												
Spio armata agg.											0.0086				
Spio decorata					0.002										
Spiophanes bombyx	0.0021	0.0046	0.008	0.0231		0.001	0.0078		0.0024	0.0151	0.0176		0.0038	0.004	0.0061
Spiophanes kroyeri															
Spionidae sp.								0.0001							
Macrochaeta sp.															
Ampharete falcata															
Ampharete lindstroemi															
Ampharete sp. (juvenile)															
Aphelochaeta sp. (type 1)															
Chaetozone setosa				0.0039									0.0027	0.0049	

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Chaetozone zetlandica			0.0001												
Cirratulus sp. (juvenile)															
Tharyx killariensis															
Cirratulidae sp.															
Diplocirrus glaucus														0.0265	0.004
Diplocirrus spp.															
Flabelligeridae															
Lagis koreni															
Pectinaria (Amphictene) auricoma															0.0086
Pectinaria sp.															
Amphitrite cirrata															
Lanice conchilega		0.0021				0.1548	0.16								
Pista cristata															
Pista elongata									0.0001						
Axionice flexuosa															
Pista mirabilis															
Polycirrus sp.			0.0138	0.0061											

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Terebellidae sp.															
Terebellides stroemii														0.0041	
Capitella sp.															
Mediomastus fragilis															
Notomastus spp.	0.0093	0.053		0.019	0.0035										
Chaetopteridae sp.															
Leiochone johnstoni												0.0057			
Clymenura sp.															
Euclymene lombricoides															0.0082
Euclymene oerstedii															
Euclymene sp. A															
Praxillura longissima															
Maldanidae						0.0001				0.0133				0.001	0.018
Ophelia borealis	0.01			0.014	0.0358				0.047						
Ophelia celtica										0.0037					
Ophelia neglecta							0.0079								

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Orbinia sp.		0.0029													
Scoloplos armiger			0.0027	0.0641		0.0085				0.0001			0.0044		
Scoloplos sp. (indet.)															
Orbiniidae spp. (damaged)								0.0067							
Aricidea (Acmira) cerrutii				0.0016				0.0001							
Aricidea (Acmira) laubieri															
Paraonides sp.															
Paraonidae sp.															
Polygordius spp.					0.0023										
Scalibregma celticum															
Scalibregma inflatum			0.0052												
Scalibregmatidae															
Travisia forbesii		0.0126		0.0807		0.0274	0.0184				0.0693				
Acari															
Verruca stroemia															
Cirripedia sp. (Cyprid larvae)			0.0001												

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Copepoda sp.	0.0005											0.0001		0.0001	0.0001
Ampelisca brevicornis			0.0112												
Ampelisca diadema															
Ampelisca tenuicornis	0.007														
Ampelisca typica					0.0031										
Ampelisca sp.															
Atylus vedlomensis															
Atylus sp. (damaged)															
Bathyporeia gracilis															
Bathyporeia pelagica	0.0003	0.0001				0.006	0.0052		0.0014	0.0077	0.0042			0.001	0.0009
Bathyporeia pilosa															
Bathyporeia sarsi															
Bathyporeia sp.			0.0001										0.0017		
Pariambus typicus															
Phtisica marina															
Pseudoprotella phasma															
Cheirocratus sp.															
Crassicorophium crassicorne		0.0018													

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Leptocheirus hirsutimanus								0.0056							
Leptocheirus pectinatus															
Isaeidae sp. (damaged)															
Siphonoecetes (Centraloecetes) kroyeranus															
Siphonoecetes (Centraloecetes) striatus															
Leucothoe lilljeborgi								0.0066							
Lepidepecreum longicornis															
Tryphosites longipes															
Othomaera othonis															
Maerella tenuimana															
Megaluropus agilis							0.0012								
Melita palmata															
Perioculodes longimanus	0.0025		0.0014												
Westwoodilla caecula															
Gammaropsis sp. (damaged)			0.001						0.0012						
Megamphopus cornutus															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Harpinia antennaria															
Harpinia serrata															
Paraphoxus oculatus															
Menigrates obtusifrons															
Urothoe elegans			0.0012				0.005	0.0143							0.0021
Urothoe marina									0.0031						
Urothoe sp.															
Amphipoda				0.0003											
Iphinoe serrata														0.0001	
Diastylis lucifera															
Eudorellopsis deformis															0.0001
Campylaspis undata															
Petalosarsia declivis	0.0005														
Cumacea sp.															
Atelecyclus rotundatus															
Galathea intermedia															
Galathea sp.			0.0016												

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Ebalia cranchii			1.0636												
Ebalia sp. (juvenile)															
Eurynome sp.															
Hyas coarctatus															
Paguridae sp. (juvenile/larvae)	0.0001						0.0038								
Liocarcinus pusillus															
Liocarcinus sp. (juvenile)															0.0065
Caridea zoea larvae															
Decapoda sp. (damaged)															
Decapoda sp. (larvae)										0.0009	0.0001				
Astacilla damnoniensis			0.0021												
Astacilla dilatata															
Astacilla longicornis															
Gnathia oxyuraea			0.0033									0.0007			
Gnathia oxyuraea Praniza larvae															
Nebalia bipes															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Tanaopsis graciloides			0.0001												
Typhlotanais tenuicornis															
Tanaidacea sp. (juvenile)														0.0001	
Ostracoda sp.															
Hippoporina pertusa															
Chaetognatha sp.															
Lotidae sp. (juvenile)					0.022										
Ammodytes sp.							1.2734								
Microchirus variegatus															
Ascidiacea sp.				0.0001											
Branchiostoma lanceolatum					0.0187										
Actinopterygii sp. (damaged)															
Edwardsia claparedii															
Edwardsia spp. (indet.)															
Edwardsiidae sp.															
Halcampa chrysanthellum			0.0025											0.0037	
Actiniaria				0.0001											

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Alcyonium digitatum															
Cerianthus lloydii															
Cerianthus sp.			0.0126												
Bougainvilliidae															
Campanulariidae sp.															
Calycella sp.															
Sertulariidae sp.															
Hydrozoa sp. (damaged)															
Antedonidae sp. (damaged)															
Strongylocentrotus droebachiensis															
Strongylocentrotus sp.															
Echinocyamus pusillus	0.0042	0.0304	0.0188	0.0086	0.0006	0.0001	0.0169	0.0239		0.0001		0.0025	0.0018		0.008
Echinocardium cordatum															
Echinoidea sp. (damaged)															
Leptosynapta decaria															
Leptosynapta sp.															
Amphiura (Ophiopeltis) securigera															
Amphiura filiformis															
Amphiura (Amphiura) incana															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Amphiura sp. (juvenile)									0.0009						
Amphiuridae sp. (juvenile)					0.0025										
Ophiura albida															
Ophiura ophiura															
Ophiura sarsii															
Ophiura sp. (juvenile)															
Ophiuridae sp. (juvenile)															
Ophiuroidea spp. (fragments)														0.0528	0.0302
Ophiuroidea spp. (juvenile)	0.0011	0.0001	0.0001	0.0001		0.0021	0.001	0.0017		0.0001			0.0001		0.0001
Hiatella arctica			0.0084												
Ensis ensis											0.0791				
Phaxas pellucidus									0.0001	0.0001				0.2445	0.0036
Pharidae sp.					6.9649										
Glycymeris glycymeris															
Parvicardium pinnulatum															
Cardiidae sp. (damaged)															
Gari costulata															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Gari fervensis	0.0032	0.0092		0.0148		0.0023	0.0099			0.012	0.0049		0.0132		
Gari tellinella															
Psammobiidae sp. (juvenile)					0.0017										
Abra nitida															
Abra prismatica	0.0026			0.0181						0.0058	0.014		0.0044	0.0132	0.0137
Abra sp. (juvenile)															
Asbjornsenia pygmaea	0.049		0.0333	0.0397	0.12	0.0047	0.0518	0.1785	0.0633	0.1025	0.0263	0.0038			
Fabulina fabula														0.006	
Limecola balthica															
Moerella sp. (juvenile)															
Astarte sulcata															
Goodallia triangularis				0.0036	0.0019		0.0044								
Astartidae sp. (juvenile)					0.0036										
Limaria hians															
Limatula subauriculata				0.0014											
Lucinoma borealis															0.0001

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Parathyasira equalis															
Thyasira flexuosa															
Thyasira sp. (juvenile)															
Crenella decussata	0.0101			0.0048						0.0061			0.0019		
Modiolus modiolus															
Mytilidae sp. (juvenile)															
Nucula hanleyi															
Nucula nitidosa															
Nucula nucleus															
Anomia ephippium			0.0068												
Arctica islandica															
Chamelea gallina															
Chamelea striatula										0.1661					
Clausinella fasciata					0.0022			0.0045							
Dosinia exoleta							0.1245				0.005				
Dosinia lupinus															
Dosinia sp. (juvenile)															
Gouldia minima					0.0017	0.0027									

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Polititapes rhomboides															
Timoclea ovata												0.0069			
Venus casina		0.0013				0.0072				0.0015	0.0089		0.0044	0.005	
Spisula elliptica	0.0024			0.0168	3.643	0.0141	0.0219	0.0091	0.0033	0.0111	0.0301				
Kurtiella bidentata															
Kurtiella sp.															
Tellimya ferruginosa															
Cochlodesma praetenue				0.0597										0.0018	
Thracia villosiuscula						0.3063	0.0852			0.013					
Thracia sp. (damaged)															
Chaetoderma nitidulum															
Cylichna cylindracea															
Philine sp.			0.0022												
Retusa obtusa															
Volvulella acuminata															
Eulima bilineata									0.001						

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Euspira nitida	0.0061				0.0032	0.006								0.0113	0.0042
Rissoidae sp. (juvenile)															
Turrisipho moebii															
Mangelia sp. (damaged)															
Turridae sp. (juvenile)															
Okenia sp.															
Nudibranchia eggs															
Pyrgiscus crenatus															
Pyramidellidae sp. (juvenile)															
Gibbula cineraria															
Gibbula tumida															
Gastropoda sp. (damaged)												0.0026			
Leptochiton asellus															
Antalis entalis														0.0197	0.3846
Antalis spp.															
Nematoda					0.0001			0.0001	0.0001						
Nemertea		0.0001		0.0026	0.0061				0.0002			0.0006		0.007	
Phoronis muelleri															
Phoronis sp.															

Taxa	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75
Phoronida sp.		0.0055		0.0323			0.001		0.016					0.0001	
Platyhelminthes sp.	0.0025		0.0045									0.0017			
Cliona celata															
Suberitidae sp.															
Porifera sp.															
Golfingia (Golfingia) elongata															
Golfingia (Golfingia) vulgaris							0.0119								
Golfingia sp.								0.0001							
Phascolion (Phascolion) strombus															
Sipuncula sp. (juvenile)															
Astrorhiza															

Taxa	W76	W77	W78	W79	W80
Grania sp.					
Protodorvillea kefersteini					
Schistomeringos neglecta					
Lumbrineris aniara		0.0734	0.0429		

Taxa	W76	W77	W78	W79	W80
Lumbrineridae					
Aponuphis bilineata				0.002	0.0079
Nothria conchylega					
Onuphidae sp. (damaged)					
Chrysopetalum debile					
Glycera alba					
Glycera capitata					
Glycera lapidum agg.					
Glycera oxycephala					
Glycera rouxii					
Glycera sp. (damaged)					
Glyceridae sp. (juvenile)					
Glycinde nordmanni					
Goniada maculata					
Goniadidae sp.					
Oxydromus flexuosus					
Podarkeopsis capensis					
Psamathe fusca					
Hesionidae sp. (damaged)					0.0001
Psamathinae (Hesiospina/Psamathe sp. damaged)					
Aglaophamus agilis					

Taxa	W76	W77	W78	W79	W80
Nephtys assimilis					
Nephtys caeca					
Nephtys cirrosa					
Nephtys hombergii					
Nephtys kersivalensis					
Nephtys spp. (juvenile/damaged)					
Nephtyidae spp.				0.0014	0.0134
Nereis zonata					
Nereididae spp. (juvenile)			0.0009		
Pholoe baltica					
Pholoe inornata					
Pholoe spp.					
Eteone flava/longa agg.					
Eteone sp. (damaged)					
Eulalia viridis					
Eumida sanguinea					
Phyllodoce groenlandica					
Phyllodoce maculata					
Phyllodoce rosea					
Phyllodoce sp. (juvenile)					

Taxa	W76	W77	W78	W79	W80
Phyllodocidae sp.			0.0078		
Gattyana cirrhosa					
Malmgrenia castanea					
Malmgrenia ljungmani					
Malmgrenia sp.					
Polynoidae sp.					
Polynoinae sp. (indet.)					
Neoleanira tetragona					
Pisione remota					
Sigalion mathildae					
Sigalion squamosus				0.0102	
Sphaerodoridium minutum					
Sphaerodorum gracilis					
Exogone verugera					
Prosphaerosyllis sp.					
Syllis amica					
Trypanosyllis (Trypanosyllis) coeliaca					
Syllidae sp. (damaged)					
Aphroditoidea sp. (indet.)					
Galathowenia oculata		0.0001			
Owenia fusiformis		0.006			0.0028

Taxa	W76	W77	W78	W79	W80
Owenia spp.					
Oweniidae sp.					
Jasmineira elegans					
Jasmineira sp. (damaged)					
Sabellidae					
Hydroides elegans					
Spirobranchus lamarcki					
Serpulidae sp.					
Magelona alleni	0.0159	0.0485			
Magelona filiformis			0.001		
Magelona johnstoni					
Poecilochaetus serpens					
Aonides paucibranchiata				0.0001	
Dipolydora caulleryi					
Dipolydora coeca agg.					
Laonice bahusiensis					
Laonice cirrata/bahusiensis					
Laonice sp. (damaged)					
Microspio mecznikowianus					
Polydora ciliata agg.					
Prionospio cirrifera	0.0008				

Taxa	W76	W77	W78	W79	W80
Prionospio ehlersi					
Prionospio fallax			0.001		
Pygospio elegans					
Scolelepis bonnieri					
Scolelepis (Scolelepis) foliosa					0.0847
Spio armata agg.					
Spio decorata					
Spiophanes bombyx		0.0037	0.0008	0.0018	0.0372
Spiophanes kroyeri					
Spionidae sp.					
Macrochaeta sp.					
Ampharete falcata					
Ampharete lindstroemi					
Ampharete sp. (juvenile)					
Aphelochaeta sp. (type 1)					
Chaetozone setosa					0.003
Chaetozone zetlandica					
Cirratulus sp. (juvenile)					
Tharyx killariensis			0.0027		
Cirratulidae sp.					
Diplocirrus glaucus	0.0059				
Diplocirrus spp.					

Taxa	W76	W77	W78	W79	W80
Flabelligeridae					
Lagis koreni					
Pectinaria (Amphictene) auricoma		0.0004	0.0212		
Pectinaria sp.	0.0118				
Amphitrite cirrata					
Lanice conchilega			0.008	0.007	
Pista cristata					
Pista elongata					
Axionice flexuosa					
Pista mirabilis					
Polycirrus sp.					0.0098
Terebellidae sp.					
Terebellides stroemii					
Capitella sp.					
Mediomastus fragilis					
Notomastus spp.					
Chaetopteridae sp.					
Leiochone johnstoni					0.001
Clymenura sp.					
Euclymene lombricoides					

Taxa	W76	W77	W78	W79	W80
Euclymene oerstedii					
Euclymene sp. A					
Praxillura longissima			0.0042		
Maldanidae		0.0001		0.013	
Ophelia borealis				0.0169	0.0139
Ophelia celtica					
Ophelia neglecta					
Orbinia sp.					
Scoloplos armiger			0.0024	0.0268	0.0076
Scoloplos sp. (indet.)					
Orbiniidae spp. (damaged)					
Aricidea (Acmira) cerrutii					0.0005
Aricidea (Acmira) laubieri					
Paraonides sp.					
Paraonidae sp.					
Polygordius spp.					
Scalibregma celticum					
Scalibregma inflatum					
Scalibregmatidae					
Travisia forbesii					0.0855
Acari					
Verruca stroemia					

Taxa	W76	W77	W78	W79	W80
Cirripedia sp. (Cyprid larvae)					
Copepoda sp.	0.0019		0.0001		
Ampelisca brevicornis					
Ampelisca diadema					
Ampelisca tenuicornis					
Ampelisca typica					
Ampelisca sp.					
Atylus vedlomensis					
Atylus sp. (damaged)					
Bathyporeia gracilis					
Bathyporeia pelagica	0.0001		0.0102		0.0004
Bathyporeia pilosa					
Bathyporeia sarsi		0.0004			
Bathyporeia sp.					
Pariambus typicus			0.0001		
Phtisica marina					
Pseudoprotella phasma					
Cheirocratus sp.					
Crassicorophium crassicorne					
Leptocheirus hirsutimanus					
Leptocheirus pectinatus					

Taxa	W76	W77	W78	W79	W80
Isaeidae sp. (damaged)					
Siphonoecetes (Centraloecetes) kroyeranus					
Siphonoecetes (Centraloecetes) striatus					
Leucothoe lilljeborgi					
Lepidepecreum longicornis					
Tryphosites longipes					
Othomaera othonis					
Maerella tenuimana					
Megaluropus agilis					
Melita palmata					
Perioculodes longimanus					0.0032
Westwoodilla caecula			0.0016		
Gammaropsis sp. (damaged)					
Megamphopus cornutus					
Harpinia antennaria					
Harpinia serrata					
Paraphoxus oculatus					
Menigrates obtusifrons				0.0001	
Urothoe elegans		0.0007	0.0001		
Urothoe marina					
Urothoe sp.					

Taxa	W76	W77	W78	W79	W80
Amphipoda					
Iphinoe serrata					
Diastylis lucifera					
Eudorellopsis deformis					
Campylaspis undata					
Petalosarsia declivis					
Cumacea sp.					
Atelecyclus rotundatus			0.0752		
Galathea intermedia					
Galathea sp.					
Ebalia cranchii					
Ebalia sp. (juvenile)					
Eurynome sp.					
Hyas coarctatus					
Paguridae sp. (juvenile/larvae)					0.001
Liocarcinus pusillus					
Liocarcinus sp. (juvenile)					
Caridea zoea larvae					
Decapoda sp. (damaged)					
Decapoda sp. (larvae)				0.0001	

Taxa	W76	W77	W78	W79	W80
Astacilla damnoniensis					
Astacilla dilatata		0.0009	0.0001		
Astacilla longicornis					
Gnathia oxyuraea					
Gnathia oxyuraea Praniza larvae					
Nebalia bipes					
Tanaopsis graciloides			0.0001		
Typhlotanais tenuicornis					
Tanaidacea sp. (juvenile)					
Ostracoda sp.					
Hippoporina pertusa					
Chaetognatha sp.					
Lotidae sp. (juvenile)					
Ammodytes sp.					
Microchirus variegatus					
Ascidiacea sp.					
Branchiostoma lanceolatum					
Actinopterygii sp. (damaged)					
Edwardsia claparedii					
Edwardsia spp. (indet.)					
Edwardsiidae sp.		0.0086		0.0126	0.0034

Taxa	W76	W77	W78	W79	W80
Halcampa chrysanthellum					
Actiniaria					
Alcyonium digitatum					
Cerianthus lloydii			0.0149		
Cerianthus sp.					
Bougainvilliidae					
Campanulariidae sp.					
Calycella sp.					
Sertulariidae sp.					
Hydrozoa sp. (damaged)					
Antedonidae sp. (damaged)					
Strongylocentrotus droebachiensis					
Strongylocentrotus sp.					
Echinocyamus pusillus		0.0062	0.0143	0.0001	0.0015
Echinocardium cordatum		27.0686	0.7606		
Echinoidea sp. (damaged)					
Leptosynapta decaria					
Leptosynapta sp.					
Amphiura (Ophiopeltis) securigera					
Amphiura filiformis					

Taxa	W76	W77	W78	W79	W80
Amphiura (Amphiura) incana					
Amphiura sp. (juvenile)					
Amphiuridae sp. (juvenile)					
Ophiura albida					
Ophiura ophiura					
Ophiura sarsii			0.0476		
Ophiura sp. (juvenile)					
Ophiuridae sp. (juvenile)					
Ophiuroidea spp. (fragments)		0.025			
Ophiuroidea spp. (juvenile)	0.0012			0.0001	0.0014
Hiatella arctica					
Ensis ensis					
Phaxas pellucidus		0.0204	0.0162		
Pharidae sp.				0.8049	
Glycymeris glycymeris					
Parvicardium pinnulatum					
Cardiidae sp. (damaged)					
Gari costulata					
Gari fervensis		0.3559	0.3377	0.0034	0.0165
Gari tellinella					
Psammobiidae sp. (juvenile)					
Abra nitida					

Taxa	W76	W77	W78	W79	W80
Abra prismatica		0.0161		0.0021	0.011
Abra sp. (juvenile)					
Asbjornsenia pygmaea				0.0714	0.0833
Fabulina fabula		0.0149	0.0004		
Limecola balthica					
Moerella sp. (juvenile)					
Astarte sulcata					
Goodallia triangularis					0.0007
Astartidae sp. (juvenile)					
Limaria hians					
Limatula subauriculata					
Lucinoma borealis	0.0014				
Parathyasira equalis					
Thyasira flexuosa					
Thyasira sp. (juvenile)					
Crenella decussata				0.0068	0.004
Modiolus modiolus					
Mytilidae sp. (juvenile)					
Nucula hanleyi					
Nucula nitidosa					
Nucula nucleus					

Taxa	W76	W77	W78	W79	W80
Anomia ephippium					
Arctica islandica					
Chamelea gallina					
Chamelea striatula					
Clausinella fasciata					
Dosinia exoleta					
Dosinia lupinus					
Dosinia sp. (juvenile)					
Gouldia minima					
Polititapes rhomboides					
Timoclea ovata					
Venus casina	0.001	0.0039			0.0328
Spisula elliptica			0.0018	0.001	0.0054
Kurtiella bidentata					
Kurtiella sp.					
Tellimya ferruginosa					
Cochlodesma praetenue				0.0081	1.2194
Thracia villosiuscula		0.0128	0.0032		
Thracia sp. (damaged)					
Chaetoderma nitidulum					
Cylichna cylindracea			0.0063		
Philine sp.					

Taxa	W76	W77	W78	W79	W80
Retusa obtusa					
Volvulella acuminata					
Eulima bilineata					
Euspira nitida			0.0055		0.0019
Rissoidae sp. (juvenile)					
Turrisipho moebii					
Mangelia sp. (damaged)					
Turridae sp. (juvenile)					
Okenia sp.					
Nudibranchia eggs					
Pyrgiscus crenatus					
Pyramidellidae sp. (juvenile)					
Gibbula cineraria					
Gibbula tumida					
Gastropoda sp. (damaged)					
Leptochiton asellus					
Antalis entalis			0.0014		
Antalis spp.					
Nematoda					
Nemertea		0.0022		0.0024	
Phoronis muelleri					

Taxa	W76	W77	W78	W79	W80
Phoronis sp.					
Phoronida sp.	0.0051		0.0033	0.0123	
Platyhelminthes sp.					
Cliona celata					
Suberitidae sp.					
Porifera sp.					
Golfingia (Golfingia) elongata					
Golfingia (Golfingia) vulgaris					
Golfingia sp.		0.0023			
Phascolion (Phascolion) strombus					
Sipuncula sp. (juvenile)					
Astrorhiza					

15 Annex 7.1J: Detailed summary of cluster groups derived from the SIMPROF routine

Group A (Average similarity: 21.14%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W6	Sandy Gravel	52.73	45.90	1.37	38.3
W43	Muddy Sandy Gravel	43.75	50.03	6.22	44.6
W63	Sandy Gravel	33.84	64.82	1.34	40.3
W72	Sandy Gravel	42.89	56.94	0.17	35.9
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Echinocyamus pusillus	5.00	100	16.1	16.1
	Aponuphis bilineata	2.00	100	15.28	31.38
	Lumbrineris aniara	12.33	75	8.26	39.64
	Gnathia oxyuraea	5.00	75	8.2	47.84
	Timoclea ovata	0.67	75	7.62	55.46
	Nemertea	1.33	75	7.62	63.09
	Chaetozone zetlandica	2.67	75	6.72	69.81
	Platyhelminthes sp.	1.00	75	6.69	76.5
	Scoloplos armiger	2.33	75	6.46	82.97
	Polynoidae sp.	0.33	50	3.9	86.87
	Asbjornsenia pygmaea	0.33	50	3.13	90
	Aonides paucibranchiata	2.00	50	2.36	92.36
	Polycirrus sp.	1.67	50	2.32	94.68
	Spirobranchus lamarcki	1.33	50	2.14	96.82
	Clausinella fasciata	0.67	50	1.67	98.49

Scalibregma inflatum	1.33	50	1.51	100

Group B (Average similarity: 38.29%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W20	Muddy Sandy Gravel	35.61	55.96	8.43	47.8
W28	Gravelly Muddy Sand	23.19	64.70	12.11	47.7
W39	Sandy Gravel	30.88	65.00	4.12	45.3
W50	Gravelly Sand	17.45	80.70	1.85	37.7
W51	Sandy Gravel	55.25	40.89	3.86	38.6
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Nematoda	75.20	100	16.75	16.75
	Echinocyamus pusillus	22.40	100	16.4	33.14
	Aonides paucibranchiata	14.20	100	10.7	43.85
	Notomastus spp.	8.00	100	9.64	53.49
	Ophiuroidea spp. (juvenile)	7.60	100	8.68	62.17
	Nemertea	6.20	100	7.96	70.12
	Pisione remota	9.00	60	3.26	73.38
	Lanice conchilega	1.20	80	2.67	76.05
	Grania sp.	5.80	60	2.63	78.67
	Aponuphis bilineata	1.20	80	2.3	80.97
	Euspira nitida	2.00	80	2.3	83.27
	Polititapes rhomboides	0.80	80	2.25	85.52
	Jasmineira elegans	4.20	60	2.07	87.59

Polygordius spp.	2.00	60	1.43	89.02
Crenella decussata	1.00	60	1.35	90.37

Group C (Average similarity: 29.67%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W5	Sandy Gravel	38.07	60.12	1.81	37.7
W65	Slightly Gravelly Sand	3.51	96.00	0.49	36.2
W68	Gravelly Sand	19.30	80.36	0.34	36.8
W69	Gravelly Sand	11.68	88.30	0.03	38.4
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Asbjornsenia pygmaea	7.75	100	30.78	30.78
	Spisula elliptica	6.00	100	20.83	51.61
	Nematoda	2.50	75	8.7	60.31
	Glycera lapidum agg.	3.00	75	8.17	68.49
	Ophelia borealis	0.75	75	6.41	74.9
	Aonides paucibranchiata	2.75	75	6.15	81.05
	Urothoe marina	0.50	50	2.86	83.92
	Echinocyamus pusillus	1.75	50	2.77	86.68
	Leptocheirus hirsutimanus	0.50	50	2.7	89.38
	Golfingia sp.	0.50	50	2.7	92.08
	Aglaophamus agilis	1.25	50	2.33	94.42
	Nemertea	1.00	50	2.33	96.75
	Pisione remota	1.50	50	1.65	98.4
	Clausinella fasciata	0.75	50	1.6	100
	Polygordius spp.	2.00	25	0	100

Group D					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W36	Gravelly Sand	6.61	89.48	3.91	43.8
	Taxa	**Abundance**	**Cum. %**		
	Bathyporeia pilosa	6	32		
	Thracia villosiuscula	2	42		
	Lumbrineris aniara	1	47		
	Nephtys kersivalensis	1	53		
	Eumida sanguinea	1	58		
	Polynoidae sp.	1	63		
	Owenia fusiformis	1	68		
	Euclymene oerstedii	1	74		
	Cheirocratus sp.	1	79		
	Ophiuroidea spp. (juvenile)	1	84		
	Cardiidae sp. (damaged)	1	89		
	Gari fervensis	1	95		
	Fabulina fabula	1	100		

Group E					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W1	Slightly Gravelly Sand	0.01	92.34	7.65	49.2
	Taxa	**Abundance**	**Cum. %**		
	Amphiuridae sp. (juvenile)	4	19		
	Magelona alleni	2	29		
	Prionospio fallax	2	38		
	Spiophanes bombyx	2	48		
	Bathyporeia sarsi	2	57		
	Goniada maculata	1	62		
	Oxydromus flexuosus	1	67		
	Nephtys kersivalensis	1	71		
	Copepoda sp.	1	76		
	Ampelisca tenuicornis	1	81		
	Edwardsia claparedii	1	86		
	Phaxas pellucidus	1	90		
	Lucinoma borealis	1	95		
	Chaetoderma nitidulum	1	100		

Group F (Average similarity: 30.50%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W2	Sand	0.00	92.15	7.85	48.5
W8	Slightly Gravelly Sand	3.51	91.95	4.54	49.5
W76	Slightly Gravelly Sand	0.13	95.26	4.61	48.2
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Copepoda sp.	2.00	100	23.4	23.4
	Diplocirrus glaucus	1.00	100	20.83	44.23
	Phoronida sp.	1.33	100	20.83	65.06
	Bathyporeia pelagica	0.67	67	8.93	73.99
	Venus casina	1.00	67	8.93	82.92
	Glycinde nordmanni	0.67	67	5.69	88.61
	Lanice conchilega	1.67	67	5.69	94.31
	Phaxas pellucidus	1.00	67	5.69	100

Group G (Average similarity: 36.16%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W4	Gravelly Sand	20.38	79.62	0.00	35.8
W34	Gravelly Sand	7.01	89.75	3.24	41.1
W46	Slightly Gravelly Sand	0.93	95.49	3.58	44.3
W47	Gravelly Sand	12.80	87.20	0.00	37.2
W48	Slightly Gravelly Sand	4.24	95.76	0.00	36.8
W49	Slightly Gravelly Sand	2.94	97.06	0.00	37.4
W53	Slightly Gravelly Sand	4.79	94.22	0.99	40.6
W54	Slightly Gravelly Sand	3.65	96.35	0.00	37.0
W55	Slightly Gravelly Sand	1.38	98.62	0.00	38.0
W56	Slightly Gravelly Sand	1.74	98.26	0.00	37.7
W57	Gravelly Sand	20.31	79.69	0.00	36.7
W58	Gravelly Sand	16.21	83.79	0.00	38.4
W59	Slightly Gravelly Sand	0.61	99.39	0.00	39.2
W60	Slightly Gravelly Sand	2.17	95.83	2.00	37.6
W61	Slightly Gravelly Sand	1.20	98.80	0.00	39.0
W62	Gravelly Sand	9.03	90.97	0.00	40.1
W64	Slightly Gravelly Sand	1.04	98.88	0.07	37.9
W66	Slightly Gravelly Sand	0.40	99.60	0.00	38.9
W67	Slightly Gravelly Sand	0.53	99.42	0.05	38.2
W70	Slightly Gravelly Sand	0.16	99.25	0.58	39.9

W71	Slightly Gravelly Sand	0.20	99.80	0.00	37.3
W73	Slightly Gravelly Sand	0.19	99.81	0.00	37.0
W79	Slightly Gravelly Sand	0.49	98.97	0.53	40.0
W80	Slightly Gravelly Sand	0.13	99.13	0.74	38.1
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Echinocyamus pusillus	7.58	96	18.26	18.26
	Spiophanes bombyx	2.83	92	12.35	30.61
	Gari fervensis	1.50	92	10.39	41.00
	Bathyporeia pelagica	1.88	79	8.28	49.28
	Spisula elliptica	2.13	75	7.27	56.55
	Asbjornsenia pygmaea	3.38	63	6.13	62.68
	Crenella decussata	1.75	54	4.44	67.11
	Abra prismatica	2.00	54	4.35	71.47
	Thracia villosiuscula	1.25	50	3.19	74.66
	Ophiuroidea spp. (juvenile)	1.29	50	3.19	77.85
	Phoronida sp.	0.71	50	2.73	80.58
	Venus casina	1.71	38	2.25	82.84
	Travisia forbesii	1.00	42	2.00	84.84
	Scoloplos armiger	0.92	42	1.90	86.74
	Lumbrineris aniara	0.79	38	1.66	88.40
	Aponuphis bilineata	0.63	38	1.29	89.69
	Decapoda sp. (larvae)	0.33	33	1.23	90.91

Group H (Average similarity: 48.41%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W3	Slightly Gravelly Muddy Sand	1.57	88.04	10.39	48.0
W10	Slightly Gravelly Sand	0.85	93.60	5.55	47.2
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Magelona alleni	2.50	100	14.64	14.64
	Edwardsiidae sp.	2.50	100	14.64	29.29
	Venus casina	3.50	100	14.64	43.93
	Thracia villosiuscula	2.50	100	14.64	58.58
	Spiophanes bombyx	1.50	100	10.36	68.93
	Echinocardium cordatum	1.00	100	10.36	79.29
	Fabulina fabula	1.50	100	10.36	89.64
	Antalis entalis	1.00	100	10.36	100

Group I (Average similarity: 32.49%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W12	Slightly Gravelly Sand	3.32	88.57	8.11	46.2
W33	Slightly Gravelly Sand	3.29	89.84	6.87	43.3
W45	Gravelly Sand	10.65	83.50	5.84	41.8
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Spiophanes bombyx	11.00	100	15.34	15.34
	Clausinella fasciata	8.67	100	9.21	24.55
	Lumbrineris aniara	5.00	100	7.82	32.38
	Thracia villosiuscula	3.67	100	6.68	39.06
	Diplocirrus glaucus	1.33	100	5.51	44.57
	Ampelisca tenuicornis	1.00	100	5.51	50.08
	Phaxas pellucidus	1.33	100	5.51	55.59
	Nucula nitidosa	1.33	100	5.51	61.1
	Bathyporeia gracilis	2.67	67	3.41	64.51
	Edwardsia claparedii	2.00	67	2.78	67.29
	Galathowenia oculata	1.33	67	2.75	70.05
	Magelona alleni	2.00	67	2.75	72.8
	Bathyporeia sp.	1.67	67	2.26	75.06
	Echinocyamus pusillus	2.33	67	2.26	77.32
	Fabulina fabula	2.33	67	2.26	79.57

Chaetozone setosa	1.00	67	1.97	81.54
Abra sp. (juvenile)	1.33	67	1.97	83.51
Cylichna cylindracea	0.67	67	1.97	85.48
Podarkeopsis capensis	0.67	67	1.95	87.42
Echinocardium cordatum	0.67	67	1.95	89.37
Ophiura sp. (juvenile)	2.33	67	1.95	91.32

Group J (Average similarity: 37.16%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W11	Slightly Gravelly Sand	0.04	91.25	8.72	48.1
W13	Slightly Gravelly Muddy Sand	0.01	87.68	12.31	47.8
W16	Slightly Gravelly Sand	0.62	90.21	9.17	46.7
W74	Slightly Gravelly Sand	1.33	91.67	7.00	45.2
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Phaxas pellucidus	3.50	100	17.69	17.69
	Antalis entalis	1.50	100	12.58	30.27
	Diplocirrus glaucus	1.75	100	11.69	41.96
	Prionospio fallax	2.00	75	9.31	51.27
	Lumbrineris aniara	3.50	75	8.52	59.78
	Chaetozone setosa	2.75	75	7.46	67.25
	Phoronida sp.	1.00	75	6.1	73.34
	Copepoda sp.	1.25	75	6	79.34
	Abra prismatica	1.50	50	3.04	82.38
	Paguridae sp. (juvenile/larvae)	0.50	50	2.15	84.53
	Eudorellopsis deformis	0.50	50	2.15	86.68
	Nephtyidae spp.	0.50	50	2.09	88.77
	Bathyporeia pelagica	0.75	50	2.09	90.86
	Nemertea	0.50	50	2.09	92.95
	Spiophanes kroyeri	0.50	50	1.79	94.74

Spiophanes bombyx	0.75	50	1.75	96.5
Fabulina fabula	0.75	50	1.75	98.25
Magelona alleni	0.75	50	1.75	100

Group K (Average similarity: 40.07%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W40	Slightly Gravelly Sand	1.60	95.57	2.83	42.9
W41	Slightly Gravelly Sand	0.86	97.47	1.67	41.9
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Echinocyamus pusillus	6.00	100	24.67	24.67
	Copepoda sp.	2.00	100	15.6	40.27
	Thracia villosiuscula	4.00	100	15.6	55.87
	Ophiuroidea spp. (juvenile)	1.50	100	11.03	66.9
	Fabulina fabula	3.00	100	11.03	77.94
	Chamelea striatula	1.50	100	11.03	88.97
	Euspira nitida	1.00	100	11.03	100

Group L					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W19	Slightly Gravelly Sand	0.75	93.33	5.92	46.8
	Taxa	**Abundance**	**Cum. %**		
	Echinocyamus pusillus	3	14		
	Magelona filiformis	2	23		
	Prionospio fallax	2	32		
	Diplocirrus glaucus	2	41		
	Phaxas pellucidus	2	50		
	Nothria conchylega	1	55		
	Owenia fusiformis	1	59		
	Spiophanes bombyx	1	64		
	Ampharete lindstroemi	1	68		
	Lanice conchilega	1	73		
	Urothoe sp.	1	77		
	Eudorellopsis deformis	1	82		
	Paguridae sp. (juvenile/larvae)	1	86		
	Amphiura (Amphiura) incana	1	91		
	Venus casina	1	95		
	Nemertea	1	100		

Group M					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W24	Slightly Gravelly Muddy Sand	1.21	86.25	12.55	46.0

Taxa	**Abundance**	**Cum. %**
Prionospio fallax	14	11
Lumbrineris aniara	9	18
Diplocirrus glaucus	9	25
Thracia villosiuscula	9	33
Bathyporeia gracilis	7	38
Amphiuridae sp. (juvenile)	7	44
Venus casina	7	49
Chaetozone setosa	5	53
Gari fervensis	5	57
Nephtys kersivalensis	4	60
Phaxas pellucidus	4	63
Abra nitida	4	67
Nemertea	4	70
Galathowenia oculata	3	72
Spiophanes bombyx	3	75
Lanice conchilega	3	77
Echinocyamus pusillus	3	79

Ampharete sp. (juvenile)	2	81

Group N (Average similarity: 46.65%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W35	Gravelly Sand	10.56	83.29	6.15	41.8
W44	Gravelly Sand	5.74	90.25	4.01	43.2
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Lumbrineris aniara	9.50	100	10.78	10.78
	Venus casina	4.00	100	8.15	18.92
	Spiophanes bombyx	8.00	100	7.06	25.98
	Bathyporeia pelagica	3.00	100	7.06	33.04
	Urothoe elegans	3.00	100	7.06	40.09
	Abra prismatica	3.50	100	7.06	47.15
	Thracia villosiuscula	5.50	100	7.06	54.2
	Echinocyamus pusillus	4	100	5.76	59.96
	Gari fervensis	2	100	5.76	65.72
	Phoronida sp.	3.5	100	5.76	71.49
	Owenia fusiformis	1.5	100	4.07	75.56
	Dipolydora coeca agg.	2.5	100	4.07	79.63
	Prionospio fallax	1	100	4.07	83.71
	Spiophanes kroyeri	2.5	100	4.07	87.78
	Scalibregma inflatum	1.5	100	4.07	91.85
	Fabulina fabula	3	100	4.07	95.93

Dosinia exoleta	2.5	100	4.07	100

Group O (Average similarity: 39.40%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
W7	Gravelly Sand	10.04	87.88	2.08	44.8
W9	Slightly Gravelly Sand	2.28	91.72	6.00	48.3
W14	Slightly Gravelly Sand	1.17	93.49	5.34	46.9
W15	Slightly Gravelly Sand	0.74	95.34	3.92	46.7
W17	Slightly Gravelly Sand	0.98	91.12	7.89	46.6
W18	Slightly Gravelly Muddy Sand	1.27	85.80	12.94	44.5
W21	Gravelly Sand	6.76	89.44	3.80	48.5
W22	Slightly Gravelly Sand	1.21	93.59	5.20	46.5
W23	Slightly Gravelly Sand	4.77	91.48	3.75	43.6
W25	Slightly Gravelly Muddy Sand	1.66	87.56	10.79	46.1
W26	Slightly Gravelly Muddy Sand	2.90	85.67	11.42	45.6
W27	Slightly Gravelly Sand	4.51	88.45	7.04	48.0
W29	Slightly Gravelly Sand	0.36	95.56	4.08	51.1
W30	Slightly Gravelly Sand	1.63	93.02	5.35	49.4
W31	Slightly Gravelly Sand	3.35	92.90	3.75	46.4
W32	Slightly Gravelly Sand	3.90	91.72	4.38	43.1
W37	Slightly Gravelly Sand	3.13	93.04	3.83	47.1
W38	Slightly Gravelly Sand	2.54	92.06	5.41	46.0
W42	Slightly Gravelly Sand	1.03	95.43	3.54	47.1
W52	Gravelly Muddy Sand	9.23	81.58	9.19	41.4

W75	Slightly Gravelly Sand	0.97	96.02	3.01	47.2
W77	Gravelly Sand	6.13	87.87	6.00	43.3
W78	Slightly Gravelly Sand	1.27	96.59	2.14	45.0
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Echinocyamus pusillus	4.78	96	12.97	12.97
	Spiophanes bombyx	2.91	96	10.52	23.48
	Phoronida sp.	2.00	87	7.53	31.01
	Lumbrineris aniara	2.17	83	6.39	37.40
	Prionospio fallax	1.96	74	5.50	42.90
	Diplocirrus glaucus	1.78	70	4.70	47.60
	Urothoe elegans	1.04	65	3.85	51.45
	Abra prismatica	1.17	61	3.59	55.04
	Magelona alleni	1.26	61	3.48	58.53
	Fabulina fabula	1.74	57	3.15	61.68
	Gari fervensis	0.78	61	2.96	64.64
	Owenia fusiformis	0.91	57	2.86	67.50
	Phaxas pellucidus	1.04	57	2.69	70.19
	Thracia villosiuscula	1.61	52	2.65	72.84
	Ophiuroidea spp. (juvenile)	2.22	48	2.59	75.42
	Nemertea	1.17	52	2.51	77.93
	Pectinaria (Amphictene) auricoma	0.65	52	2.05	79.98

16 Annex 7.1K: Epifaunal Data from Trawl Survey

Epifaunal Taxa	W2	W4	W6	W8	W12	W22	W30	W33	W40	W44	W48	W58	W59	W61	W68
Porifera				P		P									
Suberitidae			P												
Suberites carnosus		P		P	P	P	P	P	P	P	P	P			P
Hydractinia echinata			P	P			P	P		P	P		P	P	P
Bougainvilliidae				P		P	P				P				P
Sertulariidae		P	P	P											P
Hydrallmania falcata			P	P	P	P	P	P	P	P	P	P		P	P
Sertularia cupressina												P	P	P	P
Thuiaria thuja		P													P
Nemertesia			P	P		P	P			P					P
Nemertesia antennina	P														
Nemertesia ramosa		P													
Campanulariidae				P			P	P							
Alcyonium digitatum	P	P	P	P	P	P	P	P	P	P	P	P	P		P
Enthemonae		1													
Metridium dianthus	2		1					1							
Calliactis parasitica				1										1	
Adamsia palliata		62	23	55		7	9	15	5	37	5	36	3	1	30
Edwardsiidae															1
Ctenophora											1				

Epifaunal Taxa	W2	W4	W6	W8	W12	W22	W30	W33	W40	W44	W48	W58	W59	W61	W68
Platyhelminthes								2	3	2	3			1	
Nemertea		1		1		2	4	10	1	9	3		1		
Golfingia vulgaris vulgaris				1											
Phascolion strombus strombus			1	4	1	1	1								
Aphrodita aculeata				1											
Alentia gelatinosa												2			
Malmgrenia												2	4		
Harmothoe						2				8					
Harmothoe imbricata					1										
Harmothoe impar					1					2	1	1			
Lepidonotus squamatus										1		2			
Phyllodoce mucosa		1				1					1		1		
Eulalia bilineata										1		1			
Eulalia viridis									1	1	2		1		
Nereimyra punctata										2		6	1		1
Syllis armillaris												1			2
Nephtyidae						1									
Nephtys caeca				7							1				
Neanthes fucata		1		1			1	3				3		1	1
Eunereis longissima				5	1	1	1	2		20	6	3	2		

Epifaunal Taxa	W2	W4	W6	W8	W12	W22	W30	W33	W40	W44	W48	W58	W59	W61	W68
Nereis zonata			1												
Nothria conchylega		1		12		3		1	2	1	1		3		
Dipolydora coeca										1					
Cirriformia tentaculata										2		1			
Amphitrite cirrata									1						
Lanice conchilega												1			
Polycirrus		1												1	
Hydroides elegans					2				2	2					
Spirobranchus lamarcki							1			1	2				
Spirobranchus triqueter							3	3	5	10	6	9	2	1	4
Scalpellum scalpellum	1														
Balanus crenatus	93		4	17		36	160	60	1	1195	394		25	96	327
Mysidae				4						1			1		
Phtisica marina															3
Pseudoprotella phasma		1		32	3										1
Caridea														1	
Pandalina brevirostris				4								3			6
Pandalus montagui				5			1		1		1				

Epifaunal Taxa	W2	W4	W6	W8	W12	W22	W30	W33	W40	W44	W48	W58	W59	W61	W68
Pontophilus spinosus		1	5		1	4	3	1				1			5
Paguridae				1			1			1		9	5		1
Anapagurus hyndmanni			1									6			1
Pagurus bernhardus		4	6	7	1	8	1	3	1	8	3	6	1	4	4
Pagurus prideaux		62	24	61		8	19	18	7	37	6	37	3	1	32
Galathea intermedia		1		3		4	1		3	17	5	14	5		14
Munida rugosa												1			
Pisidia longicornis										5	1	15		2	4
Brachyura															4
Ebalia										1					
Ebalia cranchii				5		1		2	3			2	1		
Ebalia tuberosa				4	1										
Hyas coarctatus		8	6	9	2	1	4	2	3	8	5	16	2		30
Inachus dorsettensis									2		1				
Macropodia			1		1										
Macropodia rostrata		6		4		3	3	1	1	2	1	5	1		15
Corystes cassivelaunus					2										
Atelecyclus rotundatus			4	9	1					7			1	3	2
Liocarcinus						1				4	1		2		

Epifaunal Taxa	W2	W4	W6	W8	W12	W22	W30	W33	W40	W44	W48	W58	W59	W61	W68
Liocarcinus depurator									1		1	2			
Liocarcinus holsatus														1	
Macropipus tuberculatus													1		
Monodaeus couchii												3			
Leptochiton asellus			1												
Calliostoma zizyphinum												6	1		6
Turritella communis							1								
Aporrhais pespelecani	1			1						1					
Buccinum undatum		1										3	1		1
Buccinum undatum												P			
Neptunea antiqua		2								2	8	3	2	1	6
Neptunea antiqua													P		
Comarmondia gracilis													1		
Nudibranchia								1							
Goniodoris castanea															1
Glycymeris glycymeris			1	5											1
Mytilidae															1
Modiolus modiolus												1			

Epifaunal Taxa	W2	W4	W6	W8	W12	W22	W30	W33	W40	W44	W48	W58	W59	W61	W68
Musculus discors											1				
Pecten maximus	3	1	1		1		1					1			
Aequipecten opercularis								1		1	1	1			
Anomia ephippium	3	3	7	1				2	10	2	12	31	1	1	19
Heteranomia squamula															1
Lucinoma borealis	1					2									
Acanthocardia echinata					1	2	2								
Spisula elliptica			1												
Ensis ensis											1				
Phaxas pellucidus		1	1												
Gari tellinella				1										1	2
Gari fervensis							2		2						
Clausinella fasciata			1	1	1				1			1			
Polititapes rhomboides															1
Dosinia exoleta											1		1		
Hiatella arctica									2	8	4			1	
Thracia phaseolina							2								
Cochlodesma praetenue											1				

Epifaunal Taxa	W2	W4	W6	W8	W12	W22	W30	W33	W40	W44	W48	W58	W59	W61	W68
Sepiola atlantica							1			1					1
Eledone cirrhosa		6	2	2	1	2	4	3	1	1	3	5	3	1	4
Tubulipora		P	P	P									P		P
Alcyonidium diaphanum	P	P		P		P		P	P	P		P		P	P
Alcyonidium parasiticum	P	P	P	P	P	P	P	P	P		P				
Eucratea loricata									P						
Flustra foliacea	P		P	P		P	P	P	P	P	P	P	P	P	P
Securiflustra securifrons					P			P		P				P	P
Bugulina flabellata							P								
Luidia ciliaris							1		1			1			
Luidia sarsii	3	1		5	18	6	3	2	5						
Astropecten irregularis	4		1	3	12	15	5	33	3	9	12	4	3	2	4
Anseropoda placenta						1	1								
Crossaster papposus							1			1		7			1
Henricia sanguinolenta						1	1	2							
Asterias rubens	25	141	194	8	51	46	15	36	111	77	78	232	121	82	337
Ophiurida							3								1
Ophiurida				1											

Epifaunal Taxa	W2	W4	W6	W8	W12	W22	W30	W33	W40	W44	W48	W58	W59	W61	W68
Ophiothrix fragilis		4										93			2
Ophiocomina nigra												7			
Ophiopholis aculeata												3			
Ophiura albida				1		1	3					3	2		2
Ophiura ophiura	7	4	3	39	13	15	12	21	11	30	2	5	4	3	2
Psammechinus miliaris		15	9	2					1	3	1	15	5		11
Echinus esculentus		2										119	6		1
Echinocardium cordatum	1				4	26	25	6	5		2				
Thyone fusus										3					1
Ascidiidae															1
Ascidiella aspersa				1							1				
Ascidiella scabra		25	4	12			2		2	22	2	7	2	3	10
Styelidae															P
Molgula		3										1			

17 Annex 7.1L: Fish Data from Trawl Survey

Fish Taxa			W2	W4	W6	W8	W12	W22	W30	W33
Lesser Spotted Dogfish	Scyliorhinus canicula		0	0	0	0	0	0	0	1
Egg case	Scyliorhinus		0	0	0	P	0	0	0	0
Cuckoo Ray	Leucoraja naevus		0	0	0	0	0	0	0	0
Angler fish	Lophius piscatorius		1	1	0	0	0	0	2	1
Gadoid	Gadidae	Juvenile	0	0	0	14	3	0	0	0
Three Bearded Rockling	Gaidropsarus vulgaris		0	0	0	0	0	0	0	0
John Dory	Zeus faber		0	0	0	0	0	0	0	0
Grey Gurnard	Eutrigla gurnardus		2	0	1	1	5	1	3	10
Bull Rout	Myoxocephalus scorpius		0	3	0	2	0	1	0	0
Pogge	Agonus cataphractus		1	11	3	3	3	10	3	4
Sand-eel	Ammodytes	Juvenile	0	0	0	1	0	0	0	0
Raitt's Sand-eel	Ammodytes marinus		0	0	3	0	0	0	0	0
Dragonet	Callionymus	Juvenile	0	0	0	0	0	0	0	0
Common Dragonet	Callionymus lyra		2	6	3	13	6	9	6	9
Reticulated Dragonet	Callionymus reticulatus		0	0	0	2	0	0	0	0
Crystal Goby	Crystallogobius linearis		0	0	0	4	2	4	3	1
Goby	Pomatoschistus	Juvenile	0	0	0	5	0	0	0	0
Common Goby	Pomatoschistus microps		0	0	0	4	0	0	0	0
Sand Goby	Pomatoschistus minutus		1	0	0	0	1	3	0	0
Flatfish	Pleuronectiformes	Juvenile	6	0	0	4	0	0	0	0
Scaldfish	Arnoglossus laterna		1	0	0	0	2	1	2	2
Norwegian Topknot	Phrynorhombus norvegicus		0	1	0	0	0	0	0	0
Dab	Limanda limanda		11	9	3	13	17	23	15	22
Lemon Sole	Microstomus kitt		1	2	0	4	0	2	5	4

Plaice	Pleuronectes platessa		5	6	9	10	3	8	6	11
Solenette	Buglossidium luteum		1	1	0	0	2	0	2	3
Thickback Sole	Microchirus variegatus		0	0	0	1	1	1	3	2
Fish Taxa			**W40**	**W44**	**W48**	**W58**	**W59**	**W61**	**W68**	
Lesser Spotted Dogfish	Scyliorhinus canicula		0	0	0	0	0	0	0	
Egg case	Scyliorhinus		0	0	0	0	0	0	0	
Cuckoo Ray	Leucoraja naevus		0	0	1	0	0	1	0	
Angler fish	Lophius piscatorius		0	1	0	0	0	0	0	
Gadoid	Gadidae	Juvenile	1	0	0	0	1	0	0	
Three Bearded Rockling	Gaidropsarus vulgaris		0	0	1	0	1	0	0	
John Dory	Zeus faber		1	1	0	0	0	0	0	
Grey Gurnard	Eutrigla gurnardus		2	0	2	2	4	0	1	
Bull Rout	Myoxocephalus scorpius		0	0	0	6	0	0	0	
Pogge	Agonus cataphractus		0	4	4	6	2	1	5	
Sand-eel	Ammodytes	Juvenile	0	0	0	0	0	0	0	
Raitt's Sand-eel	Ammodytes marinus		0	0	0	0	0	0	1	
Dragonet	Callionymus	Juvenile	0	0	0	0	1	0	0	
Common Dragonet	Callionymus lyra		2	4	2	2	1	1	10	
Reticulated Dragonet	Callionymus reticulatus		0	0	0	1	1	0	0	
Crystal Goby	Crystallogobius linearis		3	2	0	0	0	0	0	
Goby	Pomatoschistus	Juvenile	0	1	0	0	0	0	1	
Common Goby	Pomatoschistus microps		0	0	1	0	0	0	0	
Sand Goby	Pomatoschistus minutus		0	1	0	0	1	0	0	
Flatfish	Pleuronectiformes	Juvenile	0	0	0	0	1	0	0	
Scaldfish	Arnoglossus laterna		0	0	0	0	1	0	1	

Norwegian Topknot	Phrynorhombus norvegicus		0	0	0	0	1	0	2	
Dab	Limanda limanda		14	14	10	5	7	13	7	
Lemon Sole	Microstomus kitt		1	6	2	5	1	0	3	
Plaice	Pleuronectes platessa		6	25	7	13	8	6	4	
Solenette	Buglossidium luteum		1	0	1	1	1	1	0	
Thickback Sole	Microchirus variegatus		3	5	1	0	1	0	2	

18 Annex 7.1M: Numbers of Taxa and Abundance from Epifaunal Trawls

Trawl Station	Number of Taxa	Total Abundance
W2	28	176
W4	45	400
W6	40	325
W8	68	417
W12	38	165
W22	48	264
W30	56	348
W33	46	301
W40	48	232
W44	61	1611
W48	57	613
W58	65	778
W59	57	252
W61	34	232
W68	70	942

19 Annex 7.1N: Characteristic Taxa from Trawl Cluster Groups

Group A (Average similarity: 55.34%)					
Sites	Dominant Taxa	Av. Abund	% of Sites	Contrib%	Cum.%
W4	Asterias rubens	226.0	100	21.68	21.7
W6	Pagurus prideaux	38.8	100	8.84	30.5
W58	Adamsia palliata	37.8	100	8.64	39.2
W68	Psammechinus miliaris	12.5	100	5.38	44.5
	Hyas coarctatus	15.0	100	4.61	49.2
	Anomia ephippium	15.0	100	3.95	53.1
	Ascidiella scabra	11.5	100	3.95	57.0
	Pleuronectes platessa	8.0	100	3.9	60.9
	Pagurus bernhardus	5.0	100	3.46	64.4
	Limanda limanda	6.0	100	3.37	67.8
	Agonus cataphractus	6.3	100	3.31	71.1
	Callionymus lyra	5.3	100	2.85	73.9
	Eledone cirrhosa	4.3	100	2.85	76.8
	Ophiura ophiura	3.5	100	2.72	79.5
	Pontophilus spinosus	3.0	100	2.03	81.5

Group B					
Site	**Dominant Taxa**	**Abundance**	**Cum. % Abundance**		
W8	Pagurus prideaux	61	15		
	Adamsia palliata	55	28		
	Ophiura ophiura	39	37		
	Pseudoprotella phasma	32	45		
	Balanus crenatus	17	49		
	Gadidae	14	52		
	Callionymus lyra	13	55		
	Limanda limanda	13	59		
	Nothria conchylega	12	61		
	Ascidiella scabra	12	64		
	Pleuronectes platessa	10	67		
	Hyas coarctatus	9	69		
	Atelecyclus rotundatus	9	71		

	Asterias rubens	8	73		
	Nephtys caeca	7	75		
	Pagurus bernhardus	7	76		
	Eunereis longissima	5	77		
	Pandalus montagui	5	79		

Group C (Average similarity: 62.19%)					
Sites	Dominant Taxa	Av. Abund	% of Sites	Contrib%	Cum.%
W44	Balanus crenatus	794.5	100	24.86	24.9
W48	Asterias rubens	77.5	100	10.99	35.9
	Limanda limanda	12	100	3.96	39.8
	Astropecten irregularis	10.5	100	3.76	43.6
	Pleuronectes platessa	16	100	3.31	46.9
	Eunereis longissima	13	100	3.07	49.9
	Spirobranchus triqueter	8	100	3.07	53.0
	Pagurus prideaux	21.5	100	3.07	56.1
	Adamsia palliata	21	100	2.8	58.9
	Galathea intermedia	11	100	2.8	61.7
	Hyas coarctatus	6.5	100	2.8	64.5
	Hiatella arctica	6	100	2.5	67.0
	Agonus cataphractus	4	100	2.5	69.5
	Nemertea	6	100	2.17	71.7
	Pagurus bernhardus	5.5	100	2.17	73.8
	Platyhelminthes	2.5	100	1.77	75.6
	Neptunea antiqua	5	100	1.77	77.4
	Anomia ephippium	7	100	1.77	79.1
	Ophiura ophiura	16	100	1.77	80.9

Group D (Average similarity: 68.37%)					
Sites	**Dominant Taxa**	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
W22	Balanus crenatus	85.3	100	10.92	10.9
W30	Asterias rubens	32.3	100	7.66	18.6
W33	Limanda limanda	20.0	100	6.91	25.5
	Ophiura ophiura	16.0	100	5.99	31.5
	Echinocardium cordatum	19.0	100	5.47	37.0

	Pagurus prideaux	15.0	100	5.47	42.4
	Astropecten irregularis	17.7	100	4.66	47.1
	Adamsia palliata	10.3	100	4.59	51.7
	Callionymus lyra	8.0	100	4.39	56.1
	Pleuronectes platessa	8.3	100	4.29	60.4
	Agonus cataphractus	5.7	100	3.03	63.4
	Nemertea	5.3	100	2.67	66.1
	Microstomus kitt	3.7	100	2.67	68.7
	Luidia sarsii	3.7	100	2.53	71.3
	Eledone cirrhosa	3.0	100	2.52	73.8
	Pagurus bernhardus	4.0	100	2.08	75.9
	Pontophilus spinosus	2.7	100	2.06	77.9
	Macropodia rostrata	2.3	100	2.06	80.0

Group E (Average similarity: 57.82%)					
Sites	**Dominant Taxa**	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
W40	Asterias rubens	116	100	23.09	23.1
W59	Limanda limanda	10.5	100	5.8	28.9
	Pleuronectes platessa	7	100	5.37	34.3
	Ophiura ophiura	7.5	100	4.38	38.6
	Adamsia palliata	4	100	3.8	42.4
	Pagurus prideaux	5	100	3.8	46.2
	Galathea intermedia	4	100	3.8	50.0
	Astropecten irregularis	3	100	3.8	53.8
	Nothria conchylega	2.5	100	3.1	56.9
	Spirobranchus triqueter	3.5	100	3.1	60.0
	Hyas coarctatus	2.5	100	3.1	63.1
	Ascidiella scabra	2	100	3.1	66.2
	Eutrigla gurnardus	3	100	3.1	69.3
	Nemertea	1	100	2.19	71.5
	Eulalia viridis	1	100	2.19	73.7
	Balanus crenatus	13	100	2.19	75.9
	Pagurus bernhardus	1	100	2.19	78.1
	Ebalia cranchii	2	100	2.19	80.3

Group F (Average similarity: 46.92%)					
Sites	**Dominant Taxa**	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
W2	Asterias rubens	52.7	100	22.82	22.8
W12	Balanus crenatus	63.0	67	13.75	36.6
W61	Limanda limanda	13.7	100	13.71	50.3
	Ophiura ophiura	7.7	100	8.19	58.5
	Pleuronectes platessa	4.7	100	7.69	66.2
	Astropecten irregularis	6.0	100	6.47	72.6
	Callionymus lyra	3.0	100	4.58	77.2
	Agonus cataphractus	1.7	100	4.02	81.2
	Buglossidium luteum	1.3	100	4.02	85.3
	Luidia sarsii	7.0	67	2.31	87.6
	Eutrigla gurnardus	2.3	67	1.89	89.5
	Anomia ephippium	1.3	67	1.43	90.9
	Pecten maximus	1.3	67	1.34	92.2
	Echinocardium cordatum	1.7	67	1.34	93.5
	Pomatoschistus minutus	0.7	67	1.34	94.9
	Arnoglossus laterna	1.0	67	1.34	96.2
	Pagurus bernhardus	1.7	67	1.26	97.5
	Atelecyclus rotundatus	1.3	67	1.26	98.7
	Eledone cirrhosa	0.7	67	1.26	100.0

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MORAY WEST
OFFSHORE WINDFARM

Intertidal Survey Report

Moray Offshore Windfarm (West) Limited

Technical Appendix 7.2

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1 Introduction

This document has been prepared by Precision Marine Survey Ltd. (PMSL) on behalf of Moray Offshore Windfarm (West) Limited ('Moray West'). It provides a summary of the results of survey work undertaken to characterise the intertidal benthic communities present in the vicinity of the Moray West Offshore Export Cable Corridor landfall site. These results will in turn inform the understanding of baseline conditions relevant to assessment of the potential impacts of the proposed development on intertidal benthic ecology as part of the Environmental Impact Assessment (EIA) process. It is expected that survey results will also inform refinements in project design as required.

2 Background

The proposed Wind Farm (Figure 3.1) is located approximately 22.5 km from the Scottish coast at its closest point and covers an area of 225 km2. An Offshore Export Cable Corridor, which is approximately 3 km wide, runs from the southern Wind Farm Site boundary to the Aberdeenshire coast where cable landfall will be made.

In line with the Wind Farm and Offshore Transmission Infrastructure (OfTI) Scoping Reports (Moray West, 2017a; 2017b) the Development (i.e. the Wind Farm and the OfTI) will consist of an array of up to 85 wind turbines linked by inter-array cables, up to two offshore substation platforms linked by interconnector cables, and export cable circuits running from the OSPs to landfall.

The OfTI Scoping Report identified a broad landfall area, which has since been subject to refinement with Sandend Bay or Sunnyside Bay originally selected as the preferred options. As outlined in the Scope of Works a benthic intertidal survey was undertaken along a series of transects at the landfall locations in both Sandend Bay and Sunnyside Beach but after the survey was completed it was decided to proceed with Sandend Bay as the preferred landfall location and as such only the results of this component of the survey are presented here.

This technical report supplements the EIA for which the Development has been subject to. The outputs of the EIA process will be presented alongside an application for offshore consents within an Environmental Report.

3 Intertidal Survey

The intertidal survey was undertaken at the landfall point in Sandend Bay (with an additional unreported survey undertaken at an alternative landfall in Sunnyside Beach). The intertidal area at Sandend comprises of a small embayment approximately 650 m wide (Figure 3.1) predominantly characterised by sandy sediments with fringing rocky habitats along the eastern and western edge of the bay. The survey utilised standard phase 1 habitat mapping and rapid in-situ biotope assessments along with quantitative intertidal core (phase 2) sampling at representative habitats for infauna and Particle Size Distribution (PSD) covering key sedimentary habitats on the upper, mid and low shore. The survey primarily focused on the main sedimentary habitats within Sandend Bay, but also took into account hard sediments on the eastern and western fringes of the Bay and survey was undertaken along a series of five survey transects (Figure 3.1).

Three transects were identified in the intertidal soft sediments from high water to mean low water at Sandend Bay with a with single 0.01m^2 core sample taken for fauna in representative soft sediment habitats on the upper, mid and low shore. A sample for PSD was also taken at each site and the distribution of biotopes/habitats down the transects recorded using phase 1 methodologies. Additional transects were also surveyed on each side of Sandend bay (to the east and west) using phase 1 biotope mapping to provide a rapid assessment of the range of rocky biotopes present. This component did not aim to exhaustively map the rocky habitats in these areas as they are unlikely to be directly affected by cable installation but aimed to highlight the range of habitats/biotopes present in these areas.

The mid-shore sites along the main survey transects in soft sediments also included additional sampling for contaminants. Contaminant samples were tested for metals (Arsenic, Cadmium, Chromium, Copper, Mercury, Nickel, Lead, Tin, Barium and Aluminium) and PAHs (Polycyclic Aromatic Hydrocarbons - specifically the US EPA16 priority pollutants). Each phase 2 sample was collected using a 0.01m^2 hand corer with each sample then sieved over a 1mm mesh sieve and full taxonomic analyses undertaken following standard methodologies. Detailed field and laboratory methodologies are provided in Sections 3.1 and 3.2 below.

3.1 Field Methods

3.1.1 Phase 1 Survey

Phase 1 habitat survey was undertaken in accordance with the Common Standards Monitoring Guidance Procedural Guidelines (JNCC, 2004). The survey was carried out to mean low water (where appropriate) and derived information on the following - biotope composition, biotope distribution, and the extent of sub-features and notable biotopes. In addition, any impacts from human activities was noted and assessed, such as presence of sewage and other anthropogenic impacts. During the fieldwork, any observations relating to ongoing change to the littoral habitats were also recorded. Methods for survey followed the standardised phase 1 mapping methodology (Marine Monitoring Handbook procedural guidance No 3-1 – Wyn & Brazier, 2001 and Wyn et al., 2000; CCW Intertidal Monitoring Handbook, 2006 and Cefas Data Acquisition Guidelines, Judd, 2012). This involved covering a systematic route within the survey area (i.e. along predefined transect lines) and map the distribution of biotopes present.

Habitat and biotope boundaries were mapped along a series of five transects across the area with any scale notable habitats adjacent to the transects also recorded where appropriate (e.g. as target notes). Detailed notes on biotope and sediment character/taxa was also recorded in key habitats along each transect on the upper, mid and low shore and supplemented by occasional dig-overs of representative habitats which entailed digging over approximately 0.1m^2 of surface sediment from and sieving through a 1mm sieve to provide a rapid in-situ assessment of benthic fauna. Voucher specimens of intertidal species were also be collected where required to assist in biotope classification. The survey also included a record of sedimentary habitat whereby sediment grain size was assessed in-situ using standardised Wentworth scale sediment comparison guides.

Three transects (SE1, SE2 and SE3) approximately 200m apart were utilised to cover the landfall site in the vicinity of the soft sediments in Sandend Bay (Figure 3.1) which comprised the majority of intertidal habitat in this area. An additional transect was surveyed in fringing rocky habitats to the west and east of the main beach (transects SE4 and SE5 respectively). Data on habitats/biotopes along each transect covered an area up to 50 m either side of the transect line (where possible) and the boundaries of major biotopes or larger scale topographic features were recorded along the transect (as appropriate depending on topographic regime). In addition, species/habitats of conservation importance (or other features of interest) in the vicinity of the survey transects were also recorded

The boundaries of biotopes/habitats or transition zones along the transects were mapped using a survey grade dGPS with differential/WAAS/EGNOSS corrections (Ashtech MobileMapper 100 or Promark 3). Periodic assessments of surfical features (e.g. *Arenicola* casts, *Lanice* beds, algal mats etc.) and biotopes were carried out at regular intervals along the survey transects (using a 1 mm sieve to assess infauna) and the boundaries of any notable biotopes of conservation importance were also recorded. Geo-tagged or geo-referenced photographs of characteristic biotopes/habitats within each sector were also taken.

Intertidal biotope/biotope complex designations were based on the most recent (2004) Marine Habitat Classification for Britain and Ireland – Version 04.05 (Connor et al, 2004). The survey was undertaken from the 25th to the 27th July 2017 during ebb conditions with any work carried out on the flood tide restricted to the upper shore.

On completion of each day's survey, all survey data both hard copies and electronic (GPS data and photographs) was catalogued/archived and following survey this information was be compiled onto GIS to derive a series of GIS layers. This information was then redrawn in GIS at the appropriate scale (e.g. 1:2500 colour maps) and used together with the standard MNCR survey data to derive a biotope map (Figure 4.1) which highlighted the distribution of biotopes along each transect and other features of interest. Smaller features and sampling sites were digitised as referenced target notes or point data. All photographs taken were cross-referenced to habitats and positions within the sites.

3.1.2 Phase 2 Quantitative Sampling

Phase 2 sampling was also undertaken using standard methodologies to obtain quantitative data on intertidal communities. Given that the survey area is predominantly sedimentary this sampling was undertaken using core sampling following Dalkin and Barnett, 2001 - procedural guideline 3-6 from the Marine Monitoring hand book (Quantitative sampling of intertidal sediment species using cores). Sampling was undertaken using 0.01m^2 cores sieved through a 1 mm sieve with a single sample taken at representative biotopes on the upper mid and low shore on transects SE1, SE2 and SE3.

The sampling strategy was timed to coincide with spring tides and low water, in order to optimise access and time available on the intertidal zone and was undertaken at the same time as the phase 1 biotope survey. At each of the sampling stations and habitats, and prior to the collection of each core, a digital image was taken of the undisturbed sediment, with the date, time and photograph number being recorded along with GPS position. A 0.01 m^2 core was then extruded from the sediment and placed into sealable plastic bags each carrying a unique code for the station which relates to client, survey/intertidal/date/lower shore/station. Samples were taken to a minimum depth of 15 cm. At each sample station an additional sample at each sampling station was collected for PSD. At the mid-shore sites additional sampling for contaminants was also undertaken with the appropriate metal or plastic scoop and transferred to appropriate containers for storage in a cool box/fridge prior to analysis.

Core samples were placed into cool boxes containing ice packs to maintain a constant low temperature for transportation back to the laboratory. A complete survey log was maintained throughout the survey detailing time, position, physical characteristics of the sediment and other features of interest. Laboratory methods for quantitative intertidal samples followed those outlined in Section 3.2.

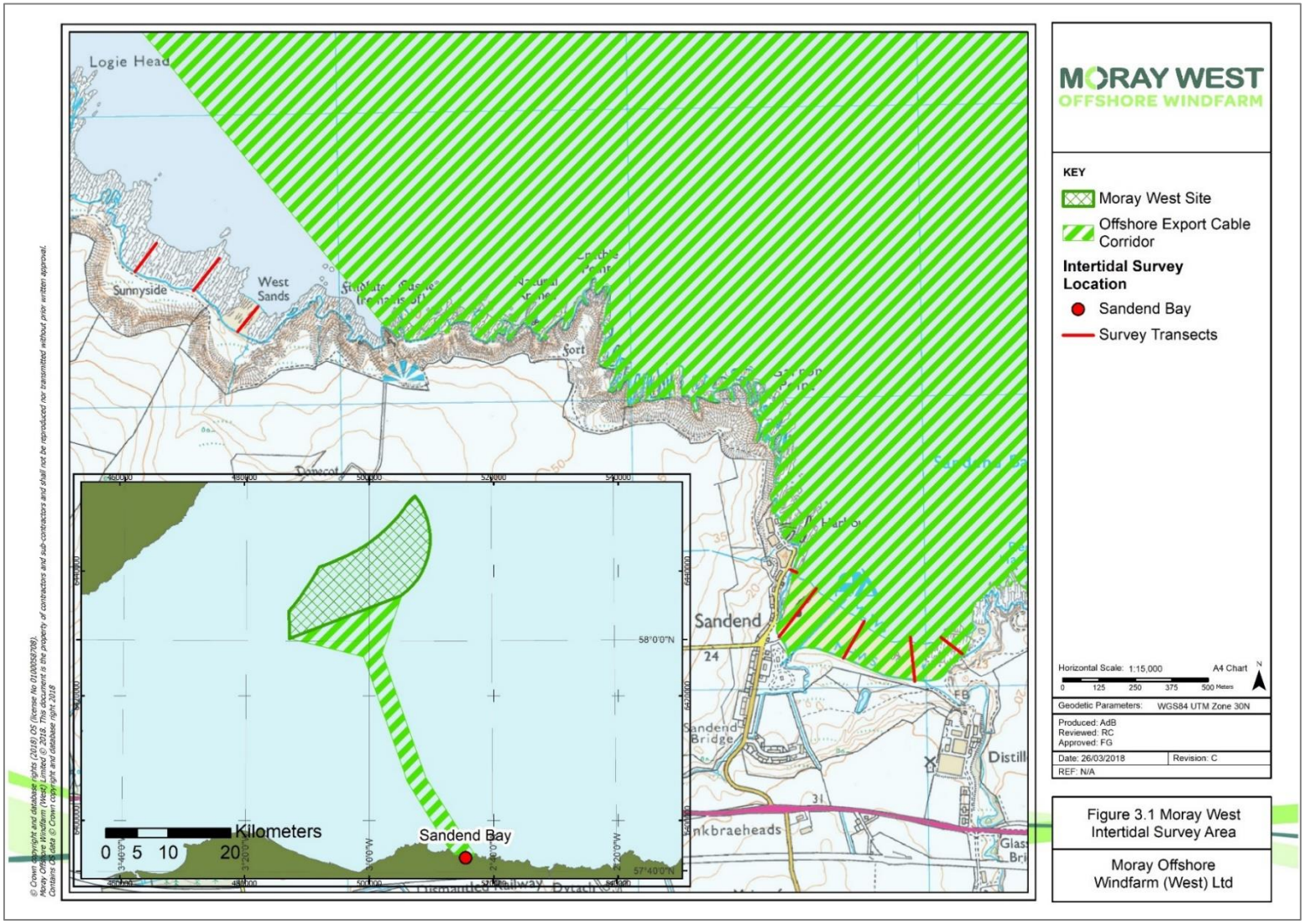


Figure 3.1 Moray West Wind Farm and Offshore Export Cable Corridor with Intertidal Survey Area

3.2 Laboratory Methodology for Intertidal Benthic Samples

All laboratory methodologies were based on best practice and follow tried and tested method statements within the industry (Marine Monitoring Handbook procedural guideline 3-9; Ware and Kenny, 2011 and Worsfield et al 2010). Laboratory analysis was undertaken by experienced marine biologists/taxonomists and PMSL are members of the National Marine Biological and Analytical Quality Control scheme (NMBAQC). A standard sample tracking procedure was followed throughout the analysis period.

3.2.1 Sample Sorting

Each sample was sieved in freshwater water and then rinsed with running tap water through a nest of 20cm diameter 5mm and 1mm stainless steel sieves with larger sieves used as appropriate to separate cobbles etc. The sieve contents were then backwashed over a white tray (to catch any potential spillage) into pre-labelled 5 litre plastic storage buckets or other suitable containers.

Each sample was then re-washed through a nest of sieves, with the smallest mesh aperture of 1mm, to remove the preservative and partition the sample for ease of sorting. The residue from each sieve was then gently washed into separate white trays. Water was added to the trays and the contents agitated and immediately after agitation, the light fraction was decanted to another tray. This procedure was repeated up to three times, and each tray of light fraction was examined separately to the heavy fraction.

The trays were marked with the appropriate sample code (relating to the client, date, specific site, sample and replicate no.) and all fractions were then examined as a monolayer under water in white trays, both by eye under a fluorescent bench light and 1.5x illuminated magnifier to remove larger animals with the remaining residue from the light and heavy fractions decanted into petri dishes for further sorting by binocular microscope stereo microscope (6x to 10x magnification). The fauna and residue derived from this process were then retained and stored by group in appropriately labelled containers. Each fraction was decanted into separate 100mm petri dishes and examined under a stereoscopic microscope with 20x eyepieces giving a maximum magnification of up to 80x. The fauna derived were added to the retained containers, preserved and stored ready for identification. Each petri dish was checked for a final time by another member of staff.

3.2.2 Taxonomic Identification

Identification was carried out using binocular zoom microscopes with 10x and 20x eyepieces, giving a maximum magnification of up to 80x. An additional 2x objective were also used as appropriate to increase the potential magnification to 160x. Compound microscopes were also used for further magnification, up to 800x.

Identification of infaunal samples was undertaken to the lowest possible taxonomic level (i.e. species) and during identification, all individuals were initially separated into families, with part animals being assigned to families where possible. The macrofaunal animals were identified to species level using standard taxonomic keys, low and high power stereoscopic microscopes and dissection, when necessary, for identification. Incomplete animals without anterior ends were recorded as present. Similarly, colonial sessile epibenthic taxa were recorded as present and not included within the infaunal quantitative data set.

Infauna were identified using standard taxonomic literature including the most up to date taxonomic keys and other more recent taxonomic publications or workshop (NMBAQC) proceedings and reporting nomenclature used the World Register of Marine Species (WoRMS) database (Appeltans, 2011).

Each sample residue was described textually and the residue retained for possible further analysis and Analytical Quality Control (AQC).

3.2.3 Biomass

Biomass analysis was performed by wet weight (tissue blotted) and carried out for each taxa. Each item to be weighed was placed on blotting paper for a minimum of 30 seconds to allow absorption of preservative into the blotting paper after which the individuals were placed on the microbalance and the reading taken. Animals with shells were weighed with shells attached and for bivalves any fluid were drained off prior to weighing whilst echinoids were punctured and drained before weighing. The macrofaunal organisms were then be placed back in their respective pots and stored. Biomass calculations included all identifiable fragments and calculated to ± 0.1mg and all biomass data was recorded in grams or fractions thereof.

3.2.4 Particle Size Determination

Particle Size Analysis (PSA) was compliant with the latest NMBAQC guidance (Mason, 2016). Prior to processing each of the sediment samples were visually assessed and the sample was mixed thoroughly until homogeneity was reached. PSA was undertaken using a combination of laser granulometry (Malvern Mastersizer 3000) and dry sieving. Any sample containing sediment greater than 1mm were processed using laser granulometry for the <1mm fraction and dry sieving for the >1mm fraction. Samples with no coarse fraction (>1mm) were processed by laser granulometry alone. A small sub-sample (approx. 100ml) was taken for laser granulometry and screened through a 1mm mesh sieve prior to analysis. If any evidence of coarser material was found then the remaining PSA sample was wet sieved through a 1mm sieve. The <1mm fraction was left to settle for 24 hours and the sediment then oven dried and weighed. The coarser sediment fraction (>1mm) was also oven dried and then dry sieved using an Endecotts sieve shaker for 20 minutes using a nest of sieves at 0.5phi intervals and each fraction weighed.

Data generated from these methods was analysed separately but for visualisation purposes the finer fractions were also merged to the coarse fraction (if present) to provide an overall grain size distribution for each sample following NMBAQC protocols. The combined data generated from the analysis of both the coarse and the fine fractions was subject to further analysis using the software programme Gradistat. Each sample was assigned a description based on the Folk and/or the Wentworth classification system. Statistics relating to PSD including mean/median grain size, skewness, kurtosis, sorting coefficient and bulk sediment classes (e.g. % silt, sand & gravel) were also calculated using the Gradistat software. These methods are consistent with the procedures identified at the recent NMBAQC PSA workshop on laboratory methods and those used for NMBAQC ring tests.

3.2.5 Loss on Ignition

Estimates of total organic carbon were determined by loss on ignition. Each sample was oven dried at 105ºC until the weight stabilised (± 0.01g). The weight of the sample was then recorded and the sample then placed into a kiln at 450ºC for 8 hours or until weights have stabilised. Once the sample had cooled sufficiently the sample was then re-weighed and the difference between the two weights expressed as the percentage loss on ignition (% LOI).

4 Results

A summary of phase 2 core sampling is provided in Annex 7.2A whilst PSD and faunal data from phase 2 sampling is given in Appendices 2 to 4. For each habitat recorded along the survey transects or at other features of interest a biotope was assigned based on the littoral sediment and rock section of the Marine Habitat Classification for Britain and Ireland – Version 04.05 (Connor et al, 2004). The boundaries of biotopes/habitats along the transects have been entered into GIS and mapped accordingly (Figure 4.1) with a summary of habitat features, sediment details and key taxa provided below.

4.1 Littoral Sediments

4.1.1 Transect SE1

Transect SE1 to the west of the beach in Sandend Bay was characterised by medium sands with a relatively sparse faunal assemblage. A summary of sediment type and fauna recorded from phase 2 core sampling is provided in Table 4.1 and representative photographs from the area are given in Table 4.2. At the top of the shore around mean high water were barren dry sands with no fauna which were classified as LS.LSa.MoSa.BarSa (Barren littoral coarse sand), although areas along the strandline also appeared to include occasional populations of the amphipod Talitrus saltator which would fall under the biotope LS.LSa.St.Tal (Talitrids on the upper shore and strand-line). Toward the lower end of the upper shore the sand became increasingly damp but still appeared to be largely devoid of invertebrate fauna (LS.LSa.MoSa.BarSa) and core sampling in this area recorded moderately well sorted (slightly gravelly) medium sand (Table 4.1). Towards the mid shore a wide area of slightly rippled wet sand was present which had a rather patchy and somewhat sparse population of polychaetes and amphipod crustacea. Dig overs in this area revealed occasional Haustorius arenarius and frequent (albeit patchy) Bathyporeia sarsi. Core sampling in this area recorded moderately well sorted (slightly gravelly) medium sand and the polychaete Scolelepis (Scolelepis) squamata and this habitat has been assigned the biotope LS.LSa.MoSa.AmSco.Sco (Scolelepis spp. in littoral mobile sand). Toward the lower shore, flat, relatively well drained sands were present from which dig-overs and core sampling indicated the presence of occasional Nephtys (Nephtys kersivalensis), Spionidae polychaetes and Bathyporeia sp. in moderately well sorted (slightly gravelly) medium sand with a slight mud content (0.05%). The low shore habitats have been recorded as rather impoverished examples of LS.LSa.FiSa.Po (Polychaetes in littoral fine sand) and are perhaps a rather sparse variant of LS.LSa.FiSa.Po.Ncir (Nephtys cirrosa dominated littoral fine sand). Other features in this area included a freshwater run-off from a stream which enters from the top of the beach to the east of the transect. This forms a small channel at the top of the beach before dispersing across the sand although there did not appear to be any different biotopes in this area to those recorded above.

Table 4.1: Summary of PSD Parameters and Taxa Recorded from Phase 2 Sampling at Transect SE1

PARAMETER	SE1 Upper	SE1 Mid	SE1 Low
TEXTURAL GROUP:	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:	Slightly Very Fine Gravelly Medium Sand	Slightly Medium Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand
MEDIAN GRAIN SIZE D_{50} (phi):	1.970	1.829	1.892
MEAN GRAIN SIZE (phi):	1.975	1.819	1.876
SORTING	0.503	0.566	0.589
	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted

Table 4.1: Summary of PSD Parameters and Taxa Recorded from Phase 2 Sampling at Transect SE1			
PARAMETER	**SE1 Upper**	**SE1 Mid**	**SE1 Low**
SKEWNESS	0.017	-0.001	-0.011
	Symmetrical	Symmetrical	Symmetrical
% GRAVEL:	0.003	0.159	0.032
% SAND:	99.997	99.841	99.918
% MUD:	0.000	0.000	0.050
Taxa	**Abundance per 0.01m^2**		
Nephtys kersivalensis			1
Scolelepis (Scolelepis) squamata		5	
Spionidae sp.			p

Table 4.2: Representative Photographs from Transect SE1

Transect SE1 Upper Shore. Image: P1170320

Transect SE1 Upper Shore. Image: P1170328

Transect SE1 Mid Shore. Image: P1170339

Transect SE1 Mid Shore. Image: P1170349

Transect SE1 Low Shore. Image: P1170359

Transect SE1 Low Shore. Image: P1170366

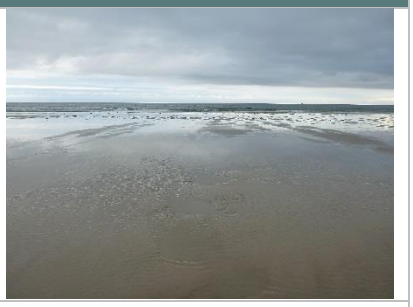
4.1.2 Transect SE2

Transect SE2 was rather similar to transect SE1 and was characterised by an upper shore area of barren dry sand classified as **LS.LSa.MoSa.BarSa** (Barren littoral coarse sand) with concrete sea defence blocks. This habitat graded into somewhat damper sand which was also very impoverished and dig-overs or core sampling indicated occasional or rare specimens of the amphipod *Haustorius arenarius*. Sediments in this area were classified as (slightly gravelly) medium sand (Table 4.3) with a low mud content (0.29%) and this upper shore habitat was classified as **LS.LSa.MoSa** (Barren or amphipod-dominated mobile sand shores).

Table 4.3: Summary of PSD Parameters and Taxa Recorded from Phase 2 Sampling at Transect SE2			
PARAMETER	**SE1 Upper**	**SE1 Mid**	**SE1 Low**
TEXTURAL GROUP:	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:	Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand
MEDIAN GRAIN SIZE D_{50} (phi):	1.725	1.751	1.7
MEAN GRAIN SIZE (phi):	1.719	1.742	1.7
SORTING	0.650	0.649	0.7
	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted
SKEWNESS	-0.017	-0.023	-0.014
	Symmetrical	Symmetrical	Symmetrical
% GRAVEL:	0.003	0.067	0.328
% SAND:	99.737	99.647	99.434
% MUD:	0.259	0.285	0.237
Taxa	**Abundance per 0.01m^2**		
Scolelepis bonnieri		1	
Bathyporeia pelagica		2	
Haustorius arenarius	2	1	

Towards the mid shore an extensive area of wet and rather rippled sand was present characterised by moderately well sorted (slightly gravelly) medium sand with a very low gravel content (0.067%) and a little mud (0.285%). Dig-overs indicated the presence of occasional *Nephtys kersivalensis* and frequent *Bathyporeia* sp. and very rare *Arenicola marina* casts. Core sampling (Table 4.3) recorded low numbers of *Haustorius arenarius*, *Scolelepis bonnieri* and *Bathyporeia pelagica* and this habitat has been classified as **LS.LSa.MoSa.AmSco.Sco** (*Scolelepis* spp. in littoral mobile sand). This habitat graded into low shore areas of flat, water logged, moderately well sorted (slightly gravelly) sand with a very low gravel and mud content. No taxa were recorded in the core sample from this location but dig-overs indicated occasional Nephtyidae polychaetes and as such has been classified as a very impoverished variant of **LS.LSa.FiSa.Po** (Polychaetes in littoral fine sand). A selection of representative photographs from transect SE2 are provided in Table 4.4.

Table 4.4. Representative Photographs from Transect SE2

		
Transect SE2 Upper Shore. Image: P1170427	Transect SE2 Upper Shore. Image: P1170415	Transect SE2 <id Shore. Image: P1170404
Transect SE2 Mid Shore. Image: P1170406	Transect SE2 Low Shore. Image: P1170382	Transect SE2 Low Shore. Image: P1170388

4.1.3 Transect SE3

Sedimentary habitats at transect SE3 were slightly more variable with areas of stones or sand covered rock adjacent to the transect but predominantly moderately well sorted (slightly gravelly) medium sands (Table 4.5) with no mud content and a very low gravel content (<0.1%). The upper shore included a narrow band of stones at the very top of the shore (**LS.LCS** – Littoral Coarse Sediment) above a band of dry barren sand (**LS.LSa.MoSa.BarSa** - Barren littoral coarse sand) with concrete blocks adjacent to a fresh water stream which dispersed over the upper shore. The concrete blocks in some cases had a modest coverage of yellow lichens (**LR.FLR.Lic** - Lichens or small green algae on supralittoral and littoral fringe rock). In some areas of the strandline it is possible that talitrid amphipods were present (**LS.LSa.St.Tal** - Talitrids on the upper shore and strand-line). Below this the upper shore comprised of damp sand with no evident infauna in which were also patches of stones or cobble with two larger areas of such habitats either side of the transect. Habitats in this area were either classified as **LS.LSa.MoSa.BarSa** (Barren littoral coarse sand) or in areas of stones **LS.LCS** (Littoral Coarse Sediments). Some of these coarser stony habitats included occasional *Littorina* sp. or limpets (*Patella* sp.) with amphipods (*Gammarus* sp.?) under stones often covered by *Ulva* sp. (*Enteromorpha* sp.). Such habitats were classified as **LR.FLR.Eph.EphX** (Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata). A further area of this habitat ran down to the midshore to the east of the transect.

Lower down the upper shore was an area of moderately well sorted (slightly gravelly) sand with occasional amphipods (*Bathyporeia pilosa*) or isopods (*Eurydice pulchra*) classified as **LS.LSa.MoSa.AmSco.Eur** (*Eurydice pulchra* in littoral mobile sand). The mid and low shore included wet, slightly rippled, well sorted sand with a low gravel and mud content (Table 4.5) colonised by a sparse community of occasional Nephtyidae polychaetes along with frequent (but patchy) *Bathyporeia* sp. (*Bathyporeia pelagica*) and lower down the shore rare *Arenicola marina*. These habitats have been classified as an impoverished variant of **LS.LSa.FiSa.Po** (Polychaetes in littoral fine sand) most likely the sub-biotope **LS.LSa.FiSa.Po.Ncir** (*Nephtys cirrosa* dominated littoral fine sand). Either side of transect SE3 on the low to midshore were areas of sand covered rock predominantly covered by *Ulva* sp. (*Enteromorpha* sp.). Such habitats often included occasional small patches of other algae such as *Mastocarpus stellatus* or *Porphyra umbilicalis* or very occasionally small clumps of *Fucus serratus*. Where Ulva dominates it has been classified as

LR.FLR.Eph.Ent (*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock) although in some areas it also showed some resemblance to **LR.FLR.Eph.EntPor** (*Porphyra purpurea* and *Enteromorpha* spp. on sand-scoured mid or lower eulittoral rock). *Littorina littorea*, *Nucella lapillus* and *Patella vulgata* were also frequently recorded. Higher up the shore on the largest of these rock features the coverage by *Ulva* decreases and barnacles such as *Semibalanus balanoides* dominate (**LR.HLR.MusB.Sem** - *Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock). A selection of representative photographs of the beach habitats are provided in

whilst photographs of some of the other adjacent features (rock, stones) are given in

.

Table 4.5. Summary of PSD Parameters and Taxa Recorded from Phase 2 Sampling at Transect SE3			
PARAMETER	**SE1 Upper**	**SE1 Mid**	**SE1 Low**
TEXTURAL GROUP:	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:	Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand
MEDIAN GRAIN SIZE D_{50} (phi):	1.828	1.816	1.804
MEAN GRAIN SIZE (phi):	1.821	1.813	1.796
SORTING	0.542	0.524	0.590
	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted
SKEWNESS	0.017	0.027	-0.008
	Symmetrical	Symmetrical	Symmetrical
% GRAVEL:	0.043	0.043	0.077
% SAND:	99.957	99.957	99.923
% MUD:	0.000	0.000	0.000
Taxa	**Abundance per 0.01m^2**		
Nephtyidae			p
Annelida			p
Bathyporeia pelagica		5	
Bathyporeia pilosa	3		
Eurydice pulchra	1		

Table 4.6. Representative Photographs of Soft sediment Habitats from Transect SE3

Transect SE3 Upper Shore. Image: P1170531	Transect SE3 Upper Shore. Image: P1170495	Transect SE3 Mid Shore. Image: P1170479
Transect SE3 Mid Shore. Image: P1170482	Transect SE3 Low Shore. Image: P1170465	Transect SE3 Low Shore. Image: P1170462

Table 4.7. Representative Photographs of Other Features Adjacent to Transect SE3

Transect SE3 Rock/Stones. Image: P1170449	Transect SE3 Rock/Stones. Image: P1170456	Transect SE3 Rock/Stones. Image: P1170507
Transect SE3 Rock/Stones. Image: P1170508	Transect SE3 Rock/Stones. Image: P1170534	Transect SE3 Rock/Stones. Image: P1170539

4.2 Littoral Rock

Survey of limited rock habitats in Sandend Bay were limited to two transects (SE4 and SE5). As outlined in Section 3 this survey did not aim to exhaustively map the biotopes within these habitats (as they are unlikely to be affected by construction activities) but rather to illustrate the range of biotopes present in the area.

4.2.1 Transect SE4

Transect SE4 was located on the western edge of Sandend Bay with a narrow fringe of littoral rock running into sand at low water. At the extreme upper shore an elevated area of slates/cobbles is present (**LS.LCS** - Littoral Coarse Sediments) which in some areas have occasional lichens and this habitat grades into a band of boulder/rock with lichens (**LR.FLR.Lic.YG** - Yellow and grey lichens on supralittoral rock). At the base of this habitat elevated ridges of rock habitats are present which are often interspersed with shallow rockpools (**LR.FLR.Rkp** – Rockpools). At the base of the lichen covered rocks these rockpools are often sparsely populated with a sandy or bare rock base with occasional algae and *Littorina* sp. or in some areas green algae such as Ulva sp. (**LR.FLR.Rkp.G** - Green seaweeds (*Enteromorpha* spp. and *Cladophora* spp.) in shallow upper shore rockpools). Rocky ridges to the seaward side of this include elevated sparsely populated bare rock primarily characterised by clumps of the brown seaweed *Pelvetia canaliculata* and occasional *Littorina* spp. or sparse barnacles (**LR.LLR.F.Pel** - Pelvetia canaliculata on sheltered littoral fringe rock) with occasional small and rather sparse clumps of *Fucus spiralis*.

Within this habitat were rockpools often with either green algae (*Cladophora* or *Ulva*) i.e. **LR.FLR.Rkp.G** (Green seaweeds (*Enteromorpha* spp. and *Cladophora* spp.) in shallow upper shore rockpools) or rock pools with red algae such as *Corallina officinalis*, *Gelidium pusillum* and *Lithothamnion* spp. which correlate to the biotope **LR.FLR.Rkp.Cor.Cor** (Coralline crusts and *Corallina officinalis* in shallow eulittoral rockpools). Beyond this habitat in slightly less elevated rock running down to the beach (or low water) were rocks dominated by abundant barnacles (*Semibalanus balanoides*) along with frequent/common *Patella vulgata*, *Littorina* spp. and *Nucella lapillus*. In crevices, small patches of juvenile mussels were sometimes present or small patches of the red algae *Mastocarpus stellatus*. This habitat shows a degree of variation with densities of barnacles generally decreasing somewhat as the rock slopes to low water but generally corresponds to the biotope **LR.HLR.MusB.Sem.Sem** (*Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock). This area also contained rock pools often with a variety of other algae including *Corallina officinalis*, Lom*entaria articulata*, *Mastocarpus stellatus*, *Osmundea pinnatifida*, *Plocamium cartilagineum* and *Polysiphonia* spp. (**LR.FLR.Rkp.Cor.Cor** - Coralline crusts and *Corallina officinalis* in shallow eulittoral rockpools). At the base of this rocky habitat was often a band or encrusting red algae (predominantly *Corallina* and *Mastocarpus stellatus*) with patchy *Ulva* spp. often overlying barnacles or *Littorina* spp. which generally correspond to the biotope **LR.HLR.FR.Coff.Coff** (*Corallina officinalis* and *Mastocarpus stellatus* on exposed to moderately exposed lower eulittoral rock on base of rock).

Off the main rock habitat smaller ridges of rock are present in the sand toward low water. These are typically characterised by a fringe of algae on the steeper sides notably *Corallina officinalis* along with clumps of *Ulva* sp. and other algae such as *Ceramium* sp., *Dumontia contorta*, *Lomentaria articulata*, *Mastocarpus stellatus* and *Osmundea pinnatifida* (**LR.HLR.FR.Coff.Coff** - *Corallina officinalis* and *Mastocarpus stellatus* on exposed to moderately exposed lower eulittoral rock on base of rock). Above this, the top of the rock ridges are primarily characterised by *Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. (**R.HLR.MusB.Sem.Sem)** often with patches of *Mastocarpus stellatus*. Less elevated parts of these rock ridges which are more influenced by sand include a variety of algae, predominantly dense clumps of *Rhodothamniella floridula* with patchy *Mastocarpus stellatus* or *Ulva* sp. (**LR.MLR.BF.Rho** - *Rhodothamniella floridula* on sand-scoured lower eulittoral rock) along with taxa such as *Littorina* spp. barnacles or juvenile *Mytilus* and *Nucella lapillus* on areas of bare rock. Occasional patches of *Fucus serratus* were also present on the lower parts of this habitat and further north where the base of these

rocky ridges are permanently submerged it is likely that *Fucus serratus* biotopes predominate. A selection of photographs from the rocky habitats at transect SE4 are provided in Table 4.8.

Table 4.8. Representative Photographs from Transect SE4

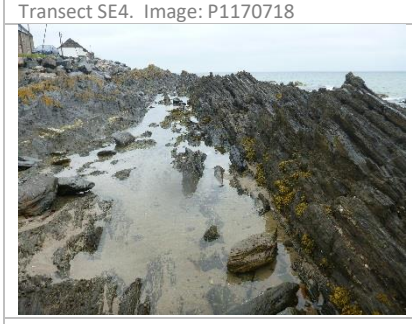
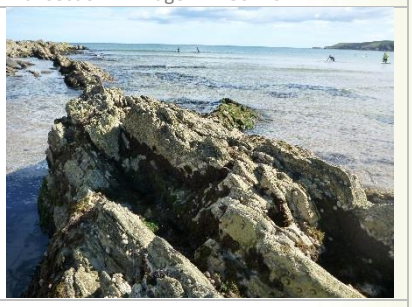
Transect SE4. Image: P1170708	Transect SE4. Image: P1170709	Transect SE4. Image: P1170713
Transect SE4. Image: P1170718	Transect SE4. Image: P1170734	Transect SE4. Image: P1170736
		
Transect SE4. Image: P1170741	Transect SE4. Image: P1170747	Transect SE4. Image: P1170748
Transect SE4. Image: P1170765	Transect SE4. Image: P1180110	Transect SE4. Image: P1180116
		
Transect SE4. Image: P1180126	Transect SE4. Image: P1180134	Transect SE4. Image: P1180142

Table 4.8. Representative Photographs from Transect SE4

Transect SE4. Image: P1180149	Transect SE4. Image: P1180153	Transect SE4. Image: P1180154

4.2.2 Transect SE5

Transect SE5 to the east of Sandend Bay includes a much more extensive area of littoral rock with a complex variety of rocky habitats (Table 4.9). In this area the extreme upper shore included a band of pebbles/gravel and cobble (**LS.LCS.Sh** - Shingle (pebble) and gravel shores) above a fringing area of mixed rocky outcrops, boulder and cobble. This mixed cobble/boulder habitat was relatively barren and included boulder or cobbles/stones with occasional *Ulva* sp. (e.g. **LR.FLR.Eph.Ent** - *Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock) or a patchy/sparse community of barnacles and *Littorina* spp. which is possibly a variant of **LR.FLR.Eph.BLitX** (Barnacles and *Littorina* spp. on unstable eulittoral mixed substrata). Much more elevated areas of bedrock in this upper shore area were often colonised by black lichens (**LR.FLR.Lic.Ver.Ver** - *Verrucaria maura* on very exposed to very sheltered upper littoral fringe rock).

Beyond this upper shore zone the main mid shore area included a broad area of heterogenous bedrock outcrops and boulder often interspersed with patches of cobbles or flat rock with sand/gravel/stones. In this area the rock habitats are characterised by a low to moderate coverage of barnacles (*Semibalanus balanoides*) with *Littorina* spp., *Patella vulgata* and *Nucella lapillus*. Along with occasional small clumps of fucoids (predominantly *Fucus spiralis*) or juvenile mussels. Depending on the nature of the substrata this area appears to form a mosaic of **LR.HLR.MusB.Sem** biotopes e.g. **LR.HLR.MusB.Sem.Sem** (*Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock) and **LR.HLR.MusB.Sem.LitX** (*Semibalanus balanoides* and *Littorina* spp. on exposed to moderately exposed eulittoral boulders and cobbles). Within this habitat and particularly higher up the shore are rockpools dominated by green algae (e.g. *Cladophora* and *Ulva* sp.) which correspond to the biotope **LR.FLR.Rkp.G** (Green seaweeds (*Enteromorpha* spp. and *Cladophora* spp.) in shallow upper shore rockpools). Other rockpools include a more diverse algal flora including coralline red algae such as *Corallina officinalis* and occasionally other red algae including *Aglaothamnion*/*Callithamnion* sp., *Ceramium* sp., *Lithothamnion* sp., *Lomentaria articulata*, *Mastocarpus stellatus*, *Membranoptera alata*, *Osmundea pinnatifida* and *Porphyra* sp. (**LR.FLR.Rkp.Cor.Cor** - Coralline crusts and *Corallina officinalis* in shallow eulittoral rockpools). A variety of grazing taxa (e.g. Limpets, *Littorina* spp. *Lacuna* sp.) are also often recoded in varying densities in these pools.

Lower down the midshore this habitat grades onto an area primarily characterised by bedrock ridges and a much denser coverage by *Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. along with patchy *Fucus* sp., with some denser patches of *Mastocarpus stellatus* on the lower edges of rock along with occasional juvenile *Mytilus*. This habitat is likely to be considered a mosaic of **LR.HLR.MusB.Sem.Sem** - *Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock or possibly **LR.HLR.MusB.Sem.FvesR** (*Semibalanus balanoides*, *Fucus vesiculosus* and red seaweeds on exposed to moderately exposed eulittoral rock). As described above, rockpools with a variety of algal taxa are also present in this area (**LR.FLR.Rkp.G** or **LR.FLR.Rkp.Cor.Cor**) and these typically include a range of algal species including *Chaetamorpha* sp., *Cladophora* spp. *Ulva* sp., *Corallina*

officinalis, *Dumontia contorta*, *Lithothamnion* spp. *Mastocarpus stellatus*, *Osmundea pinnatifida*, *Polysiphonia* spp. and *Porphyra* sp.

At the low water end of the rocky habitats along Transect SE5 are areas of sand (**LS.LSa.FiSa.Po** - Polychaetes in littoral fine sand) adjacent to a ridge of sand influenced rock. These sand influenced rocky habitats are predominantly covered with *Ulva* sp. with clumps of *Mastocarpus stellatus* and may be a variant of **LR.FLR.Eph.Ent** (*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock) or in areas with higher densities of red algae may grade into **LR.FLR.Eph.EntPor** (*Porphyra purpurea* and *Enteromorpha* spp. on sand-scoured mid or lower eulittoral rock). This habitat typically grades into more sand influenced rock with are mounds of *Rhodothamniella floridula* under the *Ulva* spp. i.e. **LR.MLR.BF.Rho** (*Rhodothamniella floridula* on sand-scoured lower eulittoral rock).

Table 4.9. Representative Photographs from Transect SE5

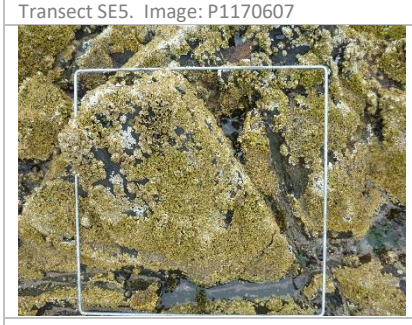
Transect SE5. Image: P1170561	Transect SE5. Image: P1170567	Transect SE5. Image: P1170591
Transect SE5. Image: P1170593	Transect SE5. Image: P1170594	Transect SE5. Image: P1170598
Transect SE5. Image: P1170607	Transect SE5. Image: P1170615	Transect SE5. Image: P1170616
		
Transect SE5. Image: P1170617	Transect SE5. Image: P1170622	Transect SE5. Image: P1170632

Table 4.9. Representative Photographs from Transect SE5

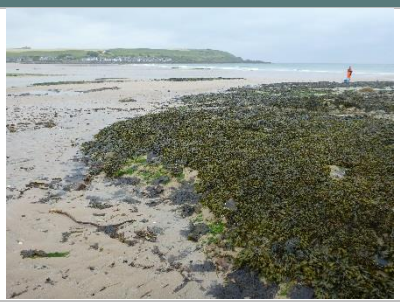
Transect SE5. Image: P1170647	Transect SE5. Image: P1170658	Transect SE5. Image: P1170665

Either side of transect SE5 a variety of other rocky habitats are also present further afield from the survey transect and representative photos for these are provided in Table 4.10. These features are also marked on the map in Figure 4.1 as target notes but not mapped further. Further north of transect SE5 a series of rocky ridges/platforms are present run down into low water which are colonised by dense *Ulva* spp. and *Fucus serratus* under which is a variety of other algae including encrusting and foliose reds such as *Aglaothamnion/Callithamnion* sp., *Ceramium* sp., *Mastocarpus stellatus*, *Phycodrys rubens* and *Phyllophora pseudoceranoides* along with *Lacuna vincta/parva*, *Littorina littorea*, Mytilidae juveniles, *Patella pellucida* and *Rissoa parva*. Such habitats are likely to include **LR.MLR.BF.Fser** (*Fucus serratus* on moderately exposed lower eulittoral rock) or **LR.MLR.BF.Fser.R** (*Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock). Examples of these rock ledges lower down the shore adjacent to sand include similar communities often with large patches of *Rhodothamniella floridula* (**LR.MLR.BF.Rho** - *Rhodothamniella floridula* on sand-scoured lower eulittoral rock) which appears to become the dominant biotope in low lying rocky ledges which run out into low shore sand. Patches of kelp (*Laminaria digitatum*) are also sometimes interspersed within in the *Fucus serratus, Ulva* and red algae community and rocky habitats which extend past low water are likely to grade into the sublittoral biotope **IR.MIR.KR.Ldig** (*Laminaria digitata* on moderately exposed sublittoral fringe rock). Further south of Transect SE5 on the landward side of the rock platforms (toward the mid-shore) low lying rocky platforms are largely colonised by fucoid algae (predominantly *Fucus spiralis*) along with *Ulva* sp., *Ceramium* sp. and *Porphyra sp.* and include the biotope **LR.LLR.F.Fspi.FS** (*Fucus spiralis* on full salinity sheltered upper eulittoral rock). Adjacent to these rocky habitats is a localised area of **LS.LSa.FiSa.Po** (Polychaetes in littoral fine sand) with quite dense *Arenicola marina* along with occasional *Scolelepis squamata* and *Macomangulus tenuis*.

Table 4.10. Representative Photographs from Other Habitats Adjacent to Transect SE5

Transect SE5. Image: P1170569	Transect SE5. Image: P1170576	Transect SE5. Image: P1170578

Table 4.10. Representative Photographs from Other Habitats Adjacent to Transect SE5

		
Transect SE5. Image: P1170687	Transect SE5. Image: P1170688	Transect SE5. Image: P1170698

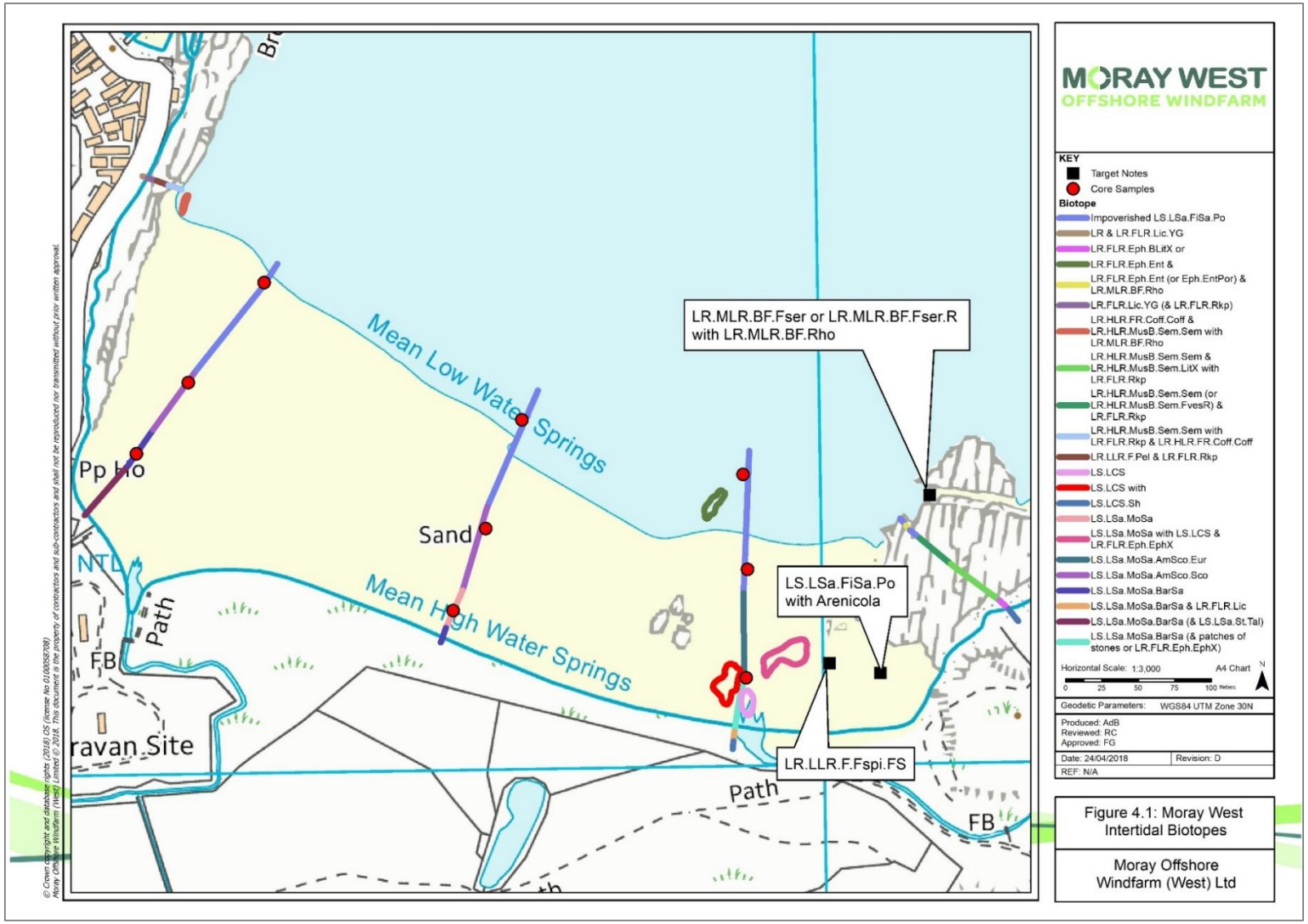


Figure 4.1 – Intertidal Biotopes at Sandend Bay

4.3 Contaminant Analysis

Three mid shore stations from Sandend Bay were sampled for contaminants including metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, barium, aluminum and tin) and polyaromatic hydrocarbons (PAHs). A summary of relevant statutory sediment quality guidelines/standards are provided in Table 4.11 whilst the results of contaminant analysis are provided in Table 4.12. All metals were found at concentrations below respective guidelines (where available) with no samples above UK limits or Dutch/Canadian standards. PAH concentrations were also low below the limit of detection (LOD) for the analytical tests although LODs for Acenaphthene, Acenaphthylene, Dibenzo(ah)anthracene were slightly higher than the Canadian TEL values.

Table 4.11. Sediment Quality Guidelines for Chemical Contamination of Marine Sediments

Contaminant	UK Guidelines (CEFAS)		Dutch Standards		ZBT	Canadian Guidelines	
	AL1	AL2	TV	RV		TEL	PEL
Heavy Metals (mg/kg dry weight)							
Arsenic	20	100	29	55	29	7.24	41.6
Cadmium	0.4	5	0.8	7.5	4	0.676	4.21
Chromium	40	400	100	380	120	52.3	160
Copper	40	400	35	90	60	18.7	108
Lead	50	500	85	530	110	30.2	112
Mercury	0.3	3	0.3	1.3	1.2	0.13	0.7
Nickel	20	200	35	45	45	15.9	42.8
Zinc	130	800	140	720	365	124	271
Polyaromatic Hydrocarbons (mg/kg dry weight)							
Acenaphthene	-	-	-	-	-	0.007	0.089
Acenaphthylene	-	-	-	-	-	0.006	0.128
Anthracene	-	-	-	-	-	0.047	0.245
Benzo(a)anthracene	-	-	-	-	-	0.075	0.693
Benzo(a)pyrene	-	-	-	-	-	0.089	0.763
Chrysene	-	-	-	-	-	0.108	0.846
Dibenzo(ah)anthracene	-	-	-	-	-	0.006	0.135
Fluoranthene	-	-	-	-	-	0.113	1.497
Fluorene	-	-	-	-	-	0.021	0.144
2-Methylnaphthalene	-	-	-	-	-	0.020	0.201
Naphthalene	-	-	-	-	-	0.035	0.391
Phenanthrene	-	-	-	-	-	0.087	0.544
Pyrene	-	-	-	-	-	0.153	1.398
Total PAH	-	-	1	10	8	-	-

Table 4.12. Results of Contaminant Analysis for Samples from Sandend Bay				
Test Description	**Units**	**SE1**	**SE2**	**SE3**
Arsenic as As, dry weight	mg/kg	2.54	2.86	2.37
Cadmium as Cd, dry weight	mg/kg	<0.40	<0.40	<0.40
Chromium as Cr, dry weight	mg/kg	4.49	4.99	5.4
Copper as Cu, dry weight	mg/kg	<1.0	<1.0	<1.0
Lead as Pb, dry weight	mg/kg	1.4	1.1	1.2
Mercury as Hg, dry weight	mg/kg	<0.20	<0.20	<0.20
Nickel as Ni, dry weight	mg/kg	2.5	2.7	2.4
Barium as Ba, dry weight	mg/kg	10.4	11.3	13.9
Aluminium as Al, dry weight	mg/kg	1450	1680	1510
Tin as Sn, Dry Weight	mg/kg	<1.0	<1.0	<1.0
Naphthalene	mg/kg DW	<0.010	<0.010	<0.010
Acenaphthylene	mg/kg DW	<0.010	<0.010	<0.010
Acenaphthene	mg/kg DW	<0.010	<0.010	<0.010
Fluorene	mg/kg DW	<0.010	<0.010	<0.010
Phenanthrene	mg/kg DW	<0.010	<0.010	<0.010
Anthracene	mg/kg DW	<0.010	<0.010	<0.010
Fluoranthene	mg/kg DW	<0.010	<0.010	<0.010
Pyrene	mg/kg DW	<0.010	<0.010	<0.010
Benzo(a)anthracene	mg/kg DW	<0.010	<0.010	<0.010
Chrysene	mg/kg DW	<0.010	<0.010	<0.010
Benzo(b)fluoranthene	mg/kg DW	<0.010	<0.010	<0.010
Benzo(k)fluoranthene	mg/kg DW	<0.010	<0.010	<0.010
Benzo(a)pyrene	mg/kg DW	<0.010	<0.010	<0.010
Indeno(1,2,3-c,d)pyrene	mg/kg DW	<0.010	<0.010	<0.010
Benzo(g,h,i)perylene	mg/kg DW	<0.010	<0.010	<0.010
Dibenzo(a,h)anthracene	mg/kg DW	<0.010	<0.010	<0.010
PAH, Sum of 16	mg/kg DW	<0.160	<0.160	<0.160
TOC, NG Method	%	<0.10	<0.10	<0.10

5 Conclusions

The intertidal habitats recorded at Sandend Bay were predominantly characterised by well sorted medium sands with low gravel and silt content (<1%). Such habitats appeared to be relatively dynamic and represented by a somewhat sparse benthic invertebrate community characterised by amphipod crustaceans, occasional isopods and polychaetes such as Nephtyidae species, *Scolelepis* species and occasionally *Arenicola marina*. Typical biotopes included **LS.LSa.MoSa** (Barren or amphipod-dominated mobile sand shores) or **LS.LSa.MoSa.BarSa** (Barren littoral coarse sand) on the upper shore and **LS.LSa.MoSa.AmSco.Sco** (*Scolelepis* spp. in littoral mobile sand) or relatively impoverished variants of **LS.LSa.FiSa.Po** (Polychaetes in littoral fine sand) on the mid and low shore. Some areas of cobbles/stones were also present in some areas on the mid to upper shore adjacent to transect SE3 which included the biotope **SS.LCS** (Littoral Coarse Sediments) or **LR.FLR.Eph.EphX** (Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata) whilst areas of sand covered rock lower down the shore near to transect SE3 included examples of **LR.FLR.Eph.Ent** (*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock) or sparse **LR.HLR.MusB.Sem** (*Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock). Contaminant sampling indicated low levels of metals and PAHs with samples generally below available sediment quality guideline thresholds.

Areas of littoral rock were primarily restricted to the eastern and western fringes of the Bay which included a variety of biotopes including SS.LCS (Littoral Coarse Sediments), **LR.FLR.Eph.Ent** (*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock) or **LR.FLR.Lic** (Lichens or small green algae on supralittoral and littoral fringe rock) on the upper shore whilst midshore rocky habitats tended to be dominated by barnacles, *Littorina* spp. and limpets with sparse fucoid or red algae coverage (E.g. *Mastocarpus stellatus*) and formed variants of the biotope **LR.HLR.MusB.Sem** (*Semibalanus balanoides* on exposed to moderately exposed or vertical sheltered eulittoral rock) often with rockpools with a variety of algal species including biotopes such as **LR.FLR.Rkp.Cor.Cor** (Coralline crusts and *Corallina officinalis* in shallow eulittoral rockpools) or **LR.FLR.Rkp.G** (Green seaweeds (*Enteromorpha* spp. and *Cladophora* spp.) in shallow upper shore rockpools). Other biotopes included LR.HLR.FR.Coff.Coff (*Corallina officinalis* and *Mastocarpus stellatus* on exposed to moderately exposed lower eulittoral rock) and LR.LLR.F.Pel (Pelvetia canaliculata on sheltered littoral fringe rock) with the latter primarily evident on transect SE4. Sand influenced rock biotoeps were also present in low shore rock habitats in sand such as LR.MLR.BF.Rho (*Rhodothamniella floridula* on sand-scoured lower eulittoral rock) often with **LR.FLR.Eph.Ent** (*Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock) and biotopes dominated by *Fucus serratus* (**LR.MLR.BF.Fser** (*Fucus serratus* on moderately exposed lower eulittoral rock) or *Fucus spiralis* **LR.LLR.F.Fspi.FS** (*Fucus spiralis* on full salinity sheltered upper eulittoral rock) were also recorded near transect SE5 on the lower and upper shore respectively.

Overall the biotopes recorded in Sandend Bay represent typical communities for moderately exposed sandy beaches and rocky habitats and no species or habitats of particular conservation importance were noted.

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7 Annex 7.2A Phase 2 Core Sample Positions

Table 7.1 Phase 2 Core Sample Positions

Sample	Longitude	Latitude	Date	Time
SE1 Upper	-2.7474191	57.68362125	25/07/2017	17:53:37
SE1 Mid	-2.746817733	57.68405984	25/07/2017	18:23:02
SE1 Low	-2.745938129	57.68467458	25/07/2017	18:55:52
SE2 Low	-2.742975459	57.68382228	25/07/2017	19:15:15
SE2 Mid	-2.743395967	57.68315178	25/07/2017	19:45:05
SE2 Upper	-2.743773571	57.68264717	25/07/2017	19:59:52
SE3 Low	-2.740428267	57.68348036	26/07/2017	07:40:04
SE3 Mid	-2.740381447	57.68289417	26/07/2017	08:03:27
SE3 Upper	-2.740400579	57.68222507	26/07/2017	08:32:38

8 Annex 7.2B: Results of PSD

Table 8.1: Results of PSD

Sediment Type	µm	phi	SE1-Upper	SE1-Mid	SE1-Low	SE2-Upper	SE2-Mid	SE2-Low	SE3-Upper	SE3-Mid	SE3-Low
Cobble	90000	-6.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	63000	-6.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Very Coarse Gravel	45000	-5.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	31500	-5.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coarse Gravel	22400	-4.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	16000	-4.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Medium Gravel	11200	-3.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	8000	-3.0	0.000	0.124	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fine Gravel	5600	-2.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	4000	-2.0	0.000	0.000	0.000	0.000	0.000	0.102	0.014	0.000	0.000
Very Fine Gravel	2800	-1.5	0.003	0.016	0.003	0.000	0.030	0.034	0.000	0.003	0.029
	2000	-1.0	0.000	0.019	0.029	0.003	0.037	0.192	0.029	0.040	0.049
Very Coarse Sand	1400	-0.5	0.000	0.030	0.029	0.023	0.071	0.195	0.052	0.022	0.051
	1000	0.0	0.003	0.005	0.045	0.075	0.135	0.316	0.046	0.052	0.037
Coarse Sand	710	0.5	0.003	0.278	0.273	2.267	1.871	3.233	0.156	0.030	0.410
	500	1.0	1.298	5.322	5.158	10.236	9.581	11.838	4.648	3.794	6.534
Medium Sand	355	1.5	14.651	20.751	18.810	23.163	22.429	22.595	20.707	21.628	21.869

Table 8.1: Results of PSD

Sediment Type	µm	phi	SE1-Upper	SE1-Mid	SE1-Low	SE2-Upper	SE2-Mid	SE2-Low	SE3-Upper	SE3-Mid	SE3-Low
	250	2.0	36.088	35.366	32.532	31.073	31.098	28.484	36.795	38.320	34.245
Fine Sand	180	2.5	32.886	27.109	27.738	22.501	23.266	21.193	27.510	27.236	25.704
	125	3.0	14.133	10.413	13.783	9.586	10.284	10.299	9.627	8.612	10.368
Very Fine Sand	90	3.5	0.934	0.568	1.541	0.812	0.912	1.279	0.416	0.262	0.702
	62.5	4.0	0.001	0.000	0.008	0.001	0.001	0.003	0.000	0.000	0.001
Very Coarse Silt	45	4.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	31.25	5.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coarse Silt	22.1	5.5	0.000	0.000	0.000	0.005	0.005	0.005	0.000	0.000	0.000
	15.63	6.0	0.000	0.000	0.000	0.050	0.045	0.022	0.000	0.000	0.000
Medium Silt	11.05	6.5	0.000	0.000	0.019	0.070	0.082	0.026	0.000	0.000	0.000
	7.81	7.0	0.000	0.000	0.023	0.078	0.083	0.109	0.000	0.000	0.000
Fine Silt	5.52	7.5	0.000	0.000	0.007	0.053	0.060	0.071	0.000	0.000	0.000
	3.91	8.0	0.000	0.000	0.000	0.003	0.011	0.003	0.000	0.000	0.000
Very Fine Silt	2.76	8.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	1.95	9.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Clay	1.38	9.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.98	10.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.69	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.49	11.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

9 Annex 7.2C: PSD Summary Statistics

Table 9.1: PSD Summary Statistics

SAMPLE	PARAMETER	SE1 Upper	SE1 Mid	SE1 Low	SE2 Upper	SE2 Mid	SE2 Low
SAMPLE TYPE:		Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:		Slightly Very Fine Gravelly Medium Sand	Slightly Medium Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand
	MEDIAN GRAIN SIZE D_{50} (µm)	255.3	281.54	269.47	302.5	297.1	308.292
FOLK AND	MEAN GRAIN SIZE (µm)	254.4	283.42	272.3	303.7	299.0	309.3
WARD METHOD	SORTING	1.417	1.481	1.50	1.569	1.568	1.6
(µm)	SKEWNESS	-0.017	0.001	0.011	0.017	0.023	0.014
	KURTOSIS	0.995	0.984	0.979	0.976	0.977	0.956
	MEDIAN GRAIN SIZE D_{50} (phi):	1.970	1.829	1.892	1.725	1.751	1.7
FOLK AND	MEAN GRAIN SIZE (phi):	1.975	1.819	1.876	1.719	1.742	1.7
WARD METHOD	SORTING	0.503	0.566	0.589	0.650	0.649	0.7
(phi)	SKEWNESS	0.017	-0.001	-0.011	-0.017	-0.023	-0.014
	KURTOSIS	0.995	0.984	0.979	0.976	0.977	0.956
	MEAN:	Medium Sand	Medium Sand	Medium Sand	Medium Sand	Medium Sand	Medium Sand

Table 9.1: PSD Summary Statistics

SAMPLE	PARAMETER	SE1 Upper	SE1 Mid	SE1 Low	SE2 Upper	SE2 Mid	SE2 Low
FOLK AND WARD METHOD	SORTING:	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted
(Description)	SKEWNESS:	Symmetrical	Symmetrical	Symmetrical	Symmetrical	Symmetrical	Symmetrical
	KURTOSIS:	Mesokurtic	Mesokurtic	Mesokurtic	Mesokurtic	Mesokurtic	Mesokurtic
BULK GRAIN SIZE	% GRAVEL:	0.003	0.159	0.032	0.003	0.067	0.328
	% SAND:	99.997	99.841	99.918	99.737	99.647	99.434
	% MUD:	0.000	0.000	0.050	0.259	0.285	0.237
	% V COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.000
	% COARSE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.000
	% MEDIUM GRAVEL:	0.000	0.124	0.000	0.000	0.000	0.000
	% FINE GRAVEL:	0.000	0.000	0.000	0.000	0.000	0.102
	% V FINE GRAVEL:	0.003	0.035	0.032	0.003	0.067	0.226
	% V COARSE SAND:	0.003	0.035	0.074	0.098	0.206	0.511
	% COARSE SAND:	1.336	5.648	5.475	12.558	11.505	15.125
	% MEDIUM SAND:	50.812	56.156	51.389	54.255	53.550	51.095
	% FINE SAND:	46.915	37.436	41.436	32.017	33.477	31.427
	% V FINE SAND:	0.931	0.566	1.543	0.809	0.909	1.277
	% V COARSE SILT:	0.000	0.000	0.000	0.000	0.000	0.000
	% COARSE SILT:	0.000	0.000	0.000	0.055	0.050	0.027
	% MEDIUM SILT:	0.000	0.000	0.042	0.148	0.164	0.135
	% FINE SILT:	0.000	0.000	0.007	0.056	0.071	0.074

Table 9.1: PSD Summary Statistics							
SAMPLE	**PARAMETER**	**SE1 Upper**	**SE1 Mid**	**SE1 Low**	**SE2 Upper**	**SE2 Mid**	**SE2 Low**
	% V FINE SILT:	0.000	0.000	0.000	0.000	0.000	0.000
	% CLAY:	0.000	0.000	0.000	0.000	0.000	0.000
% LOI @450°C		0.62	0.64	0.68	0.58	0.96	1.20

Table 9.2: Summary Statistics

SAMPLE	PARAMETER	SE3 Upper	SE3 Mid	SE3 Low
SAMPLE TYPE:		Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:		Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand
	MEDIAN GRAIN SIZE D_{50} (µm)	281.7	284.1	286.4
FOLK AND	MEAN GRAIN SIZE (µm)	283.088	284.525	288.065
WARD METHOD	SORTING	1.456	1.438	1.506
(µm)	SKEWNESS	-0.017	-0.027	0.008
	KURTOSIS	0.972	0.972	0.981
	MEDIAN GRAIN SIZE D_{50} (phi):	1.828	1.816	1.804
FOLK AND	MEAN GRAIN SIZE (phi):	1.821	1.813	1.796
WARD METHOD	SORTING	0.542	0.524	0.590
(phi)	SKEWNESS	0.017	0.027	-0.008
	KURTOSIS	0.972	0.972	0.981
	MEAN:	Medium Sand	Medium Sand	Medium Sand
FOLK AND WARD METHOD	SORTING:	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted
(Description)	SKEWNESS:	Symmetrical	Symmetrical	Symmetrical
	KURTOSIS:	Mesokurtic	Mesokurtic	Mesokurtic
BULK GRAIN SIZE	% GRAVEL:	0.043	0.043	0.077
	% SAND:	99.957	99.957	99.923

Table 9.2: Summary Statistics				
SAMPLE	**PARAMETER**	**SE3 Upper**	**SE3 Mid**	**SE3 Low**
	% MUD:	0.000	0.000	0.000
	% V COARSE GRAVEL:	0.000	0.000	0.000
	% COARSE GRAVEL:	0.000	0.000	0.000
	% MEDIUM GRAVEL:	0.000	0.000	0.000
	% FINE GRAVEL:	0.014	0.000	0.000
	% V FINE GRAVEL:	0.029	0.043	0.077
	% V COARSE SAND:	0.098	0.074	0.088
	% COARSE SAND:	4.853	3.876	6.996
	% MEDIUM SAND:	57.543	59.986	56.147
	% FINE SAND:	37.048	35.760	35.991
	% V FINE SAND:	0.415	0.261	0.700
	% V COARSE SILT:	0.000	0.000	0.000
	% COARSE SILT:	0.000	0.000	0.000
	% MEDIUM SILT:	0.000	0.000	0.000
	% FINE SILT:	0.000	0.000	0.000
	% V FINE SILT:	0.000	0.000	0.000
	% CLAY:	0.000	0.000	0.000
% LOI @450°C		0.50	0.59	0.66

10 Annex 7.2D: Species data from Phase 2 core sampling

Table 10.1: Species Data from Phase 2 Core Sampling

Taxa	Abundance per 0.01m²									
	Notes	SE1 Upper	SE1 Mid	SE1 Low	SE2 Upper	SE2 Mid	SE2 Low	SE3 Upper	SE3 Mid	SE3 Low
Scolelepis squamata			5							
Nephtys kersivalensis				1						
Spionidae				p						
Haustorius arenarius					2	1				
Scolelepis bonnieri						1				
Bathyporeia pelagica						2			5	
Bathyporeia pilosa								3		
Eurydice pulchra								1		
Nephtyidae										p
Annelida	proboscis									p
Taxa	**Biomass (wet weight in g) per 0.01m²**									
	Notes	**SE1 Upper**	**SE1 Mid**	**SE1 Low**	**SE2 Upper**	**SE2 Mid**	**SE2 Low**	**SE3 Upper**	**SE3 Mid**	**SE3 Low**
Scolelepis squamata			0.4404							
Nephtys kersivalensis				0.0572						
Spionidae				0.0052						
Haustorius arenarius					0.0033	0.0169				
Scolelepis bonnieri						0.0015				

Table 10.1: Species Data from Phase 2 Core Sampling										
Bathyporeia pelagica						0.0015			0.0043	
Bathyporeia pilosa								0.0029		
Eurydice pulchra								0.0036		
Nephtyidae										0.0349
Annelida	proboscis									0.0071

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Electromagnetic Field Modelling

Moray Offshore Windfarm (West) Limited

Technical Appendix 8.1

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Environmental Statement

Technical Appendix 4.3 D - Electromagnetic Fields Modelling

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1.0 Introduction

The following report has been produced in support of the assessment of the potential effect of electro-magnetic fields (EMFs) on fish and shellfish ecology and includes an estimate of the magnetic fields expected to be produced by the cabling of the three wind farm sites and the offshore transmission infrastructure (OfTI) during the operational phase. The assessment of the likely effect of EMFs on fish and shellfish species is provided for the three wind farm sites and the OfTI in Chapter 7.2 and Chapter 10.2 respectively.

A number of species of conservation and commercial importance which are sensitive to EMFs are known to be present in the Moray Firth. Concerns were raised during consultation with relevant stakeholders in relation to the potential for EMFs to result in adverse effects on these species, particularly in the case of salmon and sea trout, for which little research in terms of the implications of potential behavioural EMF related effects has been undertaken to date. It should be noted that Marine Scotland Science (MSS) is currently undertaking research into the potential effects of EMF. An outline of the methodology of MSS current research is given in Annex 01 at the end of this document.

2.0 Methodology

Based on available reference information TNEI calculated and plotted both the HVDC and AC magnetic field magnitudes and the predicted compass deviation due to HVDC cables.

2.1 Assumptions

The calculations undertaken take account of the following assumptions:

- **DC Magnetic Fields (Export Cables)**
  - 2 x 750MW ±320kV HVDC links
  - Cables installed close-laid (touching)
  - Burial depth of 1m and 0.25m (under rock placement)
  - The two links are independent and thus do not impact on each other
  - The Earth's Magnetic field is excluded
- **Compass Deviation (Export Cables)**
  - The calculations assume the worst case condition of the cable running (Magnetic) North to South
  - The Earth's Magnetic field is assumed to be 50MicroTesla.
- **AC Magnetic Fields (Inter Array and OSPs Cables)**
  - AC cables are carrying rated power
    - 33kV AC cables are 630mm^2 and rated at 715A
    - 66kV AC cables are 630mm^2 and rated at 715A
    - 220KV 800mm^2 are rated at 775A
    - 220KV 300mm^2 are rated at 525A
  - Cable burial depth is 1m
  - AC Magnitude values are Peak not RMS

2.2 Calculations

The electromagnetic field (B) generated by a single conductor was derived from Biot-Savarts Law as:

$$B = \frac{\mu I}{2\pi l}$$

Where l = the distance from the centre of the conductor

The magnetic field surrounding 2 core (DC) and 3 core (AC) was calculated by the superposition of fields due to single conductors.

2.3 References

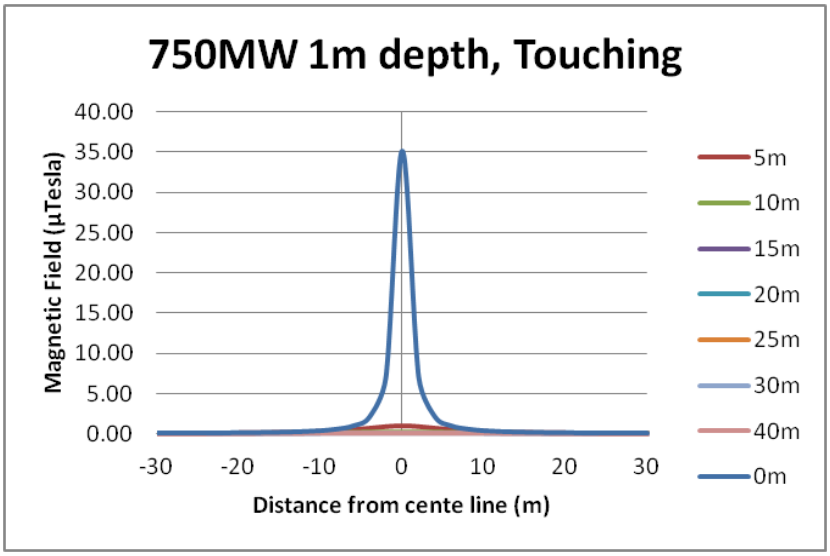
- Cowrie-EMF-01-2002 – A baseline assessment of electromagnetic fields generated by offshore windfarms (July 2003).
- Cowrie-EM FIELD – COWRIE 1.5 Electromagnetic fields review (July 2005).
- OWET – Electromagnetic field study. The study of electromagnetic fields generated by submarine power cables (September 2010).
- BOEMRE – Effects of EMFs from undersea power cables on elasmobranchs and other marine species (September 2011).

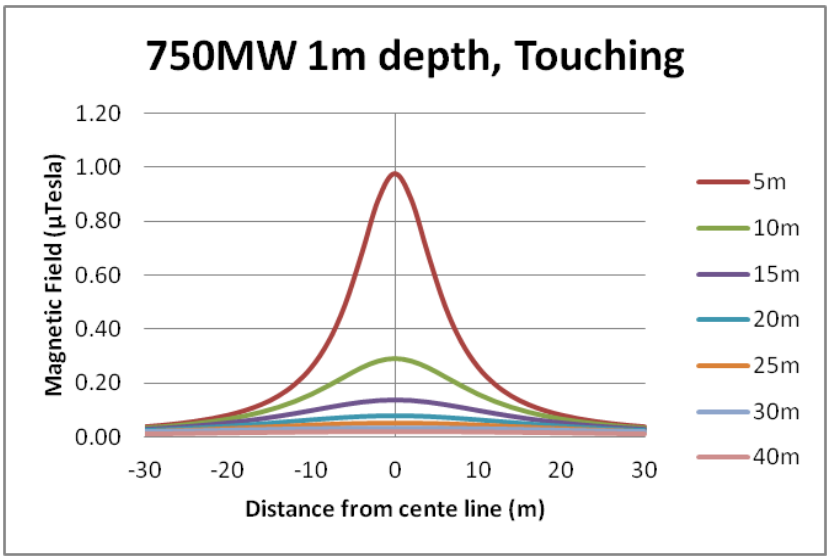
3.0 Modelling Results

The outputs of the modelling undertaken for HVDC export cables and AC inter-array and inter-platform cables are given below in Figure 3.1 to Figure 3.8:

- Figure 3.1 and Figure 3.2 show the predicted magnetic field produced by HVDC export cables assuming cable burial (1m) and protection (0.25 m under rock placement), respectively.
- Figure 3.3 and Figure 3.4 show the predicted compass deviation (degrees) expected from HVDC cables assuming cable burial (1m) and cable protection (0.25 m under rock placement).
- Figure 3.7 and Figure 3.8 show the predicted magnetic field produced by 33kV and 66kV AC inter-array cables assuming 1m burial.
- Figure 3.5 to Figure 3.6 show the predicted magnetic field produced by 800mm^2 and 300mm^2 220 kV AC inter-platform cables assuming 1m burial

In each of the figures below, the x axis indicates distance from the cable centre and the y axis Magnetic field strength in MicroTesla (10^{-6} Tesla) or compass deviation (degrees). Each plot shows multiple levels above the seabed (0, 5, 10, 15, 20, 25, 30 and 40m for DC cables and 0, 5, 10, 15, 20 and 25m for AC cables).





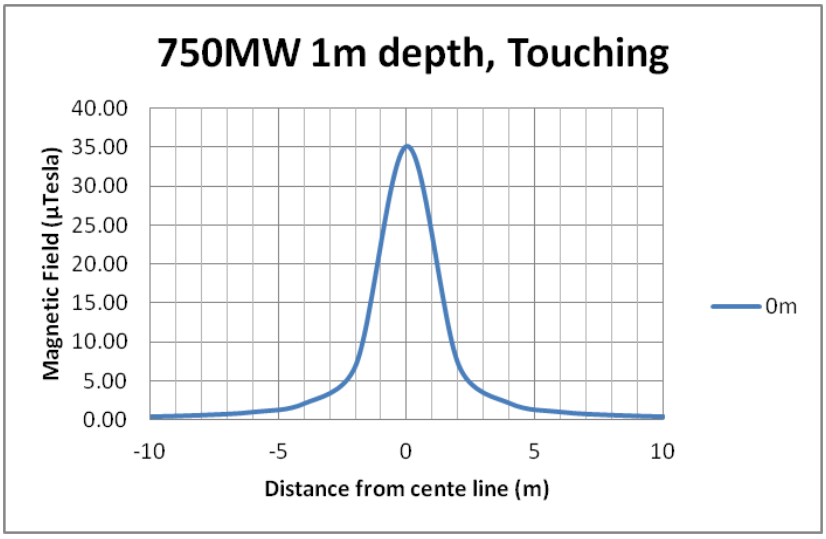
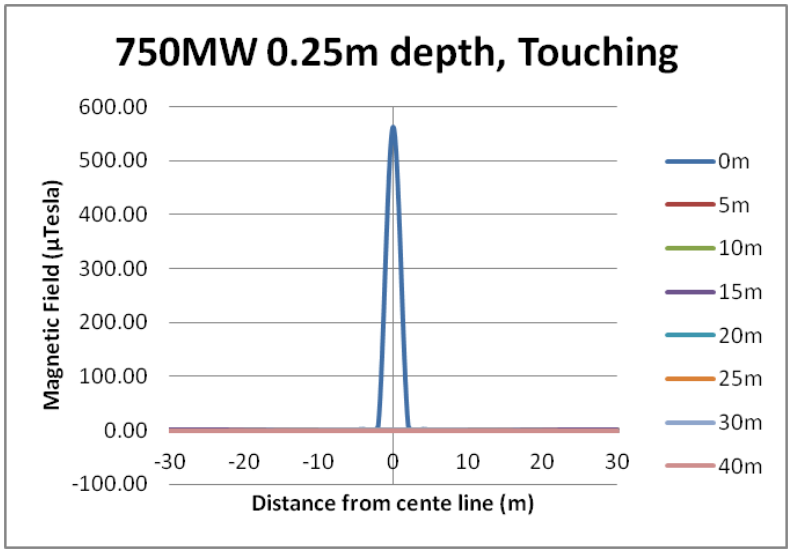
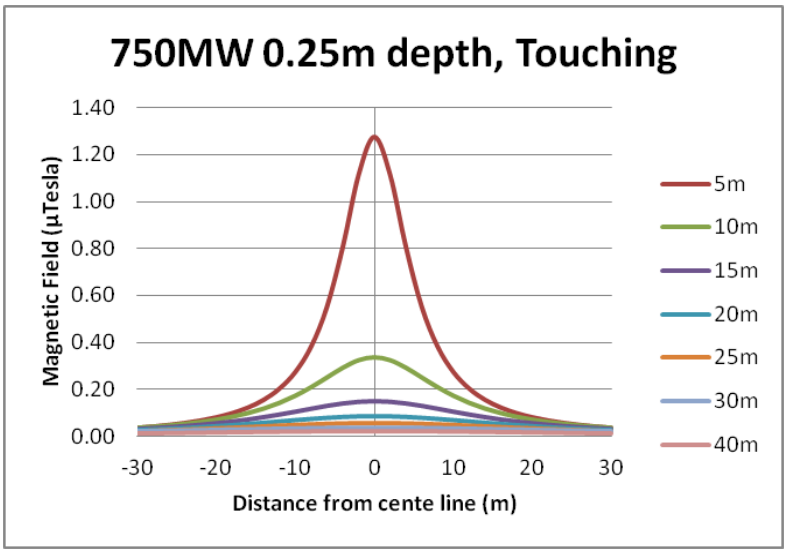


Figure 3.1 Magnetic field expected from HVDC Export Cables (bundled) assuming 1m burial





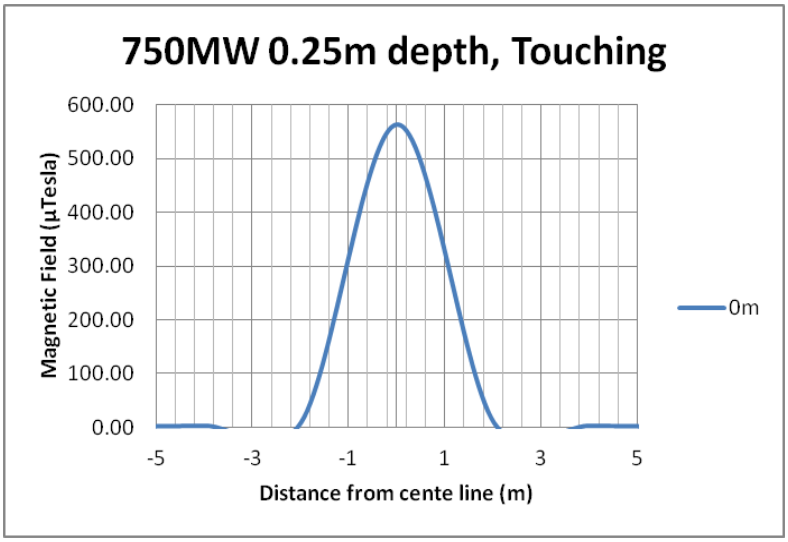
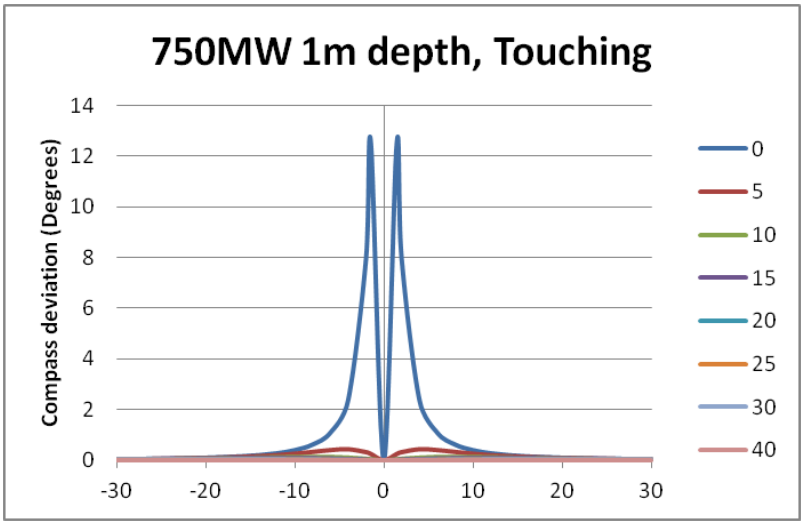
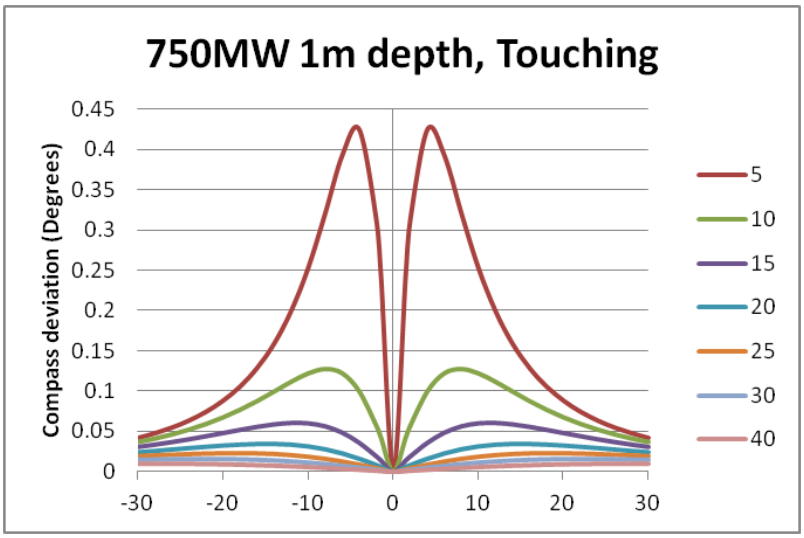


Figure 3.2 Magnetic field expected from HVDC Export Cables (bundled) cable protection (0.25 m under rock placement)





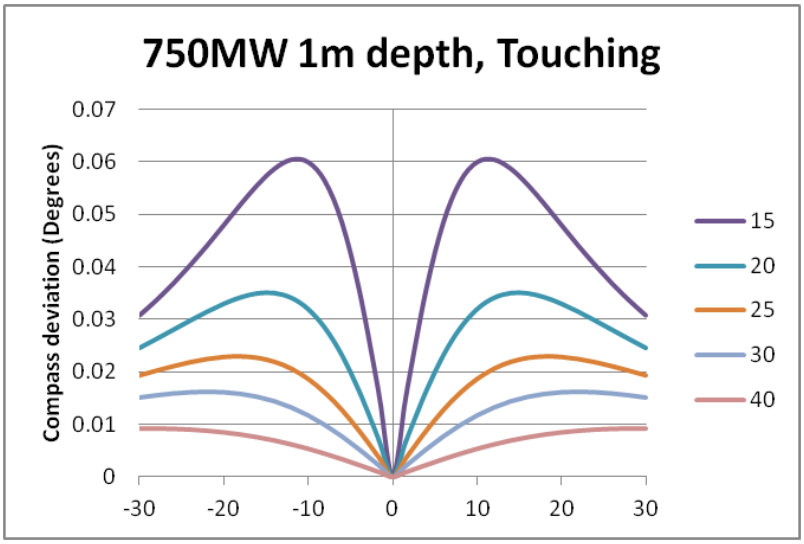


Figure 3.3 Compass Deviation calculated for HVDC Export Cables (bundled) assuming 1m burial

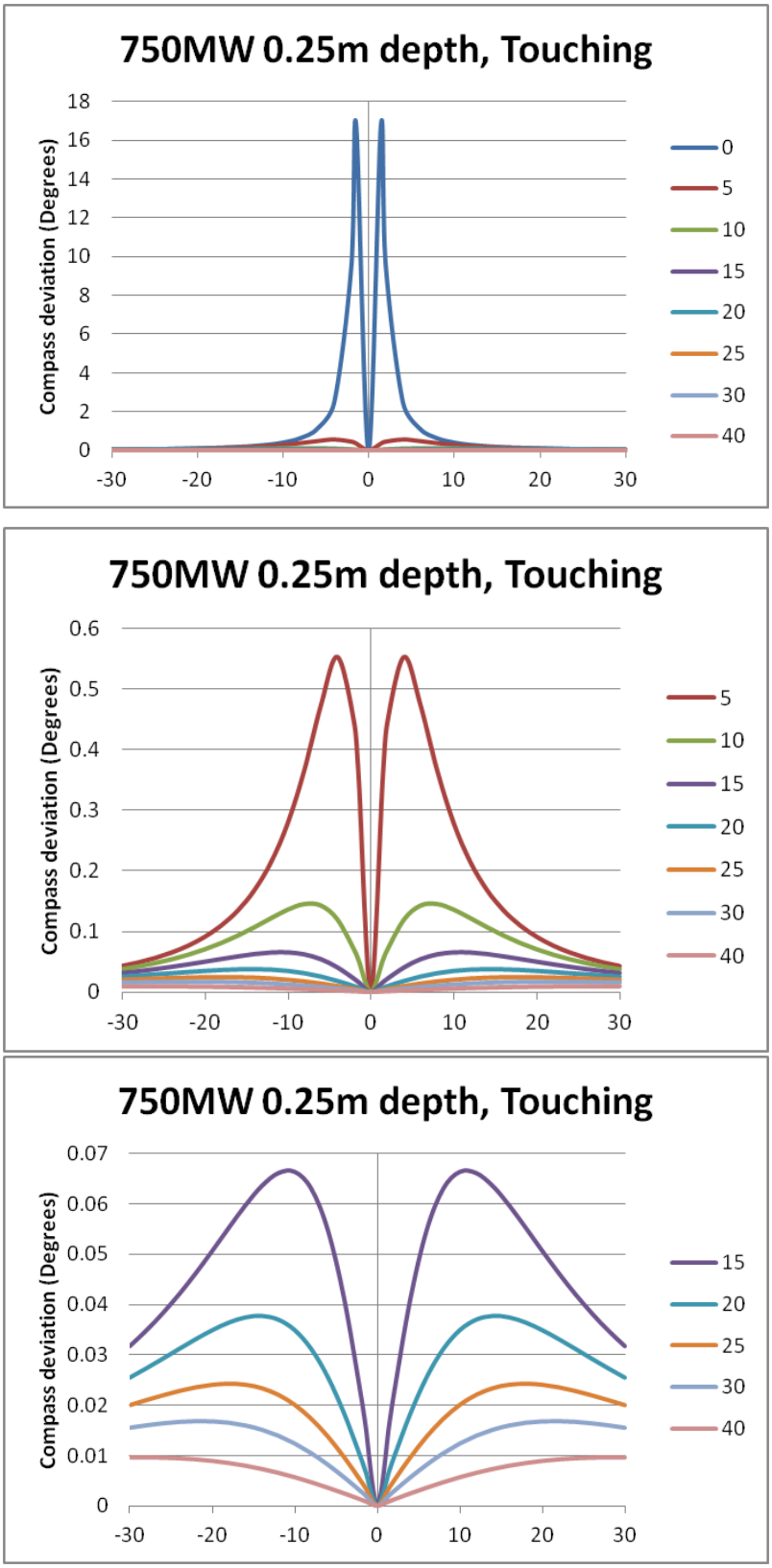
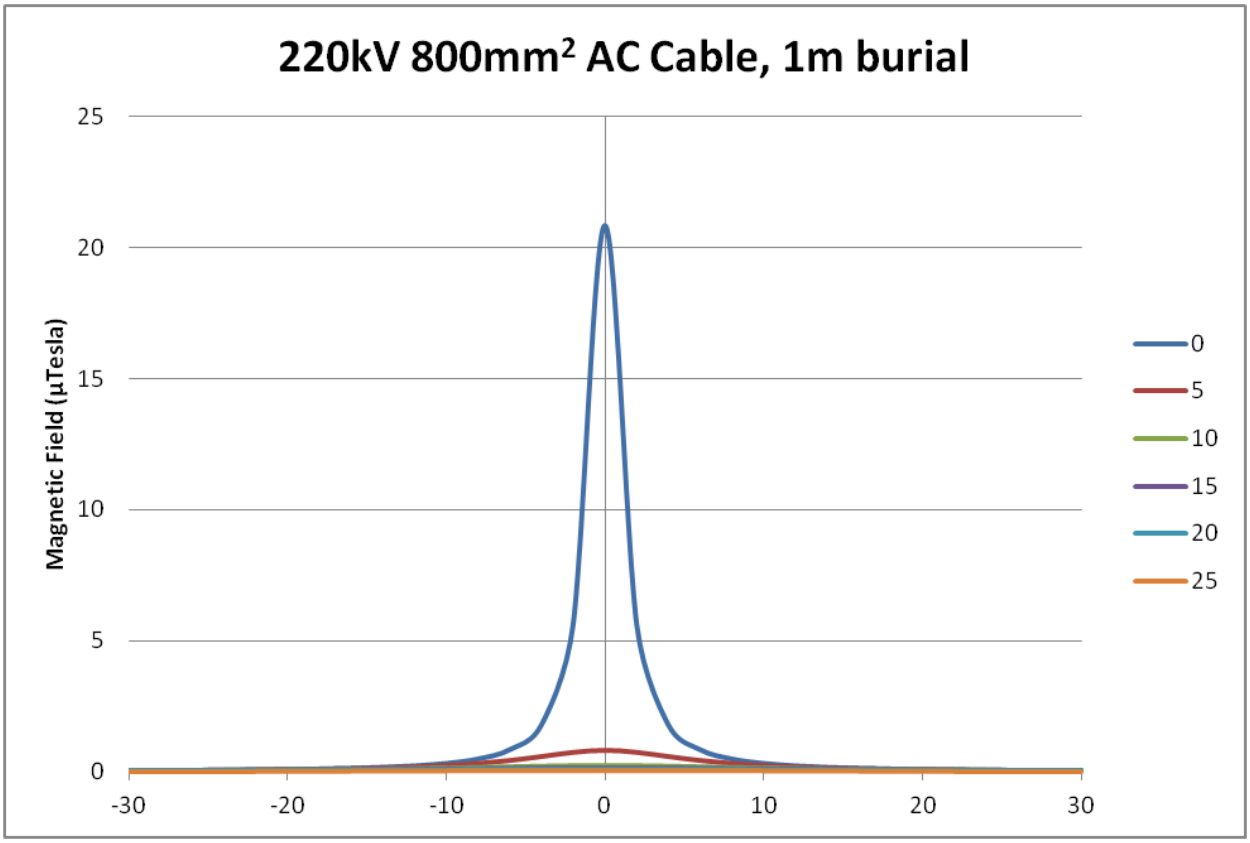


Figure 3.4 Compass Deviation calculated for HVDC Export Cables (bundled) cable protection (0.25m under rock placement)



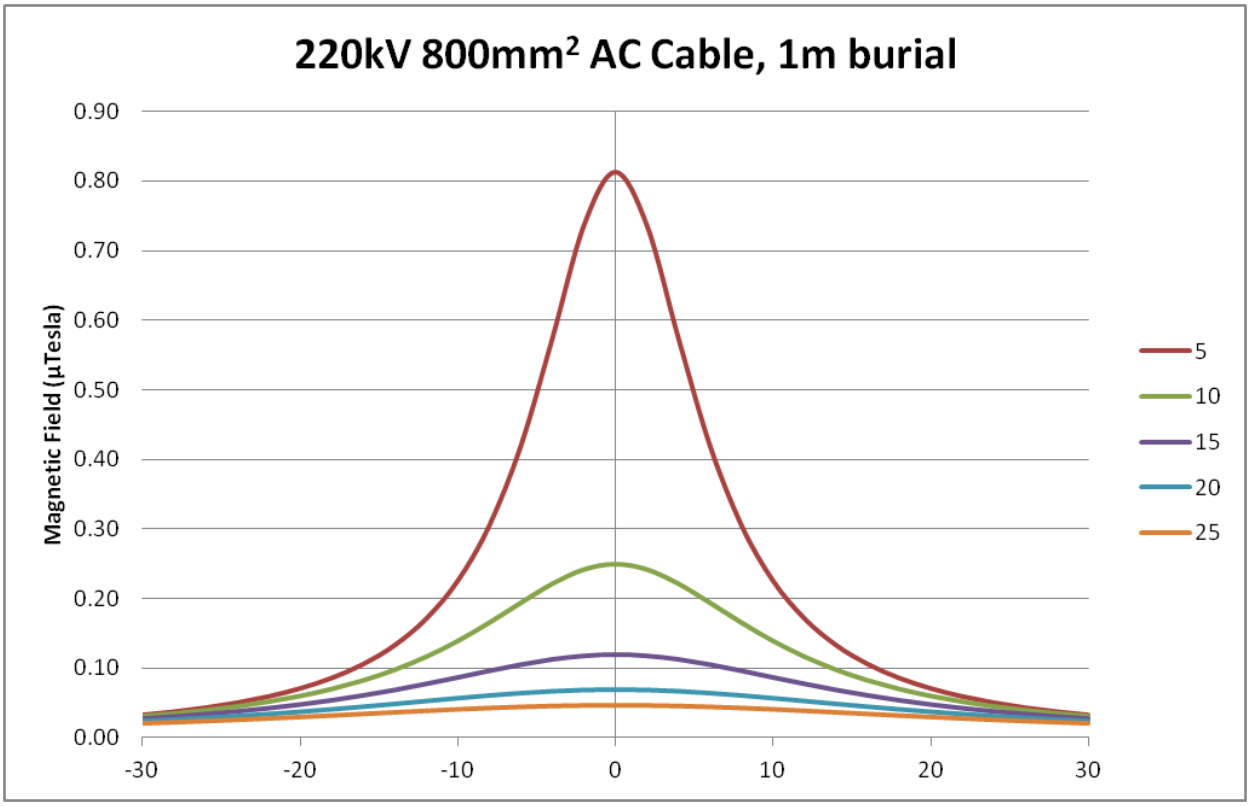
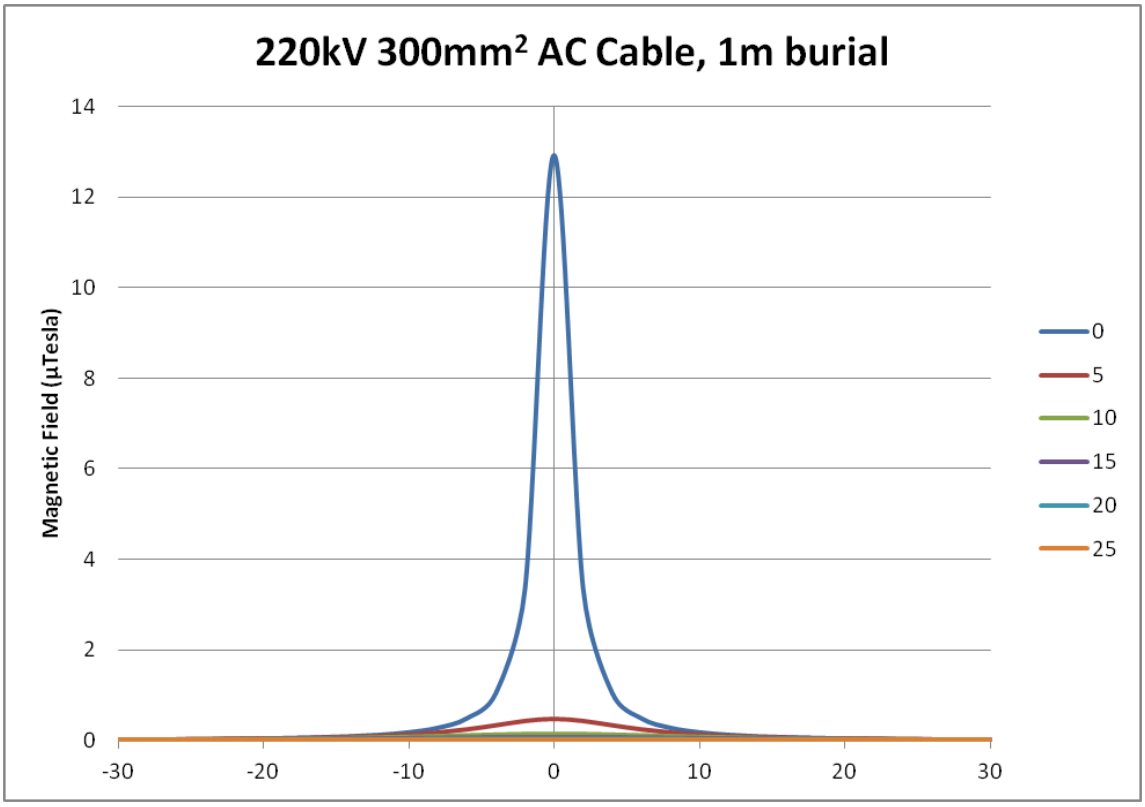


Figure 3.5 Magnetic field expected from 800mm² AC 220 kV inter-platform cables assuming 1m burial



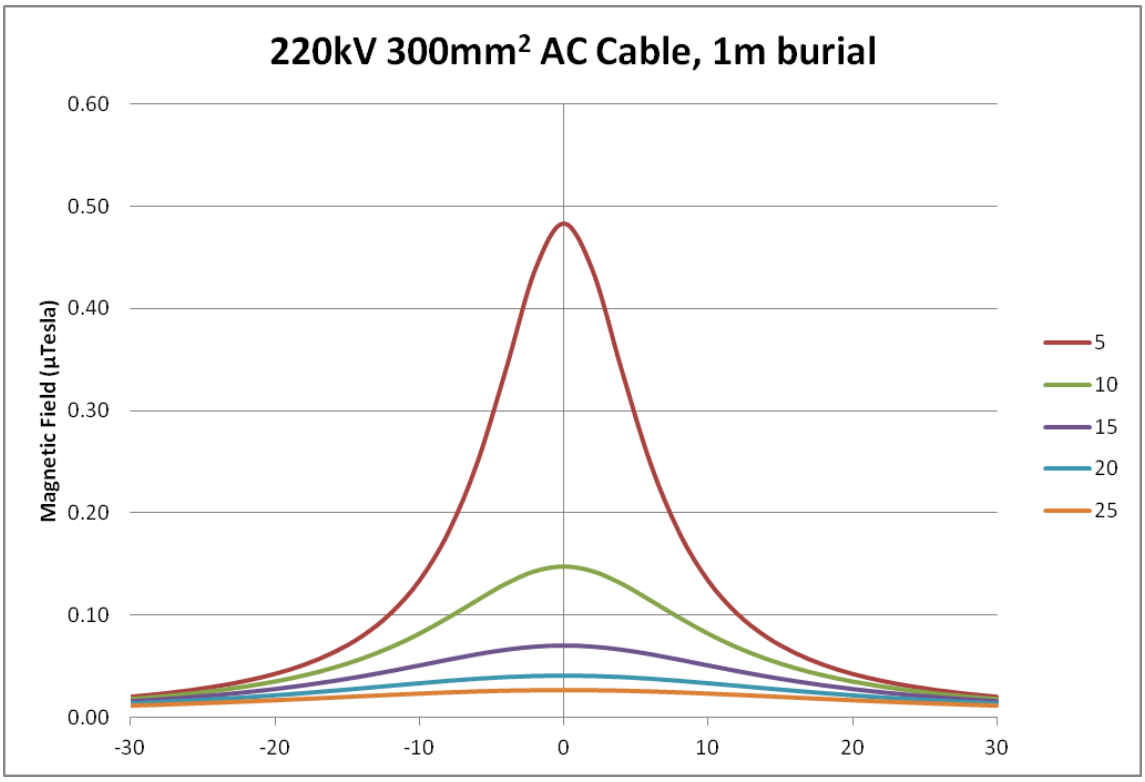
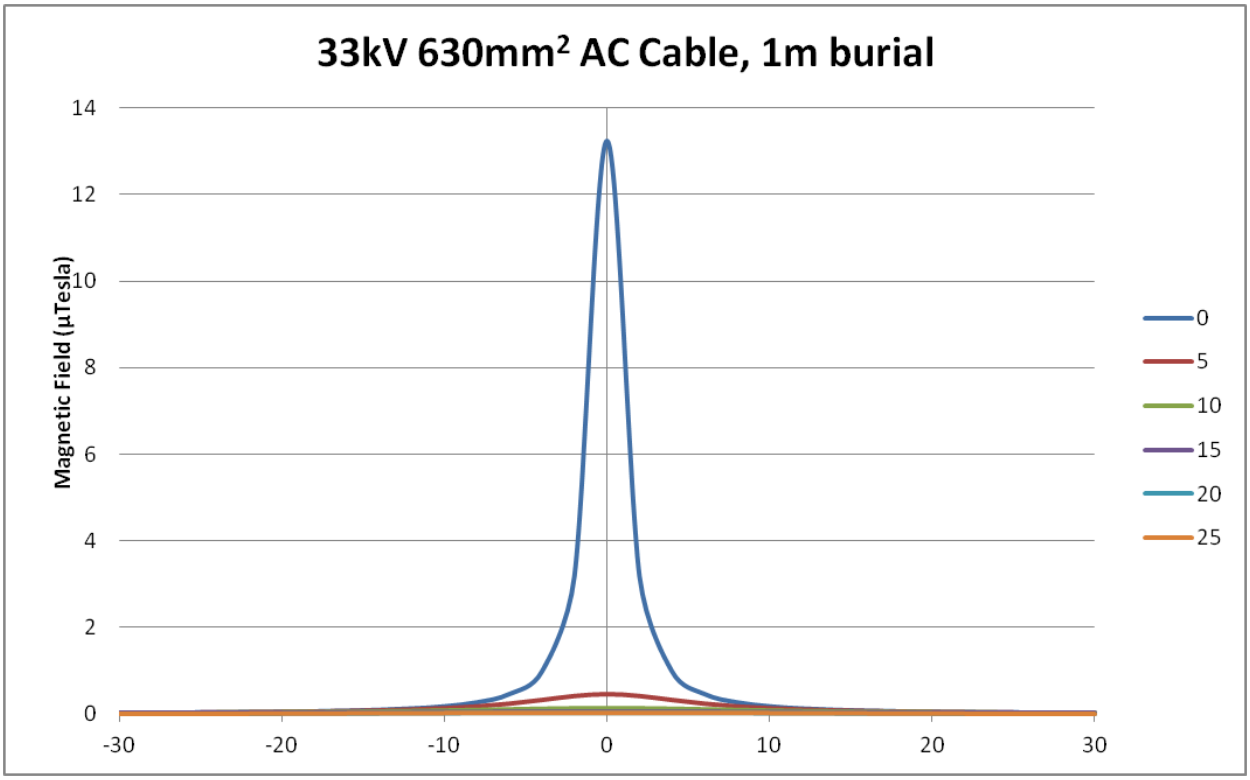


Figure 3.6 Magnetic field expected from 300mm² AC 220 kV OSP cables assuming 1m burial



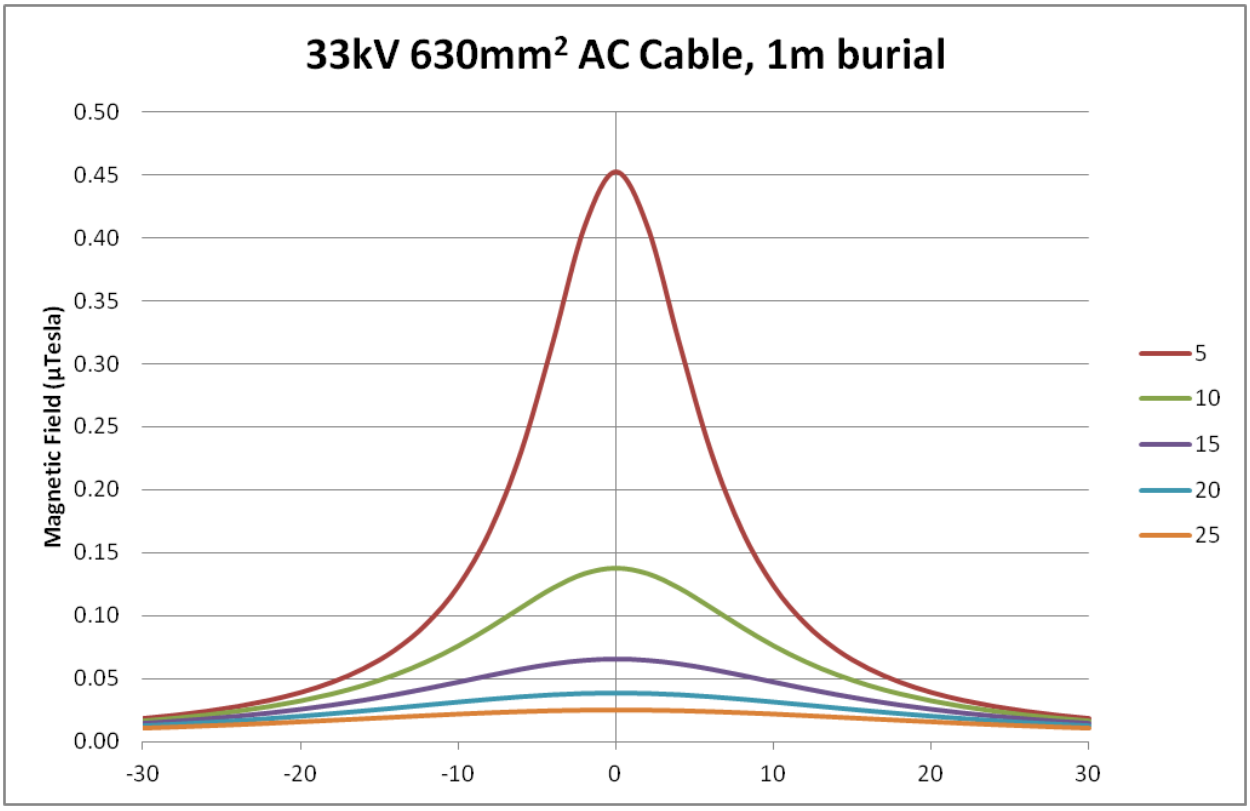
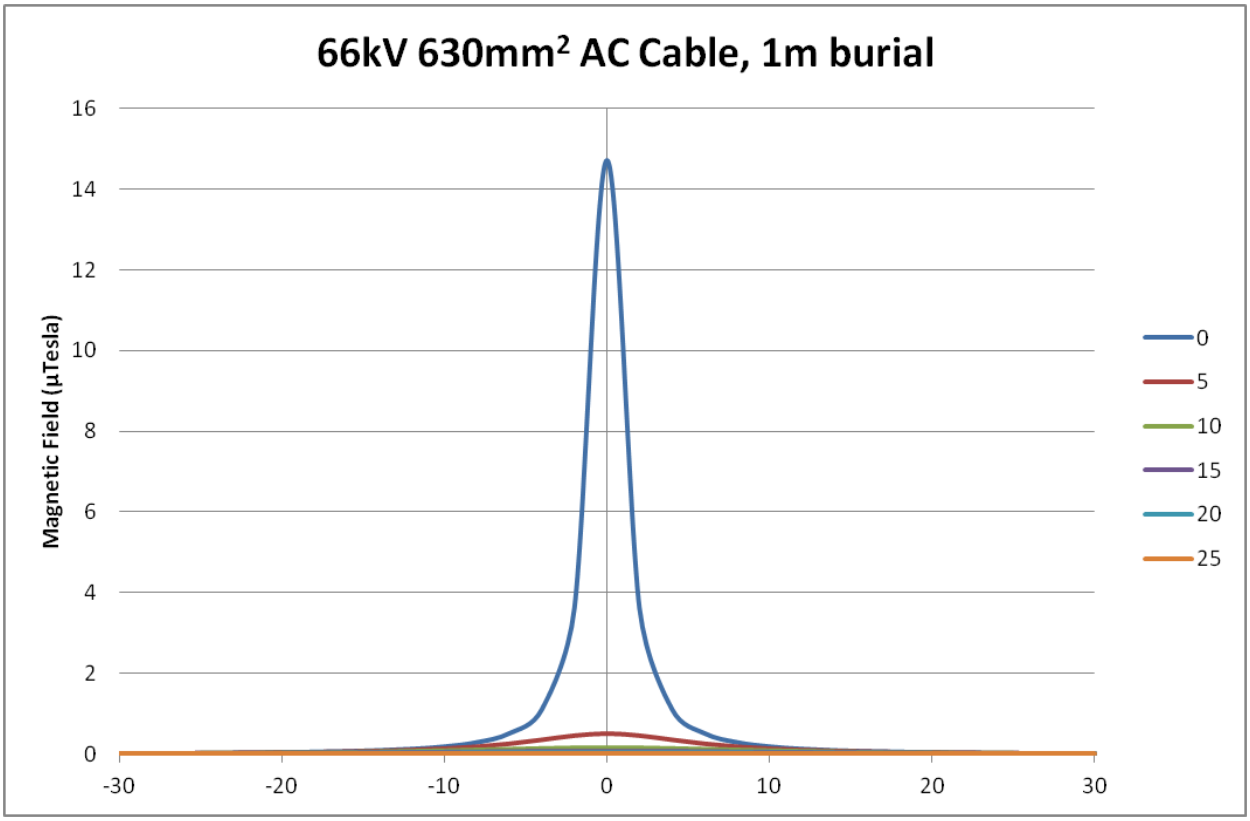


Figure 3.7 Magnetic field expected from 33kV inter-array cables assuming 1m burial



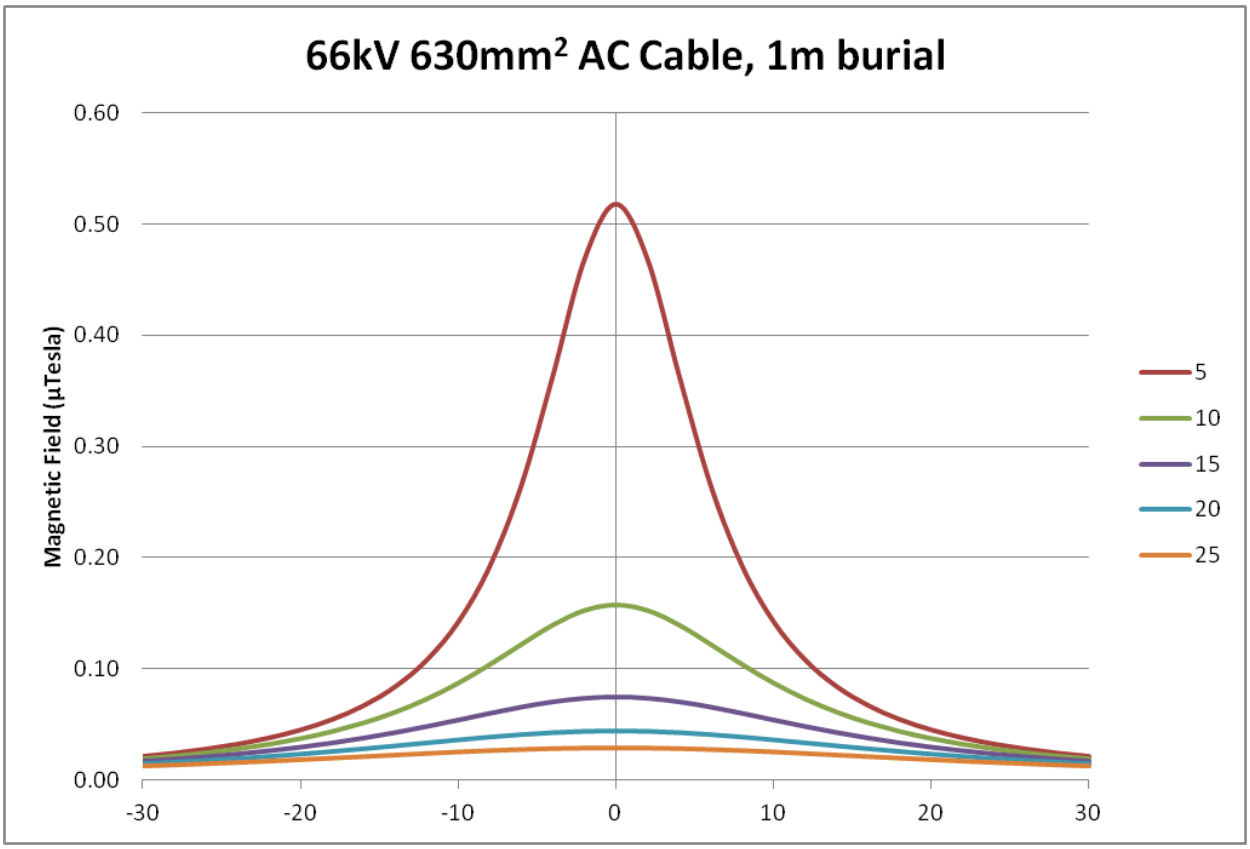


Figure 3.8 Magnetic field expected from 66 kV inter-array cables assuming 1m burial

4.0 Discussion

The highest magnetic fields are expected from the DC export cables. These will reach a maximum of approx. 35 µT at the seabed assuming 1 m burial (Figure 3.1 and Figure 3.2) and a maximum of approx. 560 µT at the seabed assuming cable protection (under 0.25 m of rock placement). As indicated in the Rochdale Envelope, it is planned to install a bundle of two export cables per trench. The two bundles would be separated by approximately 4 times water depth. For 80 km of the 105 km length of the offshore export cables route, it is expected that cables will be buried to a target depth of 1 m. As a result, the magnitude of the magnetic field associated to DC cables in approximately 80 km of the export cables route would be expected to be as shown in Figure 3.1 (where burial to 1 m has been assumed). The seabed in a 24 km section of the export cables route leading to shore contains areas of rock at, or close to, the surface, which is unsuitable for burial and cables will therefore have to be laid on the seabed. Where this is the case, cables will be protected by graded rock placement, concrete mattresses or other suitable protective coverings. Over this 24 km section, it is anticipated that only between 5 and 19 km may require such protection, the rest will be buried. It will be within this smaller section that the magnetic fields produced by export cables would be expected to be as shown in Figure 3.2 (where protection under 0.25 m of rock placement has been assumed).

For both buried and protected DC cables the magnetic field will decrease exponentially with vertical distance from the seabed (the magnetic field 5 m from the seabed is expected to be reduced to approx. 1 µT and 1.25 µT assuming cable burial and cable protection respectively). Similarly, the magnetic field will decrease rapidly with horizontal distance from the cables (within a few metres), whether cables are buried or protected.

As shown in Figure 3.3 and Figure 3.4 the compass deviation (degrees) expected from DC cables calculated assuming cable burial and protection respectively, will also decrease rapidly with vertical and horizontal distance from the cables (within a few metres).

Magnetic fields generated by inter-platform AC cables are expected to reach a maximum value at the seabed of approximately 21 µT for 800 mm^2 cables and 13 µT for 300 mm^2 cables (assuming cable burial to 1 m). As described above for DC cables, an exponential reduction in the strength of the magnetic field is also expected with distance from the seabed (reduced to approximately 0.80 µT and 0.50 µT within 5 m from the seabed for 800 mm^2 and 300 mm^2 respectively) and horizontally with distance from the cable (within a few metres).

Similarly, in the case of AC inter array cables., a significant reduction in the strength of the magnetic field is expected to occur within 5 m from the seabed for both 33 kV and 66 kV cables. The levels expected at the seabed are comparatively small (approximately 13 µT and 15 µT for 33 kV and 66 kV cables respectively) assuming cable burial to 1 m. As previously described for DC and inter-platform cables, in this case, the predicted magnetic fields are also expected to rapidly decrease horizontally with distance from the cable (within a few metres).

As shown above, the magnetic field produced by the proposed DC and AC cables will decrease rapidly both vertically and horizontally. In all cases, where cables are buried to 1 m depth, the predicted magnetic field is expected to be below the earth's magnetic field (assumed to be 50 µT). Where DC cables cannot be buried and are instead protected, the magnetic field is expected be below the earth's magnetic field within 5 m from the seabed.

Annex 01: Marine Scotland Science EMF Research

An EMF generating system as a tool for investigating the behavioural responses of migratory fishes to EMFs

An EMF generating system based on Helmholtz coils has been developed by Marine Scotland Science as a tool for investigating the behavioural responses of migratory fishes to magnetic fields associated with alternating currents. It consists of four pairs of Helmholtz coils used to create four channels through which fish can swim in a toroidal tank. The strength of the generated EMF emitted by the coils is varied by altering the input between 1/16 V AC and 8 V AC, generating an EMF strength which can range from < 1 µT to nearly 100 µT. The relative strength of the EMF according to position within the channel is made for calibration purposes at the time of installation. Fish behaviour is recorded using underwater and overhead video cameras. The system has been tested with a small number of European eels Anguilla anguilla. Trials will be conducted on Atlantic salmon Salmo salar smolts and eels during the coming year. No results are available yet.

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Marine Mammal Baseline

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Technical Appendix 9.1

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Acronyms	
Acronym	**Expanded Term**
ASCOBANS	Agreement on the Conservation of Small Cetaceans in the Baltic, North-East Atlantic, Irish and North Seas
BOWL	Beatrice Offshore Wind Ltd.
CODA	Cetacean Offshore Distribution and Abundance in the European Atlantic
CPOD	Brand name for passive acoustic monitoring instruments that detect toothed whales, dolphins and porpoises by identifying the trains of echo-location sounds they produce.
CRRU	Cetacean Research and Rescue Unit
cSAC	Candidate Special Area of Conservation
DBEIS	Department for Business, Energy and Industrial Strategy
DECC	Department of Energy & Climate Change (former name for the DBEIS)
Distance	Software for the design and analysis of distance sampling surveys of wildlife populations. This software takes two forms: a Windows-based program and a suite of packages for the statistical programming language R
EARs	Ecological Acoustic Recorders
ECOMMAS	East Coast Marine Mammal Acoustic Study
EEZ	Exclusive Economic Zone
EPS	European Protected Species
ES	Environmental Statement
ESAS	European Seabird at Sea
FCS	Favourable Conservation Status
GAM	Generalised Additive Model
GAMM	Generalised Additive Mixed Model
HPDI	Highest Posterior Density Intervals
IAMMWG	Inter-Agency Marine Mammal Working Group
ICES	International Council for the Exploration of the Sea
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
MMMP	Marine Mammal Monitoring Plan
MPA	Marine Protected Area
MU	Management Unit
NERC	Natural Environment Research Council
NPC	Natural Power Consultants
PAM	Passive Acoustic Monitoring
SAC	Special Area of Conservation
SCANS	Small Cetacean Abundance and density in the North Sea
SCOS	Special Committee on Seals

Acronyms	
Acronym	**Expanded Term**
SEERAD	Scottish Executive Environment and Rural Affairs Department
SM2M	Brand name for the Song Meter SM2M Ultrasonic autonomous submersible marine recorder provides researchers the ability to record and monitor anthropogenic and biological acoustics from 2Hz up to the ultrasonic frequency of 192kHz.
SMRU	Sea Mammal Research Unit
SNH	Scottish Natural Heritage
TPOD	Timed Porpoise Detector; Brand name for passive acoustic monitoring instruments which ceased production in 2008 and was superseded by the CPOD.
UK BAP	UK Biodiversity Action Plan

1 Introduction

The proposed Moray West Offshore Wind Farm Site is located approximately 22 km from the Caithness coastline in the outer Moray Firth. The Moray West Site will comprise of a maximum of 85 wind turbine generators in an area of approximately 225 km^2. The export cable landfall will be located between Sandend Bay and Pedhythe Point on the Moray/Aberdeenshire coastline.

The purpose of this document is to provide a characterisation of the baseline environment to understand the range of species, and the abundance and density of marine mammals that could potentially be impacted by the Moray West development. This document firstly outlines the legislation, policy and guidance that is relevant to the assessment of the potential impacts on marine mammals, then provides a detailed characterisation of the marine mammal species present in the area, presenting information from multiple data sources and providing abundance and density estimates that will be taken forward for the impact assessment for each species.

2 Legislation, Policy and Guidance

This section outlines the legislation, policy and guidance that is relevant to the assessment of the potential impacts on marine mammals associated with the construction, operation and decommissioning of the Project. In addition, other national, regional and local policies are considered within this assessment where they are deemed to be relevant.

2.1 Habitats Directive

All cetaceans in Northern European waters are listed under Annex IV of the EU Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive) as European protected species (EPS) of community interest and in need of strict protection. The harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), harbour seal[1] (*Phoca vitulina*) and grey seal (*Halichoerus grypus*) have protection under Annex II as species of Community interest whose conservation requires the designation of Special Areas of Conservation (SACs).

In Scotland, the Habitats Directive is transposed through the Conservation of Habitats and Species Regulations 2010 (in relation to reserved matters) and the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended). These are referred to as the 'Habitats Regulations', which implement the Habitats Directive within Scottish territorial waters out to 12nm. The Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007 (as amended; referred to as the 'Offshore Marine Regulations') transpose the provisions of the Habitats Directive in offshore waters, beyond 12 nautical miles. The Habitat Regulations provide protection for designated sites, known as Natura 2000 sites which include SACs.

The closest bottlenose dolphin SAC to the Moray West site is the Moray Firth SAC, the boundary of which is 17 km from the array site, however, it should be noted that the SAC population range extends east beyond the boundary of the SAC along the outer Moray Firth and south to the Firth of Forth, with approximately 50% of the population using the SAC in any given year (Cheney *et al*. 2013). This SAC is described as containing the only known resident population of bottlenose dolphins in the North Sea, with dolphins present year round and ranging widely in the Moray Firth.

The closest harbour seal SAC to the Moray West site is the Dornoch Firth and Morrich More SAC, the boundary of which is 46 km from the array site (Figure 2-1). This SAC lists harbour seals as the primary reason for site selection and is described as being the most northerly large estuary in Britain, containing a significant proportion of the inner Moray Firth population of harbour seals. The seals use the sand banks and shores at the mouth of the estuary to haul-out and breed.

[1] Otherwise referred to as the common seal.

The closest grey seal SAC to the Moray West site is the Faray and Holm of Faray SAC in north Orkney which is approximately 112 km from the array site (Figure 2-1) and located within the North Coast & Orkney seal Management Unit (MU). This SAC lists grey seals as the primary reason for site selection and is described as two uninhabited islands in the north of Orkney where there is a well-established breeding colony of grey seals.

The only Scottish harbour porpoise SAC is the proposed Inner Hebrides and the Minches candidate Special Area of Conservation (cSAC), the northern-most boundary of which is located approximately 210 km from the array site. There is also a cSAC for harbour porpoise in the Southern North Sea, the northern-most boundary of which is approximately 368 km from the array site.

2.2 The Habitats Regulations

The Habitats Regulations and the Offshore Marine Regulations implement certain requirements of the European Habitats Directive. The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) outlines the following offences:

Regulation 39 (1) makes it an offence to

(a) deliberately or recklessly to capture, injure, or kill a wild animal of a European protected species;

(b) deliberately or recklessly

> (i) to harass a wild animal or group of wild animals of a European protected species;
>
> (ii) to disturb such an animal while it is occupying a structure or place which it uses for shelter or protection;
>
> (iii) to disturb such an animal while it is rearing or otherwise caring for its young;
>
> (iv) to obstruct access to a breeding site or resting place of such an animal, or otherwise to deny the animal use of the breeding site or resting place;
>
> (v) to disturb such an animal in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species to which it belongs;
>
> (vi) to disturb such an animal in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young; or
>
> (vii) to disturb such an animal while it is migrating or hibernating. Due to the differing lifestyles of cetaceans and the small amount we know about them, the law gives them further protection through an additional disturbance offence.

Regulation 39(2) provides that it is an offence to deliberately or recklessly disturb any dolphin, porpoise or whale (cetacean).

2.3 European Protected Species

If the risk of injury or significant disturbance cannot be reduced to negligible levels with mitigation, then an EPS licence is required. In Scotland, EPS licencing is managed by Marine Scotland. The Scottish Government and Scottish Natural Heritage (SNH) have provided guidance on definitions and rationale for interpretation of the deliberate and reckless disturbance offences (Marine Scotland 2014b). Licenses are granted if 1) the reason for the license relates to one of the specified purposes listed in Regulation 44(2) of the Habitats Regulations (as amended), which includes renewable energy purposes, 2) there is no satisfactory alternative way to reduce injury or disturbance risk and 3) the action authorised must not be detrimental to the maintenance of the population of the species concerned at a Favourable Conservation Status (FCS) in their natural range (Regulation 44(3)(b)).

The guidance provided by Marine Scotland (2014b) states that: *Due to the complexities of interactions between activities, species and local circumstances, it is impractical for this guidance to consider every permutation and state where an offence is or is not likely to occur. It is for the Courts to assess whether an offence has been committed as a result of an activity*. The guidance recommends that other sources of information on disturbance should be consulted to understand what type of disturbance might constitute an offence (including the European Commission Guidance document on the strict protection of animal species of Community interest under the Habitats Directive 92/43/EEC[2] and the Scottish Marine Wildlife Watching Code[3]). When assessing what causes a disturbance, the European Commission Guidance states that: *different species will have different sensitivities or reactions to the same type of disturbance which has to be taken into account in any meaningful protection system. Factors causing disturbance for one species might not create disturbance for another. Also, the sensitivity of a single species might be different depending on the season or on certain periods in its lifecycle*. The Habitats Directive states that periods of rearing, breeding, hibernation and migration are particularly sensitive periods in the context of disturbance. When considering disturbance, the rarity of the species should also be taken into account, where disturbance of species that are declining in number is likely to be more harmful than disturbance of species that are increasing in number. The Habitats Directive specified disturbance as likely "*to significantly affect the local distribution or abundance of the species to which it belongs*". The European Commission Guidance suggests that a significant effect would be more than a transient effect, but does not necessarily mean it has to be a permanent effect.

2.4 Bonn Convention

The Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention) requires members to conserve migratory species and their habitats by providing strict protection for endangered migratory species (Appendix I of the Convention), and lists migratory species which would benefit from multilateral Agreements for conservation and management (Appendix II). There are 16 cetacean species listed under Appendix I of the Bonn Convention.

The UK ratified the Convention in 1985. The legal requirement for the strict protection of Appendix I species is provided by the Wildlife & Countryside Act 1981 (as amended). The UK has entered into legally binding Agreements under the Convention, including the Agreement on the Conservation of Small Cetaceans in the Baltic, North-East Atlantic, Irish and North Seas (ASCOBANS).

2.5 ASCOBANS

Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) came into force in 1994. The aim of the Agreement is for member parties to co-operate to achieve and maintain a FCS for small cetaceans. ASCOBANS is applied in all UK waters in accordance with existing statutory protection for cetacean species.

2.6 Berne Convention

The Convention on the Conservation of European Wildlife and Natural Habitats (the Berne Convention) aims to ensure conservation and protection of wild plant and animal species and their natural habitats (listed in Appendices I and II of the Convention). There are 19 species of cetacean listed under Annex II of the Berne Convention (strictly protected fauna), including harbour porpoise, bottlenose dolphins, common dolphins (*Delphinus delphis*), Risso's dolphins (*Grampus griseus*), white-beaked dolphins (*Lagenorhynchus albirostris*) and minke whales (*Balaenoptera acutorostrata*). All other cetacean species as well as both grey and harbour seals are listed under Annex III of the Berne Convention (protected

[2] http://ec.europa.eu/environment/nature/conservation/species/guidance/pdf/guidance_en.pdf
[3] https://www.nature.scot/scottish-marine-wildlife-watching-code-smwwc-part-1

fauna). The obligations of the Convention is transposed into national law by means of the Wildlife and Countryside Act 1981 (as amended).

2.7 UK Biodiversity Action Plan and the UK Post-2010 Biodiversity Framework (2012)

The UK Biodiversity Action Plan (UK BAP) was published in 1994 as a response to the 1992 Rio de Janeiro Convention on Biological Diversity. The UK BAP identified biological resources in the UK and planned for their conservation. This was succeeded by the UK Post-2010 Biodiversity Framework (July 2012) in response to the Convention on Biological Diversity's Strategic Plan for Biodiversity 2011-2020 (published in 2010) and the EU Biodiversity Strategy (published in 2011). The UK Post-2010 Biodiversity Framework describes how the UK can meet the Aichi Biodiversity Targets. The UK BAP identified priority species that are the most threatened and require conservation. These UK BAP priority species include the cetacean and seal species present in UK waters. This list of priority species is still used to inform statutory lists of priority species in the UK.

2.8 Scottish Biodiversity List

The Scottish Biodiversity List contains a list of animals that Scottish Ministers consider to be of principal importance for Scottish biodiversity conservation. The species included on this list were informed by the UK BAP as required under Section 2(4) of the Nature Conservation (Scotland) Act 2004. The Scottish Biodiversity List includes the various marine mammal species present in Scottish waters, but identifies certain marine mammal species for which conservation action is needed. These marine mammal species requiring conservation action include: common, Risso's, white-beaked and bottlenose dolphins, minke whales, killer whales (*Orcinus orca)*, harbour porpoise and both species of seal.

2.9 Marine (Scotland) Act, 2010

The Marine (Scotland) Act came into force in March 2010. It introduced a duty to protect and enhance the marine environment and includes measures to help boost economic investment and growth in areas such as marine renewables.

As part of the Marine (Scotland) Act (2010), the Scottish Marine Protected Area (MPA) Project has put forward a proposal for a Southern Trench Marine Protected Area (MPA) in the southern outer Moray Firth, located around the Southern Trench which is a deep (~200 m) valley that is approximately 10 km off the coast of the southern outer Moray Firth between Banff and Fraserburgh. Minke whales are listed as a protected feature for this MPA. The Moray West export cable corridor and landfall area overlaps with the Southern Trench MPA (Figure 2-1).

The Act also contains specific protection for Scottish seal populations. Under the provisions of section 117 of the Marine (Scotland) Act (2010), Marine Scotland, in consultation with the Sea Mammal Research Unit (SMRU), produced a list of specific seal haul-out sites for additional protection from intentional or reckless harassment. In June 2014, a total of 194 haul-out sites were designated under The Protection of Seals (Designation of Haul-Out Sites) (Scotland) Order 2014. At these designated seal haul-out sites it is an offense to harass seals, where harassment is defined as "an activity that pesters, torments, troubles or attacks a seal on a designated haul-out site". This includes any action that causes a significant proportion of seals on a haul-out site to leave that site either more than once or repeatedly or, in the worst cases, to abandon it permanently (Marine Scotland 2014a).

2.9.1 Scottish Priority Marine Features

SNH, JNCC and Marine Scotland have developed a priority list of marine species in Scottish waters in order to help Scotland deliver marine nature conservation targets as outlined in the Marine Nature Conservation Strategy. This list of Priority Marine Features was adopted by the Cabinet Secretary in 2014. The list aims to focus future conservation action and marine planning, identify areas of research needed and promote

an approach to marine nature conservation advice. The Priority Marine Features include the cetacean and seal species present in Scottish waters.

2.10 UK Marine Policy Statement

Within the UK, there has been a UK wide Marine Policy Statement in place since 2011 (HM Government, 2011). This policy statement contributes to the achievement of sustainable development in the marine area and sets out the framework for preparing marine plans and taking decisions affecting the marine environment. Each of the UK countries has then produced a Marine Plan in accordance with UK policies.

2.11 Scotland's National Marine Plan

A National Marine Plan was put in place by MS-LOT in 2015, under the Marine (Scotland) Act 2010. This sets up a system for which marine planning and policy in Scotland is set. The plan covers the management of both Scottish inshore waters (out to 12 nm) and offshore waters (12 to 200 nm). The Plan sets out the strategic policies for which management decisions will be made across the main marine sectors including offshore wind and marine renewable energy. Local policies are then set out within Regional Marine Plans. As the Regional Marine Plans are not yet in place, the National Marine Plan is implemented. A set of General Planning Policies are set, along with Sectoral Policies for specific marine sectors. In addition, the National Marine Plan set out the regional policies that should be considered within the Regional Marine Plans.

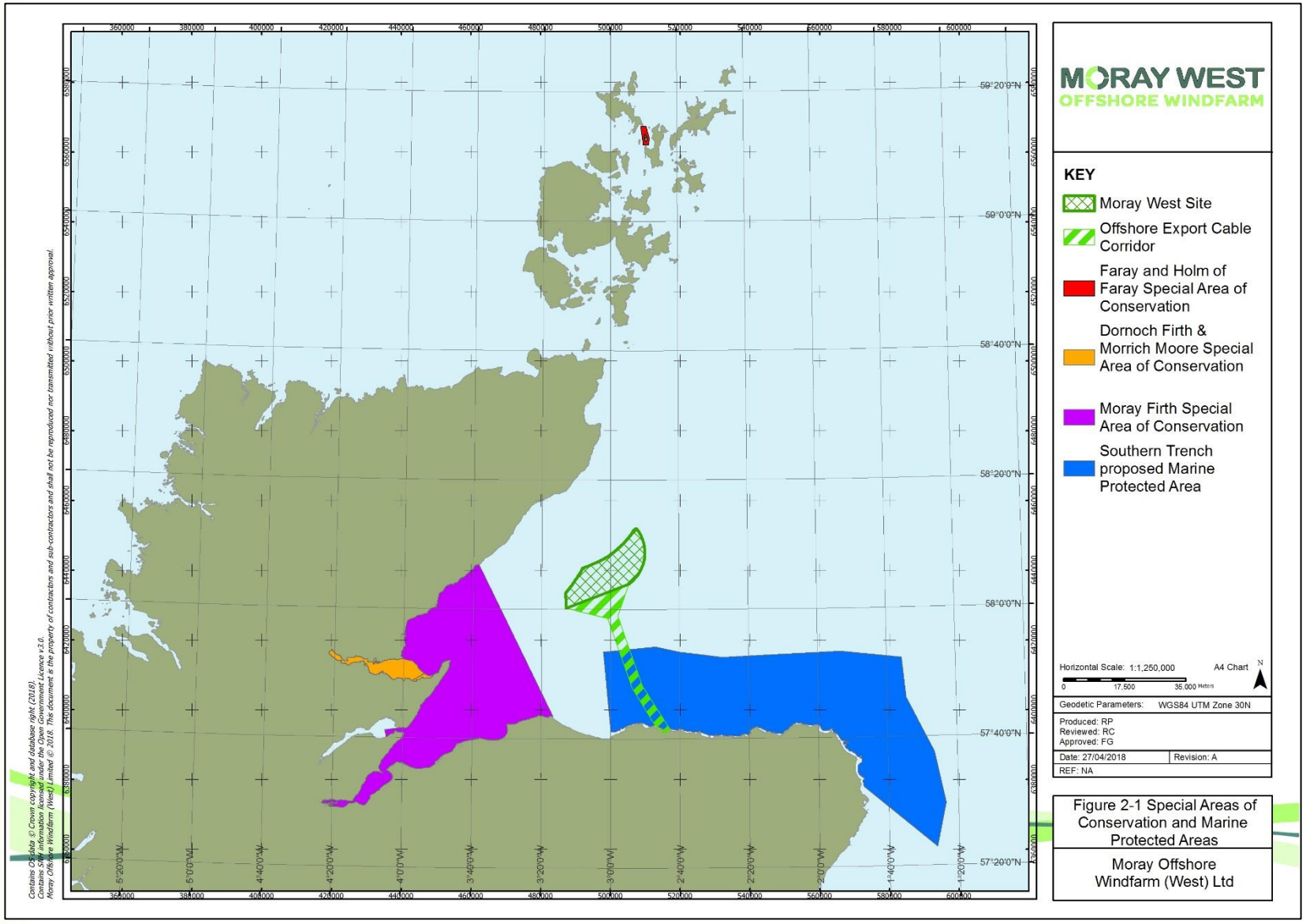

Figure 2-1: Closest relevant SACs and proposed MPAs with marine mammal features to the Moray Firth.

3 Baseline Characterisation Approach

Characterisation of the baseline environment was undertaken to understand the spatial and temporal diversity, abundance and density of marine mammals that could potentially be impacted by the Moray West development. Information for the marine mammal baseline characterisation is taken largely from the Moray East ES (2012), complemented with additional data that has been collected since its production which was compiled through a combination of a literature review and site-specific surveys. This section of the report summarises the key data sources examined to establish the baseline.

3.1 Study Area and Data Sources

The study area considered for marine mammals is the entire Moray Firth.

3.1.1 Small Cetaceans in the European Atlantic and North Sea (SCANS) Surveys

The main objective of the SCANS surveys was to estimate small cetacean abundance and density in the North Sea and European Atlantic continental shelf waters. The SCANS I surveys were completed in 1994, SCANS II in July 2005 and SCANS III in July 2016 and all comprised of a combination of vessel and aerial surveys. Both aerial and boat-based survey methodologies were designed to correct for availability and detection bias and allow the estimation of absolute abundance. The aerial surveys involved a single aircraft method using circle-backs (or race-track) methods (Hammond *et al*. 2006) whereas the boat-based surveys involved a double platform 'primary' and 'secondary' tracker methodology. The Moray West Site is located with the SCANS I and II survey area J. The 1994 aerial surveys within survey area J covered a total transect length of 684 km and an area of 31,059 km^2 (Hammond *et al*. 2002). The 2005 aerial surveys within survey area J covered a total transect line length of 1,600 km and an area of 37,477 km^2 (Burt *et al*. 2006b).

The Moray West Site is located in SCANS III survey block S which was surveyed by aircraft covering a total surface area of 40,383 km^2 of which, 1,370.9 km was surveyed as the primary search effort (Hammond *et al*. 2017). It is important to note the change in the survey blocks used in SCANS III as shown in Figure 3-1. Therefore, block wide abundance and density information will not be directly comparable between the two surveys.

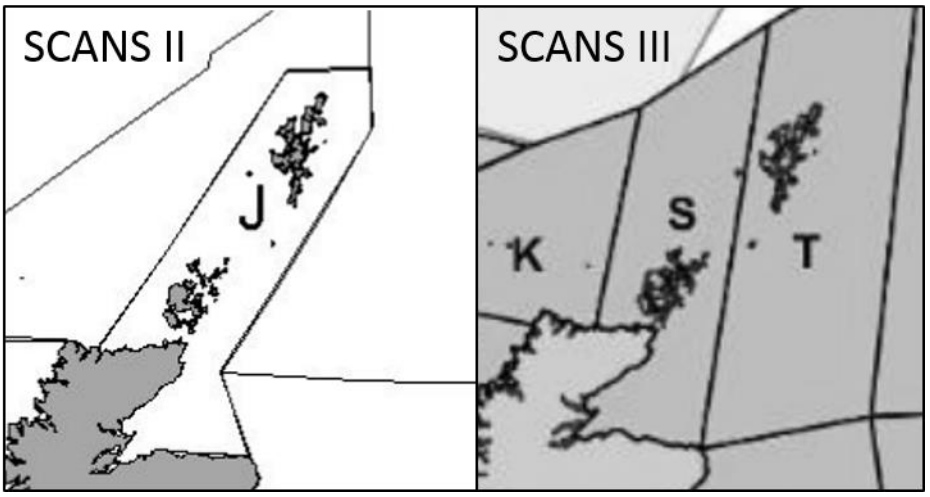

Figure 3-1: SCANS II and SCANS III survey blocks (Hammond *et al*. 2017). Moray West is within SCANS II block J and SCANS III block S.

While the SCANS surveys provide sightings, density and abundance estimates at a wide spatial scale, the surveys are conducted during a single month, every 11 years and therefore do not provide any fine scale temporal or spatial information on species abundance and distribution.

3.1.2 Joint Cetacean Protocol (JCP) Phase III Analysis

The JCP Phase III analysis included datasets from 38 sources, totalling over 1.05 million km of survey effort between 1994 and 2010 from a variety of platforms (Paxton *et al*. 2016). The JCP Phase III analysis was conducted to combine these data sources to estimate spatial and temporal patterns of abundance for seven species of cetaceans: harbour porpoise, minke whale, bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, white-beaked dolphin and Atlantic white-sided dolphin (*Lagenorhynchus acutus*). Density surface models were used to predict species density over a fine scale grid of 25 km^2 resolution for one day in each season in each survey year. The data are divided into regions for which seasonal estimates of abundance are presented for winter (January-March), spring (April-June), summer (July-September) and autumn (October-December). The Moray Firth is included in the analysis as an area of commercial interest for which abundance estimates are presented. R code[4] has been provided by JNCC to extract abundance estimates averaged for summer 2007-2010 and scaled to the SCANS III estimates.

3.1.3 JNCC Report 544: Harbour Porpoise Density

Heinänen and Skov (2015) conducted a detailed analysis of 18 years of survey data on harbour porpoise around the UK between 1994 and 2011 held in the JCP database. The goal of this analysis was to try to identify "*discrete and persistent areas of high density*" that might be considered important for harbour porpoise with the ultimate goal of determining SACs for the species. The approach involved constructing predictive models using corrected sightings rates analysed with respect to topographic, hydrodynamic and anthropogenic covariates and then generating predicted distribution maps of density estimates for the waters around the UK. The analysis grouped data into three subsets: 1994-1999, 2000-2005 and 2006-2011 to account for patchy survey effort and analysed summer (April-September) and winter (October-March) data separately to explore whether distribution patterns were different between seasons. The authors note that "*due to the uneven survey effort over the modelled period, the uncertainty in modelled distributions vary to a large extent*." It is worth highlighting that the analysis presented in Heinänen and Skov (2015) relies on extensive extrapolation of survey data over space and time. Any such extrapolation is sensitive to the covariates used in models, and makes the assumption that these relationships hold outside of the surveyed areas. Subjective decisions in the retention of covariates in Heinänen and Skov (2015) could limit the wider validity of such extrapolation. The survey effort on which the analysis is based was particularly patchy in the south-east Moray Firth which may limit the degree of confidence for any predictions in this area.

3.1.4 Special Committee on Seals (SCOS)

Under the Conservation of Seals Act 1970 and the Marine (Scotland) Act 2010, the Natural Environment Research Council (NERC) provides scientific advice to government on matters related to the management of seal populations through the advice provided by the SCOS. The SMRU provides this advice to SCOS on an annual basis through meetings and an annual report. The report includes advice on matters related to the management of seal populations, including general information on British seals, information on their current status and addresses specific questions raised by regulators and stakeholders. The most recent publicly available SCOS report is SCOS (2017) which presents the data collected up to 2016.

3.1.5 Designated Haul-Out Sites

Under Section 117 of the Marine (Scotland) Act 2010, specific seal haul-out sites have been designated to provide protection for seals from intentional or reckless harassment. A total of 194 haul-outs sites were designated based on the SMRU annual August survey counts in preceding years in 2014 through The Protection of Seals (Designation of Haul-Out Sites) (Scotland) Order 2014. This came into force on 30 September 2014. This was then revised in 2017 to include one additional haul-out site through The

[4] R is a free software environment for statistical computing and graphics (https://www.r-project.org/).

Protection of Seals (Designation of Haul-Out Sites) (Scotland) Amendment Order 2017. There are seven harbour seal designated haul-out sites in the Moray Firth MU that were designated based on August survey counts, which range from 29 to 78 km from the Moray West Site (Table 3-1, Figure 3-2). There are also three grey seal designated haul-out sites in the Moray Firth MU that were designated based on the presence of grey seal breeding colonies, which range from 21 to 46 km from the Moray West Site (Table 3-2, Figure 3-2).

Table 3-1: Harbour seal designated haul-out sites in the Moray Firth MU. Distance to Moray West Site is the shortest straight line distance to either the wind farm site or the export cable route.

Site ID	Site Name	Site Location	Site Details	Distance to Moray West Site
MF-001	Ardersier	West of Nairn	Intertidal sandbanks west of Whiteness Head and north of Kirkton within the MoD Danger Area.	65 km
MF-002	Beauly	Beauly Firth	Intertidal sandbanks in the Beauly Firth.	70 km
MF-003	Findhorn	Findhorn, West of Elgin	Intertidal sandbanks at the mouth of the River Findhorn but outside Findhorn Bay itself.	44 km
MF-004	Loch Fleet	Loch Fleet	Intertidal sandbanks in Loch Fleet.	48.5 km
MF-005	Cromarty Firth	Cromarty Firth	Intertidal sandbanks and mudbanks and rocky coastline between Shoreton and the A9 Bridge on the south shore and between Ardullie Lodge and Drummond on the north shore and between these two.	78 km
MF-006	Brora	Brora, North East of Loch Fleet	Intertidal sandbanks and rocky coastline between Brora and Strathsteven.	37.5 km
MF-007	Lothmore	Between Helmsdale and Brora	Intertidal sandbanks and rocky coastline between Sron Rubha na Gaoithe and Kilmore.	29 km

Table 3-2: Grey seal designated haul-out sites in the Moray Firth MU. Distance to Moray West Site is the shortest straight line distance to either the wind farm site or the export cable route.

Site ID	Site Name	Site Location	Site Details	Distance to Moray West Site
BC-040	Dunbeath-Helmsdale	South West of Wick	Two areas of rocky coastline: the first from Dunbeath Castle south to Berriesdale and the second from Berriedale south to Dun Glas, excluding the harbour of Berriedale itself.	21 km
BC-041	Duncansby Head	North of Wick	Rocky coastline between The Knee and Wife Geo and associated rocky outcrops.	46 km
BC-042	Dunbeath-Wick	South West of Wick	Rocky coastline between Skerry Mor and Cleit Mhor and associated rocky outcrops.	22 km

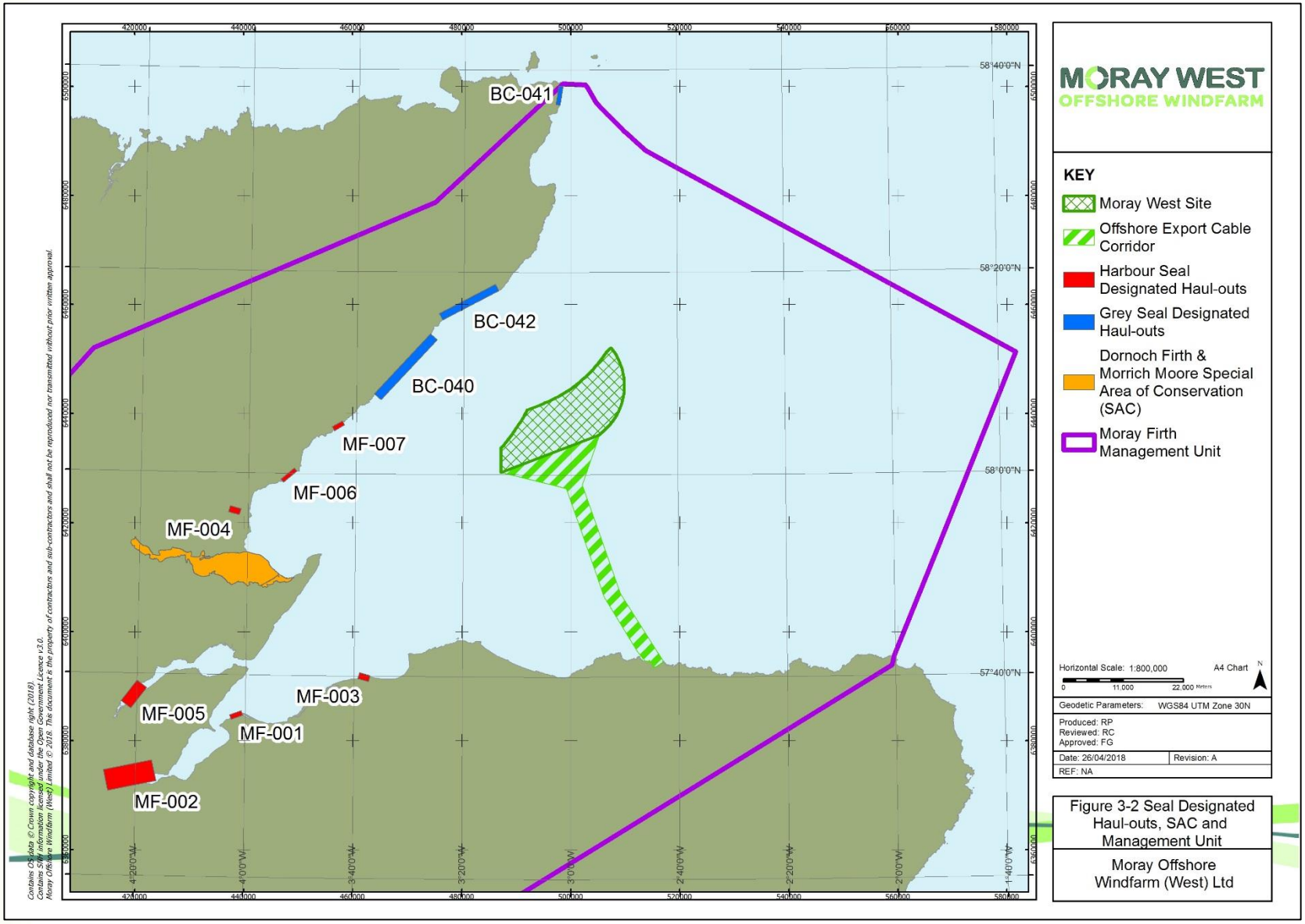

Figure 3-2: Harbour and grey seal designated haul-out sites.

3.1.6 SMRU Seal Haul-Out Surveys

SMRU carries out surveys of harbour and grey seals in Scotland and on the east coast of England to contribute to NERC's statutory obligation under the Conservation of Seals Act 1970 'to provide the (UK government) with scientific advice on matters related to the management of seal populations'. These SMRU surveys are funded by NERC, SNH and Natural England and constitute the routine, statutory monitoring of seal populations around the UK.

3.1.6.1 Harbour Seals

Surveys of harbour seals are carried out during the summer months. The main population surveys are carried out when harbour seals are moulting, during the first three weeks of August, as this is the time of year when the largest numbers of seals are ashore. To maximise the numbers of seals onshore and to reduce the effects of environmental variables on counts, surveys are restricted to within two hours either side of afternoon low tides on days with no rain. Grey seals are also counted on all harbour seal surveys, although these data do not necessarily provide a reliable index of population size. The counts obtained represent the number of seals that were onshore at the time of the survey and are an estimate of the minimum size of the population. They do not represent the total size of the local population since a number of seals would have been at sea at the time of the survey but telemetry data from tagged seals can are used to scale this estimate to take account of the proportion of animals at sea at the time of survey. It is noted that these data refer to the numbers of seals found within the surveyed areas only at the time of the survey; numbers and distribution may differ at other times of the year.

3.1.6.2 Grey Seals

Grey seals aggregate in the autumn to breed at traditional colonies. Their distribution during the breeding season can be very different to their distribution at other times of the year. SMRU's main surveys of grey seals are designed to estimate the numbers of pups born at the main breeding colonies around Scotland. Breeding grey seals are surveyed biennially between mid-September and late November using large-format vertical photography from a fixed-wing aircraft. Over 60 colonies are surveyed between three and seven times, at 10 to 12 day intervals, through the breeding season. Total pup production for each colony is derived from the series of counts obtained. Approximately 40 additional colonies are surveyed less regularly. The main grey seal breeding colonies in Shetland, England, Wales and Northern Ireland are counted by other, local organisations. SNH staff count pups in Shetland in a manner compatible with counts from aerial surveyed colonies.

3.1.7 University of Aberdeen Harbour Seal Pupping Surveys

The University of Aberdeen have been conducting surveys of harbour seals at the Loch Fleet National Nature Reserve since 1988. These data provide information on sex-specific survival rates, fecundity rates, the timing of births and an index of over-winter body condition (Cordes and Thompson 2013, 2014).

As part of the strategic Moray Firth Marine Mammal Monitoring Plan (MMMP), the University of Aberdeen have conducted harbour seal pupping (15th June – 15th July) and moult (1st – 31st August) count surveys at four additional sites (Figure 3-3). Dunrobin, Sputie Burn and Lothmore were counted from June 2014 and Lothbeg from May 2015 (Graham *et al*. 2016). During the pupping season and the moult a minimum of four counts were conducted at each site, and monthly counts were made in the winter months.

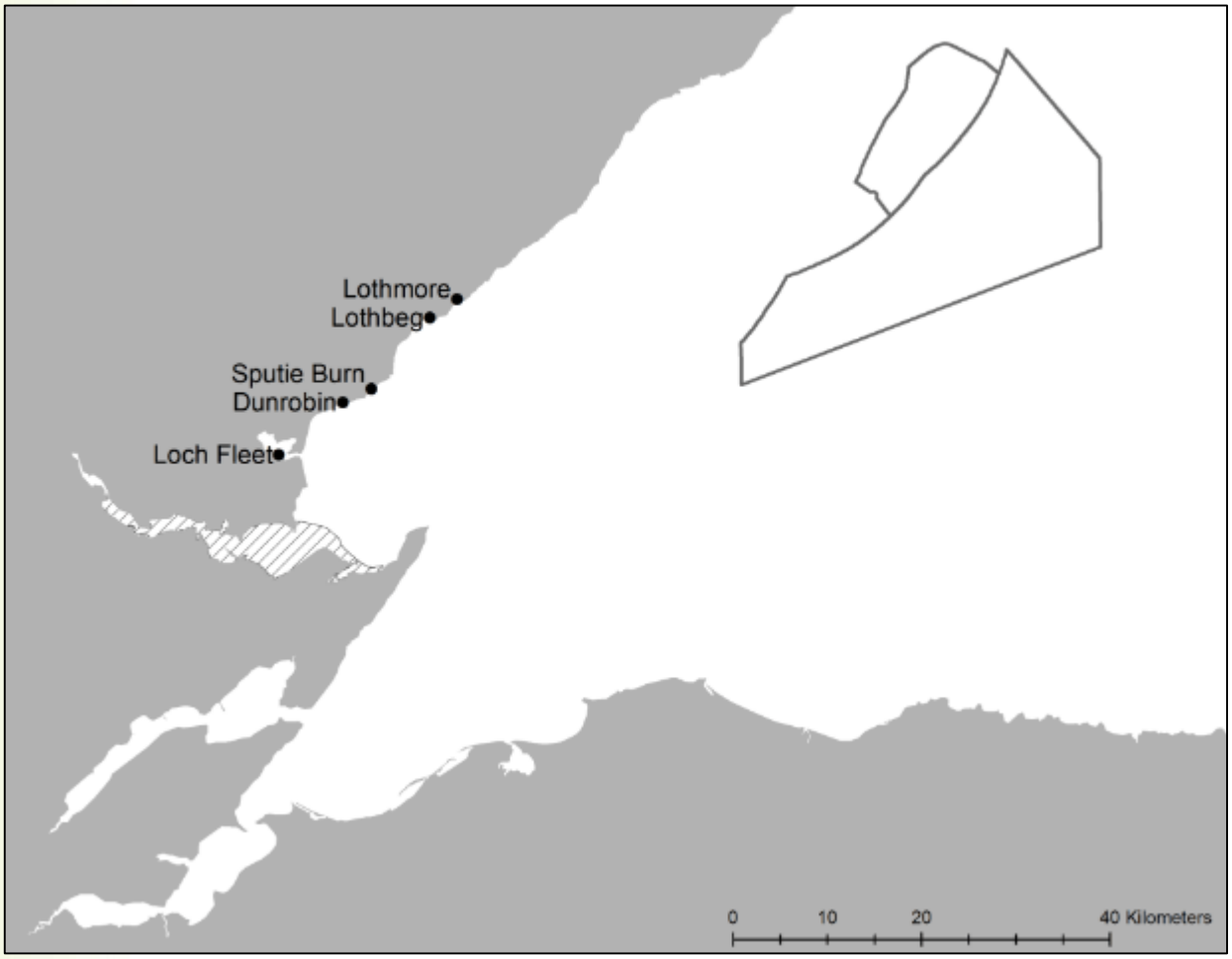

Figure 3-3: Location of the seal pupping survey sites in relation to the Moray West, Moray East and BOWL wind farm sites (Graham *et al*. 2016). The Dornoch Firth and Morrich More SAC is denoted by the hatched area.

3.1.8 Seal Telemetry

SMRU has deployed telemetry tags on grey seals and harbour seals in the UK since 1988 and 2001, respectively. In addition to this, the University of Aberdeen have been tagging harbour seals at the Dornoch Firth and Loch Fleet for various studies between 1989 and 2009 (Thompson *et al*. 1996, Thompson *et al*. 1997, Thompson *et al*. 1998, Sharples *et al*. 2008, Cordes *et al*. 2011). The telemetry tags transmit data on seal locations with the tag duration (number of days) varying between individual deployments. Telemetry data are particularly useful as they provide information on seal movement patterns away from their haul-out sites, provide data on the foraging behaviour of seals at sea and demonstrate connectivity between areas.

There are two types of telemetry tag which differ in their data transmission methods. Data transmission can be through the Argos satellite system (Argos tags) or using the GSM mobile phone network (GPS Phone tags). Both types of transmission result in location fixes, but data from GPS phone tags comprise better quality and more frequent locations by incorporating the Fastloc GPS system (Wildtrack Telemetry Systems, UK) which obtains the GPS location within a fraction of a second and therefore collects data even when the animal surfaces for a short period. Both types of tags use precision wet/dry sensors as well as pressure and temperature sensors to obtain detailed individual dive (max depth, shape, time at depth, etc.) and haul-out records. Data are stored on board the tags and then relayed by a satellite (Argos tags) or by quad-band GSM mobile phone module to SMRU when the animal is within range of the GSM mobile phone network. The data are then stored in databases, cleaned according to methods described in (Russell *et al*. 2011) and processed for analysis.

As part of the Moray Firth strategic MMMP, the University of Aberdeen have conducted additional harbour seal telemetry studies in the Moray Firth. During the pre-construction phase of the BOWL project, SMRU GPS-GSM[5] tags were deployed on 12 harbour seals in September 2014 and on 13 harbour seals in February 2015 in order to obtain data over two seasons. Additional deployments are currently being conducted in 2017 to monitor harbour seal movement in relation to the construction activities at the BOWL site.

3.1.9 State-Space Modelling

The location and activity data obtained from telemetry tags were used in a state-space model to identify travelling and foraging locations (Graham *et al*. 2016). The state-space model was based on that described in Russell *et al*. (2015) where foraging is defined as area-restricted searching behaviour and travelling is defined as faster movement with lower turning angles. In order for a location to be assigned as either a travelling or a foraging location, the probability of that activity state had to be above 0.9 and the state-space model excluded all locations within 1 km of a haul-out site. This state-space modelling was conducted for harbour seals only.

3.1.10 Grey Seal Usage Maps

Russell *et al*. (2017) have produced revised estimated at-sea distribution usage maps for grey seals. The revised maps contain telemetry data from 270 grey seals tagged within the UK only and incorporate count data between 1996 and 2015. The at-sea usage maps represent the number of grey seals estimated to be in the water in each grid cell at any given time.

3.1.11 Visual Surveys in the Moray Firth

3.1.11.1 Bottlenose dolphin photo-ID surveys

The University of Aberdeen have been conducting photo-ID surveys of bottlenose dolphins in the Moray Firth SAC since 1989 in order to estimate population size, fecundity rates and sex specific survival rates. The photos collected during these surveys are quality graded and individual dolphins are identified based on distinct marking on their dorsal fins. These data are then analysed in the program MARK[6] to estimate the population size, fecundity and survival rates.

3.1.11.2 Moray Firth SAC boat based surveys 2004-2005 (Beatrice Demonstrator baseline surveys)

Boat based line transect surveys of the Moray Firth SAC were conducted in 2004 (Aug, Sep & Oct) and 2005 (Apr, May, Jun & July) (Figure 3-4). These surveys were conducted in order to provide a baseline for the Beatrice Demonstrator project. The aim of the surveys was to assess habitat associations of bottlenose dolphins and harbour porpoises and to estimate their relative abundance across the Moray Firth SAC to identify hotspot areas. Observations were recorded by a single visual observer located 3.5m above sea level. The total survey distance was 1,628 km at a survey speed of ~7 knots.

[5] The GPS Phone tag combines GPS quality locations with efficient data transfer using the international GSM (Global System for Mobile communication) mobile phone network (http://www.smru.st-and.ac.uk/Instrumentation/GPSPhoneTag/)

[6] Program MARK is a Windows-based software application for the analysis of data from marked individuals (http://www.phidot.org/software/mark/index.html)

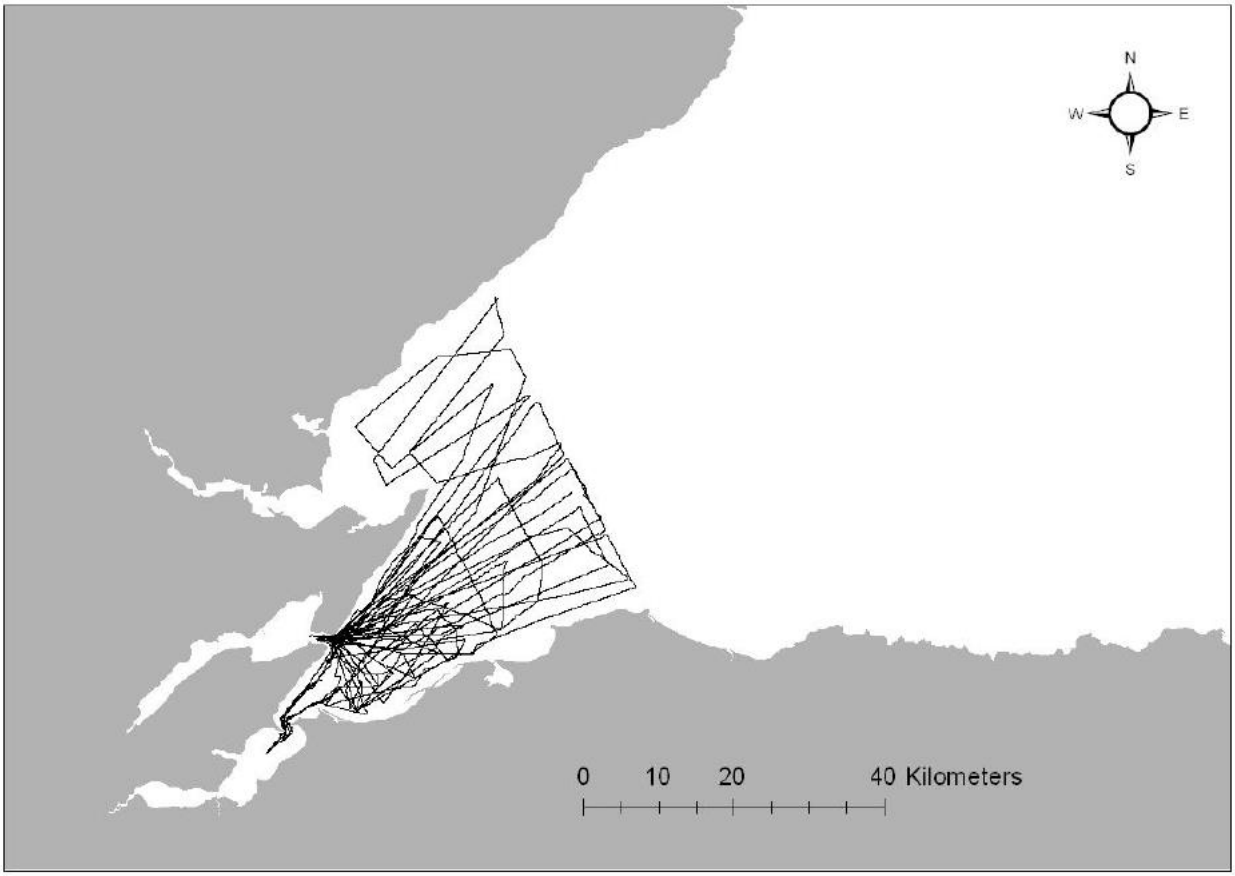

Figure 3-4: Moray Firth SAC boat based survey transect lines surveyed in 2004-2005 (Moray East ES 2012).

3.1.11.3 Outer Moray Firth boat based surveys 2009, Department of Energy & Climate Change (DECC)

Boat based line transect surveys of the outer Moray Firth were conducted in the summer (Jun, Aug, Sep & Oct) of 2009 (Figure 3-5). The total survey distance was 1,671 km surveyed over 14 survey days and was surveyed by two observers, each scanning half of a 180° arc in front of the boat. These surveys were conducted for DECC to support their assessment of proposed oil and gas exploration activities in the Moray Firth, with the aim to determine which species of marine mammals are present in the outer Moray Firth.

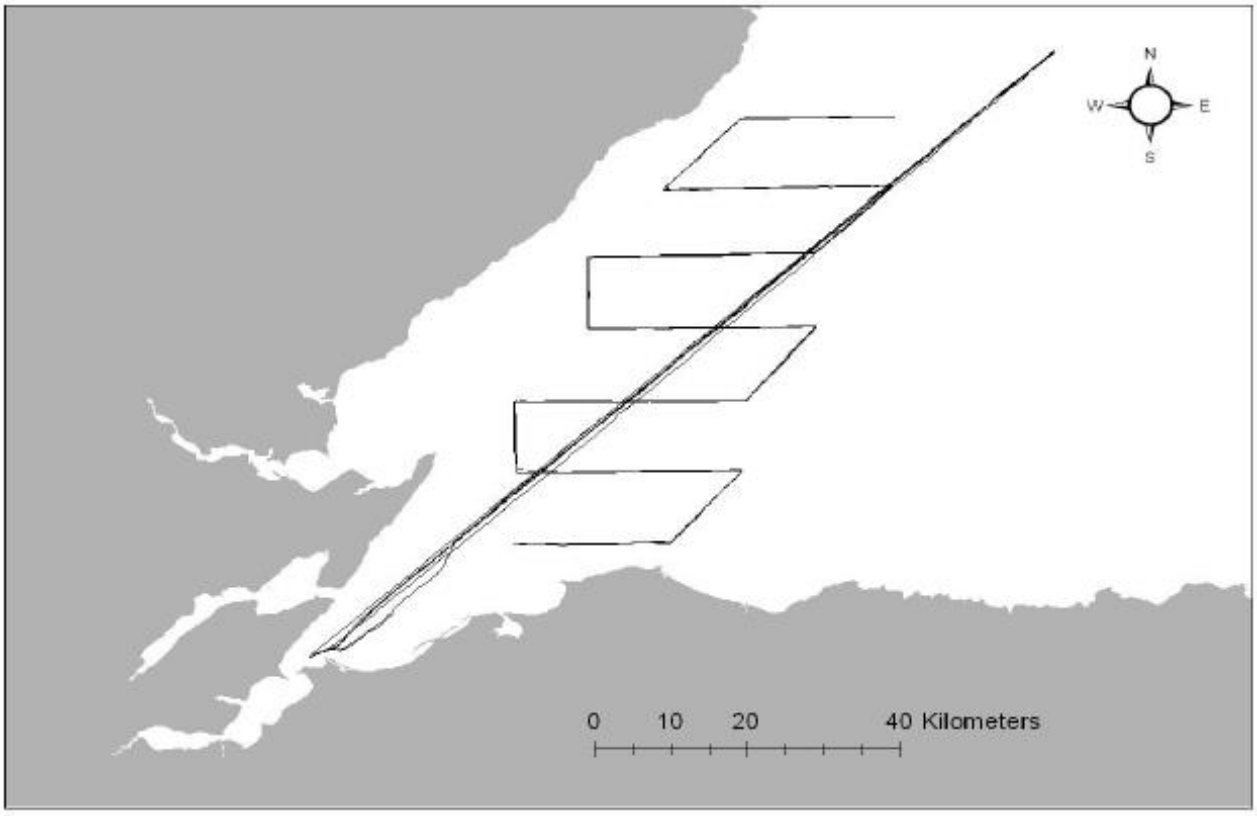

Figure 3-5: Outer Moray Firth boat based survey transect lines surveyed in 2009 (Moray East ES 2012).

3.1.11.4 Aerial transect surveys 2010 (DECC)

In August and September 2010 aerial line transect surveys were conducted in four survey blocks in the Moray Firth: one 25 km^2 survey block covering the BOWL and Moray East development areas, one 25 km^2 survey block in the central Moray Firth and two survey blocks in coastal areas of the Moray Firth (one northern and one southern) (Figure 3-6). A total of five surveys were flown in August 2010 and eight surveys in September 2010. Funded by DECC, the purpose of these surveys was to assess the impacts of seismic activities on the distribution of cetaceans at an impact and control site, before and during a seismic survey in September 2010. It should be noted that the surveys of the BOWL and MORL sites were primarily located in the BOWL and Moray East areas, with very little survey effort in the Moray West wind farm site.

The transect lines flown in the two 25 km survey blocks were spaced at 4 km; these blocks were surveyed a total of nine times between August and September 2010. For the coastal transects the plane flew 1 km offshore parallel to the coast; the north coastal survey block was surveyed six times and the southern coastal survey block was surveyed five times. Observations were conducted by two visual surveyors from the observer bubble windows on each side of the plane while a third observer recorded environmental variables. The data were then analysed using the Distance package to estimate the abundance and density of marine mammals in these survey areas. Full details are presented in the Moray East ES (2012).

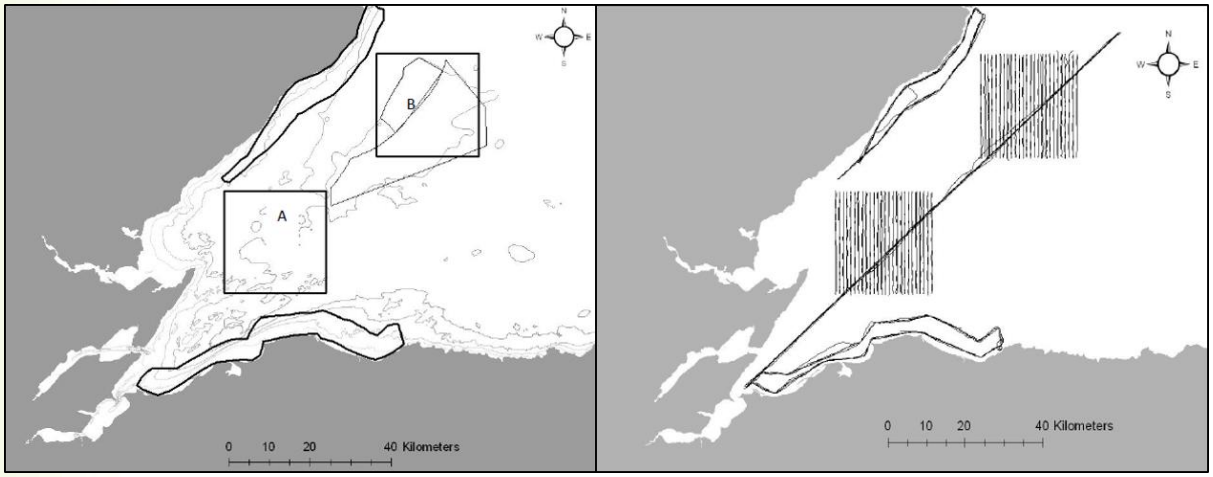

Figure 3-6: Survey blocks in relation to the BOWL and Moray East sites (left) and transect lines flown during the aerial surveys in August and September 2010 (right) (Moray East ES 2012).

3.1.11.5 Moray East site boat based surveys 2010-2012 (Moray East pre-consent)

Between April 2010 and March 2012, 28 boat based line transect surveys of the Moray East wind farm site were conducted (Figure 3-7). These surveys were conducted by Natural Power as part of the two year program of bird and marine mammal surveys to support the Moray East ES. Sightings of marine mammals were recorded by both dedicated marine mammal surveyors and by European Seabirds At Sea (ESAS) bird surveyors. The purpose of these surveys was to obtain fine scale, site specific data on marine mammal distribution and abundance within the proposed Moray East Offshore Wind Farm and a 4km buffer around the site. Part of the 4 km buffer zone was within the Moray West Site, however, these only covered a small part of the Moray West Offshore Wind Farm.

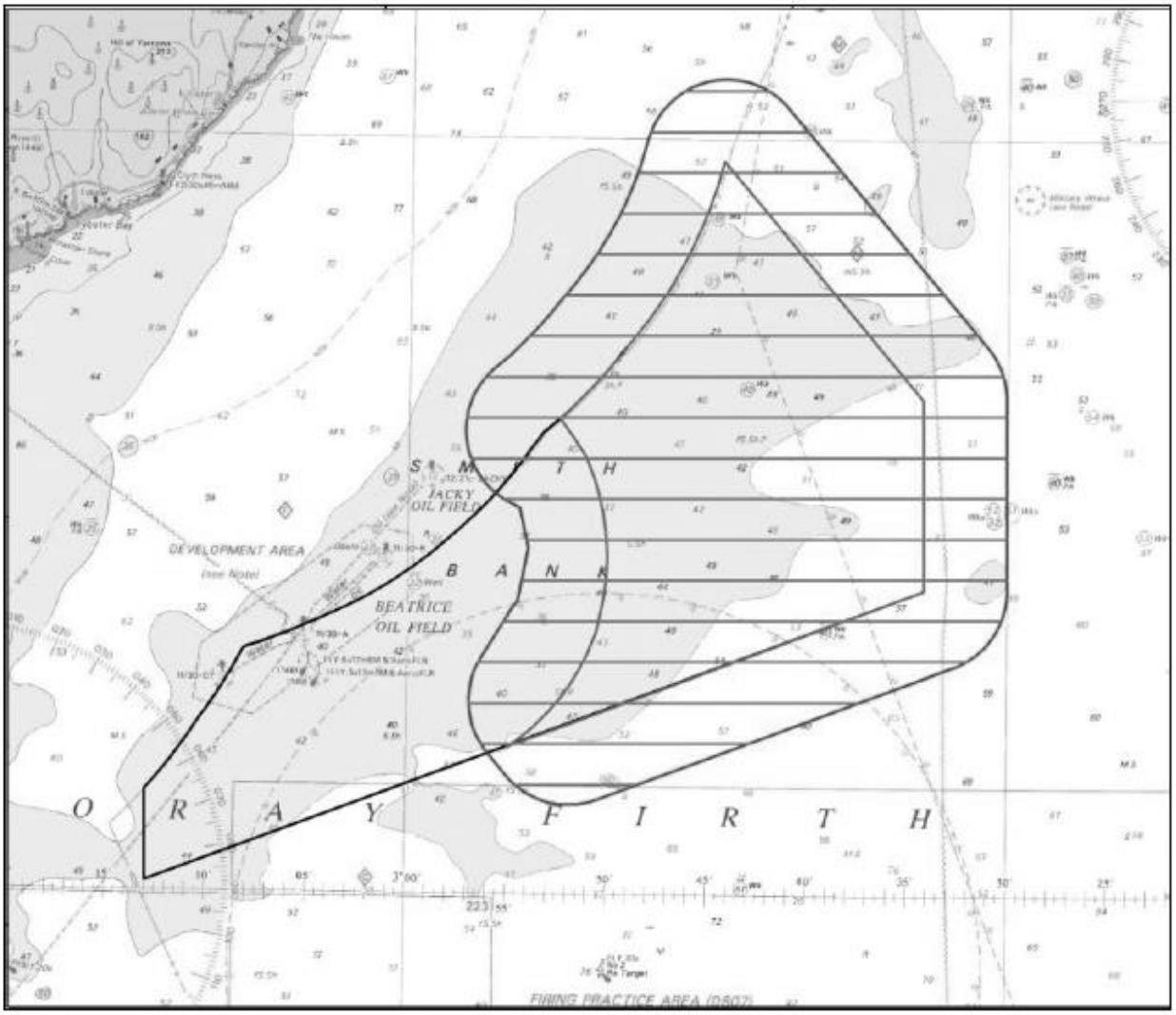

Figure 3-7: Moray East site boat based survey transect lines surveyed in 2010-2012 in relation to the Moray East and West sites (Moray East ES 2012).

3.1.11.6 BOWL site boat based surveys 2010 (BOWL pre-consent)

Between April and September 2010, boat based line transect surveys of the BOWL site were conducted (Figure 3-8) resulting in a total of 14 survey days spread across the six months of surveys. The surveys were conducted as part of a two year monitoring program for birds and marine mammals in order to support the BOWL ES. A total of 1,390 km was surveyed over 14 survey days.

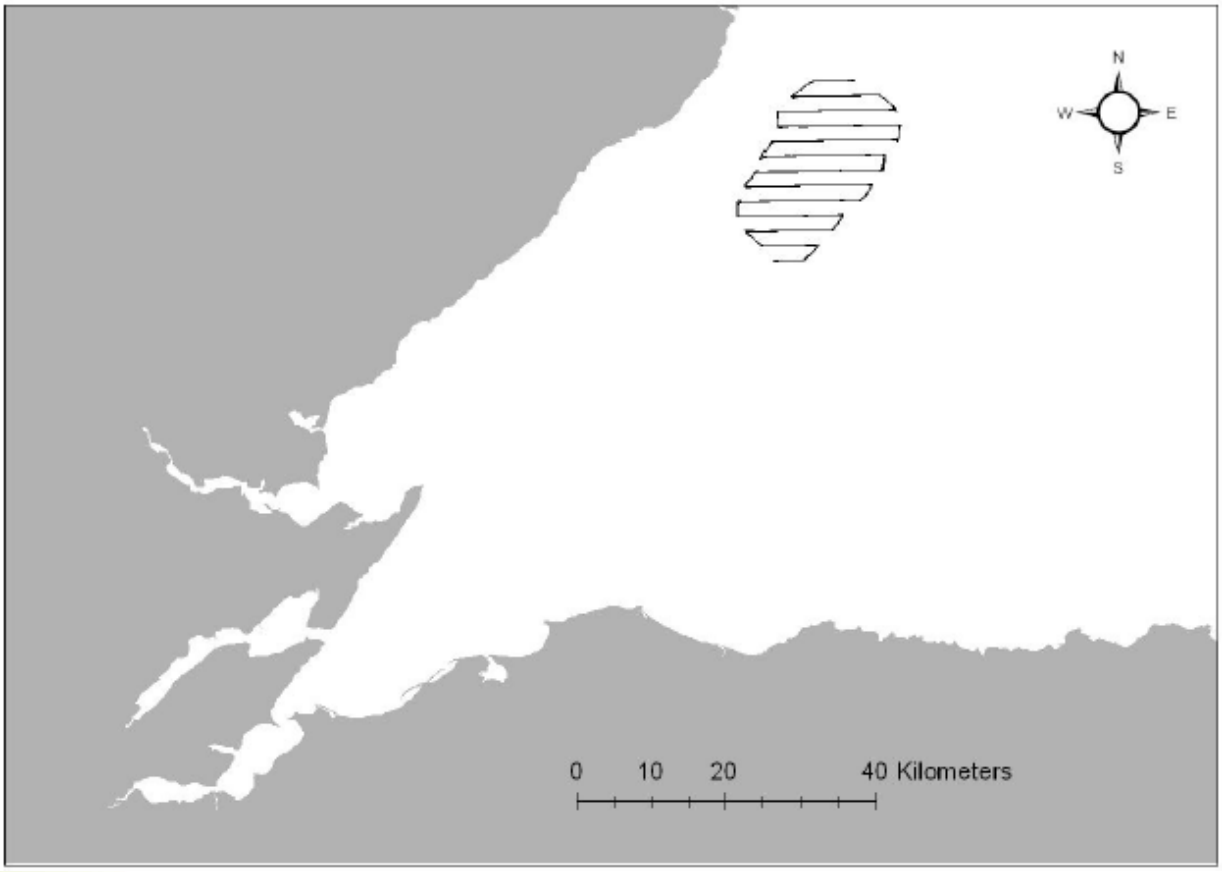

Figure 3-8: BOWL site boat based survey transect lines surveyed in 2010 (Moray East ES 2012).

3.1.11.7 Cetacean Research and Rescue Unit (CRRU) minke whale surveys

The CRRU have been conducting surveys of minke whales along the southern Moray Firth coast since 2000. These surveys are conducted throughout the summer between Lossiemouth and Fraserburgh, following four standardised survey routes that run parallel to the shore providing a total survey area of approximately 860 km^2 (Robinson *et al*. 2009). Between May and October 2001 to 2006 inclusive, a total of 314 survey days were completed, covering a total distance of 12,571.6 km. This survey area includes most of the proposed Southern Trench MPA and data collected by the CRRU were used in the selection of the MPA (SNH 2014).

3.1.11.8 HiDef Aerial Site-Specific Surveys

HiDef conducted monthly aerial surveys of the Moray West Site between April 2016 and March 2017 as part of the baseline pre-construction monitoring. The survey area covered the Moray West Site plus a 4 km buffer with strip transects 2,531 m apart approximately perpendicular to the depth contours along the coast in order to sample over a range of habitats relating to water depth.

Surveys were flown approximately 550 m above sea level and photographs were taken using four HiDef Gen II cameras with a resolution of 2 cm ground sample distance. Each camera surveyed a strip width of 125 m and was separated from the next camera by ~25 m, therefore resulting in a combined sampled width of 500 m within a 575 m overall strip.

The data were viewed by trained reviewers who identified birds and marine mammals for further analysis. Full details of the HiDef quality assurance process and the external QA process can be found in (Webb 2017).

3.1.12 Acoustic Surveys in the Moray Firth

There have been several acoustic surveys conducted in the Moray Firth since 2001 using click detector devices (CPODS and their predecessor TPODS[7]) and sound recorders (EARs[8] and SM2Ms[9]) to determine the presence/absence of vocalizing marine mammals. This type of data collection is called Passive Acoustic Monitoring (PAM) and the resulting data can be used to indicate spatial and temporal patterns in use of an area. Click detectors such as CPODs detect and log the clicks produced by toothed whales, dolphins and porpoise while EARs and SM2Ms record underwater sound which is then run through detection algorithms to extract detections of clicks, whistles and underwater noise.

3.1.12.1 TPOD study 2005-2007 (Beatrice Demonstrator)

Between August and October in 2005, 2006 and 2007 three sites were monitored by passive acoustic monitoring instruments (TPODs) with the aim of validating methods to assess changes in the occurrence of cetaceans in response to offshore wind turbine construction (Figure 3-9). The site at the Sutors of Cromarty was also monitored visually to validate the TPOD detections.

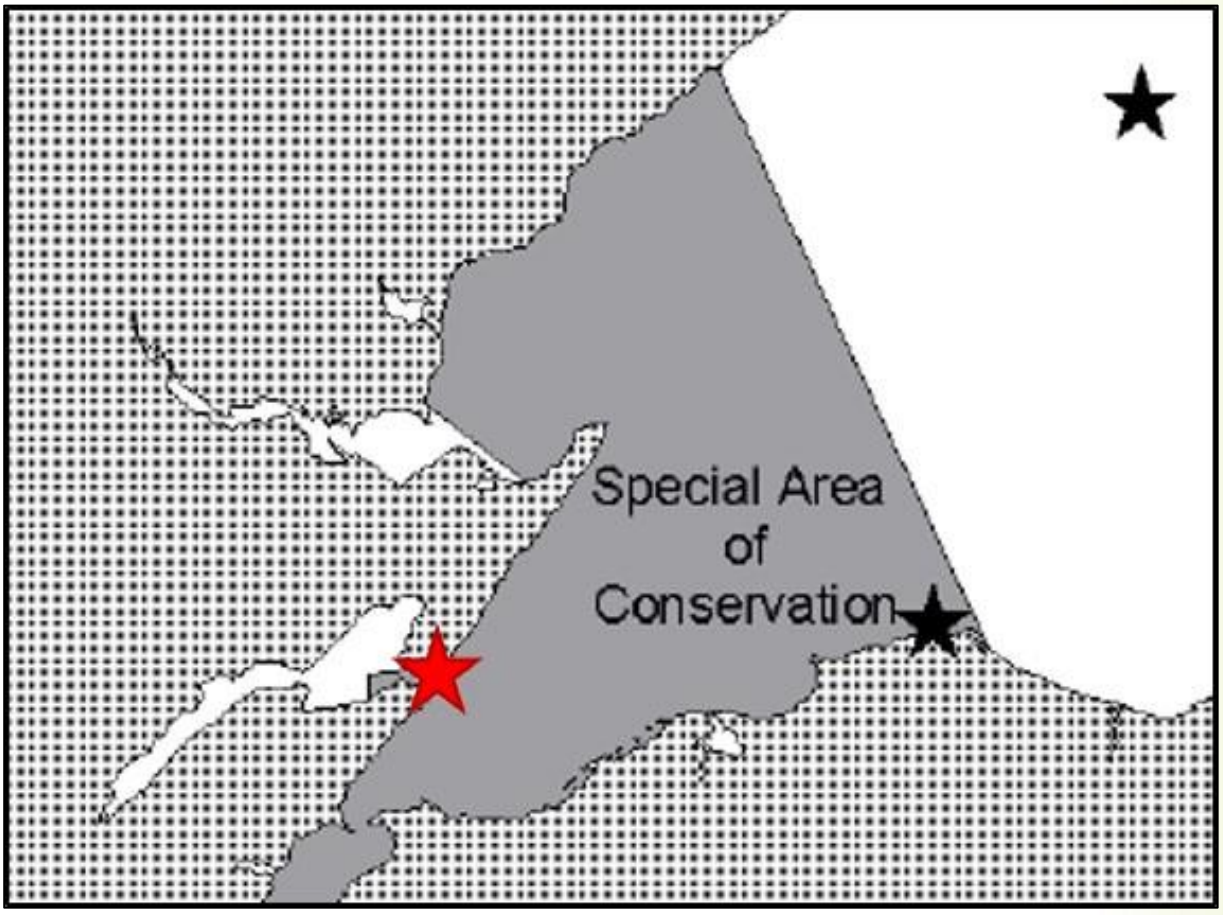

Figure 3-9: Passive Acoustic Monitoring (PAM) sites monitored for the 2005-2007 Beatrice Demonstrator study (Moray East ES 2012). Red star indicates the PAM site at the Sutors of Cromarty.

[7] Cetacean Porpoise Detector (CPOD) and Timing Porpoise detector (TPOD) developed by Chelonia Ltd http://www.chelonia.co.uk
[8] Ecological Acoustic Recorders (EARs) developed by the University of Hawaii and NOAA Fisheries
[9] Song Meter SM2M developed by Wildlife Acoustics www.wildlifeacoustics.com

3.1.12.2 SNH & Scottish Executive Environment and Rural Affairs Department (SEERAD) Passive Acoustic Monitoring (PAM) surveys 2006-2009

Between 2006 and 2009 a study funded by SNH and SEERAD was conducted to assess the distribution and abundance of bottlenose dolphins in Scottish coastal waters (Figure 3-10).

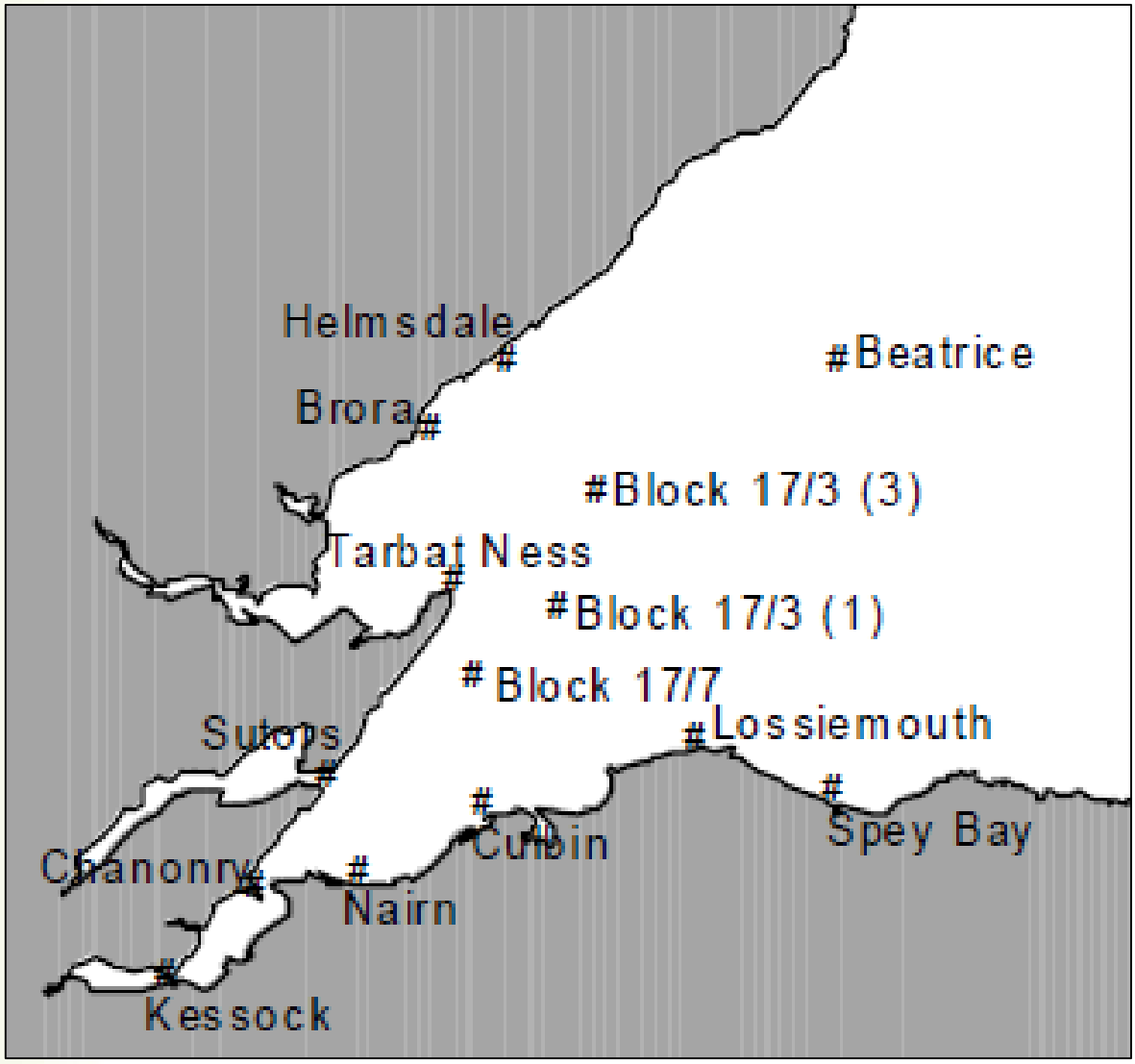

Figure 3-10: PAM sites monitored in the SNH and SEERAD surveys 2006-2009 (Moray East ES 2012).

3.1.12.3 DECC funded CPOD surveys 2009-2010

PAM surveys were conducted using passive acoustic monitoring instruments (CPODS) during 2009 and 2010 as part of a DECC funded study to support the assessment of proposed oil and gas exploration in the Moray Firth. In 2009 the CPODs were deployed between May and November and in 2010 the CPODs were deployed between July and December. The aim of these surveys was to collect data on cetacean distribution in the Moray Firth in relation to the management of oil and gas activities. A total of 64 and 68 CPODS were deployed (Figure 3-11 and Figure 3-12), with 56 and 60 being recovered in 2009 and 2010 respectively. In both years there were CPODs located both within and adjacent to the Moray West wind farm site.

One limitation of CPODs is that they are not able to discriminate between dolphin species. As such, a further study was conducted where six Ecological Acoustic Recorders (EARs) were deployed, five in the MORL or BOWL sites and one in the inner Moray Firth at the Sutors of Cromarty. A whistle classifier was developed by Booth *et al*. (2011) and used on the EAR recordings to discriminate between dolphin species in order to investigate which dolphin species were being recorded at the MORL and BOWL sites.

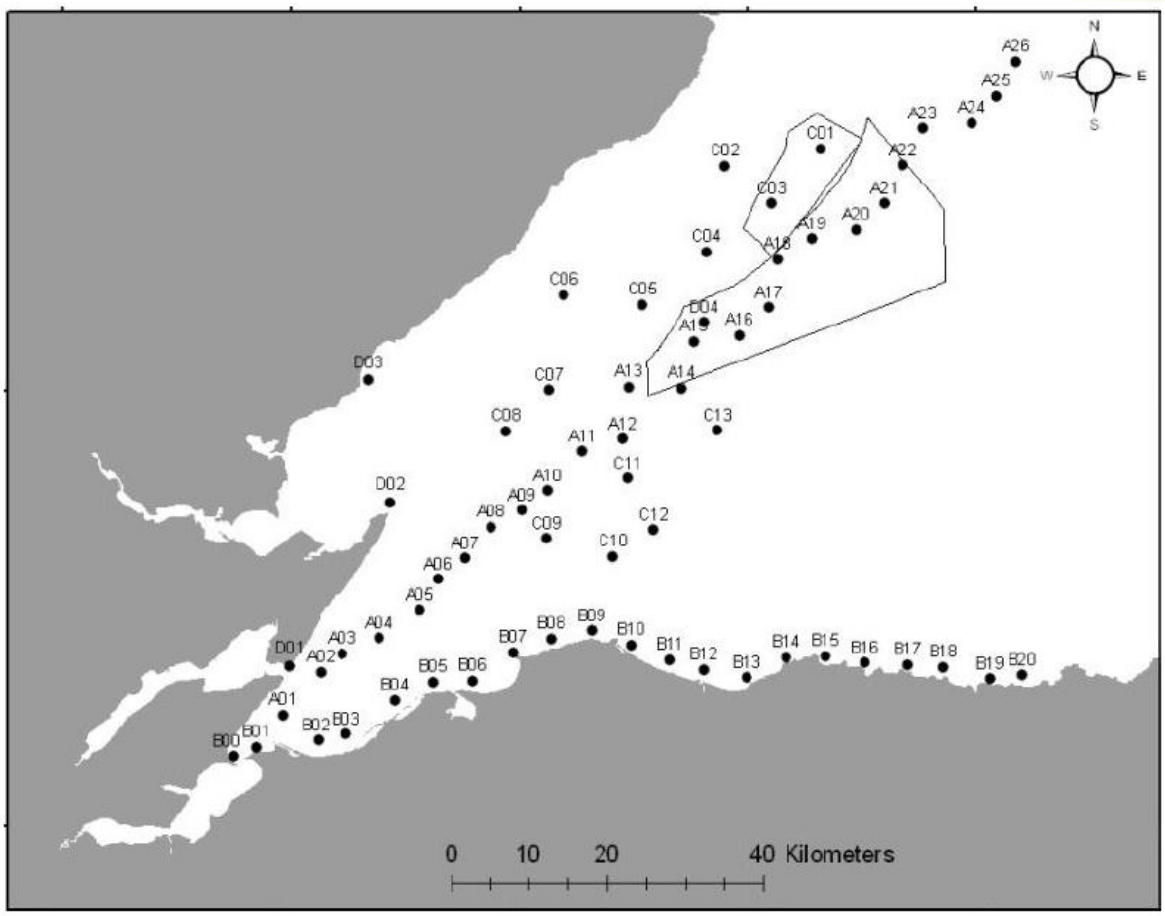

Figure 3-11: Locations of CPOD deployments in 2009 (Moray East ES 2012).

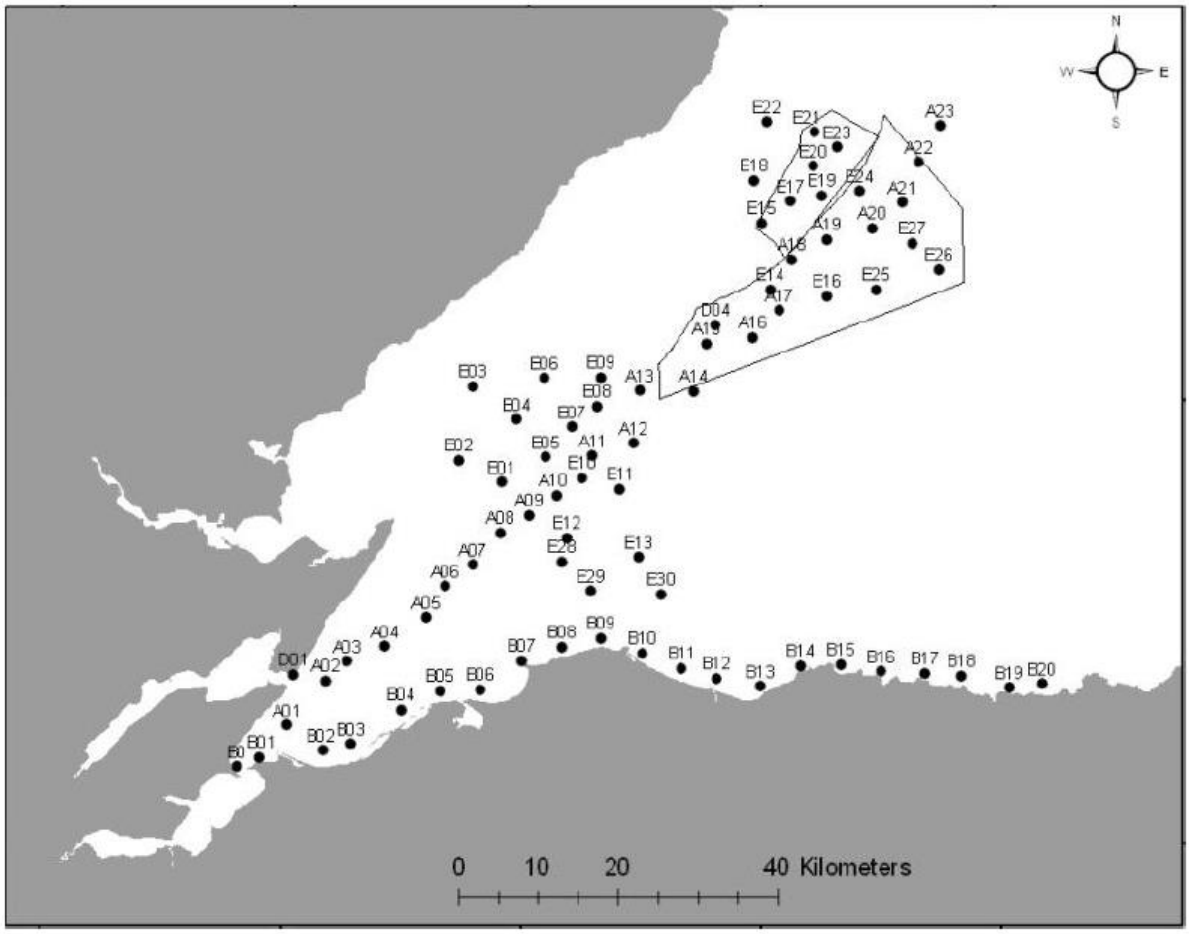

Figure 3-12: Locations of CPOD deployments in 2010 (Moray East ES 2012).

3.1.12.4 Long-term CPOD sites and the BOWL MMMP

The University of Aberdeen have been collecting PAM data year round from four CPOD sites in the Moray Firth since 2001: the Sutors of Cromarty (D01), Chanonry (B00) Lossiemouth (B09) and Spey Bay (B12) (Figure 3-13). In addition to these long-term sites, four additional sites around Lossiemouth and Spey Bay were monitored during the summer (June-September) of 2014 and 2015 as part of the BOWL MMMP (B07, B08, B10 & B11). All four long-term sites and the four additional summer sites included in this study are also presented as data-points in the DECC CPOD surveys 2009-2010, described above.

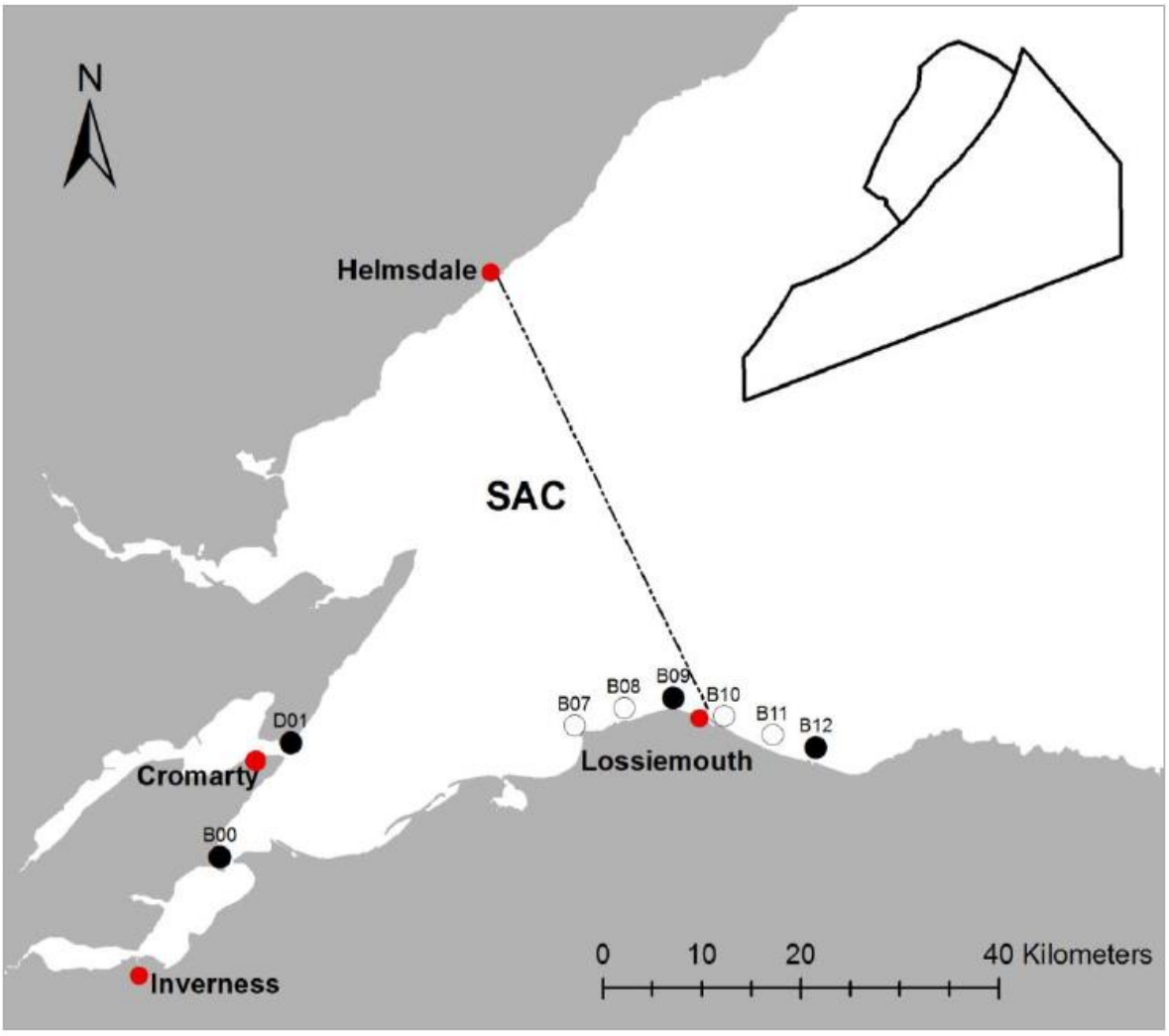

Figure 3-13: Long-term CPOD PAM monitoring sites in the Moray Firth studied since 2001 (black circles) and additional sites studies in the summers of 2014 and 2015 (white circles).

3.1.12.5 The East Coast Marine Mammal Acoustic Study (ECOMMAS)

The ECOMMAS began in 2013 and involved 30 PAM sites along the east coast of Scotland to collect data on the relative abundance of dolphins and porpoise. Every PAM site contained a CPOD capable of detecting dolphin and porpoise echolocation clicks and some sites also contained an SM2M capable of recording underwater noise and the vocalisations of dolphin species. 15 of the ECOMMAS PAM sites are within the Moray Firth and are located at: Cromarty in the inner Moray Firth, Helmsdale in the northern mid Moray Firth, Helmsdale in the northern outer Moray Firth, Spey Bay in the southern mid Moray Firth and Fraserburgh in the southern outer Moray Firth (Figure 3-14).

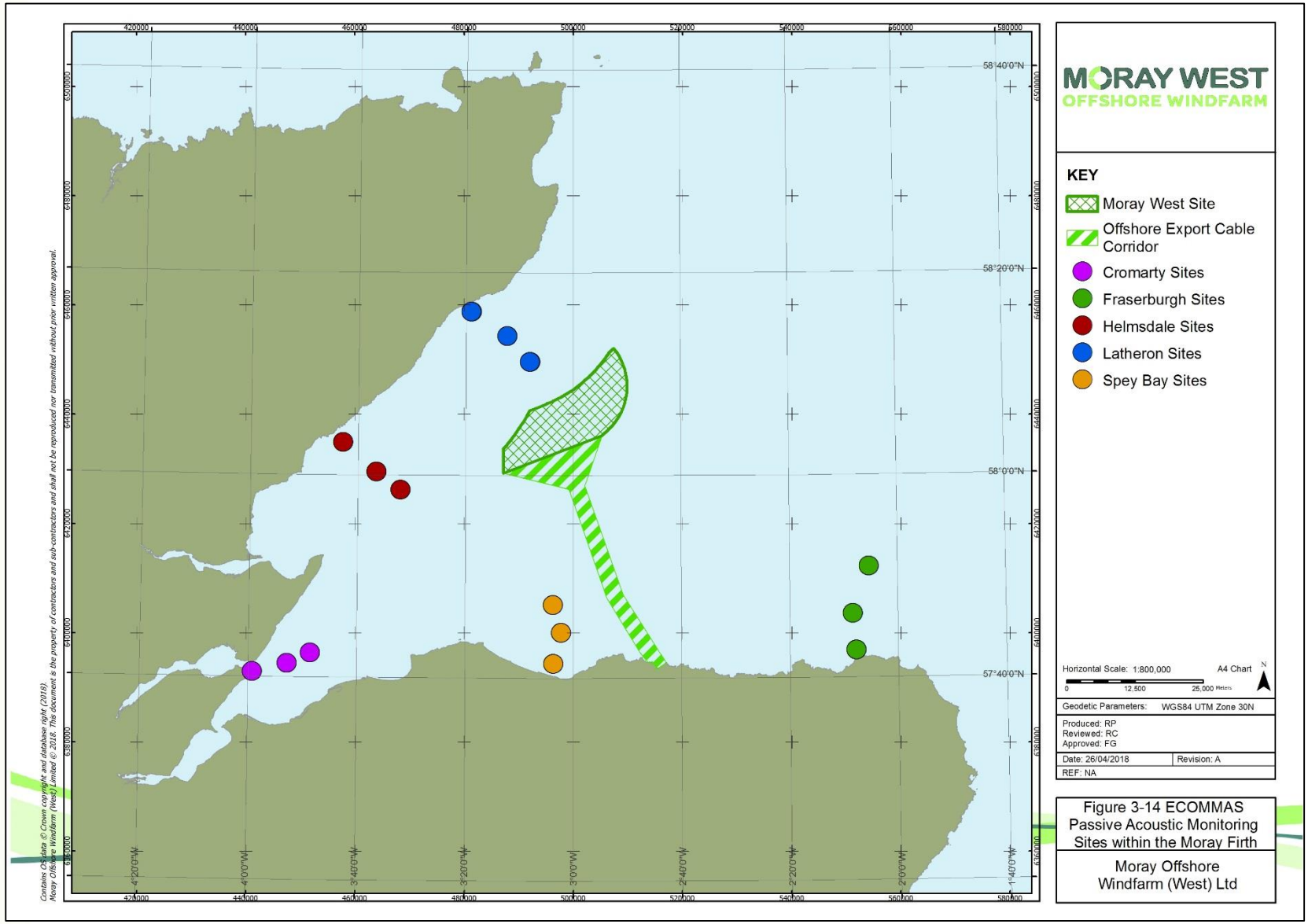

Figure 3-14: Locations of the 15 ECOMMAS PAM sites within the Moray Firth.

3.1.13 Habitat Modelling to Provide Spatially Explicit Density Estimates

For the Moray East impact assessment, habitat modelling was conducted to create spatially explicit density estimates for harbour seals, harbour porpoise and bottlenose dolphins in the Moray Firth. This section provides more detail on this modelling process.

3.1.13.1 Harbour Seal

Habitat modelling for harbour seals was conducted in 2011 for the Moray East ES (2012) which produced spatially explicit estimates of density. Since this work was carried out, additional harbour seal telemetry data has been collected which have been used to update and refine the model and resulting density map. The new data include 25 GPS/GSM tags that were deployed on harbour seals at Loch Fleet in Autumn 2014 and Spring 2016 and a further 31 tags deployed on harbour seals at Loch Fleet in February/March 2017. This resulted in a total dataset of 93 individual seals tagged at either Loch Fleet or the Dornoch Firth between 1989 and 2017.

The data were modelled using a case-control approach (Aarts *et al*. 2008b, Bailey *et al*. 2014) where 26 control points were generated in each grid cell. The case points (seal GPS locations) and the generated control points were combined with environmental data and modelled using a Generalised Additive Mixed Model (GAMM, with a binomial error distribution and logit link function with the individual track included as a random effect). The environmental covariates included in the model were: water depth, seabed slope, seabed sediment type and distance from the nearest haul-out. The resulting model predictions were scaled to the population abundance estimate of 1,304 to estimate the number of seals within each grid cell (Bailey 2017) (Annex 9.1A).

3.1.13.2 Bottlenose Dolphin

Acoustic datasets were used to investigate the bottlenose dolphin distribution within the Moray Firth. These datasets included the CPOD surveys described above:

- Beatrice Demonstrator study (2005-2007).
- DECC Study (2009-2010).

These data were assessed to identify dolphin detection rates, however, CPODs cannot discriminate between dolphin species, presenting instead only “dolphin” detections that include wideband and lower frequency echolocation clicks which could be produced by a variety of dolphin species. Therefore, visual sightings of dolphins between 1982 and 2010 obtained from publicly available survey datasets from the Moray Firth were used in a classification tree to predict the dolphin species most likely to be detected within a 4 × 4 km grid, based on the habitat available within each grid cell.

The visual sightings data included in this classification tree were from the following sources:

- Boat and helicopter-based line transect (JNCC Seabirds at Sea Database).
- Ad hoc boat-based observations (JNCC Database of observations from seismic vessels).
- Boat-based line transects 2010 (Moray East ES).
- Aerial visual and video line transects 2009-2010 (The Crown Estate enabling actions).
- Aerial visual line transects 2010 (University of Aberdeen).
- Boat-based line transects 2001-2009 (University of Aberdeen).
- Photo-ID boat-based surveys 1990-2010 (University of Aberdeen).

The classification tree results demonstrated that dolphins encountered along the coastal areas were most likely to be bottlenose dolphins, while those encountered in offshore areas were more likely to be other species such as common, Risso’s or white-beaked dolphins. The results of the classification tree were used to predict the likelihood that detected dolphins in the 4x4 km grid cells were bottlenose dolphins as

opposed to other dolphin species. This was then scaled to the population estimate to provide an estimate of the number of bottlenose dolphins in each grid cell (for full model details see Moray East ES 2012).

3.1.13.3 Harbour Porpoise

A total of five different datasets from surveys conducted within the Moray Firth were used to model the harbour porpoise distribution across the Moray Firth. These datasets were:

- Aberdeen University boat surveys in the Beatrice Demonstrator site (2004 and 2005).
- Aberdeen University boat surveys in the outer Moray Firth (2009).
- Aberdeen University aerial surveys in the outer Moray Firth (2010).
- NPC boat surveys of the Moray East site (Apr 2010 – Mar 2012).
- International Council for the Exploration of the Sea (ICES) boat surveys of the BOWL site (Apr-Oct 2010).

The harbour porpoise sightings data were modelled using a GAMM to predict the spatial variation in the relative abundance of porpoise across the Moray Firth. The predicted number of porpoise in each 4 x 4 km grid cell was modelled against the environmental covariates depth and substrate type and standardised for a constant unit of effort. The values for the predicted relative abundance were scaled to absolute abundance using the density estimates obtained from the 2010 aerial line transect survey (for full model details see Moray East ES 2012).

4 Current Baseline and Species Accounts

The following sections describe the available data on marine mammals within the Moray Firth and in relation to the Moray West Wind Offshore Farm, and provides a detailed picture of their spatial and temporal patterns of abundance and density.

4.1 Harbour Seal

Harbour seals are the smaller of the two species of seal resident in UK waters. They forage at sea and haul-out on land to rest, moult and breed. Harbour seals normally feed within 40 to 50 km around their haul-out sites and take a wide variety of prey including sandeels, gadoids, herring and sprat, flatfish, octopus and squid (SCOS 2017).

Harbour seals come ashore in sheltered waters, typically on sandbanks and in estuaries, but also in rocky areas. They give birth to their pups in June and July and moult in August. At these, as well as other times of the year, harbour seals haul-out on land regularly in a pattern that is often related to the tidal cycle.

Approximately 30% of European harbour seals are found in the UK; this proportion has declined from approximately 40% in 2002. Harbour seals are widespread around the west coast of Scotland and throughout the Hebrides and Northern Isles. On the east coast, their distribution is more restricted with concentrations in the major estuaries of the Thames, The Wash, Firth of Tay and the Moray Firth.

In the UK, harbour seals are considered to have an "Unfavourable Inadequate Conservation Status" (JNCC 2013) which means that "*a change in management or policy is required to return the habitat type or species to favourable status but there is no danger of extinction in the foreseeable future*" (ETC/BD 2014).

The following sections describe the available data on harbour seals in the Moray Firth seal MU and, specifically, in relation to the Moray West Site, in order to determine their spatial and temporal patterns of abundance and density. Harbour seal haul-out surveys

4.1.1.1 SMRU August moult surveys

The most recent UK wide harbour seal count presented in SCOS (2017) combines data collected between 2011 and 2016. This produced a total count for the UK of 31,300 seals which, scaled to account for the proportion of animals at sea at the time of the count, gives an estimated UK population size of 43,500 (95% CI: 35,600 to 58,000), of which 85% are located in Scotland (SCOS 2017).

The Moray West Site is located within the Moray Firth seal management area where the most recent harbour seal August moult count was 940 in 2016 (SCOS 2017). This scales to a population estimate of 1,306 harbour seals (95% CI: 1,068 to 1,741) which accounts for approximately 3.1% of the total population in Great Britain

Overall, across the time series of data between 2002 and 2016, it appears that the population in the Moray Firth MU is reasonably stable, though with inter-annual variation (Figure 4-1). The population appeared to be declining between 2012 and 2015 (from 1,476 in 2012 to 1,018 in 2014 and 1,035 in 2015); however, the 2016 estimate of 1,306 animals was higher than that obtained in 2014 and 2015 and is more in line with the previous estimate in 2012.

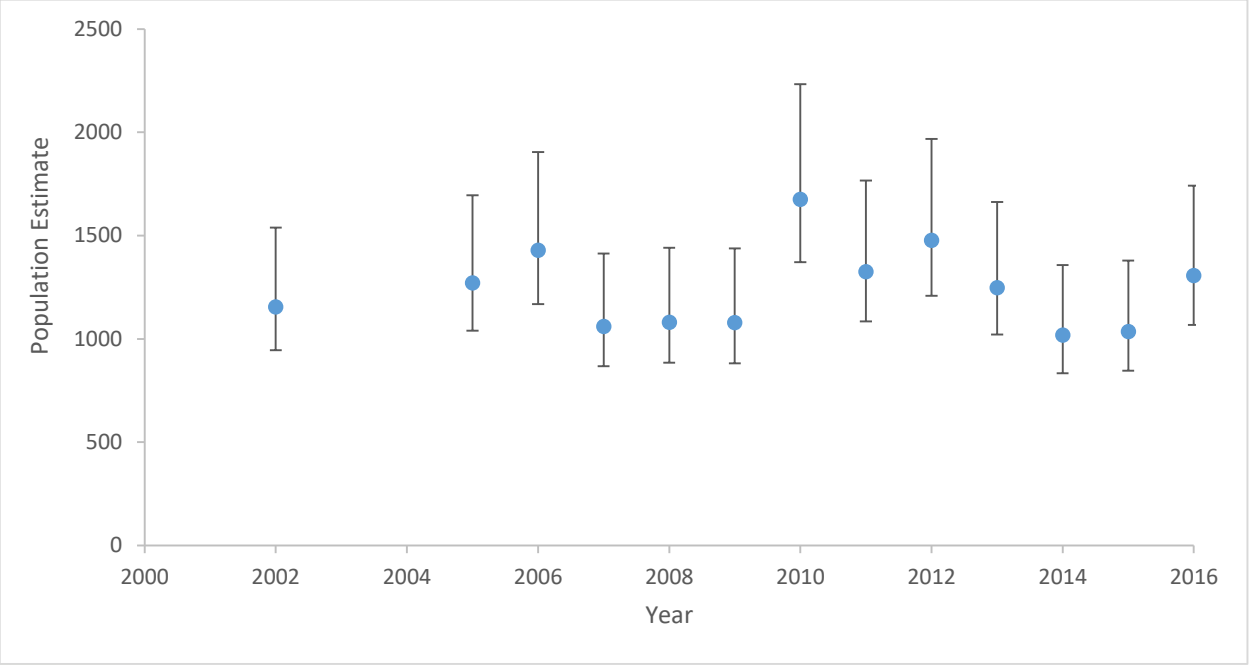

Figure 4-1: Moray Firth MU harbour seal population estimates (raw counts scaled to account for the proportion at sea) between 2002 and 2016. Error bars show the 95% CIs. Data obtained from SCOS (2017).

A breakdown of the counts in the different areas surveyed within the Moray Firth are available up to 2016. The limitation of this data is that not all sections of the Moray Firth MU are surveyed in each year. Annual surveys are conducted between Helmsdale and Findhorn, while other areas are surveyed less frequently. The 2016 survey included Helmsdale to Findhorn and Findhorn to Fraserburgh. Areas north of Helmsdale have not been surveyed since 2011. The haul-out data for the annually surveyed sites show that the Loch Fleet counts have increased from 59 animals in 2002 to 145 animals in 2016 (average p.a. increase of 8.35%). If the 2016 count of 145 is scaled to include the proportion of seals in the water at the time of the count, the abundance of harbour seals in Loch Fleet during the 2016 August moult is estimated as 201 animals (95% CI 165 to 269). Unlike the Loch Fleet site, the annual moult count at the Dornoch Firth and Morrich More SAC has fluctuated annually from 220 in 2002 to a maximum of 290 in 2003 and a minimum of 85 in 2016. Over the period between 2002 and 2016 the counts show an average per annum 0.48% decline in counts. If the 2016 count of 85 is scaled to include the proportion of seals in the water at the time of the count, the abundance of harbour seals in the Dornoch Firth and Morrich More SAC during the 2016 August moult is estimated as 118 animals (95% CI 97 to 157).

Other haul-out sites in the Moray Firth that are surveyed annually during the moult count include Culbin & Findhorn which has shown a large increase in counts from 49 in 2004 to 484 in 2016. All other annually monitored sites (Helmsdale to Brora, Cromarty Firth, Beauly Firth and Ardersier) have shown large fluctuations in annual moult counts but overall, they have all shown overall declines in counts since 2002 (Figure 4-2). The distribution of counts and the variation over time indicate that there has been a change in usage within the Moray Firth over time, from most counts being located within the Dornoch Firth and Morrich Moore SAC in the 1990s to most seals being counted in Culbin and Findhorn in more recent years (Figure 4-2).

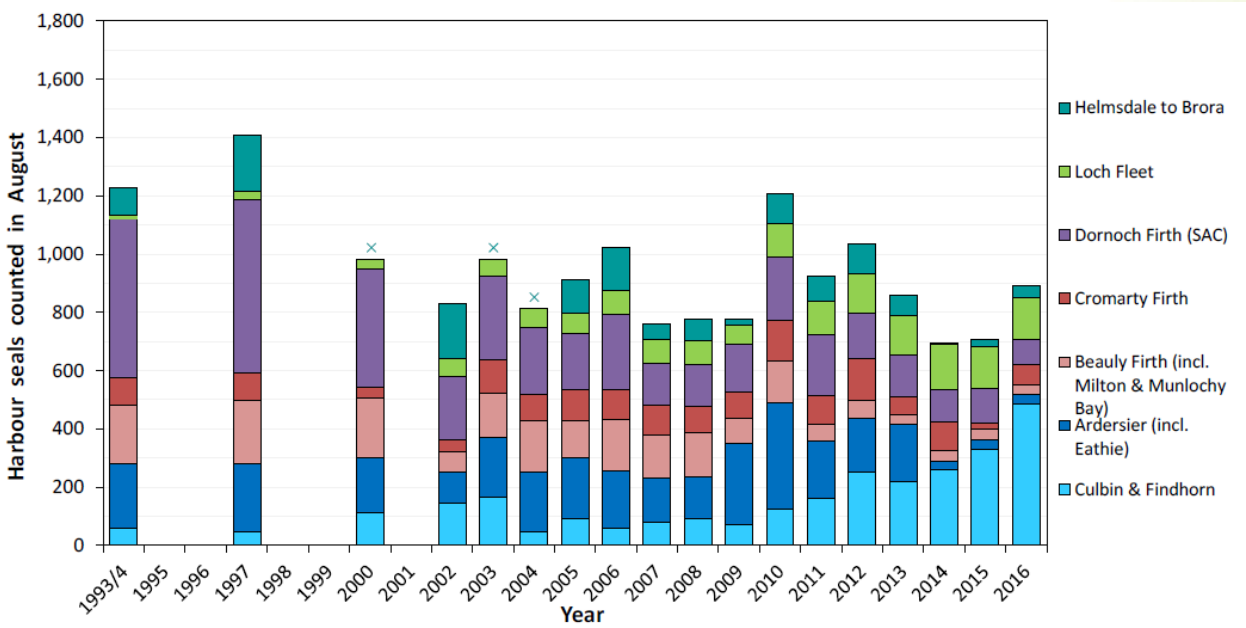

Figure 4-2: Harbour seal counts at haul-out sites in the Moray Firth between 1993 and 2016 (SCOS 2017). : Helmsdale to Brora not surveyed in 2000, 2003 or 2004.

4.1.1.2 University of Aberdeen harbour seal haul-out surveys

The Loch Fleet National Nature Reserve is the nearest major harbour seal breeding site to the Moray West site. In 2015 the first pup was seen on 4th June and the maximum number of pups counted on a survey day was 51 on the 5th of July. The fecundity rate at Loch Fleet was determined by dividing the number of females seen with a pup by the number of reproductive females seen. The mean fecundity rate between 2006 and 2015 was 0.84 (range: 0.75 to 0.97, SE: 0.02) (Graham *et al*. 2016). The estimated abundance of harbour seals at the Loch Fleet National Nature Reserve has increased since the mid 1990's and reached its highest estimate in 2015 of 167 seals (95% CI: 146 to 187; estimated by adjusting counts made during the pupping season) (Figure 4-3).

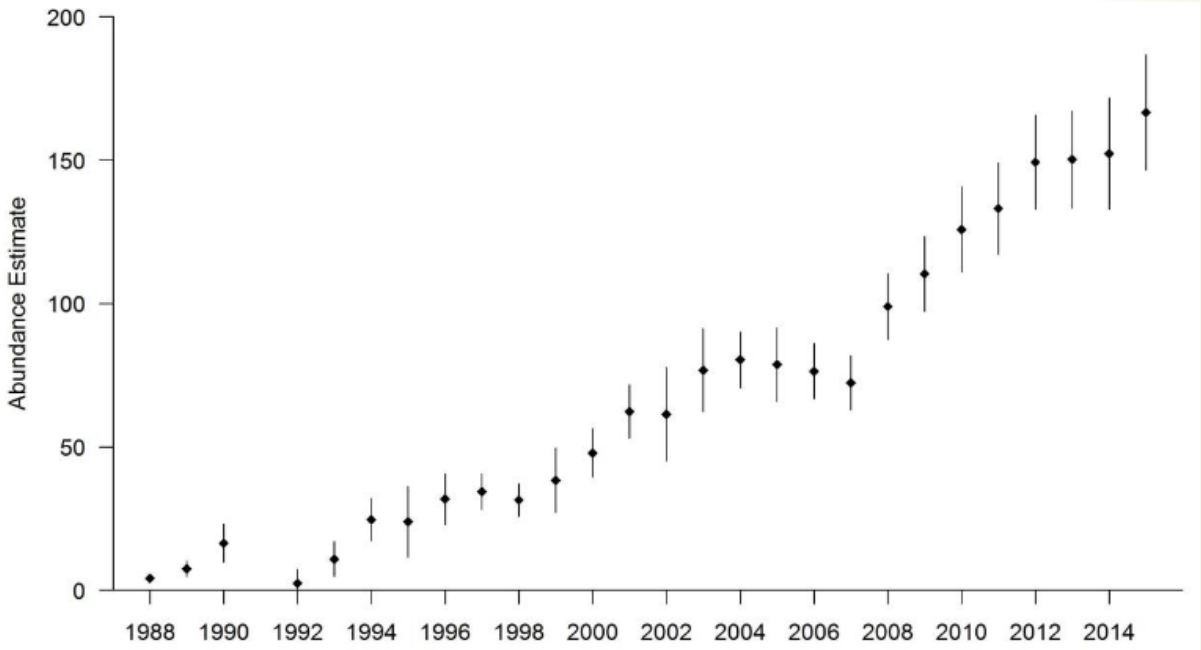

Figure 4-3: Estimated number of seals using Loch Fleet from 1988 to 2015 with 95% confidence intervals (Graham *et al*. 2016).

Other haul-out sites along the northern coast from the Dornoch Firth and Morrich More SAC have been monitored monthly as part of the BOWL strategic pre-construction MMMP in 2014 and 2015, including Lothmore, Lothbeg, Sputie Burn and Dunrobin (in addition to the Loch Fleet surveys). These data show that Loch Fleet supports considerably more seals than the other surveyed sites (mean count up to 128.75 in 2014), however there are also a number of harbour seals that haul-out at Sputie Burn year round (mean count up to 38.75 in 2014) (Table 4-1).

Table 4-1: Mean counts (± 1 SE) of adult harbour seals at each site during the 2014 and 2015 pupping season, moult and winter (Graham *et al.* 2016)

	Year	Lothmore	Lothbeg	Sputie Burn	Dunrobin	Loch Fleet
Pupping	2014	0.2 (0.2)	-	22.4 (1.3)	0	92.8 (4.2)
	2015	2 (0.4)	0.8 (0.5)	29 (2.2)	0	101.6 (4.1)
Moult	2014	6.3 (1.9)	-	38.8 (5.0)	0.3 (0.3)	123.2 (8.25)
	2015	3 (1.2)	1.8 (1.2)	37.5 (7.2)	2.0 (1.1)	128.8 (11.2)
Winter	2014	2.2 (1.1)	3.0	24.6 (4.2)	0	79.8 (10.0)
	2015	0.5 (0.5)	3.0 (1.0)	30.0 (4.6)	1.1 (0.9)	76.4 (10.0)

4.1.1.3 Landfall Site

Since there is the potential for cable landfall activities to disturb seals at their haul-out sites, the proposed landfall area between the west end of Sandend Bay to Redhythe Point were investigated further in terms of haul-out counts and seal distribution. There are no haul-out sites within the export cable corridor and proposed landfall area between west end of Sandend Bay and Redhythe Point on the Moray/Aberdeenshire coastline (Figure 4-4). The closest haul-out sites to the export cable corridor and landfall area where harbour seals have been recorded during SMRU August moult count surveys are listed below in Table 4-2. These data show that the haul-out sites adjacent to the export cable corridor and landfall area are not major haul-out sites for harbour seals during the moult in comparison to haul-out sites elsewhere in the Moray Firth (Figure 4-4).

Table 4-2: Location of the harbour seal haul-out sites surveyed between 1997 and 2016 that are located adjacent to the export cable corridor and landfall area

Year	Haul-out	Latitude	Longitude	Count	Distance (km)
1997	Portsoy	57.68942	-2.66419	1	3
2005	Buckie	57.67103	-3.00083	3	13
2011	Boyne Bay	57.68102	-2.62144	11	6
2011	Portgordon	57.66816	-3.00405	11	13
2013	Boyne Bay E	57.68096	-2.62079	12	6
2013	Port Gordon	57.66798	-3.00428	21	13
2016	Port Gordon	57.667766	-3.003676	33	13
2016	Whitehills	57.680186	-2.615174	12	6

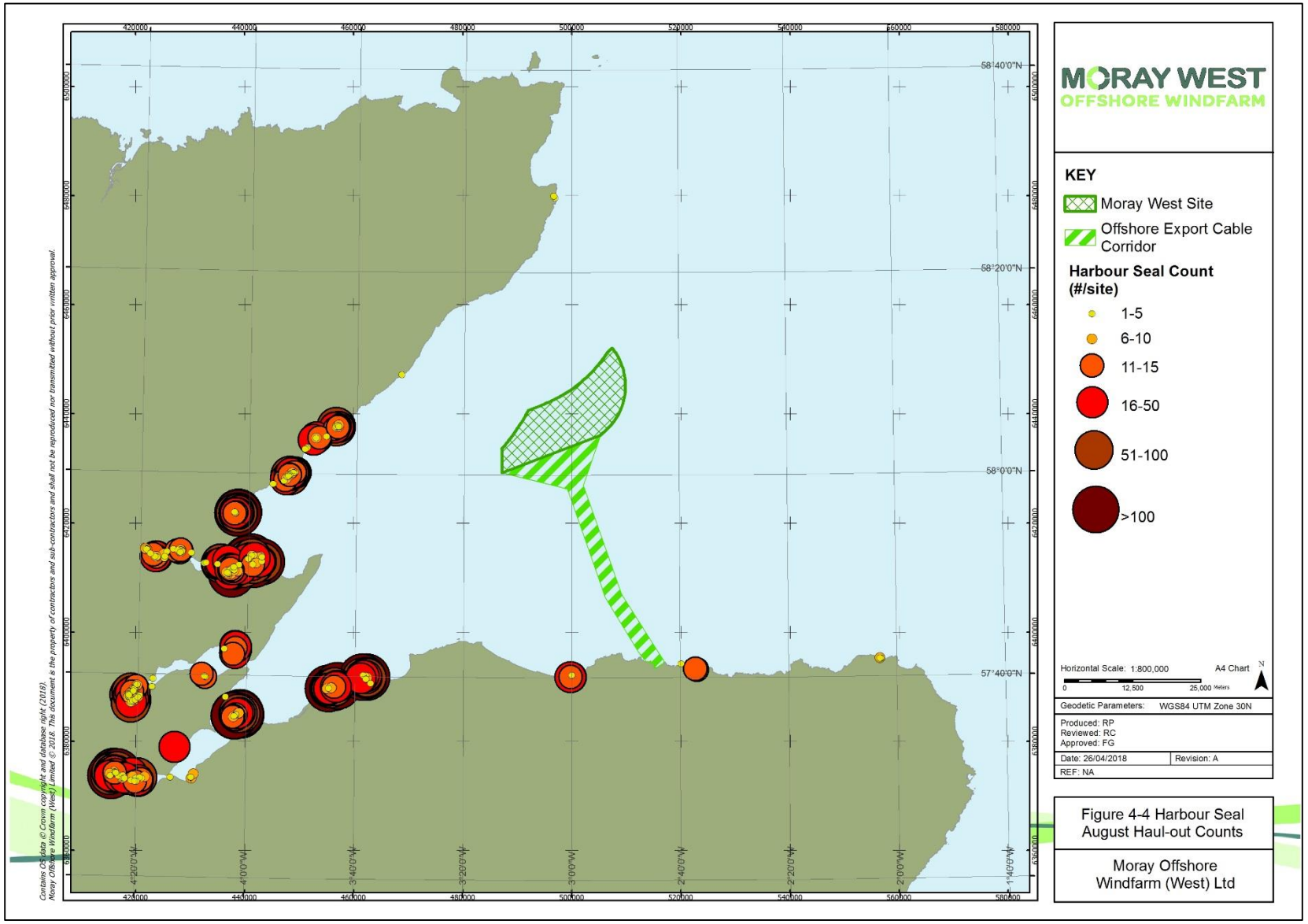

Figure 4-4: Harbour seal haul-out counts during the SMRU August moult count between 1997 and 2016.

4.1.2 Telemetry Data – Seal Movements and Distribution

A total of 37 adult harbour seals were tagged in the Moray Firth between 2004 and 2015, with tag durations lasting between 20 and 185 days (mean 115 days) (Table 4-3). Of these, 12 seals recorded tag locations within the Moray West Offshore Wind Farm, however, the proportion of their total tag locations within the Moray West site boundary was low (maximum 4.14%) (Figure 4-5). The more recent telemetry data (2014 and 2015 deployments) show much less usage of the Moray West, Moray East and BOWL wind farm development sites than previous tag deployments (Figure 4-5). While this may simply be due to individual variations in range and movement patterns, there is the potential that these data could reflect a change in harbour seal usage of this area in recent years.

Table 4-3: Details of the 37 adult harbour seals tagged in the Moray Firth MU between 2004 and 2015 and the proportion of their recorded locations that were within the Moray West Site (MW).

Seal ID	Tagging Location	Tag Type	Age	Sex	Tag Date	End Date	Duration (days)	% GPS within MW
pv9-Angus-04	Dornoch	ARGOS	1+	M	29/09/2004	01/12/2004	63	3.41
pv9-Burt-04	Dornoch	ARGOS	1+	M	29/09/2004	15/11/2004	47	3.72
pv9-Chris-04	Dornoch	ARGOS	1+	M	29/09/2004	02/04/2005	185	0.98
pv9-dory-04	Dornoch	ARGOS	1+	F	17/10/2004	09/03/2005	143	0
pv9-Gabe-04	Dornoch	ARGOS	1+	M	17/10/2004	14/03/2005	148	1.29
pv11-Helen-05	Dornoch	ARGOS	1+	F	05/03/2005	23/05/2005	79	1.55
pv11-Isla-05	Dornoch	ARGOS	1+	F	05/03/2005	26/07/2005	143	0.96
pv11-James-05	Dornoch	ARGOS	1+	M	05/03/2005	06/04/2005	32	3.65
pv11-Kath-05	Dornoch	ARGOS	1+	F	06/03/2005	22/06/2005	108	1.42
pv11-Lewis-05	Dornoch	ARGOS	1+	M	06/03/2005	13/07/2005	129	0
pv12g-F524r-06	River Conon	phone	1+	F	04/02/2007	24/02/2007	20	4.14
pv12a-181-07	River Oykel	ARGOS	1+	F	01/03/2007	13/06/2007	104	1.76
pv58-115-14	Loch Fleet	phone	1+	M	29/09/2014	05/02/2015	129	0.02
pv58-207-14	Loch Fleet	phone	1+	F	28/09/2014	20/01/2015	114	0
pv58-208-14	Loch Fleet	phone	1+	M	28/09/2014	03/02/2015	128	0
pv58-209-14	Loch Fleet	phone	1+	M	29/09/2014	19/01/2015	112	0
pv58-210-14	Loch Fleet	phone	1+	F	28/09/2014	23/01/2015	117	0
pv58-212-14	Loch Fleet	phone	1+	F	29/09/2014	16/02/2015	140	0
pv58-213-14	Loch Fleet	phone	1+	M	29/09/2014	22/01/2015	115	0
pv58-214-14	Loch Fleet	phone	1+	M	28/09/2014	22/03/2015	175	0.5
pv58-915-14	Loch Fleet	phone	1+	F	28/09/2014	04/02/2015	129	0
pv58-919-14	Loch Fleet	phone	1+	M	29/09/2014	23/10/2014	116	0
pv-58-921-14	Loch Fleet	phone	1+	F	28/09/2014	23/01/2015	117	0
pv58-922-14	Loch Fleet	phone	1+	F	29/09/2014	15/01/2015	108	0
pv59-01-15	Loch Fleet	phone	1+	F	25/02/2015	04/07/2015	129	0
pv59-02-15	Loch Fleet	phone	1+	M	26/02/2015	11/06/2015	105	0
pv59-03-15	Loch Fleet	phone	1+	F	25/02/2015	19/07/2015	144	0

Table 4-3: Details of the 37 adult harbour seals tagged in the Moray Firth MU between 2004 and 2015 and the proportion of their recorded locations that were within the Moray West Site (MW).

Seal ID	Tagging Location	Tag Type	Age	Sex	Tag Date	End Date	Duration (days)	% GPS within MW
pv59-04-15	Loch Fleet	phone	1+	F	27/02/2015	13/07/2015	136	0
pv59-05-15	Loch Fleet	phone	1+	F	25/02/2015	26/06/2015	121	0
pv59-06-15	Loch Fleet	phone	1+	M	23/02/2015	23/05/2015	89	0
pv59-07-15	Loch Fleet	phone	1+	F	17/02/2015	27/06/2015	130	0
pv59-08-15	Loch Fleet	phone	1+	F	25/02/2015	16/07/2015	141	0
pv59-09-15	Loch Fleet	phone	1+	M	25/02/2015	11/05/2015	75	0
pv59-10-15	Loch Fleet	phone	1+	M	27/02/2015	08/07/2015	131	0
pv59-11-15	Loch Fleet	phone	1+	M	26/02/2015	16/06/2015	110	0
pv59-12-15	Loch Fleet	phone	1+	F	26/02/2015	04/07/2015	128	0
pv59-13-15	Loch Fleet	phone	1+	M	23/02/2015	19/06/2015	116	0

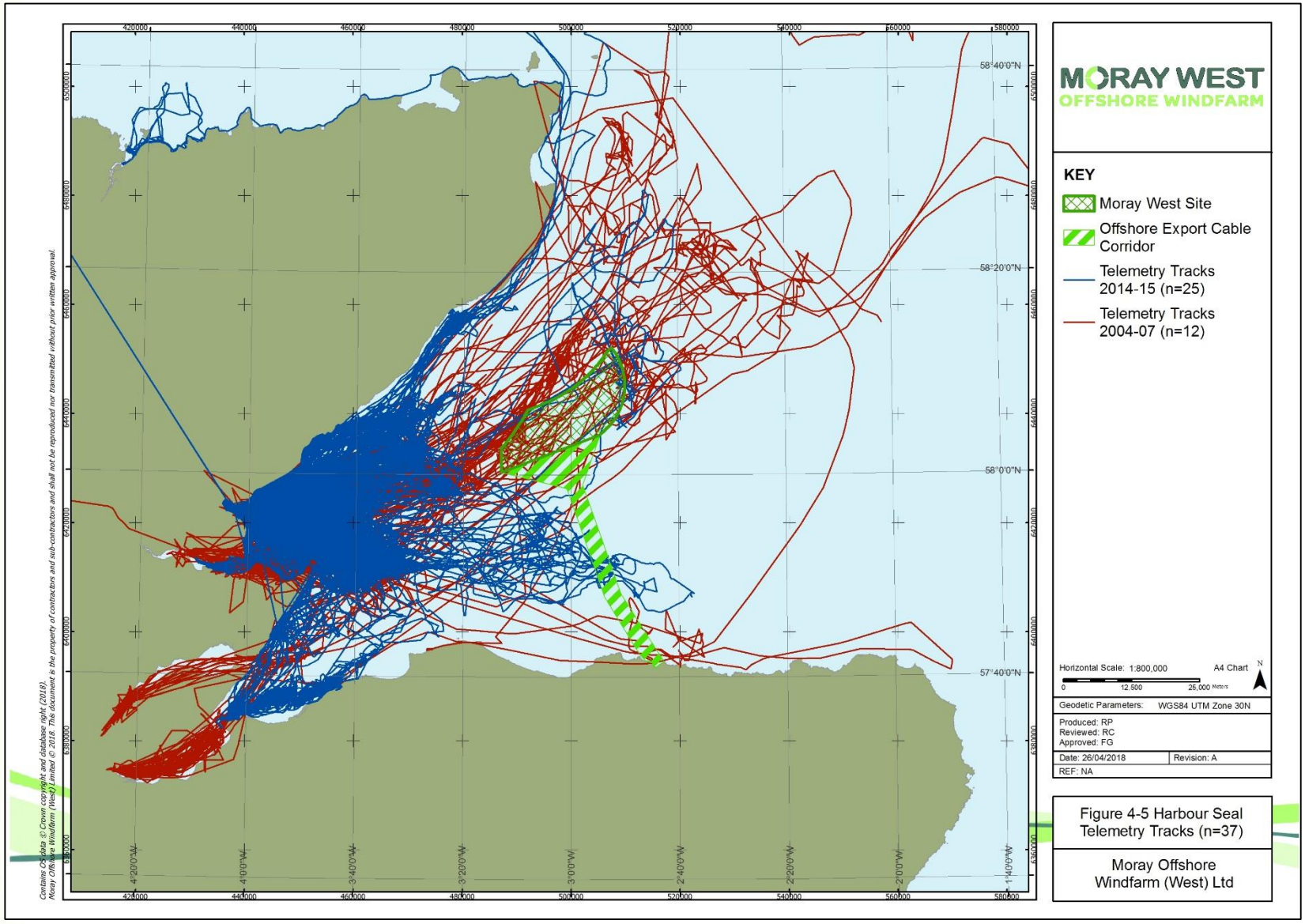

Figure 4-5: Harbour seal telemetry tracks for deployments between 2004-2007 and 2014-2015.

4.1.3 At-Sea Usage

Both the previous (2004-2007) and the most recent telemetry data (2014-2015, which showed much less usage of the Moray West, Moray East and BOWL wind farm development sites than previous tag deployments) were modelled using a GAMM to predict harbour seal at-sea usage in the Moray Firth (described in paragraphs 0 and 0). The GAMM predicted that harbour seal occurrence in the Moray Firth was significantly related to water depth (more likely to occur in shallow waters), seabed slope (more likely to occur in less steep slopes), distance to haul-out sites (more likely to occur close to the haul-outs) and sediment type (more likely to occur over sandy or muddy-sand) (Bailey 2017).

The resulting harbour seal at-sea usage map (Bailey 2017) shows that harbour seals are not predicted to be evenly distributed within the Moray Firth (Figure 4-6). There are hotspots of higher predicted densities in the inner Moray Firth, with highest densities around the Dornoch Firth and Morrich More SAC.

The grid cell with the maximum density within the Moray West Site has an estimated at-sea density of 3.97 seals/cell which, assuming uniform distribution within a grid cell, equates to 0.16 seals/km^2.

4.1.4 State Space Modelling

A state space model (described in Russell *et al*. 2015) was used to classify travelling and foraging locations from the telemetry data of 19 of the 25 harbour seals tagged in 2014 and 2015. Locations were classified as travelling or foraging (area restricted search) when the probability of that state was greater than 0.9. These data show that there is an important foraging area off the headland near the haul-out sites in the Dornoch Firth and Loch Fleet (Figure 4-7). A previous study on harbour seal locations in the Moray Firth (Bailey *et al*. 2014), using data obtained from tags deployed between 1989 and 2009 also identified this area as an area of persistently high usage which had been previously identified as a harbour seal foraging habitat (Thompson *et al*. 1996, Tollit *et al*. 1998). This area is known to have high currents and a sandy seabed, which is the preferred habitat of sandeels on which the harbour seals forage. The data also show that the Moray West Offshore Wind Farm was not an area used for foraging by any of the 19 tagged harbour seals, nor was it an important area where travelling behaviour was observed (Figure 4-7).

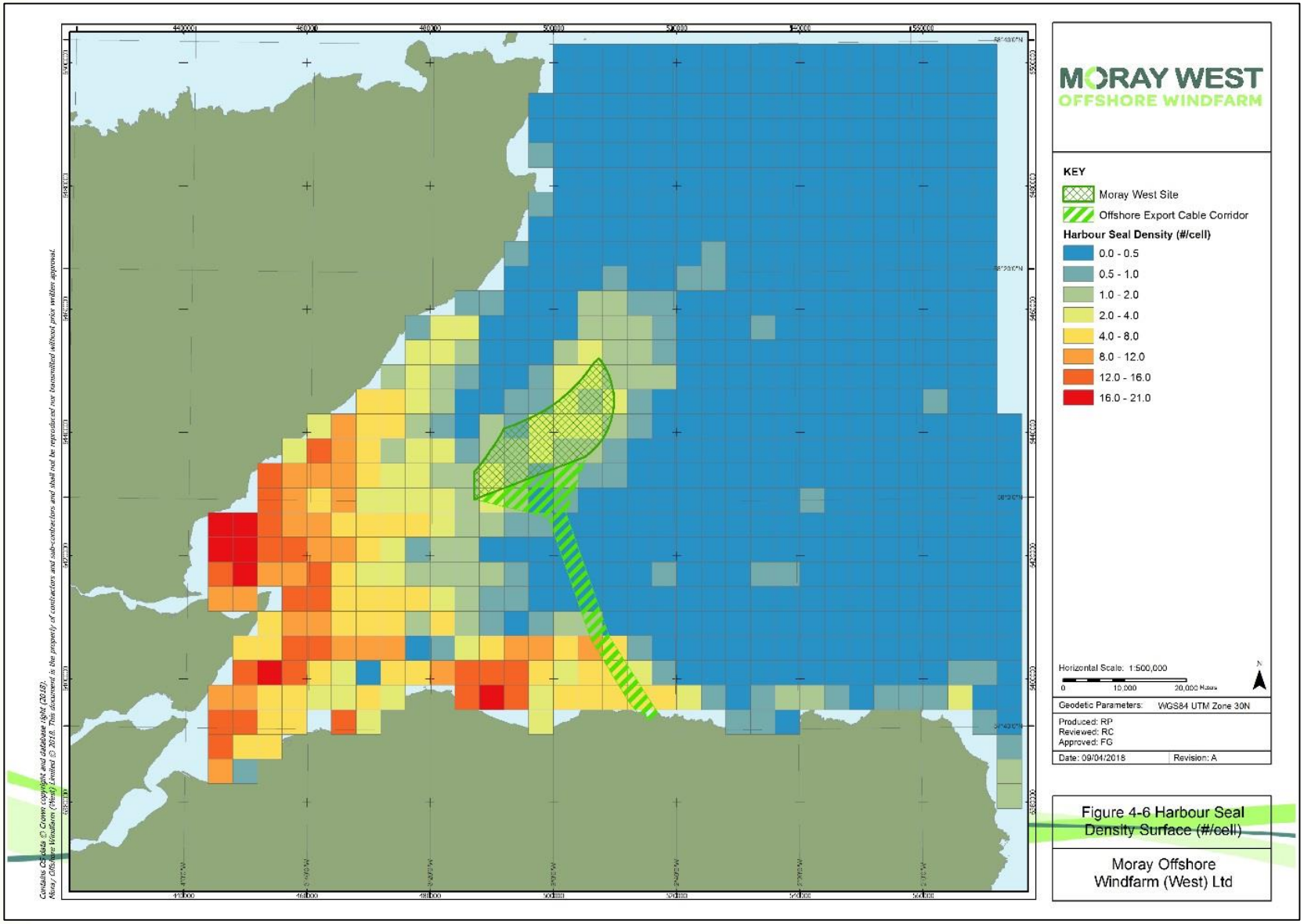

Figure 4-6: Harbour seal at-sea usage showing the predicted number of animals in each 4 km x 4 km grid cell (Bailey 2017).

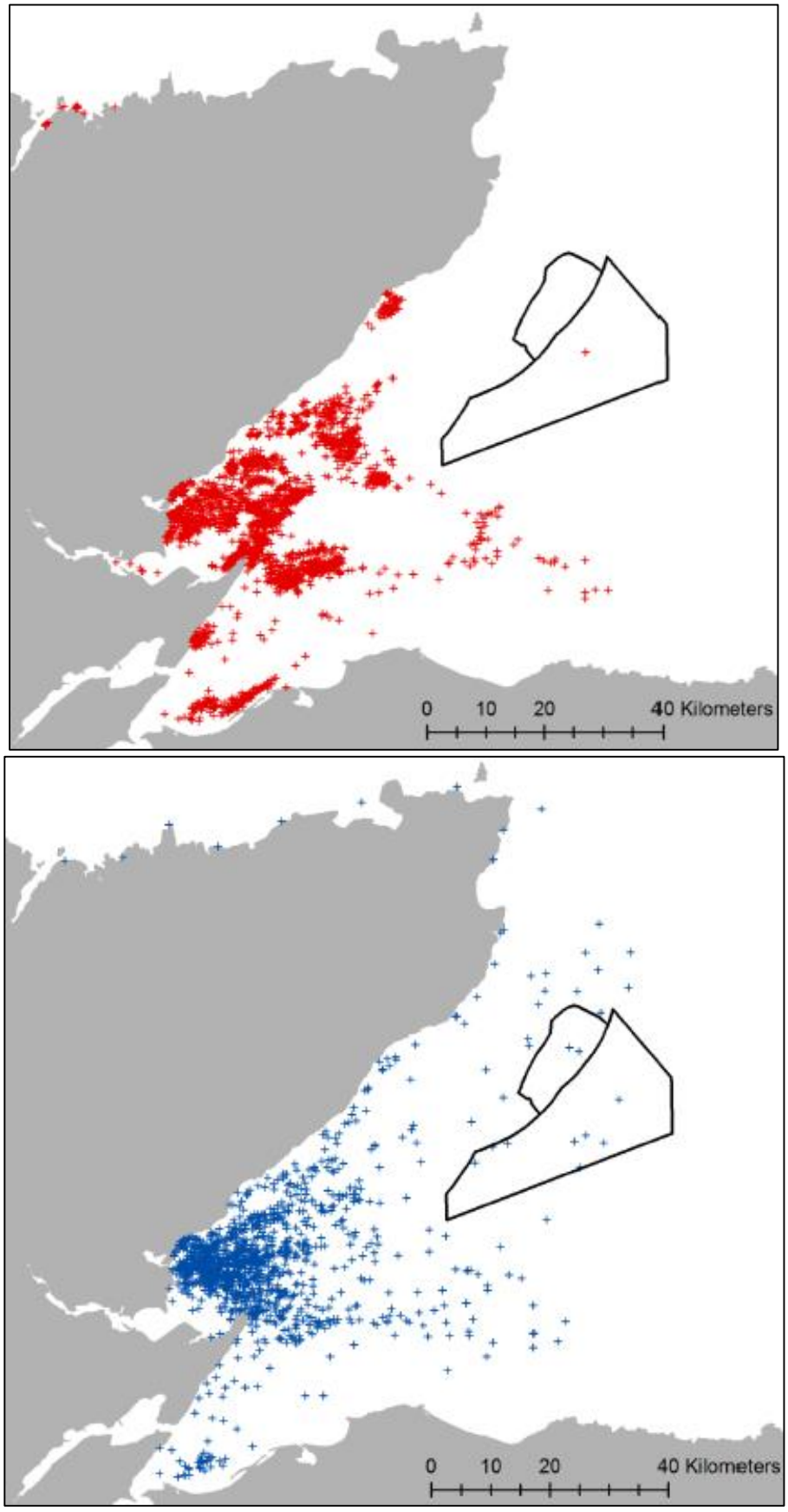

Figure 4-7: Foraging (top) and travelling (bottom) locations identified by state space modelling of location data from 19 of the harbour seals tagged in the Moray Firth in 2014 and 2015 (Graham *et al*. 2016).

4.1.5 Conclusion

In the UK, harbour seals are considered to have an "Unfavourable Inadequate Conservation Status". However, the harbour seal population in the Moray Firth has remained relatively stable since 2002, though there is inter-annual variation in population estimates. The current Moray Firth population size estimate is 1,306 harbour seals which accounts for approximately 3% of the total UK population. The main haul-out sites for harbour seals in the Moray Firth are located at Culbin and Findhorn and no haul-out sites are located within the export cable corridor and proposed landfall area. The nearest breeding site to the Moray West site is Loch Fleet, which supported an estimated 167 harbour seals in 2015. The most recent telemetry data show less usage of the Moray West, Moray East and BOWL wind farm development sites than previous tag deployments. The at-sea usage map confirms that harbour seals are not evenly distributed throughout the Moray Firth, and that they occur at highest densities around the Dornoch Firth and Morrich More SAC. Due to the proximity of the Moray West Site to the Dornoch Firth and Morrich More SAC, Habitats Regulations Appraisal (HRA) will be required for harbour seals (Moray Offshore Windfarm (West) Ltd 2018).

4.2 Grey Seal

Grey seals are the larger of the two species of seal resident in UK waters. They haul-out on land to rest, moult and breed and forage at sea where they range widely, frequently travelling for up to 30 days with over 100 km between haul-out sites (SCOS 2017). Approximately 38% of the worlds grey seal population breeds in the UK with 86% of these breeding in Scotland. Grey seal population data are assessed using pup counts during the autumn breeding season when females haul-out to give birth. The number of pups throughout Britain has grown steadily since the 1960s but there is clear evidence that the population growth is levelling off in all areas except the central and southern North Sea where growth rates remain high.

In the UK, grey seals typically breed on remote uninhabited islands or coasts and in small numbers in caves. Preferred breeding locations allow females with young pups to move inland away from busy beaches and storm surges. Seals breeding on exposed, cliff-backed beaches and in caves may have limited opportunity to avoid storm surges and may experience higher levels of pup mortality as a result. UK grey seals breed in the autumn, but there is a clockwise cline in the mean birth date around the UK. The majority of pups in south west Britain are born between August and September, in north and west Scotland pupping occurs mainly between September and late November and eastern England pupping occurs mainly between early November to mid-December.

The grey seal is considered to have a "Favourable Conservation Status" in the UK (JNCC 2013). The most recent UK wide grey seal pup production count was in 2014, which produced a total UK pup production estimate of 60,500 (95% CI: 53,900 to 66,900), which, modelled to estimate the non-pup portion of the population, gives an estimate of 139,800 aged 1+ grey seals in the UK (95% CI: 116,500 to 167,100) (SCOS 2017).

The following sections describe the available data on grey seals in relation to the Moray West Site, in order to determine their spatial and temporal patterns of abundance and density.

4.2.1 SMRU August Haul-Out Counts

The number of grey seals counted during the August haul-out surveys has varied considerably between years within the Moray Firth Seal Management Area, with lowest counts of 392 in 2002 and highest in 2015 with 1917 (Figure 4-8). Grey seals haul-out for approximately 0.35 (95% CI: 0.32 to 0.38) of the survey time (Lonergan *et al*. 2011). Therefore, the counts can be scaled to produce population estimates for the Moray Firth MU. The most recent grey population estimate for the Moray Firth MU is for 2016 with a value of 3,577 (95% CI: 3,295 to 3,913). Most of the grey seals counted during the August surveys are located in the inner Moray Firth, between Loch Fleet and Findhorn, with concentrations of counts in the Dornoch Firth, Ardersier, Culbin, Lothbeg and Findhorn (Figure 4-9).

It is important to note that since the timing of the surveys are conducted to coincide with the harbour seal moult, these surveys are not conducted during a key haul-out period for grey seals. Counts of greys seals during these surveys can be highly variable and although these counts are not used as a population index, they provide useful information on the distribution of grey seals in August.

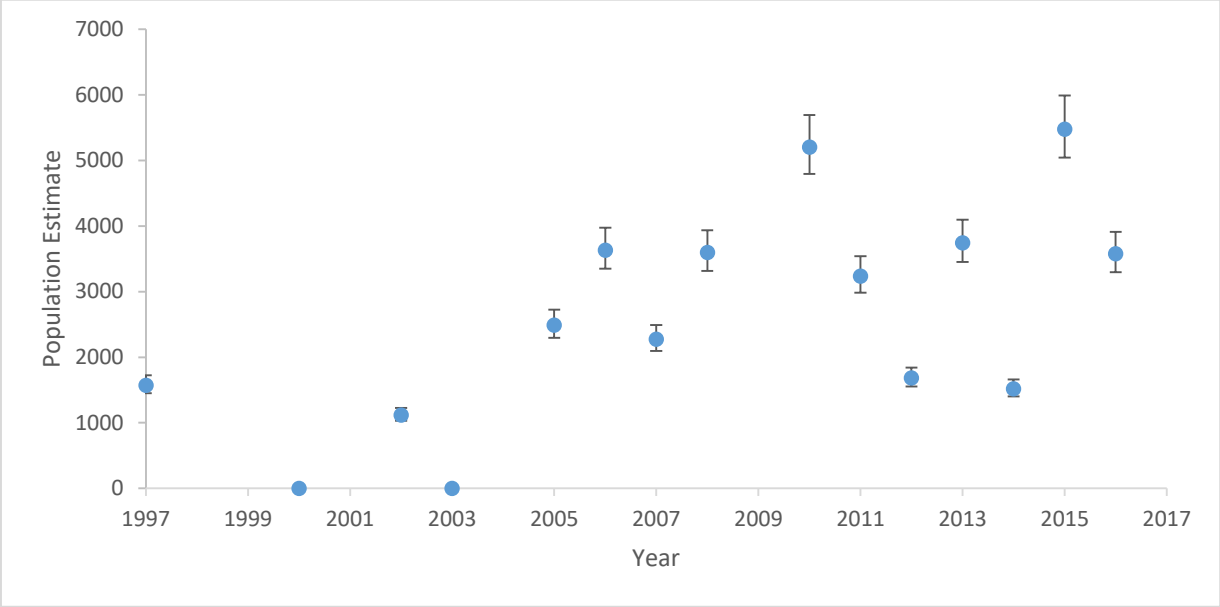

Figure 4-8: Grey seal population estimates (based on scaled raw counts from August surveys) for the Moray Firth MU. Error bars show 95% CIs.

4.2.1.1 Landfall Site

The export cable landfall will be located between the west end of Sandend Bay to Redhythe Point on the Moray/ Aberdeenshire coastline. There are known grey seal haul-out sites immediately adjacent to this landfall area, one at Cullen and one at Port Soy (Figure 4-9). The last count at Cullen was in 1997 where eight seals were counted and in Port Soy two seals were counted in 2005. There are several other known grey seal haul-out sites along the coast adjacent to the export cable corridor and landfall area (Table 4-4). These haul-out sites do not represent major grey seal haul-outs, however, the haul-out at Findochty supported 40 grey seals in 2013. As stated above, these counts cannot be used as a population index, but do provide useful information on the distribution of grey seals in the month of August. These haul-out sites are not considered to be important breeding or moulting haul-out sites for grey seals.

Table 4-4: Location of the grey seal haul-out sites surveyed between 1997 and 2016 that are located adjacent to the export cable corridor and landfall area

Year	Haul-out	Latitude	Longitude	Count	Distance (km)
1997	Portsoy	57.691194	-2.667575	3	3
1997	Cullen	57.701288	-2.78689	8	<0.2
2005	Port Soy	57.683317	-2.627182	8	5.4
2005	Port Soy	57.688596	-2.649077	5	4
2005	Port Soy	57.698583	-2.788509	2	0.4
2005	Buckie	57.694022	-2.931003	25	8
2005	Buckie	57.693998	-2.934358	11	8
2007	Portsoy	57.688587	-2.650755	12	4
2007	Portsoy	57.687663	-2.65577	4	4

Table 4-4: Location of the grey seal haul-out sites surveyed between 1997 and 2016 that are located adjacent to the export cable corridor and landfall area

Year	Haul-out	Latitude	Longitude	Count	Distance (km)
2007	Findochty	57.694022	-2.931003	14	8
2011	Boyne Bay	57.681018	-2.62144	6	6
2013	Boyne Bay E	57.683111	-2.625249	25	5.5
2013	Findochty	57.693459	-2.931928	40	8
2013	Port Gordon	57.668243	-3.003618	1	13
2013	Port Gordon	57.667977	-3.004281	17	13
2013	Port Gordon	57.667289	-3.00505	3	13
2016	Port Gordon	57.667766	-3.003676	1	13

4.2.2 SMRU Breeding Counts

Grey seal pup production at surveyed breeding sites in the Moray Firth has remained stable over the last 10 years, while in the Orkney MU has increased by an average of 3.84% per year (Table 4-5). The closest grey seal breeding site to the Moray West wind farm site is approximately 21 km away. These data demonstrate that there is a stable population of breeding grey seals in the Moray Firth MU and an increasing breeding population in the Orkney MU.

Table 4-5: Grey seal pup production counts between 2005 and 2014 for the Moray Firth and the Orkney Management Units

	2005	2006	2007	2008	2009	2010	2012	2014
Moray Firth MU	**1,174**	**1,284**	**1,201**	**1,201**	**1,098**	**1,043**	**1,602**	**1,658**
Helmsdale to Dunbeath	1,174	1,284	1,201	1,201	1,098	1,043	1,003	1,032
Dunbeath to Wick	-	-	-	-	-	-	163	231
Duncansby Head	-	-	-	-	-	-	436	395
Orkney MU	**17,643**	**18,966**	**18,805**	**18,415**	**18,715**	**19,850**	**22,470**	**22,783**
Faray & Holm of Faray SAC	2,833	3,148	3,315	2,788	2,709	3,192	3,152	3,074

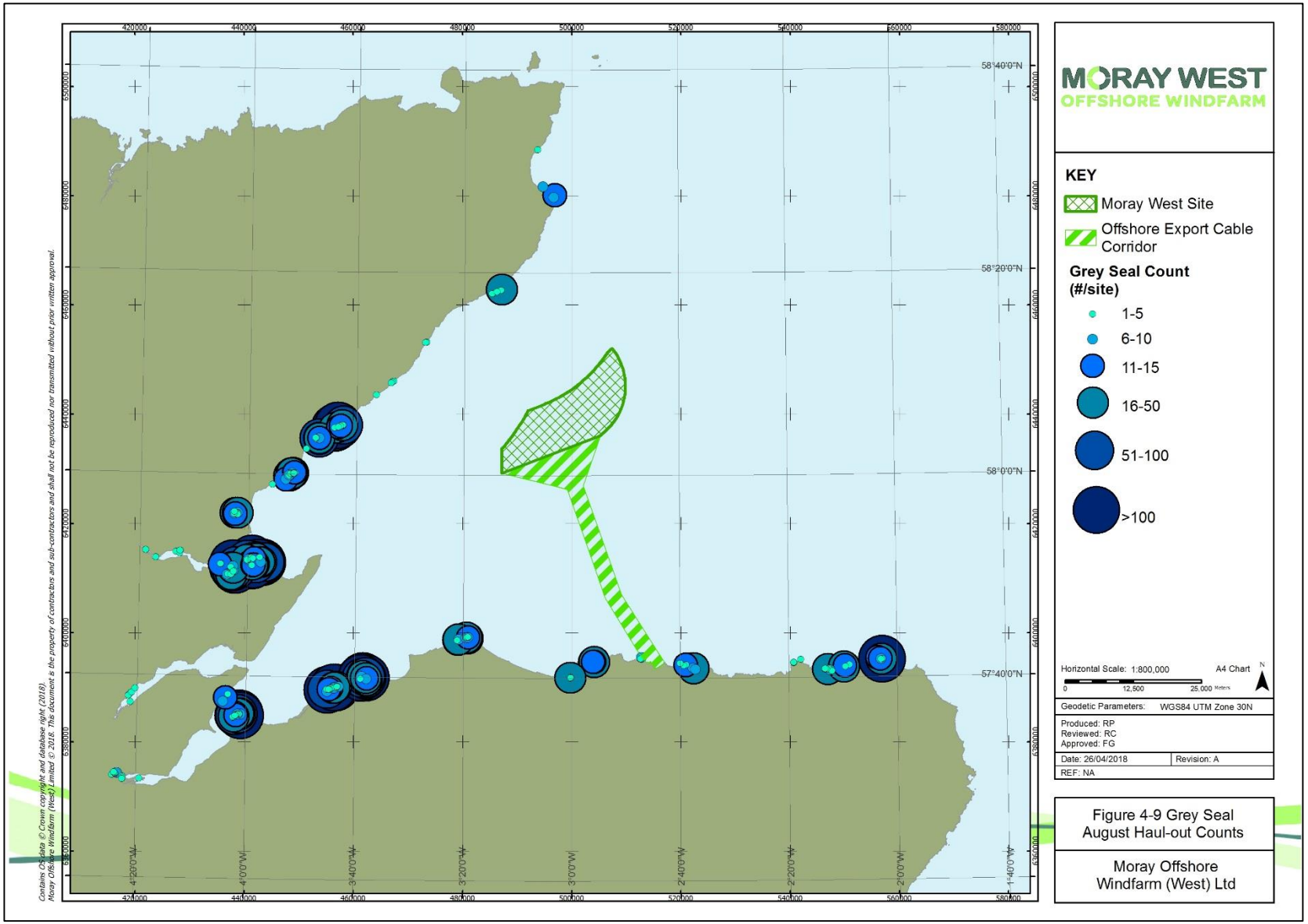

Figure 4-9: Grey seal haul-out counts during the SMRU August moult count between 1997 and 2016.

4.2.3 Telemetry Data

Grey seals are known to travel further than harbour seals, and they can travel over 100 km from haul-out sites (SCOS 2016). For this reason, a 100 km buffer was placed around the Moray West Site and the grey seal telemetry data within this area is presented here (this replicates the approach taken in the Moray East ES (2012)). Since 1993, 69 tagged grey seals have recorded telemetry tracks that are within a 100 km buffer of the Moray West wind farm site (Figure 4-10). Of these, 30 were tagged in the Orkney and the North Coast MU and 28 were tagged in the East England MU (Table 4-6). The mean tag duration for these 69 grey seals was 126 days (range 1 to 252). Of the 69 grey seals, 43 were adults (aged 1+), 22 were pups and four were of unknown age; and 28 were female, 37 were male and four were of unknown sex.

These data show that there is connectivity between the Moray Firth and the following four SACs where grey seals were the primary qualifying feature for site selection: Berwickshire and North Northumberland Coast, Isle of May, Faray and Holm of Faray and North Rona. They also show connectivity with the Humber Estuary SAC which lists grey seals as an Annex II species as a qualifying feature.

Within the 100 km buffer around the Moray West wind farm site, most of the telemetry tracks are located around the Orkney Islands and the Aberdeenshire coastline, with very little telemetry data in the inner Moray Firth or overlapping with the Moray West wind farm. It should, however, be highlighted that there have been no grey seals tagged at Loch Fleet or the Dornoch Firth and so the usage of these areas are likely to be underestimated by the telemetry data.

Table 4-6: The number of grey seals with telemetry tracks within the 100 km buffer around the Moray West wind farm site and the Management Unit they were tagged in

MU	Location	1992	1993	1995	1996	1997	1998	2000	2001	2002	2003	2004	2005	2006	2008	2010
E Coast	Abertay, Eden, Isle of May					2	7		3	5	3	1	2	1	4	
NE England	Farnes	1				2		1							3	
Orkney & N Coast	various[10]		3		7		6									14
SE England	Donna Nook												1			
Shetland	Mousa						1									
W Isles	Monarchs			2												

[10] Eynhallow, Gairsay, Greenholm, Sweyn Holm, Sanday, Stroma, Taing Skerry

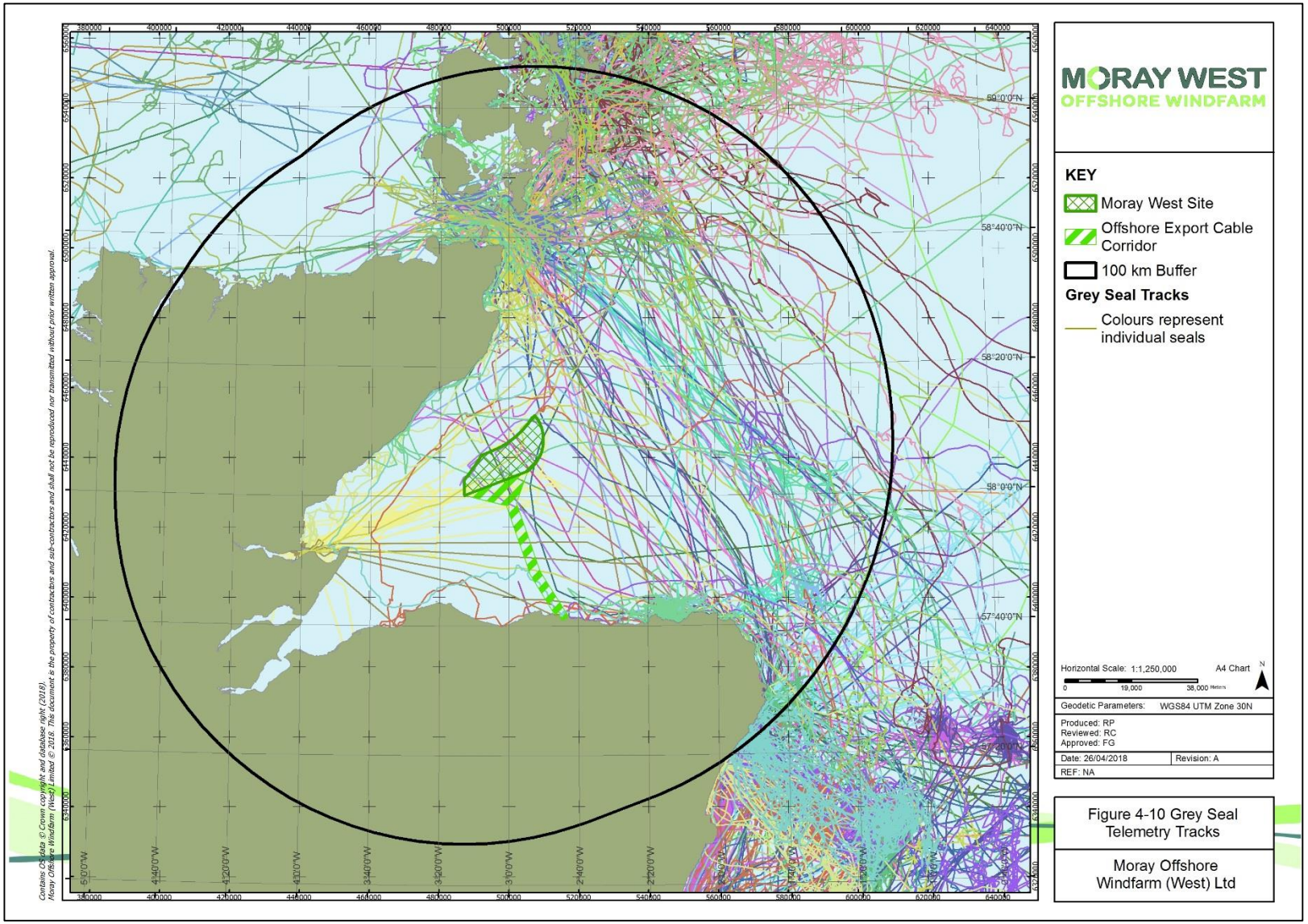

Figure 4-10: Tracks of all grey seals tagged between 1992 and 2010 that had telemetry tracks within the 100 km buffer around the Moray West wind farm site.

4.2.4 At-Sea Usage

The grey seal at-sea usage maps show that grey seals are not predicted to be evenly distributed within the Moray Firth. There are hotspots of higher predicted densities at the very north of the Moray Firth and around the Orkney Islands, and in the waters to the north and around the entrance to the Dornoch Firth and Morrich More SAC.

The grid cell with the maximum density within the 25 km buffer around the Moray West Site has an estimated mean at-sea density of 150.3 seals/cell which, assuming uniform distribution within a grid cell equates to 6.0 seals/km^2. This high density cell is located adjacent to the south west corner of the Moray West Site.

4.2.5 Visual Surveys in the Moray Firth

Grey seals were sighted regularly during the boat based surveys of the Moray East wind farm site between April 2010 and March 2012. During the 28 surveys conducted in this study, there were a total of 178 grey seal sightings and 121 unidentified seal species sightings recorded within the Moray East wind farm site and the 4 km buffer round the site. Grey seal sightings occurred year round but with a peak in sightings in spring (April) and late summer (August). These data were analysed with Distance to produce a density estimate of 0.05 grey seals/km^2 within the Moray East wind farm site (95% CI: 0.03 to 0.07) and 0.04 grey seals/km^2 within the 4 km buffer zone around the Moray East wind farm site (95% CI: 0.03 to 0.06).

4.2.6 Hi-Def Aerial Surveys

During the 12 months of aerial surveys a total of seven grey seals have been identified from survey photographs which made up 3% of the total number of marine mammal sightings. Additionally, there were four sightings of unknown seal species and six sightings of unknown seal/small cetaceans (Figure 4-12).

4.2.7 Conclusion

The grey seal is considered to have a “Favourable Conservation Status” in the UK. Grey seals haul-out within the Moray Firth, though August haul-out counts vary considerably between years. The most recent grey seal population estimate for the Moray Firth MU based on the 2016 August count is 3,577 grey seals, which are located mainly Loch Fleet and Findhorn, with concentrations of counts in the Dornoch Firth, Ardersier, Culbin, Lothbeg and Findhorn. There are grey seal haul-outs within and adjacent to the export cable landfall between Portknockie and Portsoy, however these haul-out sites are not considered to be important breeding or moulting haul-out sites for grey seals. Telemetry data show that grey seals that have tracks within the Moray Firth also show connectivity with the Berwickshire and North Northumberland Coast SAC, the Isle of May SAC, the Faray and Holm of Faray and North Rona SAC and the Humber Estuary SAC. Most of the telemetry tracks show grey seal movement located around the Orkney Islands and the Aberdeenshire coastline, with very little telemetry data in the inner Moray Firth or overlapping with the Moray West Site.

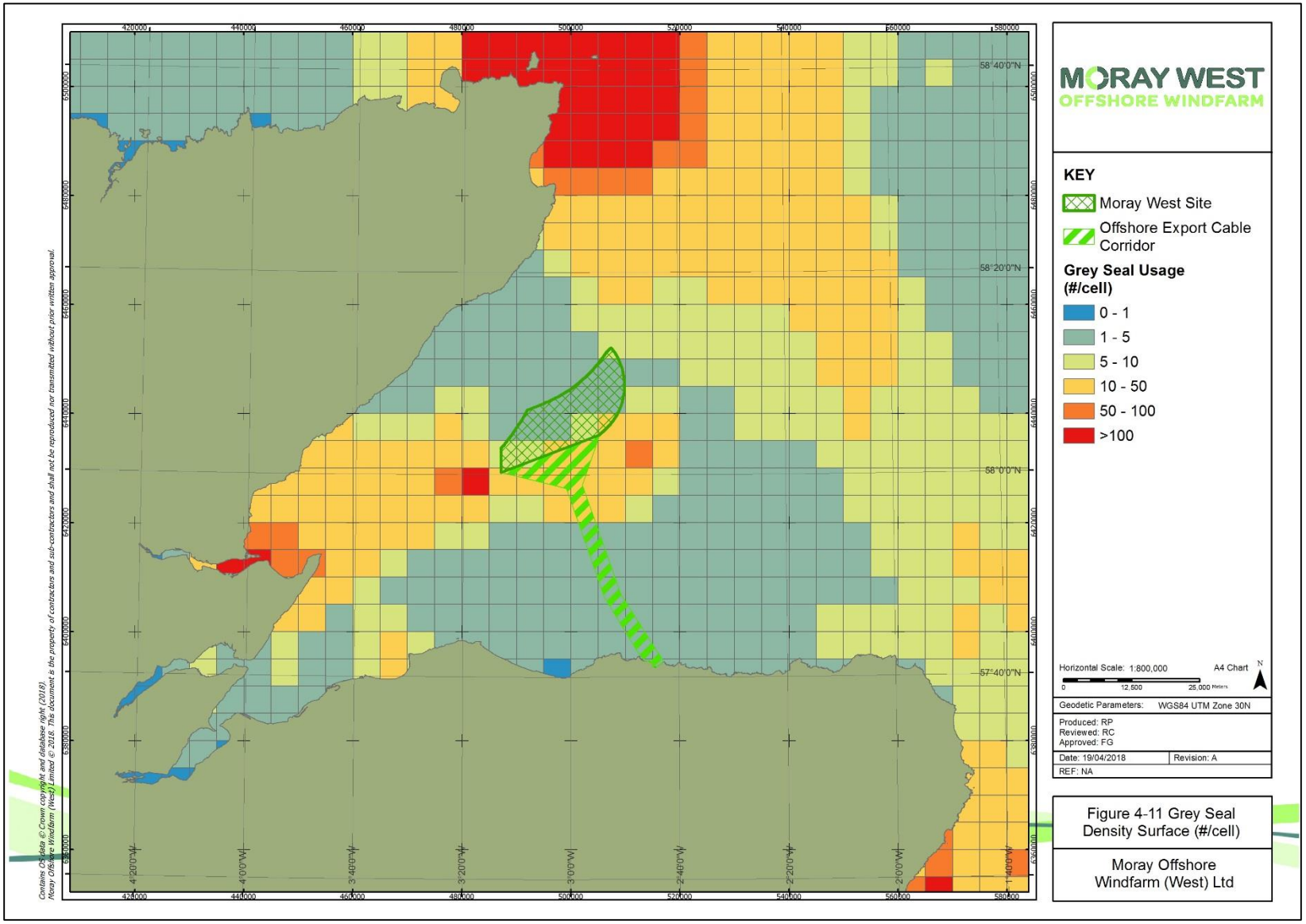

Figure 4-11: Grey seal at-sea usage showing the mean estimated number of animals in each 5 km x 5 km grid cell (Jones and Russell 2016).

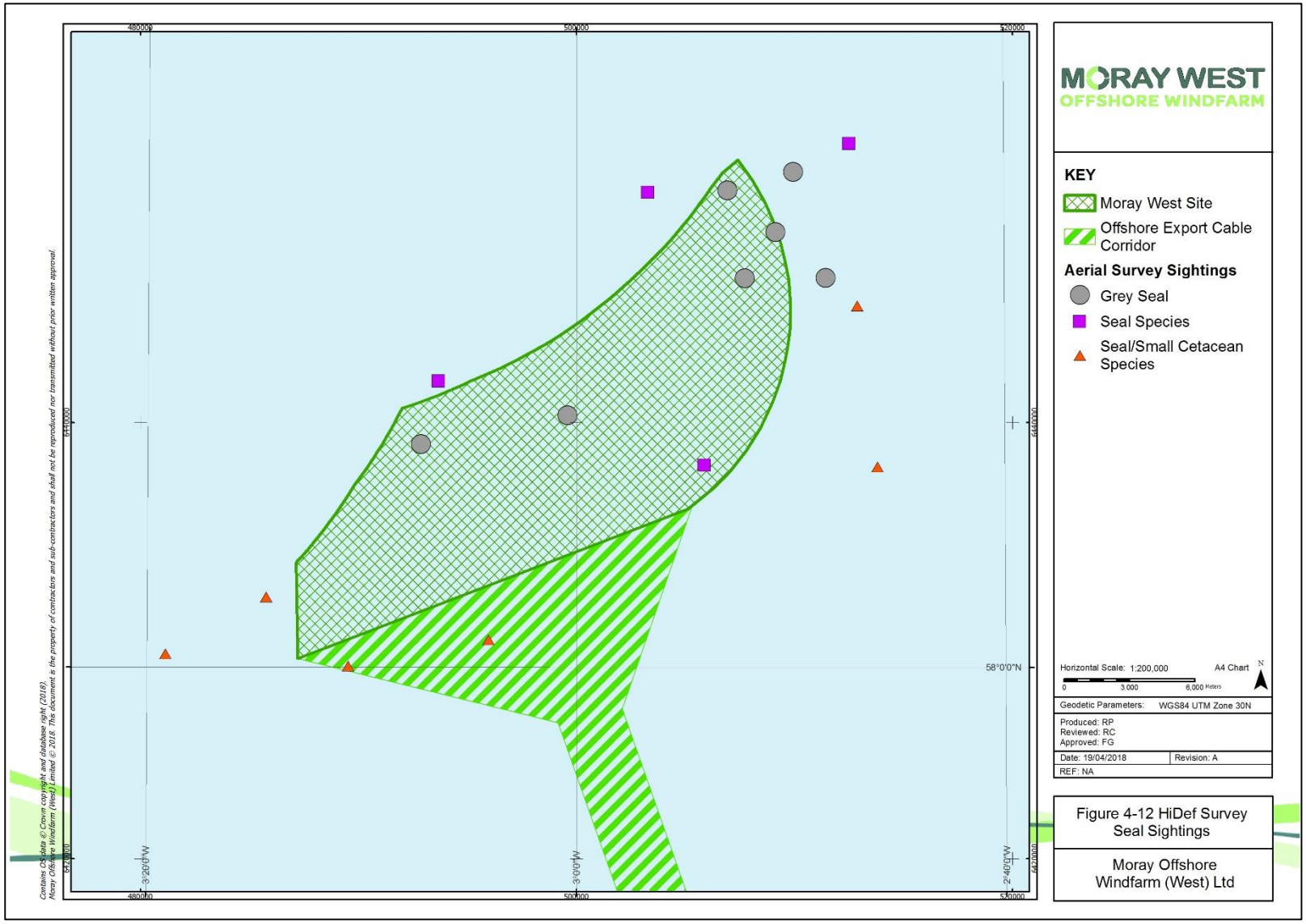

Figure 4-12: Location of grey seals, unknown seal species and unknown seal/small cetacean species during the monthly HiDef aerial surveys of the Moray West Site between April 2016 and March 2017.

4.3 Bottlenose Dolphin

In the UK, bottlenose dolphins are considered to have a "Favourable Conservation Status" (JNCC 2013). The Moray Firth population of bottlenose dolphins is the only known remaining resident population in the North Sea and it was for this reason that the Moray Firth SAC was established in order to protect this population. The conservation objectives of the Moray Firth SAC are to avoid the deterioration of the bottlenose dolphin habitat, to achieve a favourable conservation status and to ensure the population size and distribution of the bottlenose dolphins is maintained in the long-term.

Analysis of stomach contents from bottlenose dolphins stranded around Scotland reveal that their main prey species are cod (*Gadas morhua*), saithe (*Pollachius virens*) and whiting (*Merlangius merlangus*) with other fish species such as salmon (*Salmo salar*) and haddock (*Melanogrammus aeglefinus*) and cephalopod species were also present (Santos *et al*. 2001).

The following sections describe the available data on bottlenose dolphins in the Moray Firth and, specifically, in relation to the Moray West Site, in order to determine their spatial and temporal patterns of abundance and density.

4.3.1 Bottlenose Dolphin Photo-ID Surveys

The current population estimate of bottlenose dolphin abundance for the Coastal East Scotland MU population is 195 individuals (95% Highest Posterior Density Intervals (HPDI): 162 to 253) based on photo-ID counts between 2006 and 2007 (Cheney *et al*. 2013). This resulted in a population growth rate estimate of 1.018 (Cheney *et al*. 2013). The results of further surveys suggests that the east coast Scotland population has continued to increase in size since 2007, therefore the current population size is likely to be larger than this (Figure 4-13)(Graham *et al*. 2016).

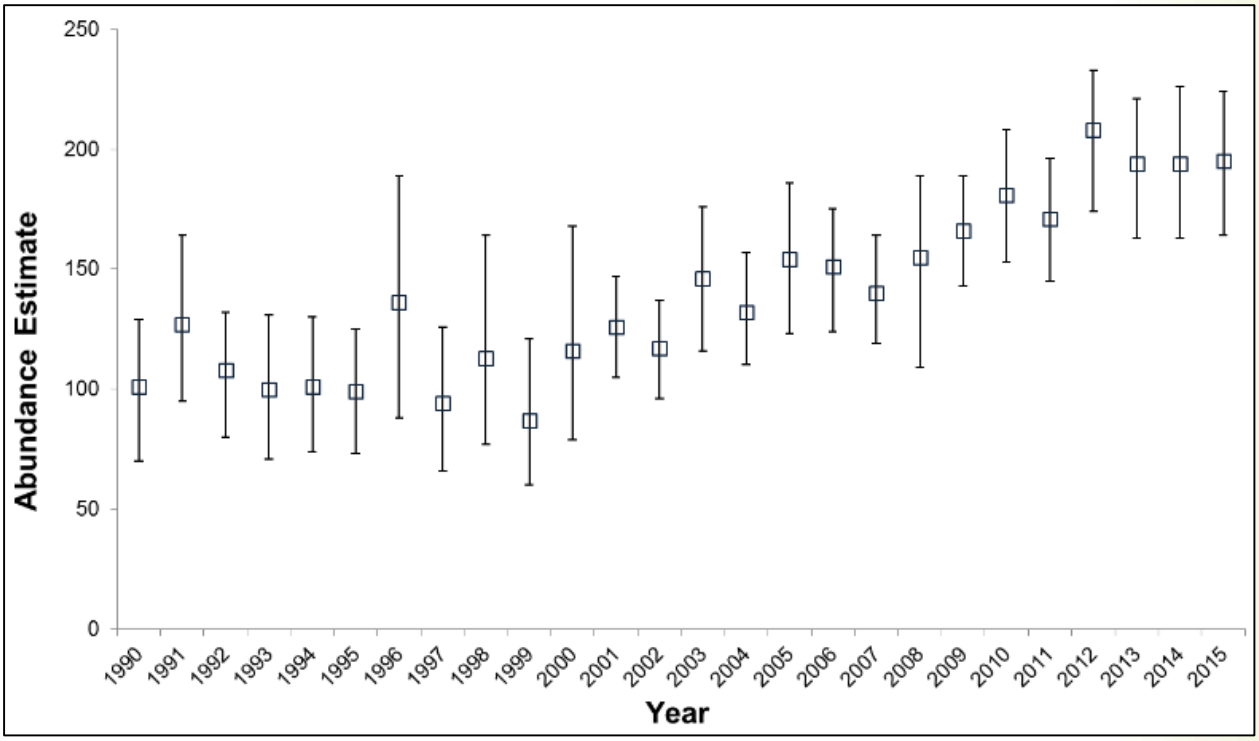

Figure 4-13: Annual estimates of the east coast of Scotland bottlenose dolphin population from1990 to 2015 with 95% highest posterior density intervals (HPDI) (Graham *et al*. 2016).

Between 1990 and 2015 the number of individuals using the SAC has remained stable, with some inter-annual variability, at 98 individuals (95% CI: 83 to 116). Whilst the population size has increased, the relative proportion of the population that uses the SAC has declined (Graham *et al*. 2016). Though the

Moray Firth is clearly an important area for this population, they are not restricted to the either the Moray Firth SAC or the wider Moray Firth. Instead, these animals are highly mobile, and have a large range that extends east along the outer Moray Firth coastline and south to the Firth of Forth (Cheney *et al*. 2013).

Breeding in bottlenose dolphins is usually seasonal and varies with location; in the Moray Firth the peak calving period is in the late summer. As a result of the photo-ID surveys, the reproductive histories are known for 56 females with 106 calves in the SAC between 2001 and 2015, with an average of seven calves born each year (range 3 to 13) (Graham *et al*. 2016). The survival rate for bottlenose dolphins in the SAC has been estimated as 0.93 (95% CI: 0.91 to 0.94) based on data from 161 well marked animals sighted between 1990 and 2014 (Graham *et al*. 2016).

Overall, the long-term photo-ID data have shown that the Moray Firth bottlenose dolphin population has increased since 1990 and is currently considered a healthy population with a "Favourable Conservation Status".

4.3.2 Visual Surveys in the Moray Firth

The five visual survey studies conducted in the Moray Firth between 2004 and 2012 have shown that bottlenose dolphins are primarily located in the Moray Firth SAC and in coastal waters. This does not, however, mean that bottlenose dolphins are completely absent from the outer Moray Firth and from offshore waters. Bottlenose dolphins were sighted during the boat based transect surveys of the MORL sites, the BOWL site and the outer Moray Firth. While the presence of bottlenose dolphins in the development area cannot be ruled out, it can be surmised that these offshore areas are not an important habitat for bottlenose dolphins and that sightings are rare in comparison to the Moray Firth SAC and the coastal areas. The boat based transect surveys of the MORL sites between 2010 and 2012 show that bottlenose dolphin sightings were rare (1 sighting in 28 surveys) compared to other dolphin species such as common dolphins (64 sightings) or white-beaked dolphins (188 sightings) (Table 4-7).

Table 4-7: Sightings of dolphin species during the five visual survey studies of the Moray Firth (Moray East ES 2012)

Species	Aerial			Boat-Based			
	BOWL/MORL	Central	Coast	SAC	Outer MF	MORL	BOWL
Bottlenose dolphin	0	0	26	56	1	1	4
Unidentified dolphin	1	1	1	0	1	66	6
Common dolphin	1	2	3	0	0	64	1
White-beaked dolphin	1	0	1	0	0	188	0
Risso's dolphin	1	0	0	0	0	1	0

4.3.3 Acoustic Studies in the Moray Firth

The CPOD studies in 2009, 2010 and 2011 showed that dolphins were detected regularly in the inner Moray Firth and along the southern Moray Firth coast; with detections also recorded in the more offshore locations within the Moray Firth, including at CPOD sites within the MORL development area (Figure 4-14) (Thompson *et al*. 2010, Thompson *et al*. 2011, Moray East ES 2012, Thompson *et al*. 2014). Since CPODs only detect "dolphins" and cannot identify the sounds to species level, these data were then analysed using the sightings data and a classification tree to estimate the likelihood that these CPOD detections were bottlenose dolphins. This analysis concluded that the dolphin detections at CPOD locations within the Moray West wind farm site were more likely to be other dolphin species such as common or white-

beaked dolphins than bottlenose dolphins (Figure 4-15). This was further confirmed with the acoustic data collected by the EARs in 2010 which demonstrated, using a whistle classifier (Booth *et al*. 2011), that the detections across the MORL site were either dolphin species other than bottlenose dolphins or false detections.

The results of the classification tree analysis and the habitat modelling provided the probability of bottlenose dolphins occurring in grid cells across the Moray Firth. This habitat model showed that the probability of detecting a bottlenose dolphin in any given hour was up to 0.117 (11.7%) in any one grid cell, and that bottlenose dolphins were more likely to be detected in coastal waters, especially along the southern coast of the Moray Firth, compared to offshore waters (Figure 4-16) (Thompson *et al*. 2014).

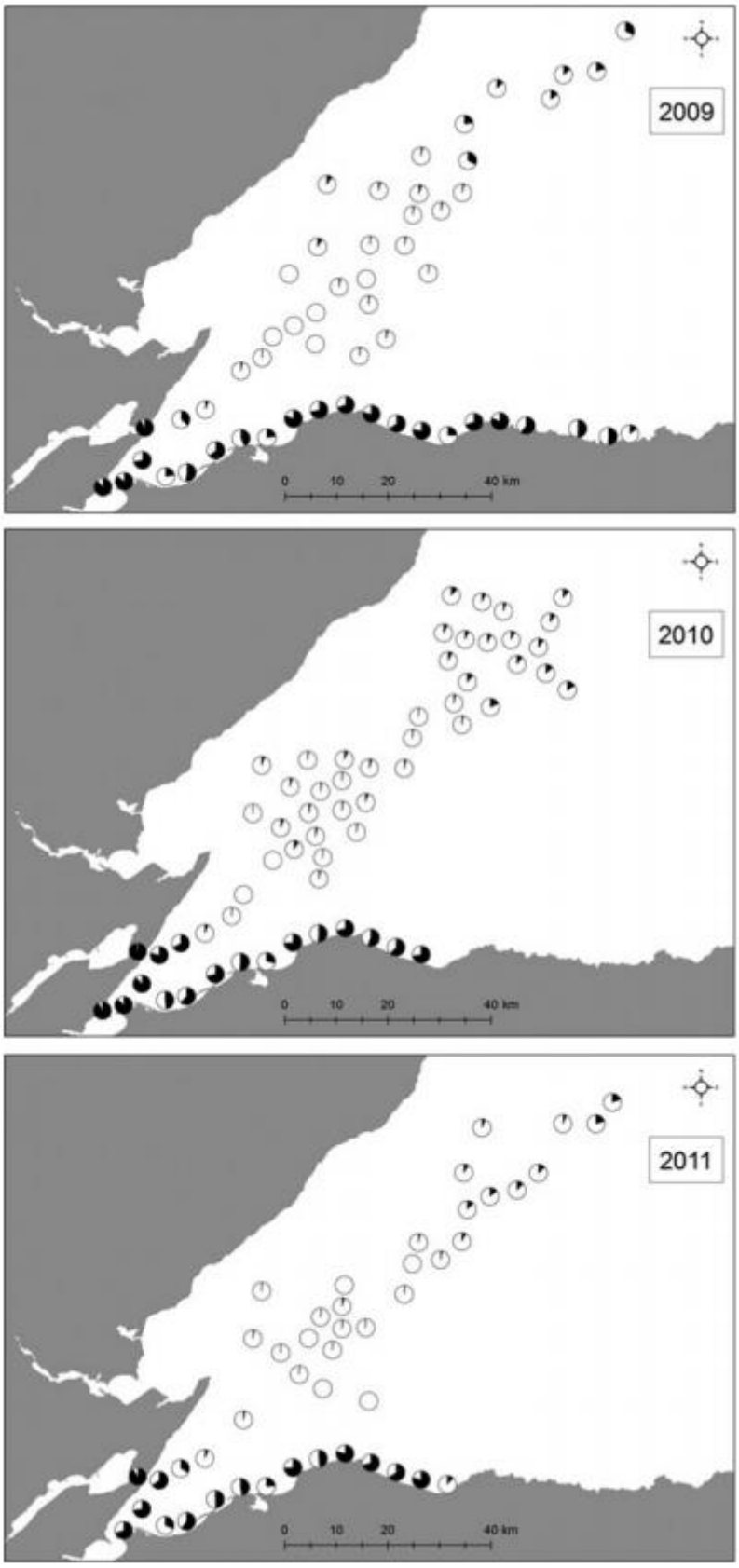

Figure 4-14: Variation in the occurrence of dolphins at different PAM sites in August, September, and October 2009, 2010, and 2011 (Thompson *et al*. 2014). Each site is represented with a pie chart, with the filled section of the pie chart representing the proportion of days that dolphins were detected.

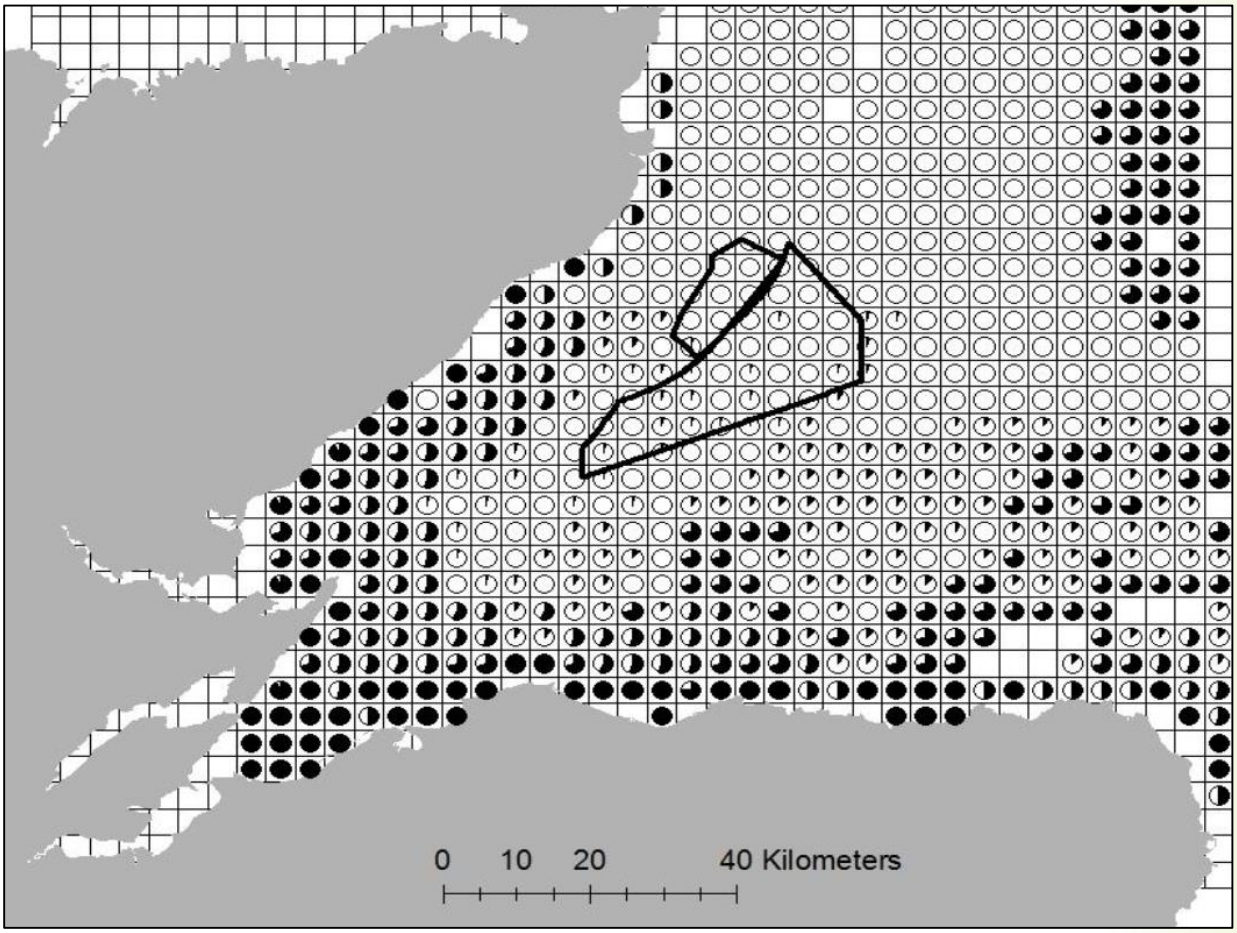

Figure 4-15: Prediction of the likelihood that dolphins encountered in each 4x4 km grid cell are bottlenose dolphins (black portion of pie chart) (Moray East ES 2012).

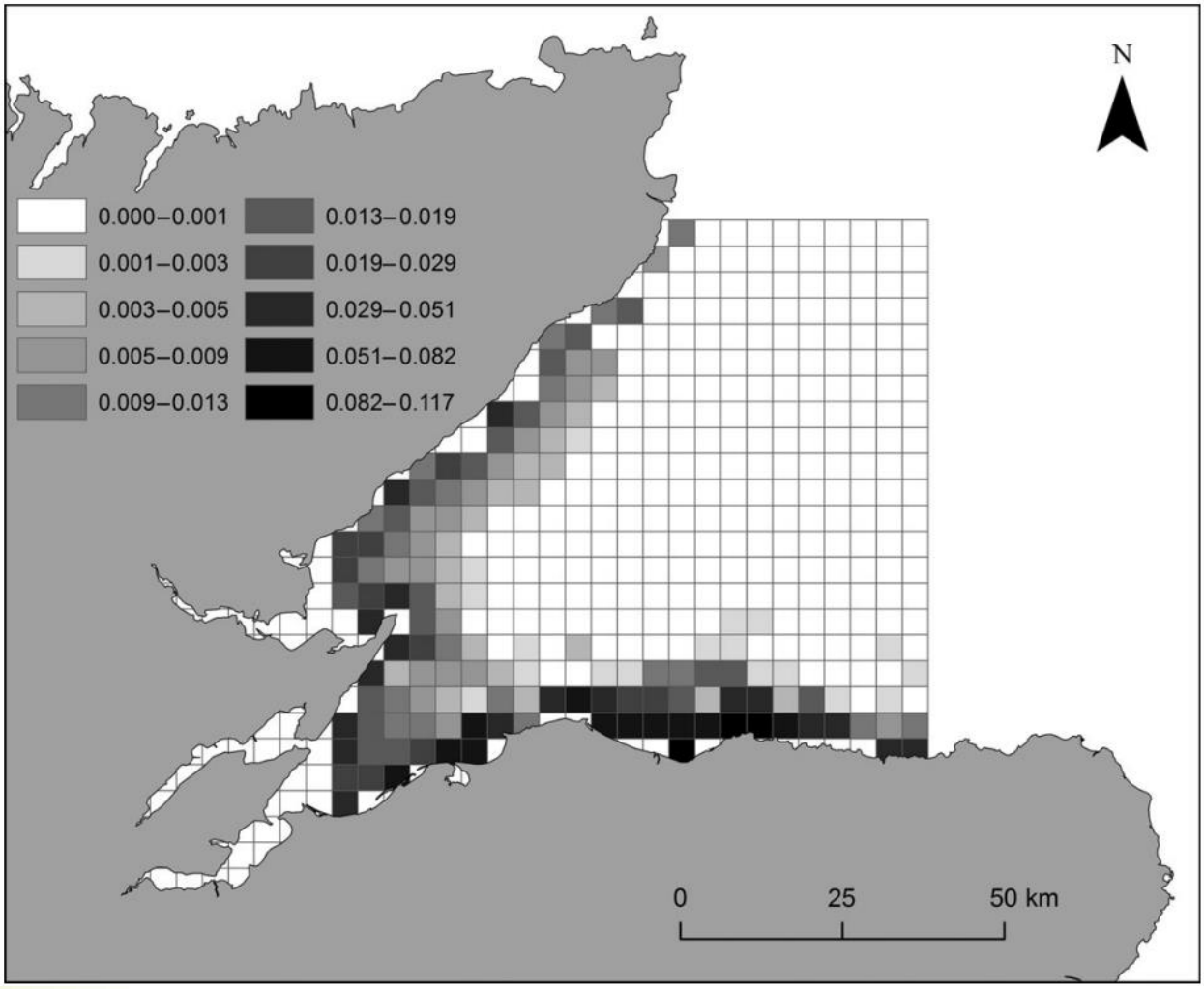

Figure 4-16: Spatial variation in the predicted probability of bottlenose dolphin occurrence across the Moray Firth. Predictions for each cell are based on the outputs from both the GEE and the classification tree analyses, and represent the probability of bottlenose dolphins occurring in that cell in any given hour (Thompson *et al*. 2014).

4.3.3.1 Long term CPOD sites and the BOWL MMMP

The results from the PAM data collected at the four long-term monitoring sites in the Moray Firth have shown that the percentage of dolphin positive days and the median detection positive hours was highest at all sites between May and August (Table 4-8). Both the percentage dolphin positive days and the median dolphin positive hours showed that the sites located in the inner Moray Firth SAC (Sutors of Cromarty and Chanonry) had higher dolphin detection rates than the sites located along the outer southern coast of the Moray Firth (Lossiemouth and Spey Bay).

Table 4-8: Percentage of dolphin positive days and median dolphin positive hours by month across the four long-term CPOD monitoring sites in the Moray Firth

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
% Dolphin Positive Days												
Chanonry	53.8	47	43	89	92.1	98.7	98.7	99	96	79.7	80.2	68.4
Lossiemouth	46	55	64	77	81.2	85.2	75.8	81	71	42.9	61.6	59.4
Spey Bay	19.4	27	40	72	90.9	94.6	89.9	84	83	62.3	55.1	52.4

Table 4-8: Percentage of dolphin positive days and median dolphin positive hours by month across the four long-term CPOD monitoring sites in the Moray Firth

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sutors	79.6	80	65	92	100	100	99.3	99	93	95.9	99.1	93.3
Median Dolphin Positive Hours												
Chanonry	1	0	0	3	4	5	7	7	5	3	3	2
Lossiemouth	0	1	1	2	2	2	2	2	1	0	1	1
Spey Bay	0	0	0	2	4	4	3.5	3	2	1	1	1
Sutors	2	1	1	5	11	10	9	8	4	7	6	5

4.3.3.2 ECOMMAS surveys

Of the five ECOMMAS PAM site groups in the Moray Firth, Cromarty had the highest proportion of dolphin positive days with site Cromarty 05 having between 89 and 96% of the survey days with dolphin detections (Table 4-9). There was also a consistent pattern of declines in the proportion of dolphin positive days with increasing distance from the coast at all site groups except Fraserburgh and Spey Bay.

Table 4-9: Proportion of survey days in which dolphins were detected (dolphin positive days) at each of the 15 ECOMMAS CPOD sites in the Moray Firth between 2013 and 2016

Site	2013	2014	2015	2016
Cromarty 05	0.89		0.95	0.96
Cromarty 10	0.32	0.43	0.37	0.36
Cromarty 15	0.02	0.00	0.04	0.01
Fraserburgh 05	0.13	0.30	0.11	0.06
Fraserburgh 10			0.00	0.00
Fraserburgh 15		0.04	0.08	0.10
Helmsdale 05	0.05	0.12	0.14	0.15
Helmsdale 10	0.00		0.02	0.04
Helmsdale 15	0.01	0.01	0.00	0.03
Latheron 05	0.19	0.02	0.20	0.27
Latheron 10	0.03		0.04	0.14
Latheron 15	0.04		0.01	0.05
Spey Bay 05	0.22	0.21	0.14	0.11
Spey Bay 10	0.00		0.00	0.00
Spey Bay 15		0.01	0.03	0.02

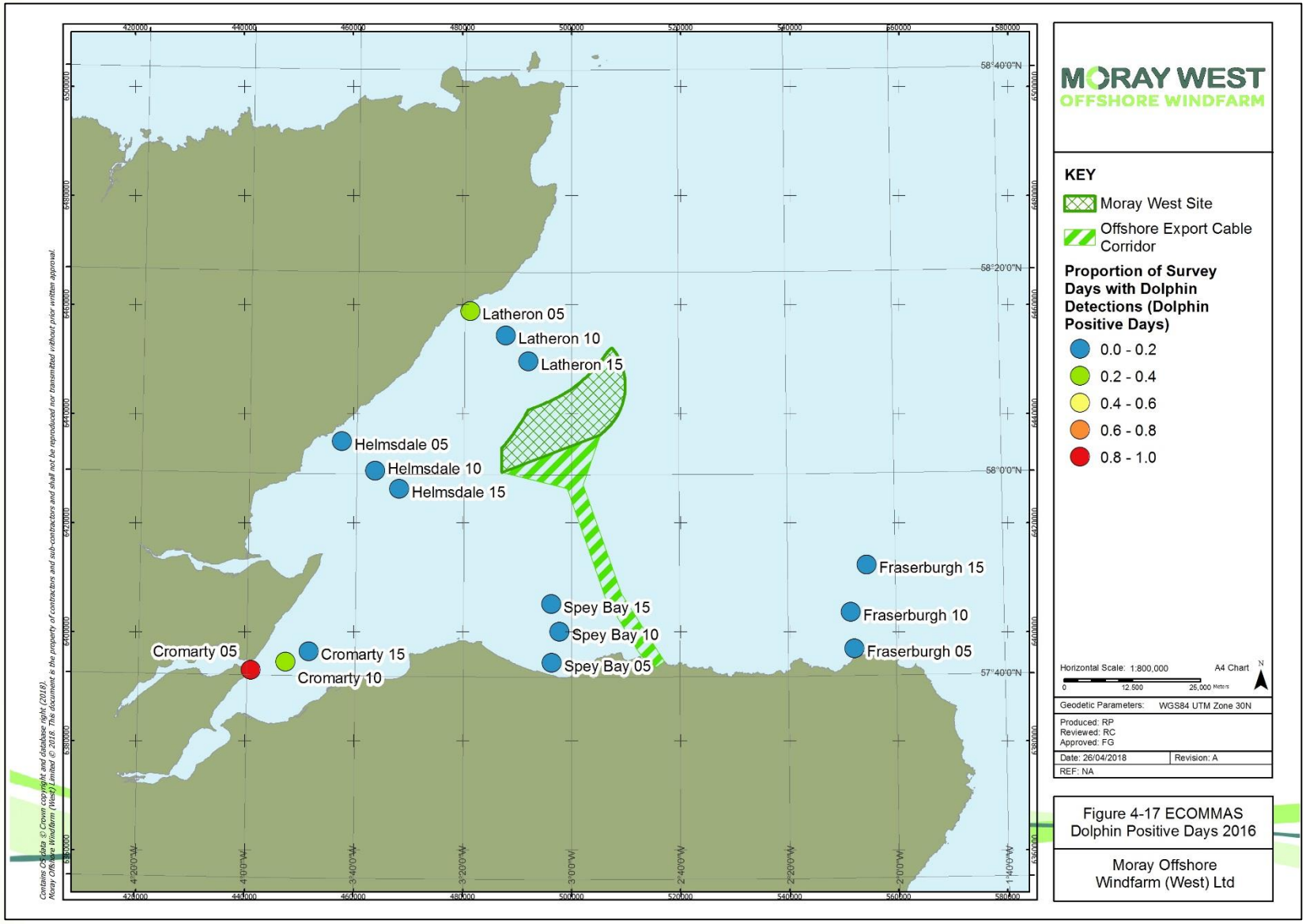

Figure 4-17: Proportion of dolphin positive days at each of the 15 ECOMMAS CPOD sites in the Moray Firth in 2016.

These data have been further analysed to separate the CPOD "dolphin" detection data into two groups: broad-band echolocation clicks (made by bottlenose and common dolphins) and frequency banded echolocation clicks (made by Risso's and white-beaked dolphins) (Palmer *et al*. 2017). The analysis of the CPOD data from the ECOMMAS surveys have shown that at the northern Moray Firth sites at Helmsdale and Latheron, the detections have mostly been frequency banded echolocation clicks (Figure 4-18) and so are likely to be either Risso's or white-beaked dolphins. At Cromarty, the detections were identified as predominantly broad-band echolocation clicks (Figure 4-18) and are most likely to be bottlenose dolphins. Along the southern coast of the Moray Firth, the Spey Bay detections were mainly broad-band (Figure 4-18) and so are attributed to either bottlenose or common dolphins and at Fraserburgh the detections were all frequency banded (Figure 4.14) and so were attributed to Risso's or white-beaked dolphins.

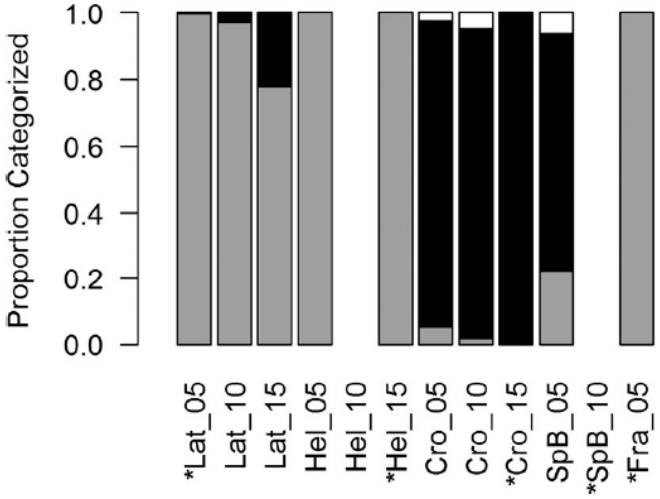

Figure 4-18: The proportion of click trains recorded at ECOMMAS PAM sites within the Moray Firth classified as broadband (black), frequency banded (grey) or unknown (white) by the combination of the Generalised Additive model (GAM) click-train classification and the encounter likelihood ratio (Palmer *et al*. 2017). Asterisks indicate joint C-POD/SM2M deployment locations from which training data were derived and where CPODs were displaced no data are presented.

The analysis of the ECOMMAS CPOD data by Palmer *et al*. (2017) highlights that the predicted probability of dolphin occurrence presented in Thompson *et al*. (2014) (Figure 4-16) was likely to have overestimated the probability of bottlenose dolphin occurrence along the northern coast of the Moray Firth. In order to provide a more realistic density surface for bottlenose dolphins in the Moray Firth, the dolphins in the grid cells located along the coast north of, and surrounding, Helmsdale and Latheron were re-distributed to other grid cells within the Moray Firth, based on the proportion of the total each cell contained (Figure 4-19). In addition to this, the number of dolphins present in each grid cell has been adjusted in order to reflect the fact that only approximately half the population is likely to be present in the Moray Firth at any one time (and available to be impacted), with the remaining population distributed further south along the east coast as far as the Firth of Forth (Cheney *et al*. 2013, Graham *et al*. 2016).

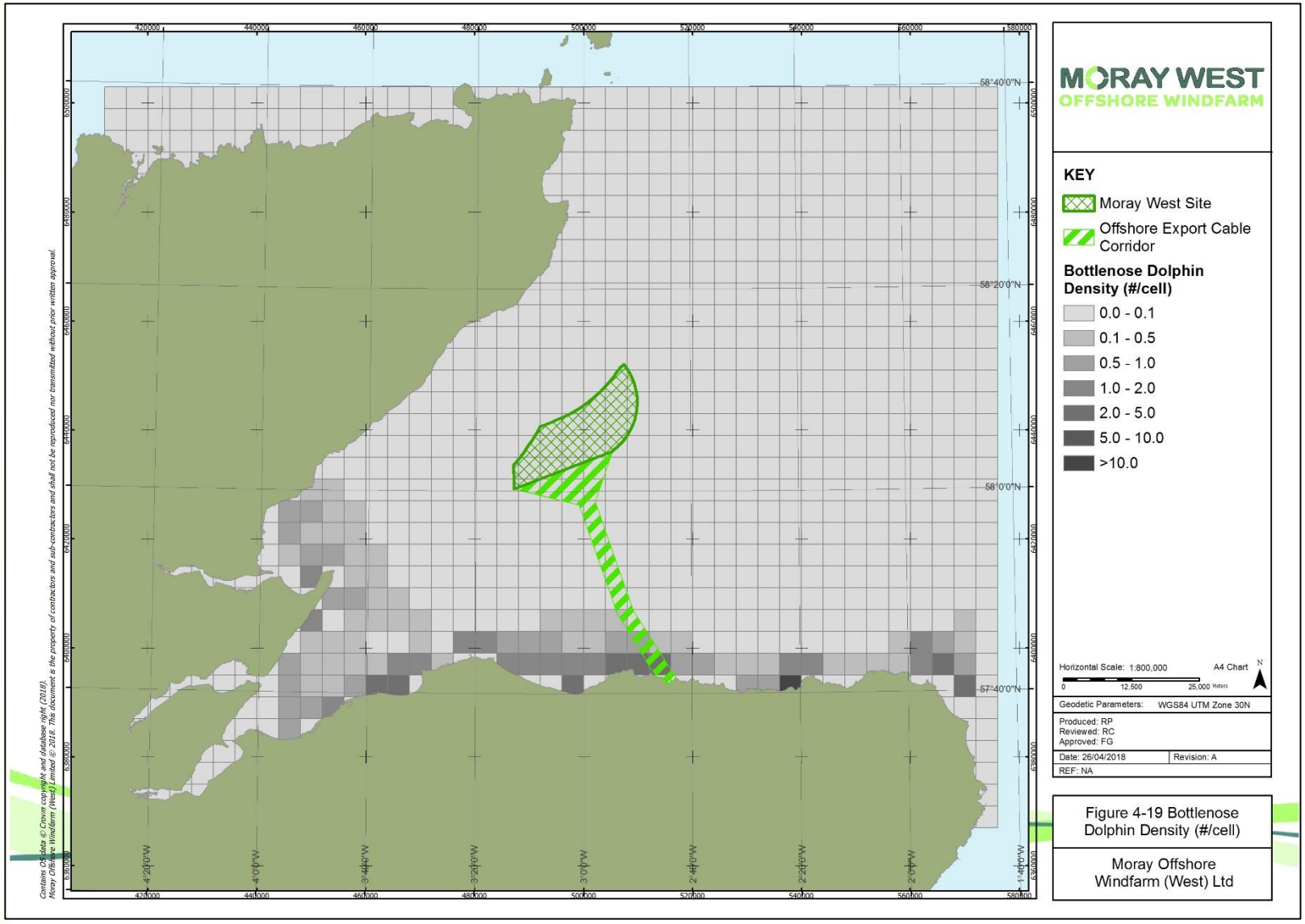

Figure 4-19: Revised spatial variation in bottlenose dolphin occurrence across the Moray Firth (revised in light of ECOMMAS data presented in Palmer *et al.*, 2017). Predictions for each cell represent the number bottlenose dolphins occurring in each 4x4 km cell.

4.3.4 SCANS Surveys

The SCANS II survey recorded the highest abundance of bottlenose dolphins in survey block J which includes the Moray Firth, Orkney and Shetland. The abundance estimate for this survey block was 412 (95% CI: 90 to 1,888) and a density estimate of 0.011 dolphins/km2 (95% CI: 0.0024 to 0.0504) (Burt *et al*. 2006a).

The SCANS III survey estimated abundance for block S was 151 bottlenose dolphins (95% CI: 0 to 527) with an estimated density of 0.004 dolphins/km^2 (Hammond *et al*. 2017). This is slightly lower than the abundance estimate for the Coastal East Scotland population derived from the dedicated photo-ID surveys of 195, however the SCANS III survey block S does not cover the full range of this population and so it was expected that the abundance estimate would be lower as it covers only the portion of the Coastal East Scotland population in the Moray Firth.

4.3.5 JCP Phase III

The JCP Phase III analysis provides estimated abundances for bottlenose dolphins in 2010 by season, and estimates highest abundance in the spring and summer months (250 to 230 animals respectively) (Table 4-10). This is slightly higher than the abundance estimate for the Coastal East Scotland population derived from the dedicated photo-ID surveys. However, as stated by Paxton *et al*. (2016), the abundance estimates produced by the JCP Phase III modelling will be less reliable than those obtained from a well-designed dedicated abundance survey given the assumptions made when standardizing the data and the spatial and temporal patchiness of the data available. Therefore, the abundance estimates obtained from the photo-ID surveys in the Moray Firth are likely to be better reflections of the true bottlenose dolphin abundance in the Moray Firth.

Table 4-10: Estimated bottlenose dolphin abundance (and 95% confidence intervals) for the Moray Firth in 2010 using the JCP Phase III data (Paxton *et al*. 2016)

	Winter	Spring	Summer	Autumn
Point Estimate	170	250	230	110
2.5%	60	60	80	40
97.5%	330	780	450	190

4.3.6 Conclusion

The Coastal East Scotland MU population of bottlenose dolphins has been increasing since 1990 and the current population estimate is 195 animals. This population extends between the Moray Firth and south along the east coast of Scotland to the Firth of Forth. The use of the Moray Firth SAC by this population varies from year to year, and in 2015 approximately half of the population used the SAC (Graham *et al*. 2016). The population is considered to be healthy and has a “Favourable Conservation Status”. The ECOMMAS acoustic surveys have determined that bottlenose dolphins are not present along the northern coast of the Moray at Helmsdale and Latheron, but are found mainly along the southern coast of the Moray Firth. Due to the proximity of the Moray West Site to the Moray Firth SAC for bottlenose dolphins, HRA will be required for bottlenose dolphins (Moray Offshore Windfarm (West) Ltd 2018).

4.4 Harbour Porpoise

Harbour porpoise are the smallest and most abundant cetacean species in UK waters (Reid *et al*. 2003). They are typically sighted in small groups between one and three individuals. Animals are frequently sighted throughout coastal habitats with studies suggesting they are highly mobile and cover large distances (Nabe-Nielsen *et al*. 2011). Harbour porpoise in the UK are considered to have a "Favourable Conservation Status" (JNCC 2013). The Moray West site is located within the ICES North Sea Assessment Unit for harbour porpoise, which is estimated to have an abundance of 345,373 porpoise (95% CI: 246,526 to 495,752) based on estimates from (Hammond *et al*. 2017).

The following sections describe the available data on harbour porpoise within the North Sea MU and, specifically, in relation to the Moray West site, in order to determine their spatial and temporal patterns of abundance and density.

4.4.1 SCANS Surveys

There were 32 sightings of harbour porpoise recorded during the SCANS I survey of Block J. From these data the abundance in Block J was estimated as 24,335 porpoise (CV 0.34) with a density of 0.784 porpoise/km^2. The SCANS II estimated abundance for survey Block J was considerably lower, at only 10,254 porpoise (95% CI: 5,005 to 20,888) and a density of 0.2736 porpoise/km^2 (95% CI: 0.1335 to 0.5574). The SCANS III estimated abundance for block S was 6,147 porpoise (95% CI: 3,401 to 10,065) with an estimated density of 0.152 porpoise/km^2 (Hammond *et al*. 2017). It should be noted that SCANS III survey block S extends considerably further than just the Moray Firth, and therefore the uniform density across the entire block may not be representative of densities in the Moray Firth when considered alone.

4.4.2 JNCC Report 544: Harbour Porpoise Density

The Heinänen and Skov (2015) analysis concluded that in the summer months, harbour porpoise presence in the North Sea MU was best predicted by season, water depth, surface salinity and eddy potential, while the density was best predicted by season, the water depth and the vertical temperature gradient. For the summer months the modelling showed a peak in densities at the inner shelf waters (30-50 m depth) and that animals seemed to avoid well mixed areas and waters with high current speeds as well as avoiding areas with muddy or hard bottom substrates.

In the winter months the presence of harbour porpoise was best predicted by the season, water depth, eddy potential and the surface sediments. For the winter months the modelling showed a peak in presence was observed at water depths of 30 to 40 m and that animals seemed to avoid waters with high current speeds as well as avoiding areas with muddy bottom substrates.

The modelling predicted high densities of harbour porpoise in the Moray Firth in the summer months. It should however, be noted that survey effort within the Moray Firth was not evenly distributed and that there was a lack of effort data in the south-east of the Moray Firth. While the data predict high porpoise densities in the summer of 2009, this was when effort significantly increased due to potential offshore developments in the area. Based on a review of the advice given by Marine Scotland Science, the Scottish Ministers determined that the evidence was not robust enough to put forward the Moray Firth as an SAC for harbour porpoise.

4.4.3 Acoustic Studies in the Moray Firth

The CPOD studies in 2009 and 2010 showed that porpoise were detected on almost every sampling day at most locations throughout the Moray Firth, including at CPOD sites within the MORL development area, with lower detections at some coastal sites compared to the more offshore sites (Figure 4-20) (Thompson *et al*. 2010, Thompson *et al*. 2011, Moray East ES 2012). These survey data have also been analysed to investigate habitat-specific differences in diel patterns of detection. This analysis found that the proportion of detection positive hours and the proportion of hours in which foraging buzzes were

detected increased significantly during the night compared to the day, with different diurnal patterns between muddy and sandy habitats (Williamson *et al*. 2017). The authors state that these data could indicate a shift in distribution or behaviour between night and day.

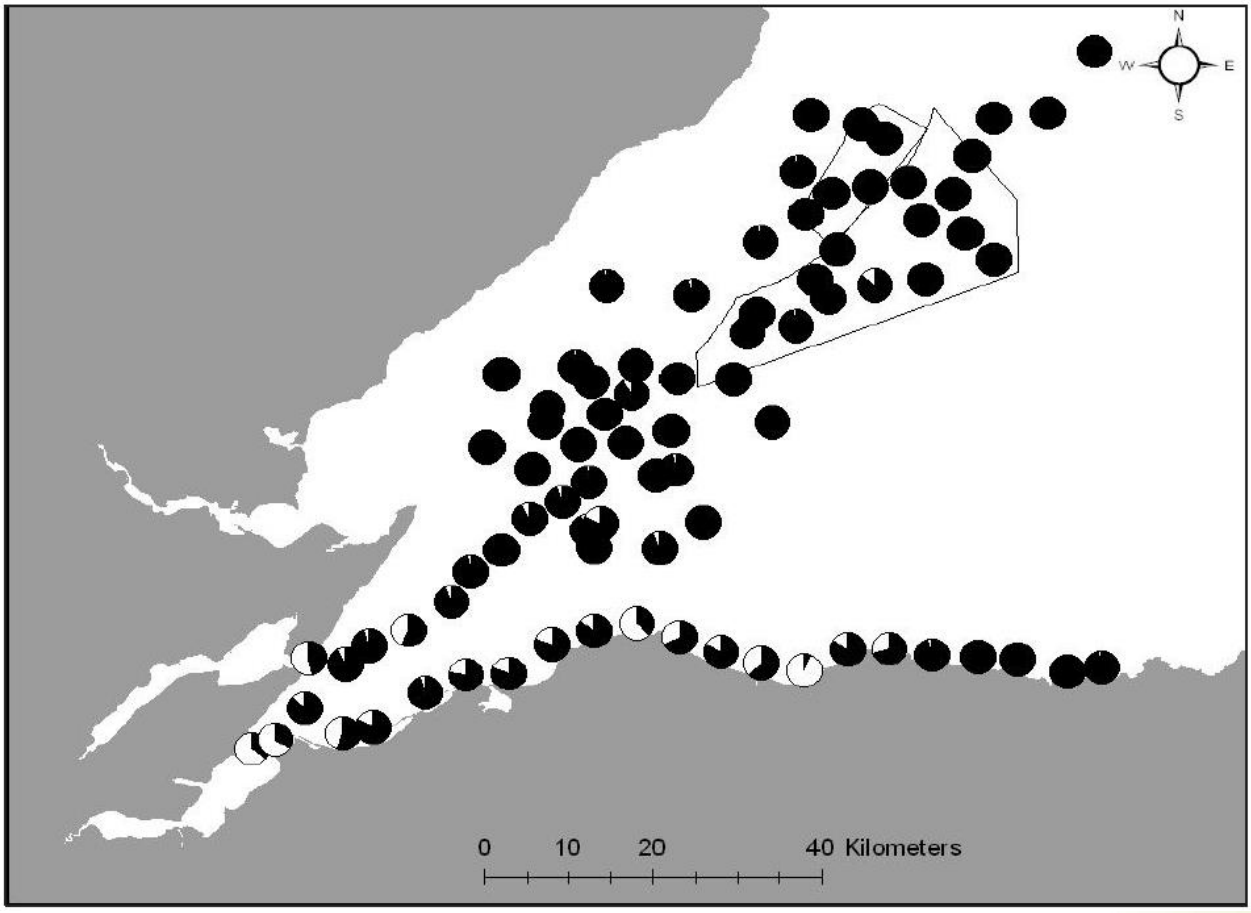

Figure 4-20: Proportion of sampling days in which porpoise were detected during the summers of 2009 and 2010 (Moray East ES 2012).

4.4.4 ECOMMAS Surveys

Porpoise were detected on almost all survey days (porpoise detection days >80%) between 2013 and 2016 at all ECOMMAS CPOD sites apart from Cromarty 05 and Spey Bay 05 where porpoise detection positive days were much lower (6-52%) (Table 4-11 and Figure 4-21).

Table 4-11: Proportion of survey days in which harbour porpoise were detected (porpoise positive days) and median porpoise positive hours at each of the 15 ECOMMAS CPOD sites in the Moray Firth between 2013 and 2016

Site	Proportion Porpoise Positive Days				Median Porpoise Positive Hours			
	2013	2014	2015	2016	2013	2014	2015	2016
Cromarty 05	0.52		0.62	0.52	1.00		1.00	1.00
Cromarty 10	0.92	0.92	1.00	0.98	6.00	4.00	11.50	7.00
Cromarty 15	0.71	0.75	0.94	0.89	1.00	1.00	3.00	2.00
Fraserburgh 05	0.99	1.00	1.00	1.00	19.00	19.00	18.00	15.00
Fraserburgh 10			1.00	1.00			18.00	11.00
Fraserburgh 15		1.00	1.00	1.00		16.00	15.00	16.00
Helmsdale 05	1.00	0.96	0.99	1.00	8.00	6.00	8.50	9.00
Helmsdale 10	1.00		0.99	0.99	9.00		9.00	9.00
Helmsdale 15	1.00	1.00	1.00	0.98	8.00	7.00	12.00	10.00
Latheron 05	1.00	1.00	1.00	0.98	10.00	6.00	11.00	9.00
Latheron 10	1.00		1.00	1.00	10.00		9.00	10.00
Latheron 15	1.00		1.00	1.00	8.00		9.00	7.00
Spey Bay 05	0.14	0.06	0.16	0.13	0.00	0.00	0.00	0.00
Spey Bay 10	0.82		0.92	0.98	2.00		4.50	4.00
Spey Bay 15		1.00	1.00	1.00		14.00	15.00	15.00

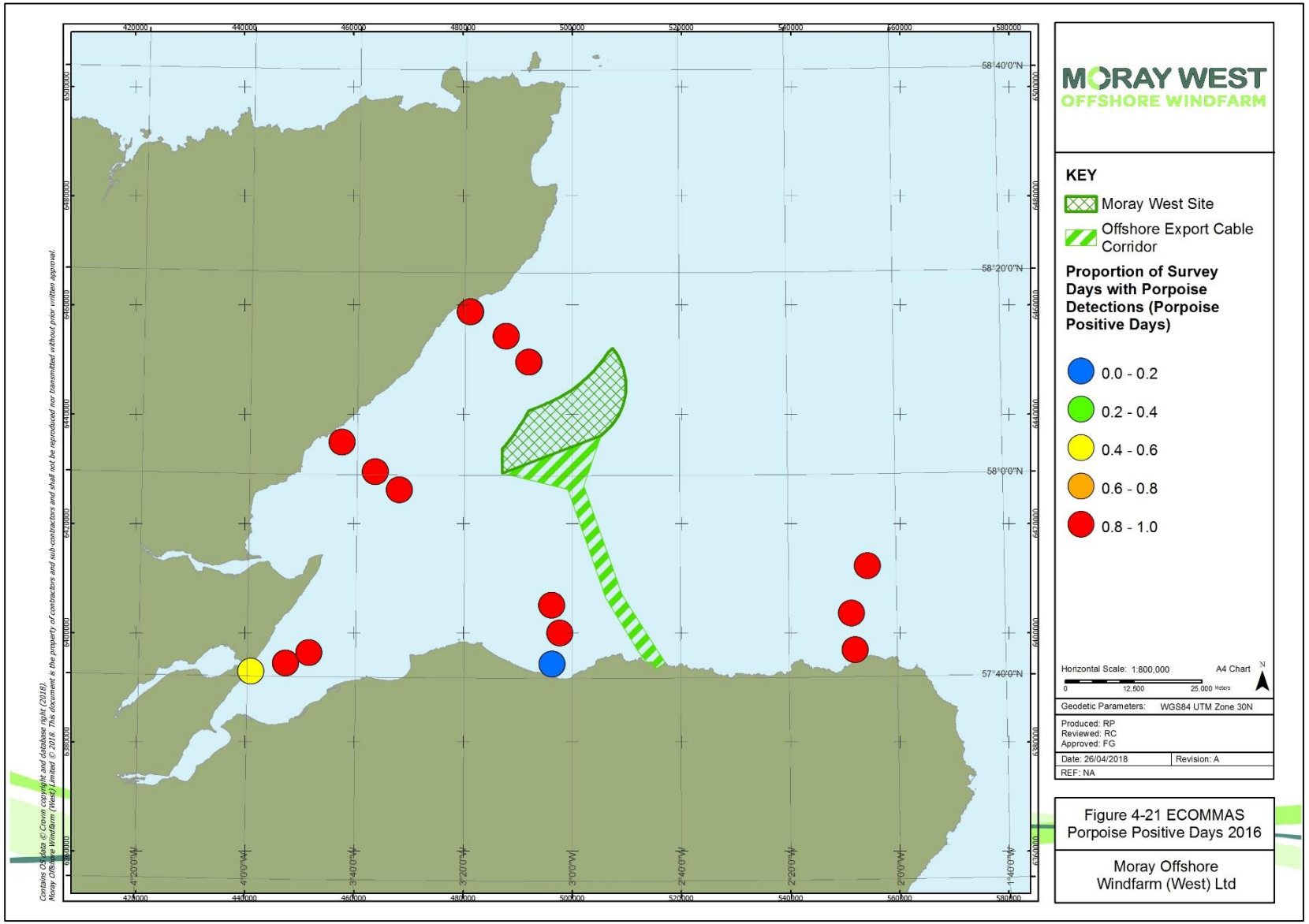

Figure 4-21: Proportion of porpoise positive days at each of the 15 ECOMMAS CPOD sites in the Moray Firth in 2016.

4.4.5 Visual Surveys in the Moray Firth

The five visual survey studies conducted within the Moray Firth have shown that harbour porpoise are present throughout the Moray Firth, including within the SAC, the outer Firth and the MORL and BOWL development sites (Moray East ES 2012). The aerial transect surveys of the Moray Firth recorded a total of 230 sightings consisting of a total of 350 individual porpoise. These data were analysed with Distance and corrected for g(0) <1 to estimate the density and abundance of porpoise. These data showed that estimated harbour porpoise density and abundance was highest in the BOWL and MORL survey area compared to the central Moray Firth survey area, with the lowest estimates for the coastal survey areas (Table 4-12). Density was also estimated for the boat based transect surveys of the MORL sites using Distance analysis and corrected for g(0) <1. The density estimate for the Moray East wind farm site was 0.72 porpoise/km^2 which is comparable to the density estimate from the aerial surveys of the BOWL and MORL survey block of 0.812 porpoise/km^2. Density and abundance data were not presented in the Moray East ES (2012) for the Moray Firth SAC, the outer Moray Firth or the BOWL boat based surveys.

Table 4-12: Number of recorded sightings and estimated density and abundance for each of the five visual surveys conducted in the Moray Firth (Moray East ES 2012). Numbers in brackets for density and abundance represent the 95% confidence intervals

	Aerial	Moray East	SAC	Outer MF	BOWL
# Sightings	230 (350 individuals)	481 (835 individuals)	54	71	114
Density (#/km^2)	All: 0.637 (0.45-0.90) BOWL & MORL: 0.812 (0.45-1.47) Central MF: 0.535 (0.38-0.76) Coastal: 0.265 (0.16-0.44)	ME: 0.72 (0.57-0.91) 4km buffer: 0.63 (0.47-0.85)	-	-	-
Abundance	All: 863 BOWL & MORL: 508 Central MF: 334 Coastal: 66	ME: 214 (170-270) 4km buffer: 224 (167-302)	-	-	-

4.4.6 Hi-Def Aerial Surveys

During the 12 months of aerial surveys a total of 189 harbour porpoise have been identified from survey photographs (Table 4-13). Harbour porpoise made up 84% of the total number of marine mammal sightings. Of these 189 porpoise, 66 were categorised as "Definite" porpoise, 10 were categorised as "Possible" porpoise and 113 were categorised as "Probable" porpoise. There was also one sighting of a "Cetacean species" and six sightings of "Seal/small cetacean species" which could not be identified to species level. Harbour porpoise were predominantly sighted between June and October with a maximum of 49 sightings in the June 2016 survey (sightings rate 0.23 porpoise/km). Harbour porpoise were sighted throughout the survey area, with no apparent spatial pattern to the sightings (Figure 4-22).

Table 4-13: Sightings of harbour porpoise, unknown cetacean species and unknown seal/small cetacean species during the monthly HiDef aerial surveys of the Moray West Site + 4 km between April 2016 and March 2017

Month	Seal / small cetacean species	Cetacean species	Harbour porpoise	Effort (km)	Porpoise Sightings Rate (#/km)
Apr-16				**210.2**	**0.00**
May-16	2		9	**211.3**	**0.04**
Jun-16	1		48	**211.6**	**0.23**

Table 4-13: Sightings of harbour porpoise, unknown cetacean species and unknown seal/small cetacean species during the monthly HiDef aerial surveys of the Moray West Site + 4 km between April 2016 and March 2017

Month	Seal / small cetacean species	Cetacean species	Harbour porpoise	Effort (km)	Porpoise Sightings Rate (#/km)
Jul-16			28	**211.6**	**0.13**
Aug-16			22	**212.0**	**0.10**
Sep-16			31	**211.2**	**0.15**
Oct-16	1	1	29	**209.2**	**0.14**
Nov-16				**211.2**	**0.00**
Dec-16				**208.4**	**0.00**
Jan-17	1		6	**209.4**	**0.03**
Feb-17	1		15	**211.5**	**0.07**
Mar-17			1	**212.1**	**0.00**
TOTAL	**6**	**1**	**189**	**2529.6**	

It is possible to correct for availability bias in aerial surveys, in order to obtain density estimates, by accounting for the proportion of animals that are in the surveyed area but not available to be detected by observers. This correction method assumes that the top two meters of water are visible in the digital images and uses animal-borne telemetry data from Teilmann *et al*. (2007) and Teilmann *et al*. (2013) on the proportion of time that harbour porpoise spend in the top two meters of the water column. The number of detections is then adjusted by this correction factor to account for animals below two meters water depth that are not available for detection. The telemetry data presented in the Teilmann *et al*. papers demonstrated significant variation in the depth distribution of porpoise with month and season. Therefore, in order to be conservative, the lowest value for the proportion of time spent between zero and two meters depth (42.5%) presented in the Teilmann *et al*. papers was used as the correction factor for the Moray West porpoise sightings.

The resulting density estimate for harbour porpoise ranges between 0 and 1.07 porpoise/km^2 across the Moray West Site + 4 km buffer, with an average density across all survey months of 0.35 porpoise/km^2 (

). This density estimate is very similar to the average density estimate for the Moray Firth obtained from the habitat model (0.31 porpoise/km^2, see below). Likewise, the maximum density estimate obtained from these aerial surveys (1.07 porpoise/km^2) is similar to the maximum density estimate within the Moray Firth Site as obtained from the habitat model (1.47 porpoise/km^2, see below).

Another approach is to apply a correction factor derived by Williamson *et al*. (2016). Comparison of digital aerial surveys with visual aerial surveys suggested that digital video detected 0.61 of all porpoises. Applying this factor to the data provides an average harbour porpoise density estimate of 0.24 porpoises per km^2.

Table 4-14: Corrected harbour porpoise sightings used to estimate porpoise density (#/km^2) at the Moray West Site + 4 km buffer

Survey Month	Porpoise Sightings	Corrected Sightings	Effort (km^2)	Corrected Density (#/km^2)
Apr-16	0	0.0	105.1	0.00
May-16	9	21.2	105.6	0.20
Jun-16	48	112.9	105.8	1.07
Jul-16	28	65.9	105.8	0.62
Aug-16	22	51.8	106.0	0.49
Sep-16	31	72.9	105.6	0.69
Oct-16	29	68.2	104.6	0.65
Nov-16	0	0.0	105.6	0.00
Dec-16	0	0.0	104.2	0.00
Jan-17	6	14.1	104.7	0.13
Feb-17	15	35.3	105.8	0.33
Mar-17	1	2.4	106.0	0.02
Total	**189**	**444.7**	**1264.8**	**0.35**

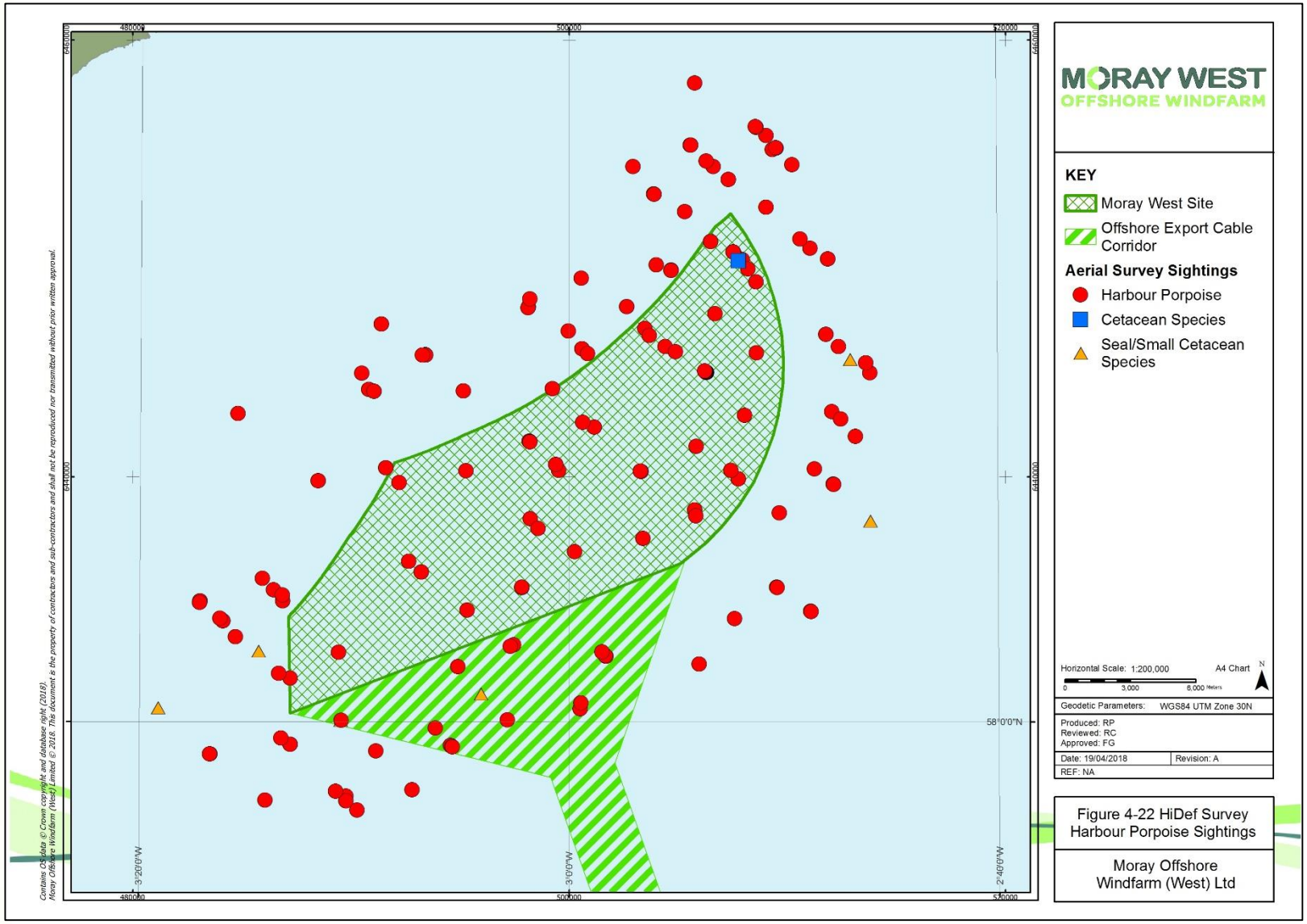

Figure 4-22: Location of harbour porpoise, unknown cetacean species and unknown seal/small cetacean species during the monthly HiDef aerial surveys of the Moray West Site between April 2016 and March 2017.

It is important to note that the assumption that all animals will be detected between zero and two meters depth has not been tested and therefore the effect of variable sighting conditions affecting the depth of the water visible during surveys has not been accounted for in these estimates. It is likely that the visible depth would vary between surveys; with environmental conditions such as sea state and weather conditions as well as other factors affecting the turbidity of the water. Such variation could have the effect of either underestimating (if the portion visible was less than two meters) or overestimating (if the portion visible is more than two meters) harbour porpoise density. However, it is likely that given typical conditions in UK waters that the portion visible is rarely greater than two meters and therefore applying this correction will not have significantly overestimated harbour porpoise density and at least will partly adjust the downward bias introduced as a result of animals below the surface.

4.4.7 Habitat Modelling

The modelled harbour porpoise density grid predicts a total of 6,815 porpoise within the Moray Firth. The average density across the entire grid was 4.89 porpoise/cell (0.31 porpoise/km^2) with a maximum of 337.27 porpoise/cell (21.08 porpoise/km^2) (Figure 4-23). The average density across the grid was higher than the SCANS III block S estimated density 0.152 porpoise/km^2 (Hammond *et al*. 2017). Harbour porpoise are not predicted to be evenly distributed throughout the Moray Firth and there is a higher density area at the north east corner of the Moray West Site where densities reach a maximum of 23.53 porpoise/grid cell (1.47 porpoise/km^2).

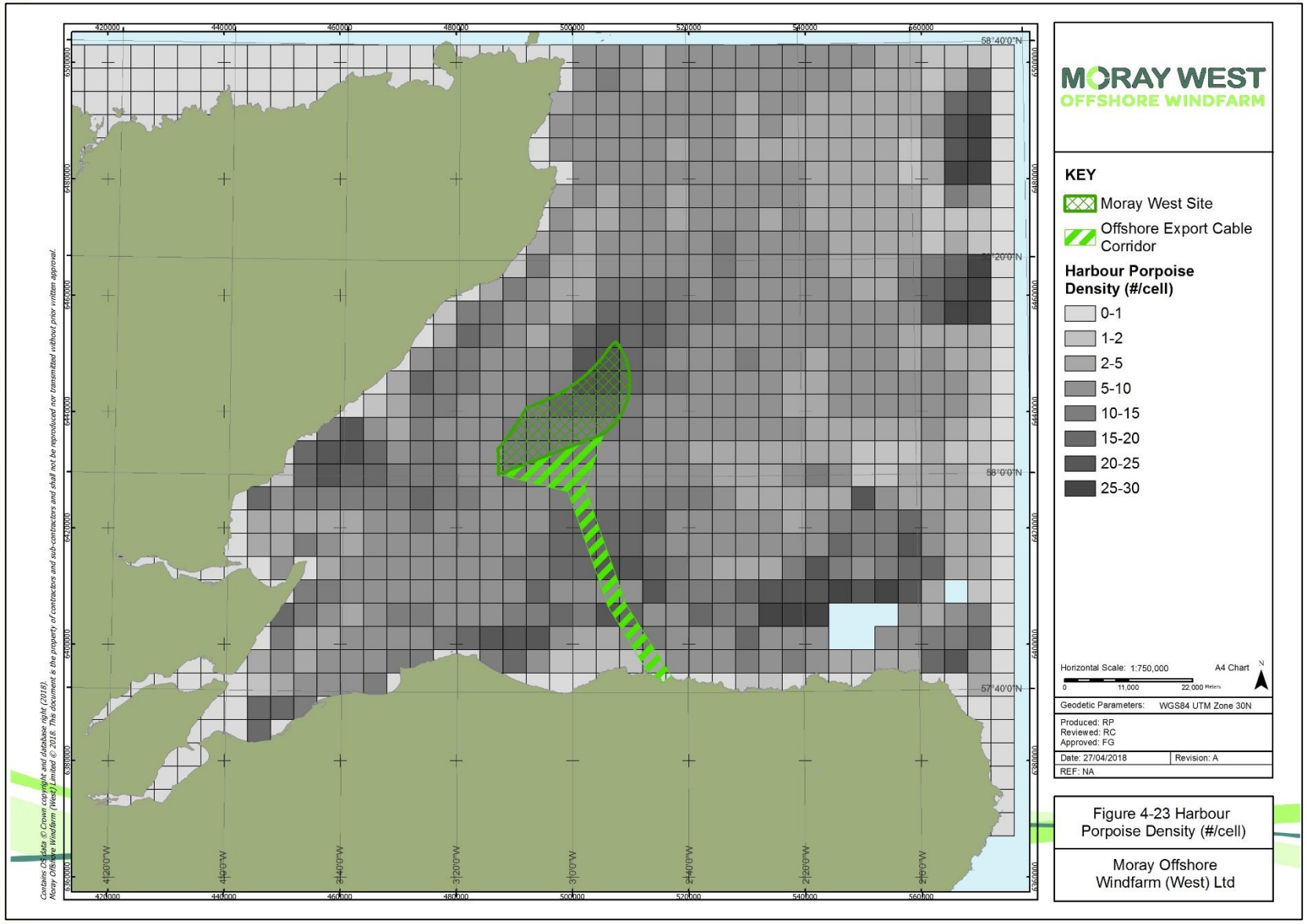

Figure 4-23: Predicted numbers of harbour porpoise in different 4x4 km grid cells across the Moray Firth (Moray East ES 2012).

4.4.8 JCP Phase III

The JCP Phase III analysis provides estimated abundances for harbour porpoise in 2010 by season, and estimates highest abundance in the winter months (13,500 animals), similar estimates in spring and summer (8,100 and 9,000 animals) and lowest estimates in autumn (5,300 animals) (Table 4-15). Between reporting period 1 (1994 to 2000) and reporting period 3 (2007 to 2010) the average annual change in harbour porpoise abundance in the Moray Firth estimated at 1.32 (95% CI: 1.14 to 1.51) which means that the abundance increased annually by 32% (Paxton *et al*. 2016). However, as stated by Paxton *et al*. (2016), the abundance estimates produced by the JCP Phase III modelling will be less reliable than those obtained from a well-designed dedicated abundance survey given the assumptions made when standardizing the data and the spatial and temporal patchiness of the data available. Therefore, the abundance estimates (actual and relative) obtained from the dedicated visual and acoustic surveys in the Moray Firth are likely to be better reflections of the true porpoise abundance in the Moray Firth.

Table 4-15: Estimated harbour porpoise abundance (and 95% confidence intervals) for the Moray Firth in 2010 using the JCP Phase III data (Paxton *et al*. 2016)

	Winter	**Spring**	**Summer**	**Autumn**
Point Estimate	13,500	8,100	9,000	5,300
2.5%	7,400	5,200	5,800	3,200
97.5%	27,100	16,200	13,500	9,500

Since the release of the JCP Phase III Report (Paxton *et al*. 2016), the density surfaces for harbour porpoise have been scaled to SCANS III abundance estimates for the different MUs and the abundance and density can be extracted from the R code provided. The abundance averaged across summer 2007-2010 resulted in an estimated density across the Moray Firth of 0.544 porpoise/km^2 (0.190 – 1.034). This is higher than the density estimate from SCANS III (0.152 porpoise/km^2) and the average density from the habitat modelling (0.31 porpoise/km^2).

4.4.9 Conclusion

Harbour porpoise in the UK are considered to have a “Favourable Conservation Status”. They are the most abundant marine mammal species in the Moray Firth, which has been confirmed by both visual and acoustic surveys and habitat modelling. Acoustic surveys have detected harbour porpoise on almost every sampling day at most locations throughout the Moray Firth, with high detection rates within the Moray West Site and with lower detections at some coastal sites compared to the more offshore sites. The site specific aerial surveys of the Moray West Site have confirmed that harbour porpoise are present throughout the site and throughout the year, with higher sightings rates between June and October. The result of the habitat modelling shows a high predicted density of harbour porpoise at the north east corner of the Moray West site. Since harbour porpoise are an EPS that is present both within the Moray West Site and the wider Moray Firth, they will require a full quantitative impact assessment.

4.5 Minke Whale

Minke whales are widely distributed around the UK, with higher densities recorded on the West coast of Scotland and the western North Sea (Reid *et al*. 2003). They occur mainly on the continental shelf in water depths less than 200 m and are sighted more frequently in the summer months between May and September. Minke whales in the UK are considered to have a "Favourable Conservation Status" (JNCC 2013) and all minke whales in UK waters are considered to be part of the Celtic and Greater North Seas MU (IAMMWG 2015). There is an abundance estimate for this MU of 23,528 animals (95% CI: 13,989 to 39,572), of which 12,295 (95% CI: 7,176 to 21,066) are estimated within the UK Exclusive Economic Zone (EEZ); however, these abundance estimates are based on data from SCANS II (Hammond *et al*. 2013) and the Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA) surveys (Macleod *et al*. 2009) which are likely to be underestimates due to the SCANS II aerial survey estimate not being corrected for perception bias and the CODA estimate not being corrected for either perception or availability bias.

4.5.1 SCANS Surveys

The SCANS II estimated abundance for survey Block J was 835 minke whales (95% CI: 155 to 4,498) and a density of 0.0223 whales/km^2 (95% CI: 0.0041 to 0.1200) (Hammond *et al*. 2006). The SCANS III estimated abundance for block S was 383 minke whales (95% CI: 0 to 1,364) with an estimated density of 0.01 whales/km^2 (Hammond *et al*. 2017).

4.5.2 Paxton et al. (2014) – Identification of MPAs for Minke Whales

The estimated densities for minke whales is generally low throughout the Moray Firth (<0.1 whales/km^2, Figure 4-24) but higher densities are estimated at the Southern Trench area in the South East of the Moray Firth where densities reach over 10 whales/km^2. From this, the Southern Trench was proposed as an MPA (see below). When only the data within the Moray Firth are assessed (within the Moray Firth Boundary line in Figure 4-24) the average density across the Moray Firth comes to 0.006 whales/km^2 (53.67 whales in an area of 8,421.81 km^2) which is similar to the density estimate for the SCANS III block S (0.01 whales/km^2). These data are therefore considered comparable, with the Paxton *et al*. (2016) density data providing a finer scale density surface than the SCANS III block-wide uniform density estimate. The use of a density surface map will allow assessments of impact to take into consideration the spatial distribution of minke whales within the Moray Firth.

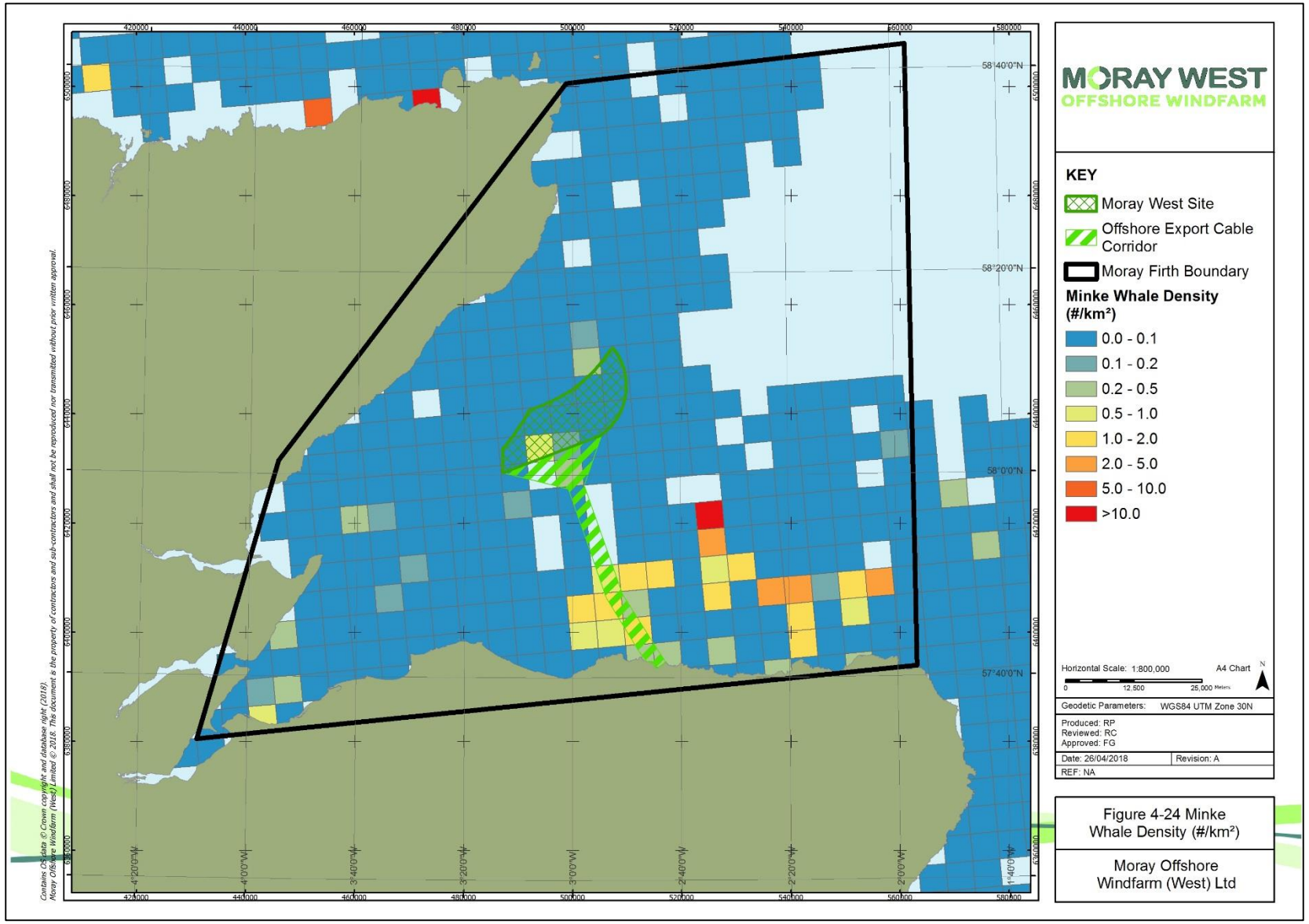

Figure 4-24: Observed adjusted relative densities of minke whale 1994 – 2012 (Paxton *et al*. 2014). Each cell is 5x5 km.

4.5.3 Southern Trench MPA

The Southern Trench MPA was proposed based on data from the JCP which included survey data between 2000 and 2012 from 23 datasets including the latest data (2010 to 2012) from the CRRU. Adjusted observed densities suggest that minke whales are observed at high relative densities within the MPA proposal area (up to 5-10 whales/km^2 within the MPA and >10 whales/km^2 in waters just north of the MPA, Figure 4-25) compared to wider Scottish territorial waters and modelled data show that the MPA area is persistently predicted to support above average densities of minke whales during summer months (Paxton *et al*. 2014) (Figure 4-26). As identified in the MPA proposal, these high density areas are highly seasonal with high densities recorded in the summer, when minke whales move into the area for foraging (SNH 2014).

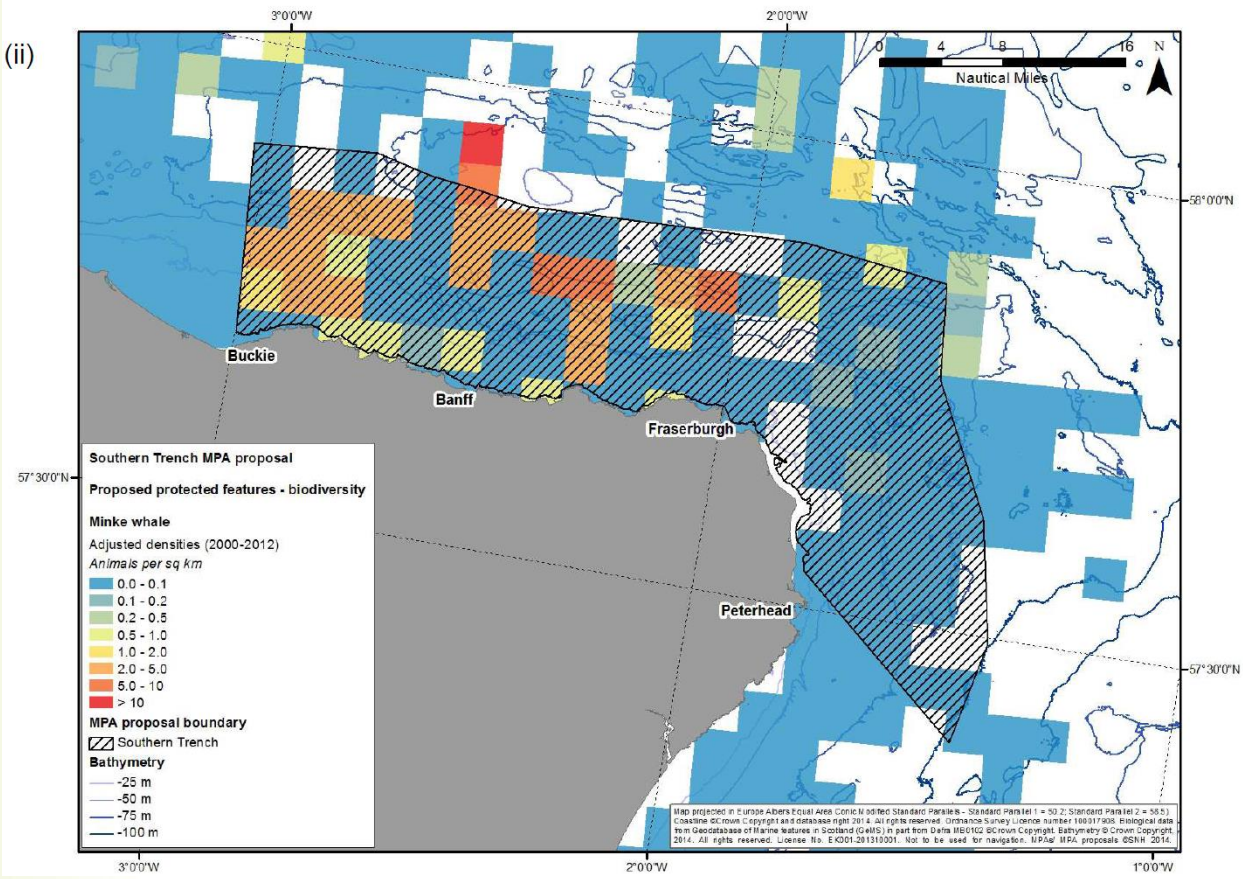

Figure 4-25: Adjusted densities of minke whales in the Southern Trench MPA (2000-2012) (SNH 2014).

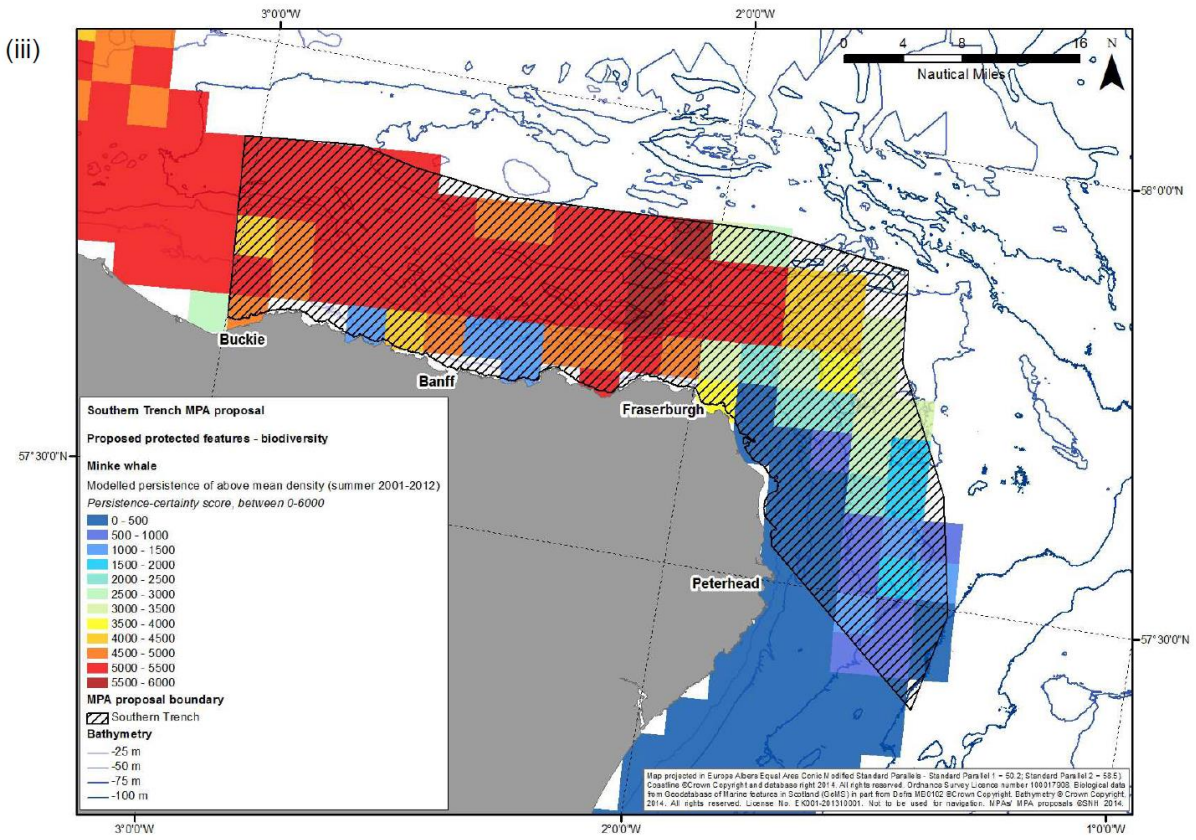

Figure 4-26: Modelled persistence of minke whales in the Southern Trench MPA based on the mean density estimates summer 2001-2012 (SNH 2014).

4.5.4 Visual Surveys in the Moray Firth

All five visual surveys conducted within the Moray Firth and presented in the Moray East ES (2012) have confirmed that minke whales are present in both the inner and outer Moray Firth, and within both the Moray East development site and the BOWL site (Table 4-16). The only survey for which there was a sufficient number of sightings to conduct Distance analysis was the Moray East wind farm site boat based surveys between April 2010 and March 2012. The analysis assumed a g(0)<1 and estimated a density of 0.01 whales/km^2 in the Moray East wind farm site doing the months April to September (95% CI: 0.007 to 0.02) and a density of 0.008 whales/km^2 within the 4km buffer zone (0.004 to 0.015).

Table 4-16: Number of recorded sightings for each of the five visual surveys conducted in the Moray Firth (Moray East ES 2012)

	Aerial	Moray East	SAC	Outer MF	BOWL
# Sightings	13	40	10	49	43

4.5.5 CRRU Survey Data

A total of 305 minke whale encounters were recorded during the CRRU dedicated boat surveys between May and October 2001 and 2006, with minke whales being sighted in all months between May and October inclusive but with higher encounters in the months of July and August where the number of encounters reached >0.03 encounters/km (Robinson *et al*. 2009). Analysis of these data showed that minke whales were more likely to be encountered in areas with water depths between 20-50 m, steep slopes and sandy-gravel sediment (Robinson *et al*. 2009) (Figure 4-27). Unfortunately, more recent survey data have not yet been published and so are not available to include here.

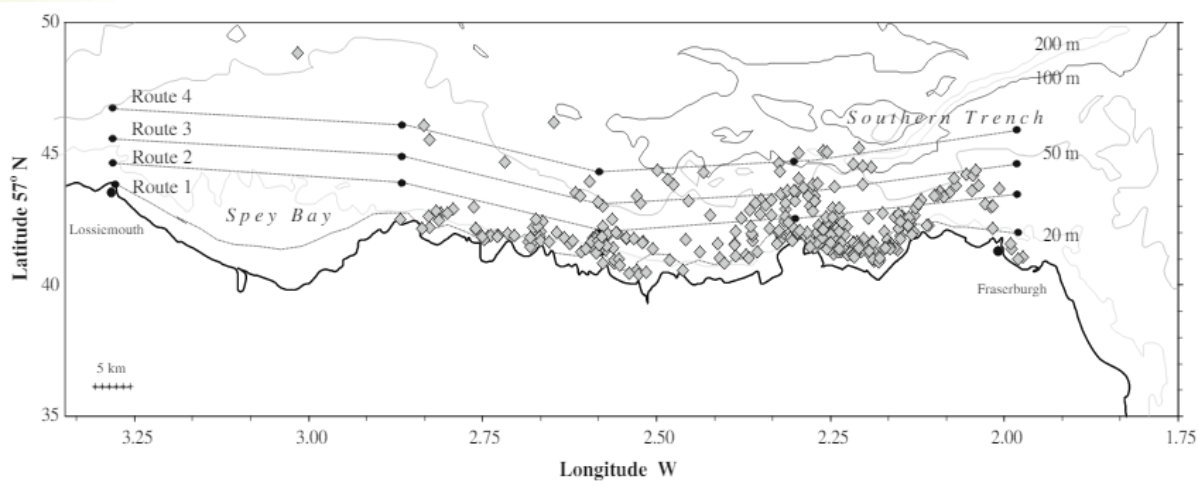

Figure 4-27: Spatial distribution of minke whale encounters in the southern outer Moray Firth between May and October 2001 to 2006 inclusive (n=305) (Robinson *et al*. 2009).

4.5.6 JCP Phase III

The JCP Phase III analysis provides estimated abundances for minke whales in 2010 by season, and estimates highest abundance in the summer months (210 animals), with similar low estimates in all other seasons (20 to 30 animals) (Table 4-17). However, as stated by Paxton *et al*. (2016), the abundance estimates produced by the JCP Phase III modelling will be less reliable than those obtained from a well-designed dedicated abundance survey given the assumptions made when standardizing the data and the spatial and temporal patchiness of the data available.

Table 4-17: Estimated minke whale abundance (and 95% CIs) for the Moray Firth in 2010 using the JCP Phase III data (Paxton *et al*. 2016)

	Winter	Spring	Summer	Autumn
Point Estimate	20	30	210	20
2.5%	0	0	80	0
97.5%	130	260	540	60

4.5.7 Hi-Def Aerial surveys

During the 12 months of aerial surveys a total of five minke have been identified from survey photographs which made up 2% of the total number of marine mammal sightings. All five minke whales were sighted during the survey in June 2016 and all were sighted in the northeast of the survey area (Figure 4-28).

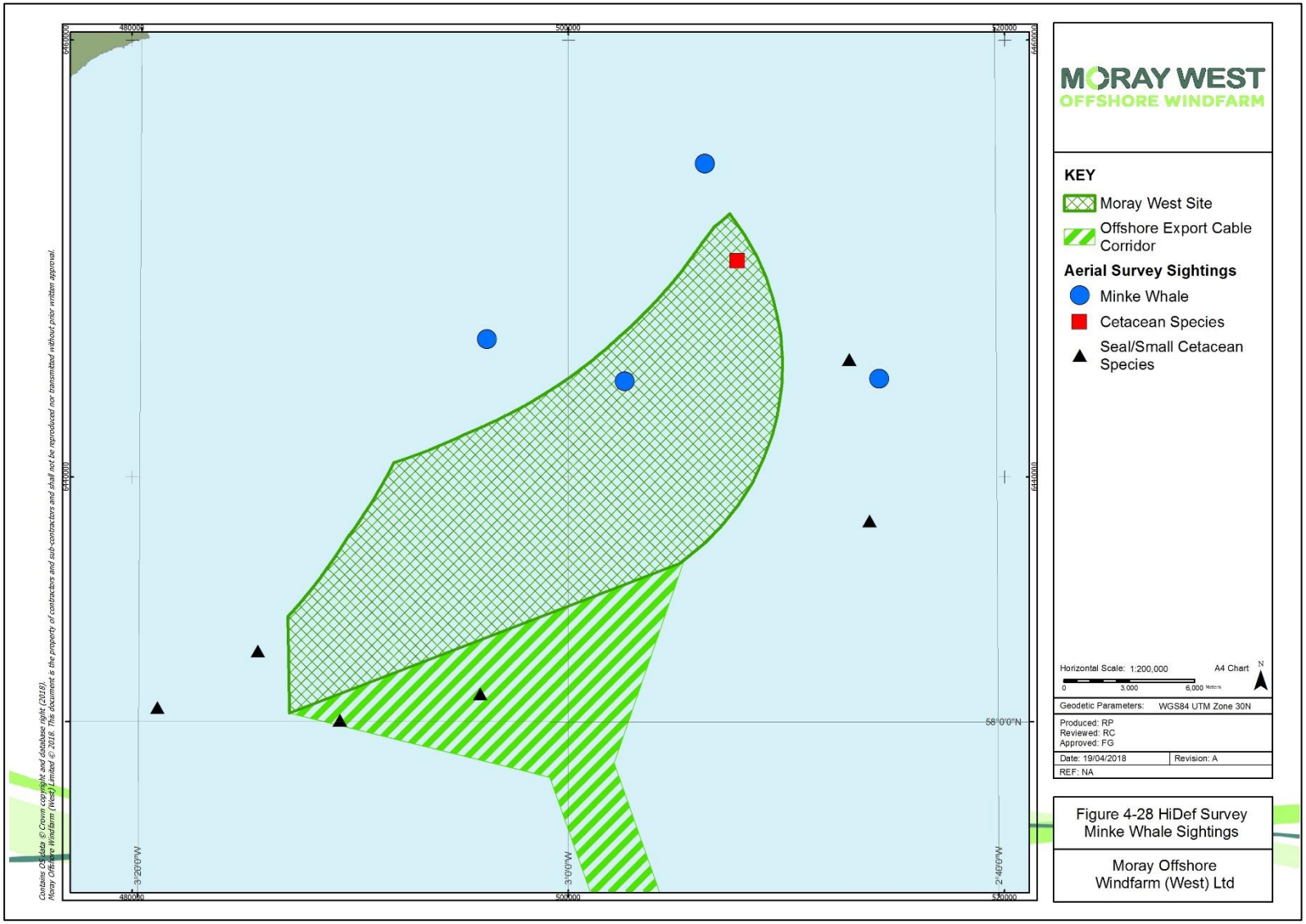

Figure 4-28: Location of minke whales, unknown cetacean species and unknown seal/small cetacean species during the monthly HiDef aerial surveys of the Moray West Site between April 2016 and March 2017.

4.5.8 Conclusion

Minke whales are considered to have a "Favourable Conservation Status" in the UK. The estimated densities for minke whales is generally low throughout the Moray Firth but with higher densities at the Southern Trench MPA in the South East of the Moray Firth during the summer when minke whales move into the area for foraging. Surveys have shown that minke whales are present throughout the summer, with higher encounter rates between July and August. Minke whales were sighted in June 2016 during the site specific aerial surveys of the Moray West Site. While minke whale presence in the Moray Firth during the winter months cannot be ruled out (the JCP III data estimates 20 animals in the Moray Firth during winter months), surveys have shown that densities are considerably lower outside of the summer months. Since minke whales are an EPS that are present both within the Moray West Site and the wider Moray Firth, they will require a full quantitative impact assessment.

4.6 Baseline Conclusions

Based on the data obtained from the baseline characterisation desk based study and the site-specific surveys conducted for Moray West, the abundance and density values for each marine mammal species presented in Table 4-18 have been identified as the most robust values to take forward for the impact assessment.

Table 4-18: MU and density estimates taken forward for impact assessment. Values in brackets show 95% Confidence Intervals

Species	MU	Abundance	Density (#/km^2)	Density Source
Harbour seal	Moray Firth	1,306 (1,068 – 1,741)	4x4 km grid specific densities	Bailey (2017)
Grey seal	Moray Firth	3,577 (3,295 - 3,913)	5x5 km grid specific densities	Russell *et al*. (2017)
Bottlenose dolphin	Coastal East Scotland	195 (164 to 224)	4x4 km grid specific revised densities	Revised from Moray Offshore Renewables Ltd (2012)
Harbour porpoise	North Sea	345,373 (246,526 – 495,752)	4x4 km grid specific densities	Moray Offshore Renewables Ltd (2012)
Minke whale	Celtic and Greater North Seas	23,528 (13,989 to 39,572)	4x4 km grid specific densities*	Paxton *et al*. (2014)

* grid cells without a density estimate will be assigned the SCANS III block wide density estimate.

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6 Annex 9.1A

Habitat-based density modeling of harbour seals

Helen Bailey

20th October 2017

Methods

Telemetry data

Telemetry data were available from 93 individual seals that were captured in either Loch Fleet or the Dornoch Firth, Scotland, and tagged between 1989 and 2017. This dataset included telemetry data previously processed using a state-space model (Bailey *et al*. 2014) as well as mean daily positions from an additional 56 seals tracked with GPS tags in 2014 to 31st March 2017. These new positions were quality checked and two positions on land (PTT 14431 3/6/2017 and PTT 13318 6/17/2015) were moved to the nearest position in-water. Only positions within the Moray Firth were used in the habitat modeling analysis.

Habitat modeling

The case-control approach was used following Aarts *et al*. (2008a) and Bailey *et al*. (2014). Briefly, 17,960 control points (five times the number of seal points) were generated using the equation for accessibility (Matthiopoulos *et al*. 2004) in distance units of 4km as $(0.8d)^{-1.98}$ (Bailey *et al*. 2014). The case (seal) and control points were combined with corresponding environmental data (water depth, seabed slope, seabed sediment type and distance from the nearest haul-out) in 4 x 4 km grid cells. A generalized additive mixed model (GAMMs) was applied with a binomial error distribution and logit link function with the individual track included as a random effect. Since GAMMs can have issues with convergence, a generalized estimating equations (GEE) model was also applied. A GAMM was also fit with various subsets (n=10,776) of the control points (three times the number of seal points) to determine if the model was robust to the selection of the control points.

The predictions from the habitat models were scaled to sum to 1 and then multiplied by the population abundance estimate of 1,304 to estimate the density of seals within each 4 x 4 km grid cell.

Results

Telemetry data

There were 3,544 daily positions from the 56 individual seals tracked in 2014-2017. In addition to the daily positions from seals tagged in 1989 to 2009, this resulted in 3,592 daily positions within the Moray Firth study area that were used in the analysis (Figure 1).

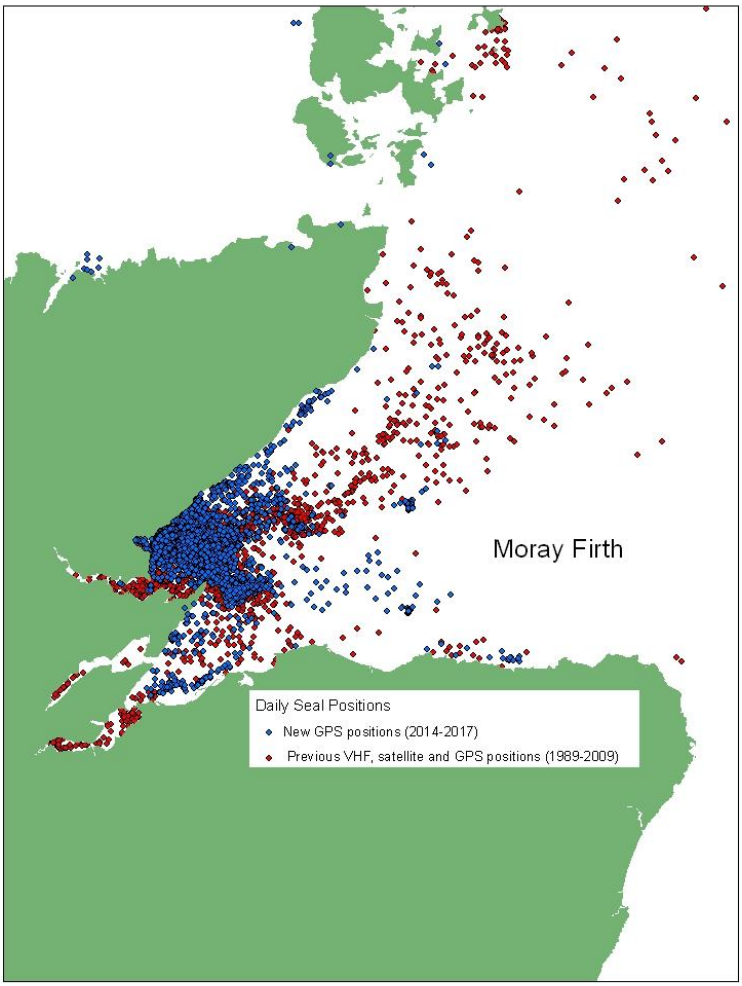

Figure 1: Map of the daily seal positions.

Habitat model

The simulated control points are shown in Figure 2.

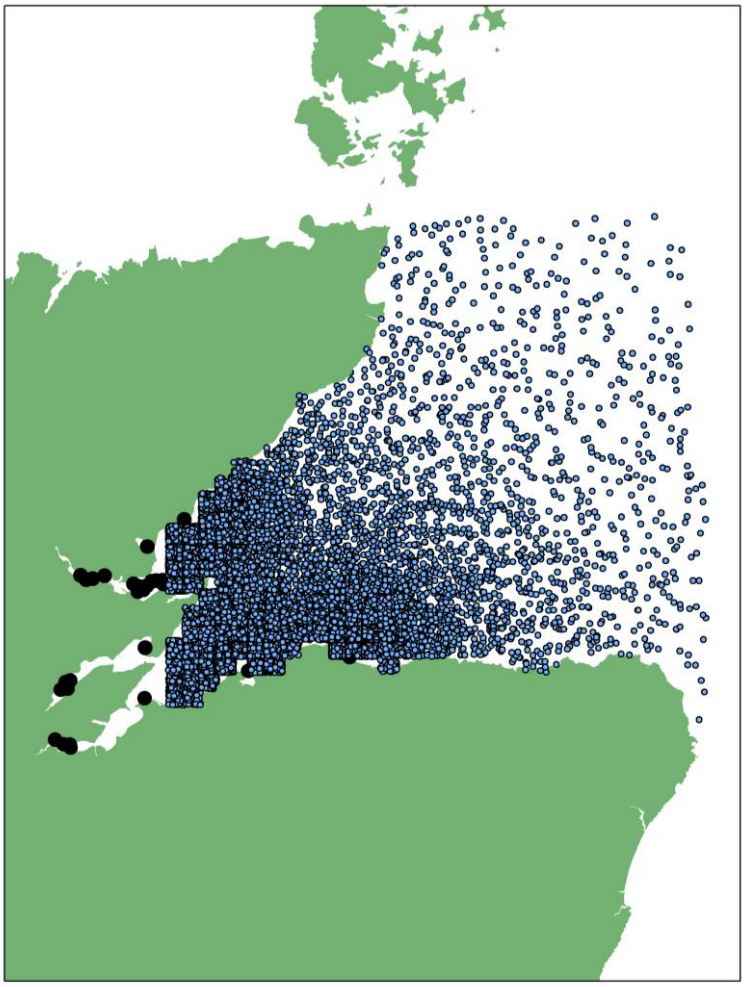

Figure 2: Map of the simulated control points (n=17,960, five times the number of seal points).

The habitat use of harbour seals was significantly related to the seabed sediment type with a preference for sand, marine muddy sediment compared to sand (Figures 3 and 4). However, the deviance explained was low (r^2=0.005).

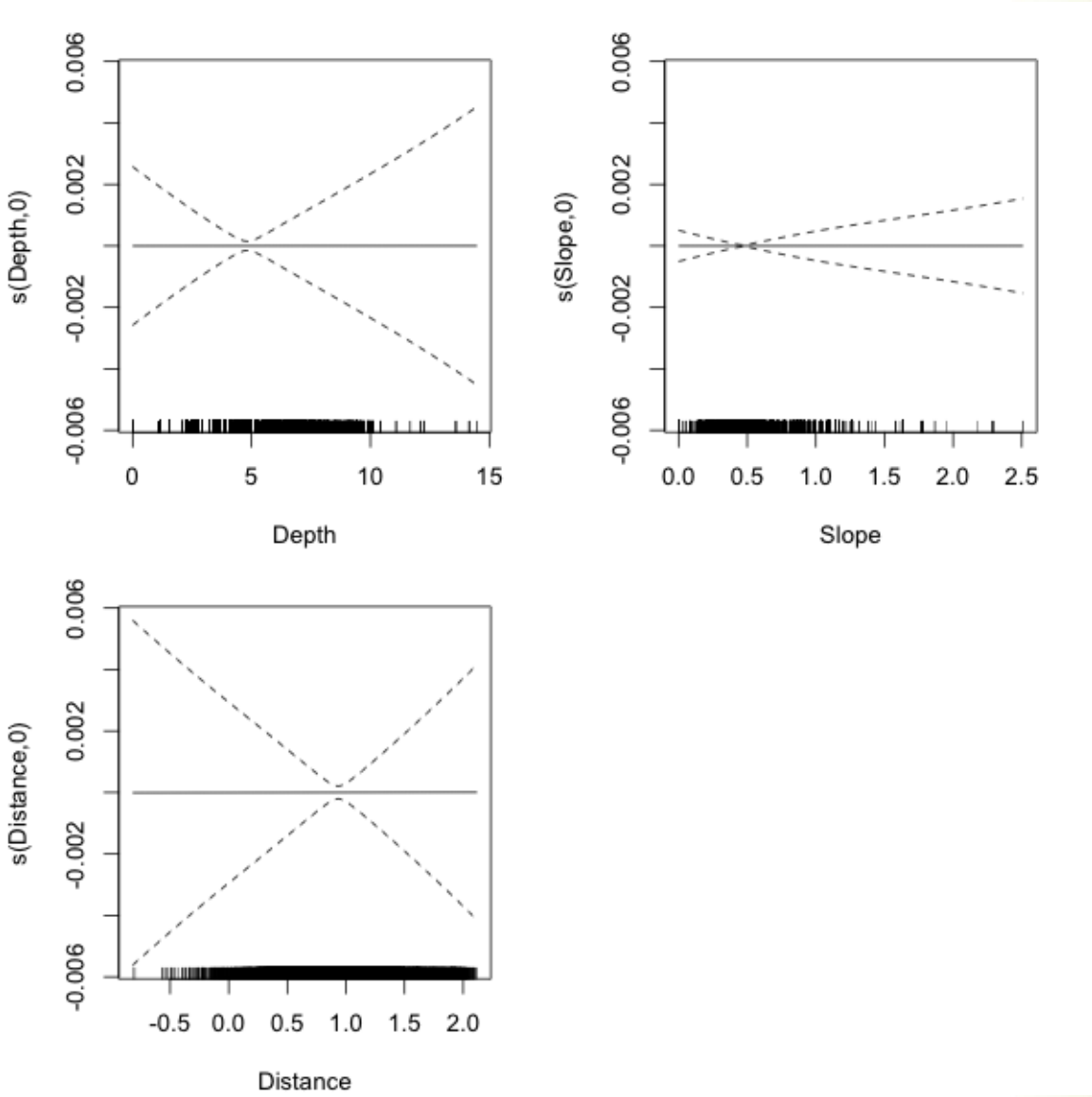

Figure 3: GAMM smoothing curves. Note that the water depth (Depth, m), seabed slope (Slope, degrees) and distance from the nearest haul-out (Distance, km) were not significantly related to the habitat use of the seals.

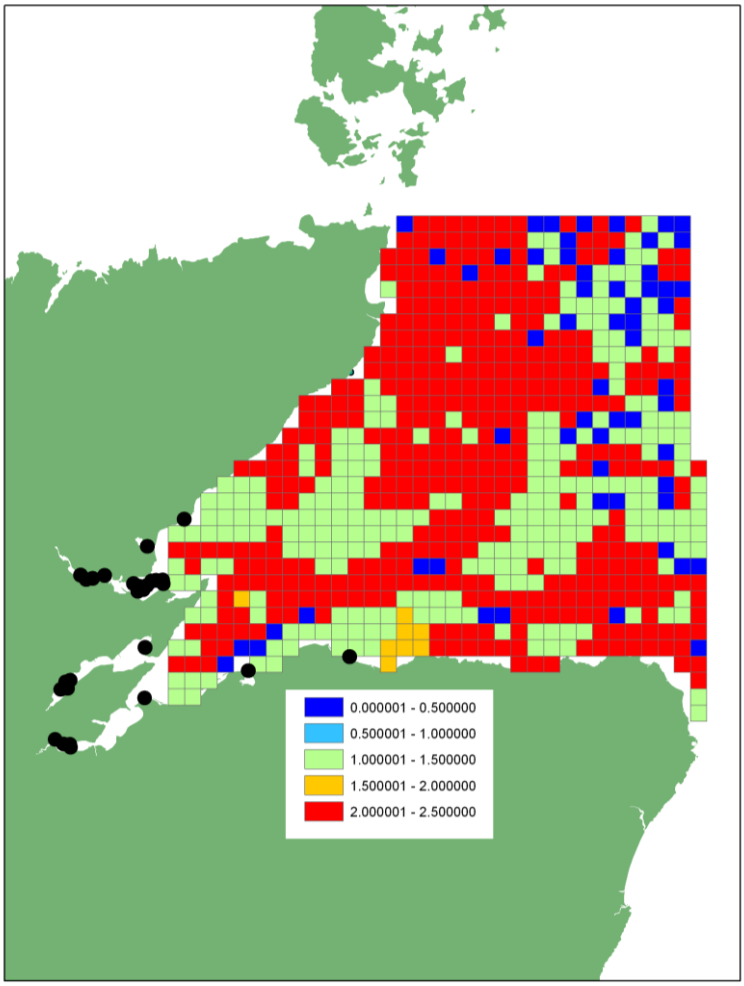

Figure 4: Predicted numbers of seals from GAMM within 4 x 4 km grid cells.

The GEE model identified water depth, seabed sediment type and distance from the nearest haul-out as significantly related to seal habitat use and predicted a very different spatial pattern of densities than the GAMM (Figure 5).

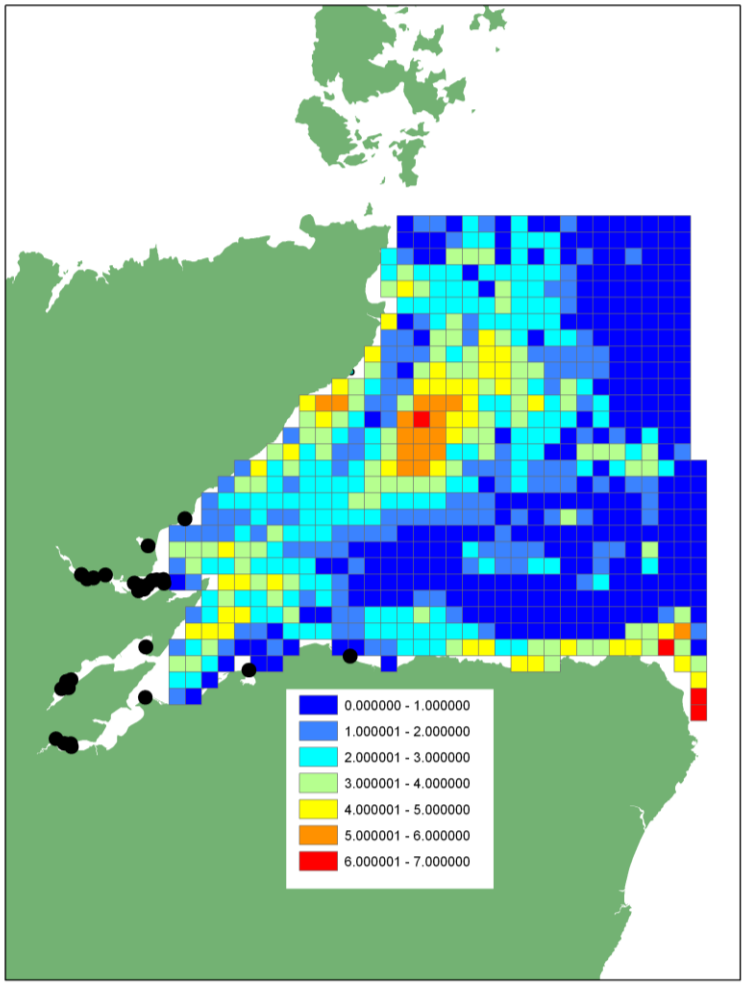

Figure 5: Predicted numbers of seals from the GEE model within 4 x 4 km grid cells.

The GAMM model did not converge with the subsets of the control points when there were three times as many as the number of seal positions with two exceptions. The first model that did converge did not identify any of the environmental variables as significantly related to seal habitat use. The second model was fit using control points that had been subset by weighting their probability of selection by the distance from the nearest haul-out so a greater proportion of distant control points were included. This model with the resampled subset of control points identified seal habitat use as significantly related to water depth, seabed slope, sediment type and distance from the nearest haul-out (Figure 6). It also had a higher deviance explained than the GAMM that had been fit with the full set of control points and the predicted densities more closely matched the distribution of the telemetry positions (r^2=0.136, Figure 7).

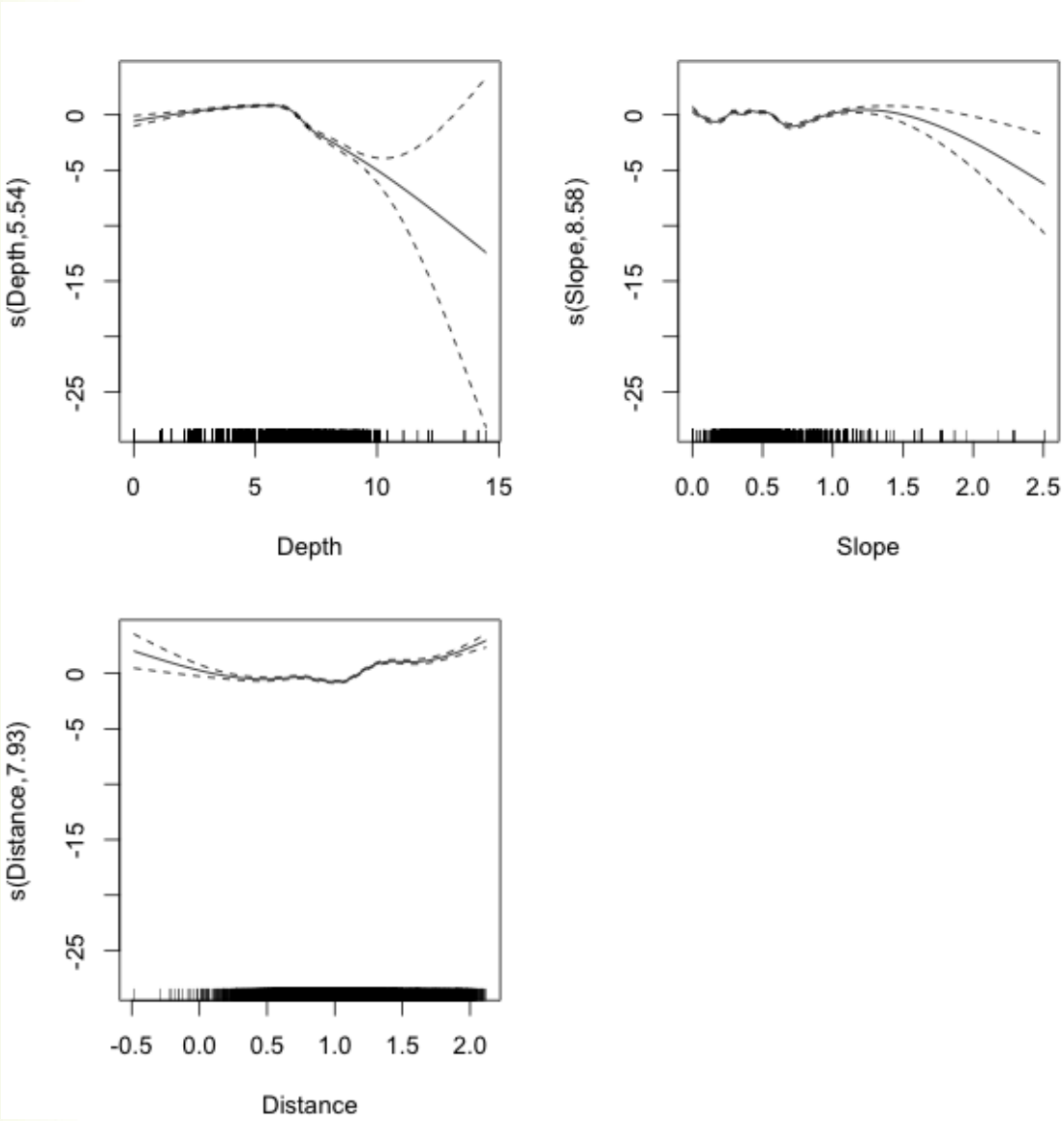

Figure 6: GAMM smoothing curves fit using a resampled subset of the control points.

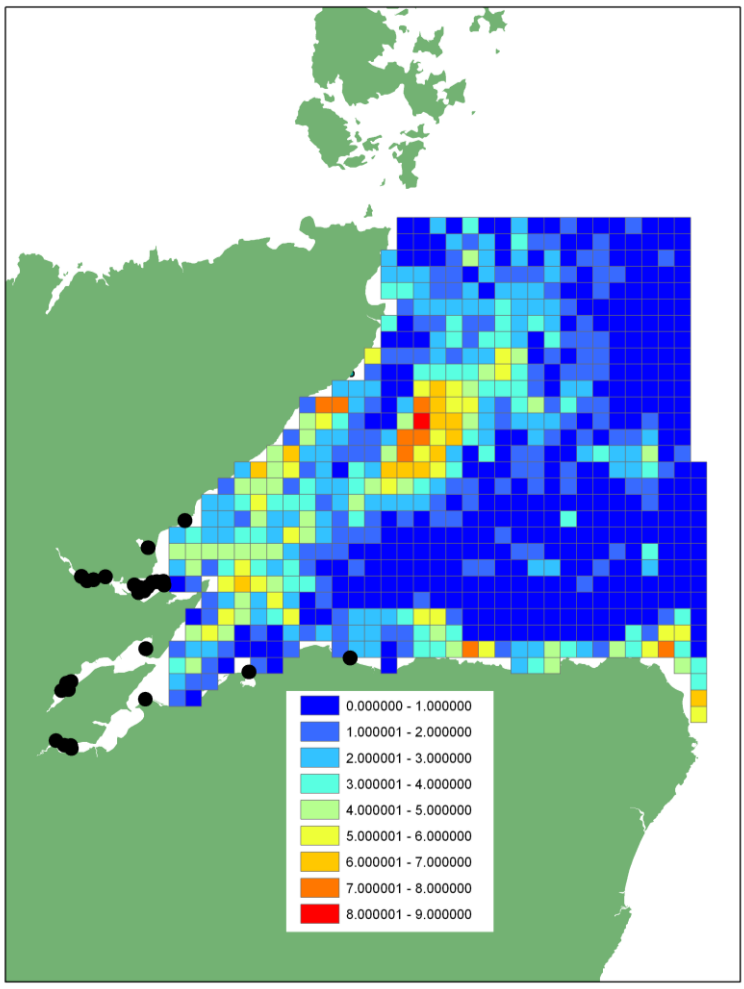

Figure 7: Predicted numbers of seals from the GAMM fit with three times the number of control points as seal points within 4 x 4 km grid cells. The control points were subset by weighting by the distance from the nearest haul-out.

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Underwater Noise Modelling

Moray Offshore Windfarm (West) Limited

Technical Appendix 9.2

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Acronyms	
Acronym	**Expanded Term**
PTS	Permanent threshold shift
SEL	Sound exposure level
SEL_{cum}	Cumulative sound exposure level
SEL_{ss}	Single-strike sound exposure level
TTS	Temporary threshold shift

Executive Summary

This report presents the results of underwater noise modelling carried out by Cefas in support of the Environmental Impact Assessment (EIA) for the Moray West Offshore Wind Farm. Predictions were made of the sound exposure levels (SELs) and peak sound pressure levels (peak SPLs) arising from percussive pile driving for maximal hammer energies of 5,000 kJ (monopiles) and 3,000 kJ (pin piles) at several locations around the perimeter of the Moray West Site, including concurrent piling at two locations. Based on these predictions, effect zones were computed for the risk of Permanent Threshold Shift (PTS) on harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), minke whale (*Balaenoptera acutorostrata*), grey seal (*Halichoerus grypus*), and harbour seal (*Phoca vitulina*), using the NMFS (2016) noise exposure criteria for marine mammals. The model included the assumption that marine mammals would flee from the pile foundation at the onset of piling. Furthermore, the risk of Temporary Threshold Shift (TTS), recoverable injury, and mortality was predicted for Atlantic salmon *(Salmo salar*), cod (*Gadus morhua*), and herring (*Clupea harengus*), using the Popper *et al.* (2014) criteria. No fleeing behaviour was assumed for fish.

Of the marine mammal species assessed, only minke whale and harbour porpoise were predicted to incur PTS at distances greater than 50 m. The NMFS (2016) guidance consists of dual criteria, with thresholds for both cumulative SEL and peak SPL. Harbour porpoises were predicted to incur PTS to a distance of 335 m from the foundation under the peak SPL criterion (PTS effect range was <50 m under the cumulative SEL criterion). Under the peak SPL criterion, minke whales were predicted to incur PTS at distances <50 m, while for the cumulative SEL criterion, the maximal effect area was for concurrent piling at two locations (for which there is no single effect range), covering an area of 36,708 ha (367 km^2). This effect area extended to the northwest of the Moray West site toward the Caithness coast, where fleeing animals were predicted to receive higher cumulative exposures as they navigated the coastline.

Effect ranges predicted for mortality of fish did not exceed 50 m for cod and salmon, and the maximal mortality range predicted for herring was 601 m. For TTS and recoverable injury, the Popper criteria are the same for all three species. The greatest effect range for recoverable injury was 1,079 m, and for TTS was 12,229 m.

1 Introduction

This report presents the results of underwater noise modelling carried out by Cefas in support of the Environmental Impact Assessment (EIA) for the Moray West Offshore Wind Farm. Predictions were made of the sound exposure levels (SELs) and peak sound pressure levels (peak SPLs) arising from percussive pile driving for maximal hammer energies of 5,000 kJ (monopiles) and 3,000 kJ (pin piles) at several locations around the perimeter of the Moray West Site, including concurrent piling at two locations. Based on these predictions, effect zones were computed for the risk of Permanent Threshold Shift (PTS) on harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), minke whale (*Balaenoptera acutorostrata*), grey seal (*Halichoerus grypus*), and harbour seal (*Phoca vitulina*), using the NMFS (2016) noise exposure criteria for marine mammals. Furthermore, the risk of Temporary Threshold Shift (TTS), recoverable injury, and mortality was predicted for Atlantic salmon *(Salmo salar*), cod (*Gadus morhua*), and herring (*Clupea harengus*), based on the Popper *et al.* (2014) criteria.

2 Methodology

2.1 Source Model

The source level estimate for pile driving was calculated using an energy conversion model (De Jong and Ainslie, 2008), whereby a proportion of the expected hammer energy is converted to acoustic energy:

$$\boldsymbol{SL_E = 120 + 10log_{10}\left(\frac{\beta E c_0 \rho}{4\pi}\right)} \quad (1)$$

where E is the hammer energy in joules, SL_E is the source level energy for a single strike at hammer energy E, $\boldsymbol{\beta}$ is the acoustic energy conversion efficiency, c_0 is the speed of sound in seawater in m s^{-1}, and ρ is the density of seawater in kg m^{-3}.

This yields an estimate of the source level in units of sound exposure level (dB re 1 µPa^2 s). This energy is then distributed across the frequency spectrum based on previous measurements of percussion piling (Ainslie *et al.*, 2012).

Hammer energy profiles for the piling scenarios (see Section 2.3) formed the basis of the source level estimates. Equation 1 was used to compute the source level energies, using an acoustic energy conversion efficiency of 0.5%, which assumes that 0.5% of the hammer energy is converted into acoustic energy. This energy conversion factor is in keeping with current understanding of how much hammer energy is converted to noise (Dahl and Reinhall, 2013; Zampolli *et al.*, 2013; Dahl *et al.*, 2015). Further detail on the current understand of how much hammer energy is converted to noise is provided in Appendix A. Equation 1 gives the source level energy for a single strike (single-strike SEL). The maximal single-pulse SEL, SEL_{ss}, as well as the cumulative SEL (the total SEL generated during a specified period), SEL_{cum}, were computed.

2.2 Propagation Model

The propagation of piling noise was modelled using the Cefas noise model (Farcas *et al.,* 2016), which is based on a parabolic equation solution to the wave equation (RAM; Collins, 1993). Unlike many propagation models, this model takes into account the bathymetry, sediment properties, water column properties, and tidal cycle, leading to more detailed and reliable predictions of sound level. It is also widely used in peer-reviewed scientific studies which have benchmarked it against empirical data.

The Cefas model is a quasi-3D model consisting of 360 2D transects extending away from the source at intervals of one degree. Sound propagation is modelled at each discrete frequency in the source spectrum

(10 frequencies per 1/3 octave band). These transects were then resampled and integrated over frequency (using the appropriate auditory weightings where needed). Finally, the resulting levels were averaged over depth to produce noise maps.

Aside from source levels of piling, the main model inputs were bathymetry, water temperature and salinity (used to compute sound speed), and the acoustic properties of the seabed sediments. Bathymetric data was provided by Moray West at 90-m resolution in UTM zone 30N projection, with the 90-m data being more than adequate for the frequency ranges and spatial scales used in the simulations.

The water temperature and salinity data, which are used by the model for calculating the water column sound speed profiles, were taken from a validated, multiyear hindcast model produced by Cefas, known as GETM-ERSEM-BFM. The model provides extensive daily coverage at 0.1 degree spatial resolution, and includes 25 depth layers. Typical November water properties were used for the acoustic propagation predictions, representing a midpoint between winter and summer sound propagating conditions. It was chosen to model water properties based on a typical November as this represents a mixture of most probable and worst case scenarios which would form a conservative but probable scenario.

The noise model also includes the acoustic properties of the seabed sediments, namely speed of sound, density and acoustic attenuation, which are used to construct a geoacoustic model of the seafloor. These properties were derived from the seabed core data provided by Moray West, by correlating the core sediment information with published acoustic properties of various sediment types (Hamilton, 1980).

2.3 Input Data

Bathymetry data were provided to Cefas, with a resolution of 90 m and a coverage of 414659.935–634619.935, 6364386.87–6500556.87 (eastings, northings WGS84 UTM30N), approximately 220 by 136 km. The pile location assessed was a worst case of the most south westerly point of the Moray West site, easting 487208.085, northing 6429170.970 (WGS84 UTM30N).

2.4 Piling Scenarios

The hammer energy profile assessed was based on a typical profile as a percentage of the maximum hammer energy: 5,000 kJ for monopiles (Table 2-1) and 3,000 kJ for pin piles (Table 2-2). For the computation of cumulative SEL, this was based on a single pile being installed in 24 hours for monopiles, and on three piles being installed in 24 hours for pin piles.

Table 2-1 Hammer Energy Profile for 1 Monopile, based on the Maximum Projected Hammer Energy of 5,000 kJ

Hammer Energy %	Hammer Energy in kJ	Source Level (dB re 1 µPa at 1 m)	Duration (mins)	Number of Strikes (at 30 strikes/min)
Stage 1 - 20%	1,000	207.9	150	4,500
Stage 2 - 40%	2,000	210.9	90	2,700
Stage 3 - 60%	3,000	212.6	50	1,500
Stage 4 - 80%	4,000	213.9	40	1,200
Stage 5 - 100%	5,000	214.9	30	900

Table 2-2 Hammer Energy Profile for 1 Pin-Pile, Based on the Maximum Projected Hammer Energy of 3,000 kJ				
Hammer Energy %	**Hammer Energy in kJ**	**Source Level (dB re 1 µPa at 1 m)**	**Duration (mins)**	**Number of Strikes (at 38.7 strikes/min)**
Stage 1 – 16.66%	500	204.9	90	3500
Stage 2 – 33.33%	1,000	207.9	65	2500
Stage 3 - 50%	1,500	209.6	65	2500
Stage 4 – 66.66%	2,000	210.9	65	2500
Stage 5 - 100%	3,000	212.6	52	2000

Three model types were run for each foundation type:

(1) SEL_{ss} based on the maximum hammer energy (to assess disturbance, see Section 2.7);
(2) Peak SPL based on maximum hammer energy (to assess PTS risk at piling onset, see Section 2.7); and
(3) SEL_{cum} over 24 hours based on the hammer energy profiles (to assess PTS, see Section 2.7).

To assess the eventuality of two piling vessels being available concurrently, scenarios were also run for simultaneous piling at two locations for the above three model types. The model types and associated abbreviations and effects are listed in Table 2-3.

Table 2-3 Metrics and Associated Effects for Each of the Three Model Types used in the Assessment			
Metric	**Abbreviation**	**Effect Assessed**	**Criterion**
Single-strike SEL	SEL_{ss}	Disturbance	Dose-response curve
Cumulative SEL	SEL_{cum}	PTS	NOAA criteria
Peak SPL	Peak SPL	PTS	NOAA criteria

2.5 Noise Exposure Criteria

For marine mammals, the risk of PTS was assessed using the NOAA criteria (National Marine Fisheries Service, 2016) based on both of the dual criteria: cumulative sound exposure level (SEL_{cum}) and peak sound pressure level (peak PL). To assess the SEL_{cum} criterion, the predictions of received sound level are frequency weighted to reflect the hearing sensitivity of each functional hearing group (first column in Table 2-4). The peak SPL criterion is for unweighted received sound level.

Table 2-4 Sound Exposure Thresholds for Marine Mammals (National Marine Fisheries Service, 2016).

Hearing Group	TTS		PTS	
	SELcum [dB re 1 µPa2 s]	Peak SPL [dB re 1 µPa]	SEL_{cum} [dB re 1 μPa^2 s]	Peak SPL [dB re 1 µPa]
Low-frequency cetaceans	168	213	183	219
Mid-frequency cetaceans	170	224	185	230
High-frequency cetaceans	140	196	155	202
Phocid seal	170	212	185	218

For fish, the Popper criteria (Popper et al., 2014) were applied (Table 2-5). These consist of dual criteria for recoverable injury and mortality, and an SELcum criterion for TTS. None of these thresholds apply frequency weightings. Note that the three fish species considered – Atlantic salmon (*Salmo salar*), cod (*Gadus morhua*), and herring (*Clupea harengus*) – all have a swim bladder, and so the 'no swim bladder' hearing group was not assessed. Herring belong to the most sensitive group (swim bladder involved in hearing), which salmon and cod have a swim bladder but it is not used in hearing.

Table 2-5 Sound Exposure Thresholds for Fish (Popper *et al.*, 2014).

Hearing Group	TTS		Recoverable Injury		Mortality
	SEL_{cum} [dB re 1 μPa^2 s]	SEL_{cum} [dB re 1 μPa^2 s]	Peak SPL [dB re 1 µPa]	SEL_{cum} [dB re 1 μPa^2 s]	Peak SPL [dB re 1 µPa]
Fish: no swim bladder	186	216	213	219	213
Fish: swim bladder is not involved in hearing	186	203	207	210	207
Fish: swim bladder involved in hearing	186	203	207	207	207

2.6 Piling Locations Assessed for Each Species (Marine Mammals)

For each marine mammal species, a piling location was assessed which would best reflect the greatest risk to that species based on available data on estimated distributions (see marine mammal ES chapter for details). Figure 2-1 shows these piling locations, and Table 2-6 shows the locations assessed for each marine mammal species.

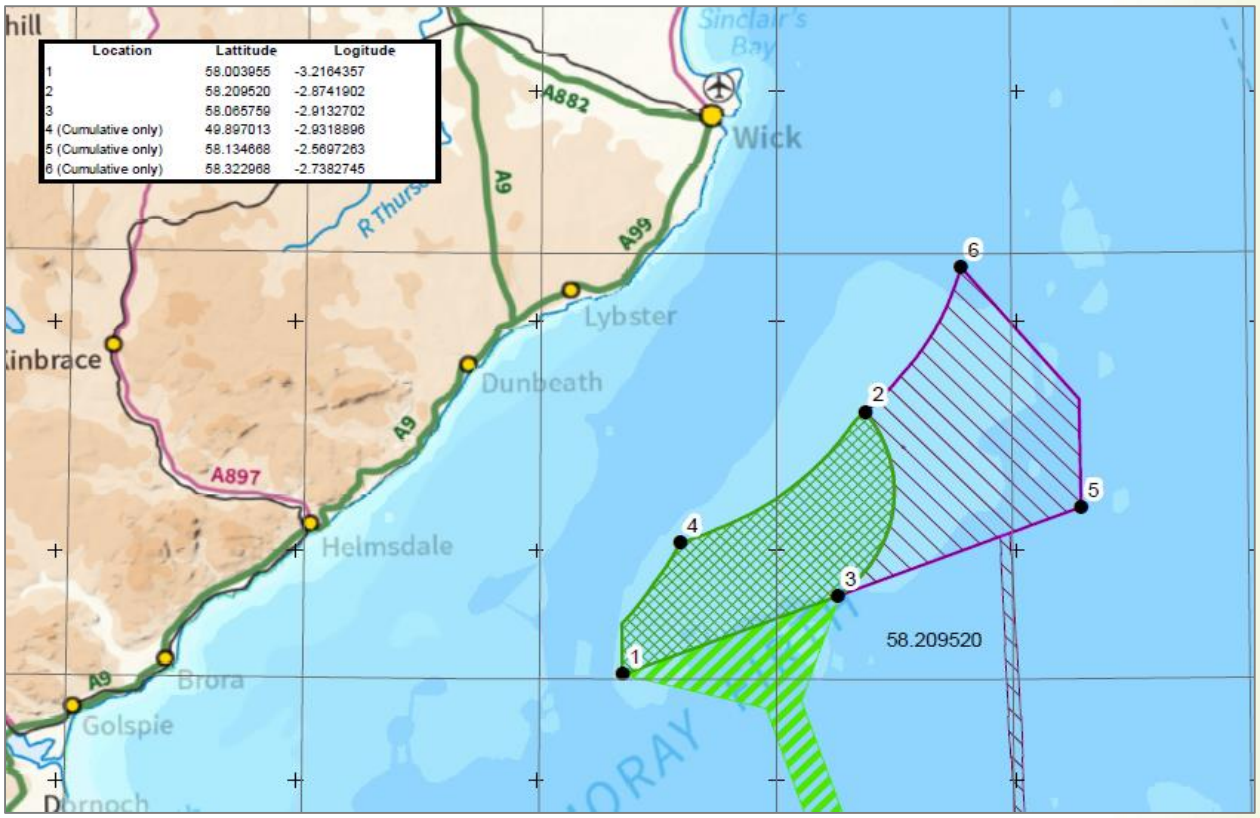

Figure 2-1 Map of Moray West project area (green hatched area) with piling location numbers 1-4 considered in the assessment.

Table 2-6 Piling Locations Modelled for Each Marine Mammal Species			
Species	**Hearing Group**	**Single Piling Location**	**Concurrent Piling Locations**
Minke whale	Low-frequency cetaceans	3	1 & 3
Bottlenose dolphin	Mid-frequency cetaceans	1	1 & 3
Harbour porpoise	High-frequency cetaceans	2	1 & 2
Harbour and grey seals	Phocids	1	1 & 2

For fish, all three hearing groups were assessed at all three locations (1, 2, 3) and all three possible combinations of concurrent locations (1 & 2, 1 & 3, 2 & 3).

2.7 Scenarios of Marine Mammal Fleeing Behaviour for PTS Estimation

To assess the risk of instantaneous and cumulative PTS, it is necessary to make assumptions of how animals may respond to noise exposure, since any displacement of the animal relative to the noise source will affect the noise exposure incurred.

For this assessment, it was assumed that animals would flee from the pile foundation at the onset of pile driving. Animals were assumed to flee out to a maximum distance of 25 km (after which they were assumed to remain stationary at that distance).

Table 2-7 Fleeing speeds assumed for each marine mammal species/taxon				
Species	**Harbour porpoise**	**Bottlenose dolphin**	**Minke whale**	**Phocid seal**
Swimming speed (m/s)	1.4	1.52	2.1	1.8
Minimum depth Constraint (m)	5	5	10	0

The fleeing model simulates the animal displacement and their noise exposure for a given piling scenario by placing an animal agent in each grid cell of the domain (i.e. every 90 m by 90 m) and allowing them to move on the domain grid according to a set of pre-defined rules. The position of all the agents is re-evaluated at regular short intervals (e.g. 1 to 5 minutes) and the cumulated exposure over each time interval is calculated according to the number of strikes and the hammer energies used within the interval, as well as the agent positions at the beginning and the end of the interval. The duration of these time intervals was optimised in order to minimise the SPL variation due to the change in position of the agents, while maintaining a good approximation of the specified fleeing speed of the agents. At the end of the scenario piling activity, the total cumulated exposure of all the agents is mapped back to their starting positions on the grid.

In the case of single location pile driving, the model assumes that the animal agents are fleeing at constant speeds (Table 2-6), along straight lines away from the pile location, as long as the local water depth exceeds a minimum value (Table 2-6). When an animal agent would arrive into shallower water than the allowed minimum depth if moving along the straight line from the pile location, then a change is direction is calculated and effected, with the allowed values, in the order of preference, being +/- 45° (forwards left or right) , +/-90° (sideways left or right), +/-135° (backwards left or right) and, as a last option 180° (backward, but not necessarily to the previous position, unless the previous move was straight forwards). It should be noted that, as indicated in Table 2-6, these rules do not apply to the seal agents, who are allowed to move in any depths of water and even move to the shore (within the 25 km maximum distance from the pile location), thus stopping their sound exposure.

In the case of dual location pile driving, the model still assumes that the animal agents are fleeing at the same constant speeds as in the case of single location pile driving, but their fleeing direction is being re-evaluated at every time step according to their position relative to the location of the two piles. Specifically, at a given time, the fleeing direction is calculated by summing up the two vectors originating at the current animal agent position, pointing straight away from the two sources, and having their magnitude proportional with the specific dose responses of the animal for the current single strike SEL from the two sources, respectively. The same minimum depth constrains and shallow water avoidance rules as in the single location pile driving described above apply also in the case of dual location pile driving.

3 Results

3.1 Single-Strike Sound Exposure Levels for Behavioural Response Assessment

The scenarios assessed for SEL_{ss} are listed in Table 3-1, and examples are shown of the worst case for monopiles and pin piles at location 2 in Figure 3-1 and Figure 3-2, respectively, and the worst case for concurrent piling of monopiles at locations 1 and 3 is shown in Figure 3-3.

Table 3-1 Scenario list for SEL_{ss}

Foundation type	Hammer energy	Location(s)	Figure number
Monopile	5000	2	Figure 3-1
Monopile	5000	1	
Monopile	5000	3	
Monopile	4000	1	
Monopile	3000	1	
Monopile	2000	1	
Monopile	1000	1	
Monopile	3500	1	
Monopile	2500	1	
Monopile	5000	1 & 3	Figure 3-3
Pin pile	3000	2	Figure 3-2
Pin pile	3000	1	
Pin pile	3000	3	
Pin pile	3000	1 & 3	

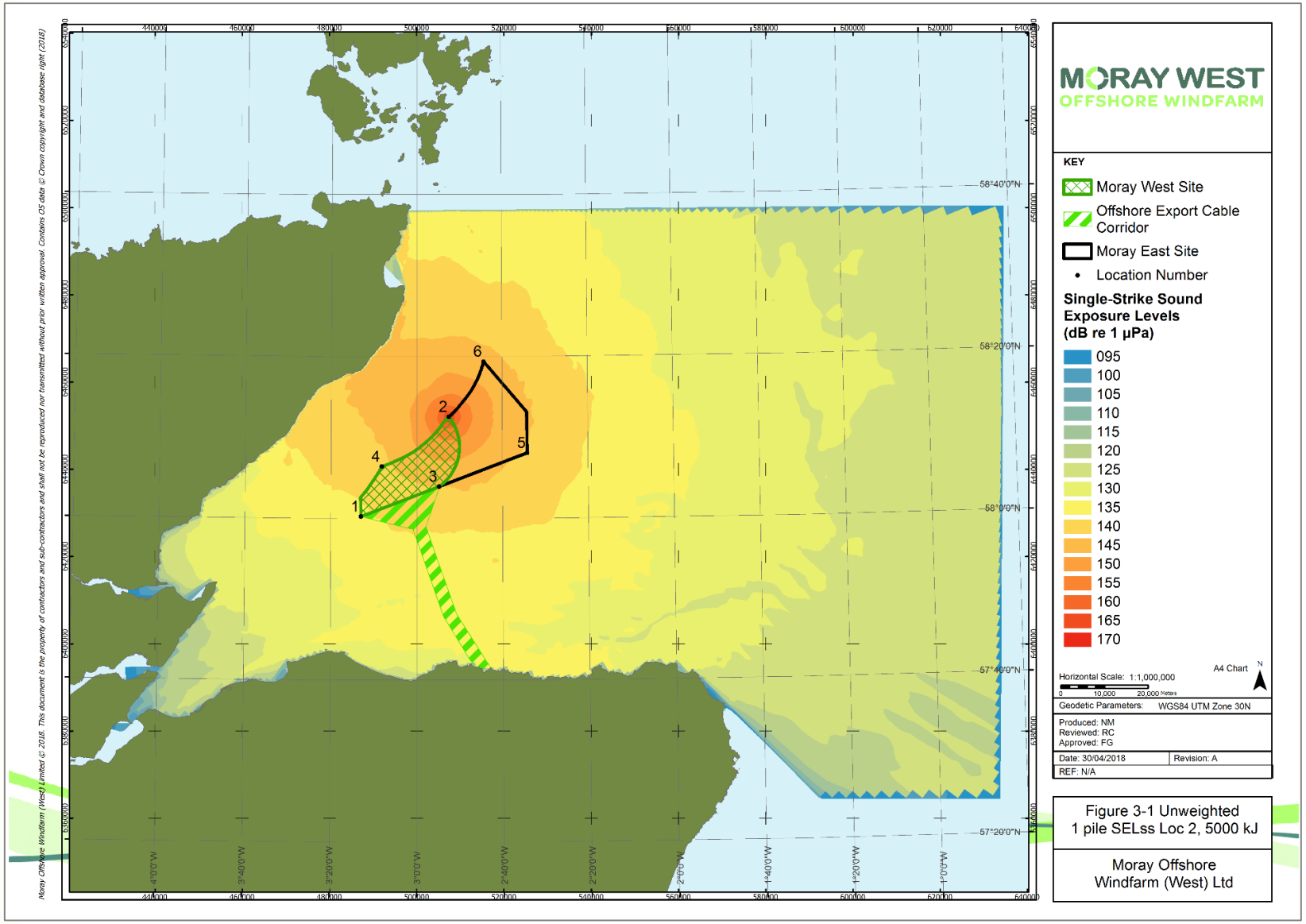

Figure 3-1 Single-strike SEL for a hammer energy of 5,000 kJ (maximum monopile hammer energy) at location 2.

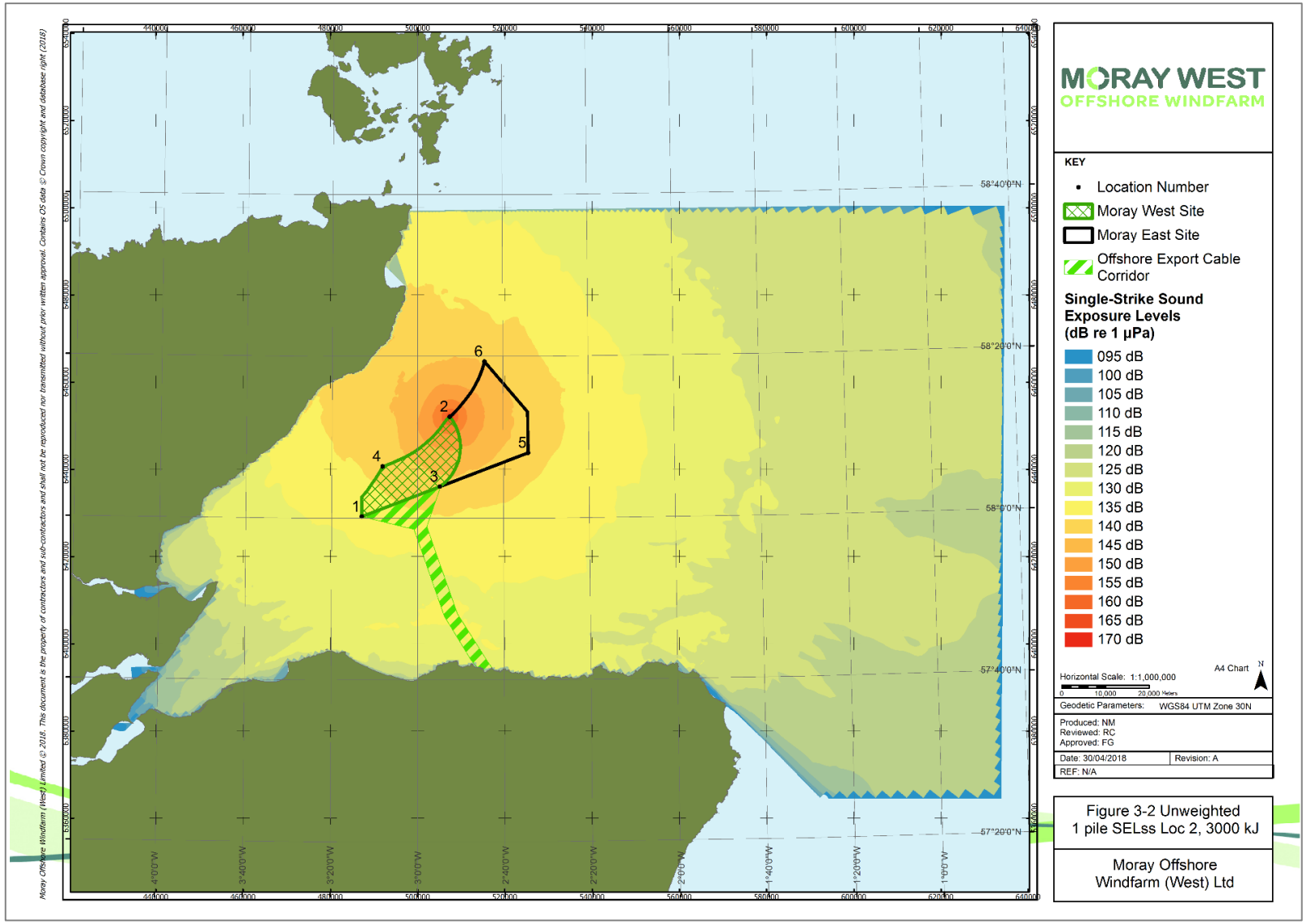

Figure 3-2 Single-strike SEL for a hammer energy of 3,000 kJ (maximum pin pile hammer energy) at location 2.

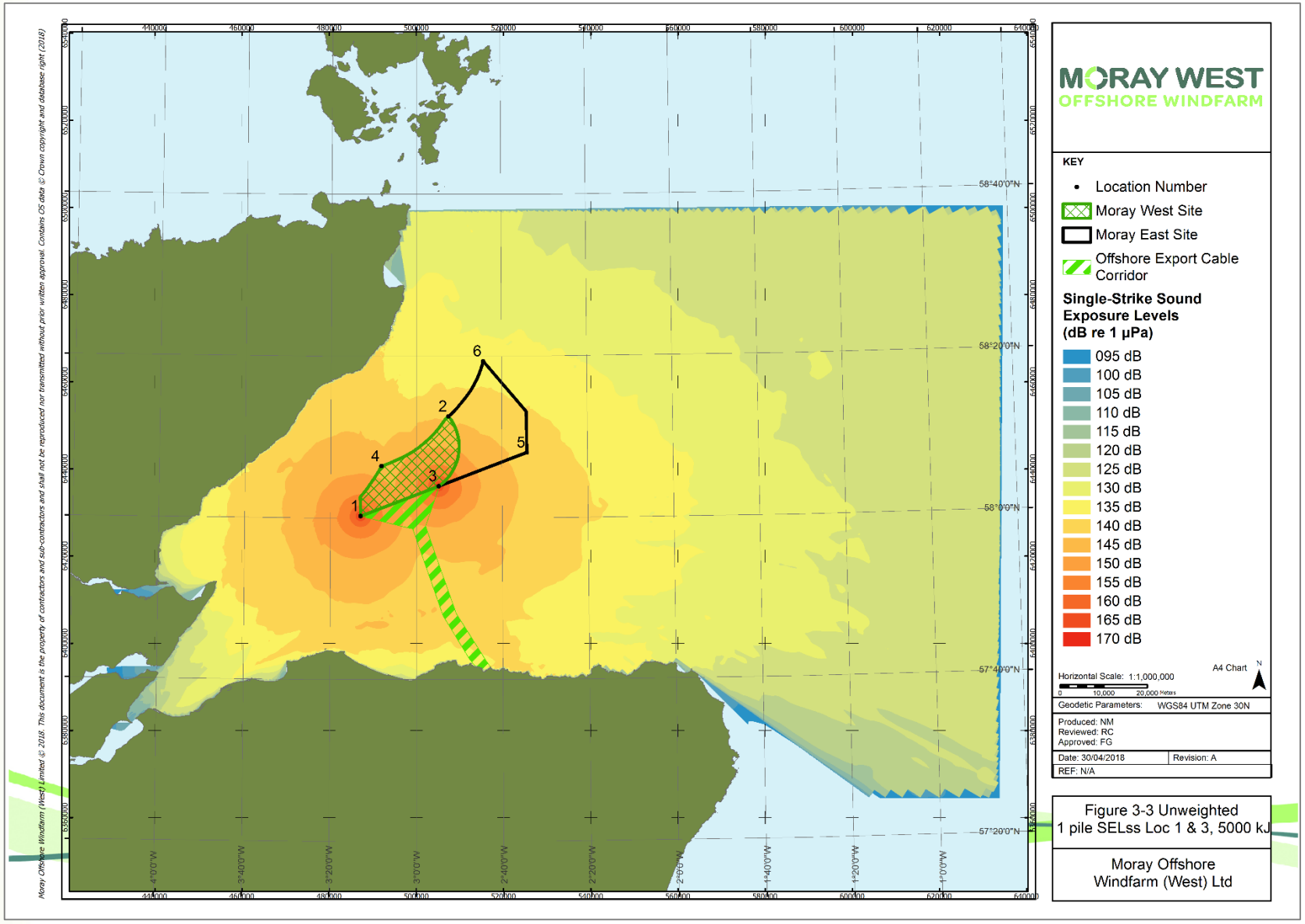

Figure 3-3 Single-strike SEL for a hammer energy of 5,000 kJ (maximum monopile hammer energy) at locations 1 and 3.

3.2 Peak SPL Assessment of Instantaneous PTS Effect Zones for Marine Mammals

All of the scenarios modelled for the peak SPL criterion for instantaneous PTS had effect ranges below 500 m (maximum was 335 m for harbour porpoise monopile scenario at 5,000 kJ). The full list of scenarios and corresponding impact ranges are provided in Table 3-2.

Table 3-2 Effect ranges for instantaneous PTS according to the NOAA peak SPL criterion for each marine mammal functional hearing group

Foundation type	Hammer energy (kJ)	Locations assessed	Species	Threshold (dB re 1 µPa)	Maximum effect range (m)
Monopile	5000	1, 2	Harbour porpoise	202	335
Monopile	5000	1, 3	Bottlenose dolphin	230	<50 m
Monopile	5000	1, 3	Minke whale	219	<50 m
Monopile	5000	1, 2	Seals	218	<50 m
Pin pile	3000	1, 2	Harbour porpoise	202	206
Pin pile	3000	1, 3	Bottlenose dolphin	230	<50 m
Pin pile	3000	1, 3	Minke whale	219	<50 m
Pin pile	3000	1, 2	Seals	218	<50 m

3.3 Peak SPL Assessment of Mortality and Recoverable Injury in Fish

The maximum effect range for mortality or recoverable injury according to the Popper criteria (which have the same threshold of 207 dB re 1 µPa) was 124 m, for the monopile scenario at 5,000 kJ. The effect range for the pin pile hammer energy was 85 m (Table 3-3).

Table 3-3 Effect ranges for mortality and recoverable injury according to the Popper peak SPL criterion for each fish hearing group. *threshold is the same for species which do and do not use the swim bladder in hearing, see Error! Reference source not found.

Foundation type	Hammer energy (kJ)	Location(s)	Fish group	Threshold (dB re 1 µPa)	Maximum effect range (m)
Monopile	5000	1, 2, 3	Swim bladder*	207	124
Pin pile	3000	1, 2, 3	Swim bladder*	207	85

3.4 Cumulative SEL Assessment of PTS Effect Zones for Marine Mammals

Only minke whale had PTS ranges > 50 m, which was predicted for both the monopile and pin pile foundations (Table 3-4). For monopiles, the predicted PTS range for a single foundation at location 3 was 507 m, corresponding to an area of 63 ha. For concurrent piling of monopiles at locations 1 and 3, an area of 79 ha was predicted. For pin pile foundations, the single foundation at location 3 resulted in an effect range of 846 m, and an effect area of 53 ha. The concurrent piling effect area was much larger at 36,708

ha (367 km^2), owing to the model predicting threshold exceedance for animals fleeing toward the shore to the northwest.

Table 3-4 Effect areas for cumulative PTS according to the NOAA SEL_{cum} criterion for each marine mammal functional hearing group

Foundation type	Max hammer energy (kJ)	Location(s) assessed	Species	Threshold (dB re 1 µPa^2 s)	Effect area (km^2); *range (m)*	Figure number
Monopile	5000	2	Harbour porpoise	155	<0.01; *<50*	N/A
Monopile	5000	1	Bottlenose dolphin	185	<0.01; *<50*	N/A
Monopile	5000	3	Minke whale	183	0.063; *507*	Figure 3-4
Monopile	5000	1	Seals	185	<0.01; *<50*	N/A
Monopile	5000	1 & 2	Harbour porpoise	155	0	N/A
Monopile	5000	1 & 3	Bottlenose dolphin	185	0	N/A
Monopile	5000	3 & 1	Minke whale	183	0.079	Figure 3-5
Monopile	5000	1 & 2	Seals	185	0	N/A
Pin pile	3000	2	Harbour porpoise	155	<0.01; *<50*	N/A
Pin pile	3000	1	Bottlenose dolphin	185	<0.01; *<50*	N/A
Pin pile	3000	3	Minke whale	183	0.053; *846*	Figure 3-6
Pin pile	3000	1	Seals	185	<0.01; *<50*	N/A
Pin pile	3000	1 & 2	Harbour porpoise	155	0 km^2	N/A
Pin pile	3000	1 & 3	Bottlenose dolphin	185	0 km^2	N/A
Pin pile	3000	2 & 3	Minke whale	183	367.08 km^2	Figure 3-7
Pin pile	3000	1 & 2	Seals	185	0 km^2	N/A

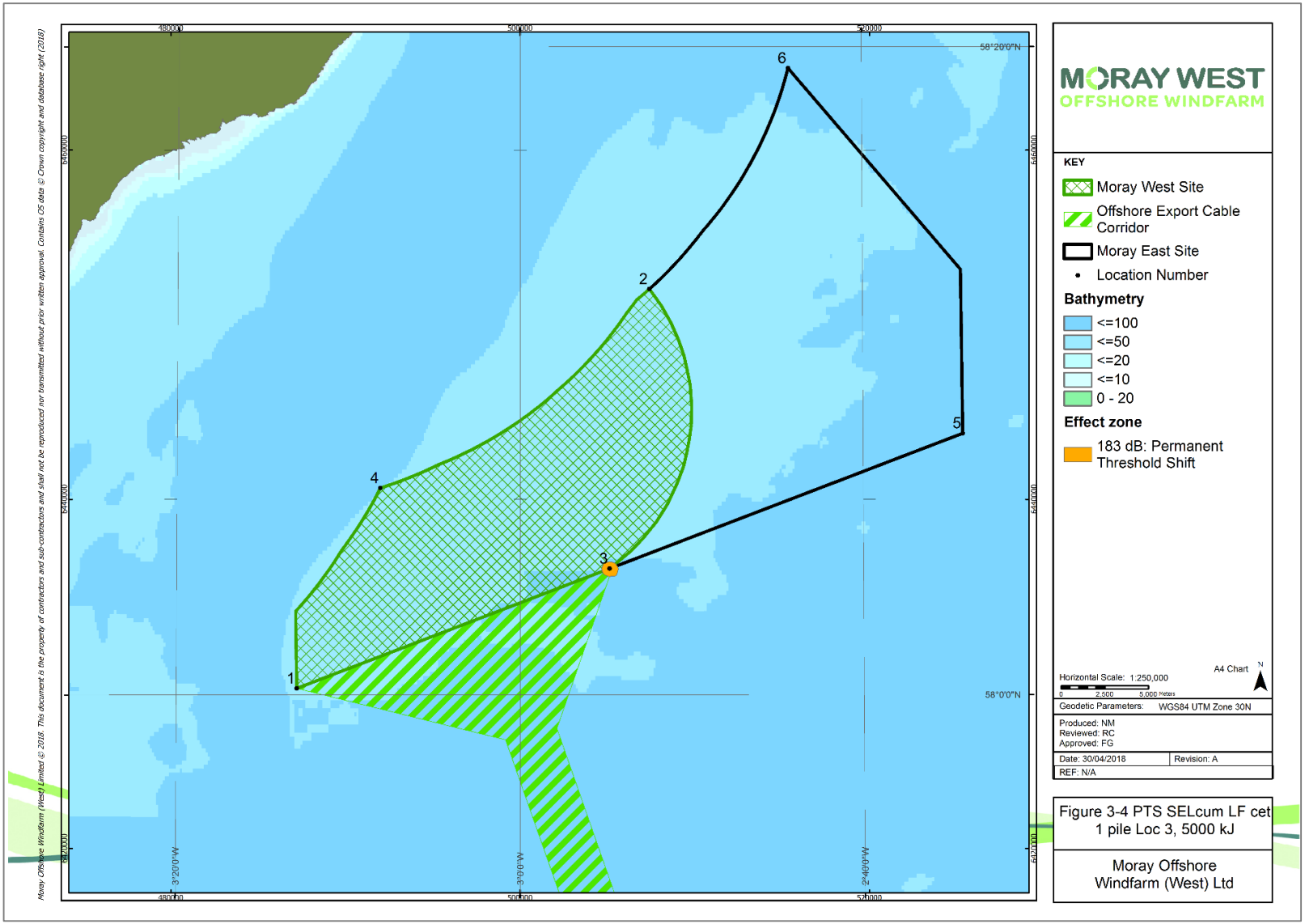

Figure 3-4 Cumulative PTS effect zones for minke whale exposed to piling of a single monopile foundation with a maximum hammer energy of 5,000 kJ at location 3.

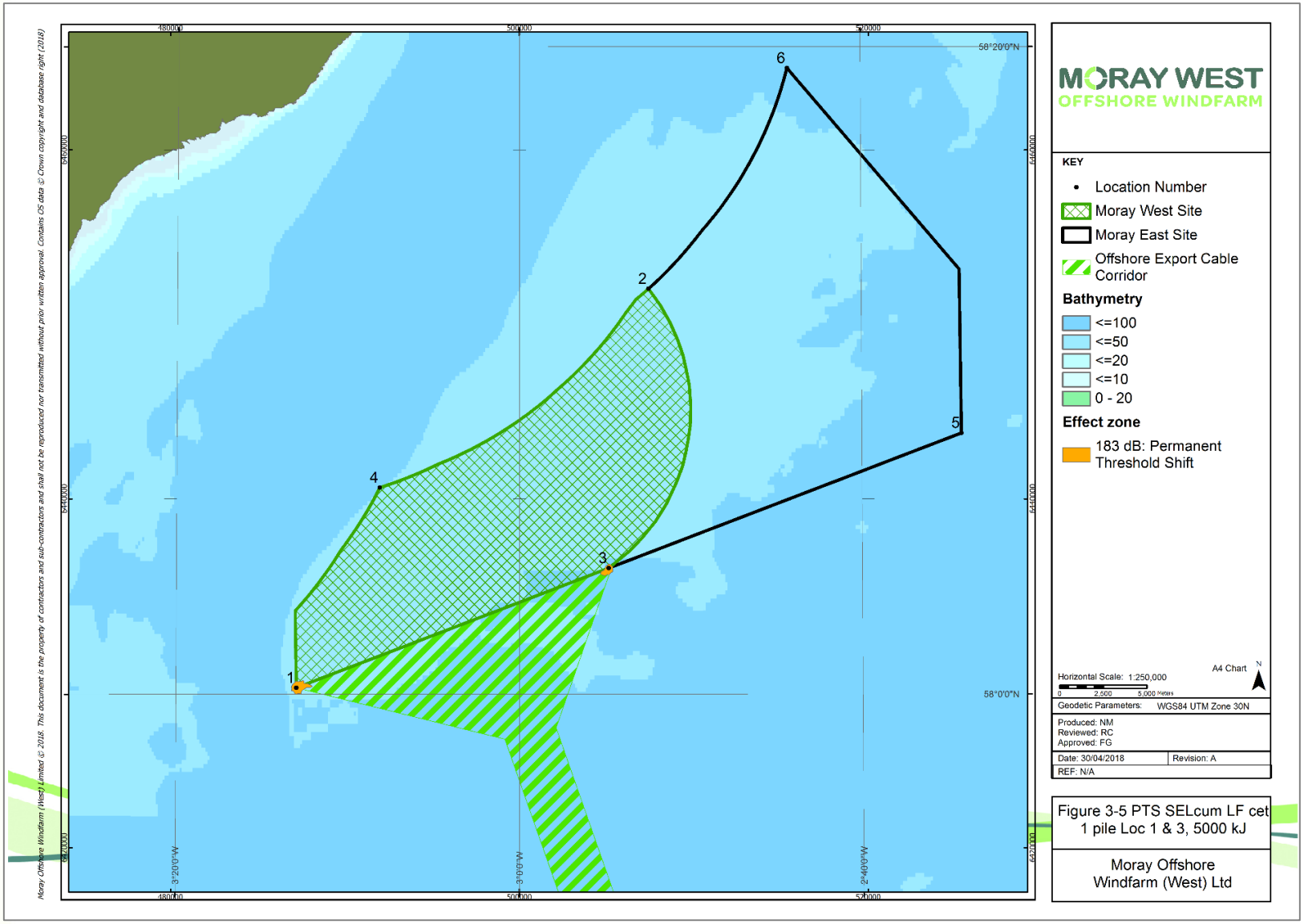

Figure 3-5 Cumulative PTS effect zones for minke whale exposed to concurrent piling of two monopile foundations with maximum hammer energy of 5,000 kJ at locations 1 and 3.

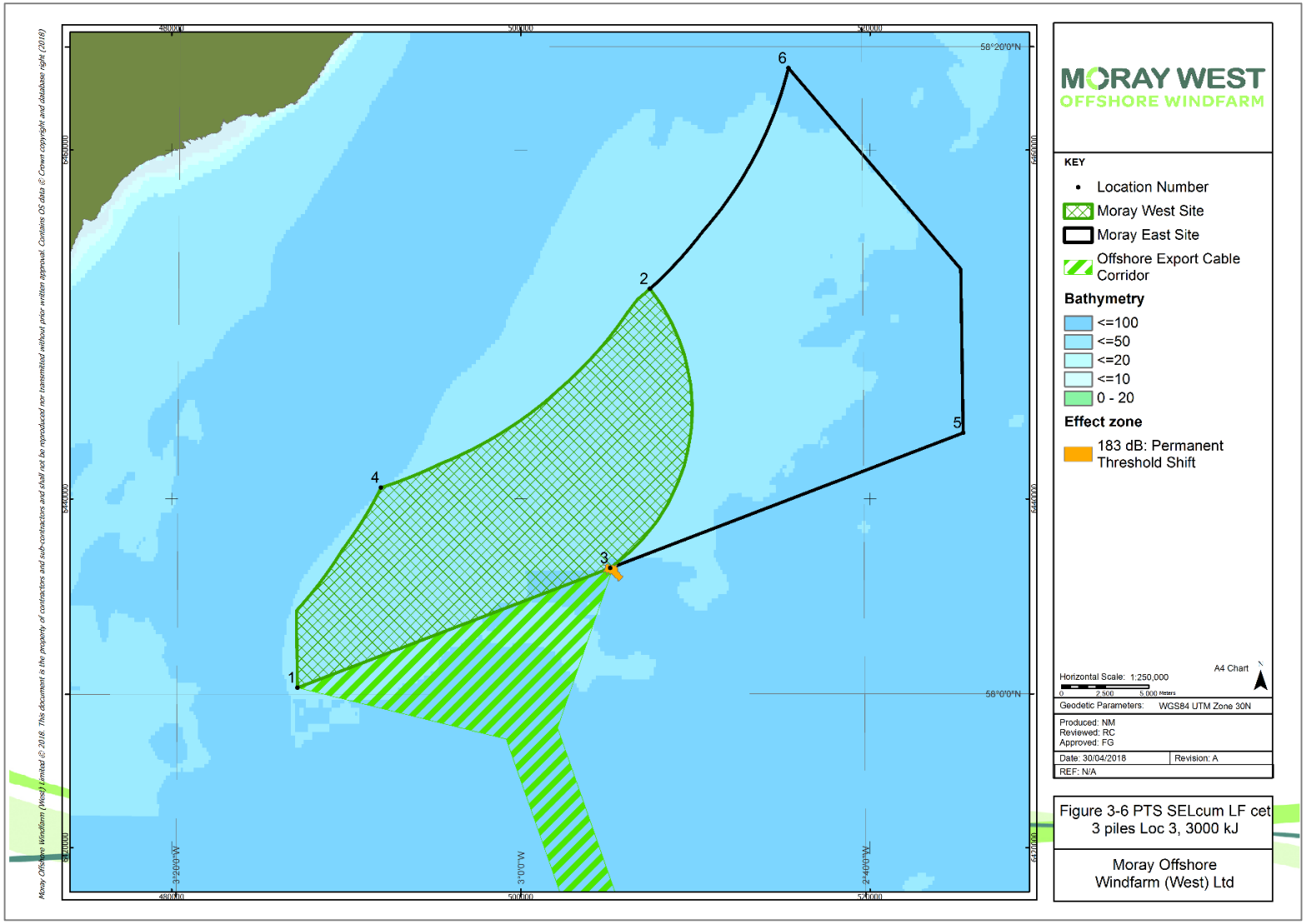

Figure 3-6 Cumulative PTS effect zones for minke whale exposed to piling of a single pin pile foundation (3 piles in 24 hours) with maximum hammer energy of 3,000 kJ at location 3.

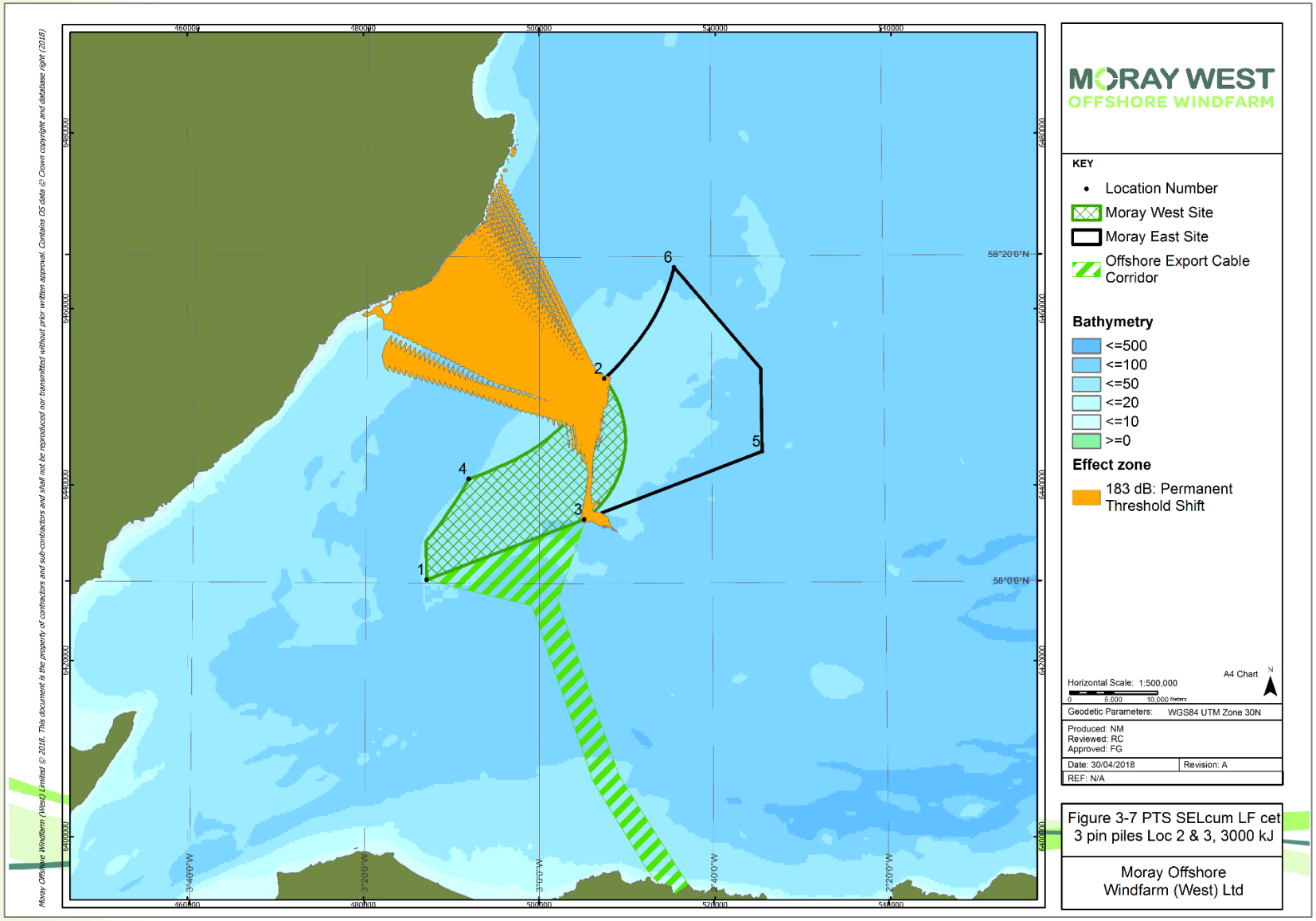

Figure 3-7 Cumulative PTS effect zones for minke whale exposed to concurrent piling of two pin pile foundations (3 piles in 24 hours) with maximum hammer energy of 3,000 kJ at locations 2 and 3.

3.5 Cumulative SEL Assessment of TTS, Recoverable Injury, and Mortality Effect Zones for Fish

Mortality effect zones were only large enough to appear on the maps for herring, meaning the effect ranges were <50 m for cod and salmon (Table 3-5, Table 3-6). The greatest mortality range predicted for herring was 601 m at location 2 for the monopile foundation. For TTS and recoverable injury, the Popper thresholds are the same for all three species. The greatest recoverable injury range was 1,079 m (location 2), and the greatest TTS range was 12,229 m (location 1). Example effect areas are shown in Figure 3-8, Figure 3-9, and Figure 3-10 for herring, and in Figure 3-11, Figure 3-12, and Figure 3-13 for cod and salmon.

Table 3-5 Effect areas for mortality, recoverable injury, and TTS according to the Popper SEL_{cum} criterion for herring. Thresholds for these effects in herring are 207, 203, and 186 dB re 1 µPa² s, respectively.

Foundation type	Max hammer energy (kJ)	Location(s) assessed	TTS area (km²); *range (m)*	Recoverable injury area (km²); *range (m)*	Mortality area km²); *range (m)*	Figure number
Monopile	5000	1	378.83; *12,229*	2.80; *953*	0.79; *507*	Figure 3-8
Monopile	5000	2	357.97; *11,495*	3.43; *1,079*	1.04; *601*	
Monopile	5000	3	341.61; *11,147*	2.75; *937*	0.77; *483*	
Monopile	5000	1 & 2	870.28	6.25	1.82	
Monopile	5000	1 & 3	859.86	5.61	1.57	
Monopile	5000	2 & 3	805.67	6.25	1.81	Figure 3-10
Pin pile	3000	1	298.66; *10,891*	1.94; *771*	0.03; *90*	Figure 3-9
Pin pile	3000	2	287.59; *10,317*	2.45; *913*	0.65; *482*	
Pin pile	3000	3	269.13; *9,932*	1.94; *771*	<0.01; *<50*	
Pin pile	3000	1 & 2	656.13	4.39	0.68	
Pin pile	3000	1 & 3	707.41	3.88	0.04	
Pin pile	3000	2 & 3	663.82	4.41	0.66	

Table 3-6 Effect areas for mortality, recoverable injury, and TTS according to the Popper SEL_{cum} criterion for cod and salmon. Thresholds for these effects in cod and salmon are 210, 203, and 186 dB re 1 µPa² s, respectively.

Foundation type	Max hammer energy (kJ)	Location(s) assessed	TTS area (km²); *range (m)*	Recoverable injury area (km²); *range (m)*	Mortality area (km²); *range (m)*	Figure number
Monopile	5000	1	378.83; *12,229*	2.80; *953*	<0.01; *<50*	Figure 3-11
Monopile	5000	2	357.97; *11,495*	3.43; *1,079*	<0.01; *<50*	
Monopile	5000	3	341.61; *11,147*	2.75; *937*	<0.01; *<50*	
Monopile	5000	1 & 2	870.28	6.25	<0.01; *<50*	
Monopile	5000	1 & 3	859.86	5.61	<0.01; *<50*	
Monopile	5000	2 & 3	805.67	6.25	<0.01; *<50*	Figure 3-13
Pin pile	3000	1	298.66; *10,891*	1.94; *771*	<0.01; <50	Figure 3-12
Pin pile	3000	2	378.83; *12,229*	2.80; *953*	<0.01; <50	
Pin pile	3000	3	357.97; *11,495*	3.43; *1,079*	<0.01; <50	
Pin pile	3000	1 & 2	341.61; *11,147*	2.75; *937*	<0.01; <50	
Pin pile	3000	1 & 3	870.28	6.25	<0.01; <50	
Pin pile	3000	2 & 3	859.86	5.61	<0.01; <50	

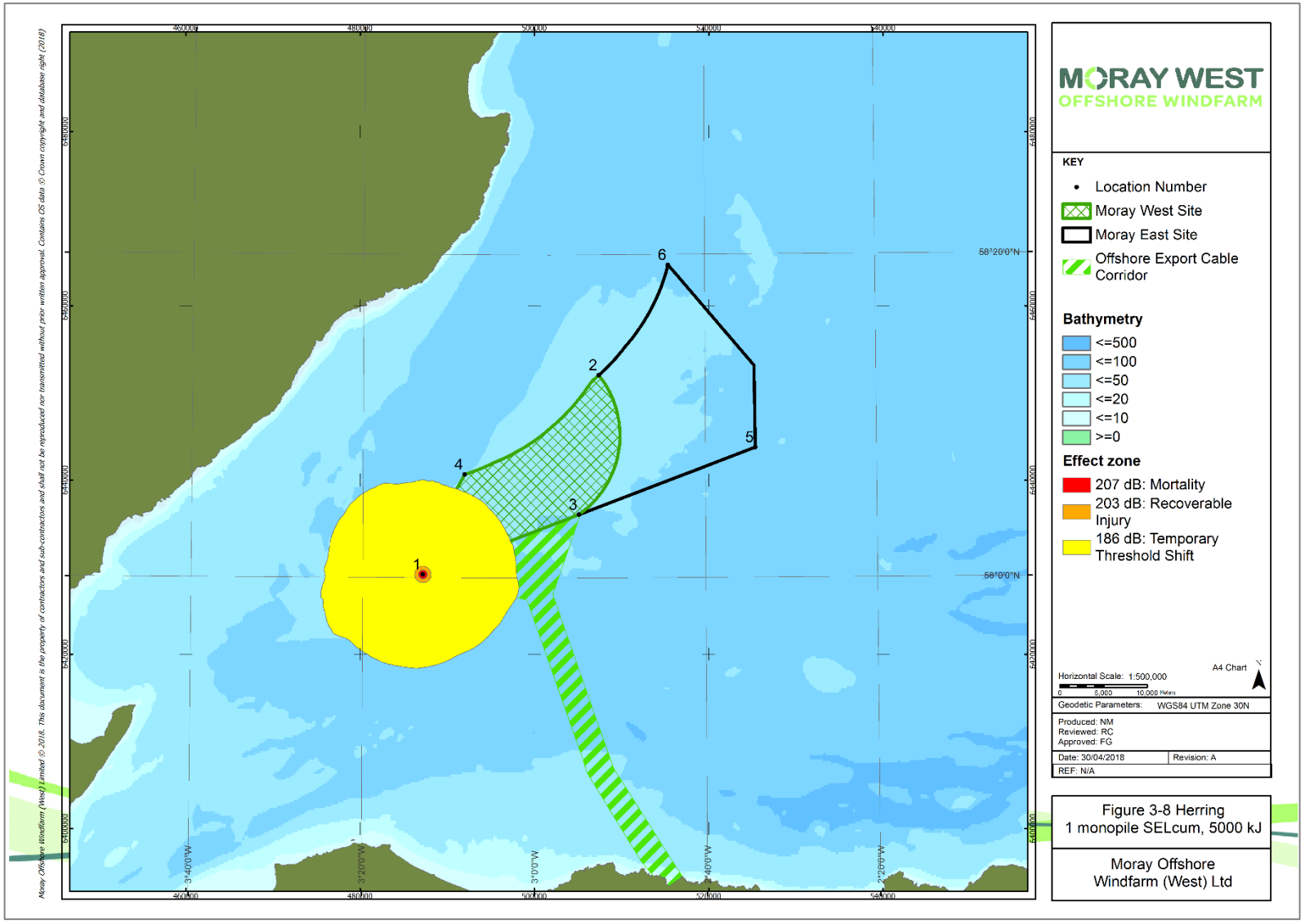

Figure 3-8 Cumulative exposure effect zones for herring exposed to piling of single monopile foundation with maximum hammer energy of 5,000 kJ at location 1.

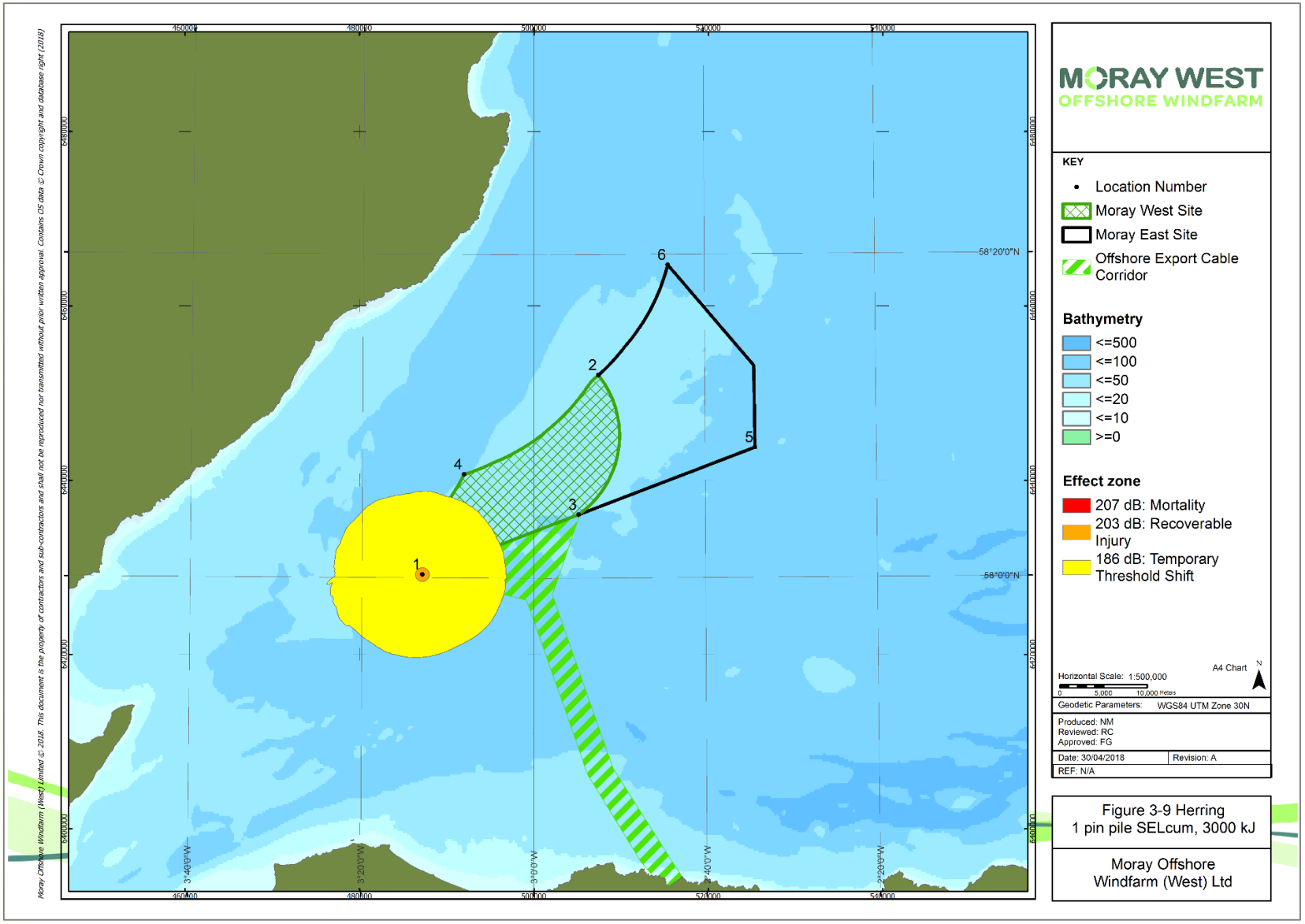

Figure 3-9 Cumulative exposure effect zones for herring exposed to piling of single pin pile foundation with maximum hammer energy of 3,000 kJ at location 1.

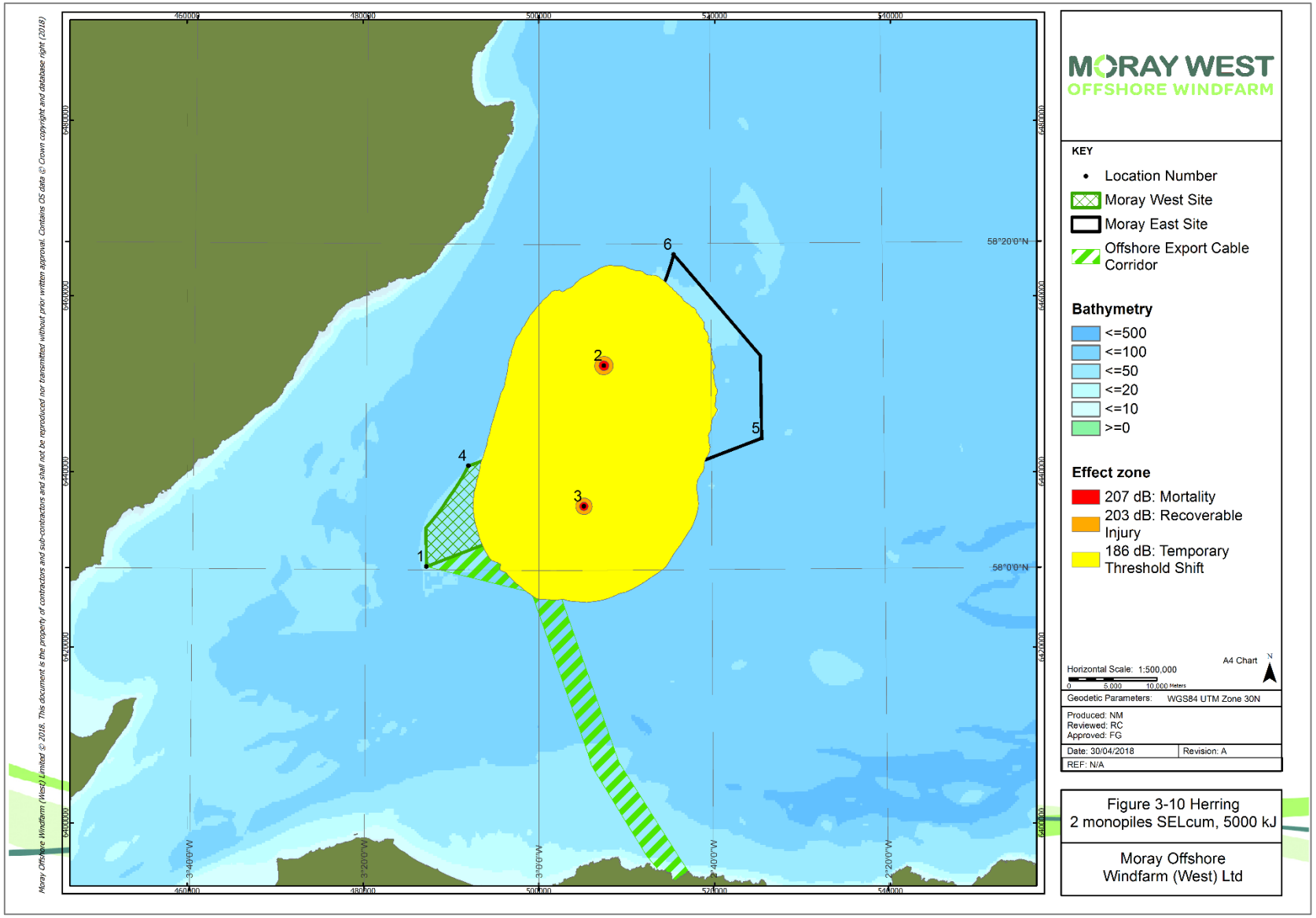

Figure 3-10 Cumulative exposure effect zones for herring exposed to concurrent piling of two monopile foundations with maximum hammer energy of 5,000 kJ at locations 2 and 3.

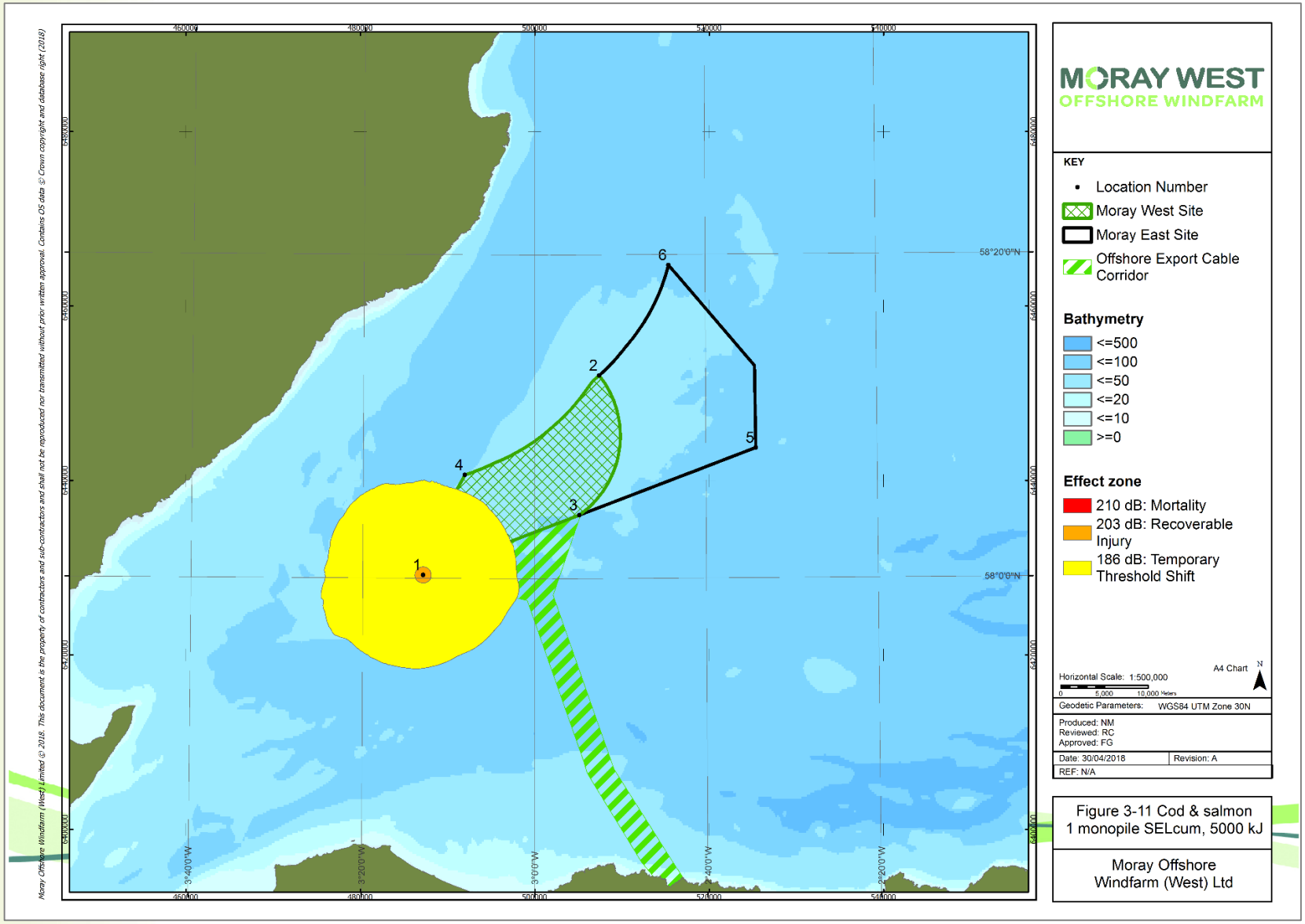

Figure 3-11 Cumulative exposure effect zones for cod and salmon exposed to piling of single monopile foundation with maximum hammer energy of 5,000 kJ at location 1.

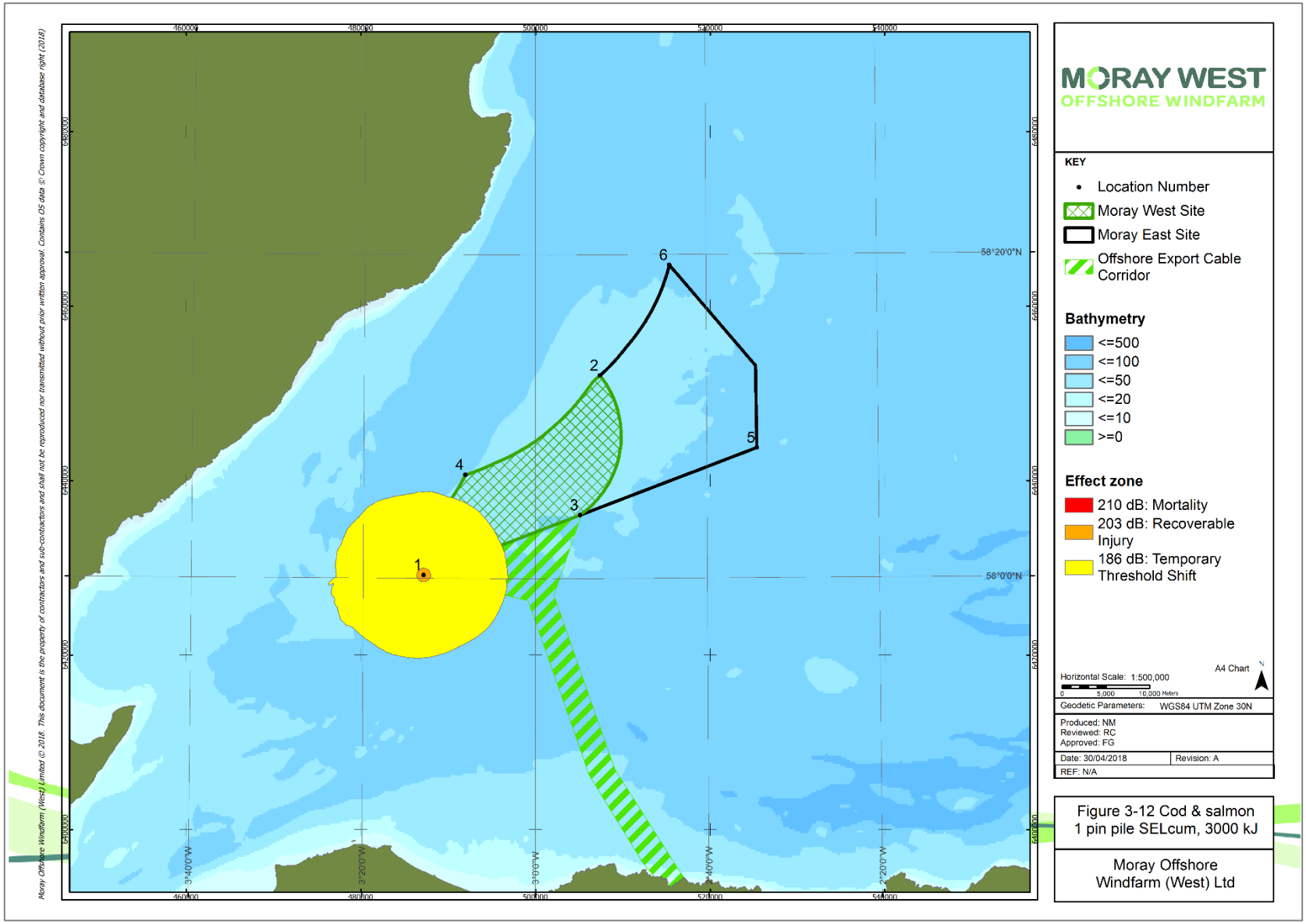

Figure 3-12 Cumulative exposure effect zones for cod and salmon exposed to piling of single pin pile foundation with maximum hammer energy of 3,000 kJ at location 1.

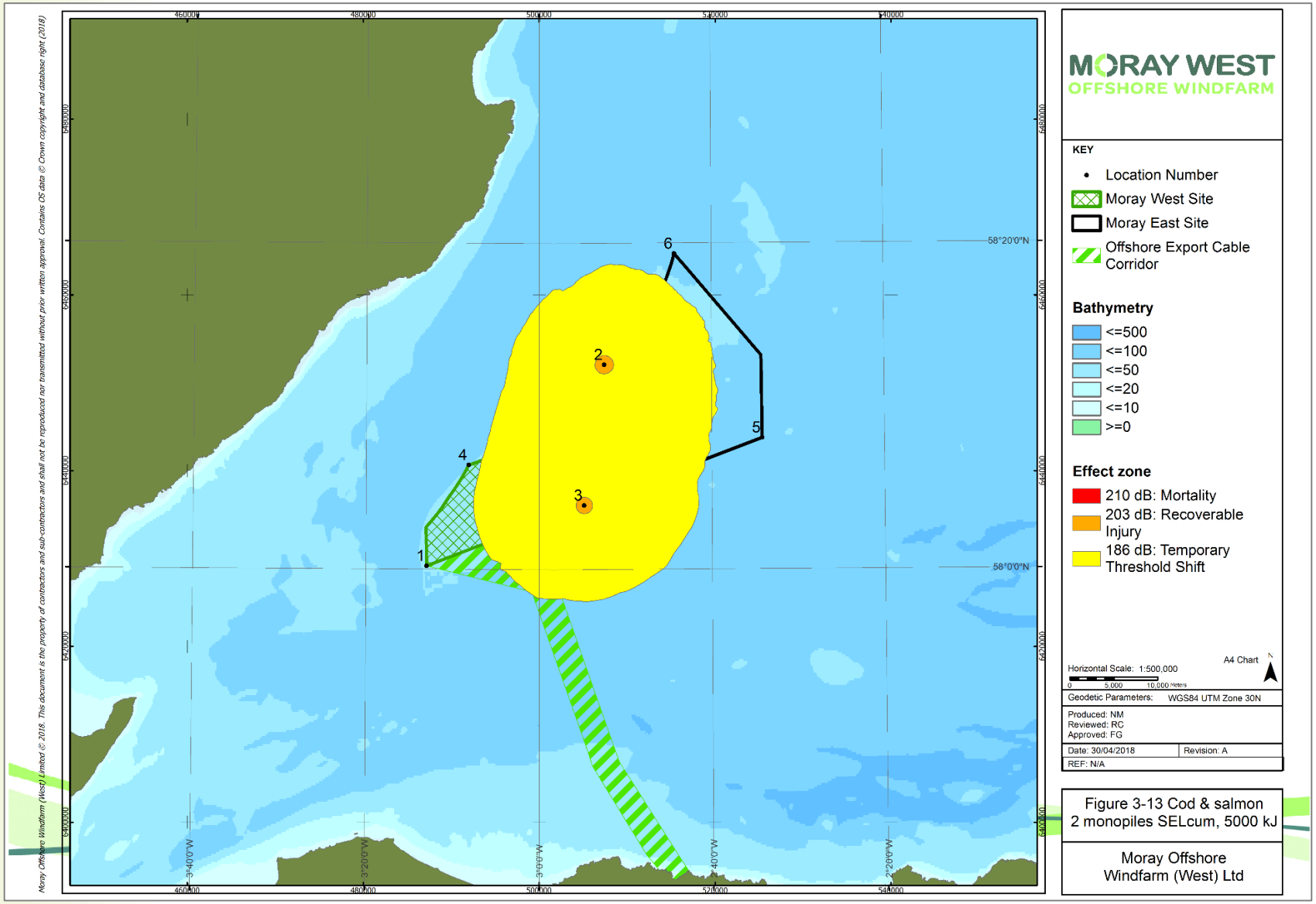

Figure 3-13 Cumulative exposure effect zones for cod and salmon exposed to concurrent piling of two monopile foundations with maximum hammer energy of 5,000 kJ at locations 2 and 3.

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Appendix A: Review of Current Literature Relating to Energy Conversion Factors

Introduction

Cefas have recently undertaken a number of projects to model the propagation of underwater noise in relation to wind turbine generator foundation piling. This work has informed impact assessments which have utilised subsequent outputs such as the range to key thresholds for injury and disturbance to marine mammal and fish receptors.

Among a range of parameters which need to be specified for the modelling is a factor applied to the relevant hammer energy in order to calculate the proportion of energy which enters the water column as acoustic energy, from which source level (SL) may be estimated. This is referred to as 'the conversion factor' in this Note.

The SL is a theoretical, idealised concept of the sound at 1 m distance from the source which is either calculated, or estimated from far-field measurements that are back-propagated with a model. In reality the sound source, whether pin pile or monopile, is not a point source at 1 m distance, but this is a necessary assumption for modelling. This assumption of an idealised point source can lead to differences between model predictions and any potential measurements taken in the immediate vicinity of the pile (e.g. <50 m away), but, nevertheless, it makes possible the realistic estimation of sound levels at greater distances, which are of most relevance to marine mammal and other receptors.

Scottish Natural Heritage (SNH), through Marine Scotland (MS), have queried the conversion factor (0.5%) adopted by Cefas in recent noise modelling studies. Specifically, Cefas understand that previous work completed by Cefas in relation to the development of piling mitigation for the Beatrice and Moray Offshore wind farms, where a conversion factor or 1% was applied, is considered to potentially represent a precedent for other studies.

The purpose of this Note is to provide a summary of the evidence base for the conversion factor applied in recent studies. This is pursued through review of relevant literature and recent and ongoing work on monitoring of piling noise during construction of Beatrice Offshore Wind Farm.

Literature Review

The review paper of Dahl, de Jong and Popper (The Underwater Sound Field from Impact Pile Driving and Its Potential Effects on Marine Life, in Acoustics Today, 2015) states that about half a percent of the hammer impact energy goes into waterborne acoustic energy, citing several observational (Robinson et al., 2007; Dahl and Reinhall, 2013) and numerical (Zampolli et al., 2013) studies.

The Robinson et al. (2007) paper and the related Lepper et al. (2007) paper present an assessment of the underwater radiated noise during a marine piling operation carried out in UK coastal waters in April 2006, namely the driving of a 2 m diameter, 65 m long test pile into a hard chalk sediment. The piling location was in an area approximately 3 km offshore and with variable water depths due to the tide and the local variations, which are given as 10 – 15 m in the piling area (Lepper et al., 2007) and 8 m to 15 m in the local area (Robinson et al., 2007). The hammer energy varied incrementally from 80 kJ to 800 kJ and the measurements were taken at two locations corresponding to ranges of 57 m and 1,850 m. The observed mean energy flux density levels (i.e. the single-pulse SEL) were reported as 178 dB re 1 μPa^2 s and 164 dB re 1 μPa^2 s, at the ranges of 57 m and 1,850 m, respectively. The authors performed calculations of the acoustic energy of the pulses *from the range of 57 m,* back-propagated to the reference distance of 1 m with a propagation model based on an implementation of the parabolic equation (based on the RAM numerical code, which is also used in the Cefas propagation model). The acoustic pulse energy was then compared with the hammer energy, and a conversion factor of around 0.3% was found, showing also a good linear data fit between 80 - 800 kJ, which suggested that extrapolation to higher energies should be

possible with reasonable accuracy. The authors also reported that "the dependence of the acoustic pulse amplitude on other factors such as pile diameter, sediment type and bathymetry is far more complex and more difficult to determine."

The second cited observational paper, namely Dahl and Reinhall (2013), presents an assessment of measurements taken at Washington State ferry dock construction site on Vashon Island in Puget Sound, for three piles of hollow steel of length 32 m, diameter 0.762 m, and wall thickness 2.54 cm. The acoustic measurements were made during the final 0.3 m of penetration depth, for which the impact hammer energy was 180 kJ, at very close ranges, namely 8 m, 12 m and 15 m from the pile to the vertical line arrays of hydrophones. The water depth at the location of the experimental setup was between 12.5 - 13 m, with the variation owing to the tide. The authors performed a complex calculation of the wave fronts associated with the Mach cone generated by the pile compression wave, and estimated the energy radiated into the water column as 2400 J +/- 400 J for the three measurements, or ~1% of the hammer energy. This was deemed reasonably consistent with more detailed numerical study of Zampolli et al. (2013) and similar in magnitude to the estimates of de Jong and Ainslie (2008) and Robinson et al. (2007). The first two references are the same as the ones cited by the review paper of Dahl et al. (2013) while the last one is an observational study that we will briefly analyse below.

The paper of de Jong and Ainslie (2008) is an assessment of the underwater radiated noise due to piling for the Q7 Offshore Wind Park in the Dutch sector of the North Sea, 23 km offshore. The local water depth in the area is between 19 m and 24 m and the sediment in the area contains mainly sand. The monopiles were 54 m long steel cylinders of 4 m diameter and varying wall thickness, and were hammered approximately 30 m into the seabed. The main part of the piling was carried out at stroke energy of circa 800 kJ and noise measurements were performed during the piling of 9 monopiles, at distances ranging from 0.4 km from the piles. However, results were presented only for two monopiles, for measurements taken between 1.0 km and 5.7 km from the piling.

Some of the measurements were compared with other studies, including that of Robinson et al. (2007), and the authors report that the SEL of 164 dB re 1 μPa^2 s measured by Robinson et al. agrees well with their own SEL measured at 1.8 km from the piling in the Q7 Park, which was also 164 dB re 1 μPa^2 s, noting the same stroke energy used in both cases (800 kJ), but the otherwise significant differences between the two cases (regarding the pile dimensions, water depths and sea bed type). The authors then give an example calculation of source level; however, they state: "***The distance of our measurements from the monopiles is too large to permit a reliable estimate of source level from our data***." (As mentioned above, the closest analysed measurements were taken at 1 km distance from piling, although other data sets were reportedly measured as close as 400 m from the piles). As an alternative, the authors use the measurement of Robinson et al. (2007) at 57 m (mentioned above), citing the similarity in the use of the same pile driver at the same energy and the similar received levels at the distance of 1.8 km, which, in the authors' opinion, is likely to results in a source level estimate similar to their Q7 source level.

This is an interesting observation, but the exercise of calculating the source level estimate is rather curious and ultimately superfluous, since Robinson et al. already performed the calculation, and although the energy source level was not given explicitly by Robinson et al, it can be readily implied by the reported 0.3% energy conversion coefficient (which, for the 800 kJ strike, would translate to a SL_E of 204.7 dB re 1 $\mu Pa^2 s$). Nevertheless, de Jong and Ainslie state that their calculation is intended as a rough estimate only. For this purpose, unlike Robinson et al. who calculated the propagation loss from 57 m back to 1 m from the source using the parabolic equation method, de Jong and Ainslie used a semi-empirical estimation of the propagation loss which is stated to vary between 28 dB (at 100 Hz) and 34 dB (at 10 kHz). By adding the average of these propagation loss estimates, namely 31 dB, to the SEL value at 57 m of 178 dB, the authors obtain an energy source level of 209 dB re 1 $\mu Pa^2 s$, also stating an uncertainty of +/- 4.5 dB. From this, the authors then estimate the source energy as ≈7 kJ and report therefore a conversion coefficient

of about 1%. Actually, when we repeated the calculation ourselves for the 209 dB source level we obtained a more accurate value of 6.5 kJ for the source energy and hence a conversion coefficient of 0.81%. Furthermore, we explored the effect of the reported +/- 4.5 dB uncertainty, and the resulting range of source energies is between 2.3 kJ and 16.5 kJ, corresponding to conversion coefficients between 0.29% and 2.06%. Reflecting on the cause of this uncertainty, this is mostly due to the simplistic choice of averaging the propagation loss estimates at 100 Hz and 10 kHz; a more informed estimate could be performed by taking note of the typical piling energy spectrum (of which an example is shown by de Jong and Ainslie in Figure 6) and observing that the energy is heavily concentrated in the low frequency bands around 100 Hz, thus implying that the propagation loss at 100 Hz is much more representative for the loss of the pulse energy. This would suggest a conversion factor towards the lower limit of the interval we calculated above, namely 0.29% rather than the mid value of 0.81%. Interestingly (but perhaps not surprisingly) the lower limit is also very close to the value of 0.3% obtained by Robinson et al. using the RAM parabolic equation method backpropagation.

Although just a simple exercise, the calculation described above has the merit of illustrating the difficulties related to the estimation of the energy source level (and implicitly of the conversion factor) even from such close-distance measurements, and adds support to the authors' statement, emphasized above, about the feasibility of reliably estimating the source level from measurements at larger distances.

Finally, the paper of Zampolli et al. (2013) presents a quantitative prediction of the acoustic radiation from a pile, based on a structural acoustic frequency domain finite element numerical model, and validated through measurements from accelerometers mounted on the head of the pile and from hydrophones deployed in the water. The experiment was set up in a shallow docking area at the IHC Hydrohammer site in Kinderdijk (The Netherlands), with average water depths of 7 m and with a sea floor described as medium sand. A steel pipe of 32.4 m in length, 91.44 cm in diameter and a wall thickness of 2.5 cm, with the bottom closed by a steel lid and the interior filled with water was driven 20 m into the ground with a hydraulic hammer, which was set to an impact energy of 87 kJ for the first blow, and which was considered representative of all the recorded subsequent blows.

The authors used the accelerometer and hydrophone measurements to scale and calibrate the numerical model transfer functions, which provide a relationship between the force exerted by the hammer and the frequency domain acoustic pressure. The model predictions were then analysed in-depth against the measurements. The authors noted that the model-measurement comparison establishes some confidence in the accuracy of the model, although discrepancies between the model results and the measurements remained, as expected due to uncertainty related to both experimental and model parameters. In the final part of the paper, the authors use their model to characterise the pile as an acoustic energy radiator. They perform an integration of the product of the model predicted time domain acoustic pressure and the particle velocity fields surrounding the pile, and obtain a value of 1.164 kJ for the energy radiated by the pile into the water, which corresponds to ratio of 0.0213 (or 2.13%) between this energy and the estimated energy transferred to the anvil. However, it should be noted that this estimated energy transferred to the anvil, namely 54.6 kJ, is less than the hammer impact energy, which was reported as 87 kJ. Although not explicitly presented by the authors, if we calculate the energy transfer from this hammer impact energy into the water, then we obtain a reduced ratio of 0.0133, or 1.33%.

In conclusion, in the primary literature that was cited (directly or indirectly) in the review paper of Dahl, de Jong and Popper (2015), several authors performed calculations of the energy conversion factor, based on various observational approaches (Robinson et al. 2007; Lepper et al. 2007; Dahl and Reinhall, 2013; de Jong and Ainslie, 2008) and on direct numerical approaches supported by measurements (Zampolli et al. 2013). The observational papers of Robinson et al. (2007) and Lepper et al. (2007) reported a conversion factor of 0.3%, from measurements taken at 57 m from the pile and backpropagated to the source with the RAM parabolic equation method.

As mentioned above, the Cefas noise model also uses the RAM parabolic equation method for calculating the sound propagation losses. Furthermore, it should be noted that it is a good practice in modelling to use the same model for forward (i.e. far field) predictions as the one used for source level estimation through backward propagation (Etter, 2017).

The observational paper of de Jong and Ainslie (2008) noted the similarity between their measured levels at the distance of 1.8 km, and those of Robinson et al (2008) at 1,850 m, for the same strike energy, which was considered remarkable given the significant differences between the two cases (pile dimensions, water depths and sea bed type). Furthermore, they stated the infeasibility of reliably estimating the source levels from their own measurements which were at ranges between 0.4 km - 5.7 km away from the pile, and they instead suggested that the source level of Robinson et al. (2008) should likely be similar to their own.

The other approaches applied more complex calculations involving the integration of Mach wave fronts as recorded in the immediate vicinity of the pile (Dahl and Reinhall, 2013) or of the pressure and particle velocity fields predicted by a numerical model (Zampolli et al. 2013). These authors obtained conversion factors of approximately 1% and 1.3%, while noting the relative large uncertainty related to the accuracy of their complex methodology.

Ultimately, much of the material of Dahl and Reinhall (2013) was presented again in the review paper of Dahl, de Jong and Popper (2015), where the authors synthetized their earlier findings and, taking note of the other evidence which we also reviewed above, stated that the conversion factor is approximately 0.5%. In selecting the conversion factor for our own purposes we also considered highly relevant the fact that, in the only major highlight of this nature the review paper, at the top of page 23, the authors stated: "**About half a percent of the hammer impact energy goes into waterborne acoustic energy**". Given this consensus view, and taking note also of the similarities between the sound propagation methodologies of Robinson et al. (2007) and our own, we feel confident and justified in our choice of 0.5% for the energy conversion factor.

Considerations Related to Cefas Modelling Work for the Beatrice Mitigation Plan

Cefas performed modelling work to inform the Beatrice piling strategy. The Beatrice Piling Strategy (Annex I of Appendix C, Protocol for mitigating the risk of instantaneous death or injury to marine mammals during piling at the BOWL and MORL Wind Farms) states that the Mitigation Zone (60m) is based on modelling completed by Cefas:

> *For this assessment, Cefas conducted additional modelling to provide a conservative estimate of impact ranges for a 300 kJ initial hammer energy. This assumed an energy conversion efficiency of 1%, which is at the upper limit of field observations (Ainslie et al. 2012; Dahl et al. (2015). This 300 kJ strike equates to 205.6 dB of acoustic energy as a single pulse SEL (de Jong & Ainslie 2008; Dahl et al. (2015).*

The reasoning for choosing 1% and not 0.5% in this instance is as described in an SNH advice note to Marine Scotland, prepared at the time:

> *…we discussed the soft start source level used in the original modelling and felt that this was most likely an overestimate. This level was based on an estimated energy conversion of 10% of impact energy being translated to acoustic energy in the environment. Within literature there are different estimates of the percentage probably related to the seabed structure. But consensus appears to be moving towards a conversion efficiency of 0.5%. We felt that this was too great a change from the original 10% and agreed to use 1% again for conservatism. Recalculation of this zone using these terms estimates an injury range of ~ 60m.*

> *We are still in discussion relating to the confidence in the estimation of this injury zone prediction and consider this to be of value for assessment of risk. The range estimated is sensitive to the propagation model, the estimated soft start source level and the PTS threshold used. This uncertainty should be explored.*

In other words, the reason 1% was used for this BOWL assessment was not because it was the most realistic number, but because a previous state of affairs specifically in the BOWL assessment meant that SNH perceived it would be "too great a change" to use the number on which there is scientific consensus. It is our view that this gross overestimation (10% hammer conversion efficiency) in one previous assessment should not continue to influence the way that future assessments are conducted, and we should instead proceed on the basis of the best available science, which supports a 0.5% hammer energy conversion factor, as acknowledged in the above statement.

Considerations Related to Cefas Modelling Work for the Monitoring of BOWL Pile Installation

Marine Scotland and others are aware that in addition to preparing noise model outputs for EIAs, Cefas is simultaneously engaged in a separate project related to the monitoring of the installation of the BOWL offshore wind farm, under contract to the University of Aberdeen. The measured data we have analysed so far were taken at relatively large distances from the piling location (between 2 km - 10km from the piling), which would make the attempt of validating the conversion factor to within 3 dB (the difference between 0.5% and 1% conversion factor) a challenging undertaking (see Section 2). The data we have modelled so far do not contradict our 0.5% conversion factor model, but the variability in these long-range measurements is too high to allow confidence in the validation of a 0.5% or 1% conversion factor. Further work may improve confidence in this, however as this is not explicitly within the scope of the work for this project, it is not a question we have been considering in detail.

Summary

Cefas endeavours to carry out EIAs according to the best available science. We have conducted a detailed review of the literature (Section 2), which supports the use of 0.5% as the energy conversion factor. It is noted that in a previous assessment for the prediction of injury to inform the mitigation zone for the BOWL Piling Strategy, a 1% conversion factor was modelled by Cefas, on the basis that one or more stakeholders felt that adopting the scientific consensus of 0.5% would be too great a change from a previous assessment of the same activity, which used a large overestimate of 10%. We do not regard this as setting a precedent for this or future assessments, since it is our view that assessments should be conducted based on the best available science, not on the peculiarities of an assessment where a compromise has been agreed due to a specific legacy issue. We also note that our separate ongoing work to model the noise from the installation of the BOWL offshore windfarm will not result in confident assessments of the conversion factor from that project within timescales which can inform the current cohort of assessments. However, we reiterate that the weight of scientific evidence from multiple studies supports the approach we have taken.

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MORAY WEST
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Report to Inform European Protected Species Licence Application

Moray Offshore Windfarm (West) Limited

Technical Appendix 9.3

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Acronyms	
Acronym	**Expanded Term**
BOWL	Beatrice Offshore Wind Ltd.
CODA	Cetacean Offshore Distribution and Abundance in the European Atlantic
CRRU	Cetacean Research and Rescue Unit
DECC	Department of Energy & Climate Change (former name for the DBEIS
Development	The Moray West Offshore Wind Farm and the associated Moray West OfTI.
EC	European Commission
ECOMMAS	East Coast Marine Mammal Acoustic Study
EEZ	Exclusive Economic Zone
EIA	Environmental Impact assessment
EPS	European Protected Species
ES	Environmental Statement
EU	European Union
FCS	Favourable Conservation Status
HDD	Horizontal Directional Drilling
HLV	Heavy Lift Vessel
HRA	Habitat Regulations Appraisal
HVAC	High Voltage Alternating Current
IAMMWG	Inter-Agency Marine Mammal Working Group
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
JUV	Jack-up Vessel
Moray Offshore	Moray Offshore Renewable Power Limited
Moray West	Moray Offshore Windfarm (West) Limited
MMMP	Marine Mammal Monitoring Plan
MS-LOT	Marine Scotland Licensing and Operations Team
MU	Management Unit
OfTI	Offshore Transmission Infrastructure
OnTI	Onshore Transmission Infrastructure
OSPs	Offshore Substation Platforms
PAM	Passive Acoustic Monitoring
PS	Piling Strategy
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation

Acronym	Expanded Term
SCANS	Small Cetacean Abundance and density in the North Sea
SEERAD	Scottish Executive Environment and Rural Affairs Department
SEL	Sound Exposure Level
SHE-T	Scottish Hydro Electric - Transmission
SNH	Scottish Natural Heritage
SPL	Sound Pressure Level
TP	Transition Piece
WTGs	Wind Turbine Generators

1 Introduction

1.1 Background

Moray Offshore Windfarm (West) Limited (known as Moray West) is promoting the development of the Moray West Offshore Wind Farm. The wind farm will be located in the Outer Moray Firth approximately 22.5 km south of the Caithness coastline at its nearest point. It will comprise an offshore array of Wind Turbines Generators (WTGs), connected to one another by subsea inter-array cables, which will in turn connect the WTGs to the Offshore Transmission Infrastructure (OfTI). The OfTI will comprise one or two Offshore Substation Platform(s) (OSP(s)) (joined by an interconnector cable if two are required) and up to two offshore export cable circuits that carry the power to an onshore landfall location to join the Onshore Transmission Infrastructure (OnTI). The OnTI will transmit the power inland to a new onshore substation where it will be transformed before being fed (via buried cables) into the National Electricity Transmission System (NETS) at the existing Blackhillock substation, approximately 1.5 km south of Keith in Moray.

Moray West submitted Scoping Reports for the Offshore Wind Farm and OfTI respectively in support of requests for an Environmental Impact Assessment (EIA) Scoping Opinion. Scoping Opinions were issued by MS-LOT in August 2016 and 2017 respectively. Within the Scoping Opinions, the Marine Scotland Licensing Operations Team (MS-LOT) requested that any applications for offshore consents made in respect of the Development should incorporate the information required to support application for an EPS licence.

This document therefore details the supporting information required by MS-LOT in support of an anticipated future application for a European Protected Species (EPS) licence, which may be required during the construction of the Moray West Offshore Wind Farm and OfTI, collectively known as 'the Development', should construction activity be expected to cause disturbance or injury to a European Protected Species (EPS).

In line with the request in the Scoping Opinions, this document has been prepared to accompany applications for Section 36 Consent and Marine Licences to construct and operate the Moray West Offshore Wind Farm and OfTI. It is recognised that the information presented within this document may need updated at the time of EPS licence application, which will be made following award of consents and in advance of construction commencement.

1.2 Purpose of this Document

This document provides the information that will be required for submission to MS-LOT in the event that construction of Moray West Wind Farm and OfTI requires the installation of piles using percussive piling or similar noisy construction activity.

The information presented in this document therefore aims to assist MS-LOT in making a judgement on the 'three tests' which comprise the assessment for a EPS Licence as detailed in Marine Scotland guidance (MS-LOT, 2014). Specifically, the information presented within the document aims to demonstrate that:

- That the activity is for one of the purposes specified in the Regulations (See Section 2.1 for more information);
- That there are no satisfactory alternatives to the activity proposed (that would not incur the risk of an offence); and
- That the licensing of the activity will not be detrimental to the maintenance of the populations of the species concerned at a Favourable Conservation Status (FCS) in their natural range.

1.3 Overview of the Development

The proposed Development is located on the Smith Bank in the Outer Moray Firth, approximately 22.5 km from the Caithness coastline (Figure 1.1: Development Location

) and covering an area of 225 km^2. The Development will comprise an offshore array of up to 85 WTGs connected to one another by subsea inter-array cables, which will in turn connect the WTGs to the OfTI. The OfTI will comprise up to two High Voltage Alternating Current (HVAC) OSPs; subsea interconnector cables linking the OSPs; and, subsea export cables circuits running from the OSPs to a landfall location on the Aberdeenshire coast.

The offshore development will comprise WTGs, and all infrastructure required to transmit the power generated to shore. Moray West Offshore Wind Farm will have a maximum of 85 WTGs and associated foundations. The project will also have up to two offshore export cables and may include up to two OSPs as part of the OfTI. The key offshore components of the Development are likely to include:

- Offshore WTGs;
- OSPs;
- Substructures and associated seabed foundations (for WTGs and OSPs);
- Subsea inter-array cables linking individual WTGs with each other and linking strings of WTGs with the OSPs;
- Subsea interconnector cables linking OSPs (if two OSPs are installed);
- Subsea export cables running from the OSPs to shoreline landfall;
- Scour protection around substructures and cable protection (if required); and
- Monitoring equipment, such as metocean buoys (if required).

From the Aberdeenshire coast, underground onshore cables will connect the Development to an onshore substation, which will in turn connect to the existing Blackhillock substation near Keith in Moray.

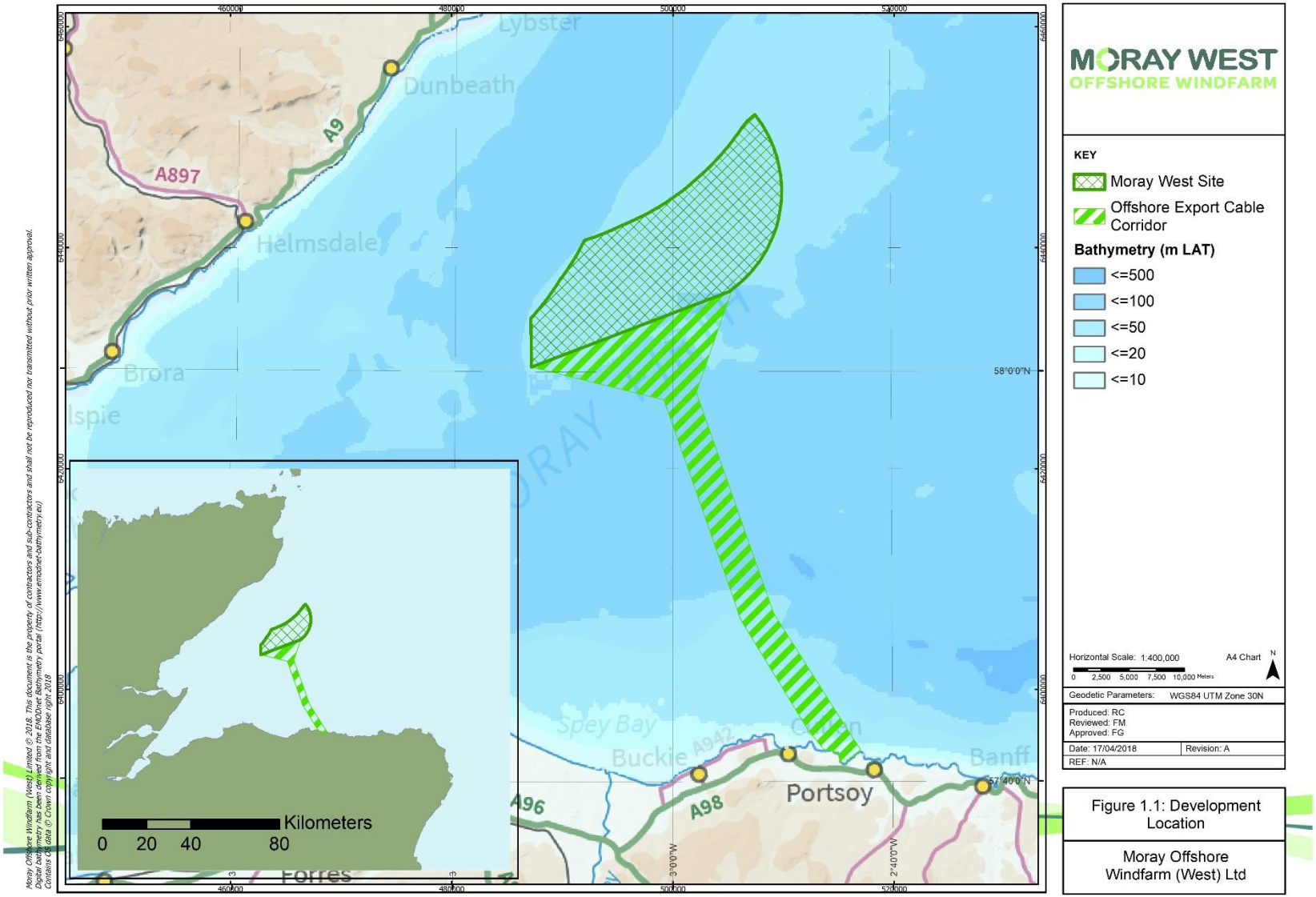
Chapter 4: Development Description of the Offshore EIA Report presents a detailed description of all elements of the Moray West Offshore Wind Farm and OfTI.

This section of the EPS Licence Application Supporting Information document focuses on the elements of the Development that have the potential to cause disturbance to EPS in the vicinity of the Development.

Activities associated with the Development that could potentially result in disturbance of marine mammals is likely to arise from installation activities associated with piled foundations. There are a number of foundation types that are being considered for the Moray West Offshore Wind Farm. The final selection will depend on factors including WTG type, physical and environmental constraints, project economics and procurement approach. The following two foundation types have the potential to result in disturbance to EPS during installation:

- Piled monopole foundations (‘monopiles’): comprising a single hollow steel pile, which penetrates the seabed. The foundation is installed by percussive piling, drilling or a combination of both; and
- Pin-piled jacket foundations: comprising a steel lattice structure, anchored to the seabed with small pin-piles. Jackets are likely to be four-legged, although three-legged jackets are also being considered;

It is currently planned that construction of the Development would commence in 2022 and end in 2024, spanning approximately 36 months. It is intended that piling activity will be completed over a 24 hour period and will take up to 12 months in total. Up to two installation vessels may be used which may result in two piling events occurring simultaneously and the overall piling duration being reduced.



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Digital bathymetry has been derived from the EMODnet Bathymetry portal (http://www.emodnet-bathymetry.eu)
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Figure 1.1: Development Location

2 Legislative Framework

European protected species are those listed on Annex IV of the EU Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna)) whose natural range includes any area in Great Britain. They are species of European Community interest in need of strict protection. The directive makes it an offence to kill, injure, capture or disturb European marine protected species. In addition, it places an obligation for member states to establish a system to monitor incidental capture and killing of such species. In Scottish waters, all species of cetaceans are listed identified on Annex IV of the Habitats Directive.

The Habitats Directive is transposed into Scottish law under the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) for the terrestrial environment and in territorial waters out to 12 nm. In Scottish offshore waters, between 12 – 200 nm, the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (as amended) and the Conservation of Offshore Marine Habitats and Species Regulations 2017 apply in relation to devolved matters and certain reserved matters respectively. These pieces of national legislation are known as the 'Habitats Regulations'.

Construction activity that may be subject to EPS licensing will occur solely in offshore waters during installation of the wind turbine generator foundations. If an EPS License is required it will be consented through the relevant offshore Habitats Regulations by Marine Scotland Licensing Operations Team (MS-LOT).

2.1 EPS Licensing

Within 12 nm of the coast, the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended in Scotland) provide protection given to EPS. Regulation 39 makes it an offence to

(a) deliberately and recklessly capture, injure, kill or disturb EPS;

(b) deliberately or recklessly –

i. to harass a wild animal or group of wild animals of a European protected species;

ii. to disturb such an animal while it is occupying a structure or place which it uses for shelter or protection;

iii. to disturb such an animal while it is rearing or otherwise caring for its young;

iv. to obstruct access to a breeding site or resting place of such an animal, or otherwise to deny the animal use of the breeding site or resting place;

v. to disturb such an animal in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species to which it belongs; or

vi. to disturb such an animal in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young; or (vii) to disturb such an animal while it is migrating or hibernating.

Regulation 39(2) of the Habitats Regulations provides further protection to cetaceans through an additional catch-all disturbance offence which states that 'subject to the provisions of [Part III of the Regulations, it is an offence to deliberately or recklessly disturb any dolphin, porpoise or whale (cetacean)'. The purpose of this regulation is to provide cetaceans with protection at all times regardless of the circumstances of the mammal at the time of the disturbance in question and, thus, it goes beyond the specific disturbance circumstances set out in Regulation 39(1)(b). Marine Scotland guidance on this provision states: "It is important to note, however, that in order to commit an offence under regulation 39, the impact on the species must be certain or real. The activity concerned must have a "negative or adverse" impact on the conservation status of the species" (Marine Scotland, 2014).

In offshore waters, Regulation 39 of the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (as amended) and Regulation 45 of the Conservation of Offshore Marine Habitats and Species Regulations 2017 make it an offence, with certain exceptions, to:

(a) deliberately captures, injures, or kills any wild animal of a European protected species;

(b) deliberately disturbs wild animals of any such species in such a way as to be likely significantly to affect—

i. the ability of any significant group of animals of that species to survive, breed, or rear or nurture their young; or

ii. the local distribution or abundance of that species.

For the purposes of the regulations, disturbance is considered to be any action which is likely to:

- impair their ability—
  - to survive, to breed or reproduce; or
  - to rear or nurture their young; or in the case of animals of a hibernating or migratory species, to hibernate or migrate.
- affect significantly the local distribution or abundance of the species to which they belong.

The above offences apply to all stages of the life of the animal to which they apply (SNH, 2014a).

The term 'deliberate' has been interpreted as an intentional act undertaken knowing that it will or may have particular consequences. The term 'reckless' arises if it is known, or reasonably foreseeable, that an action undertaken is likely to cause injury or disturbance. The deliberate injury offence has been interpreted as occurring if a cetacean receives a sound exposure level, which may cause permanent threshold shift in hearing (Marine Scotland, 2014; JNCC, 2010).

EPS licensing in Scottish waters of commercial activities such as seismic surveying or testing, or installing renewable energy devices in inshore waters which might affect cetaceans is the responsibility of MS-LOT. Marine Scotland may seek advice from SNH and/or JNCC.

MS-LOT have the power to grant a license to carry out activities which would otherwise be unlawful. Licences are granted subject to conditions and licence holders are responsible for ensuring compliance with any conditions attached to the license.

MS-LOT can only issue licences for specific purposes. MS-LOT must be satisfied that the activities that are the subject of the licence are as follows:

- In the interests of public health or public safety or for other imperative reasons of overriding public interest including those of a social or economic nature and beneficial consequences of primary importance for the environment;
- For the purpose of preventing serious damage to fisheries;
- For the purpose of preventing serious damage to property;
- In the interest of protecting wild flora or fauna or conserving natural habitats;
- For the purpose of preventing the spread of disease;
- For scientific or educational purposes; or
- For the purposes of the re-population of an area with, or the re-introduction into an area of, wild animals or wild plants (including any breeding or artificial propagation necessary for those purposes.

In addition, the licensable activities may only be carried out if it can be demonstrated that by doing so the licensing authority remains fully compliant with the requirements of the Habitats Regulations. It must be demonstrated that:

- There is no satisfactory alternative; and
- That the action authorised will not be detrimental to the maintenance of the population of the species concerned at a favourable conservation status in their natural range.

2.2 Licensing Process

To ensure that the criteria detailed above are met MS-LOT follow a structured decision-making process as illustrated in Figure 2.1.

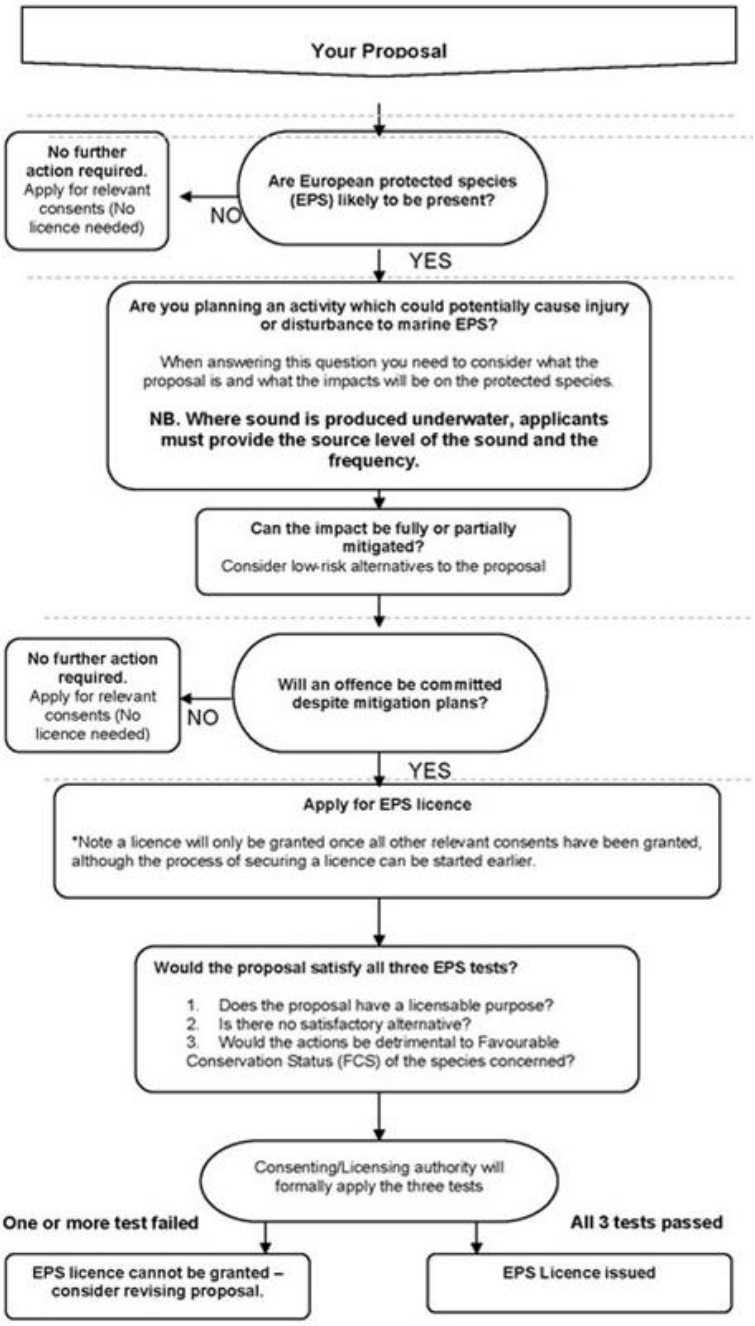

Figure 2.1: MS-LOT EPS Licensing Process (MS-LOT, 2014)

As part of the process MS-LOT will consider the following three tests which must be satisfied in order to grant a license:

- Test 1 – Licensable purpose: Licences can only be issued for the purposes detailed in the relevant regulations as detailed above;
- Test 2 – No satisfactory alternative – MS-LOT must be satisfied that there are no suitable alternatives and that evidence is provided of a lack of satisfactory alternative; and
- Test 3 – Favourable conservation status (FCS) – The licensed activities will not compromise the FCS of any species disturbed by the activities.

Favourable conservation status for species is defined in Article 1(i) of the EC Habitats Directive. It will be considered that a species is 'favourable' when:

- The population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats;
- The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future; and
- There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

2.3 Test 1 – Licensable Purpose

The Habitats Regulations identifies the licensable purposes for which an EPS licence may be granted by the licensing authority. These purposes include

- preserving public health or public safety or other imperative reasons of overriding public interest including those of a social or economic nature and beneficial consequences of primary importance for the environment; (Marine Scotland, 2012a).

SNH guidance details what may be considered when identifying Imperative Reasons of Overriding Public Interest (IROPI) (SNH, 2011). The guidance states that the imperative reasons must serve the public interest and not be in the sole interest of a company or individual. In addition, it must be clearly demonstrated that the public interest is of a social or economic nature and is beneficial in the long term and as such is 'overriding'.

Scottish Government (Scottish Executive, 2000) and SNH (SNH, 2011) guidance on determining IROPI considers the following objectives or principles for EPS Licensing:

- the interests of national security and defence;
- where there is clear and demonstrable direct environmental benefit on a national or international scale;
- where it is shown that there is a vital contribution to strategic economic development or regeneration;
- where failure to proceed would have unacceptable social and/or economic consequences; or
- where the project is of national importance, or, possibly, regional importance.

Chapter 2: Policy and Legislative Context, of the Offshore EIA Report, sets out the over-arching national and international policy drivers for reducing greenhouse gas emissions. The chapter demonstrates the Scottish and UK Governments and EU's commitment on tackling climate change and outlines targets for low carbon, renewable and sustainable energy sources at national and international level based on published policy documents.

The Development will act to offset greenhouse gas emissions that might otherwise be produced by other means of electricity generation and will also increase the security of electricity supply, thereby assisting with the delivery of UK and Scottish government policy and the meeting of renewable energy commitments. Moray West is applying for consent for 50 years, with the Development expected to be operational for at least 35 years, taking into account current design life of the various component of the Development. The Development will provide a long term beneficial contribution to reducing greenhouse gas emissions.

The Development will also provide socioeconomic benefits to Scotland and the UK and contribute to the development of the offshore wind industry in domestic markets. Chapter 15: Socioeconomics, Tourism and Recreation, of the Offshore EIA Report, details the national economic development policy and the positive effects on employment and gross value added (GVA) to the local and national economy.

The Development will provide a direct environmental benefit in terms of tackling climate change in accordance with both international and national policies and targets. In addition, the Development will have local and national benefits on the local economy and employment. It is therefore considered that the Development meets the criteria for a project of Imperative Overriding Public Interest.

2.4 Test 2 – No Satisfactory Alternative

The following section summarises the considerations of alternatives at the Project level and within the Development design envelope.

2.4.1 Project Level Alternatives

Following an extensive zone selection process the Crown Estate identified suitable 'areas of opportunity' for offshore wind farm projects, that had the ability to deliver the required capacity of energy from offshore wind within acceptable environmental limits. The Moray Firth zone was one of these locations.

Following award of the Moray Firth zone a rigorous site selection process has been undertaken to refine the boundary of the Development commencing with the Round 3 offshore wind licensing process. Site selection for the Development has been guided by four key factors:

- The selection and subsequent award of the Moray Firth Round 3 Zone;
- The Zone Appraisal and Planning (ZAP) process which identified areas for the development of wind farms within the Zone;
- The grid connection agreement between Moray West, National Grid and Scottish Hydro Electric -Transmission (SHE-T), which confirmed Blackhillock, Moray, as the grid interface point for the Development, and which enabled the identification of offshore and onshore export cable route corridors and the onshore substation; and
- Consultation and technical investigations which have enabled refinements to be made in the location and design of the Development.

Full details of the site selection process and consideration of alternatives are presented in Volume 2, Chapter 3: Site Selection and Alternatives of the EIA Report.

2.4.2 Design Envelope Alternatives

With regard to defining the final Development in terms of turbine sizes, substructure, numbers, layouts, construction methods etc., it is necessary to consider a range of possible development options based on different design parameters. This is referred to as the 'Design Envelope' approach to consenting, and is recognised as standard practice across the offshore wind industry. This approach has been developed specifically to give Developers flexibility within their consents to accommodate any future improvements in technology or construction methods in their final Development design.

Although the 'Design Envelope' has been developed specifically to take into account future developments in turbine technologies and construction methods, the final extent of that Design Envelope (e.g. maximum design parameters) is influenced by environmental and physical (i.e. seabed characteristics, water depth etc.) factors. These factors include specific design measures and limits that have already been put in place, or have been developed during the EIA process, to prevent or minimise the potential for any potential adverse effects on the environment (referred to as embedded measures) or any changes introduced / limits applied to the Design Envelope based on specific outcomes from this EIA Report e.g. where potentially significant effects have been identified.

As the front end engineering design work proceeds the design envelope will be further refined and where practical and appropriate mitigation applied to manage environmental risk. In relation to the foundation type considered within the design envelope additional survey data including geotechnical and geophysical data will be analysed to determine the most appropriate foundation solution that will ultimately be installed within the Moray West site taking into consideration physical and environmental constraints.

At this stage, the design envelope retains maximum flexibility with regards to foundation type. However, the final EPS Application will be updated to reflect additional considerations of alternatives. The 'Information to Support an EPS Licence Application' document has been produced assuming that piled foundations will be required to demonstrate that the EIA Report incorporates sufficient information to inform a EPS licence application, if required.

The Design Envelope for this Development is described in detail in Volume 2, Chapter 4: Description of the Development.

2.5 Test 3 - Favourable Conservation Status

Sections 3 and 4 of this document provides a summary of the baseline and an assessment of the implications of percussive piling in the context of FCS, respectively. Where relevant this document cross-references to the relevant information presented within the wider Offshore EIA Report and supporting application documents.

3 Survey and Site Assessment

3.1 Pre-existing Information on the Species at the Survey Site

A comprehensive review of marine mammal data is provided within the Moray West Application Offshore EIA Report and Appendices and the Report to Inform an Appropriate Assessment (RIAA). The following sections of the Offshore EIA Report and supporting documents have been used to inform the Information to Support a EPS Licence Application document:

- Moray West Offshore EIA Report:
  - Volume 2, Chapter 9: Marine Mammals;
  - Volume 4, Technical Appendix 9.1: Marine Mammal Baseline;
  - Volume 4, Technical Appendix 9.2: Underwater noise modelling; and
- Moray West Report to Inform an Appropriate Assessment.

The Information to Support a EPS Licence Application document presents a summary of the marine mammal survey and site assessment information presented in the above documents.

During Scoping for the Moray West Development, the Scoping Opinion identified three cetacean species that were potentially at risk of disturbance resulting from piling noise due to their likely presence in the Moray Firth. As a result, the EPS License Supporting Information document focuses on these three key cetacean species:

- Harbour porpoise *Phocoena phocoena*;
- Bottlenose dolphin *Tursiops truncatus*; and
- Minke whale *Balaenoptera acutorostrata*.

3.2 Surveys and Data Sources

The survey area considered for the purposes of this Information to Support a EPS Licence Application document is synonymous with that considered for the purposes of EIA and Habitats Regulation Appraisal (HRA). Data collected within the entire Moray Firth has been considered within this document.

Extensive work has been undertaken within the Moray Firth to record marine mammal presence and distribution as part of national and regional monitoring strategies in addition to renewable project site-specific monitoring.

Full details of the survey areas of the studies used to inform the baseline are presented in Technical Appendix 9.2 (Section 1.2).

3.3 Baseline Conditions

The following section summarises the species accounts and baseline conditions that have been used to inform the Information to Support a EPS Licence Application, the EIA and the HRA. Full species accounts and interpretation of all available data is presented in detail in Section 1.2.3 of Appendix 9.2: Marine Mammal Baseline Technical Report.

3.3.1 Harbour Porpoise Baseline Condition

Harbour porpoise in the UK are considered to have a “Favourable Conservation Status”. They are the most abundant marine mammal species in the Moray Firth, which has been confirmed by both visual and acoustic surveys and habitat modelling. Acoustic surveys have detected harbour porpoise on almost every sampling day at most locations throughout the Moray Firth, with high detection rates within the Moray West Site and with lower detections at some coastal sites compared to the more offshore sites. The site

specific aerial surveys of the Moray West Site have confirmed that harbour porpoise are present throughout the site and throughout the year, with higher sightings rates between June and October. The result of the habitat modelling shows a high predicted density of harbour porpoise at the north east corner of the Moray West site.

3.3.2 Dolphin Baseline Condition

In the UK, bottlenose dolphins are considered to have a "Favourable Conservation Status" (JNCC, 2013). The Moray Firth population of bottlenose dolphins is the only known remaining resident population in the North Sea and it was for this reason that the Moray Firth SAC was established in order to protect this population.

The Coastal East Scotland Management Unit (MU) population of bottlenose dolphins has been increasing since 1990 and the current population estimate is 195 animals. This population extends between the Moray Firth and south along the east coast of Scotland to the Firth of Forth. The use of the Moray Firth SAC by this population varies from year to year, and in 2015 approximately half of the population used the SAC (Graham *et al*. 2016). The population is considered to be healthy and has a "Favourable Conservation Status". The analysis from the ECOMMAS acoustic surveys detailed in (Palmer *et al*. 2017) have determined that the click detections along the northern coast of the Moray Firth are more likely to be species other than bottlenose dolphins, and that bottlenose dolphins are found mainly along the southern coast of the Moray Firth.

3.3.3 Minke Whale Baseline Condition

Minke whales are widely distributed around the UK, with higher densities recorded on the West coast of Scotland and the western North Sea (Reid *et al*. 2003). They occur mainly on the continental shelf in water depths less than 200 m and are sighted more frequently in the summer months between May and September. Minke whales in the UK are considered to have a "Favourable Conservation Status" (JNCC 2013) and all minke whales in UK waters are considered to be part of the Celtic and Greater North Seas MU (IAMMWG 2015). There is an abundance estimate for this MU of 23,528 animals (95% CI: 13,989 to 39,572), of which 12,295 (95% CI: 7,176 to 21,066) are estimated within the UK Exclusive Economic Zone (EEZ).

The estimated densities for minke whales is generally low throughout the Moray Firth but with higher densities at the Southern Trench MPA in the South East of the Moray Firth during the summer when minke whales move into the area for foraging. Surveys have shown that minke whales are present throughout the summer, with higher encounter rates between July and August. Minke whales were sighted in June 2016 during the site specific aerial surveys of the Moray West Site. While minke whale presence in the Moray Firth during the winter months cannot be ruled out (the JCP III data estimates 20 animals in the Moray Firth during winter months), surveys have shown that densities are considerably lower outside of the summer months.

4 Impact Assessment, Mitigation and Compensation

4.1 Percussive Piling Impact Assessment in the Absence of Mitigation

Moray West has conducted an EIA in (detailed within the Offshore EIA Report) for Consents to construct and operate Moray West Offshore Wind Farm and OfTI. Chapter 9 of the Offshore EIA Report presents an assessment of potential impacts to marine mammals. The assessment presented within Chapter 9 has been summarised here and cross-referenced to demonstrate adequacy in terms of applying for an EPS Licence for percussive piling during Construction of the Wind Farm and OfTI (as far as they relate to the OSPs).

Marine mammals rely on their hearing to locate prey, communicate, reproduce, detect predators and navigate. Therefore, these animals are sensitive to anthropogenic noise sources introduced into their environment. Subsea noise, particularly the loud impulsive sounds associated with pile driving, are considered likely to cause impacts on marine mammals. The key impact of piling noise relates to the potential for hearing injury and/or behavioural disturbance (such as displacement from a feeding area) on marine mammals during the piling activity. Appendix 9.2 presents details of the noise propagation modelling undertaken to understand the potential scale of injury (assessed as Permanent Threshold Shift (PTS)) and disturbance. Section 9.7.1 of Chapter 9 provides a detailed assessment of the implications of underwater noise from foundation piling and other construction activities at Moray West in relation to both physical injury and disturbance on key cetacean species. Section 9.8.2 provides a detailed assessment of the implications of underwater noise from foundation piling at Moray West acting cumulatively with underwater noise from other plans and projects.

4.1.1 Noise Propagation Modelling

Monopile scenarios were determined to present the worst-case spatial impact, i.e. would result in the largest overall impact range, whereas the installation of jacket foundations using pin piles would result in the worst-case temporal impact as the total duration of piling will be longer compared to monopile installation.

For monopiles, the maximum hammer energy that was modelled is up to 5,000 kJ, with a start-up hammer energy of 20% (1,000 kJ). For pin pile installation the maximum hammer energy that was modelled was up to 3,000 kJ with a start-up hammer energy of 500 kJ.

A total of three locations were selected for the noise modelling assessment (Figure 9.7.1 in Volume 3a). Each location was chosen due to its proximity to important areas for a particular species. These locations were agreed in consultation with Scottish Natural Heritage (SNH) and Marine Scotland Science (MSS).

Full details of the piling parameters and noise modelling is presented in Appendix 9.2: Underwater noise modelling.

4.1.1.1 Harbour porpoise

Injury

Using the peak (SPL_{zp}) threshold, the predicted range of PTS for harbour porpoise was 335 m for the monopile maximum hammer energy of up to 5,000 kJ and 206 m for the pin pile maximum hammer energy of up to 3,000 kJ (Table 4.1:).

Using the SEL_{cum} threshold, and a fleeing threshold of 25 km, the predicted range of PTS was 90 m for the worst case monopile ramp up, and 81 m for pin piles (Table 4.1:).

Based on these ranges, it was concluded that alongside the adoption of appropriate mitigation provided in a detailed piling strategy to be agreed post consent with statutory consultees (e.g. a soft start and the use of acoustic deterrents (ADDs)) the risk of PTS to any harbour porpoise as a result of exposure to piling noise is considered negligible.

Table 4.1: Maximum impact ranges (m) for harbour porpoise auditory injury when installing monopiles and pin piles at 100 % blow energy at Location 2.		
	Monopile WC (5,000 kJ)	**Pin pile (3,000 kJ)**
Unweighted SPL_{zp} 202 dB	335	206
$NOAA_{HF}$ weighted SEL_{cum} 155 dB (25 km fleeing threshold)	90	81

Disturbance

The number of animals predicted to be affected under both single and two vessel scenarios for both pile types are presented in T . These represent a maximum of 0.40 % and 0.49 % of the harbour porpoise reference population (North Sea MU) for one and two vessel monopile installation respectively, and 0.19 % and 0.39 % for the equivalent pin pile scenarios. (Table 4.2).

For single vessel installation the total number of days of disturbance will be up to 87 for monopile installation and up to 340 days for pin pile installation, with all disturbance relating to monopile installation occurring within a single year and the activity for pin pile installation occurring over two years. Therefore, either a total of 1,377 individual porpoises may be affected over one breeding cycle or 639 porpoises may be affected over two breeding cycles; although it is important to consider that actual active piling will only be for a small proportion of this time and there will be gaps from periods of hours to days between each active piling period.

The concurrent two vessel installation scenario results in an overall shorter period of disturbance; 44 days compared to 87 days of piling for monopiles and 133 days compared to 340 days for pin piles. Therefore, despite the small increase in the number of individuals predicted to be affected during operations, the difference in the overall effects on the population are negligible (a maximum of 0.49 % of the population affected for a maximum of a single breeding cycle).

Although there is uncertainty around individual behavioural responses, the availability of alternative foraging areas and return times, it is unlikely that individuals will experience disturbance throughout the whole of the foundation installation period, although the worst case assumption is that every affected individual is affected to this extent. Due to the high mobility of harbour porpoises and the availability of alternative foraging areas at the scale of the wider management unit, the survival of individuals is unlikely to be affected. The worst case outcome would be that each affected harbour porpoise would fail to breed in the year that disturbance occurs. Therefore, this would result in a maximum of 0.49 % of the population failing to breed for a single breeding season under the monopile scenario, or 0.24% of the population failing to breed across a maximum of two breeding seasons.

This is a highly precautionary assessment and these impacts are likely to be significantly overestimated. This level of effect may cause a very small and temporary change in the population growth rate, over one or two years, but is highly unlikely to significantly affect the size or overall health or affect the Favourable Conservation Status of the harbour porpoise population at the Management Unit scale.

Table 4.2: Number of harbour porpoise potentially disturbed by monopile (5,000 kJ) and pin pile (3,000 kJ) foundation installation at Location 2 (single vessel installation) and Location 1 & 3 (two vessel concurrent installation)			
Foundation Type	**Max. Hammer Energy (kJ)**	**# Porpoise Impacted**	**% Population**
Monopile Location 2	5,000	1377	0.40%
Pin pile Location 2	3,000	639	0.19%

Table 4.2: Number of harbour porpoise potentially disturbed by monopile (5,000 kJ) and pin pile (3,000 kJ) foundation installation at Location 2 (single vessel installation) and Location 1 & 3 (two vessel concurrent installation)

Foundation Type	Max. Hammer Energy (kJ)	# Porpoise Impacted	% Population
Monopile Locations 1 & 3	5,000	1,609	0.49%
Monopile Locations 1 & 3	3,500	1,448	0.42%
Pin pile Locations 1 & 3	3,000	1,348	0.39%

4.1.1.2 Bottlenose dolphin

Injury

Using the peak (SPL_{zp}) threshold, the predicted range of PTS was <50 m for the maximum hammer energy for both monopiles and pin piles (Table 4.3).

Using the SEL_{cum} threshold, and a fleeing threshold of 25 km, the predicted range of PTS was <50 m for the WC ramp up, and <50 m for pin piles.

These very small ranges and the lack of overlap between the project area and the coastal areas used by bottlenose dolphins suggests that the risk of PTS to any bottlenose dolphin as a result of exposure to piling noise is considered negligible.

Table 4.3 : Maximum impact ranges (m) for bottlenose dolphin auditory injury when installing monopiles and pin piles at 100 % blow energy at Location 1.

	Monopile (5,000 kJ)	Pin pile (3,000 kJ)
Unweighted SPL_{zp} 230 dB	<50	<50
$NOAA_{HF}$ weighted SEL_{cum} 185 dB (25 km fleeing threshold)	<50	<50

Disturbance

Due to bottlenose dolphin being an EPS, the presence of a nearby SAC and the requirement for HRA, and based on the percentages affected from these scenarios (all were greater than 5% of the total reference population, see Table 4.4), a more refined assessment was undertaken for bottlenose dolphin, using a 'most likely' maximum hammer energy of 3,500 kJ (defined as the maximum hammer energy likely to be required on most of the foundation installations) recognising that the majority of the foundation installations would require less energy than the worst case parameters would suggest.

The corresponding number of animals predicted to be affected under each scenario are given in Table 4.4. The total numbers of animals predicted to respond within each sound contour is detailed in Table 4.5. A total of 13 dolphins are predicted to be disturbed when piling is occurring at 5,000 kJ for monopile installation (worst case maximum hammer energy). For the 'most likely' maximum hammer energy of 3,500 kJ for monopiles, this number reduces to 11. These represent 6.8% and 5.7% of the bottlenose dolphin reference population (East Coast MU) respectively. The equivalent number for the worst case maximum hammer energy for pin pile installation is 9.4 dolphins, representing 4.8% of the population. The total number of days of disturbance is predicted to be up to 87 for monopiles and up to 340 days for pin piles, with all disturbance relating to monopile installation occurring within a single year and the activity for pin pile installation occurring over two years.

According to the opinions of the experts involved in the expert elicitation for Population Consequence of Disturbance (PCoD), which forms our best available knowledge on the topic, disturbance would be most likely to affect bottlenose dolphin calf survival, but have little effect on adult survival.

The figures below and Table 4.5 highlight that the majority of the affected dolphins occur within the 130-140 dB contours, which occur in the coastal areas of high predicted bottlenose dolphin density, relatively distant from the piling locations, where there is a high level of uncertainty in both received levels, and the probability of response. In light of these uncertainties the predictions of response are based on precautionary assumptions.

There is uncertainty around individual behavioural responses and, given the availability of alternative foraging areas, it is unlikely that individual dolphins will experience disturbance throughout the whole of the foundation installation period. Due to the high mobility of bottlenose dolphins and the availability of alternative known foraging areas and other areas of high usage within the Moray Firth, short-term displacement is unlikely to result in any effect on the survival of individuals.

It is important to bear in mind that this is a precautionary assessment and that there is significant uncertainty in both the received levels in the shallower coastal areas and the responsiveness of bottlenose dolphins to these lower levels of noise. Table 4.4 indicates that the noise levels where dolphins are predicted to be are in the region of 140-120 dB, approaching likely ambient noise levels in coastal environments. These areas are likely to be relatively noisy with vessel traffic and wave action contributing to ambient noise, potentially at levels that may mask the piling noise at these ranges from source.

Table 4.4: Number of dolphins potentially disturbed by monopile (5,000 kJ) and pin pile (3,000 kJ) foundation installation at Location 1 using the harbour porpoise dose-response curve. Results are shown including and excluding the animals present within the contours between 120 and 130 dB.

Foundation Type	Hammer Energy (kJ)	120 – 170 dB		130 – 170 dB	
		# Dolphins Impacted	% Population	# Dolphins Impacted	% Population
	5,000	13.6	6.96%	13.2	6.76%
	3,500	11.5	5.90%	11.0	5.65%
	3,000	10.0	5.10%	9.4	4.84%
	2,500	8.8	4.51%	8.2	4.22%
	2,000	7.7	3.96%	7.1	3.65%
	1,000	4.9	2.52%	3.9	2.01%
Pin pile	3,000	10.0	5.10%	9.4	4.84%

Table 4.5: Number of dolphins potentially disturbed in each dose-response contour (5 dB steps) by monopile (various hammer energies) and pin pile (3,000 kJ) foundation installation at Location 1 using the harbour porpoise dose-response curve. The shading in the table indicates the contour bands with the highest numbers of dolphins present for each hammer energy.

dB	Monopile							Pin pile
	5,000 kJ	4,000 kJ	3,500 kJ	3,000 kJ	2,500 kJ	2,000 kJ	1,000 kJ	3,000 kJ
170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4.5: Number of dolphins potentially disturbed in each dose-response contour (5 dB steps) by monopile (various hammer energies) and pin pile (3,000 kJ) foundation installation at Location 1 using the harbour porpoise dose-response curve. The shading in the table indicates the contour bands with the highest numbers of dolphins present for each hammer energy.

dB	Monopile							Pin pile
	5,000 kJ	4,000 kJ	3,500 kJ	3,000 kJ	2,500 kJ	2,000 kJ	1,000 kJ	3,000 kJ
165	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
160	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
155	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
145	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
140	4.3	2.8	2.2	1.7	1.2	0.6	0.0	1.7
135	7.5	7.7	7.2	5.2	4.0	3.2	1.1	5.2
130	1.2	1.3	1.5	2.5	2.9	3.3	2.8	2.5
125	0.4	0.4	0.4	0.5	0.5	0.5	0.8	0.5
120	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1
	13.6	**12.3**	**11.5**	**10.0**	**8.8**	**7.7**	**4.9**	**10.0**

A similar approach was adopted to assess disturbance from concurrent piling scenarios with SEL unweighted noise contours decreasing in 5 dB steps from the source, overlain on the bottlenose dolphin density surface from two monopile installation locations at 5,000 kJ hammer energy.

The number of animals predicted to be affected are given in Table 4.6. A total of 15 dolphins are predicted to be disturbed when piling occurs at 5,000 kJ for two concurrent monopile installations (worst case maximum hammer energy).

As discussed previously, the majority of the affected dolphins occur within the 120-140 dB contours, which overlap with the coastal areas of high potential bottlenose dolphin density, relatively distant from the piling locations, where the uncertainty in these predictions of received levels of noise is high. A slightly higher number of animals are predicted to be affected relative to single vessel operations (a maximum of 15 animals during concurrent operations compared to 14 during single operations), however the concurrent piling of monopiles would result in a total of only 44 days of piling compared to 87 days for single monopile installation.

Table 4.6: Number of bottlenose dolphins predicted to experience behavioural disturbance as a result of the concurrent installation of monopiles and pin piles at location 1 and 3.

Foundation Type	Hammer Energy (kJ)	120 - 180		130 - 180	
		# Dolphins Impacted	% Population	# Dolphins Impacted	% Population
Monopile Locations 1 & 3	5,000	14.6	7.5%	14.2	7.3%
Monopile Locations 1 & 3	3,500	12.6	6.5%	12.2	6.2%

Table 4.6: Number of bottlenose dolphins predicted to experience behavioural disturbance as a result of the concurrent installation of monopiles and pin piles at location 1 and 3.

Foundation Type	Hammer Energy (kJ)	120 - 180		130 - 180	
		# Dolphins Impacted	% Population	# Dolphins Impacted	% Population
Pin pile Locations 1 & 3	3,000	11.9	6.1%	11.4	5.8%

Population Modelling (interim Population Consequence of Disturbance (iPCoD))

Chapter 9 of the Offshore EIA Report concluded that bottlenose dolphin is the only species where the magnitude of potential disturbance was considered high enough to require the need for population modelling to rule out a long term population effect. No PTS effects were included in the population models due to the very small impact ranges predicted and the lack of any overlap in piling activity with areas used by bottlenose dolphins. Population modelling scenarios are summarised below for the following construction scenarios:

- Single Piling Operation:
  - Monopile installation using worst case maximum hammer energy (5,000 kJ) over 87 days – this assessment assumes that during each day of piling, the number of animals predicted to be disturbed is 13.6 (Table 4.4).
  - Pin pile installation using maximum hammer energy (3,000 kJ) over 133 days– this assessment assumes that during each day of piling, the number of animals predicted to be disturbed is 10 (Table 4.4).
- Concurrent Vessel Operations
  - Concurrent installation of two monopiles using worst case maximum hammer energy (5,000 kJ) over 44 days– this assessment assumes that during each day of piling, the number of animals predicted to be disturbed is 14.6 (Table 4.6).
  - Pin pile installation using maximum hammer energy (3,000 kJ) over 67 days– this assessment assumes that during each day of piling, the number of animals predicted to be disturbed is 11.9 (Table 4.6).

When considering the differences in predicted future impacted population size between the different scenarios, the concurrent piling scenario resulted in fractionally more of a population level impact compared to the other scenarios, where, after 24 years, the mean impacted population size under the concurrent pin pile scenario was 98.2% of the baseline population size, and the equivalent for the concurrent monopile scenario was 98.5 %. The equivalent for the single monopile and pin pile scenarios were 99.6 % and 98.5 %. Based on this comparison, the least amount of impact is predicted from the monopile concurrent scenario, where the impacted median population was 99.6 % of the baseline (un-impacted) population. However, these differences are very small and with a maximum predicted reduction in population size of 1.8 % after 24 years, this effect is very small. Therefore we can conclude that the predicted levels of disturbance will not affect the Favourable Conservation Status of the Scottish East Coast bottlenose dolphin population.

4.1.1.3 Minke whale

Injury

Using the peak (SPL_{zp}) threshold, the predicted range of PTS was <50 m for the maximum hammer energy for both monopiles and pin piles (Table 4.7).

Using the SEL_{cum} threshold, and a fleeing threshold of 25 km, the predicted range of PTS was 542 m for the worst case ramp up, and 846 m for pin piles.

Based on the results of the field trials of McGarry *et al*. (2017), the adoption of an ADD based mitigation (e.g. the use of an ADD prior to a soft start) the risk of PTS to any minke whale would be negligible.

Table 4.7: Maximum impact ranges (m) for minke whale auditory injury when installing monopiles and pin piles at 100% blow energy at Location 3.

	Monopile (5,000 kJ)	Pin pile (3,000 kJ)
Unweighted SPL_{zp} 219 dB	<50	<50
$NOAA_{HF}$ weighted SEL_{cum} 183 dB (25 km fleeing threshold)	542	846

Using the SEL_{cum} threshold, and a fleeing threshold of 25 km, the predicted range of PTS from concurrent piling for minke whales was up to a maximum distance of 28.5 km at Location 2 for pin piles at maximum hammer energy (Table 4.8). This large range for location 2 is a result of the fleeing algorithm used which meant that any whales fleeing to the north-west of location 2 would be restricted due to the coastline, and would unable to reduce exposure by further responsive movement away from the pile source. However, this area of impact overlaps with very low predicted densities of minke whales (most cells have an estimated density of 0 whales/km2), and so while the impact range is large, the number of animals predicted to be within this area and therefore available to be impacted is negligible. Even if very small numbers of minke whales were exposed to PTS as a result of cumulative exposure over the installation of pin piles over 24 hours, there is no likelihood that this would affect enough individuals to have any affect at the population level.

Table 4.8: Concurrent piling auditory injury impact ranges.

	Monopile WC (5,000 kJ)	Pin pile (3,000 kJ)
Minke whale $NOAA_{LF}$ weighted SEL_{cum} 183 dB	Location 1: 922 m Location 3: 559 m	Location 2: 28.5 km Location 3: 3.6 km

Disturbance

The numbers of animals predicted to be affected by disturbance were calculated by applying the proportion of animals expected to respond (from the dose-response curve) to the abundance of animals within each 5 dB contour. The corresponding number of animals predicted to be affected under each scenario are 29 minke whales for the 5,000 kJ monopile installation and 23 minke whales for the 3,000 kJ pin pile installation (Table 9.7.16). These represent a maximum of 0.12 % and 0.10 % of the minke whale reference population (Celtic and Greater North Sea MU) respectively (Table 4.9). The total number of days of disturbance is up to 87 for monopiles and up to 340 days for pin piles, with all disturbance relating to monopile installation occurring within a single year and the activity for pin pile installation occurring over two years.

Table 4.9: Number of minke whales disturbed by monopile (5,000 kJ) and Pin pile (3,000 kJ) foundation installation at Location 3.

Foundation Type	Hammer Energy (kJ)	# Whales Impacted	% Population
Monopile	5,000	29	0.12%
Pin pile	3,000	23	0.10%

The maximum number of animals predicted to be affected by disturbance under the concurrent scenario is 30 minke whales. This represents a maximum of 0.13 % of the minke whale reference population but would only be for a reduced period of 44 days (Table 4.10).

Chapter 9 of the Offshore EIA Report concluded that this level of disturbance would be highly unlikely to have any long term effect on individual fitness and therefore this magnitude of impact would be very unlikely to have any significant effects on the long term population health at the management unit scale. Therefore, the predicted disturbance will not affect the Favourable Conservation Status of the Central and Greater North Sea minke whale population.

Table 4.10: Number of minke whales predicted to experience behavioural disturbance as a result of the concurrent installation of monopiles and pin piles at location 1 and 3.

Foundation Type	Hammer Energy (kJ)	# Whales Impacted	% Population
Monopile Locations 1 & 3	5,000	30.1	0.13%
Monopile Locations 1 & 3	3,500	28.8	0.12%
Pin pile Locations 1 & 3	3,000	24.5	0.10%

4.1.2 Summary of Assessment

In summary, no significant lethal, physical injury or PTS ranges were predicted for any species. This suggests that alongside the adoption of a piling strategy with appropriate mitigation (e.g. a soft start and/or use of acoustic deterrents) the risk of lethal or physical injury or PTS to any marine mammal species is negligible.

The predicted levels of disturbance were relatively low for all species assessed and across all piling scenarios. Given the fact that the modelling resulted in >5% of the bottlenose population being predicted to experience disturbance, a population assessment using the iPCoD framework was conducted for this species which suggested no significant long term population effects from this level of disturbance.

4.2 Scale of Impact on Regional, National and International Levels

FCS is a judgment on the integrity of the species which is assessed against the requirements of the Habitats Directive (Article 1). The FCS status for a species will be taken as 'favourable' when:

i. Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats;

ii. The natural range of the species is neither being reduced nor will be reduced for the foreseeable future; and

iii. There is, and will continue to be, a sufficiently large habitat to maintain its population on a long-term basis (JNCC *et al*., 2010).

4.2.1 Harbour Porpoise

Harbour porpoise are assessed as having a 'favourable' conservation status in UK waters (www.jncc.defra.gov.uk/page-4063).

Harbour porpoise are currently assessed as being in FCS across the North Sea MU. Essentially, this can be taken to mean that the existing conditions within the North Sea are sufficient to support a viable population of harbour porpoise. The stability of the UK harbour porpoise population indicates that the available habitat is at or near its carrying capacity.

The baseline data suggest that the area encompassed by the Development and within the wider Moray Firth is regularly used by harbour porpoise with both visual and acoustic detections common on most of the surveys undertaken within the Study Area.

Harbour porpoise are highly mobile and widespread throughout the North Sea. The proportion of habitat which will be potentially affected by piling forms a very small part of the population's natural range and will only be for a limited duration. Following cessation of piling it is anticipated that the individuals will return to the area of impact. Therefore, both spatially and temporally the extent of noise impacts from piling for Moray West is considered small. Therefore, the North Sea population of harbour porpoise is likely to continue maintaining itself on a long-term basis as a viable component of its natural habitats.

The second FCS test, ensuring that "the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future", is also likely to be met. Essentially, while the Development itself will physically claim a small amount of habitat, the area is trivial in comparison to the wider area available.

Due to the intermittent and temporary nature of the piling related impacts on harbour porpoise and the anticipated return of individuals to the area following piling, "there is, and will continue to be, a sufficiently large habitat to maintain its population on a long term basis", thus ensuring that the requirements of the third FCS test are also met.

4.2.2 Bottlenose Dolphin

The Scottish East coast bottlenose dolphin population associated with the Moray Firth SAC is currently assessed as having a 'favourable' status (SNH, 2013). The current agreed abundance for the management unit is 195 individuals and is based on analysis of photo-id data collected in 2007. Annual photo id surveys have indicated a trend of an increasing population since then, although an agreed, robust re-estimate of the total population size has not been produced it is likely that the current population size is larger than this.

The core range of bottlenose dolphins is well outside of the Moray West development area and outside the range of any modelled physical or auditory injury ranges. The core range of bottlenose dolphins within the inner Moray Firth and south coast of the Moray Firth is an area where noise levels could reach levels that may result in some disturbance of a small number of bottlenose dolphins, although the quantitative assessment presented in Chapter 9 of the Offshore EIA Report and summarised above is highly precautionary. Population modelling has indicated that the proposed development will not have a significant population effect on bottlenose dolphins and therefore will not affect the maintenance of the species on a long term basis as a viable component of its natural habitats.

The second FCS test, ensuring that "the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future", is also likely to be met. None of the direct habitat loss occurring as part of the development is within in the range of bottlenose dolphins.

Due to the intermittent and temporary nature of any piling related impacts on bottlenose dolphins and the limited overlap with core bottlenose dolphin areas "there is, and will continue to be, a sufficiently large habitat to maintain its population on a long term basis", thus ensuring that the requirements of the third FCS test are also met.

4.2.3 Minke Whale

Minke whale are assessed as having a 'favourable' FCS in UK waters (JNCC, 2013).

The baseline data suggest that area encompassed by the Development supports relatively low numbers of minke whale with observations peaking in summer months between July and August. Sightings are more common to the south of the Moray Firth around the Southern Trench. Minke whales are a mobile species that have a wide distribution around the UK with the highest densities reported on the West coast of Scotland and the western North Sea (Reid *et al.* 2003).

The population of minke whale was assessed as having a 'favourable' FCS in UK waters and therefore it is likely that, as concluded in the marine mammal assessment, any short term displacement and any resulting fitness effects will be fully recoverable following cessation of piling activities. Minke whale are highly mobile and widespread throughout their range which extends significantly beyond the Moray Firth. The proportion of habitat which will be potentially affected by piling is restricted to the Moray Firth and therefore represents only a small fraction of the full range of the population.

Therefore, the population of minke whale is likely to continue maintaining itself on a long-term basis as a viable component of its natural habitats.

The second FCS test, ensuring that "the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future", is also likely to be met. Essentially, while the Project itself will physically claim a small amount of habitat, the area is trivial in comparison to the wider area available and in any case is not important for minke whales.

Due to the intermittent and temporary nature of the piling related impacts on minke whale and the anticipated return of individuals to the area following piling, "there is, and will continue to be, a sufficiently large habitat to maintain its population on a long term basis", thus ensuring that the requirements of the third FCS test are also met.

4.3 Cumulative Impacts

In line with the assessment of the potential for adverse effect from the Development alone, the cumulative assessment has drawn on existing information contained within the Offshore EIA Report and appendices, where it remains valid and relevant.

The offshore search area extent for marine mammals is within the relevant management unit for each key species. For bottlenose dolphins this is the East Coast management unit. For harbour porpoise and minke whales, whose management units extend over very large areas beyond the Moray Firth, quantitative assessment of cumulative impacts is carried out for projects in the wider Moray Firth and Scottish east region (including Forth and Tay developments) where there is sufficient detailed information, cumulative impacts with other projects throughout the North Sea were considered qualitatively. Full details of the cumulative impact assessment are presented in Section 9.8 of Chapter 9 of the Offshore EIA Report.

The existing list of plans, projects and proposals considered in-combination with Moray West are detailed in Chapter 9 of the Offshore EIA Report.

4.3.1 Harbour Porpoise

The cumulative assessment totalled the number of disturbed individuals across the relevant projects to determine the maximum number that would be impacted if all projects were constructing at once, assuming no overlap in impact ranges. The greater the temporal overlap across these individual projects, the shorter the period of impact but the more intense the impact will be. The maximum number of harbour porpoises potentially affected by projects in the Moray Firth and east coast of Scotland (based on numbers from each project summed) was predicted to be 8882, which represents 2.6% of the total reference population. If we assume that the unquantified projects in the wider North Sea are of similar impact magnitude as Moray West, this would increase this value to approximately 4%. Based on the worst case assumption detailed in the project alone assessment that each year of disturbance would result in a failure to breed for each disturbed individual, this is still considered low magnitude relative to the overall size of the MU population.

A simulation modelling exercise carried out by (Booth *et al.,* 2017) used the iPCoD framework to predict the long term consequences of planned offshore wind developments in the eastern North Sea concluded that, even with a total of 15% of the population being predicted to be disturbed, spread out over a period of 12 years, there was no evidence for any significant risk to the long term health of the North Sea harbour

porpoise population. Although there is little empirical information to inform the consequences of disturbance from pile driving at the population level, but the iPCoD model represents best available scientific expert judgement on the links between individual disturbance and vital rates.

More recent population modelling using the DEPONS model has demonstrated that the North Sea harbour porpoise population was not affected by the construction of 65 offshore wind farms within the North Sea (assuming porpoise responded in the same way as recorded during construction at the Gemini wind farm) (Nabe-Nielsen *et al.*, 2018). The modelling results demonstrated that, at the North Sea scale, the population dynamics of the impacted population (when responding out to 8.9 km from construction sites) was indistinguishable from the baseline scenario.

In addition, harbour porpoise have a very widespread distribution and individuals have been documented moving relatively large distances on a daily basis (Sveegaard *et al.,* 2011). The availability of alternative suitable habitat elsewhere in the management unit and the mobility of the species suggests that individuals will move to alternative foraging grounds and at most will suffer a reduction in breeding success in a limited number of breeding cycles. This level of impact is not expected to affect the favourable conservation of harbour porpoise at the management unit scale.

4.3.2 Bottlenose Dolphin

The potential impact of disturbance to bottlenose dolphins from underwater noise from the construction of Moray West cumulatively with other projects and plans was assessed quantitatively; by population modelling using the interim Population Consequences of Disturbance (iPCoD) framework. This is detailed in Section 9.8.2 of Chapter 9 of the Offshore EIA Report. Based on the cumulative scenario considered to be the most realistic, the bottlenose dolphin population was predicted to experience a small initial decline relative to the baseline as a result of the disturbance events, after which it then returned to the same growth rate as the baseline population and continued to increase at the same rate as the baseline population for the remainder of the simulations. Therefore, there is no predicted long term effect on the East Coast Scotland bottlenose dolphin population as a result of the cumulative disturbance from Moray East, Moray West, AHEP, Neart na Gaoithe, Seagreen and Inch Cape. Due to the lack of any density dependent mechanism being included in the modelling, despite recovery after the period of disturbance, the mean impacted population growth rate is not predicted to increase above the baseline growth rate and therefore although the population growth rate is expected to recover once the period of disturbance is over, the impacted population size is predicted to remain slightly lower than the equivalent baseline population. In the absence of any empirical evidence for density dependence, this is a precautionary assessment. As a result of the rapid return to baseline growth rates and the temporary nature of the predicted population level effect, this level of impact is not expected to affect the favourable conservation of bottlenose dolphins at the management unit scale.

4.3.3 Minke Whale

The cumulative assessment totalled the number of disturbed individuals across the relevant projects to determine the maximum number that would be impacted if all projects were constructing at once, assuming no overlap in impact ranges. The maximum number of harbour porpoises potentially affected by projects in the Moray Firth and east coast of Scotland (based on numbers from each project summed) was predicted to be 814, which represents 3.5% of the total reference population. Based on the worst case assumption detailed in the project alone assessment that each year of disturbance would result in a failure to breed for each disturbed individual, this is still considered low magnitude relative to the overall size of the MU population. This level of impact is not expected to affect the favourable conservation of minke whales at the management unit scale.

4.4 Mitigation

It is anticipated that any future consents granted for the Project will require a Piling Strategy (PS) be submitted, for approval, to the Scottish Ministers prior to the commencement of Construction. The Piling Strategy will detail the refinements in the project design and the implications in respect of marine mammals in the vicinity of the Moray West site. In addition, the PS will incorporate a Marine Mammal Mitigation Plan (MMMP) that will be applied for the duration of piling to manage, and reduce to negligible, the risk of injury to EPS. Contractors engaged in piling activities will be required to adhere to the MMMP for the duration of foundation installation.

The primary aim of the MMMP is to prevent instantaneous auditory injury to any marine mammal species in close proximity of the pile driving for the foundation structures. Measures presented within an MMMP for the Development will be developed in line with standard industry guidance and practice in consultation with relevant statutory and non-statutory stakeholders. The MMMP will be focused on reducing the potential for injurious or lethal effects occurring on marine mammals.

Potential mitigation measures that will be considered within the PS and MMMP include the following:

- EMBEDDED DEDIGN MITIGATION: Completion of a pile driveability study based on analysis of site specific geophysical and geotechnical data to determine most appropriate hammer energy. Hammer energy will be minimised as far as reasonably practicable;
- EMBEDDED PROCEDURE: A 20 minute soft start procedure followed by appropriate ramp-up procedures will be carried out where piling is required;
- EMBEDDED PROCEDURE: An MMMP procedure developed specifically for final foundation substructure design in line with standard industry guidance and to include:
    - Pre-piling deployment of ADDs;
    - Concurrent Marine Mammal Observation (MMO); and
    - PAM. deployment
- EMBEDDED PROGRAMMING: 24 hour working to reduce the overall construction period; and
- EMBEDDED PROGRAMMING: consideration of concurrent piling to reduce overall piling duration.

5 Conclusions

It is understood that for an EPS licence to typically be issued, the Licensing Authority must be satisfied that the three legal tests as set out in Section 2.2 are met. Following consideration of the information summarised in this Information to Support a EPS Licence Application and the wider Application documents (including the Offshore EIA Report and RIAA) Moray West's position on the three tests are presented in Table 4.1Table 5.1 below.

Table 5.1: EPS Licensing tests conclusions
Test 1 – Licensable purpose
The Development will generate renewable energy and contribute to meeting both UK and Scottish Government targets by providing low carbon electricity to the National Grid.
Test 2: No satisfactory alternative
The design alternatives have been considered and provided mitigation as far as reasonably practicable in terms of minimising the impact of disturbance to the species.
Test 3: The licensed activities will not compromise the FCS of any species disturbed by the activities
The assessment undertaken as part of the EIA and RIAA concludes that there would be no adverse impact on the Favourable Conservation Status of any EPS as a result of the Development activities.

6 References

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MORAY WEST
OFFSHORE WINDFARM

Offshore Ornithology Technical Report

Moray Offshore Windfarm (West) Limited

Technical Appendix 10.1

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Acronyms	
Acronym	**Expanded Term**
WTGs	Wind Turbines Generators
OfTI	Offshore Transmission Infrastructure
OSPs	Offshore Substation Platforms
MRSea	Marine Renewables Strategic Environmental Assessment
VORs	Valued Ornithological Receptors
NMP	National Marine Plan
EIA	Environmental Impact Assessment
HRA	Habitats Regulation Appraisal
EU	European Union
SPAs	Special Protection Areas
SSSIs	Sites of Special Scientific Interest
GPS	Global Positioning System
CI	Confidence Interval
CV	Coefficient of Variance
DSS	Decision Support System
BOWL	Beatrice Offshore Wind Limited
MHWS	Mean High Water Springs
JNCC	Joint Nature Conservation Committee
BTO	British Trust for Ornithology
SMP	Seabird Monitoring Programme
FAME	Future of the Atlantic Marine Environment
BDMPS	Biologically Defined Minimum Population Scale
WEB	Wetland Bird Survey
SNH	Scottish Natural Heritage
SNCBs	UK Statutory Nature Conservation Bodies
STAR	Seabird Tracking and Research
pSPA	Potential Special Protection Area
CIEEM	Chartered Institute of Ecology and Environmental Management
DECC	Department of Energy and Climate Change
SDF	Standard Data Form
IEEM	Institute of Ecology and Environmental Management
NERC	Natural Environment Research Council
KDE	Kernel Density Estimation
Obs	Observation

1 Introduction

1.1 Purpose and Scope

Moray Offshore Windfarm (West) Limited (known as Moray West) is promoting the development of the Moray West Offshore Wind Farm. The wind farm will be located in the Outer Moray Firth, approximately 22 km south of the Caithness coastline at its nearest point. It will comprise up to 85 Wind Turbines Generators (WTGs), connected via subsea inter-array cables to the Offshore Transmission Infrastructure (OfTI) which comprises up to two Offshore Substation Platforms (OSPs), OSP interconnector cables and the offshore export cables.

The purpose of this Technical Report is to provide a detailed baseline characterisation of birds based on the digital aerial surveys within and around the Moray West Site and the Offshore Export Cable Corridor (referred to as the Development area) (Figure 2.1).

An overview of the baseline and consultation undertaken, together with the impact assessment, cumulative and transboundary impact assessment are provided in the Chapter 10: Offshore Ornithology. It is therefore recommended that this Technical Report is read in-conjunction with Chapter 10: Offshore Ornithology.

This report presents an outline of the survey methodology, together with baseline results from the site-specific aerial surveys which were designed to best inform the ornithological baseline characterisation of the Moray West Site. This report therefore:

- Collates ornithological data from the digital aerial surveys gathered to date for the Moray West Site plus buffer and provides a baseline description of the ornithological interests within the Moray West Site and along the Offshore Export Cable Corridor; and
- Establishes the ornithological importance of Moray West Site for breeding, wintering and migratory birds by analysing the aerial survey data.

As part of seabird baseline data collection to inform the application for Moray West Offshore Wind Farm, digital aerial surveys of the Moray West Site plus a 4 km buffer have been completed. These surveys were undertaken over a 12 month period from April 2016 to March 2017. Whilst this year of site-specific survey data provides a characterisation of the bird fauna of the Moray West Site across all seasons, it provides more limited information on the variability of bird densities, particularly inter-annual variability, than is often the case for offshore wind farm impact assessments.

The intention has been therefore to use contextual information from other surveys undertaken in the Moray Firth, including from the neighbouring Beatrice and Moray East Sites to better understand this inter-annual variability so that the aerial survey data collected for the Moray West Site can be placed in context. This process is outlined in Technical Appendix 10.1A: Baseline Data Decision Support Flow Charts which should also be read in conjunction with this Appendix. As part of this process the digital aerial survey data collected for the Moray West Site (2016 to 2017) has been processed through the MRSea statistical package (Scott-Hayward *et al.,* 2013) for a select number of species (gannet, kittiwake, puffin, guillemot and razorbill) to provide increased confidence in the data presented. Results from this exercise are presented in this report and further inform the judgements made on the value and important of bird populations recorded.

The structure of this report is as follows:

- Section 2 provides an overview of the methodologies used to gather, analyse and present baseline data, as well as the rationale behind, and procedures used, to define population importance and sensitivity for each key species.
- Section 3 presents the results gathered from desk-based studies and aerial surveys to characterise the baseline environment. Information is provided for raw counts of all species

recorded at Moray West Site.

- Section 4 presents an overview of each key species' sensitivity based on a literature review.
- Section 5 identifies sites of conservation concern with potential connectivity with Moray West Site during the breeding season, based on the foraging behaviour of those species designated as qualifying features at relevant sites of conservation concern.
- Section 6 contains individual species accounts for species recorded during surveys of the Moray West Site and provides discussion pertaining to trends in spatial, seasonal or inter-annual variation. The relative importance of the Moray West Site to the species' background populations are also considered in a wider spatial context.
- Section 7 then takes all the presented information to summarise which species should be considered for impact assessment, based on the importance of the populations recorded during the baseline period.

1.2 Planning Policy Context and Legislation

1.2.1 Planning Policy

The Marine (Scotland) Act 2010 required Scottish ministers to prepare and adopt a National Marine Plan for the Scottish marine area. The plan states the Scottish Ministers' policies for, amongst other things, sustainable development in the Scottish marine area.

Policies included in Scotland's National Marine Plan (NMP) identified as being relevant to offshore wind and the marine ecosystem include:

- Renewables 1: Proposals should be sited in the Plan Option areas. Proposals are subject to licensing and consenting processes.
- Renewables 3: Test and demonstration proposals for sustainable development should consider on a case-by-case basis where sites are identified. Regional Locational Guidance should be taken into account and proposals are subject to licensing and consenting processes.
- Renewables 5: Projects must demonstrate compliance with Environmental Impact Assessment (EIA) and Habitats Regulations Appraisal (HRA) legislative requirements.
- Renewables 6: Cable and network owners and marine users should ensure a co-ordinated and strategic approach to development and activities to minimise impacts on the marine natural environment.
- Renewables 7: Ensure infrastructure is fit for purpose now and in future. Consideration should be given to the potential for climate change impacts on coasts vulnerable to erosion.
- Renewables 9: Support the development of joint research and monitoring programmes.

1.2.2 Legislation

In relation to nature conservation importance, there are three potential legislative impact pathways on seabird assemblages during the construction, operation and maintenance, and decommissioning of Moray West Offshore Wind Farm, these include the following and are discussed further below:

- The potential for the project to adversely affect seabirds of highest conservation concern, listed on Annex 1 of the EU Birds Directive (2009/147/EC, the codified version - updated to incorporate the original Directive and all amendments of Council Directive [79/409/EEC]), and/or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended):

- The potential for the project to adversely affect qualifying ornithological features of nearby designated sites; Natura 2000 sites (Special Protection Areas [SPAs]), sites of national value (Sites of Special Scientific Interest [SSSIs]), and internationally designated sites (Ramsar); and
- The potential for the project to adversely affect other species in internationally-, nationally- or regionally-important numbers in winter, during migration, or whilst commuting locally between foraging areas (which may include the Moray West Site and breeding colonies.

Within the European Union, the key legislative measures providing for the protection of birds are the European Parliament and Council Directive 2009/147/EC on the conservation of wild birds (the 'Birds Directive'), and Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the 'Habitats Directive').

Articles 2 and 3 of the Birds Directive aim to maintain the populations of all wild bird species across their natural range and encourage various activities which promote this. Article 4 of the Birds Directive allows for the designation of SPAs for rare and vulnerable species listed in Annex I of the Birds Directive, as well as for regularly occurring migratory species, especially wetland species of international significance. The Birds Directive satisfies the commitments of the European Community under the Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention).

SPAs designated under the Birds Directive (together with Special Areas of Conservation designated under the Habitats Directive) form part of the network of Natura 2000 sites.

The Habitats and Birds Directives have been transposed into national legislation through the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended in Scotland) and The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2017 (as amended) (together the 'Habitats Regulations'). These Regulations allow for the designation of SPAs and set out a mechanism for the protection of those sites including the requirement to undertake a Habitats Regulations Appraisal to assess development projects which have the potential to affect Natura 2000 sites.

Sites designated under the Convention on Wetlands of International Importance especially as Waterfowl Habitat (the Ramsar Convention) are afforded the same status as Nature 2000 sites by the UK and devolved governments. The statutory protection of Ramsar sites in the UK is typically underpinned by the contiguous designation as a Natura 2000 site and/or SSSI. Ramsar sites are also required by the UK and devolved governments to be subject to an HRA to assess development projects which have the potential to affect them.

The Wildlife and Countryside Act 1981 (as amended in Scotland) implements the Birds Directive. The Act provides protection for wild birds by making it an offence to:

- Intentionally kill, injure, or take any wild bird or take, damage or destroy the nest or eggs of a wild bird;
- Disturb breeding birds listed on Schedule 1 of the Act;
- Intentionally or recklessly take, damage, destroy or interfere with any nest which are used habitually at any time by birds listed on Schedule A1; and
- Intentionally or recklessly harass birds listed on Schedule 1A at any time.

The Act also provides for the designation of Sites of Special Scientific Interest (SSSI) and National Nature Reserves (NNR).

2 Methodology for Characterising the Ornithological Baseline of the Development Area

2.1 Site-specific Digital Aerial Surveys

The survey methodology was designed to provide information suitable to support an EIA and HRA of the potential effects of a large offshore wind farm, for which an accurate assessment of abundance and distribution of seabirds is required.

Aerial surveys involve transects placed 2.5 km apart within Moray West Site plus a 4 km buffer (Figure 2.1) using a transect-based survey design in which strip transects are placed approximately perpendicular to the depth contours along the coast. Such a design ensures that each transect samples a similar range of habitats (primarily relating to water depth) and reduces the difference in bird abundance estimates for each transect.

Surveys were undertaken using an aircraft equipped with four (4) HiDef Gen II cameras with sensors set to a resolution of 2 centimetres ("cm") Ground Sample Distance ("GSD"). Each camera sampled a strip of 125 m width, separated from the next camera by ~25m, thus providing a combined sampled width of 500 m within a 575 m overall strip. The surveys covered the Moray West Site plus a 4 km buffer representing an area of 1,230 km^2. Analyses were conducted utilising data from two of the four cameras representing 10% coverage of this area.

The surveys were flown using a Diamond DA42 aircraft at a height of approximately 550 m above sea level ("ASL") (~1800'). Flying above 500 m ensures that there is no risk of flushing those species which have been proven to be easily disturbed by aircraft noise (Thaxter *et al.,* 2015).

Position data for the aircraft was captured from a Garmin GPSMap 296 receiver with differential GPS enabled to give 1 m for the positions, and recording updates in location at 1 second intervals for later matching to bird and marine mammal observations.

2.2 Data Processing

2.2.1 Data Review and Object Detection

Data collected during aerial surveys were analysed by trained reviewers who marked any objects in footage that require further analysis as well as determining which objects were birds or other objects that may be recorded during surveys (marine mammals, ships, etc.). A review of raw data was then conducted incorporating 20% of the raw dataset with the results obtained compared to the original review. If 90% agreement was not attained during this process the remaining dataset was reviewed and, if necessary all data re-analysed.

All objects identified by the data review were assigned to a species group and where possible, each of these then further identified to species level. Species identifications were given a confidence rating of possible, probable or definite.

2.2.2 Population Estimates and Distribution

The abundance of each species observed was estimated separately using a design-based strip transect analysis with variance and confidence intervals ("CI") derived through 10,000 bootstraps. The bootstrapping technique uses total length of transect to limit selection rather than total number of transects. This method has an advantage when transects are of unequal length and provides better precision estimates.

In a strip transect analysis, each transect is treated as an independent analysis unit, and the assumption is made that transects can be treated as statistically independent random samples from the site. The length of each transect and its breadth (i.e. the width of the field of view of the camera) multiplied

together give the transect area; dividing the number of observations on that transect by the transect area gives a point estimate of the density of that species for the site. The density of animals at the site (and hence the population size), the standard deviation, 95% CI and coefficient of variance ("CV") are then estimated using a non-parametric bootstrap method with replacement (Buckland *et al.,* 2001). Population estimates are calculated by multiplying the resulting density estimate by the area of the whole site. The upper and lower confidence intervals for the density and population estimates define the range that the abundance metric falls within with 95% certainty.

Density estimates and population estimates are calculated separately for birds on the water, birds in flight and total birds (birds on the water and birds in flight combined). As these estimates are calculated using a bootstrap method these estimates are relative and as such, totalling the relevant abundance metrics for birds on the water and birds in flight may not necessarily equal the combined abundance metric.

2.2.3 Availability Bias

In wildlife surveys, a proportion of seabirds that spend any time underwater, especially while feeding, will not be detectable at the surface. This may lead to an under-estimate of their abundance during surveys, known as availability bias. For species that make long dives underwater, this bias might be significant (e.g. auks). This is particularly the case for digital aerial survey data which provide a snapshot of the birds' behaviour at the time of detection.

There are two main approaches to account for availability bias either by using double platform surveys (for example Borchers *et al.,* 2002) which is logistically difficult to achieve and relatively expensive or by using known data on time spent underwater to apply correction factors to abundance estimates (for example Barlow *et al.,* 1988).

The following equation (Barlow *et al.,* 1988) to determine the proportion of time that an animal is not available in equation 1 was applied to the aerial survey data:

$$\Pr(being\ visible) = \frac{(s+t)}{(s+d)}$$

Where s is the average time spent below the surface, t is the window of time that the animal is within view and d is the average time spent at the surface. In the case of digital video surveys, the value of t is negligibly small and is treated as 0.

All available data for seabirds relate to diving behaviour obtained by direct observation, or in the case of guillemots and razorbills, to data obtained during the breeding season using data loggers. Thaxter *et al.* (2010) give average times for these species engaged in flying, feeding and spent underwater during the chick-rearing period. The correction for availability applied here used the mean time spent underwater (1.9 and 0.8 hours for guillemots and razorbills respectively) as a percentage of the mean time spent at sea not flying (8.0 and 4.6 hours respectively). Thus the percentage time spent underwater for guillemots is 23.75% and for razorbills of 17.4%. For puffins, data from data loggers were used from Spencer (2012), which estimated that puffins spend 14.16% of daylight time underwater when not flying.

These figures are only applied to estimates of relative abundance of birds sitting on the sea, and should be added to the true abundance of flying birds to give an estimate of true abundance for the species. For this reason, it was necessary to calculate the percentage of birds as a total of all observations and apply these to the estimates of abundance for guillemot and razorbill. Because of low sample sizes of guillemots and razorbills in many months, the percentage of sitting birds was used to calculate the correction factors for abundance estimates within the proposed development area. These percentage figures were used to scale up the relative abundance estimate of guillemots, razorbills and puffins sitting on the sea by factors of 1.2375, 1.174 and 1.1416 respectively, and then added to abundance estimates for flying birds. A scaling factor was also applied for large auks and auk species in proportion to the ratio of the estimated abundance of sitting guillemots, razorbills and puffins to each other and to other species within each of the mapped grid cells.

2.3 Analysis of Moray Firth Ornithological Data

As part of the preparation of data for use in an EIA of the Development, a detailed analysis of existing data has been conducted in order to understand the inherent inter-annual variability in the digital aerial data.

In order to select suitable densities for use in the impact assessment for the proposed wind farm, a decision support system (DSS) was created. The DSS compared the point density estimate from the Moray West digital aerial survey data with the corresponding upper and lower confidence interval from other sources in other years. The DSS then provided a recommended density value to use, which was then extrapolated to the Moray West Site plus a 2 km buffer, for displacement assessment, or to the Moray West Site only for collision risk modelling. All of the density values recommended from the DSS were compared with existing densities estimated from the Moray West digital aerial survey data analysed using MRSea (Scott-Hayward *et al.,* 2013), and other data sources from the Moray Firth (e.g. Moray East boat surveys, Beatrice Offshore Wind Ltd. (BOWL) digital aerial survey data surveys) analysed using MRSea. When bird numbers were too low to enable use of MRSea, density was calculated using the mean of density in each transect with bootstrapped confidence limits (Buckland *et al.*, 2001). The methodology and results of this process are fully outlined in Technical Annex 10.1A: Baseline Data Decision Support Flow Charts.

Outputs from the MRSea processing of the Moray West digital aerial survey data have been used to inform key assessment analyses for the EIA Report (Chapter 10: Offshore Ornithology). As detailed in Technical Annex 10.1A: Baseline Data Decision Support Flow Charts, this therefore has focussed on impact assessment requirements for collision and displacement effects. This involves consideration of flying birds alone for species sensitive to collision while both flying and sitting birds are considered for those sensitive to displacement.

To inform baseline characterisation within this Technical Appendix in terms of establishing populations of importance, digital aerial survey data including a full 4 km buffer without analysis thorough MRSea is used initially. MRSea outputs are nevertheless presented in this Technical Appendix at 4 km buffer scale where available and commentary made on the differences with the unprocessed digital aerial survey data.

2.4 Defining Population Importance and Sensitivity Levels

The significance of an effect on any particular species can be determined as a combination of the size and importance of the species' population affected, and the sensitivity of the species to a particular impact.

The importance of species present in the Moray West Site was defined in relation to estimated international, national and regional populations through the use of the 1% threshold criterion. The 1% threshold for each population is obtained by dividing the respective biogeographic population by 100. The qualification of any SPA species found within the survey areas and the conservation status of each species as per the latest Birds of Conservation Concern classification (Eaton *et al.,* 2015), and any national or international designated status (e.g., Annex I, Schedule 1) are also considered. It is important to note that other criteria (e.g. the conservation importance of a species) are also considered when identifying Valued Ornithological Receptors (VORs) with these criteria presented in Section 1.6.

Threshold values for international populations were derived from figures provided in Wetlands International (2014), Mitchell *et al.* (2004) or del Hoyo *et al.* (1996). The 1% criterion, whilst not necessarily of biological relevance, has been previously used as a standard for designating areas of conservation interest (Kuijken, 2006). National population thresholds were derived from Musgrove *et al.* (2013), Burton *et al.* (2012) or Stienen *et al.* (2007). Appropriate numbers for both breeding and wintering populations were determined for each species from the most recent literature, taking into account seasonal patterns of movement (e.g., Furness, 2015).

Classification of the regional importance of breeding populations observed on site (i.e., if the population exceeded 1% of the regional population) was based on the following:

- Estimates of foraging range (e.g. Thaxter *et al.,* 2012);

- Data presented from the Seabird 2000 census in Mitchell *et al.* (2004) and the subsequent JNCC Seabird Monitoring Programme (SMP; JNCC 2017a); and/ or
- Colony-specific data, where available (e.g. tagging studies as part of the Future of the Atlantic Marine Environment (FAME) project [www.fameproject.eu] or Archibald *et al.,* 2014).

For non-breeding species present in winter or on passage, the relevant regional population was considered to be the North Sea with relevant Biologically Defined Minimum Population Scale (BDMPS) populations taken from Furness (2015). Furness (2015) uses demographic data, to incorporate the number of immature birds associated with breeding colonies within the BDMPS populations defined for the non-breeding and passage seasons.

Species were assigned sensitivity levels based on the evaluation of ornithological effects of offshore wind farms by Wade *et al.* (2016). When a species or impact was not detailed by Wade *et al.* (2016) information from Langston (2010), Maclean *et al.* (2009) and Garthe and Hüppop (2004) was consulted. A summary of core data from these sources including species-specific collision risk, displacement and barrier effect sensitivities can be found in Table 3.1. This evaluation used the data outlined in Table 3.1, in addition to analysing the behavioural ecology of the species and synthesising current field research on the vulnerability of these species to specific impact types, and has been used to help inform which species found during baseline surveys are taken forward for impact assessment in Chapter 10: Offshore Ornithology, as Valued Ornithological Receptors.

2.5 Current Baseline

2.5.1 Study Area

In order to characterise the baseline environment a number of study areas have been defined:

- The Moray West Site plus 4 km buffer across which aerial surveys were undertaken (Figure 2.1);
- The Offshore Export Cable Corridor including all offshore areas below Mean High Water Springs (MHWS) (Figure 2.1);
- The Development area (Moray West Site and the Offshore Export Cable Corridor);
- The Moray Firth, which represents a regional offshore ornithology study area, within which the Development and the adjacent consented Beatrice and Moray East Offshore Wind Farms are located.
- North Sea which represents wider regional or national study area for certain species (in the non-breeding season) and coincides with the northern North Sea as defined by the regional seas identified by JNCC for implementing UK nature conservation strategy (JNCC, 2004) (Figure 2.2).

The Moray Firth study area providing a wider context for the Development-specific data including consideration of species specific foraging ranges, migration routes and wintering areas. In addition, a number of areas present in the Moray Firth and North Sea that are considered important for birds are also discussed as part of the wider baseline characterisation.

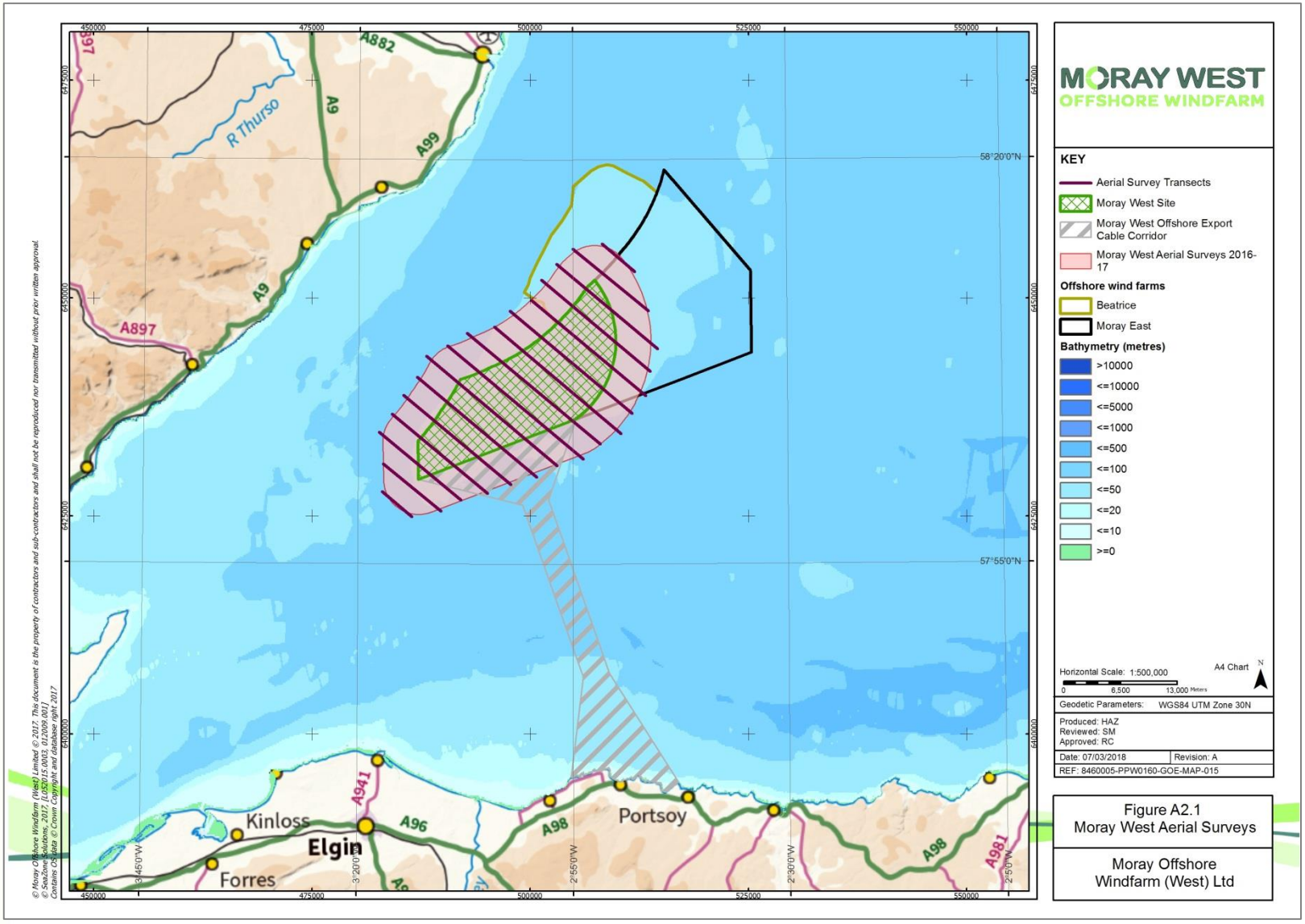


Figure 2.1: Study areas defined to characterise the ornithological baseline of the Development Area.

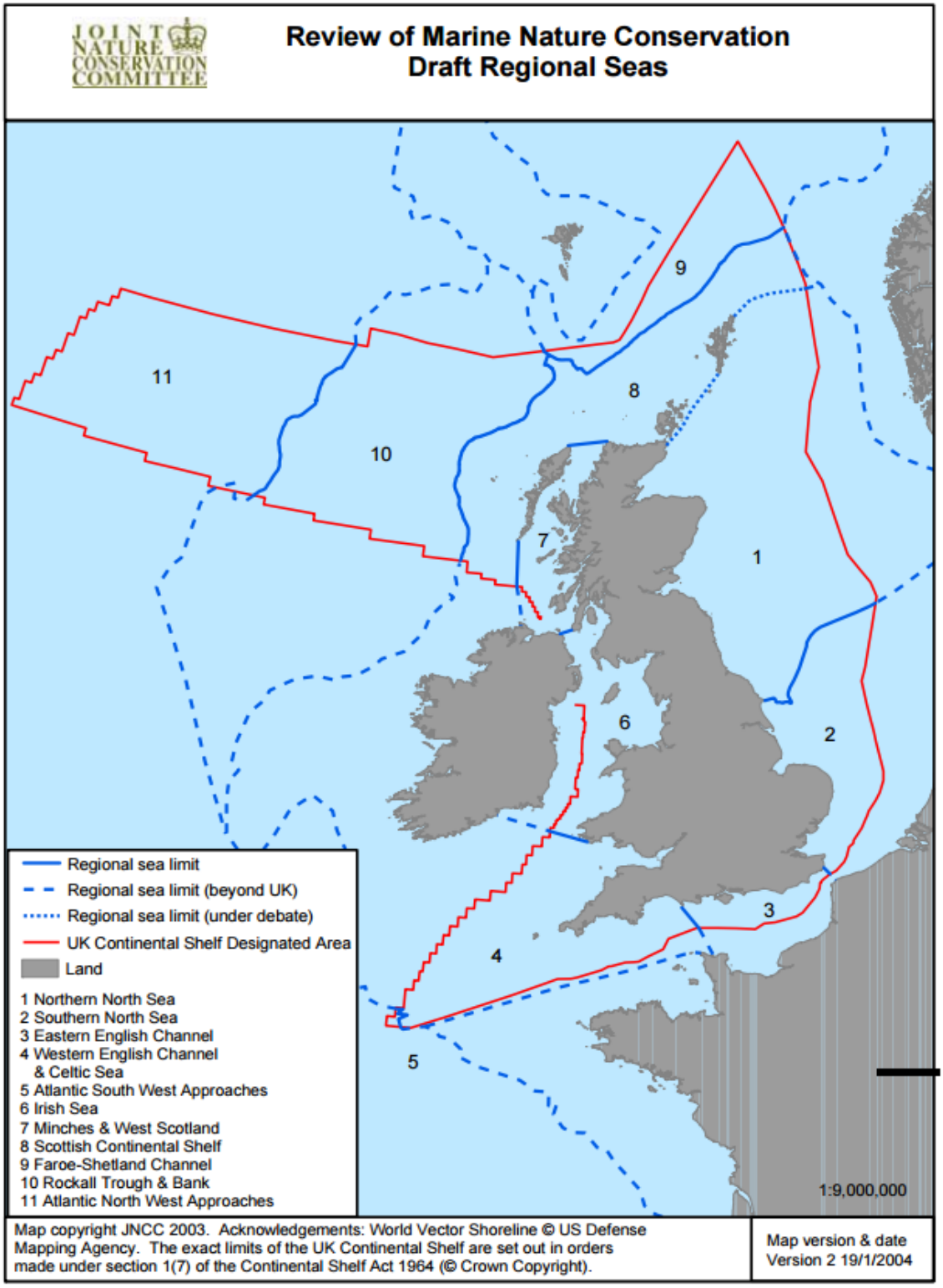


Figure 2.2: Draft Regional Seas in UK waters (JNCC, 2004) (Moray West Site is located in Area 1 – Northern North Sea)

2.5.2 Seabird Distribution in Relation to the Marine Environment

Overview

Seabird distribution is the result of a combination of interacting factors. Prey distribution is thought to be more important than physical factors, although nest site availability and foraging ranges for each species are also limiting factors (see Stone *et al.,* 1995 for review). Each species' behaviour in the northern North Sea or Moray Firth is discussed in more detail in the Species Accounts below.

Physical processes such as wind and weather conditions may have a seasonal effect on seabird distribution, often indirectly through prey distribution. Water movements, temperature and salinity may also have an effect on accumulating prey.

Mixing of waters brings nutrients to the surface which encourages plankton growth, and attracts fish and seabirds. Fronts between water masses with different properties may also be highly productive for birds. Plume fronts exist at the outflow of many large rivers (Stone *et al.,* 1995) including those that flow into Moray Firth (Baxter *et al.,* 2008; Tetley *et al.,* 2008).

Cold water enters the Moray Firth from the north Atlantic (the Dooley Current) and is circulated clockwise into and around the Moray Firth (Tetley *et al.,* 2008). The decreasing bathymetry of the inner Moray Firth (Baxter *et al.,* 2008) results in the warming of circulating cold water which is then pushed out into the wider Moray Firth and North Sea by freshwater outflows forming a warm water plume (Tetley *et al.,* 2008).

This nutrient-rich water is temporary, and of seasonal importance, resulting in an increased availability in sandeel *Ammodytes* sp. (Tetley *et al.,* 2008) for a large number and diversity of seabirds and marine mammals.

Upwellings are common at shelf breaks and are often characterised by higher bird densities. The northern North Sea is relatively uniform compared to the 'North west approaches' and has one major sandbank system; the Viking Bank located east of Shetland and extending into Norwegian waters. Viking Bank is a known wintering ground for mackerel *Scomber scombrus* (Scottish Government, 2015) and a spawning ground for sandeel (Norwegian Ministry of the Environment, 2014). Viking Bank is a feeding ground for marine mammals (Norwegian Ministry of the Environment, 2014) and also seabirds, particularly gannet (Camphuysen, 2005; Hamer *et al.,* 2007). Auks have been found to remain mostly within coastal shelf waters, while fulmars are most common at the outer shelf, shelf edge and deep waters (Stone *et al.,* 1995). Discussion is provided in relation to the importance of these features for seabirds in the following sections.

Bathymetry and Sea Conditions

The North Sea is mainly shallow (<100 m), particularly in the southern part where depths rarely exceed 50 m. These shallow areas are characterised by sand substrates or sand and gravel mixtures. The sandy conditions provide an ideal habitat for species such as sandeel, an important dietary component for many seabirds.

In winter, surface waters are warmer offshore than inshore and in summer the reverse is true as shallow coastal waters warm up more rapidly than deep waters. Surface salinity is lower nearer the coasts than further offshore as a result of freshwater influence from rivers. The northern North Sea is largely made up of well mixed shelf water with relatively narrow transition zones between the shelf water and the weakly stratified freshwater areas in the Moray Firth, Firth of Tay and Firth of Forth (Connor *et al.,* 2006). A wedge of well mixed oceanic water is located south of Shetland (Connor *et al.,* 2006).

Seabird Prey Species and Distribution

The important prey species of seabirds in the North Sea are summarised in Table 2.1. A full description of the fish community associated with the Moray West Site and Offshore Export Cable Corridor is provided in Chapter 8: Fish and Shellfish Ecology with a summary presented below.

Table 2.1: Seabird Prey Species

Seabird Species/Species Group	Important Prey Species
Eider	Blue mussel, as well as sea urchins, starfish and other marine invertebrates
Divers, grebes, cormorants and mergansers	Fish
Fulmars and shearwaters	Crustaceans, squid, fish, offal, carrion mostly from surface.
Gannet	Mackerel
	Herring
Skuas	Fish, caught through piracy of other birds.
Little gull	No specific data relating to the marine environment, thought to be chiefly small fish and invertebrates.
Large gulls	Omnivorous: fish, offal, carrion from surface and through piracy of other birds.
Kittiwake	Sandeel spp.
	Sprat
	Other species: capelin, herring, cod, whiting, pollock, crustaceans, molluscs.
Terns	Herring, sprat, sandeel spp.
Auks	Sandeel spp., sprat, herring, capelin, mackerel, cod, haddock, whiting.

Outer Moray Firth Zone

Based on geographic, hydrographic and physical differences within the North Sea, the Outer Moray Firth Zone falls within the Shetland, Orkney and Moray Firth seabird distribution study area (Figure 2.3; [Stone *et al.,* 1995]). The northern North Sea, as defined by the JNCC (2004) also includes the Western North Sea and the Central and North Sea seabird distribution study areas (Stone *et al.,* 1995).

The division of the North Sea into a number of sectors by Stone *et al.* (1995) allows comparisons of relative importance of the Moray West Site to each species population found within the Outer Moray Firth Zone survey areas, in relation to the wider area. The overlap of these three sectors with the northern North Sea means that the differing characteristics of each may play a role in influencing seabird abundance and distribution within the site.

Shetland, Orkney and Moray Firth area contains breeding colonies on Shetland and Orkney and was characterised by Stone *et al.* (1995) as being important for guillemot and razorbill around the outer Moray Firth throughout the year. The area was also used in winter by gulls, with fulmar, skuas, gulls and terns abundant in summer around Shetland and Orkney.

The Western North Sea sector contains breeding colonies such as at Flamborough Head and the Farne Islands and was characterised by Stone *et al.* (1995) as being important for auks throughout the year. The area was also used in winter by gulls and eider, with gulls and terns abundant in summer. Skuas, among other species, pass through the area on autumn passage.

The Central and North Sea sector was characterised as being important for guillemots, although less so during the breeding season, when birds are constrained to coastal colonies. Fulmars, gannets and kittiwakes were also found throughout the year, with other gulls more widespread during winter. Depth in this sector is mostly shallow, with the exception of the Rinne off the coast of Norway.

As a reflection of this mixture of habitat types, the area is likely to include a bird assemblage comprising a mixture of 'true' seabirds, some species which spend part of their annual life cycle at sea (e.g., divers and seaduck), some species associated with the shallow sea area of the Moray Firth, and a wide range of other species on migration both to and from the UK and continental Europe, such as waterbirds and passerines.

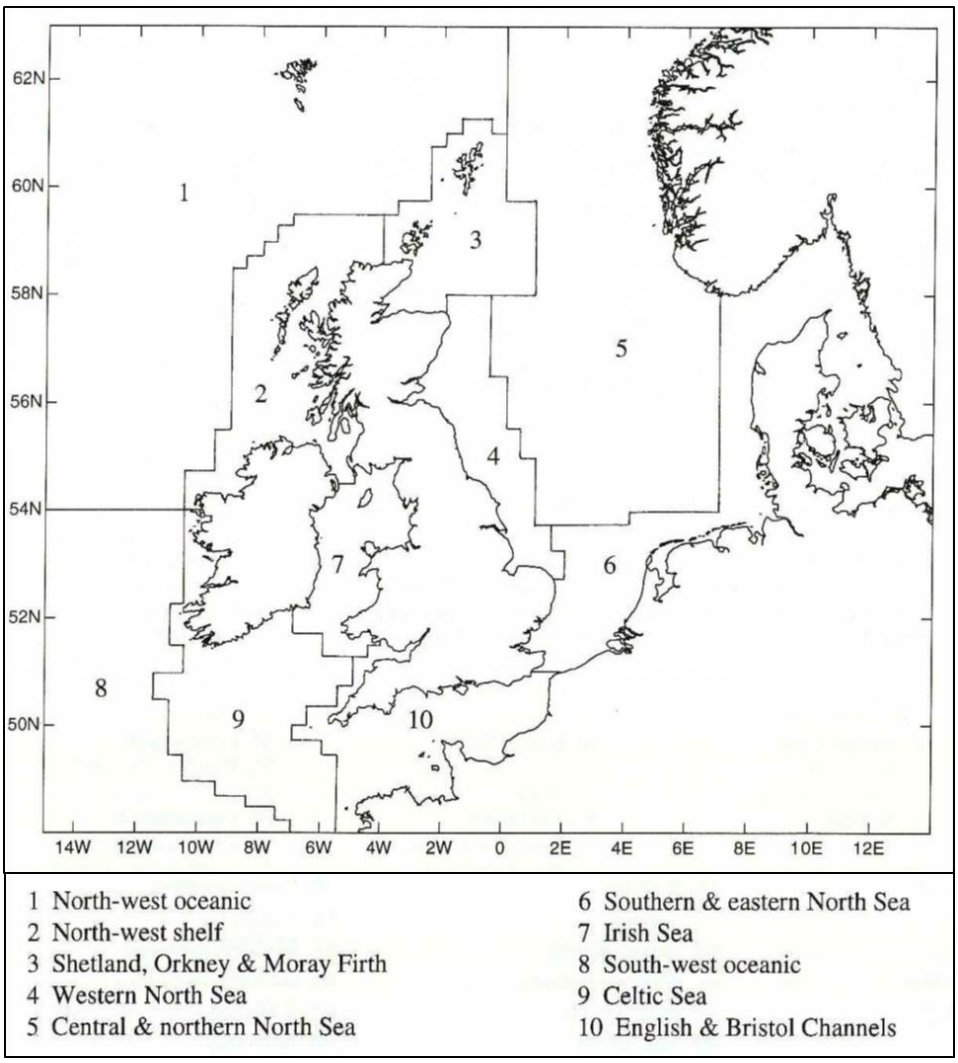


Figure 2.3: Areas for analysis of seabird distribution in Stone *et al.* (1995) (Moray West Site lies within Zone 3 – Shetland, Orkney and Moray Firth).

2.5.3 Recent Seabird Population Trends

Overview

Increasing sea temperatures have had an impact on seabird populations in the UK, mainly through indirect effects via the food chain, on which they rely (JNCC, 2013). Sea-surface temperatures in the north east Atlantic and UK coastal waters have been rising since the 1980s by around 0.2-0.9°C per decade, with the most rapid rises occurring in the southern North Sea and the English Channel (Holliday *et al.,* 2008).

Climate-driven changes in the food chain have had acute negative impacts upon seabirds breeding on Britain's North Sea coast. Rising sea temperatures caused a change in the North Sea plankton community in the late 1980s and consequently large reductions in abundance of the zooplankton on which larval fish feed (Beaugrand *et al.,* 2003). Climate impacts on plankton may be responsible for the association between warmer sea-surface temperatures and poor sandeel productivity (Arnott and Ruxton, 2002).

Low breeding success of kittiwakes, and of other species that rely on sandeels such as common guillemot, has occurred with increasing frequency in recent years. Kittiwakes in eastern Britain have fledged fewer young in recent, warmer years (Frederiksen *et al.,* 2004; Frederiksen *et al.,* 2007), which is thought to be linked to the relationship between temperature and sandeel productivity.

Observations at colonies have confirmed that seabirds were catching fewer and smaller sandeels than normal during years of poor breeding performance (JNCC, 2017a). The calorific content of these sandeels was much lower than usual in 2004, which was one of the least successful breeding seasons for seabirds overall in recent times (Wanless *et al.,* 2005). Long-term declines in numbers of kittiwake are expected to continue unless the recent rises in sea-surface temperature are reversed (Frederiksen *et al.,* 2004).

Winter storms can make it difficult for seabirds to forage at sea and consequently result in reduced survival. At times, this impact can be dramatic and some storms have resulted in large-scale mortality events or 'wrecks', when large numbers of dead or emaciated seabirds have been washed up on the shore (e.g., puffins in spring 2013 (BirdGuides, 2013)). Frederiksen *et al.* (2008) demonstrated that mortality during storms has had a significant negative effect upon the numbers of European shags breeding at a colony in south-east Scotland.

An increase in frequency of extreme weather events, as predicted by climate-change models, could lead to population declines and an increasing probability of extinction of vulnerable species from exposed areas (Frederiksen *et al.,* 2008). Increased storminess and sea level rise may also reduce available breeding habitat for shoreline-nesting species (e.g., terns).

Seabird Monitoring Programme (SMP) Data Trends

Seabird population trends have been used by UK Government as a 'sustainable development strategy indicator'. JNCC, through the SMP (JNCC, 2017a), publishes annual updates on seabird population trends. The latest trends of species relevant to the Moray West Site are summarised in Table 2.2 (JNCC, 2016).

The closest seabird colony to the Moray West Site is the East Caithness Cliffs SPA. This SPA colony is designated for nationally important populations of fulmar, cormorant, shag, razorbill, guillemot, kittiwake, herring gull and great black-backed gull and a seabird assemblage of which puffin is a component feature.

Full counts of fulmar, shag, herring gull, great black-backed gull, kittiwake and auk species have been made once since Seabird 2000 East Caithness Cliffs. No counts were made prior to Seabird 2000 and only partial counts of cormorants were made before (12) and after (10) Seabird 2000 (Malcolm *et al.,* 2012).

Work by SNH (Swann, 2016), has identified post-1999 increases in shag (3.6% but 53% down since 1986) great black-backed gull (47.8% but 74% down since 1977) and razorbill (69.5%). Declines in fulmar (3.6%), cormorant (41.1%, 81% since 1977), kittiwake (39.5%); herring gull (4.2%; 79% since 1977), guillemot (6.2% but up 40% on 1977 and 1986) and puffin (70% since 1977).

Table 2.2: Summary of Seabird Population Trends in the UK (JNCC, 2016).			
Species	**Population Change (%)**		
	1985-88	**1985-88 to 1998-2002**	**2000-2015**
Fulmar	+77	-3	-31
Manx shearwater	N/A	N/A	N/A
Storm petrel	N/A	N/A	N/A
Leach's petrel	N/A	N/A	N/A
Gannet	+39	+391	+342
Cormorant	+9	+10	-8
Shag	+21	-27	-34
Arctic skua	+226	-37	-64
Great skua	+148	+26	+18
Kittiwake	+24	-25	-44
Black-headed gull	+5	0	+38
Common gull	+25	+36	N/A
Lesser black-backed gull	+29	+40	N/A
Herring gull	-48	-13	N/A
Great black-backed gull	-7	-4	-11
Sandwich tern	+33	-15	+13
Common tern	+9	-9	-10
Arctic tern	+50	-31	+17
Guillemot	+77	+31	+5
Razorbill	+16	+21	+32
Puffin	+15	+19	N/A

[1] Change between censuses in 1984-85 and 2004-05
[2] Change between censuses in 2003-04 and colonies surveyed in 2013-14 and 2015

2.5.4 Raw Counts of Birds Recorded in Moray West Offshore Wind Farm Baseline Surveys

A total of 35,372 seabirds were recorded during eleven aerial surveys undertaken across the Moray West Site plus a 4 km buffer between April 2016 and March 2017. Results comprise a total of 21 species with guillemot, kittiwake and razorbill the three most frequently encountered species. These three species accounted for over 86% of all birds records (Table 2.3). Only 5.6% of all records could not be assigned to species level. Further discussion in relation to monthly abundance of each species included in Table 2.3 is provided in the species accounts in Section 1.6.

There was a single record of Sabine's gull, a scarce passage migrant (Forrester *et al*., 2012) and two non-seabird species, pink-footed goose and woodcock. These three species are not considered to be key species and are not considered further in this report.

Table 2.3: Raw Counts of Birds Recorded During Aerial Surveys of Moray West Site plus a 4 km Buffer between April 2016 and March 2017.

Species	No. of records
Eider	1
Great northern diver	1
Fulmar	1,301
Sooty shearwater	286
Manx shearwater	8
Gannet	417
Pomarine skua	1
Arctic skua	6
Great skua	11
Puffin	466
Razorbill	3,138
Guillemot	23,496
Sandwich tern	1
Arctic tern	4
Kittiwake	3,950
Little gull	2
Common gull	3
Lesser black-backed gull	1
Herring gull	88
Great black-backed gull	213
Unidentified birds	1,977
Total	35,372

2.5.5 Seasonal Definitions and Population Importance

Seasons differentiate periods of time within the annual lifecycle for a species. Species specific seasons have been defined primarily referring to guidance from SNH who have provided suggested definitions for all regularly occurring birds in the Scottish marine environment. A further range of sources including Furness (2015), Kober *et al.* (2010) and the seasonal definitions used for previous offshore wind farm assessments considered to be comparable to Moray West Site are referred to where appropriate.

Seasonal definitions for species relevant to Moray West Site are included in Table 2.4.

Depending on the biology and life history of a species the following seasonal definitions are applied:

- Breeding — when birds are attending colonies, nesting and provisioning young;
- Non-breeding — when birds are over-wintering in an area; but may also include one or both of the following definitions;
- Post-breeding —when birds are migrating to wintering areas or dispersing from colonies; and/or
- Pre-breeding — when birds are migrating to breeding grounds.

Seasonal definitions are used to determine the importance of populations estimated within Moray West Site and to apportion impacts to relevant seasons and populations. Regional, national and international populations are shown in Table 2.4 and have been defined for every species recorded in the Moray West Site. These have been derived using a number of sources that are referenced in footnotes below Table 2.5.

Regional populations are defined using the BDMPS relevant to each species (Furness, 2015). The BDMPS is defined as the smallest geographical range and population scale that can be supported by evidence relating to the life history of a species including seasonal distribution and migratory movements. Relevant BDMPS populations are calculated for all seasons defined for a species, with those in the breeding season based on the number of birds within foraging range of Moray West Site and those in the post-breeding, non-breeding and pre-breeding seasons obtained from Furness (2015) or other relevant sources.

The seasonal definitions presented in Table 2.4 aim to take account of the seasonal trends in bird populations at the Moray West Site, therefore considering, in the breeding season for example, both local breeding populations that may have connectivity with Moray West Site and populations of migrating birds moving through the Moray West Site. The consideration of all populations that may interact with the Moray West Site in a given month is important so as not to over or under-estimate the importance of the Moray West Site in a given season. It also ensures that the apportioning of birds to relevant populations (e.g. SPA breeding populations or non-breeding populations) is not over or under-estimated.

Table 2.4: Seasonal Definitions for Species Considered in this Report.[1]

Species	Source	Breeding	Post-breeding	Non-breeding	Pre-breeding
Scaup	SNH			September–March	
Eider	SNH	May–August		September–April[2]	
Long-tailed duck	SNH			September–April	
Common scoter	SNH			July–April	
Velvet scoter	SNH			September–April	
Goldeneye	SNH			September–April	
Red-breasted merganser	SNH			August–March	
Red-throated diver	SNH			September–March	
Great northern diver	SNH			October–May	
Storm petrel	SNH	May–October[3]		November–May	
Fulmar	SNH/Furness (2015)/Site-specific	April–August[4]	September–October	November	December–March
Sooty shearwater	Consistent with Manx shearwater			October–March	
Manx shearwater	SNH	April–September		October[5]–March	

[1] SNH guidance does not provide guidance on post- and pre-breeding seasons and therefore these have been defined using Furness (2015)
[2] SNH guidance indicates the breeding season starts in mid-April. Eider were only recorded during aerial surveys at Moray West during the non-breeding season and as such on a precautionary basis April has been included as a non-breeding month
[3] SNH guidance indicates the breeding season starts in mid-May and non-breeding season concludes in early May.
[4] SNH guidance identifies the end of the breeding season as mid-September. Low densities of fulmar are recorded throughout the Moray Firth in September when compared to other months defined as breeding months (see Baseline Characterisation Report) indicating that the Moray Firth is not an important area for fulmar at this time. Therefore September has been included as a post-breeding month.
[5] SNH guidance identifies mid-October as the end of the breeding season. There is considered to be no connectivity between Manx shearwater breeding colonies and Moray West and therefore October is included as a non-breeding month.

Table 2.4: Seasonal Definitions for Species Considered in this Report.[1]

Species	Source	Breeding	Post-breeding	Non-breeding	Pre-breeding
Gannet	SNH/Furness (2015)	April–September	October–November		December–March[6]
Cormorant	SNH			September–February	
Shag	SNH			October–January	
Slavonian grebe	SNH			September–April	
Pomarine skua	Consistent with Arctic skua			September–April	
Arctic skua	SNH/Furness (2015)	May–August	September–October		April
Great skua	SNH/Furness (2015)	May–August[7]	September–October	November–February	March–April
Puffin	SNH/Furness (2015)	April–August[8]		August–March	
Razorbill	SNH/Furness (2015)	April–August[9]	September–October	November–December	January–March
Guillemot	SNH/Furness (2015)	April–July		August[10]–February	

[6] SNH guidance identifies mid-March as the start of the breeding season. Low densities of gannet have been recorded throughout the Moray Firth in March when compared to other months defined as breeding months (see Baseline Characterisation Report) indicating that the Moray Firth is not an important area for gannet at this time. Therefore March is included as a pre-breeding month.

[7] SNH guidance identified the breeding season as mid-April to mid- September. There is considered to be limited connectivity between great skua breeding colonies and Moray West and therefore the breeding season is defined as May to August.

[8] SNH guidance identifies mid-August as the end of the breeding season. Survey data collected throughout the Moray Firth indicates increases in the abundance of puffin in August. However, it is not known if this is due to post-breeding dispersal of breeding birds or due to an influx of immature birds. Therefore on a pre-cautionary basis August is included as part of the breeding season.

[9] SNH guidance identifies mid-August as the end of the breeding season. Survey data collected throughout the Moray Firth indicates increases in the abundance of razorbill in August. However, it is not known if this is due to post-breeding dispersal of breeding birds or due to an influx of immature birds. Therefore on a pre-cautionary basis August is included as part of the breeding season.

[10] SNH guidance identifies mid-August as the end of the breeding season. The aerial survey data for Moray West indicated a considerable increase in the abundance of guillemot present in August and into September when compared to other breeding season months. However, other surveys in the Moray Firth have shown much lower densities of the species in August (see Baseline Characterisation Report). As such, it is considered that the increase of birds in August is due to post-breeding dispersal of breeding guillemot and August is included as a non-breeding month.

Table 2.4: Seasonal Definitions for Species Considered in this Report.[1]					
Species	**Source**	**Breeding**	**Post-breeding**	**Non-breeding**	**Pre-breeding**
Sandwich tern	SNH	May–August[11]		September–April	
Arctic tern	SNH	May - August		September - April	
Kittiwake	SNH/Furness (2015)	April[12] - August	September – December		January - March
Little gull	SNH			August - April[13]	
Common gull	SNH	April – August		September - March	
Lesser black-backed gull	SNH/Furness (2015)	April- August	September – October	November – February	March[14]
Herring gull	SNH	April - August		September - March	
Great black-backed gull	SNH/Furness (2015)	April - August		September - March	

[11] SNH guidance identifies mid-April to mid-September as the breeding season. There is considered to be limited connectivity between Sandwich tern breeding colonies and Moray West and therefore April and September are included as part of the non-breeding season

[12] SNH guidance identifies mid-April as the start of the breeding season. The abundance of kittiwake as recorded during surveys undertaken throughout the Moray Firth is relatively high in April when compared to non-breeding months and therefore, on a precautionary basis April is included as part of the breeding season.

[13] SNH guidance identifies the end of the non-breeding season as mid-April. Little gull does not breed in the UK and therefore, on a precautionary basis April is included as a non-breeding month.

[14] SNH guidance identifies mid-March as the start of the breeding season. Lesser black-backed gull were only recorded in June during aerial surveys and therefore it is unlikely that breeding birds are utilising the Moray West site. Therefore March is included as part of the pre-breeding season.

Table 2.5: Regional, National and International Population Importance Levels for Species Included in this Report. (All population estimates are for individual birds) (The 1% threshold for each population is obtained by dividing the respective population by 100).

Species	Breeding			Post-breeding		Non-breeding		Pre-breeding	
	Regional BDMPS[15]	National[16]	International[17]	Regional BDMPS[18]	National[18]	Regional BDMPS[18]	National[19]	Regional BDMPS[18]	National[18]
Scaup							12,000		
Eider							63,000		
Long-tailed duck							11,000		
Common scoter							1000,000		
Velvet scoter							2,500		
Goldeneye							27,000		
Red-breasted merganser							9,000		
Red-throated diver						1,523	17,000		
Great northern diver						1,000	2,600		
Storm petrel	2,948	26,000	257,000						

[15] Calculated based on those colonies within the mean-maximum or maximum foraging range of a species.
[16] Sourced from Musgrove *et al.* (2013).
[17] Sourced from Wetlands International (2014), Mitchell *et al.* (2004) or del Hoyo *et al.* (1996).
[18] Sourced from Furness (2015) unless otherwise stated.
[19] Sourced from Musgrove *et al.* (2013), Burton *et al.* (2012) or Furness (2015)

Table 2.5: Regional, National and International Population Importance Levels for Species Included in this Report. (All population estimates are for individual birds) (The 1% threshold for each population is obtained by dividing the respective population by 100).

Species	Breeding			Post-breeding		Non-breeding		Pre-breeding	
	Regional BDMPS[15]	National[16]	International[17]	Regional BDMPS[18]	National[18]	Regional BDMPS[18]	National[19]	Regional BDMPS[18]	National[18]
Fulmar	42,686	1,000,000	5,400,000 – 8,200,000	957,502	1,785,696	568,736	1,125,103	957,502	1,785,696
Sooty shearwater			8,000,000				7,500+[20]		
Manx shearwater		600,000	680,000 – 820,000	8,507	1,589,402			8,507	1,589,402
Gannet	168,144	440,000	780,000	456,298	1,002,252			248,385	910,273
Cormorant	53						41,000		
Shag	1,098						110,000		
Slavonian grebe							1,100		
Pomarine skua							100-2,000[21]		
Arctic skua	428	2,400	30,000 – 70,000	6,427	11,714			1,227	6,338
Great skua		19,200	32,000	19,556	35,892	143	1,541	8,485	33,575
Puffin	119,600	1,160,000	11,000,000 – 13,200,000			231,957	536,514		
Razorbill	107,711	260,000	1,060,000	591,874	1,198,788	218,622	560,044	591,874	1,198,788

[20] Sourced from Forrester *et al*. (2007)
[21] Sourced from Forrester *et al*. (2007)

Table 2.5: Regional, National and International Population Importance Levels for Species Included in this Report. (All population estimates are for individual birds) (The 1% threshold for each population is obtained by dividing the respective population by 100).

Species	Breeding			Post-breeding		Non-breeding		Pre-breeding	
	Regional BDMPS[15]	National[16]	International[17]	Regional BDMPS[18]	National[18]	Regional BDMPS[18]	National[19]	Regional BDMPS[18]	National[18]
Guillemot	998,623	1,900,000	5,600,000 – 5,800,000			1,617,306	2,756,526		
Sandwich tern		24,000	166,000 – 171,000	38,051	48,812			38,051	48,812
Arctic tern		106,000	1,000,000	163,930	235,328			163,930	235,328
Kittiwake	39,360	760,000	6,600,000	829,937	1,741,523			627,816	1,319,342
Little gull			72,000 – 174,000			1,500–3,000[22]			
Common gull		98,000	1,200,000 – 2,250,000				705,392		
Lesser black-backed gull		220,000	530,000 – 570,000	209,007	372,311	39,314	125,113	197,483	360,787
Herring gull	11,667	280,000	1,300,000 – 3,100,000			466,511	743,360		
Great black-backed gull	266	34,000	330,000 – 540,000			91,399	76,610		

[22] Autumn passage estimate sourced from Forrester et al. (2007). Spring passage estimated to be 100–400 birds with 20–400 birds in winter (Forrester *et al.*, 2007).

The regional, national and international population levels presented in Table 2.5 are divided by 100 in order to provide the 1% thresholds against which population estimates calculated for each species in the Moray West Site plus a 4 km buffer are assessed. This is used as part of an initial screening exercise to identify those species for which further assessment is required. Originally developed for the Ramsar Convention (Kuijken, 2006), the 1% threshold level signifying importance has been used extensively for site designation (Kuijken, 2006) and in assessing potential impacts of proposed developments (Skov *et al.,* 2007) and its use here is considered appropriate to provide a coarse screening filter. Where possible, thresholds are taken from temporally appropriate population levels, with particular attention given in this assessment to breeding, post-breeding, non-breeding and pre-breeding populations.

Although some 1% thresholds are low in terms of actual numbers of individuals, a value of 50 individuals is normally used as a minimum threshold in the British Trust for Ornithology's (BTO) Wetland Bird Survey (WeBS) reports (e.g. Holt *et al.,* 2012), and is considered relevant here.

3 Overview of Species Sensitivity

Consideration of the sensitivity of seabird species to the potential impacts arising from the construction, operation and maintenance, and decommissioning of Moray West Offshore Wind Farm is provided in Table 3.1. These sensitivity values have been obtained from a number of sources including Wade *et al.* (2016), Bradbury *et al.* (2014) Maclean *et al.* (2009), Langston (2010) and Garthe and Hüppop (2004).

Table 3.1: Summary of seabird sensitivities to impacts associated with offshore wind farms (Wade *et al.* (2016) unless stated otherwise).

Species	Displacement[12]	Habitat loss[12]	Collision risk[13]	Barrier effects[14]
Scaup	High	High	Very Low	Moderate
Eider	Moderate	Low	Low	Moderate
Long-tailed duck	High	High	Low	Moderate
Common scoter	Very High	High	Low	Moderate
Velvet scoter	Very High	Moderate	Low	Moderate
Goldeneye	High	High	Low	Moderate
Red-breasted merganser[15]	Moderate	High	Low	Moderate
Red-throated diver	Very High	High	Moderate	Moderate
Great northern diver	Very High	Moderate	Moderate	Moderate
Storm petrel	Very Low	Very Low	Low	-
Fulmar	Very Low	Very Low	Very Low	Low
Sooty shearwater	Very Low	Very Low	Very Low	-
Manx shearwater	Very Low	Very Low	Very Low	-
Gannet	High	Very Low	High	Very low
Cormorant	High	Moderate	High	Moderate
Shag	High	Moderate	Moderate	Moderate
Slavonian grebe	Moderate	High	Low	Moderate
Pomarine skua[15]	Very Low	Low	Low	Low
Arctic skua	Very Low	Low	High	Low

Table 3.1: Summary of seabird sensitivities to impacts associated with offshore wind farms (Wade *et al.* (2016) unless stated otherwise).

Species	Displacement[12]	Habitat loss[12]	Collision risk[13]	Barrier effects[14]
Great skua	Very Low	Low	High	Low
Puffin	Moderate	Moderate	Very Low	High
Razorbill	High	Moderate	Very Low	High
Guillemot	High	Moderate	Very Low	High
Sandwich tern	Low	Moderate	High	Very low
Arctic tern	Low	Moderate	Moderate	Very Low
Kittiwake	Low	Low	High	Low
Little gull[16]	Very Low	Moderate	Low	Low
Common gull	Low	Low	Very High	Low
Lesser black-backed gull	Low	Very Low	Very High	Low
Herring gull	Low	Very Low	Very High	Low
Great black-backed gull	Low	Very Low	Very High	Low

Key to shading – uncertainty level					
Not included in Wade *et al.* (2016)	Very low	Low	Moderate	High	Very high

[2] The five point scales in Wade *et al.* (2016), Bradbury *et al.* (2014), Maclean *et al.* (2009) and Garthe and Hüppop (2004) have been translated to sensitivities of Very High, High, Moderate, Low and Very Low. Where the sensitivity of a species has been obtained this is identified in Table 1.6 as Langston (2010) uses a three point scale (High, Moderate and Low risk).
[13] Based on the overall vulnerability score in Wade *et al.* (2016).
[14] Taken from Maclean *et al.* (2009) or Langston (2010).
[15] Bradbury *et al.*, 2014.
[16]Garthe and Hüppop, 2004.

Although these qualitative categories are not site-specific, these are used to provide context and inform conclusions in relation to the identification of Valued Ornithological Receptors.

4 Designated Sites

Breeding seabirds are central-place foragers, with the nest or colony forming the central location. Foraging range varies widely between species and is determined by environmental conditions, dietary needs, flight physiology and ability to transport food.

The foraging range of each species was used to infer potential connectivity between the Moray West Site and important colonies or designated sites. Generally mean-maximum foraging range (Thaxter *et al.,* 2012) is considered to be the appropriate metric to determine connectivity between a breeding colony and a project site. However, additional data from tracking studies (e.g. Wakefield *et al.,* 2013, Archibald *et al.,* 2014, the Future of the Atlantic Marine Environment (FAME) (http://www.fameproject.eu/en/project/partnership/) and Seabird Tracking and Research (STAR) projects) have been incorporated into the assessment for the Moray West Site where available. The mean-maximum foraging range of a species is the average maximum length of the trip taken by individuals to obtain food, based on data obtained from relevant studies of that species (Thaxter *et al.,* 2012). A maximum foraging range encompasses the longest distance from home colony recorded for a given species.

Following joint Statutory Nature Conservation Body (SNCB) advice, mean-maximum foraging range is the primary metric used to determine connectivity and regional populations throughout this chapter (Marine Industry Group for Ornithology [MIG-Birds], 2017). However, in some cases, it has been considered that the maximum foraging range should be used, with evidence from baseline surveys and also from tagging results recently published as part of the FAME project showing that birds (including fulmar and guillemot at northern Scottish colonies) may travel further than previously thought.

The distance between the Moray West Site, and the relevant breeding colonies indicated that, for the majority of species, the proposed Development is beyond their mean-maximum foraging ranges even from the nearest colony.

Figure 4.1 and Table 4.1 shows SPAs with possible connectivity to the Moray West Site, and the listed species within foraging range (Thaxter *et al*., 2012). This potential for connectivity is also used to inform the evaluation of species' importance. SPAs and pSPAs (potential Special Protection Areas) in Scotland have been considered where species that are a qualifying feature of an SPA were recorded within the Moray West Site.

Table 4.1: Qualifying SPA Species with Foraging Ranges that Interact with the Moray West Site from Relevant Breeding Colonies			
(p)SPA	**Distance to the Moray West Site / Offshore Export Cable Corridor (km)**	**Qualifying Feature (foraging range[23])**	**Justification**
Breeding			
Auskerry	92.4 / 108.4	Storm petrel (91.7 ± 27.5 km)	Foraging range overlaps with Moray West Site only when 1 SD taken into account.
Buchan Ness to Collieston Coast	92.7 / 59.6	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km) Herring gull (61.1 ± 44.0 km) Kittiwake (60 ± 23 km)	Foraging ranges overlap with Moray West Site for fulmar, and herring gull. Guillemot foraging range overlaps only when 1 SD is taken in to account. Foraging range of kittiwake only overlaps with the Offshore Export Cable Corridor.
Calf of Eday	111.7 / 127.7	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km)	Foraging range of fulmar overlaps with Moray West Site.
Cape Wrath	110.3 / 112.9	Fulmar (400 ± 245.8 km) Puffin (105.4 ± 46 km) Guillemot (84 ± 50.1 km)	Foraging range of fulmar overlaps with Moray West Site. Puffin and guillemot foraging ranges only overlap when 1 SD is taken into account.
Copinsay	74.3 / 90.3	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km) Kittiwake (60 ± 23 km)	Foraging ranges of fulmar and guillemot overlap with Moray West Site. Kittiwake foraging range only overlaps when 1 SD is taken into account.
East Caithness Cliffs	19.9 / 23.1	Fulmar (400 ± 245.8 km) Cormorant (25 ± 10 km) Shag (35 km) Puffin (105.4 ± 46 km) Guillemot (84 ± 50.1 km) Razorbill (48.5 ± 35 km) Herring gull (61.1 ± 44.0 km) Great black-backed gull (20km) Kittiwake (60 ± 23 km)	Foraging ranges overlap with Moray West Site.

[23] Foraging range represented by mean-maximum range (plus 1 Standard Deviation around this value) as provided by Thaxter *et al*. (2012)

Table 4.1: Qualifying SPA Species with Foraging Ranges that Interact with the Moray West Site from Relevant Breeding Colonies			
(p)SPA	**Distance to the Moray West Site / Offshore Export Cable Corridor (km)**	**Qualifying Feature (foraging range[23])**	**Justification**
Fair Isle	157.8 / 173.2	Fulmar (400 ± 245.8 km) Gannet (229.4 ± 124.3 km)	Foraging ranges overlap with Moray West Site.
Fetlar	281.2 / 296.8	Fulmar (400 ± 245.8 km)	Foraging range overlaps with Moray West Site.
Flannan Isles	254.6 / 255.4	Fulmar (400 ± 245.8 km)	Foraging ranges overlaps with Moray West Site.
Forth Islands	202.9 / 163.8	Fulmar (400 ± 245.8 km) Gannet (229.4 ± 124.3 km)	Foraging ranges overlaps with Moray West Site.
Foula	213.5 / 229.5	Fulmar (400 ± 245.8 km)	Foraging ranges overlaps with Moray West Site.
Fowlsheugh	132 / 88.4	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km)	Foraging ranges overlap with Moray West Site. Guillemot foraging range only overlaps when 1 SD is taken into account.
Handa	118.9 / 120.5	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km)	Foraging range of fulmar overlaps with Moray West Site. Guillemot foraging range only overlaps when 1 SD is taken into account.
Hermaness, Saxa Vord and Valla Field	300.2 / 315.8	Fulmar (400 ± 245.8 km) Gannet (229.4 ± 124.3 km)	Foraging range of fulmar overlaps with Moray West Site. Gannet foraging range only overlaps when 1 SD is taken into account.
Hoy	64.9 / 79.5	Fulmar (400 ± 245.8 km) Puffin (105.4 ± 46 km) Guillemot (84 ± 50.1 km) Arctic skua (62.5 ± 17.7 km) Kittiwake (60 ± 23 km)	Foraging ranges of fulmar, puffin and guillemot overlap with Moray West Site. Arctic skua and kittiwake foraging ranges only overlap when 1 SD is taken into account.
Marwick Head	101.9 / 116.8	Guillemot (84 ± 50.1 km)	Foraging range of guillemot overlaps with Moray West Site only when 1 SD taken into account.
North Caithness Cliffs	41.6 / 57	Fulmar (400 ± 245.8 km) Puffin (105.4 ± 46 km) Guillemot (84 ± 50.1 km)	Foraging ranges overlap with Moray West Site.

Table 4.1: Qualifying SPA Species with Foraging Ranges that Interact with the Moray West Site from Relevant Breeding Colonies			
(p)SPA	**Distance to the Moray West Site / Offshore Export Cable Corridor (km)**	**Qualifying Feature (foraging range[23])**	**Justification**
		Razorbill (48.5 ± 35 km) Kittiwake (60 ± 23 km)	
North Rona and Sula Sgeir	188.7 / 192.2	Fulmar (400 ± 245.8 km) Gannet (229.4 ± 124.3 km)	Foraging ranges overlaps with Moray West Site.
Noss	235.8 / 251.1	Fulmar (400 ± 245.8 km) Gannet (229.4 ± 124.3 km)	Foraging range of fulmar overlaps with Moray West Site. Gannet overlaps with Moray West site when 1 SD taken into account.
Rousay	104.2 / 119.8	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km)	Foraging range of fulmar overlaps with Moray West Site. Guillemot foraging range only overlaps when 1 SD is taken into account
Shiant Isles	182 / 182.1	Fulmar (400 ± 245.8 km)	Foraging range overlaps with Moray West Site.
Sule Skerry and Sule Stack	126.6 / 133.3	Gannet (229.4 ± 124.3 km)	Foraging ranges overlap with Moray West Site.
Sumburgh Head	201.8 / 217.1	Fulmar (400 ± 245.8 km)	Foraging range overlaps with Moray West Site.
Troup, Pennan and Lion's Heads	52.5 / 21	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km) Razorbill (48.5 ± 35 km) Herring gull (61.1 ± 44.0 km) Kittiwake (60 ± 23 km)	Foraging ranges overlap with Moray West Site.
West Westray	116.7 / 132.4	Fulmar (400 ± 245.8 km) Guillemot (84 ± 50.1 km)	Foraging range of fulmar overlaps with Moray West Site. Guillemot foraging range only overlaps when 1 SD is taken into account
Non-breeding			
Moray Firth	10.8 / 0.0	Scaup Eider Long-tailed duck	Offshore Export Cable Corridor located partly within Moray Firth pSPA

Table 4.1: Qualifying SPA Species with Foraging Ranges that Interact with the Moray West Site from Relevant Breeding Colonies			
(p)SPA	**Distance to the Moray West Site / Offshore Export Cable Corridor (km)**	**Qualifying Feature (foraging range[23])**	**Justification**
		Common scoter Velvet scoter Goldeneye Red-breasted merganser Red-throated diver Great northern diver Cormorant Shag Slavonian grebe	

A total of 26 (p)SPAs are potentially at risk of being affected by the Development during the breeding season (Table 4.1).

The Scottish Government has initiated formal consultation on a suite of 14 marine pSPAs including the Moray Firth pSPA. The Moray West Site is located approximately 10.7 km from the Moray Firth pSPA and the Offshore Export Cable Corridor is partly located within the pSPA. Therefore, the Moray Firth pSPA is potentially at risk of being affected by the Development during the non-breeding season.

In addition to the Moray Firth pSPA, there is predicted connectivity between four further pSPAs and the Moray West Site, these are the Outer Firth of Forth and St Andrews Bay Complex, Pentland Firth, Seas of Foula and the Seas off St Kilda (these are not shown in Figure 4.1). These pSPAs are located approximately 165.2 km, 38.2 km, 187.5 km and 259.5 km from the Moray West Site, respectively. As these sites relate to core foraging areas of seabirds from colony sites rather than breeding sites themselves, foraging range to Moray West Offshore Wind Farm is not a relevant tool to assume connectivity. Given that the Moray West Site is not immediately adjacent to any of these sites, and that all relevant seabird individuals are considered through assessment of their breeding colonies, there is considered to be no potential for connectivity.

During the non-breeding period, birds from colonies further afield may also be present within the Moray West Site, although there is significant uncertainty regarding how many individuals from each of the colonies will be affected by the Development. Details of how potential impacts are apportioned across colonies from within the region are provided in the supporting documents to the HRA for Development.

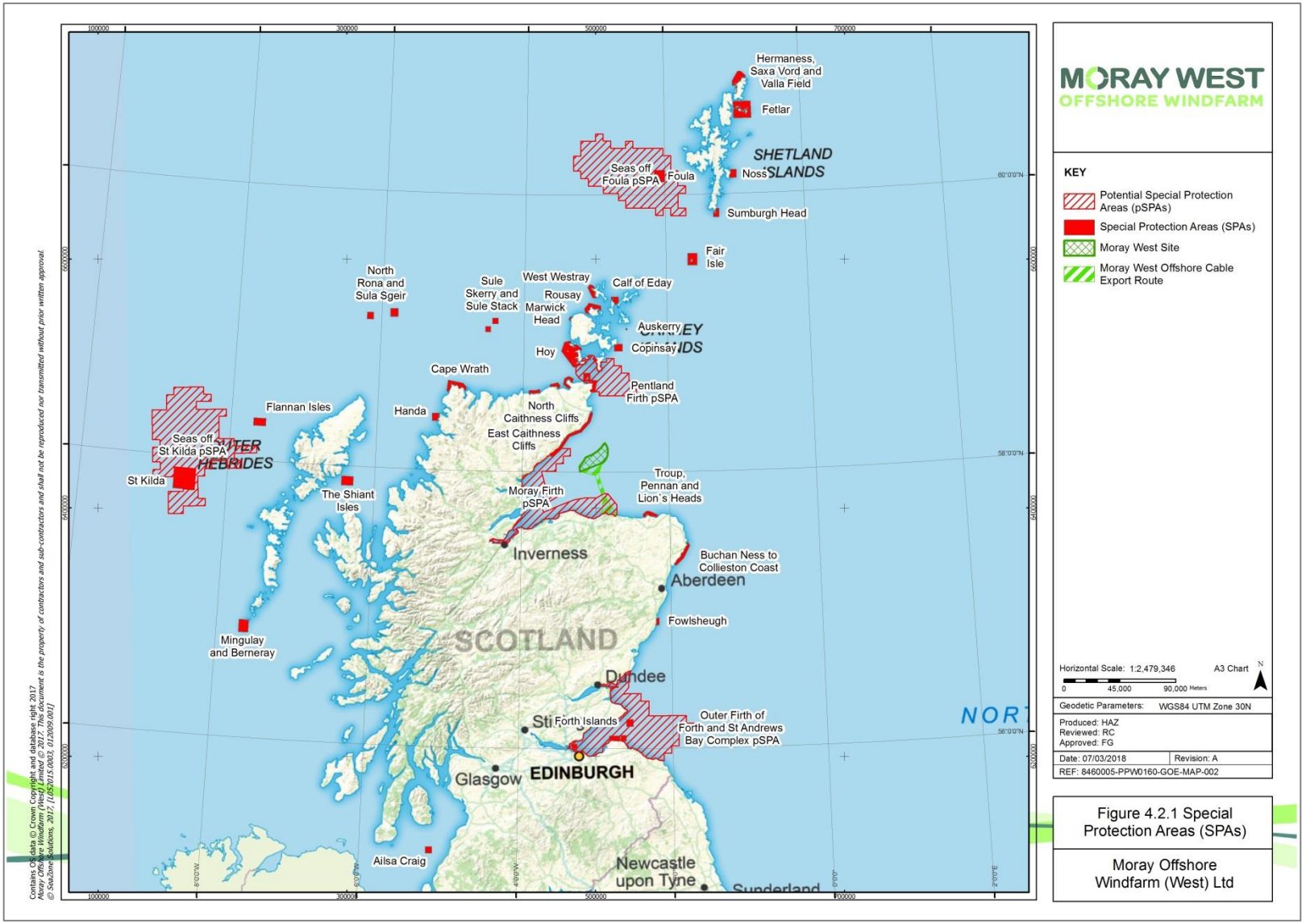


Figure 4.1: SPAs of relevance to offshore ornithological receptors in relation to the Moray West Site.

5 Species Accounts

5.1 Overview

The definition of offshore ornithology for the purposes of Chapter 10: Offshore Ornithology incorporates all birds that occur below MHWS. This therefore includes the coastal environment where the offshore export cable circuits will make landfall on the Aberdeenshire coast. Surveys of the intertidal habitat in the Landfall Area identified a narrow strip of cobble/shingle/sand which was considered to provide minimal opportunities for foraging and roosting by intertidal birds. As such, it was considered that local intertidal bird species populations will remain viable and sustainable and these are not considered for further assessment (Chartered Institute of Ecology and Environmental Management [CIEEM], 2016).

This section therefore includes species accounts for seabird species that may utilise the Development area. The waters of the outer Moray Firth and the nearshore waters off the Moray and Aberdeenshire coasts are important feeding areas for seabirds and seaduck (Tasker, 1996). Of the seabirds, fulmars are known to be widely distributed throughout the year, whilst gannet, kittiwake and auk numbers peak during the summer or autumn. The surrounding coastal waters are of particular year-round importance for shags and herring gulls (DTI, 2004; DECC, 2009).

The species accounts for species present in digital aerial surveys are presented below. Population estimates for the Moray West Site plus a 4 km buffer are used as a screening tool to identify those species which require further assessment within Chapter 10: Offshore Ornithology.

Species identified for further assessment are summarised in Section 1.7. For species along the Offshore Export Cable Corridor, the suite of species considered is based on those identified as part of the designation for the Moray Firth pSPA. Information relating to the abundance and distribution of these species has been obtained from the consultation supporting documents (SNH, 2017a).

To determine the need for further assessment, each species account also includes an overview of species population status, conservation status, sensitivity to impacts associated with offshore wind developments and the importance of populations estimated within the Moray West Site plus a 4 km buffer. All relevant qualifying features and assemblage features have been identified for all SPAs and pSPAs in Scotland.

For each SPA there are two legal documents (JNCC, 2017b); the citation and the Standard Data Form (SDF). The citation sets out the current legally protected features as entered into the Register of European sites by the Secretary of State. The SDF is a mechanism through which any proposed amendments to the citation by the Secretary of State can be communicated with the European Commission prior to a revised citation being entered into the Register of European sites. As a result there may be times where the species listed or the population estimates may differ between the citation and the SDF. A total of 32 differences have been identified between the citations and SDFs of SPAs relevant to the Moray West Site; these are highlighted in each species account where they occur. SNH, as the SNCB, have identified three SPA citations relevant to the Moray West Site that require updating; these are Loch of Strathbeg, Papa Westrey (North Hill and Holm) and Ythan Estuary, Sands of Forvie and Meikle Loch'.

Each species account section uses criteria associated with a species' conservation status and the importance of the estimated population within Moray West Site and a 4 km buffer to identify Valued Ornithological Receptors (Table 5.1). These selection criteria were informed by the Institute of Ecology and Environmental Management's guidance (IEEM, 2010) adapted to be relevant for the avifauna present at the Moray West Site.

Table 5.1: Definition of terms relating to the conservation value of ornithological receptors.	
Conservation Value	**Definition**
Negligible	Conservation status All species of lowest conservation status (e.g., Green-listed species listed on the Birds of Conservation Concern).
	Importance None
Local	Conservation status Any other species of conservation status (e.g., Amber-listed species listed on the Birds of Conservation Concern) not covered in the categories below.
	Importance A species which is present at the Moray West Site in numbers less than 1% of the regional population.
Regional	Conservation status Species listed on the Birds of Conservation Concern Red list; and/or Species that are the subject of a specific action plan within the UK or are listed as Species of Principal Importance in England (Section 41 of the NERC Act 2006).
	Importance A species which is present at the Moray West Site in numbers of greater than 1% of the regional population.
National	Conservation status Species listed on Schedule 1 of the Wildlife and Countryside Act 1981 (as amended) not already covered by International criteria; Species listed on Annex 1 of the EU Birds Directive; Bird species that form part of an SSSI that may potentially interact with Moray West Offshore Wind Farm at some stage of their life cycle; At least 50% of the UK breeding or non-breeding population found in ten or fewer sites; and/or An impact on an ecologically-sensitive species (<300 breeding pairs or <900 wintering individuals in the UK).
	Importance A species which is present at the Moray West Site in numbers of greater than 1% of the national population
International	Conservation status Bird species that form part of a cited interest of an SPA or Ramsar site that may potentially interact with Moray West Offshore Wind Farm at some stage of their life cycle including those listed as assemblage features; and/or At least 20% of the European breeding or non-breeding population is found in the UK.
	Importance A species which is present at the Moray West Site in numbers of greater than 1% of the international biogeographic population.

5.2 Scaup

5.2.1 Status Overview

Scaup is not listed under Annex I of the EU Birds Directive (2009/147/EEC) but as an occasional breeder in the UK it is listed on Schedule 1 (Part 1) of the Wildlife and Countryside Act 1981 (as amended). Scaup is currently red-listed on the UK Birds of Conservation Concern as a result of a non-breeding population decline over 25 years and the longer term (Eaton *et al.,* 2015).

An estimated 5,200 individuals winter in Britain (Musgrove *et al.,* 2013) where it is widespread around the coast although numbers are relatively small except in a few locations where significant concentrations are consistently present. Their diet consists predominantly of molluscs and in particular blue mussels (*Mytilus edulis*) obtained in waters less than four metres in depth (Cabot, 2009).

Wade *et al.* (2016) assessed scaup as being at very low risk of collision with turbines. However, the species is considered to be at high risk of displacement and high risk of habitat loss. Langston (2010) assessed scaup as being of moderate risk to barrier effects (Table 3.1).

Scaup is listed as a qualifying interest species for two SPAs and two pSPAs in the non-breeding season in Scotland (Table 5.2).

Table 5.2: SPAs cited for non-breeding scaup in Scotland. The Offshore Export Cable Corridor lies within those sites in bold.

SPA	Distance to the Offshore Export Cable Corridor (km)	SPA population (individuals)	
		Citation	Standard Data Form
Firth of Forth	156.4	437	437
Moray Firth pSPA	**0.0**	**930**	-
Solway Firth pSPA*	299.8	2,300	-
Upper Solway Flats and Marshes^	299.8	1,544	2,300

***Subsumes Upper Solway Flats and Marshes; ^Citation has been identified as requiring amendment (SNH, 2017b).**

5.2.2 Seasonal Abundance and Distribution

Scaup was not recorded on aerial surveys of the Moray West Site plus a 4 km buffer, however it is a qualifying feature of the Moray Firth pSPA for which the Offshore Export Cable Corridor passes through. An area of relatively low scaup density in the Moray Firth is likely to coincide with the area overlapped by the offshore export cable circuit routes.

5.2.3 Conclusion

Although absent from the aerial surveys of the Moray West Site, the Offshore Export Cable Corridor passes through the Moray Firth pSPA where scaup are likely to be present. Scaup is therefore identified as a Valued Ornithological Receptor and considered to be of international conservation value.

Although impacts from the Offshore Transmission Infrastructure (OfTI) components of Development are unlikely, applying the precautionary principle, scaup is considered for further assessment in the EIA and HRA in respect to the Offshore Export Cable Corridor only.

5.3 Eider

5.3.1 Status Overview

Eider is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 (Part 1) of the Wildlife and Countryside Act 1981 (as amended). Eider is however currently amber-listed on the UK Birds of Conservation Concern because of its threatened European conservation status (Eaton *et al.,* 2015).

Eider is the commonest breeding species of seaduck in the UK, with a mainly sedentary breeding population of around 27,000 pairs (Musgrove *et al.,* 2013). The British wintering population is estimated at 60,000 individuals (Musgrove *et al.,* 2013) and the 1% threshold for national importance is 550 birds (Frost *et al.,* 2017). Eiders are an inshore species, usually found within 10 km of the coast. Their diet consists predominantly of blue mussels, as well as sea urchins, starfish and other marine invertebrates (Forrester *et al.,* 2007).

Although distributed around the UK coastline in winter, the largest concentrations are found along the North Sea coast from Shetland to North Yorkshire, Argyllshire, the Firth of Clyde and Morecombe Bay as well as is northern parts of Ireland. Breeding is largely confined to Northern Britain and Northern Ireland.

Eider is listed as a qualifying interest species for two SPAs and seven pSPAs in the non-breeding season in Scotland (Table 5.3).

Table 5.3: SPAs cited for non-breeding eider in Scotland. Moray West Offshore Export Cable Corridor lies within those sites in bold.

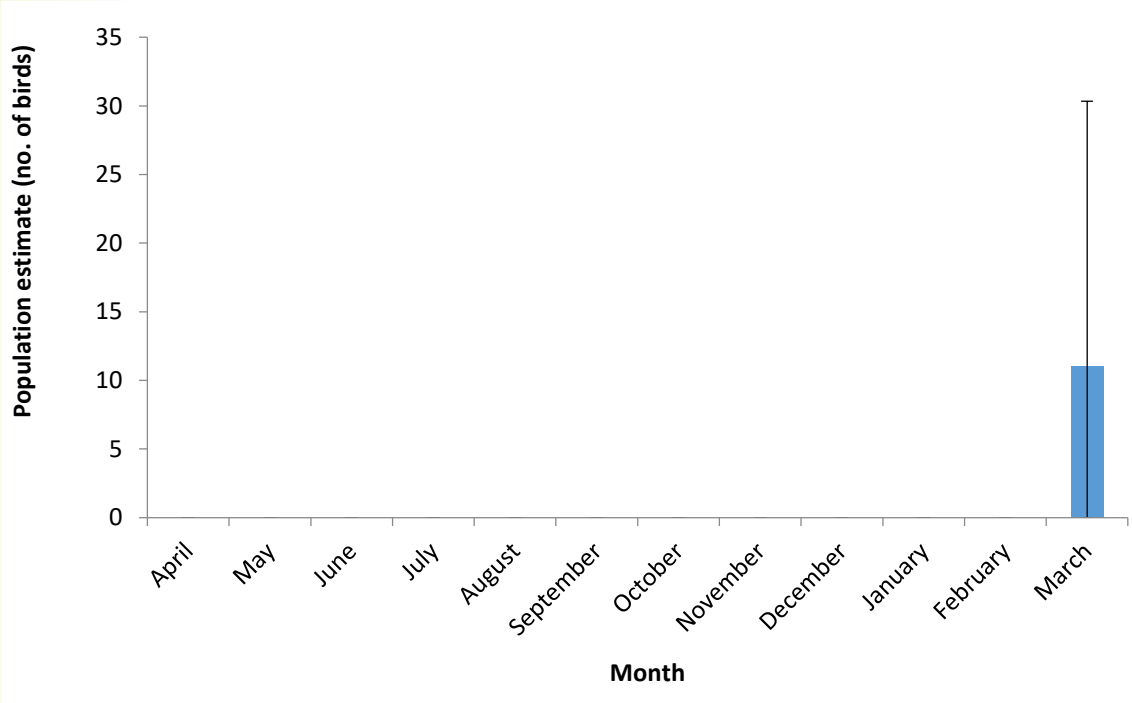
SPA	Distance to Offshore Export Cable Corridor (km)	SPA population (individuals)	
		Citation	Standard Data Form
Coll and Tiree pSPA	236.4	1,465	-
East Mainland Coast, Shetland pSPA*	253.5	242	?
Firth of Forth	156.4	9,400	9,400
Firth of Tay and Eden Estuary	132.8	13,800	13,800
Moray Firth pSPA	**0.0**	**1,733**	**-**
North Orkney pSPA	95.2	1,453	-
Outer Firth of Forth and St Andrews Bay Complex pSPA	124.7	21,546	-
Sound of Gigha pSPA	256.3	1,295	-
West Coast of the Outer Hebrides pSPA	213.4	5,074	-

*** Common eider *Somateria mollissima faeroeensis,* population only regularly found on Shetland.**

Wade *et al.* (2016) assessed eider as being at very low risk of displacement from wind farms although this is associated with a high degree of uncertainty. A similar conclusion was also drawn for collision with turbines due to a limited proportion of flights occurring at turbine height. Eider is considered to be at very low risk of habitat loss (Wade *et al.,* 2016) and low risk of barrier effects (Maclean *et al.,* 2009) (Table 3.1).

5.3.2 Seasonal Abundance and Distribution

Eider was recorded in one of the aerial surveys undertaken across the Moray West Site plus a 4 km buffer in the non-breeding season (Graph 5.1 and Table 5.4). Furthermore, the Offshore Export Cable Corridor passes through an area of the Moray Firth pSPA with moderate to low densities of eider in the non-breeding season (September–mid-April).



Graph 5.1: Population estimates of eider (with 95% confidence intervals) estimated from aerial surveys undertaken across the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.3.3 Behaviour

The single record involved birds flying in a south westerly direction.

Table 5.4: Monthly Population Estimates and Densities of Eider in the Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
June	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
July	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
August	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
September	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
March	11	0	11	30	0	0.02	0.00	0.02	0.05	0.00

5.3.4 Conclusion

The population of eider recorded during aerial surveys did not exceed the 1% threshold of the species' regional migratory BDMPS population in the northern North Sea. Therefore it is considered unlikely that significant impacts will occur on eider at the Moray West Site.

The Offshore Export Cable Corridor passes through the Moray Firth pSPA where eider are likely to be present. Eider is therefore identified as a Valued Ornithological Receptor and considered to be of international conservation value.

Although impacts from the OfTI components of the Development are unlikely, applying the precautionary principle, eider is considered for further assessment in the EIA and HRA in respect to the Offshore Export Cable Corridor only.

5.4 Long-tailed Duck

5.4.1 Status Overview

Long-tailed duck is not listed under Annex I of the EU Birds Directive (2009/147/EEC) but as a potential breeder in the UK it is listed on Schedule 1 (Part 1) of the Wildlife and Countryside Act 1981 (as amended). Long-tailed duck is currently red-listed on the UK Birds of Conservation Concern as a result of its threatened global status (Eaton *et al.,* 2015).

The UK population is estimated at 11,000 individuals with the 1% threshold for national importance being 110 birds. Long-tailed duck distribution is concentrated around Orkney and the Moray Firth between November and May (Stone *et al.,* 1995). Their diet consists predominantly of molluscs and crustaceans obtained by diving to at least 5–15 metres in depth (Cabot, 2009).

Wade *et al.* (2016) assessed long-tailed duck as being at low risk of collision with turbines. However, the species is considered to be at high risk of displacement and high risk of habitat loss. Langston (2010) assessed long-tailed duck as being of moderate risk to barrier effects (Table 3.1).

Long-tailed duck is listed as a qualifying interest species for two SPAs and six pSPAs in the non-breeding season in Scotland (Table 5.5).

Table 5.5: SPAs cited for non-breeding long-tailed duck in Scotland. The Offshore Export Cable Corridor lies within those sites in bold.

SPA	Distance to the Offshore Export Cable Corridor (km)	SPA population (individuals)	
		Citation	Standard Data Form
Firth of Forth	156.4	1,045	1,045
Firth of Tay and Eden Estuary	132.8	560	560
East Mainland Coast, Shetland pSPA	253.5	162	-
Moray Firth pSPA	**0.0**	**5,001**	**-**
North Orkney pSPA	95.2	937	-
Outer Firth of Forth and St Andrews Bay Complex pSPA	124.7	1,948	-
Scapa Flow pSPA	55.2	1,393	-

Table 5.5: SPAs cited for non-breeding long-tailed duck in Scotland. The Offshore Export Cable Corridor lies within those sites in bold.

SPA	Distance to the Offshore Export Cable Corridor (km)	SPA population (individuals)	
		Citation	Standard Data Form
West Coast of the Outer Hebrides pSPA	213.4	821	-

5.4.2 Seasonal Abundance and Distribution

Long-tailed duck was not recorded on aerial surveys however it is a qualifying feature of the Moray Firth pSPA for which the Offshore Export Cable Corridor passes through. An area of relatively low long-tailed duck density in the Moray Firth is likely to coincide with the area overlapped by the Offshore Export Cable Corridor.

5.4.3 Conclusion

Although absent from the aerial surveys of the Moray West Site, the Offshore Export Cable Corridor passes through the Moray Firth pSPA where long-tailed duck are likely to be present. Long-tailed duck is therefore identified as a Valued Ornithological Receptor and considered to be of international conservation value.

Although impacts from the OfTI components of the Development are unlikely, applying the precautionary principle, long-tailed duck is considered for further assessment in the EIA and HRA in respect to the Offshore Export Cable Corridor only.

5.5 Common Scoter

5.5.1 Status Overview

Common scoter is not listed under Annex I of the EU Birds Directive (2009/147/EEC) but as a rare breeder in the UK it is listed on Schedule 1 (Part 1) of the Wildlife and Countryside Act 1981 (as amended). Common scoter is currently red-listed on the UK Birds of Conservation Concern as a result of declines in breeding status and meeting the amber list criteria for its localised non-breeding distribution (Eaton *et al.,* 2015).

The majority of the UK wintering population of common scoter is concentrated in a few large flocks off the mouths of major estuaries around the UK coast. A review of numbers for the UK and survey work at key sites suggested that the number of wintering common scoter is likely to be in the region of 100,000 birds (Musgrove *et al.,* 2011).

Wade *et al.* (2016) assessed common scoter as being at low risk of collision with turbines. However, the species is considered to be at very high risk of displacement and high risk of habitat loss. Maclean *et al.* (2009) assessed common scoter as being of moderate risk to barrier effects (Table 3.1).

Common scoter is listed as a qualifying interest species for four SPAs and two pSPAs in the non-breeding season in Scotland (Table 5.6).

Table 5.6: SPAs cited for non-breeding common scoter in Scotland. Offshore Export Cable Corridor lies within those sites in bold.			
SPA	**Distance to Offshore Export Cable Corridor (km)**	**SPA population (individuals)**	
		Citation	**Standard Data Form**
Firth of Forth	156.4	2,880	2.880
Firth of Tay and Eden Estuary	132.8	3,100	3,100
Moray Firth pSPA	**0.0**	**5,479**	**-**
Outer Firth of Forth and St Andrews Bay Complex pSPA	124.7	4,677	-
Solway Firth pSPA	299.8	1.588	-

5.5.2 Seasonal Abundance and Distribution

Common scoter was not recorded on aerial surveys however it is a qualifying feature of the Moray Firth pSPA for which the Offshore Export Cable Corridor passes through. An area of relatively low common scoter density in the Moray Firth is likely to coincide with the area overlapped by the Offshore Export Cable Corridor.

5.5.3 Conclusion

Although absent from the aerial surveys of the Moray West Site, the Offshore Export Cable Corridor passes through the Moray Firth pSPA where common scoter are likely to be present. Common scoter is therefore identified as a Valued Ornithological Receptor and considered to be of international conservation value.

Although impacts from the OfTI components of the Development are unlikely, applying the precautionary principle, common scoter is considered for further assessment in the EIA and HRA in respect to the Offshore Export Cable Corridor.

5.6 Velvet Scoter

5.6.1 Status Overview

Velvet scoter is not listed under Annex I of the EU Birds Directive (2009/147/EEC) but as a potential breeder in the UK it is listed on Schedule 1 (Part 1) of the Wildlife and Countryside Act 1981 (as amended). Velvet scoter is currently red-listed on the UK Birds of Conservation Concern as a result of its globally threatened status and meeting the amber list criteria for its localised non-breeding distribution (Eaton *et al.,* 2015).

Approximately 2,500 individuals winter in the UK (Musgrove *et al.,* 2013) where they are widespread around the UK coast with the majority in eastern mainland Scotland, particularly the Moray Firth, as well as Orkney.

Wade *et al.* (2016) assessed velvet scoter as being at low risk of collision with turbines. However, the species is considered to be at very high risk of displacement and moderate risk of habitat loss. Langston (2010) assessed velvet scoter as being of moderate risk to barrier effects (Table 3.1).

Velvet scoter is listed as a qualifying interest species for two SPAs and three pSPAs in the non-breeding season in Scotland (Table 5.7).

Table 5.7: SPAs cited for non-breeding velvet scoter in Scotland. Offshore Export Cable Corridor lies within those sites in bold.

SPA	Distance to Offshore Export Cable Corridor (km)	SPA population (individuals)	
		Citation	Standard Data Form
Firth of Forth	156.4	635	635
Firth of Tay and Eden Estuary	132.8	730	730
Moray Firth pSPA	**0.0**	**1,488**	**-**
North Orkney pSPA	95.2	147	-
Outer Firth of Forth and St Andrews Bay Complex pSPA	124.7	775	-

5.6.2 Seasonal Abundance and Distribution

Velvet scoter was not recorded on aerial surveys however it is a qualifying feature of the Moray Firth pSPA for which the Offshore Export Cable Corridor passes through. An area of relatively low velvet scoter density in the Moray Firth is likely to coincide with the area overlapped by the Offshore Export Cable Corridor (SNH, 2016).

5.6.3 Conclusion

Although absent from the aerial surveys of the Moray West Site, the Offshore Export Cable Corridor passes through the Moray Firth pSPA where velvet scoter are likely to be present. Velvet scoter is therefore identified as a Valued Ornithological Receptor and considered to be of international conservation value.

Although impacts from the OfTI components of the Development are unlikely, applying the precautionary principle, velvet scoter is considered for further assessment in the EIA and HRA in respect to the Offshore Export Cable Corridor only.

5.7 Goldeneye

5.7.1 Status Overview

Goldeneye is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 (Part 1) of the Wildlife and Countryside Act 1981 (as amended). Goldeneye is currently amber-listed on the UK Birds of Conservation Concern as a result of its localised breeding distribution (Eaton *et al.,* 2015).

Goldeneye is widely distributed in the non-breeding season on both freshwater and marine sites in the UK with an estimated population of 27,000 individuals (Musgrove *et al.,* 2013). The UK distribution is largely concentrated in the north — on or around the east coast of Scotland, notably the Moray Firth, as well as around Orkney (SNH, 2016).

Wade *et al.* (2016) assessed goldeneye as being at low risk of collision with turbines. However, the species is considered to be at high risk of displacement and high risk of habitat loss. Langston (2010) assessed goldeneye as being of moderate risk to barrier effects (Table 3.1).

Goldeneye is listed as a qualifying interest species for four pSPAs in the non-breeding season in Scotland (Table 5.8).

Table 5.8: SPAs cited for non-breeding goldeneye in Scotland. Offshore Export Cable Corridor lies within those sites in bold.

SPA	Distance to Offshore Export Cable Corridor (km)	SPA population (individuals)	
		Citation	Standard Data Form
Moray Firth pSPA	**0.0**	**907**	**-**
Outer Firth of Forth and St Andrews Bay Complex pSPA	124.7	589	-
Scapa Flow pSPA	55.2	219	-
Solway Firth pSPA	299.8	300	-

5.7.2 Seasonal Abundance and Distribution

Goldeneye was not recorded on aerial surveys however it is a qualifying feature of the Moray Firth pSPA for which the Offshore Export Cable Corridor passes through. An area of relatively low goldeneye density in the Moray Firth is likely to coincide with the area overlapped by the Offshore Export Cable Corridor (SNH, 2016).

5.7.3 Conclusion

Although absent from the aerial surveys of the Moray West Site, the Offshore Export Cable Corridor passes through the Moray Firth pSPA where goldeneye are likely to be present. Goldeneye is therefore identified as a Valued Ornithological Receptor and considered to be of international conservation value.

Although impacts from the OfTI components of the Development are unlikely, applying the precautionary principle, goldeneye is considered for further assessment in the EIA and HRA in respect to the Offshore Export Cable Corridor only.

5.8 Red-breasted Merganser

5.8.1 Status Overview

Red-breasted merganser is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 (Part 1) of the Wildlife and Countryside Act 1981 (as amended) and is currently green-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

Approximately 2,600 pairs breed in the UK, mainly in north and west Scotland (Forrester *et al.,* 2007), with 9,000 individuals wintering (Musgrove *et al.,* 2013). It is widely distributed at low density around the coastal waters of the UK in the non-breeding season (Stone *et al.,* 2016) with concentrations close inshore (SNH, 2016).

Bradbury *et al.* (2014) assessed red-breasted merganser as being at low risk of collision with turbines but at high risk of habitat loss. However, the species is considered to be at moderate risk of displacement and Langston (2010) assessed red-breasted merganser as being of moderate risk to barrier effects (Table 3.1).

Red-breasted merganser is listed as a qualifying interest species for two SPAs and seven pSPAs in the non-breeding season in Scotland (Table 5.9).

Table 5.9: SPAs cited for non-breeding red-breasted merganser in Scotland. Offshore Export Cable Corridor lies within those sites in bold.

SPA	Distance to Offshore Export Cable Corridor (km)	SPA population (individuals)	
		Citation	Standard Data Form
Firth of Forth	156.4	670	670
Inner Moray Firth*	61.9	1,184	1,184
East Mainland Coast, Shetland pSPA	253.5	234	-
Moray Firth pSPA	**0.0**	**907**	**-**
North Orkney pSPA	95.2	344	-
Outer Firth of Forth and St Andrews Bay Complex pSPA	124.7	369	-
Scapa Flow pSPA	55.2	539	-
Sound of Gigha pSPA	256.3	117	-
West Coast of the Outer Hebrides pSPA	213.4	239	-

*** Citation has been identified as requiring amendment (SNH, 2017b)**

5.8.2 Seasonal Abundance and Distribution

Red-breasted merganser was not recorded on aerial surveys however it is a qualifying feature of the Moray Firth pSPA for which the Offshore Export Cable Corridor passes through. An area of relatively low red-breasted merganser density in the Moray Firth is likely to coincide with the area overlapped by the Offshore Export Cable Corridor (SNH, 2016).

5.8.3 Conclusion

Although absent from the aerial surveys of the Moray West Site, the Offshore Export Cable Corridor passes through the Moray Firth pSPA where red-breasted merganser are likely to be present. Red-breasted merganser is therefore identified as a Valued Ornithological Receptor and considered to be of international conservation value.

Although impacts from the OfTI components of the Development are unlikely, applying the precautionary principle, red-breasted merganser is considered for further assessment in the EIA and HRA in respect to the Offshore Export Cable Corridor only.

5.9 Red-throated Diver

5.9.1 Status Overview

Red-throated diver is listed on Annex I of the EU Birds Directive (2009/147/EEC) and Schedule 1 of the Wildlife and Countryside Act. The species is currently green-listed on the UK Birds of Conservation Concern list (Eaton *et al.,* 2015).

An estimated 1,300 pairs of red-throated diver breed in Britain, with the majority of pairs found in the north and west of Scotland (Musgrove *et al.,* 2013; Balmer *et al.,* 2013). The wintering population around Britain has been estimated at 17,000 individuals (O'Brien *et al.,* 2008). Wintering red-throated divers show a preference for sheltered shallow waters and sandy bays along North Sea coasts with significant

concentrations in the north on the Solway on the west coast and the Forth/Tay and the Moray Firth on the east (SNH, 2016). Numbers may however fluctuate widely in response to weather and other factors affecting the supply of prey species such as sandeels, crustaceans and small fish (Lack, 1986).

Wade *et al.* (2016) assessed red-throated divers as being at very high risk of displacement from offshore wind farms, and there is published evidence from some offshore wind farm studies to support this (e.g., Petersen, 2005; Barton *et al.,* 2008). Red-throated diver has also been assessed as being at high risk of barrier effects (Maclean *et al.,* 2009) and habitat loss, and at moderate risk of collision with turbines (Wade *et al.,* 2016) (Table 3.1).

Red-throated diver is listed as a qualifying interest species in the non-breeding season for one SPA and three pSPAs (Table 5.10).

Table 5.10: SPAs cited for non-breeding red-throated diver in Scotland. Offshore Export Cable Corridor lies within those sites in bold.

SPA	Distance to Offshore Export Cable Corridor (km)	SPA population (individuals)	
		Citation	Standard Data Form
Firth of Forth	156.4	90	90
Moray Firth pSPA	**0.0**	**324**	**-**
Outer Firth of Forth and St Andrews Bay Complex pSPA	124.7	851	-
Solway Firth pSPA	299.8	521	-

5.9.2 Seasonal Abundance and Distribution

Red-throated diver was not recorded on aerial surveys however it is a qualifying feature of the Moray Firth pSPA for which the Offshore Export Cable Corridor passes through. An area of relatively moderate to low red-throated diver density in the Moray Firth area is likely to coincide with the area overlapped by the Offshore Export Cable Corridor (SNH, 2016).

5.9.3 Conclusion

Although absent from the aerial surveys of the Moray West Site, the Offshore Export Cable Corridor passes through the Moray Firth pSPA where red-throated diver are likely to be present. Red-throated diver is therefore identified as a Valued Ornithological Receptor and considered to be of international conservation value.

Although impacts from the OfTI components of the Development are unlikely, applying the precautionary principle, red-throated diver is considered for further assessment in the EIA and HRA in respect to the Offshore Export Cable Corridor only.

5.10 Great Northern Diver

5.10.1 Status Overview

Great northern diver is listed under Annex I of the EU Birds Directive (2009/147/EEC) and Schedule 1 (Part 1) of the Wildlife and Countryside Act 1981 (as amended). Great northern diver is also currently amber-listed on the UK Birds of Conservation Concern because of its threatened European conservation status and the international importance of the UK winter population (Eaton *et al.,* 2015).

Approximately 2,600 individuals winter in the UK (Musgrove *et al.,* 2013) when its distribution shifts southward from their subarctic breeding grounds to include inshore UK waters. It is widely distributed with the majority of UK birds concentrated in north and west Scotland, particularly off Orkney, Shetland and the Outer Hebrides (Natural England, 2012).

Great northern diver is usually found within 10 km of the coast. Their diet consists predominantly of fish, as well as crustaceans and molluscs (Snow & Perrins, 2006).

Great northern diver is listed as a qualifying interest species for six pSPAs in the non-breeding season in Scotland (Table 5.11).

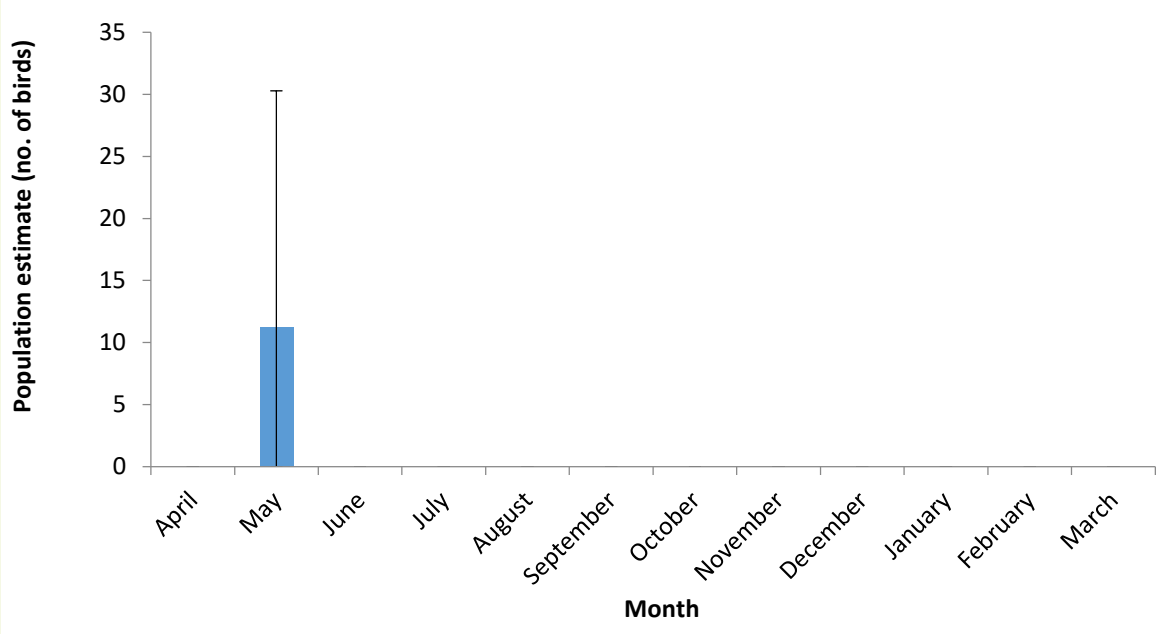
Table 5.11: SPAs cited for non-breeding great northern diver in Scotland. Moray West Site lies within those sites in bold.

SPA	Distance to Offshore Export Cable Corridor (km)	SPA population (individuals)	
		Citation	Standard Data Form
Coll and Tiree pSPA	236.4	450	-
East Mainland Coast, Shetland pSPA	253.5	182	-
Moray Firth pSPA	**0.0**	**144**	**-**
North Orkney pSPA	95.2	310	-
Sound of Gigha pSPA	256.3	505	-
West Coast of the Outer Hebrides pSPA	213.4	1,298	-

Wade *et al.,* (2016) assessed great northern diver as being at very high risk of displacement from wind farms although this is associated with a very high degree of uncertainty. For collision with turbines, habitat loss (Wade *et al.,* 2016) and barrier effects (Maclean *et al.,* 2009) great northern diver is considered to be at moderate risk (Table 3.1).

5.10.2 Seasonal Abundance and Distribution

Great northern diver was recorded in one of the aerial surveys undertaken across the Moray West Site plus a 4 km buffer in the non-breeding season (October–May) (Graph 5.1and Table 5.12). The single record involved birds sitting on water.



Graph 5.2: Population estimates of great northern diver (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017

Table 5.12: Monthly population estimates and densities of great northern diver in the Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	0	11	11	30	0	0.00	0.02	0.02	0.05	0.00
June	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
July	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
August	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
September	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

5.10.3 Conclusion

The population of great northern diver recorded at the Moray West Site during aerial surveys did not exceed the 1% threshold of the species' regional migratory BDMPS population in the northern North Sea. It is unlikely therefore that significant impacts will occur on great northern diver at the Moray West Site.

The Offshore Export Cable Corridor passes through the Moray Firth pSPA where great northern diver are likely to be present. Great northern diver is therefore identified as a Valued Ornithological Receptor and considered to be of international conservation value.

Although impacts from the OfTI components of the Development are unlikely, applying the precautionary principle, great northern diver is considered for further assessment in the EIA and HRA in respect to the Offshore Export Cable Corridor only.

5.11 Storm Petrel

5.11.1 Status Overview

Storm petrel is listed on Annex I of the EU Birds Directive, and the species is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al.,* 2015).

Storm petrels breed at a few colonies around the UK, primarily on Shetland, Orkney, the Western Isles and the west coast of Scotland, as well as on islands off the Welsh coast, Isles of Scilly and the Channel Islands. Seabird 2000 estimated the UK breeding population to be 25,710 pairs, however outside of Orkney and Shetland, there are no breeding colonies on the east coast of Britain (Mitchell *et al.,* 2004; Balmer *et al.,* 2013). After the breeding season, birds migrate south and spend the winter off the coast of southern Africa.

Storm petrel is listed as a qualifying interest species in the breeding season for seven SPAs and one pSPA in Scotland (Table 5.13).

Table 5.13: SPAs cited for breeding storm petrel in Scotland. Moray West Site lies within the mean-maximum foraging range[24] of storm petrel from those sites in bold

SPA	Distance to Moray West Site (km)	SPA population (pairs)	
		Citation	Standard Data Form
Auskerry	92.7	3,600	3,600
Mousa	220.9	4,750	6,760
North Rona and Sula Sgeir	188.7	>1% GB breeding pop$^{n.}$	1,000
Priest Island*	134.9	10,000	2,200
Seas off St Kilda pSPA	259.5	954 birds	-
St Kilda	308.7	850	850
Sule Skerry and Sule Stack	126.6	500–5,000	500
Treshnish Isles	252.1	2,000	5,040

*** Citation has been identified as requiring amendment (SNH, 2017b)**

[24] No mean-maximum foraging range for storm petrel is detailed in Thaxter *et al.* (2012). However, the maximum foraging range is given as >65 km.

Wade *et al.* (2016) assessed storm petrel as being at very low risk of displacement from wind farms and habitat loss. The species is also considered to be at low risk of collision with turbines and although no assessment has been made of the species sensitivity to barrier effects within Maclean *et al.* (2009) or Langston (2010) barrier effects are not considered to be an issue for this species due to its pelagic nature (Table 3.1).

5.11.2 Seasonal Abundance and Distribution

Storm petrel was not recorded on aerial surveys however it is a qualifying feature of Auskerry SPA which is within the mean maximum foraging range of the Moray West Site (Thaxter *et al.,* 2012).

5.11.3 Conclusion

Storm petrel is not considered to be a Valued Ornithological Receptor because of its absence from the aerial surveys. This species is therefore not considered for further assessment for impacts associated with the Development.

5.12 Fulmar

5.12.1 Status Overview

Fulmar is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). Fulmar is however currently amber-listed on the UK Birds of Conservation Concern because of its threatened European conservation status and its localised breeding distribution (Eaton *et al.,* 2015).

Fulmar numbers and distribution around the UK have increased considerably since the mid-19th century (Pennington *et al.,* 2004). The species is one of the most common seabirds in Britain, with an estimated breeding population of 499,081 pairs (Mitchell *et al.,* 2004), although since Seabird 2000 when the UK breeding population was last estimated, the population is predicted to have decreased by 31% (JNCC, 2016). The largest breeding colonies are located off the north and west coasts of Scotland with birds often present at these colonies outside of the breeding season.

Stone *et al.* (1995) describe the densities for fulmar in the North Sea as being low to moderate except for high densities of in the Moray Firth (December to February), the continental shelf edge north and west of Scotland (March to April), Shetland (March to April and August to November), Orkney (August to November) and north Scotland (August to November). High densities are also known from the western and southern edges of the Norwegian Trench (May to July) and moderate to high densities can be found in Dogger Bank (May to July).

Fulmars forage at sea over a wide area in search of small fish (sandeels), crustaceans and squid. They also scavenge extensively around fishing vessels, with offal and fish discards from trawlers now forming a major part of their diet (Phillips *et al.,* 2009).

Fulmar is listed as a qualifying interest species for 24 SPAs in the breeding season in Scotland (Table 5.14). Fulmar is a proposed qualifying interest species for two pSPAs in the breeding season in Scotland.

Table 5.14: SPAs cited for breeding fulmar in Scotland. Moray West Site lies within the mean-maximum foraging range of fulmar (400 km) from those sites in bold.

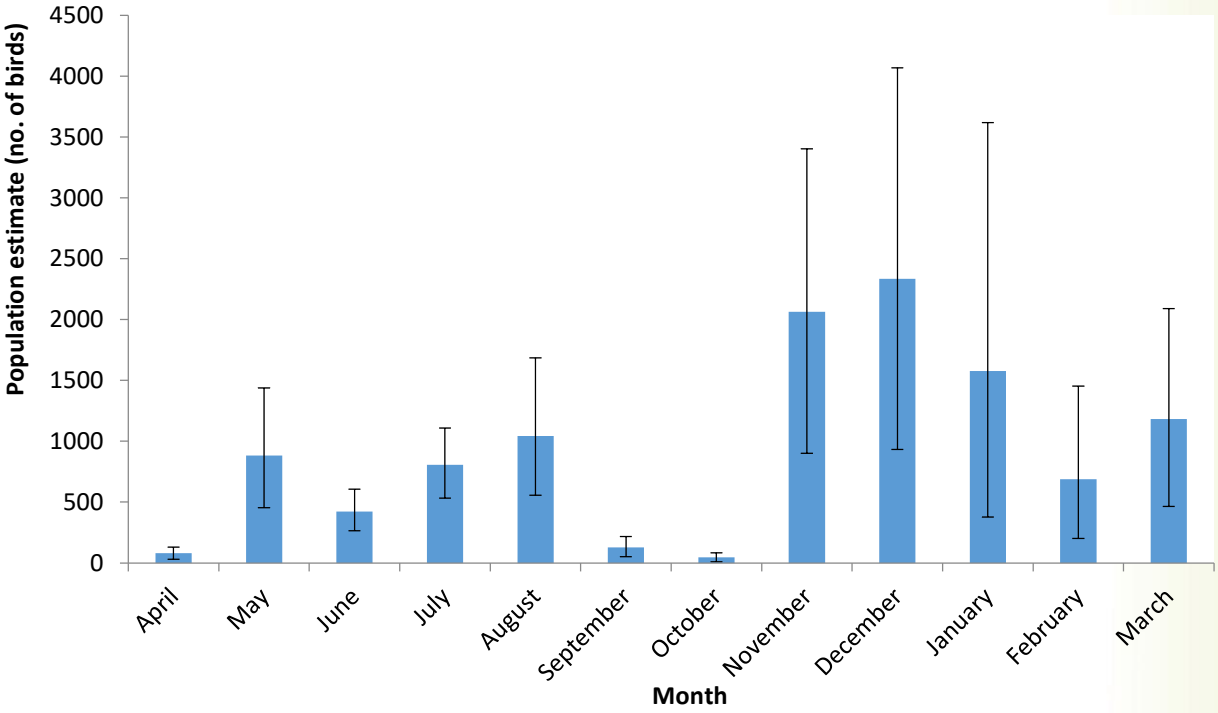
SPA	Distance to Moray West Site (km)[25]	SPA population (pairs)	
		Citation	Standard Data Form
Buchan Ness to Collieston Coast	**92.7**	**1,765**	**1,765**
Calf of Eday	**111.7**	**1,955**	**1,955**
Cape Wrath	**110.3**	**2,300**	**2,300**
Copinsay	**74.3**	**1,615**	**1,615**
East Caithness Cliffs	**19.9**	**15,000**	**15,000**
Fair Isle	**157.8**	**35,210**	**43,320**
Fetlar	**281.2**	**9,500**	**9,800**
Flannan Isles	254.6	4,730	4,730
Forth Islands	**202.9**	**798**	**798**
Foula	**213.5**	**46, 800**	**46,800**
Fowlsheugh	**132.0**	**1,170**	**1,170**
Handa	**118.9**	**3,500**	**3,500**
Hermaness, Saxa Vord and Valla Field	**300.2**	**19,539**	**19,539**
Hoy	**64.9**	**35,000**	**35,000**
Mingulay and Berneray	291.7	10,450	12,500
North Caithness Cliffs	**41.6**	**14,700**	**16,310**
North Rona and Sula Sgeir	188.7	11,500	11,500
Noss	**235.8**	**6,350**	**5,870**
Rousay	**104.2**	**1,240**	**1,240**
Seas off Foula pSPA	**187.5**	**8,379 individuals**	**-**
Seas off St Kilda pSPA	259.5	3,310 individuals	-
Shiant Isles	182.0	6,820	6,820
St Kilda	308.7	62,800	62,800
Sumburgh Head	**201.8**	**2,542**	**2,542**
Troup, Pennan and Lion's Heads	**52.5**	**4,400**	**4,400**
West Westray	**116.7**	**1,400**	**1,400**

[25] Distance from SPAs to the Moray West Site is given as a direct line which may be over land. Those SPAs that are considered to represent an at sea distance of over 400 km from the Moray West Site (e.g. those in the Western Isles) are not therefore highlighted in bold.

Wade *et al.,* (2016) assessed fulmar as being at very low risk of displacement from wind farms although this is associated with a high degree of uncertainty. A similar conclusion was also drawn for collision with turbines due to a limited proportion of flights occurring at turbine height. Fulmar is considered to be at very low risk of habitat loss (Wade *et al.,* 2016) and low risk of barrier effects (Maclean *et al.,* 2009) (Table 3.1).

5.12.2 Seasonal Abundance and Distribution

Fulmars were recorded in all twelve of the aerial surveys undertaken across the Moray West Site plus 4 km buffer (Graph 5.3 and Table 5.16). There are two periods of higher population estimates (May to August and November to March) separated by two periods of relatively low population estimates (April and September to October).



Graph 5.3: Population estimates of fulmar (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.12.3 Behaviour

The majority of the records were of birds siting on the water in the pre-breeding and breeding seasons (Table 5.15). Cumulatively, flights with an easterly bias predominated in all seasons with a south westerly flight direction the most frequent single direction in the breeding season (April–mid-August) (Figure 5.1: Fulmar flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017. and Table 5.15).

Table 5.15: Fulmar behaviour recorded from aerial surveys over Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	9	38	36	25	10	12	11	16	0	525	0	1	0	0
Breeding	7	29	26	15	7	30	16	7	0	259	0	1	0	0
Post-breeding	1	3	0	0	1	1	4	0	0	6	0	0	0	0
Non-breeding	6	29	56	21	14	10	11	5	0	52	0	0	0	0

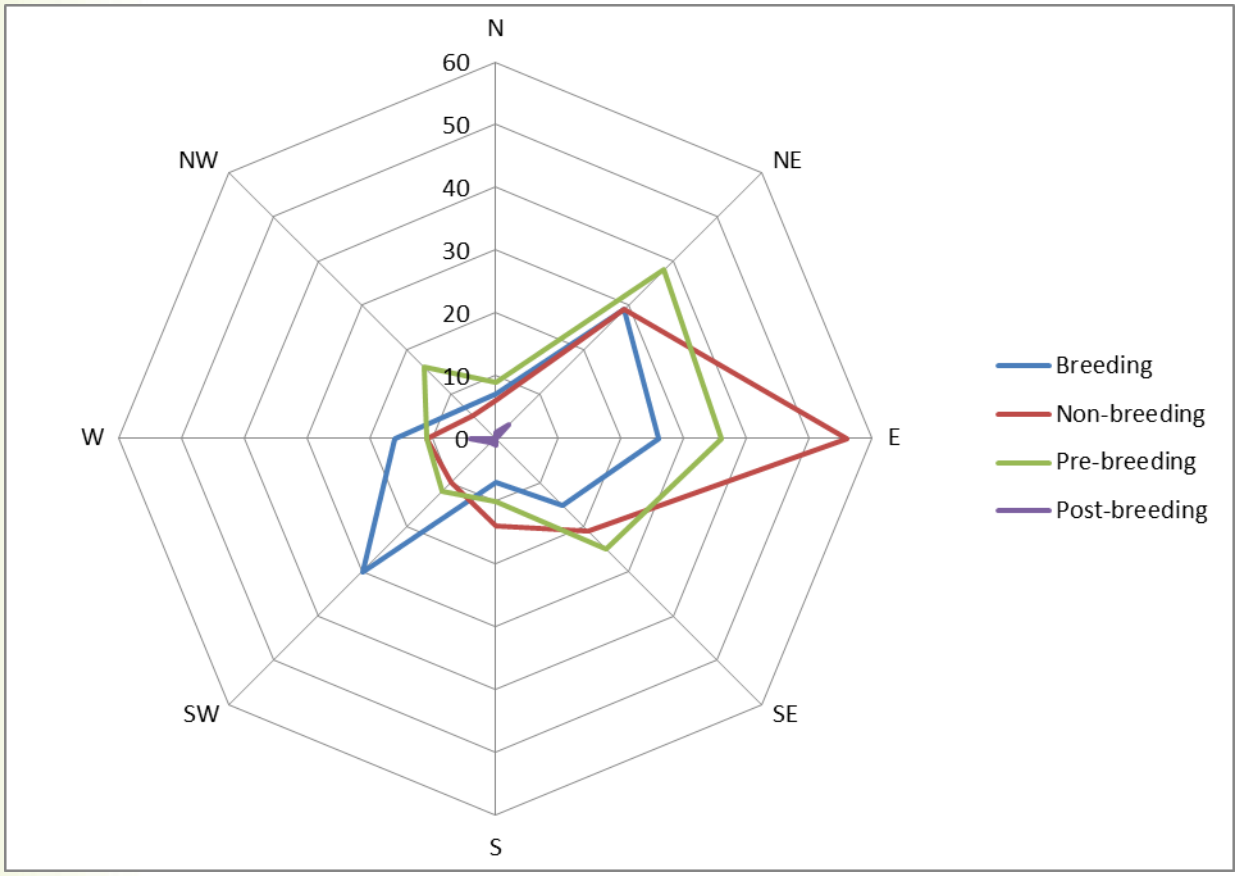


Figure 5.1: Fulmar flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

Table 5.16: Monthly population estimates and densities of fulmar in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	79	0	79	131	30	0.14	0.00	0.14	0.24	0.05
May	259	624	884	1,437	454	0.47	1.13	1.59	2.59	0.82
June	181	242	423	606	265	0.33	0.44	0.76	1.09	0.48
July	326	474	806	1,108	533	0.59	0.85	1.45	2.00	0.96
August	290	754	1,042	1,686	557	0.52	1.36	1.88	3.04	1.00
September	92	35	127	218	52	0.16	0.06	0.23	0.39	0.09
October	22	27	46	83	10	0.04	0.05	0.08	0.15	0.02
November	1,477	580	2,064	3,403	900	2.66	1.04	3.72	6.13	1.62
December	451	1,871	2,336	4,068	934	0.81	3.37	4.21	7.33	1.68
January	352	1,227	1,578	3,618	377	0.63	2.21	2.84	6.52	0.68
February	225	465	688	1,453	203	0.41	0.84	1.24	2.62	0.37
March	516	655	1,182	2,089	465	0.93	1.18	2.13	3.76	0.84

5.12.4 Conclusion

The population estimates of fulmar in the Moray West Site plus a 4 km buffer in the breeding season for April, May, July and August exceed the 1% threshold of the regional population. The 1% thresholds of the national and international populations for fulmar are not surpassed in any month.

Based on the presence of an important population, fulmar is identified as a Valued Ornithological Receptor and considered for further assessment in the EIA as a species with regional importance and international conservation value.

The mean-maximum foraging range of fulmar (Thaxter *et al.,* 2012) from a number of SPA breeding colonies overlaps with the Moray West Site plus a 4 km buffer. Based on the potential SPA connectivity and the inclusion of fulmar in the Moray East HRA, fulmar is included in the Moray West Offshore Wind Farm HRA.

5.13 Sooty Shearwater

5.13.1 Status Overview

Sooty shearwater is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). Having undergone a moderately rapid decline, sooty shearwater is globally near threatened (BirdLife International, 2017) but currently green-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

Sooty shearwater only occurs in significant numbers in European waters before its migration to its southern hemisphere breeding grounds from August to October (BirdLife International, 2004). They forage inshore and at sea in search of squid, crustaceans and small fish.

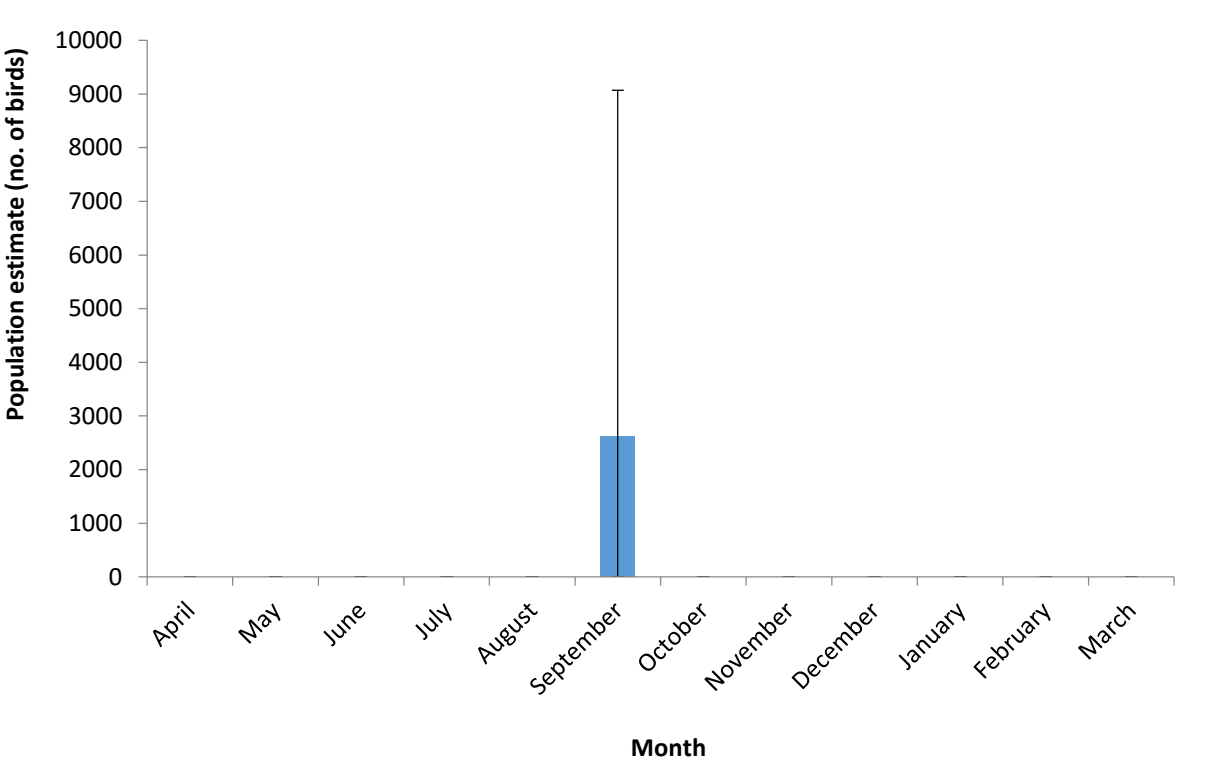
Stone *et al.* (1995) describe sooty shearwater as a widespread species in the North Sea, generally at low densities but occurring less frequently in the south. The highest densities occur in the Minch (July to August), the west coast of Ireland, Caithness and Orkney (July to August). Moderate densities occur around Rockall Bank, the west coast of Ireland, around continental shelf north and west of Scotland, Shetland, the Moray Firth and northeast England (July to August).

Sooty shearwater is not a qualifying interest species for any SPA in the UK.

Wade *et al.,* (2016) assessed sooty shearwater as being at very low risk of displacement from wind farms collision with turbines and habitat loss (Wade *et al.,* 2016). There is no evidence, either way, regarding the potential for barrier effects (Table 3.1).

5.13.2 Seasonal Abundance and Distribution

Sooty shearwater were recorded in one of the aerial surveys (September) undertaken across Moray West Site plus a 4 km buffer (Graph 5.4 and Table 5.17).



Graph 5.4: Population estimates of sooty shearwater (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.13.3 Behaviour

The single record involved birds sitting on water.

Table 5.17: Monthly population estimates and densities of sooty shearwater in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
June	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
July	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
August	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
September	49	2,606	2,626	9,070	0	0.09	4.70	4.73	16.35	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

5.13.4 Conclusion

The peak population of sooty shearwater estimated during aerial surveys was 2,626 birds in September. This peak population estimate does not exceed the relevant 1% thresholds of the international population. Therefore, sooty shearwater is not considered for further assessment.

5.14 Manx Shearwater

5.14.1 Status Overview

Manx shearwater is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). Manx shearwater is currently amber-listed on the UK Birds of Conservation Concern because of a moderate breeding range decline, breeding localisation and the international importance of the breeding population (Eaton *et al.,* 2015).

Manx shearwater is a summer visitor to UK waters, occurring at breeding colonies between March and September. Seabird 2000 estimated the British breeding population at 295,089 breeding pairs, with large colonies on the west coast of Scotland and off south-west Wales (e.g., Rum, Skomer and Skokholm) (Mitchell *et al.,* 2004). However, it is evident that the British population of Manx shearwater is now higher with 316,070 breeding pairs estimated on Skomer Island, Wales in 2012 alone (Perrins *et al.,* 2012). The majority of Manx shearwater breeding colonies are found on the western coast of the UK, with only one potential small colony, on the Isle of May, found on the eastern coast of Britain (Balmer *et al.,* 2013). Manx shearwater is also included as part of the potential designation for the Outer Firth of Forth and St Andrews Bay Complex pSPA (2,885 individuals), although the status of these birds is uncertain and are likely to be a mixture of breeding birds from distant colonies, sabbatical adults, pre-breeding age birds and possibly failed breeders.

Small fish, cephalopods, small crustaceans and surface floating offal make up the majority of Manx shearwater diet.

Wade *et al.,* (2016) assessed Manx shearwater as being at very low risk of collision with turbines due to a limited proportion of birds occurring at turbine height although this was associated with a high level of uncertainty. The species is also considered at very low risk of displacement although this also has a high associated level of uncertainty. A similar conclusion was also drawn for habitat loss associated with wind farms due to the high flexibility of Manx shearwater in terms of habitat use. The species is not assessed in terms of barrier effects in Maclean *et al.* (2009) or Langston (2010) however, the species is not considered likely to be exposed due to their notable wide ranging pelagic nature. Overall, Manx shearwater is assessed as being at low risk from offshore wind developments (Table 3.1).

Manx shearwater is listed as a qualifying interest species for two SPAs and one pSPA in the breeding season in Scotland (Table 5.18).

Table 5.18: SPAs cited for breeding Manx shearwater in Scotland. Moray West Site lies within the mean-maximum foraging range of Manx shearwater (330 km) from those sites in bold

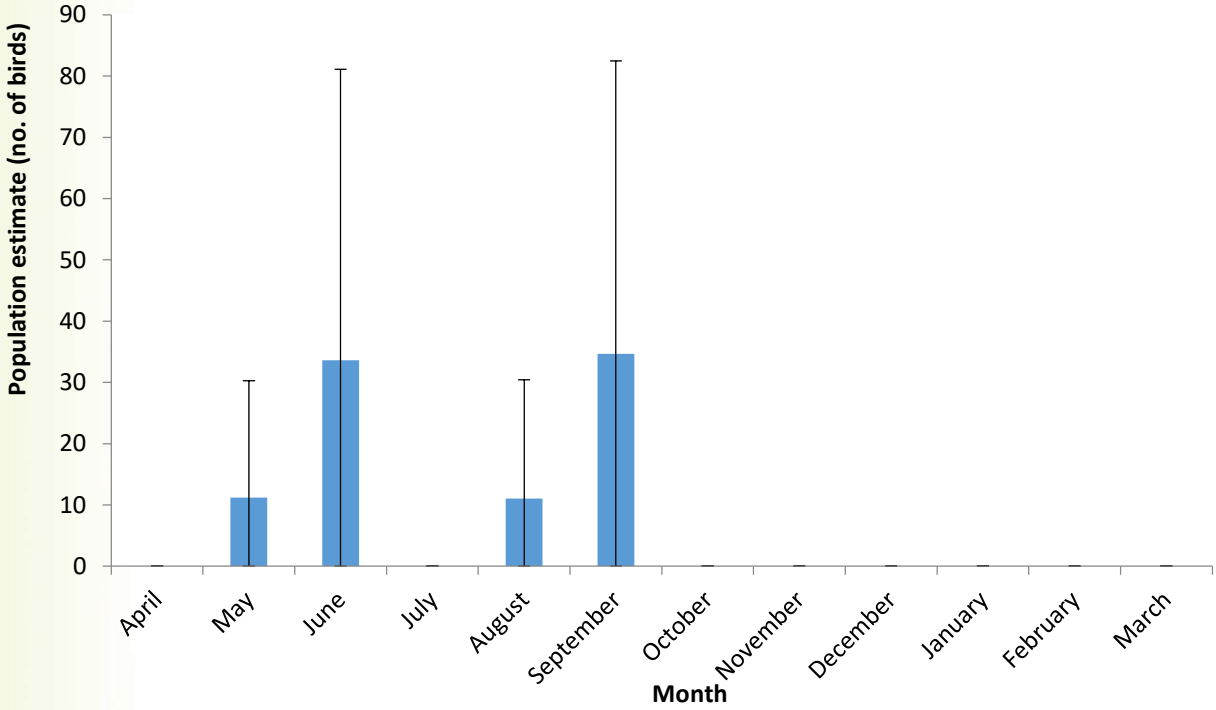
SPA	Distance to Moray West Site (km)[26]	SPA population (pairs)	
		Citation	Standard Data Form
Outer Firth of Forth and St Andrews Bay Complex pSPA	**165.2**	**2,885 individuals**	**-**

[26] Distance from SPAs to the Moray West Site is given as a direct line which may be over land. Those SPAs that are considered to represent an at sea distance of over 330 km from the Moray West Site (e.g. those in the Western Isles) are not therefore highlighted in bold.

Table 5.18: SPAs cited for breeding Manx shearwater in Scotland. Moray West Site lies within the mean-maximum foraging range of Manx shearwater (330 km) from those sites in bold			
SPA	**Distance to Moray West Site (km)[26]**	**SPA population (pairs)**	
		Citation	**Standard Data Form**
Rum	203.6	61,000	61,000
St Kilda	308.7	5,000	1,000

5.14.2 Seasonal Abundance and Distribution

Manx shearwater were recorded in four of the aerial surveys undertaken across Moray West Site plus a 4 km buffer (Graph 5.5 and Table 5.20) with two peaks, one in June and one in September.



Graph 5.5: Population estimates of Manx shearwater (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.14.3 Behaviour

The majority of the records were of birds flying in the breeding season with south being the dominant flight direction (Figure 5.2: Manx shearwater flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017. and Table 5.19).

Table 5.19: Manx shearwater behaviour recorded from aerial surveys over the Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Breeding	0	0	0	1	3	0	1	1	0	2	0	0	0	0
Post-breeding	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-breeding	0	0	0	0	0	0	0	0	0	0	0	0	0	0

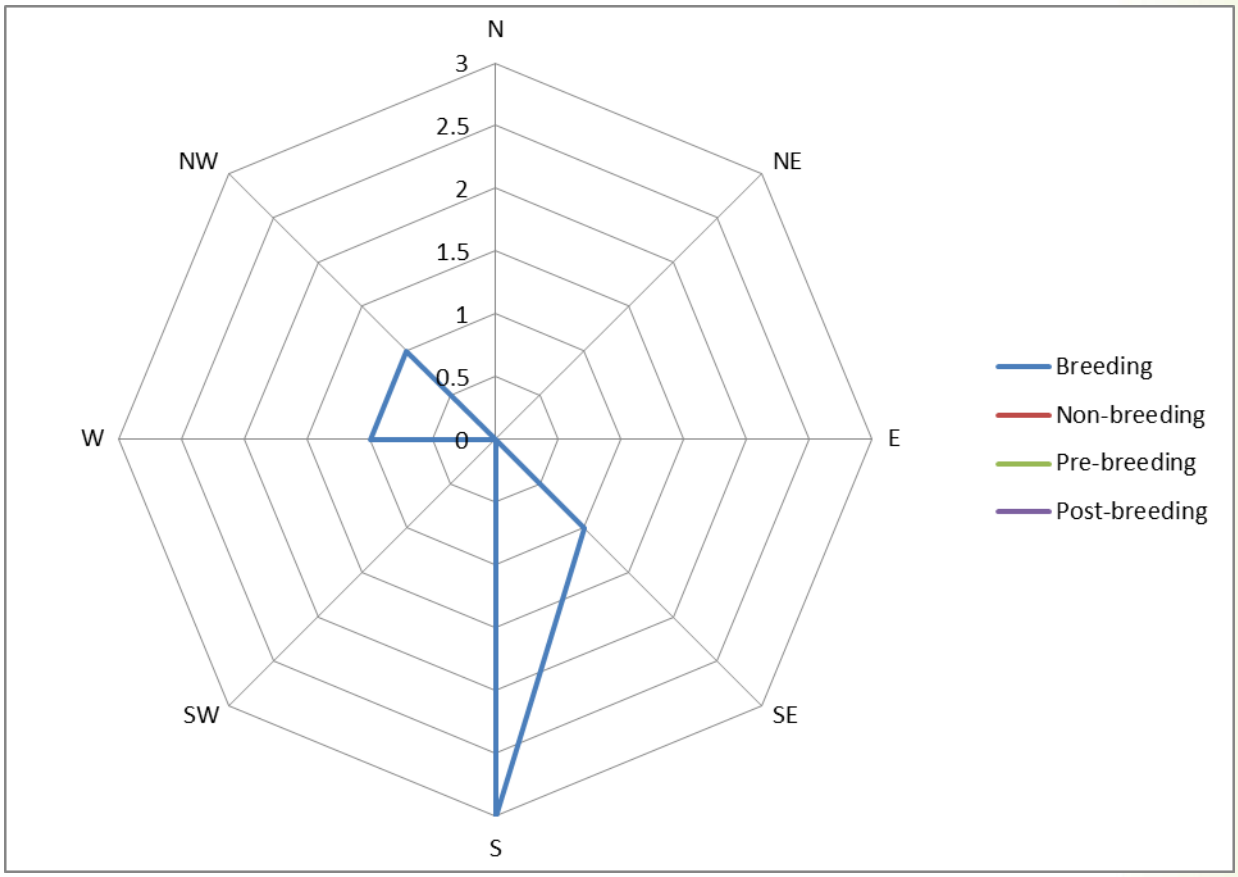


Figure 5.2: Manx shearwater flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

Table 5.20: Monthly population estimates and densities of Manx shearwater in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	11	0	11	30	0	0.02	0.00	0.02	0.05	0.00
June	34	0	34	81	0	0.06	0.00	0.06	0.15	0.00
July	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
August	11	0	11	30	0	0.02	0.00	0.02	0.05	0.00
September	12	24	35	82	0	0.02	0.04	0.06	0.15	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

5.14.4 Conclusion

The peak population of Manx shearwater estimated during aerial surveys was 35 birds in September. This peak population estimate does not exceed the relevant 1% thresholds of the international or national populations.

Manx shearwater is therefore not considered for further assessment in the EIA.

The mean-maximum foraging range of Manx shearwater (Thaxter *et al.,* 2012) means there is the potential for interaction between birds from two SPA colonies and Moray West Offshore Wind Farm. Manx shearwater was not however included in the HRA of Moray East and therefore, based on advice from Marine Scotland (2017), this species will not be included in the HRA of Moray West.

5.15 Gannet

5.15.1 Status Overview

Gannet is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). Gannet is currently amber-listed on the UK Birds of Conservation Concern because of its localised breeding distribution and the international importance of the breeding population (Eaton *et al.,* 2015).

Gannet distribution is widespread around the UK with concentrations around key colonies during the breeding season, i.e. St. Kilda, Ailsa Craig, Grassholm, Bass Rock, Ortec and south-west Ireland (Stone *et al.,* 1995). The UK and Scottish breeding populations have seen a long-term increase (JNCC, 2016) with an estimated 220,000 nests in the UK (Musgrove *et al.,* 2013).

Wade *et al.,* (2016) assessed gannet as being at high risk of collision with turbines due to a moderate proportion of birds at collision height, a moderate flight agility and moderate proportion of time spent in flight. Gannet is also considered to be at high risk of displacement and habitat loss associated with offshore wind farms. Maclean *et al.* (2009) assessed gannet as being at very low risk of barrier effects (Table 3.1).

Gannet is listed as a qualifying interest species for eight SPAs and two pSPA in the breeding season in Scotland (Table 5.21).

Table 5.21: SPAs cited for breeding gannet in Scotland. Moray West Site lies within the mean-maximum foraging range of gannet (229.4 km) from those sites in bold

SPA	Distance to Moray West Site (km)[27]	SPA population (pairs)	
		Citation	Standard Data Form
Ailsa Craig	324.3	23,000	23,000
Fair Isle	**157.8**	**1,166**	**1,166**
Forth Islands	**202.9**	**21,600**	**21,600**
Hermaness, Saxa Vord and Valla Field	300.2	16,400	16,400
North Rona and Sula Sgeir	188.7	10,400	10,400

[27] This distance is measured as the direct (and therefore potentially overland) distance to the Moray West Site. Therefore SPAs where at sea distance to the Moray West Site is considered to be within mean-maximum foraging range are highlighted in bold.

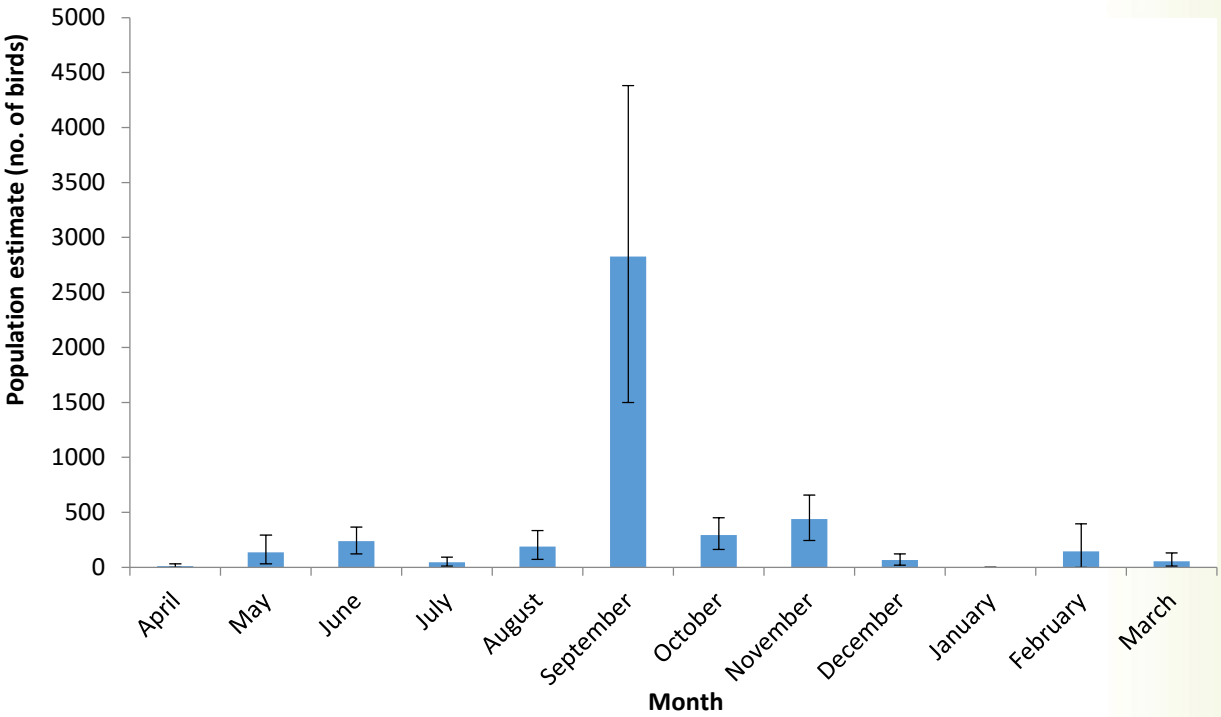
Table 5.21: SPAs cited for breeding gannet in Scotland. Moray West Site lies within the mean-maximum foraging range of gannet (229.4 km) from those sites in bold

SPA	Distance to Moray West Site (km)[27]	SPA population (pairs)	
		Citation	Standard Data Form
Noss	235.8	6,860	6,860
Outer Firth of Forth and St Andrews Bay Complex pSPA	**165.2**	**10,945 individuals**	**-**
Seas off St Kilda pSPA	259.5	50,332 individuals	-
St Kilda	308.7	50,050	50,050
Sule Skerry and Sule Stack	126.6	5,900	5,900

5.15.2 Seasonal Abundance and Distribution

Gannet were recorded in 11 of the aerial surveys undertaken across Moray West Site plus a 4 km buffer (Graph 5.6 and Table 5.23) with a peak in abundance in September corresponding with the post-fledging period.

Population estimates of gannets in flight calculated using MRSea and KDE (Kernel Density Estimation) models are presented in Table 5.24. These are presented at a scale including both a 4 km buffer (as in Table 5.23) and also for the Moray West Site only, with the latter data set used to inform the process applied in Annex 10.1A.



Graph 5.6: Population estimates of gannet (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017 (data presented is without processing through MRSea).

5.16 Behaviour

The majority of the records were of birds sitting on water in the breeding season (Table 5.19). No single flight direction dominated in the breeding season although a north westerly flight direction was the least recorded (Figure 5.3; Table 5.22). In the post-breeding season a similar pattern was observed with westerly and north westerly flight directions the least recorded. Cumulatively, westerly flight directions dominated in the pre-breeding season.

Table 5.22: Gannet behaviour recorded from aerial surveys over Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	0	0	3	0	0	2	1	3	0	16	0	0	0	0
Breeding	12	15	19	16	14	16	10	6	0	206	0	9	0	0
Post-breeding	8	12	7	7	5	7	3	3	0	16	0	1	0	0
Non-breeding	0	0	0	0	0	0	0	0	0	0	0	0	0	0

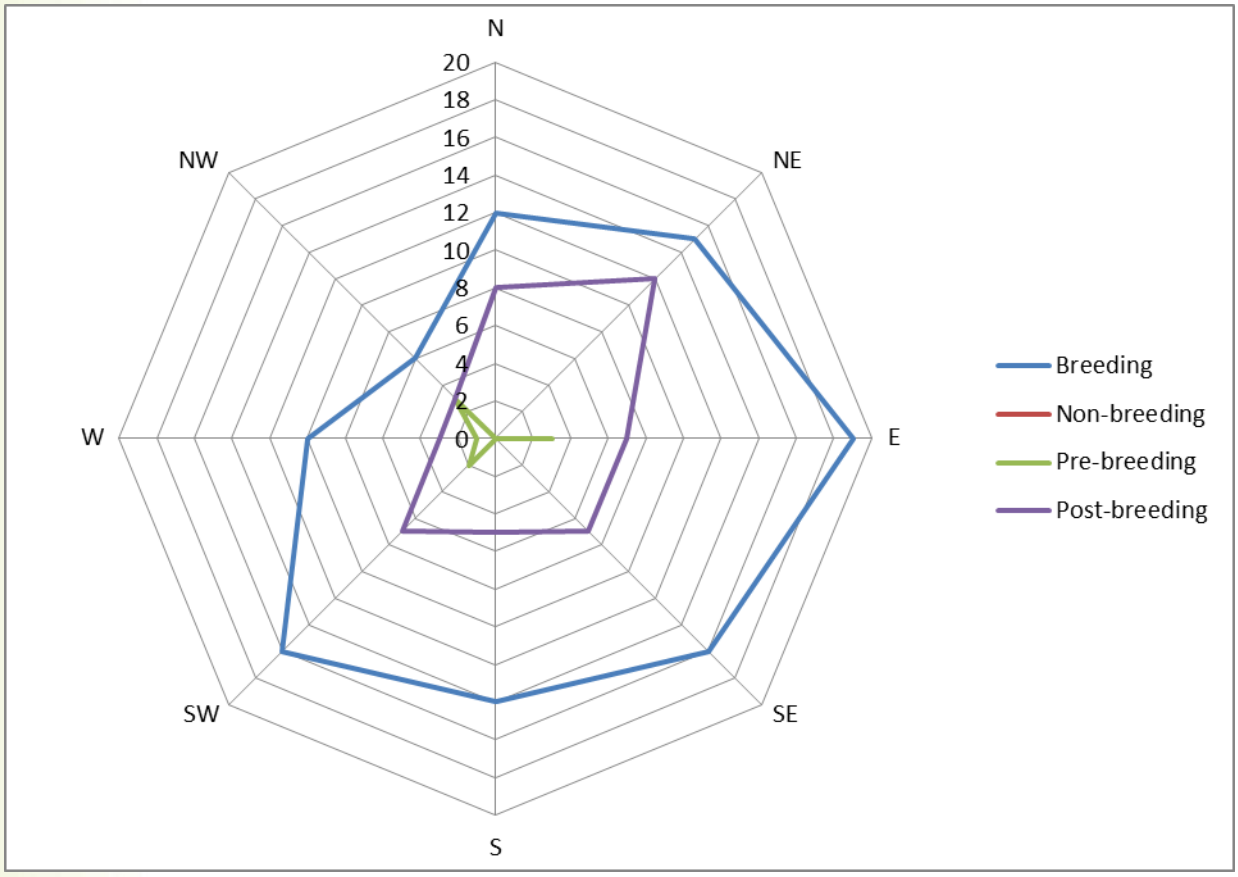


Figure 5.3: Gannet flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

Table 5.23: Monthly population estimates and densities of gannet in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	11	0	11	30	0	0.02	0.00	0.02	0.05	0.00
May	22	111	135	293	30	0.04	0.20	0.24	0.53	0.05
June	46	190	238	365	122	0.08	0.34	0.43	0.66	0.22
July	11	22	45	92	10	0.02	0.04	0.08	0.17	0.02
August	89	101	189	334	71	0.16	0.18	0.34	0.60	0.13
September	963	1,874	2,827	4,381	1498	1.74	3.38	5.10	7.90	2.70
October	193	103	295	450	163	0.35	0.19	0.53	0.81	0.29
November	360	78	439	658	243	0.65	0.14	0.79	1.19	0.44
December	55	11	67	121	20	0.10	0.02	0.12	0.22	0.04
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	147	144	395	0	0.00	0.26	0.26	0.71	0.00
March	44	11	55	131	10	0.08	0.02	0.10	0.24	0.02

Table 5.24: Monthly population estimates of gannets in flight at Moray West Site with and without a 4 km buffer calculated using MRSea / KDE models

Month	Model applied	Population estimates (no. of birds)					
		Moray West Site	Upper confidence limit	Lower confidence limit	Moray West Site + 4km	Upper confidence limit	Lower confidence limit
April	KDE	0	0	0	11	30	0
May	KDE	12	30	0	22	50	0
June	KDE	0	0	0	46	101	0
July	KDE	12	40	0	11	31	0
August	KDE	47	101	10	89	172	20
September	MRSea	336	516	247	882	1,278	699
October	MRSea	63	166	36	174	398	111
November	MRSea	90	202	55	323	583	256
December	KDE	12	30	0	55	111	10
January	Obs	0	0	0	0	0	0
February	Obs	0	0	0	0	0	0
March	KDE	45	111	0	44	111	0

5.16.1 Conclusion

The population estimates of gannet in the Moray West Site plus a 4 km buffer in the breeding season for September exceed the 1% threshold of the regional population. The 1% thresholds of the national and international populations for gannet are not surpassed in any month.

Based on the presence of an important population, gannet is identified as a Valued Ornithological Receptor and considered for further assessment in the EIA as a species with regional importance and international conservation value.

The mean-maximum foraging range of gannet (Thaxter *et al.,* 2012) from a number of SPA breeding colonies overlap with the Moray West Site plus a 4 km buffer. Based on the potential SPA connectivity and the inclusion of gannet in the Moray HRA, gannet is also included in the Moray West Offshore Wind Farm HRA.

5.17 Cormorant

5.17.1 Status Overview

Cormorant is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 (Part 1) of the Wildlife and Countryside Act 1981 (as amended) and is currently green-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

Approximately 9,000 pairs breed the UK with 41,000 individuals present in coastal waters around the UK in the non-breeding season (Musgrove *et al.,* 2013). High densities are found in Liverpool Bay and Moray Firth (Stone *et al.,* 1995).

Cormorant is listed as a qualifying interest species for three SPAs in the breeding season in Scotland.

Wade *et al.,* (2016) assessed cormorant as being at high risk of collision with turbines, high risk of displacement and moderate risk of habitat loss. Langston (2010) assessed cormorant as being of moderate risk to barrier effects (Table 3.1).

5.17.2 Seasonal Abundance and Distribution

Cormorant was not recorded during the aerial surveys. However, it is a qualifying feature of the East Caithness Cliffs SPA.

5.17.3 Conclusion

Cormorant is not considered to be a Valued Ornithological Receptor because it was absence from the aerial surveys and because the distance separating the Development area from the East Caithness Cliffs SPA is greater than the maximum foraging range for cormorant.

Cormorant is therefore not considered for further assessment for impacts associated with the Development.

5.18 Shag

5.18.1 Status Overview

The subspecies of shag present in the UK, *Phalacrocorax aristotelis aristotelis*, is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 (Part 1) of the Wildlife and Countryside Act 1981 (as amended). Shag is currently red-listed on the UK Birds of Conservation Concern as a result of its breeding population decline (Eaton *et al.,* 2015).

Approximately 27,000 pairs breed and 110,000 individuals winter in the UK (Musgrove *et al.,* 2013) where they are widely distributed in coastal water around the western and northern coasts of the UK (Stone *et al.,* 1995). The greatest abundance is in the north and west of Scotland in particular the Moray Firth and the Firth of Forth (SNH, 2016).

Wade *et al.,* (2016) assessed shag as being at moderate risk of collision with turbines, high risk of displacement and moderate risk of habitat loss. Langston (2010) assessed shag as being of moderate risk to barrier effects (Table 3.1).

Shag is listed as a qualifying interest species for four pSPA in the breeding season in Scotland (Table 5.25).

Table 5.25: SPAs cited for non-breeding shag in Scotland. Moray West Offshore Export Cable Corridor lies within those sites in bold

SPA	Distance to Moray West Offshore Export Cable Corridor (km)	SPA population (pairs)	
		Citation	Standard Data Form
Moray Firth pSPA	**0.0**	**6,462**	**-**
North Orkney pSPA	95.2	1,742	-
Outer Firth of Forth and St Andrews Bay Complex pSPA	124.7	2,426	-
Scapa Flow pSPA	55.2	2,929	-

5.18.2 Seasonal Abundance and Distribution

Shag was not recorded on aerial surveys. However, it is a qualifying feature of the Moray Firth pSPA for which the Offshore Export Cable Corridor passes through. The Moray West Site does not have any connectivity with either the foraging range of breeding shag or known wintering areas.

An area of relatively low shag density in the Moray Firth is likely to coincide with the area overlapped by the Offshore Export Cable Corridor in the non-breeding season (SNH, 2016).

5.18.3 Conclusion

Although shag is absent from the aerial surveys of the Moray West Site, the Offshore Export Cable Corridor passes through the Moray Firth pSPA where shag are likely to be present. Shag is therefore identified as a Valued Ornithological Receptor and considered to be of international conservation value.

Although impacts from the OfTI components of the Development are unlikely, applying the precautionary principle, shag is considered for further assessment in the EIA and HRA in respect to the Offshore Export Cable Corridor only.

5.19 Slavonian Grebe

5.19.1 Status Overview

Slavonian grebe is listed under Annex I of the EU Birds Directive (2009/147/EEC) and Schedule 1 (Part 1) of the Wildlife and Countryside Act 1981 (as amended). Slavonian grebe is currently red-listed on the UK Birds of Conservation Concern as a result of its threatened global status and declining breeding population (Eaton *et al.,* 2015).

Approximately 30 pairs breed and 1,100 individuals winter in the UK, the later Slavonian grebe being widely distributed round the entire UK coastline with particular concentrations in Scotland in the Firth of Forth, the Moray Firth, the Northern Isles, north-west Scotland including the Outer Hebrides and Kintyre (SNH, 2016).

Wade *et al.,* (2016) assessed Slavonian grebe as being at low risk of collision with turbines, moderate risk of displacement and high risk of habitat loss. Langston (2010) assessed Slavonian grebe as being of moderate risk to barrier effects (Table 3.1).

Slavonian grebe is listed as a qualifying interest species for one SPA and five pSPAs in the non-breeding season in Scotland. The Moray West Site has no connectivity with SPAs including Slavonian Grebe as a qualifying feature while the Offshore Export Cable Corridor potentially interacts with one site (Moray Firth pSPA) (Table 5.26).

Table 5.26: SPAs cited for non-breeding Slavonian grebe in Scotland. Moray West Offshore Export Cable Corridor lies within those sites in bold

SPA	Distance to Offshore Export Cable Corridor (km)	SPA population (individuals)	
		Citation	Standard Data Form
Firth of Forth	156.4	84	84
East Mainland Coast, Shetland pSPA	253.5	54	-
Moray Firth pSPA	**0.0**	**43**	**-**
North Orkney pSPA	95.2	120	-
Outer Firth of Forth and St Andrews Bay Complex pSPA	124.7	30	-
Scapa Flow pSPA	55.2	135	-

5.19.2 Seasonal Abundance and Distribution

Slavonian grebe was not recorded during aerial surveys of the Moray West Site. However, it is a qualifying feature of the Moray Firth pSPA which the Offshore Export Cable Corridor passes through. An area of relatively low Slavonian grebe density in the Moray Firth is likely to coincide with the area overlapped by the Offshore Export Cable Corridor (SNH, 2016).

5.19.3 Conclusion

Although absent from the aerial surveys of the Moray West Site, the Offshore Export Cable Corridor passes through the Moray Firth pSPA where Slavonian grebe are likely to be present. Slavonian grebe is therefore identified as a Valued Ornithological Receptor and considered to be of international conservation value.

Although impacts from the OfTI components of the Development are unlikely, applying the precautionary principle, Slavonian grebe is considered for further assessment in the EIA and HRA in respect to the Offshore Export Cable Corridor only.

5.20 Pomarine Skua

5.20.1 Status Overview

Pomarine skua is currently green-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015). The species is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended).

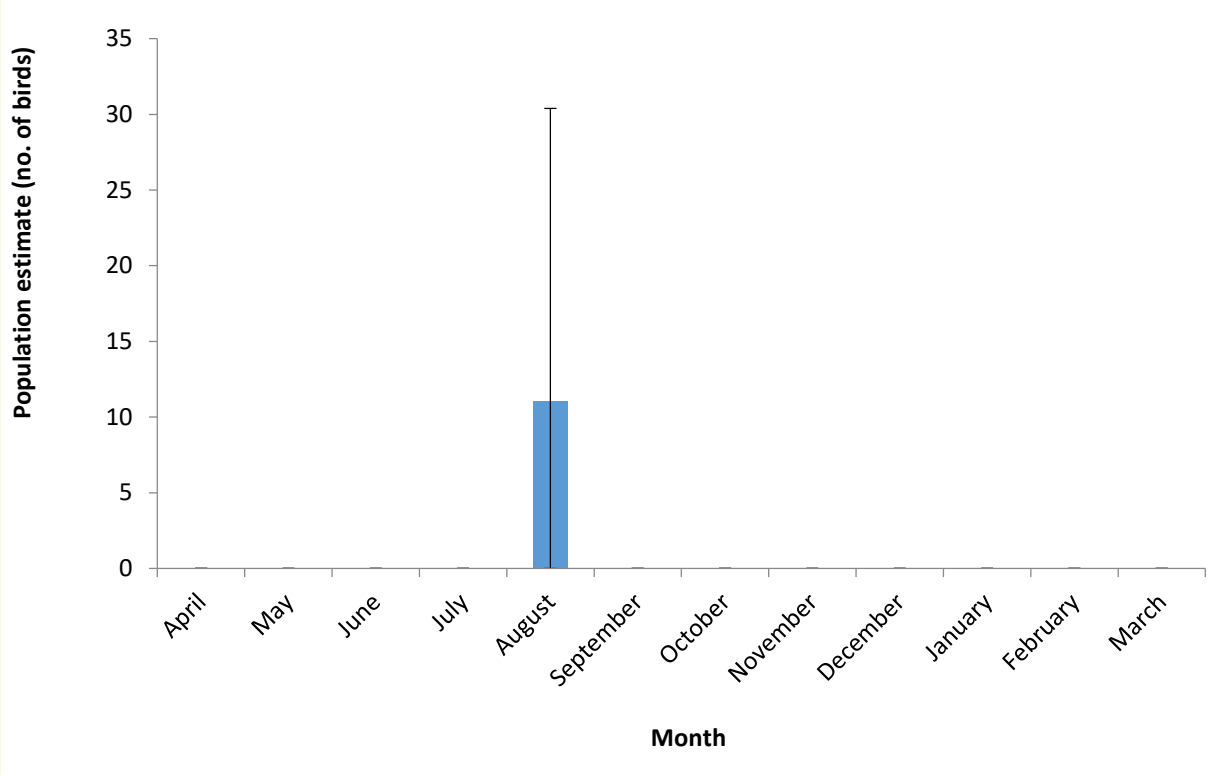
Pomarine skua is a passage migrant in spring and autumn in the North Sea.

Bradbury *et al.,* (2014) assessed pomarine skua as being at low risk of collision with turbines, very low risk of displacement and at low risk of habitat loss. Maclean *et al.,* (2009) assessed pomarine skua as being at low risk of barrier effects from offshore wind farms (Table 3.1)

Pomarine skua is not a qualifying interest species for any SPA in the UK.

5.20.2 Seasonal Abundance and Distribution

Pomarine skua was recorded in one of the aerial surveys undertaken across Moray West Site plus a 4 km buffer (Graph 5.7 and Table 5.27).



Graph 5.7: Population estimates of pomarine skua (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.20.3 Behaviour

The single record involved birds sitting on water.

Table 5.27: Monthly population estimates and densities of pomarine skua in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
June	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
July	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
August	0	11	11	30	0	0.00	0.02	0.02	0.05	0.00
September	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

5.20.4 Conclusion

The peak population of pomarine skua estimated during aerial surveys was 11 birds in August. This peak population estimate does not exceed the relevant 1% thresholds of the international or national populations.

Pomarine skua is therefore not identified as a Valued Ornithological Receptor and is therefore not considered for further assessment in the EIA.

5.21 Arctic Skua

5.21.1 Status Overview

Arctic skua is currently red-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015) due to its significant recent decline with the UK breeding population showing declines of 37% between 1985/88 and 1998/2002 and 64% between 1998/2002 and 2015 (JNCC, 2016). The species is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended).

Arctic skua is a passage migrant in spring and autumn in the North Sea, and a scarce UK breeding species, restricted to Shetland, Orkney, north Scotland and the Western Isles (Forrester *et al.,* 2007). Seabird 2000 estimated the Scottish breeding population at 2,136 pairs (Mitchell *et al.,* 2004).

Wade *et al.,* (2016) assessed Arctic skua as being at high risk of collision with turbines due to a high proportion of time spent in flight. Risk of displacement and habitat loss resulting from offshore wind farms were ranked as very low and low, respectively due to the species ability to utilise a wide-range of habitats, although the species sensitivity to displacement reported by Wade *et al.,* (2016) has an associated very high degree of uncertainty. Maclean *et al.,* (2009) assessed Arctic skua as being at low risk of barrier effects from offshore wind farms (Table 3.1).

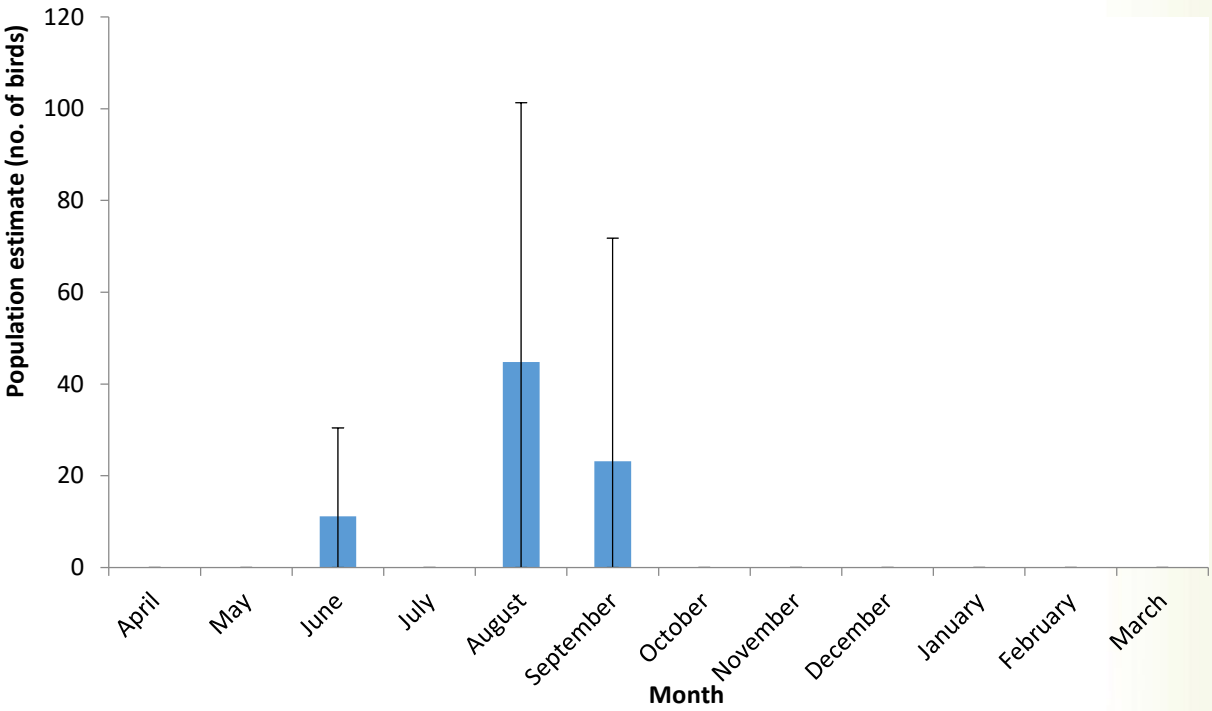
Arctic skua is listed as a qualifying interest species for eight SPAs and two pSPAs in the breeding season in Scotland (Table 5.28).

Table 5.28: SPAs cited for breeding Arctic skua in Scotland. Moray West Site lies within the mean-maximum foraging range of Arctic skua (62.5 km) from those sites in bold

SPA	Distance to Moray West Site (km)	SPA population (pairs)	
		Citation	Standard Data Form
Fair Isle	157.8	94	94
Fetlar	281.2	130	130
Foula	213.5	133	133
Handa	118.9	Not listed	31
Hoy	**64.9**	**59**	**59**
Papa Westray (North Hill and Holm)	126.5	150	Not listed
Pentland Firth pSPA	**38.2**	**75 individuals**	**?**
Rousay	104.2	130	130
Seas off Foula pSPA	187.5	219 individuals	-
West Westray	116.7	77	77

5.21.2 Seasonal Abundance and Distribution

Arctic skua was recorded in three of the aerial surveys undertaken across Moray West Site plus a 4 km buffer with peak abundance occurring in August (Graph 5.8 and Table 5.30).



Graph 5.8: Population estimates of Arctic skua (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.21.3 Behaviour

The majority of the records were of birds sitting on water in the breeding season with only one record of a bird in flight (south westerly) in the post-breeding season (Table 5.29).

Table 5.29: Arctic skua behaviour recorded from aerial surveys over Moray West Offshore Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Breeding	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Post-breeding	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Non-breeding	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.30: Monthly population estimates and densities of Arctic skua in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
June	0	11	11	30	0	0.00	0.02	0.02	0.05	0.00
July	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
August	0	45	45	101	0	0.00	0.08	0.08	0.18	0.00
September	11	0	23	72	0	0.02	0.00	0.04	0.13	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

5.21.4 Conclusion

The peak population of Arctic skua estimated during aerial surveys during the breeding season was 45 birds in August and in the post-breeding season the peak count was 23 birds in September. The breeding season peak population estimate exceeds the regional 1% threshold but the post-breeding estimate does not exceed any 1% threshold.

Arctic skua is therefore not identified as a Valued Ornithological Receptor and is therefore not considered for further assessment in the EIA.

Based on Arctic skuas mean-maximum foraging range (Thaxter *et al.,* 2012) there is potential for interaction between birds from single SPA and pSPA sites and Moray West. Arctic skua was not however included in the HRA of Moray East and therefore, based on advice from Marine Scotland (2017) this species will not be included in the HRA of Moray West.

5.22 Great Skua

5.22.1 Status Overview

Great skua is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). Great skua is currently amber-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

The species regularly occurs in the North Sea on spring and autumn passage, with some birds remaining for the winter months (Stone *et al.,* 1995). Great skuas breed on Shetland, Orkney and the Western Isles (Balmer *et al.,* 2013), with an estimated population of 9,634 pairs during Seabird 2000 (Mitchell *et al.,* 2004). The UK breeding population of great skua has shown increases of 26% between 1985-88 and 1998-2002 and 18% between 1998-2002 and 2015. Great skuas breed close to other seabird colonies, in order to scavenge and parasitize food from other seabirds, as well as predating other birds and nests.

Wade *et al.,* (2016) assessed great skua as being at high risk of collision with turbines due to a high proportion of time spent in flight. Risk of displacement and habitat loss resulting from offshore wind farms were considered to be very low and low, respectively due to the species ability to use a wide range of habitats, although the species sensitivity to displacement reported by Wade *et al.,* (2016) has an associated high degree of uncertainty. Maclean *et al.,* (2009) assessed great skua as being at low risk of barrier effects from offshore wind farms (Table 3.1).

Great skua is listed as a qualifying interest species for nine SPAs and one pSPAs in the breeding season in Scotland (Table 5.31).

Table 5.31: SPAs cited for breeding great skua in Scotland. Moray West Site lies within the mean-maximum foraging range of great skua (86.4 km) from those sites in bold

SPA	Distance to Moray West Site (km)	SPA Population (pairs)	
		Citation	Standard Data Form
Fair Isle	157.8	110	110
Fetlar	281.2	508	508
Foula	213.5	2,270	2,270
Handa	118.9	66	113
Hermaness, Saxa Vord and Valla Field	300.2	788	788
Hoy	**64.9**	**1,900**	**1,900**

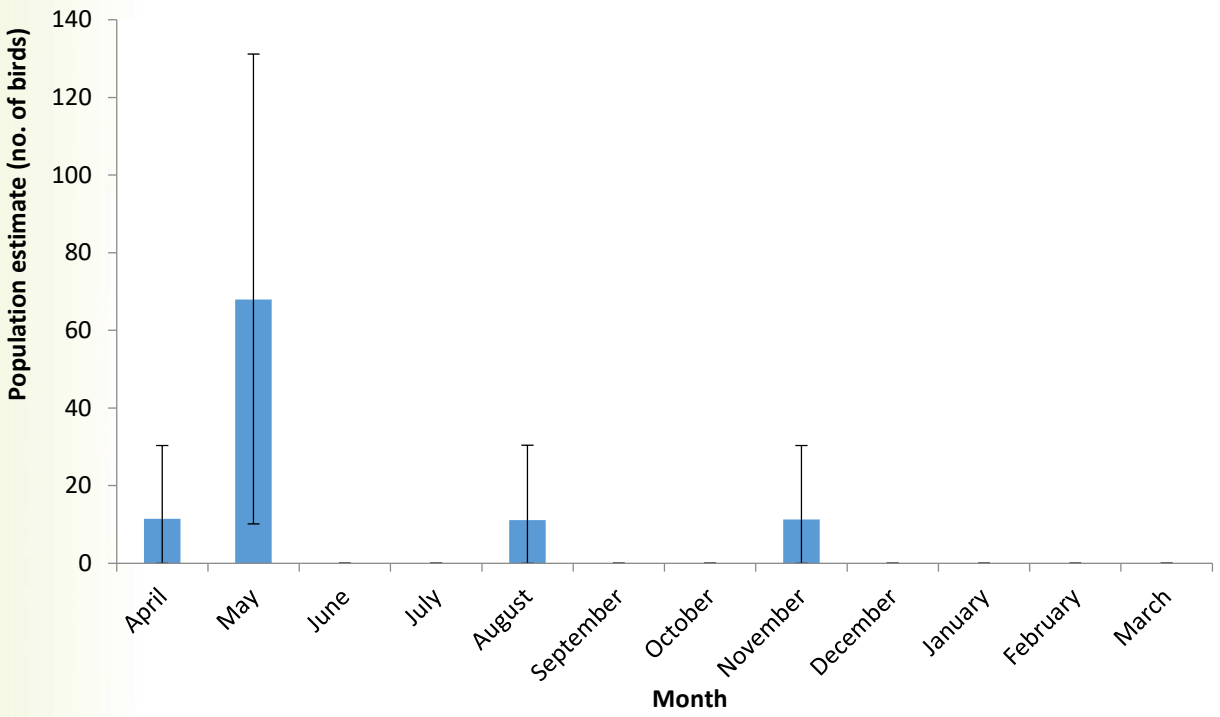
Table 5.31: SPAs cited for breeding great skua in Scotland. Moray West Site lies within the mean-maximum foraging range of great skua (86.4 km) from those sites in bold

SPA	Distance to Moray West Site (km)	SPA Population (pairs)	
		Citation	Standard Data Form
Noss	235.8	420	420
Ronas Hill – North Roe and Tingon*	267.4	130	128
Seas off Foula pSPA	187.5	1,594 individuals	-
St Kilda	308.7	270	270

*** Citation has been identified as requiring amendment (SNH, 2017b)**

5.22.2 Seasonal Abundance and Distribution

Great skua were recorded in four of the aerial surveys undertaken across Moray West Site plus a 4 km buffer with peak abundance occurring in May (Graph 5.9 and Table 5.33).



Graph 5.9 Population estimates of great skua (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.22.3 Behaviour

The majority of the records were of birds flying in the breeding season with a southerly bias in flight direction (Table 5.32; Figure 5.4).

Table 5.32: Great skua behaviour recorded from aerial surveys over Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Breeding	0	0	1	1	1	3	0	1	0	3	0	0	0	0
Post-breeding	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-breeding	0	1	0	0	0	0	0	0	0	0	0	0	0	0

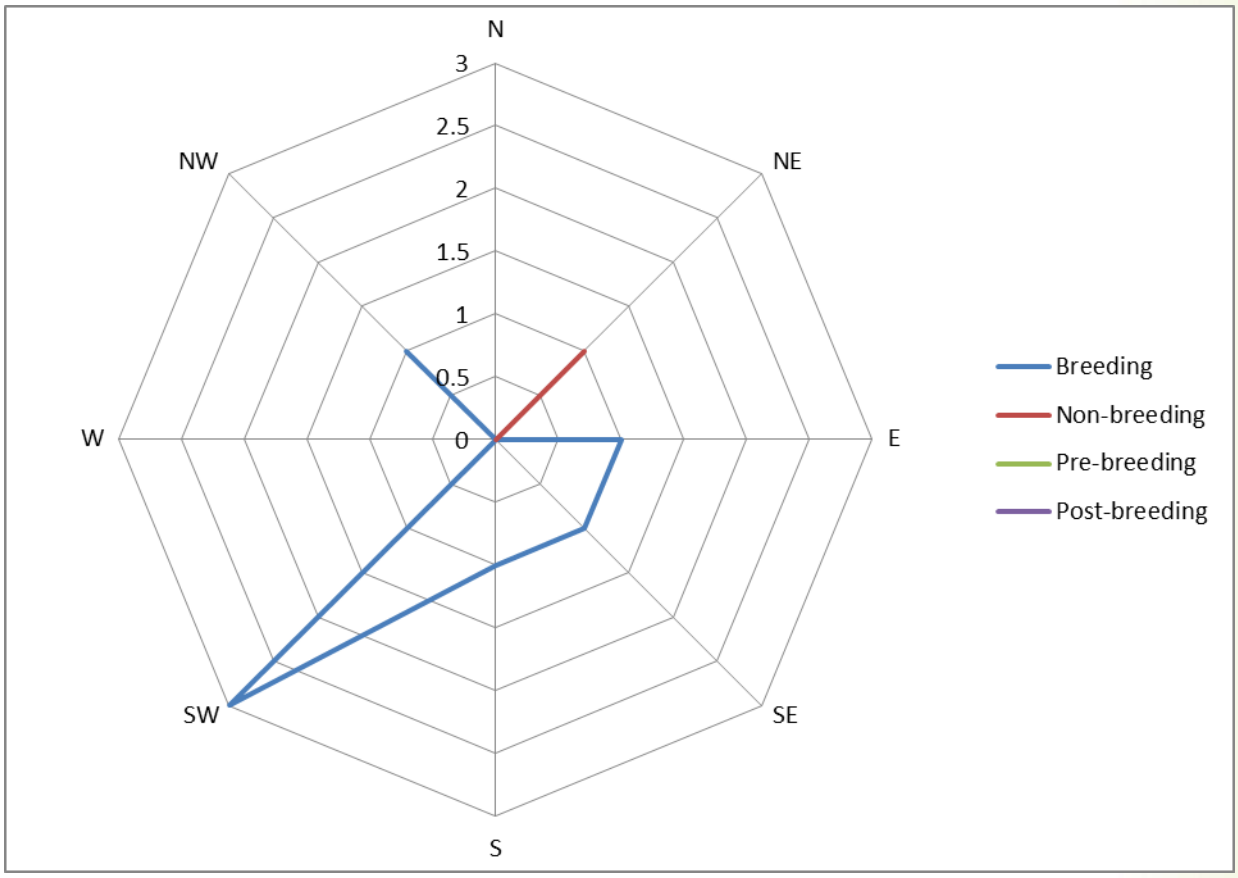


Figure 5.4: Great skua flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

Table 5.33: Monthly population estimates and densities of great skua in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	11	0	11	30	0	0.02	0.00	0.02	0.05	0.00
May	46	22	68	131	10	0.08	0.04	0.12	0.24	0.02
June	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
July	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
August	11	0	11	30	0	0.02	0.00	0.02	0.05	0.00
September	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	11	0	11	30	0	0.02	0.00	0.02	0.05	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

5.22.4 Conclusion

The peak population of great skua estimated during aerial surveys was 68 birds in May. This peak population estimate does not exceed the relevant 1% thresholds of the international or national populations.

Great skua is therefore not identified as a VOR and is therefore not considered for further assessment in the EIA.

Based on the mean-maximum foraging range of great skua (Thaxter *et al.,* 2012) there is no potential for interaction between birds from any SPAs and Moray West. Great skua is therefore not included for assessment in the HRA.

5.23 Puffin

5.23.1 Status Overview

Puffin is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). The species is however currently red-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

Puffins are one of the most abundant seabird species in Britain, breeding in coastal colonies. Seabird 2000 recorded 579,500 pairs at breeding colonies around Britain (Mitchell *et al.,* 2004). Lesser sandeel is the commonest prey item for puffins, but they also eat sprat, herring and a wide range of young gadoid fish (Harris, 1984).

Wade *et al.,* (2016) assessed puffin as being at moderate risk of displacement and habitat loss due to offshore wind farms due to the limited ability of the species to utilise alternative habitats. The species is considered to be at very low risk of collision with turbines due to a very low proportion of birds flying at turbine height. Maclean *et al.,* (2009) assessed auks as being at high risk of barrier effects at offshore wind farms (Table 3.1).

Puffin is listed as a qualifying interest species for 15 SPAs and three pSPAs in the breeding season in Scotland (Table 5.34).

Table 5.34: SPAs cited for breeding puffin in Scotland. Moray West Site lies within the mean-maximum foraging range of puffin (105.4 km) from those sites in bold.

SPA	Distance to Moray West Site (km)	SPA population (pairs)	
		Citation	Standard Data Form
Canna and Sanday	219.1	1,200 individuals	1,200 individuals
Cape Wrath	110.3	5,900	5,900
Fair Isle	157.8	23,000 individuals	23,000 individuals
Flannan Isles	254.6	4,400	5,500
Forth Islands	202.9	14,000	14,000
Foula	213.5	48,000	33 calling males
Hermaness, Saxa Vord and Valla Field	300.2	55,000 individuals	55,000 individuals
Hoy	**64.9**	**3,500**	**3,500**
Mingulay and Berneray	291.7	4,000	4,000

Table 5.34: SPAs cited for breeding puffin in Scotland. Moray West Site lies within the mean-maximum foraging range of puffin (105.4 km) from those sites in bold.

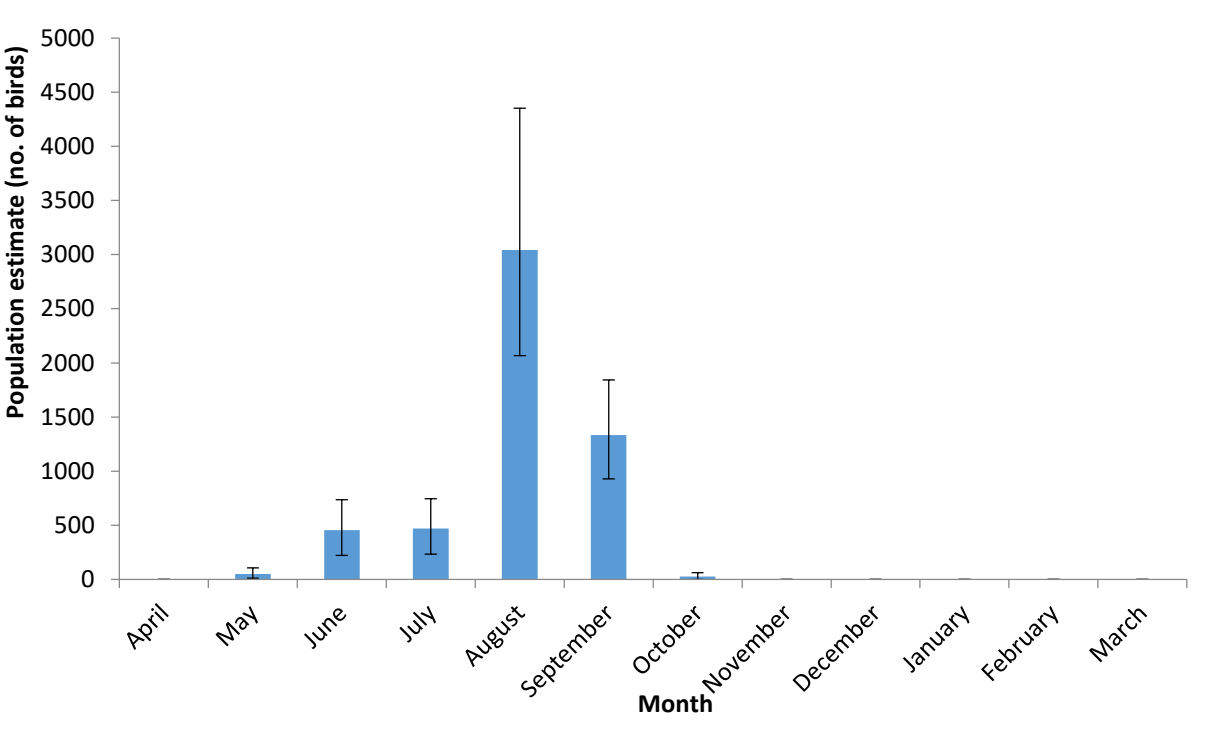
SPA	Distance to Moray West Site (km)	SPA population (pairs)	
		Citation	Standard Data Form
North Caithness Cliffs[28]	**41.6**	**1,750**	**1,750**
North Rona and Sula Sgeir	188.7	5,300	5,300
Noss	235.8	2,348 individuals	2,348 individuals
Outer Firth of Forth and St Andrews Bay Complex pSPA	165.2	61,086 individuals	-
Seas off Foula pSPA	187.5	14,886 individuals	-
Seas off St Kilda pSPA	259.5	6,198	-
Shiant Isles	182.0	77,000	77,000
St Kilda	308.7	155,000	155,000
Sule Skerry and Sule Stack	126.6	46,900	46,900

5.23.2 Seasonal Abundance and Distribution

Puffin were recorded in six of the aerial surveys undertaken across the Moray West Site plus a 4 km buffer with peak abundance occurring in August (Graph 5.10 and Table 5.36).

Population estimates of puffins in flight and on the water calculated using MRSea and KDE models are presented in Table 5.37. These are presented at scales including both 2 km and 4 km buffers. MRSea was able to predict populations in four months only; other months are populated by aerial survey observations.

[28] Puffin is also cited as a qualifying feature of East Caithness Cliffs SPA. However, SNH have advised for Moray West that puffin populations at North Caithness have previously been erroneously referred to as being at East Caithness. Most recent counts of puffin are 189 individuals at East Caithness (2015) and 3,507 individuals at North Caithness.



Graph 5.10: Population estimates of puffin (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017 (based on digital aerial survey data not processed through MRSea).

5.23.3 Behaviour

The majority of the records were of birds sitting on water in the non-breeding and breeding seasons (Table 5.35). There were only two records of puffin in flight, one in the non-breeding season (south east) and one in the breeding season (direction unknown).

Table 5.35: Puffin behaviour recorded from aerial surveys over Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Breeding	0	0	0	0	0	0	0	0	0	106	0	0	0	1
Post-breeding	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-breeding	0	0	0	1	0	0	0	0	0	358	0	0	0	0

Table 5.36: Monthly population estimates and densities of puffin in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	0	51	52	106	12	0.00	0.09	0.09	0.19	0.02
June	11	443	457	737	222	0.02	0.80	0.82	1.33	0.40
July	0	469	471	746	233	0.00	0.84	0.84	1.34	0.42
August	0	3,027	3,042	4,353	2,067	0.00	5.46	5.48	7.85	3.73
September	0	1,336	1,335	1,842	928	0.00	2.41	2.41	3.32	1.67
October	0	25	27	62	0	0.00	0.05	0.05	0.11	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

Table 5.37: Monthly population estimates and densities of puffin in Moray West Site plus 2 km and 4km buffers using MRSea / KDE models

Month	Model	Population estimates (Moray West plus 2 km buffer) (no. of birds)							Population estimates (Moray West plus 4 km buffer) (no. of birds)						
		Flying	Upper confidence limit	Lower confidence limit	On water	Upper confidence limit	Lower confidence limit	Combined	Flying	Upper confidence limit	Lower confidence limit	On water	Upper confidence limit	Lower confidence limit	Combined
April	Obs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May	Obs	0	0	0				0	0	0	0	6			6
June	MRSea	11	41	11	167	311	118	178	11	41	0	350	601	281	361
July	MRSea	0	0	0	234	487	167	234	0	0	0	351	742	277	351
August	MRSea	0	30	0	1,810	2,444	1,475	1,810	11	30	0	2,376	3,235	2,013	2,387
September	MRSea	0	0	0	576	815	471	576	0	0	0	1,047	1,456	882	1,047
October	KDE	0	0	0					0	0	0	23	51	0	23
November	Obs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
December	Obs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
January	Obs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
February	Obs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
March	Obs	0	0	0	0	0	0	0	0	0	0	0	0	0	0

5.23.4 Conclusion

The population estimates of puffin in the Moray West Site plus a 4 km buffer in the breeding season for August exceed the 1% threshold of the regional population. The 1% thresholds of the national and international populations for puffin are not surpassed in any month.

Based on the presence of an important population, puffin is identified as a VOR and considered for further assessment in the EIA as a species with regional importance and international conservation value.

The mean-maximum foraging range of puffin (Thaxter *et al.,* 2012) from a number of SPA breeding colonies overlap with the Moray West Site plus a 4 km buffer. Based on the potential SPA connectivity and the inclusion of puffin in the Moray East HRA, puffin is included in the Moray West Offshore Wind Farm HRA.

5.24 Razorbill

5.24.1 Status Overview

Razorbill is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). The species is currently amber-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

Razorbill is one of the most common seabirds in Britain, breeding in large colonies with other seabirds on suitable coastal cliffs. Seabird 2000 recorded 164,557 individuals at breeding colonies around Britain (Mitchell *et al.,* 2004).

Wade *et al.,* (2016) assessed razorbill as being at high risk of displacement from wind farms and moderate risk of habitat loss due to the limited ability of the species to utilise alternative habitats. The species is considered to be at very low risk of collision with turbines due to a low proportion of birds flying at turbine height. Maclean *et al.,* (2009) assessed auks as being at high risk of barrier effects at offshore wind farms (Table 3.1).

Razorbill is listed as a qualifying interest species for 16 SPAs and one pSPAs in the breeding season in Scotland (Table 5.38).

Table 5.38: SPAs cited for breeding razorbill in Scotland. Moray West Site lies within the mean-maximum foraging range (48.5 km) of razorbill from those sites in bold

SPA	Distance to the Moray West Site (km)	SPA population (individuals)	
		Citation	Standard Data Form
Cape Wrath	110.3	1,800	1,800
East Caithness Cliffs	19.9	15,800[29]	15,800
Fair Isle	157.8	3,400	3,050
Flannan Isles	254.6	3,160	3,160
Forth Islands	202.9	1,400 pairs	1,400 pairs
Foula	213.5	6,200	6,200
Fowlsheugh	300.2	5,800	6,830
Handa	64.9	16,394	16,394
Mingulay and Berneray	291.7	16,890	16,890

[29]The most recent razorbill population count at East Caithness is 30,042 individuals (2015)

Table 5.38: SPAs cited for breeding razorbill in Scotland. Moray West Site lies within the mean-maximum foraging range (48.5 km) of razorbill from those sites in bold

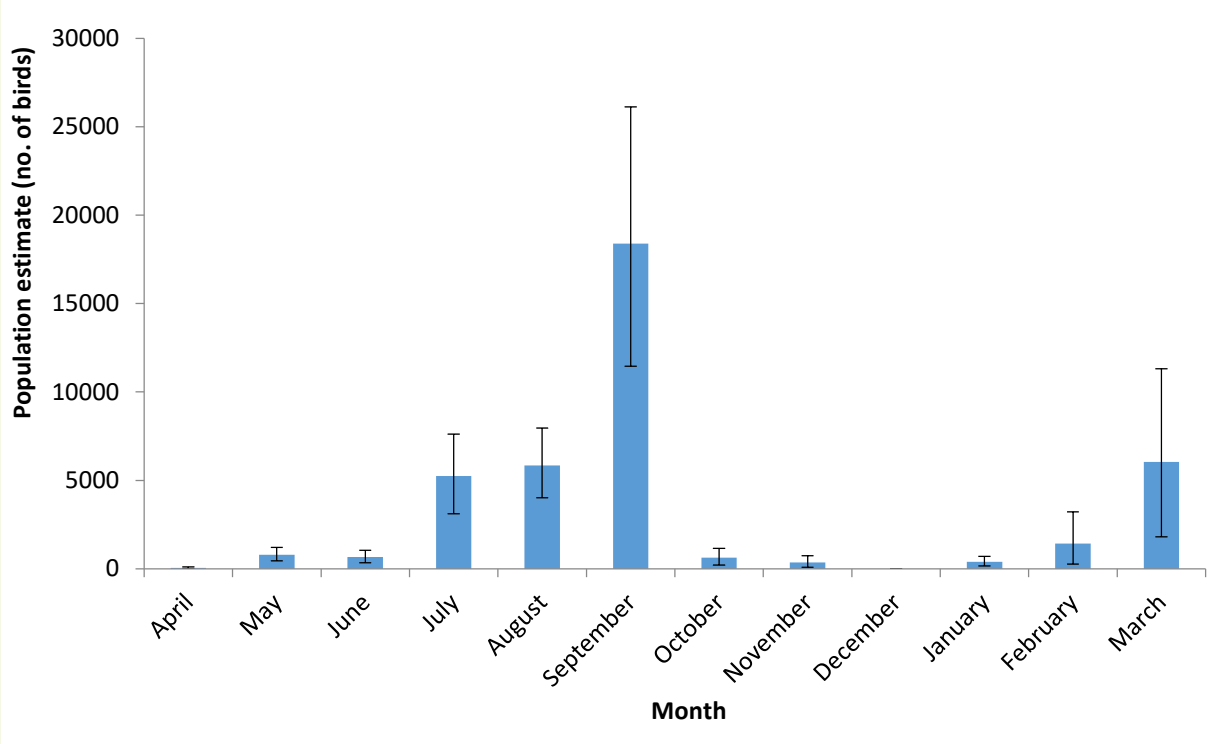
SPA	Distance to the Moray West Site (km)	SPA population (individuals)	
		Citation	Standard Data Form
North Caithness Cliffs	**41.6**	**4,000[30]**	**3,302**
North Rona and Sula Sgeir	188.7	2,300	2,300
Outer Firth of Forth and St Andrews Bay Complex pSPA	235.8	5,481	-
Shiant Isles	165.2	10,950	10,950
St Abb's Head and Fast Castle	187.5	2,180	2,180
St Kilda	259.5	3,810	3,800
Troup, Pennan and Lion's Heads	182.0	4,800	4,800
West Westray	116.7	1,946	1,950

5.24.2 Seasonal Abundance and Distribution

Razorbill were recorded in 11 of the aerial surveys undertaken across Moray West Site plus a 4 km buffer with peak abundance occurring in September followed by a secondary peak in March (Graph 5.11 and Table 5.40).

Population estimates of puffins in flight and on the water calculated using MRSea and KDE models are presented in Table 5.41. These are presented at scales including both 2 km and 4 km buffers. MRSea was able to predict populations in four months only; other months are populated by aerial survey observations.

[30] The most recent razorbill population count at North Caithness is 3,507 individuals (2015)



Graph 5.11: Population estimates of razorbill (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017 (based on data not processed through MRSea)

5.25 Behaviour

The majority of the records were of birds sitting on water, notably in the post-breeding season (Table 5.39). A westerly flight direction predominated in the pre-breeding and breeding seasons, with north west and north flight directions dominating in the post-breeding and non-breeding seasons respectively (Table 5.39; Figure 5.5). An approximate east/west flight axis is formed in the breeding season. In the post-breeding season a similar pattern was observed with westerly and north westerly flight directions the least recorded. Cumulatively, westerly flight directions dominated in the pre-breeding season.

Table 5.39: Razorbill behaviour recorded from aerial surveys over Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	1	0	0	0	0	0	7	0	0	583	0	0	0	0
Breeding	0	3	2	5	3	8	16	4	0	513	0	0	2	0
Post-breeding	0	0	0	2	2	0	0	3	0	1520	0	1	1	2
Non-breeding	6	0	0	0	2	0	2	0	0	19	0	0	0	0

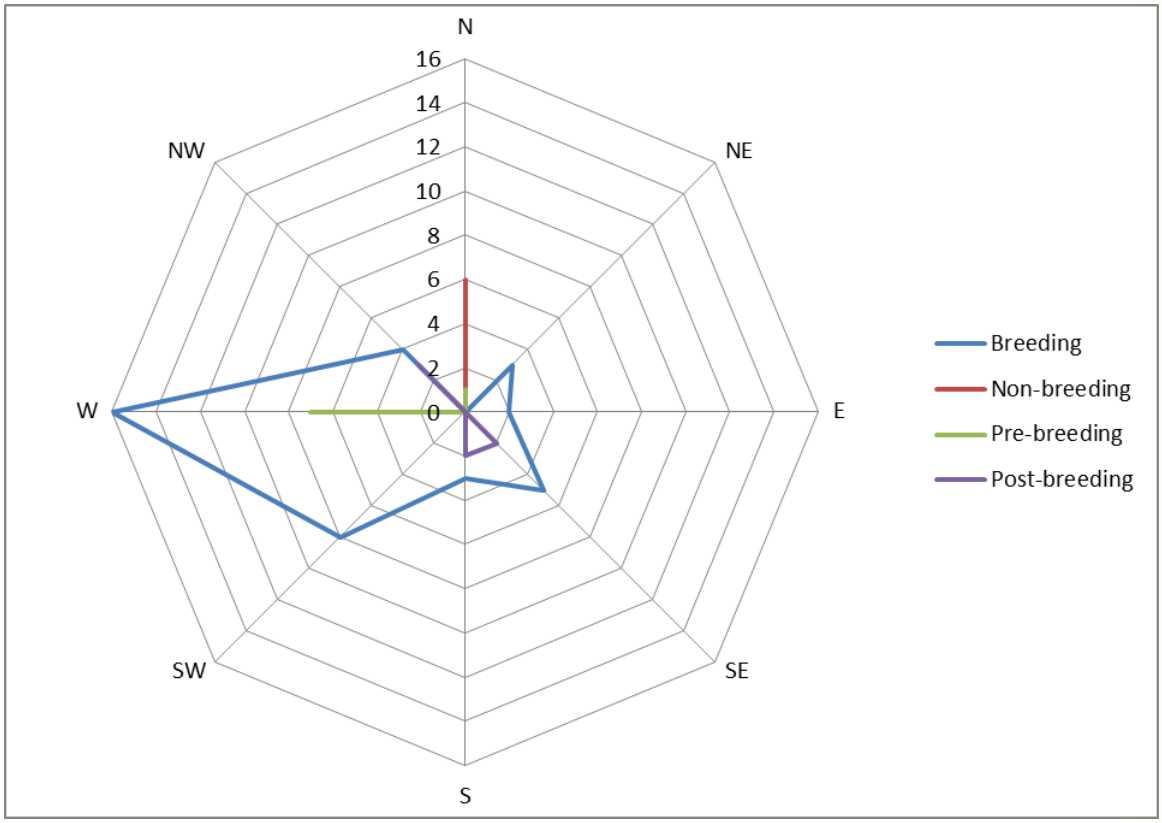


Figure 5.5: Razorbill flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

Table 5.40: Monthly population estimates and densities of razorbill in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	46	0	46	102	0	0.08	0.00	0.08	0.18	0.00
May	11	781	792	1,205	446	0.02	1.41	1.43	2.17	0.80
June	48	619	664	1,037	343	0.09	1.12	1.21	1.87	0.62
July	256	4,988	5,246	7,623	3,114	0.46	8.99	9.45	13.74	5.61
August	0	5,848	5,852	7,957	4,018	0.00	10.54	10.54	14.35	7.24
September	131	18,254	18,391	26,129	11,448	0.24	32.91	33.15	47.11	20.64
October	37	593	628	1,161	214	0.07	1.07	1.14	2.09	0.39
November	126	228	355	731	89	0.23	0.41	0.64	1.32	0.16
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	397	399	693	160	0.00	0.72	0.72	1.25	0.29
February	16	1,413	1,430	3,220	260	0.03	2.55	2.58	5.81	0.47
March	55	5,978	6,036	11,315	1,813	0.10	10.78	10.88	20.40	3.27

Table 5.41: Monthly population estimates and densities of razorbill in Moray West Site plus 2k m and 4km buffers using MRSea / KDE models

Month	Model	Population estimates (Moray West plus 2 km buffer) (no. of birds)							Population estimates (Moray West plus 4 km buffer) (no. of birds)						
		Flying	Upper confidence limit	Lower confidence limit	On water	Upper confidence limit	Lower confidence limit	Combined	Flying	Upper confidence limit	Lower confidence limit	On water	Upper confidence limit	Lower confidence limit	Combined
April	MRSea	34	91	0	3,585	17,042	2,903	3,619	45	121	0	4,172	24,479	3,458	4,217
May	Obs	44	100	0	0	0	0	44	45	101	0	0	0	0	45
June	MRSea	11	30	0	392	682	304	403	11	30	0	574	1,006	483	585
July	MRSea	35	91	0	300	581	233	335	46	101	0	459	914	394	505
August	MRSea	178	339	120	2,808	3,962	2,341	2,986	223	435	150	3,467	4,884	2,927	3,690
September	MRSea	**0**	0	0	**3,344**	4,320	2,849	3,344	0	0	0	4,218	5,390	3,666	4,218
October	MRSea	**22**	50	0	**7,765**	9,354	6,839	7,787	57	113	10	13,318	15,594	12,020	13,375
November	MRSea	34	80	0	184	378	139	218	34	82	0	388	702	313	422
December	KDE	100	241	10	78	171	0	178	102	243	10	178	334	61	280
January	Obs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
February	KDE	0	0	0	246	452	80	246	0	0	0	326	560	132	326
March	KDE	11	30	0	1,001	2,314	121	1,011	11	30	0	1,136	2,522	213	1,147

5.25.1 Conclusion

The population estimates of razorbill in the Moray West Site plus a 4 km buffer in the breeding season for July and August exceed the 1% threshold of the regional population as well as in the non-breeding season (February) and pre-breeding season (March). The 1% thresholds of the regional and national populations for razorbill are exceeded in the post-breeding season in September.

Based on the presence of an important population, razorbill is identified as a VOR and considered for further assessment in the EIA as a species with national importance and international conservation value.

The mean-maximum foraging range of razorbill (Thaxter *et al.,* 2012) from a number of SPA breeding colonies overlap with the Moray West Site plus a 4 km buffer. Based on the potential SPA connectivity and the inclusion of razorbill in the Moray East HRA, razorbill is included in the Moray West Offshore Wind Farm HRA.

5.26 Guillemot

5.26.1 Status Overview

Guillemot is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). The species is currently amber-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

Guillemot is one of the most abundant seabird species in Britain, breeding in large colonies on suitable coastal cliff habitat. Seabird 2000 recorded 1,322,830 individuals at breeding colonies in Britain (Mitchell *et al.,* 2004).

Wade *et al.,* (2016) assessed guillemot as being at high risk of displacement from wind farms and moderate risk from habitat loss due to the limited ability of the species to utilise alternative habitats. The species is considered to be at very low risk of collision with turbines due to a very low proportion of birds flying at turbine height. Maclean *et al.,* (2009) assessed auks as being at high risk of barrier effects at offshore wind farms (Table 3.1).

Guillemot is listed as a qualifying interest species for 30 SPAs and four pSPAs in the breeding season in Scotland (Table 5.42).

Table 5.42: SPAs cited for breeding guillemot in Scotland. Moray West Site lies within the mean-maximum foraging range of guillemot (84 km) from those sites in bold

SPA	Distance to Moray West Site (km)	SPA population (individuals)	
		Citation	Standard Data Form
Ailsa Craig	324.3	3,350 pairs	3,350 pairs
Buchan Ness to Collieston Coast	92.7	8,640 pairs	8,640 pairs
Calf of Eday	111.7	12,645	12,645
Canna and Sanday	219.1	5,800	5,800
Cape Wrath	110.3	13,700	13,670
Copinsay	**74.3**	**29,450**	**19,900**
East Caithness Cliffs	**19.9**	**106,700**	**106,700**

Table 5.42: SPAs cited for breeding guillemot in Scotland. Moray West Site lies within the mean-maximum foraging range of guillemot (84 km) from those sites in bold

SPA	Distance to Moray West Site (km)	SPA population (individuals)	
		Citation	Standard Data Form
Fair Isle	157.8	32,300[31]	32,300
Flannan Isles	254.6	21,930	21,930
Forth Islands	202.9	16,000 pairs	16,000 pairs
Foula	213.5	37,500	37,500
Fowlsheugh	132.0	56,450	56,450
Handa	118.9	98,686	98,686
Hermaness, Saxa Vord and Valla Field	300.2	25,000	25,000
Hoy	**64.9**	**13,400 pairs**	**13,400 pairs**
Marwick Head	101.9	37,700	37,700
Mingulay and Berneray	291.7	30,900	30,900
North Caithness Cliffs	**41.6**	**38,300[32]**	**38,300**
North Colonsay and Western Cliffs	272.6	6,656 pairs	6,656 pairs
North Rona and Sula Sgeir	188.7	43,200	43,200
Noss	235.8	38,970	38,970
Outer Firth of Forth and St Andrews Bay Complex pSPA	165.2	28,123	-
Pentland Firth pSPA	**38.2**	**34,410**	**-**
Rousay	104.2	10,600	10,600
Rum	203.6	4,000	4,000
Seas off Foula pSPA	187.5	11,142	-
Seas off St Kilda pSPA	259.5	3,147	-
Shiant Isles	182.0	18,380	18,380
St Abb's Head to Fast Castle	237.1	31,750	31,300
St Kilda	308.7	22,700	22,700
Sule Skerry and Sule Stack	126.6	6,298	6,298
Sumburgh Head	201.8	16,000	16,000
Troup, Pennan and Lion's Heads	**52.5**	**44,600**	**44,600**

[31] The most recent guillemot population count at East Caithness is 149,228individuals (2015)
[32] The most recent guillemot population count at North Caithness is 38,863 individuals (2016)

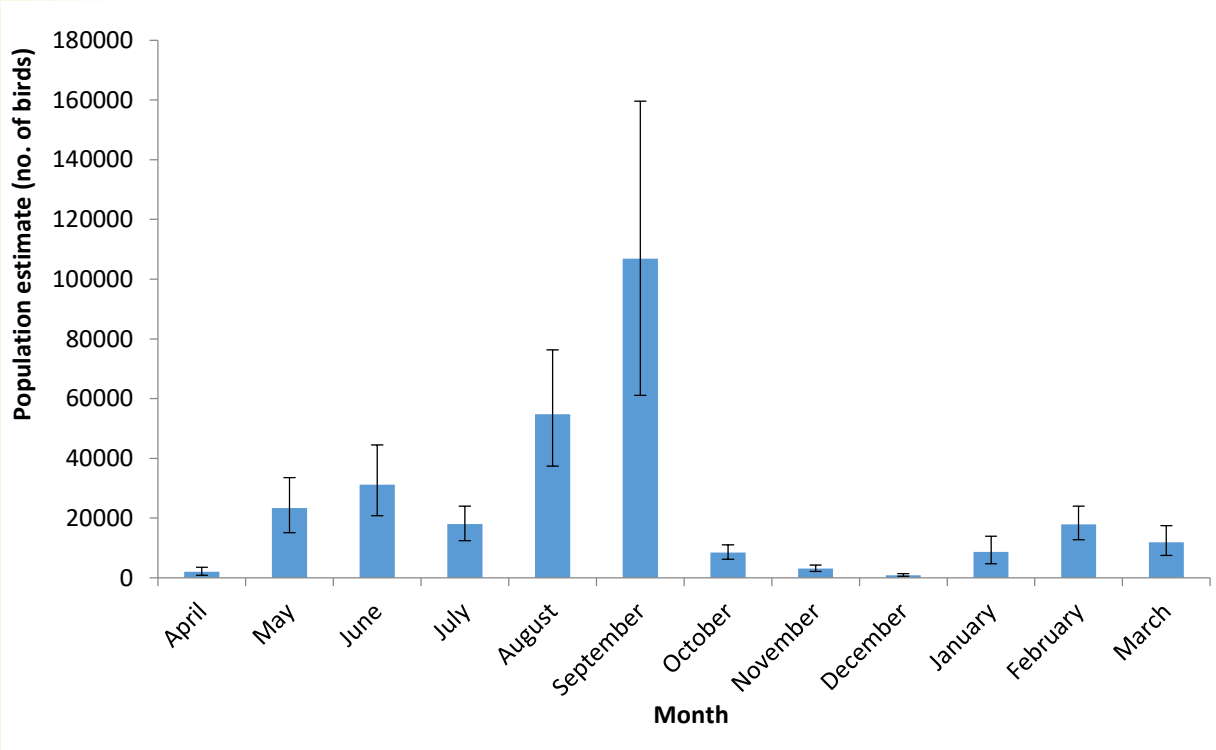
Table 5.42: SPAs cited for breeding guillemot in Scotland. Moray West Site lies within the mean-maximum foraging range of guillemot (84 km) from those sites in bold

SPA	Distance to Moray West Site (km)	SPA population (individuals)	
		Citation	Standard Data Form
West Westray	116.7	42,150	42,150

5.26.2 Seasonal Abundance and Distribution

Guillemot were recorded in all 12 of the aerial surveys undertaken across the Moray West Site plus a 4 km buffer with peak abundance occurring in September (Graph 5.12 and Table 5.44).

Population estimates of guillemots in flight and on the water calculated using MRSea and KDE models are presented in Table 5.45. These are presented at scales including both 2 km and 4 km buffers. MRSea was able to predict populations in eleven month with the remaining month (April) modelled through KDE.



Graph 5.12 Population estimates of guillemot (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017 (based on data not processed through MRSea).

5.26.3 Behaviour

The majority of the records were of birds sitting on water, notably in the non-breeding season (Table 5.43). A westerly flight direction predominated in the breeding season with a south easterly flight direction approximately forming an east/west axis (Table 5.43; Figure 5.6). Fewer birds were recorded in flight in the non-breeding season with a north/south flight axis formed by dominant southerly and north westerly flight directions.

Table 5.43: Guillemot behaviour recorded from aerial surveys over Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	N/A													
Breeding	21	54	96	185	30	94	307	133	0	7,264	0	1	20	2
Post-breeding	N/A													
Non-breeding	3	0	0	3	14	9	5	12	0	15,233	0	1	9	0

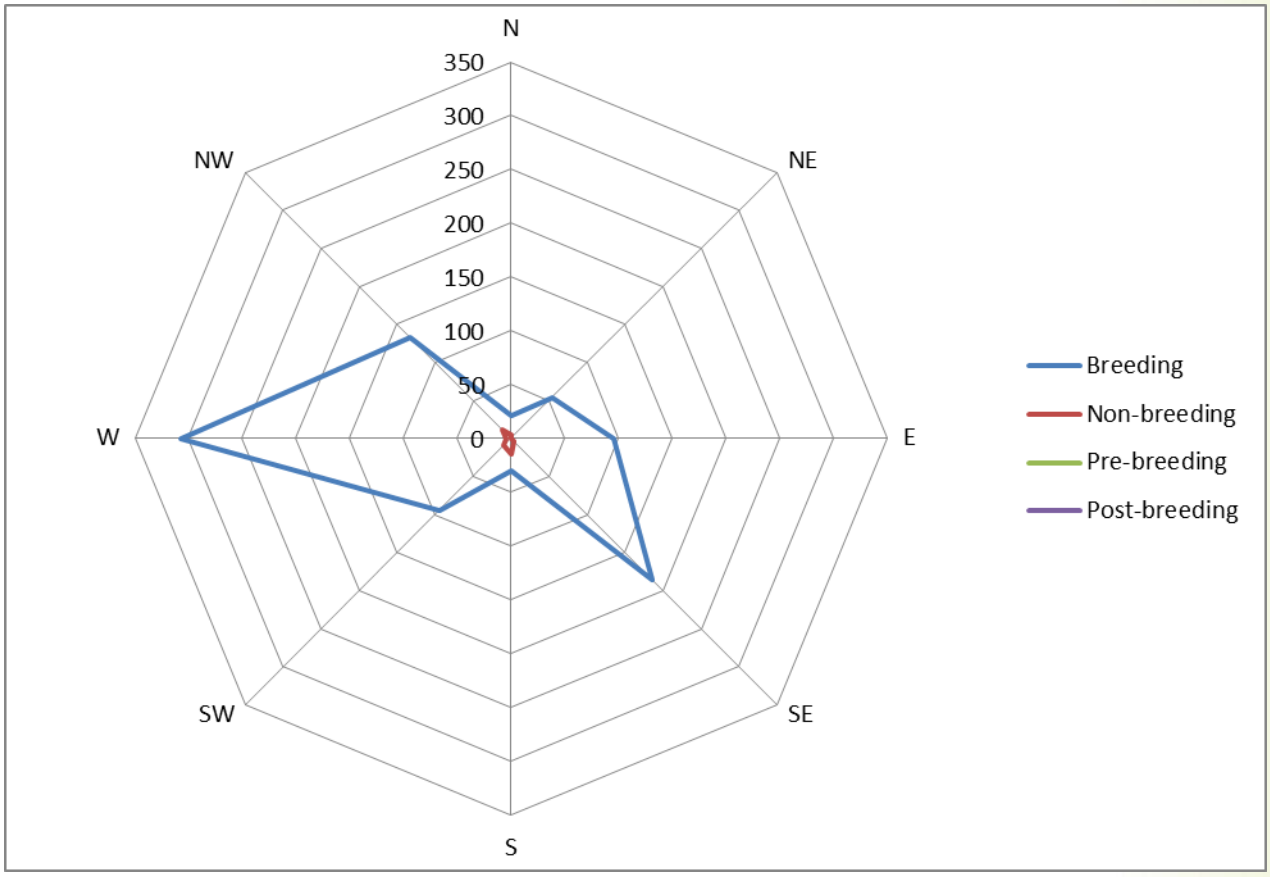


Figure 5.6: Guillemot flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

Table 5.44: Monthly population estimates and densities of guillemot in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	1,733	327	2,066	3,578	848	3.12	0.59	3.71	6.45	1.53
May	963	22,410	23,382	33,568	15,071	1.74	40.40	42.14	60.52	27.17
June	2,629	28,534	31,172	44,510	20,747	4.74	51.44	56.18	80.24	37.40
July	1,268	16,702	17,976	24,029	12,399	2.29	30.11	32.40	43.32	22.35
August	11	54,710	54,732	76,301	37,406	0.02	98.63	98.65	137.55	67.44
September	106	106,674	106,810	159,567	61,078	0.19	192.31	192.50	287.66	110.11
October	135	8,298	8,437	11,013	6,213	0.24	14.96	15.20	19.85	11.20
November	221	2,984	3,119	4,244	2,127	0.40	5.38	5.62	7.65	3.83
December	0	915	911	1,389	496	0.00	1.65	1.65	2.50	0.89
January	12	8,725	8,736	13,984	4,668	0.02	15.73	15.75	25.21	8.42
February	198	17,723	17,926	24,046	12,754	0.36	31.95	32.31	43.35	22.99
March	1,204	10,700	11,909	17,470	7,500	2.17	19.29	21.46	31.49	13.52

Table 5.45: Monthly population estimates and densities of guillemot in Moray West Site plus 2 km and 4 km buffers using MRSea / KDE models

Month	Model	Population estimates (Moray West plus 2 km buffer) (no. of birds)							Population estimates (Moray West plus 4 km buffer) (no. of birds)						
		Flying	Upper confidence limit	Lower confidence limit	On water	Upper confidence limit	Lower confidence limit	Combined	Flying	Upper confidence limit	Lower confidence limit	On water	Upper confidence limit	Lower confidence limit	Combined
April	MRSea	368	629	246	4,557	5,759	3,918	4.925	860	1,381	622	7,023	8,585	6,239	7,883
May	KDE	1143	3319	885	188	332	70	1,331	1,550	5,786	1,354	246	404	121	1,796
June	MRSea	677	1,035	490	10,226	12,510	8,798	10,903	861	1,282	631	15,844	19,068	14,268	16,705
July	MRSea	1,146	1,603	936	13,090	16,229	11,366	14.236	2,222	2,949	1,947	20,136	24,533	17,889	22,358
August	MRSea	813	1,231	638	8,726	10,507	7,649	9,539	1,107	1,652	901	11,107	13,413	9,844	22,214
September	MRSea	**11**	30	0	**27,657**	33,245	24,445	27,668	11	30	0	37,431	44,452	33,753	37,442
October	MRSea	**22**	50	0	**38,174**	43,409	34,231	38,196	46	82	10	74,154	82,794	68,167	74,200
November	MRSea	112	211	30	3,236	3,926	2,826	3,247	126	225	41	5,235	6,227	4,680	5,361
December	MRSea	134	251	40	1,059	1,400	880	1,193	178	364	51	2,006	2,510	1,721	2,184
January	MRSea	0	0	0	384	603	301	384	0	0	0	593	918	495	593
February	MRSea	0	0	0	2,692	3,420	2,278	2,692	12	41	0	6,160	7,236	5,539	6,172
March	MRSea	100	221	0	8,217	9,607	7,319	8,317	135	284	30	12,035	13,800	10,859	12,170

5.26.4 Conclusion

The population estimates of guillemot in the Moray West Site plus a 4 km buffer in the breeding season for breeding season for May, June and July exceed the 1% threshold of the national population. The 1% thresholds of the international population for guillemot is surpassed in August and September in the non-breeding season.

Based on the presence of an important population, guillemot is identified as a VOR and considered for further assessment in the EIA as a species of international importance and international conservation value.

The mean-maximum foraging range of guillemot (Thaxter *et al.,* 2012) from a number of SPA breeding colonies overlap with the Moray West Site plus a 4 km buffer. Based on the potential SPA connectivity and the inclusion of guillemot in the Moray East HRA, razorbill is included in the Moray West Offshore Wind Farm HRA.

5.27 Sandwich Tern

5.27.1 Status Overview

Sandwich tern is listed on Annex I of the EU Birds Directive (2009/147/EEC), and the species is currently amber-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

Sandwich terns are summer visitors to Britain, breeding in coastal colonies. Seabird 2000 recorded 12,490 adults on occupied nests in Britain (Mitchell *et al.,* 2004). In autumn, Sandwich terns migrate to West Africa and return the following spring (Wernham *et al.,* 2002).

Wade *et al.,* (2016) assessed Sandwich tern as being at low risk of displacement from wind farms (with a low degree of associated uncertainty) and moderate risk of habitat loss due to the species moderate ability to utilise alternative habitats. Sandwich tern is considered to be at low risk of disturbance from vessels although this conclusion has a high degree of associated uncertainty. The species is also assessed as being at high risk of collision with turbines due to the high proportion of time the species spends in flight. Maclean *et al.,* (2009) assessed terns as being at very low risk of barrier effects at offshore wind farms (Table 3.1).

Sandwich tern is listed as a qualifying interest species for three SPAs and one pSPAs in the breeding season in Scotland (Table 5.46).

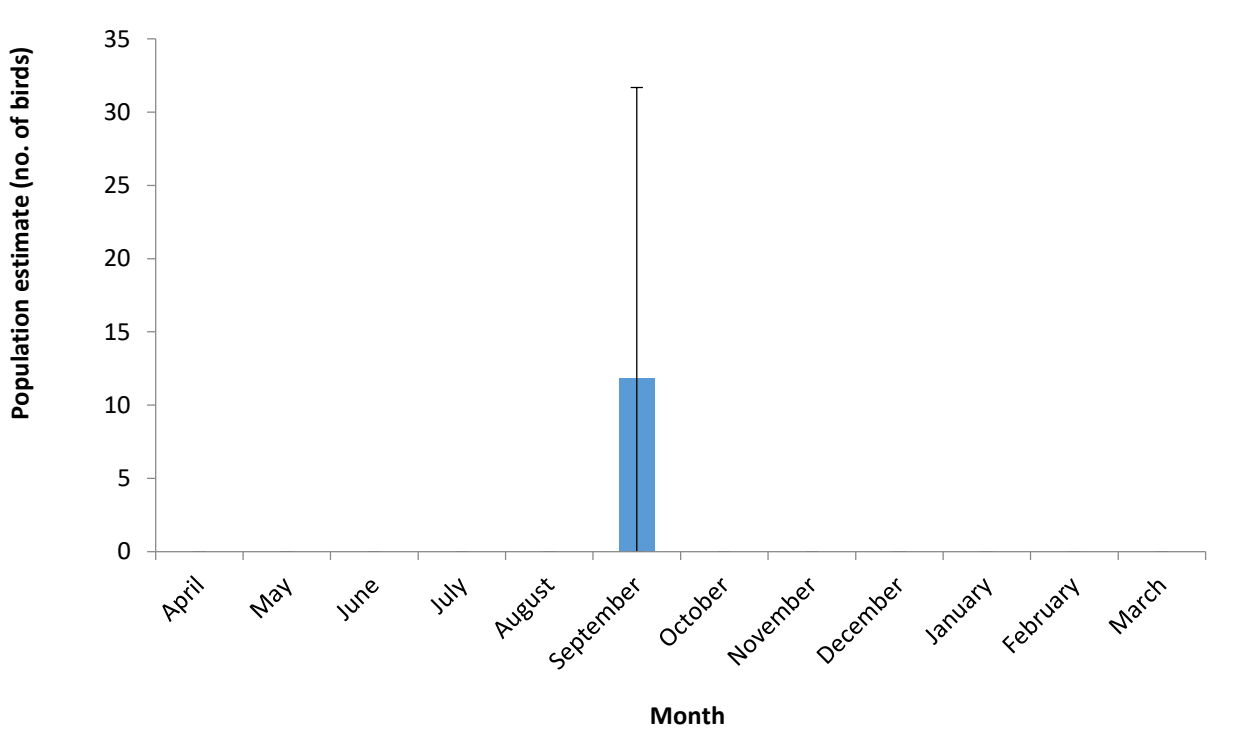
Table 5.46: SPAs cited for breeding Sandwich tern in Scotland. Moray West Site lies within the mean-maximum foraging range of Sandwich tern (49.0 km) from those sites in bold

SPA	Distance to Moray West Site (km)	SPA population (pairs)	
		Citation	Standard Data Form
Forth Islands	202.9	440	440
Loch of Strathbeg	76.2	280*	530
Ythan Estuary, Sands of Forvie and Meikle Loch	94.3	1,125*	600
Ythan Estuary, Sands of Forvie and Meikle Loch (extension [pSPA])	95.0	1,125	-

*** Citation has been identified as requiring amendment (SNH, 2017b)**

Seasonal Abundance and Distribution

5.27.1.1 Sandwich tern was recorded in one of the aerial surveys undertaken across Moray West Site plus a 4 km buffer with peak abundance occurring in September (Graph 5.13 and Table 5.47).



Graph 5.13: Population estimates of Sandwich tern (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.27.2 Behaviour

The single record involved birds flying south east.

Table 5.47: Monthly population estimates and densities of Sandwich tern in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
June	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
July	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
August	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
September	12	0	12	32	0	0.02	0.00	0.02	0.06	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

5.27.3 Conclusion

The peak population of Sandwich tern estimated during aerial surveys of the Moray West Site plus 4 km buffer was 12 birds in September. This peak population estimate does not exceed the relevant 1% thresholds of the international or national populations.

Sandwich tern is therefore not identified as a VOR and is therefore not considered for further assessment in the EIA.

The mean-maximum foraging range of Sandwich tern (Thaxter *et al.,* 2012) means that there is no potential for interaction between birds from any (p)SPA breeding colony and the Moray West Site. Sandwich tern is therefore not considered in the Moray West Offshore Wind Farm HRA.

5.28 Arctic Tern

5.28.1 Status Overview

Arctic tern is listed on Annex I of the EU Birds Directive, and the species is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al.,* 2015).

Arctic terns are summer visitors to Britain, breeding in coastal colonies, predominantly in the north. Seabird 2000 recorded 52,621 pairs in Britain (Mitchell *et al.,* 2004). In autumn, Arctic terns migrate down the west coast of Europe and Africa to the Antarctic seas for the winter, returning the following spring (Wernham *et al.,* 2002).

Wade *et al.,* (2016) assessed Arctic tern as being at low risk of displacement from wind farms and moderate risk of habitat loss due to the species moderate ability to utilise alternative habitats. The species was also considered to be at moderate risk of collision with turbines due to the high proportion of time the species spends in flight. Maclean *et al.,* (2009) assessed terns as being at very low risk of barrier effects at offshore wind farms (Table 3.1).

Arctic tern is listed as a qualifying interest species for 12 SPAs and two pSPAs in the breeding season in Scotland (Table 5.48).

Table 5.48: SPAs cited for breeding Arctic tern in Scotland. Moray West Site lies within the mean-maximum foraging range of Arctic tern (24.2 km) from those sites in bold

SPA	Distance to Moray West (km)	SPA population (pairs)	
		Citation	Standard Data Form
Auskerry	92.4	780	780
Fair Isle	157.8	1,100	1,100
Fetlar	281.2	1,065	1,065
Forth Islands	202.9	540	540
Foula	213.5	1,500	1–1,500
Mousa	220.9	1,000	767
Outer Firth of Forth and St Andrews Bay Complex pSPA	165.2	(540 — foraging birds from Forth Islands)	-
Papa Stour	244.1	850	850
Papa Westray (North Hill and Holm)	126.5	1,700*	1,950

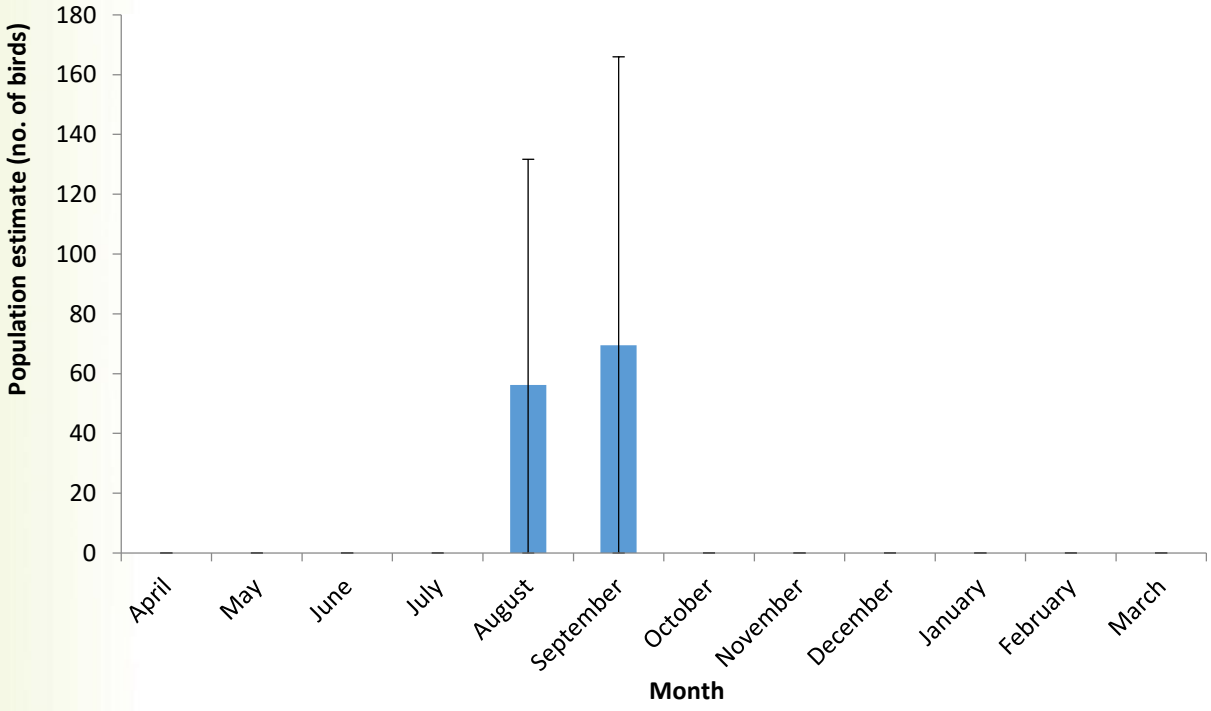
Table 5.48: SPAs cited for breeding Arctic tern in Scotland. Moray West Site lies within the mean-maximum foraging range of Arctic tern (24.2 km) from those sites in bold

SPA	Distance to Moray West (km)	SPA population (pairs)	
		Citation	Standard Data Form
Pentland Firth Islands	53.1	1,000	1,200
Pentland Firth pSPA	38.2	1,000	-
Rousay	104.2	790	790
Sumburgh Head	201.8	700	700
West Westray	116.7	1,140	1,140

*** Citation has been identified as requiring amendment (SNH, 2017b)**

5.28.2 Seasonal Abundance and Distribution

Arctic tern were recorded in two of the aerial surveys undertaken across the Moray West Site plus a 4 km buffer with peak abundance occurring in September (Graph 5.14 and Table 5.47).



Graph 5.14: Population estimates of Arctic tern (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.28.3 Behaviour

All the records were of birds in flight (Table 5.49). An east/west flight axis was formed in the breeding season with only a south eastern flight direction in the non-breeding season (Figure 5.7).

Table 5.49: Arctic tern behaviour recorded from aerial surveys over Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	N/A													
Breeding	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Post-breeding	N/A													
Non-breeding	0	0	0	2	0	0	0	0	0	0	0	0	0	0

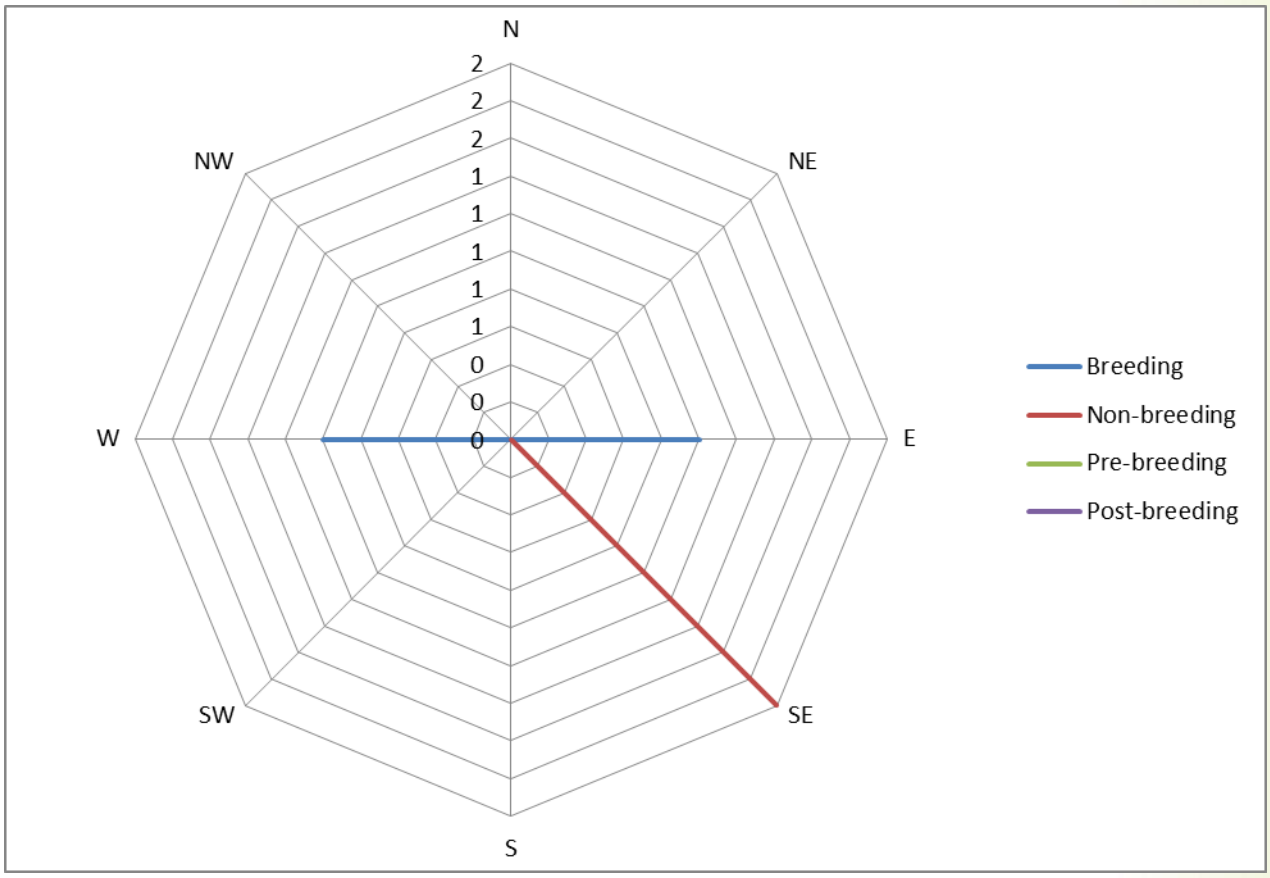


Figure 5.7: Arctic tern flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

Table 5.50: Monthly population estimates and densities of Arctic tern in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
June	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
July	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
August	22	0	56	132	0	0.04	0.00	0.10	0.24	0.00
September	71	0	70	166	0	0.13	0.00	0.13	0.30	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

5.28.4 Conclusion

The peak population of Arctic tern estimated during aerial surveys was 70 birds in September. This peak population estimate does not exceed the relevant 1% thresholds of the international or national populations.

Arctic tern is therefore not identified as a VOR and is therefore not considered for further assessment in the EIA.

The mean-maximum foraging range of Arctic tern (Thaxter *et al.,* 2012) means that there is no potential for interaction between birds from any (p)SPA breeding colony with the Moray West Site. Arctic tern is therefore not considered in the Moray West Offshore Wind Farm HRA.

5.29 Kittiwake

5.29.1 Status Overview

Kittiwake is currently red-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015). The species is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended).

Kittiwake is one of the commonest seabirds in the UK, breeding in large colonies on coastal cliff habitat. Seabird 2000 recorded 366,835 pairs in the UK, with the largest numbers on the east coast (Mitchell *et al.,* 2004). The nearest large colony to Moray West is at East Caithness Cliffs. Kittiwakes mostly prey on small fish such as sandeels as well as fishery discards (Forrester *et al.,* 2007).

Between April and July, kittiwakes are dispersed widely around the coast of Britain, with relatively high densities around the coast of Scotland where the main breeding colonies are located (Stone *et al.,* 1995).

From August to October, kittiwakes begin to disperse across the North Sea, although the predominant distribution still reflects the location of breeding colonies. From November to March, birds are dispersed over much larger areas of the North Sea, and in the southern parts, numbers peak during this period. This reflects the kittiwake's preference for pelagic habitats in winter.

Wade *et al.,* (2016) assessed kittiwake as being at low risk of displacement from wind farms and habitat loss due to the ability of the species to utilise alternative habitats. Kittiwake is however considered to be at high risk of collision with turbines due to the relatively high proportion of birds at turbine height. Maclean *et al.,* (2009) assessed gulls as being at low risk of barrier effects at offshore wind farms (Table 3.1).

Kittiwake is listed as a qualifying interest species for 29 SPAs and one pSPAs in the breeding season in Scotland (Table 5.51).

Table 5.51: SPAs cited for breeding kittiwake in Scotland. Moray West Site lies within the mean-maximum foraging range of kittiwake (60.0 km) from those sites in bold

SPA	Distance to Moray West Site (km)	SPA population (pairs)	
		Citation	Standard Data Form
Ailsa Craig	324.3	3,100	3,100
Buchan Ness to Collieston Coast	92.7	30,452	30,452
Calf of Eday	111.7	1,717	1,717
Canna and Sanday	219.1	930	930

Table 5.51: SPAs cited for breeding kittiwake in Scotland. Moray West Site lies within the mean-maximum foraging range of kittiwake (60.0 km) from those sites in bold

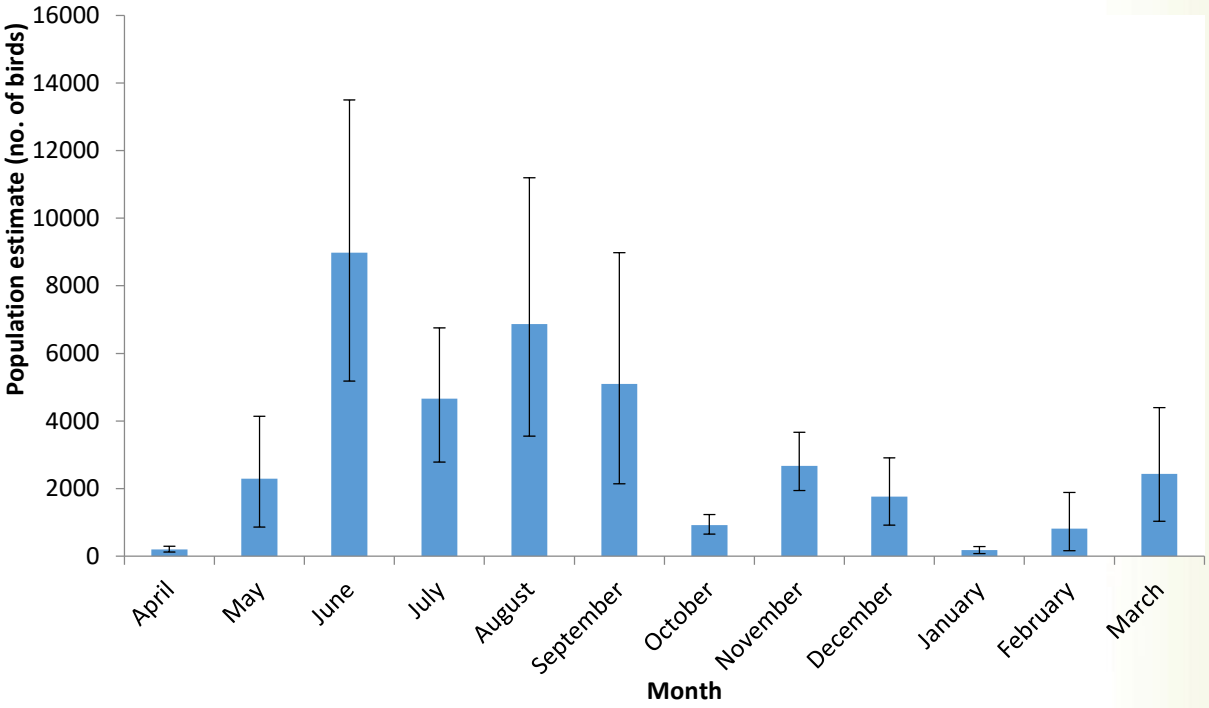
SPA	Distance to Moray West Site (km)	SPA population (pairs)	
		Citation	Standard Data Form
Cape Wrath	110.3	9,700	9,660
Copinsay	74.3	9,550	3,610
East Caithness Cliffs	**19.9**	**32,500[33]**	**32,500**
Fair Isle	157.8	18,160	58
Flannan Isles	254.6	2,780	2,780
Forth Islands	202.9	8,400	8,400
Foula	213.5	3,840	3,840
Fowlsheugh	132.0	36,650	36,650
Handa	118.9	10,732	7,420
Hermaness, Saxa Vord and Valla Field	300.2	922	922
Hoy	64.9	3,000	3,000
Marwick Head	101.9	7,700	7,110
Mingulay and Berneray	291.7	8,600	8,610
North Caithness Cliffs	**41.6**	**13,100[34]**	**15,630**
North Colonsay and Western Cliffs	272.6	4,512	4,512
North Rona and Sula Sgeir	188.7	5,000	5,000
Noss	235.8	7,020	4,270
Outer Firth of Forth and St Andrews Bay Complex pSPA	165.2	12,020 individuals	-
Rousay	104.2	4,900	Not stated
Rum	203.6	1,500	1,500
Shiant Isles	182.0	1,800	1,800
St Abb's Head to Fast Castle	237.1	21,170	21,170
St Kilda	308.7	7,830	7,800
Sumburgh Head	201.8	1,366	1,366
Troup, Pennan and Lion's Heads	**52.5**	**31,600**	**31,600**
West Westray	116.7	23,900	24,000

[33] The most recent population count of kittiwake at East Caithness is 24,460 pairs (2015)
[34] The most recent population count of kittiwake at North Caithness is 5,573 pairs (2015)

5.29.2 Seasonal Abundance and Distribution

Kittiwake were recorded in all 12 of the aerial surveys undertaken across Moray West Site plus a 4 km buffer (Graph 5.15 and Table 5.53) with a peak in abundance in June corresponding with the breeding season.

Population estimates of guillemots in flight and on the water calculated using MRSea and KDE models are presented in Table 5.45. These are presented at scales including both 2 km and 4 km buffers. MRSea was able to predict populations in eleven month with the remaining month (April) modelled through KDE.



Graph 5.15 Population estimates of kittiwake (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017 (based on data not processed through MRSea).

5.29.3 Behaviour

The majority of the records were of birds sitting on water in the breeding season (Table 5.52). A south easterly flight direction predominated in the breeding and post-breeding seasons with a flight axis approximately between south east/north west and east/west (Table 5.52; Figure 5.8). In the pre-breeding season a south westerly flight direction predominated forming a south west/north east flight axis (Table 5.52; Figure 5.8).

Table 5.52: Kittiwake behaviour recorded from aerial surveys over Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	6	17	5	21	21	42	18	15	0	188	0	0	0	0
Breeding	73	104	161	224	96	98	108	105	1	1,568	0	17	0	65
Post-breeding	38	65	109	137	110	54	34	36	0	411	0	0	0	3
Non-breeding	N/A													

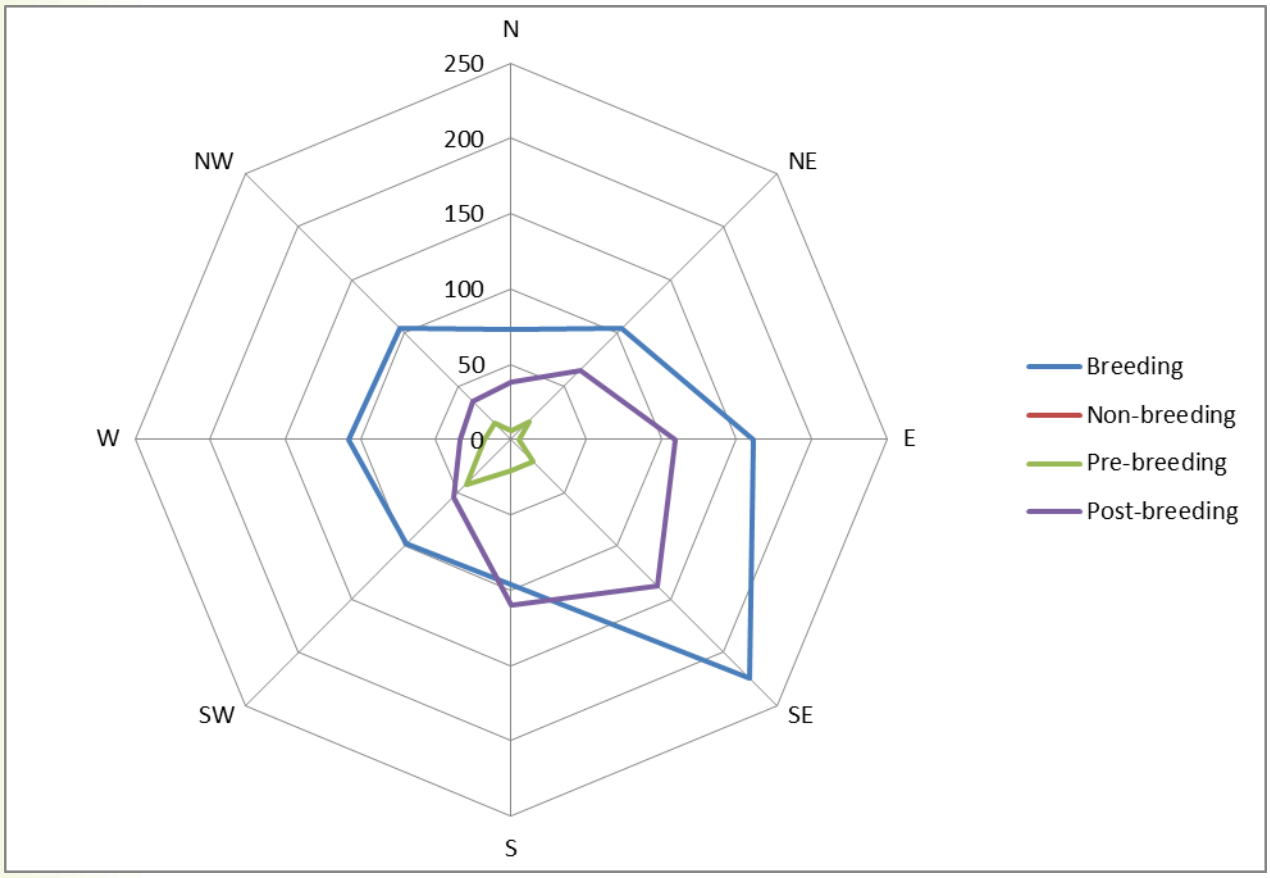


Figure 5.8: Kittiwake flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

Table 5.53: Monthly population estimates and densities of kittiwake in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	201	0	201	293	121	0.36	0.00	0.36	0.53	0.22
May	991	1,287	2,292	4,138	868	1.79	2.32	4.13	7.46	1.56
June	3,712	5,296	8,978	13,499	5,184	6.69	9.54	16.18	24.33	9.34
July	1,920	2,665	4,665	6,757	2,787	3.46	4.80	8.41	12.18	5.02
August	2,226	4,684	6,870	11,195	3,557	4.01	8.44	12.38	20.18	6.41
September	1,750	3,362	5,100	8,979	2,143	3.15	6.06	9.19	16.18	3.86
October	885	27	921	1,237	654	1.59	0.05	1.66	2.23	1.18
November	2,276	401	2,673	3,668	1,942	4.10	0.72	4.82	6.61	3.50
December	1,213	551	1,766	2,914	920	2.19	0.99	3.18	5.25	1.66
January	170	12	185	290	81	0.31	0.02	0.33	0.52	0.15
February	268	541	812	1,883	162	0.48	0.98	1.46	3.39	0.29
March	927	1,508	2,433	4,397	1,031	1.67	2.72	4.38	7.93	1.86

Table 5.54: Monthly population estimates and densities of kittiwake in Moray West Site plus 2 km and 4 km buffer using MRSea / KDE models

Month	Model	Population estimates (Moray West plus 2 km buffer) (no. of birds)							Population estimates (Moray West plus 4 km buffer) (no. of birds)						
		Flying	Upper confidence limit	Lower confidence limit	On water	Upper confidence limit	Lower confidence limit	Combined	Flying	Upper confidence limit	Lower confidence limit	On water	Upper confidence limit	Lower confidence limit	Combined
April	KDE	90	161	30	0	0	0	90	201	293	121	0	0	0	
May	MRSea	645	942	500	635	994	491	1,280	878	1,291	688	1,115	1,697	889	
June	MRSea	1,945	2,619	1,597	3,231	6,175	2,303	5,176	3,366	4,277	2,891	4,640	8,658	3,446	
July	MRSea	1,234	1,605	1,043	1,955	3,601	1,448	3,189	1,753	2,223	1,495	2,388	4,357	1,815	
August	MRSea	1,647	2,676	1,259	4,007	6,387	2,909	5,654	2,019	3,294	1,599	4,224	6,803	3,092	
September	MRSea	963	1,382	788	1,470	10,865	993	2,433	1,480	2,141	1,250	3,148	17,047	2,325	
October	MRSea	583	769	479	39	84	0	622	799	1,061	663	23	51	0	
November	MRSea	1,378	1,664	1,187	212	20,249	127	1,590	2,064	2,497	1,801	373	158,169	326	
December	MRSea	786	1,093	625	364	1,389	242	2,740	1,059	1,477	859	469	3,245	358	
January	KDE	100	171	40	0	0	0	100	170	275	71	11	31	0	
February	KDE	191	332	91	440	1,157	0	631	268	436	132	451	1,175	20	
March	MRSea	590	798	477	1,074	1,676	792	1,664	844	1,142	689	1,335	2,140	1,031	

5.29.4 Conclusion

The population estimates of kittiwake in Moray West Site plus a 4 km buffer in the breeding season for June and August exceed the 1% threshold of the regional population and surpass the 1% thresholds of the national populations in June.

Kittiwake is therefore identified as a VOR and considered for further assessment in the EIA as a species of national importance and international conservation value.

The mean-maximum foraging range of kittiwake (Thaxter *et al.,* 2012) means that there is potential for interaction between birds from a number of SPA breeding colonies and Moray West. Taking into account the foraging range overlap with Moray West and the inclusion of kittiwake in the Moray East HRA, kittiwake is included in the Moray West Offshore Wind Farm HRA.

5.30 Little Gull

5.30.1 Status Overview

Little gull is listed on Annex I of the EU Birds Directive and Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). It is currently green-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

Little gull occurs on passage in the North Sea in spring and autumn with autumn concentrations known in Scotland from the Firth of Forth and Firth of Tay (Stone *et al.,* 1995).

Garthe and Hüppop (2004) assessed little gull as being at low risk of collision with turbines and displacement due to the moderate proportion of birds at turbine height and the moderate ability of the species to use alternative habitats. The species was considered to be at moderate risk of habitat loss. Maclean *et al.,* (2009) assessed gulls as being at low risk of barrier effects from offshore wind farms. (Table 3.1).

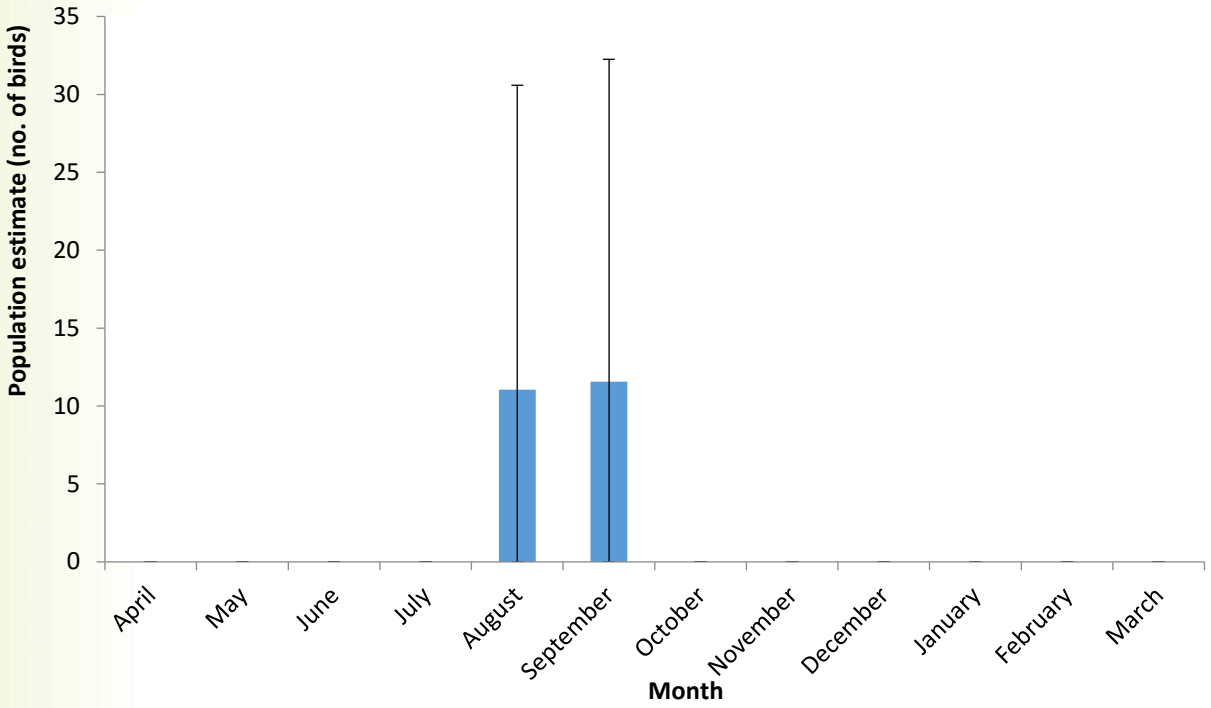
Little gull is listed as a qualifying interest species for one pSPAs in the breeding season in Scotland (Table 5.55).

Table 5.55: SPAs cited for wintering little gull in Scotland.

SPA	Distance to Moray West Site (km)	SPA population (individuals)	
		Citation	Standard Data Form
Outer Firth of Forth and St Andrews Bay Complex pSPA	165.2	126	-

5.30.2 Seasonal Abundance and Distribution

Little gull were recorded in two of the aerial surveys undertaken across Moray West Site plus a 4 km buffer (Graph 5.16 and Table 5.53) with a peak in abundance in August and September corresponding with the passage period for post-breeding adults and juveniles (Forrester *et al.,* 2007).



Graph 5.16: Population estimates of little gull (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.30.3 Behaviour

All the records were of birds in flight (Table 5.56). An east/west flight axis was formed in the non-breeding season (Figure 5.9).

Table 5.56: Little gull behaviour recorded from aerial surveys over Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	N/A													
Breeding	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Post-breeding	N/A													
Non-breeding	0	0	1	0	0	0	1	0	0	0	0	0	0	0

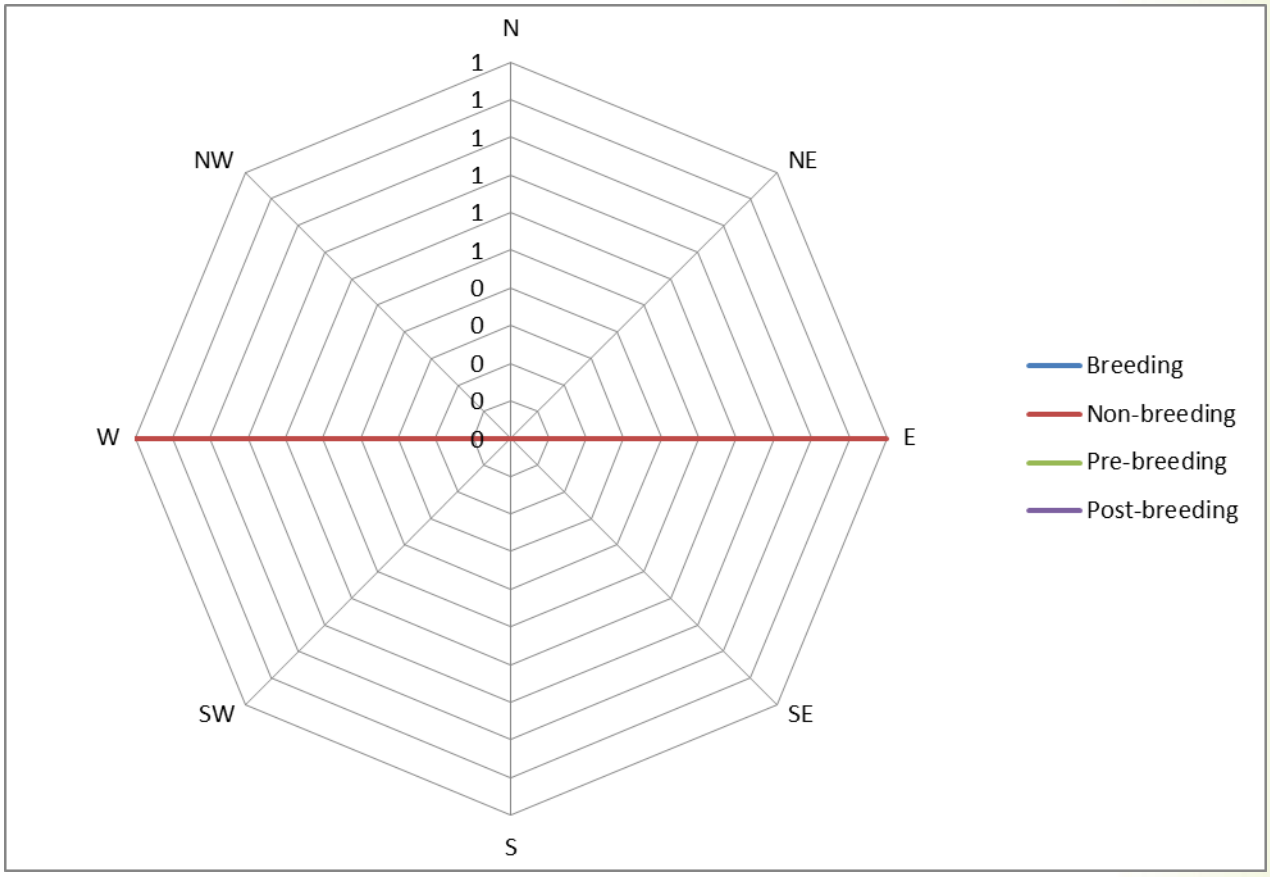


Figure 5.9: Little gull flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

Table 5.57: Monthly population estimates and densities of little gull in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
June	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
July	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
August	11	0	11	31	0	0.02	0.00	0.02	0.06	0.00
September	12	0	12	32	0	0.02	0.00	0.02	0.06	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

5.30.4 Conclusion

The peak population of little gull estimated during aerial surveys was 12 birds in September. This peak population estimate does not exceed the relevant 1% thresholds of the international or national populations. Based on the absence of an important population, little gull is not identified as a VOR and is not considered for further assessment in the EIA.

Little gull was not included in the Moray East HRA and on the advice of Marine Scotland (2017), little gull is not included in the Moray West Offshore Wind Farm HRA.

5.31 Common Gull

5.31.1 Status Overview

Common gull is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). The species is currently amber-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

Common gulls are common and widespread in the UK in lowland, urban and coastal areas in winter, and at breeding colonies in coastal and inland locations in summer. Seabird 2000 recorded 48,163 pairs of common gulls breeding in Britain (Mitchell *et al.,* 2004). Common gulls typically feed on farmland, playing fields, estuaries and in coastal waters, and are comparatively uncommon offshore (Forrester *et al.,* 2007; Stone *et al.,* 1995). The UK wintering population of common gull has been estimated at over 700,000 individuals (Burton *et al.,* 2012).

Wade *et al.,* (2016) assessed common gull as being at low risk of displacement from wind farms and habitat loss due to the species ability to use a wide range of habitats. However, the species is assessed as being at very high risk from collision with turbines due to the relatively high proportion of birds at turbine height. Maclean *et al.,* (2009) assessed gulls as being at low risk of barrier effects at offshore wind farms (Table 3.1).

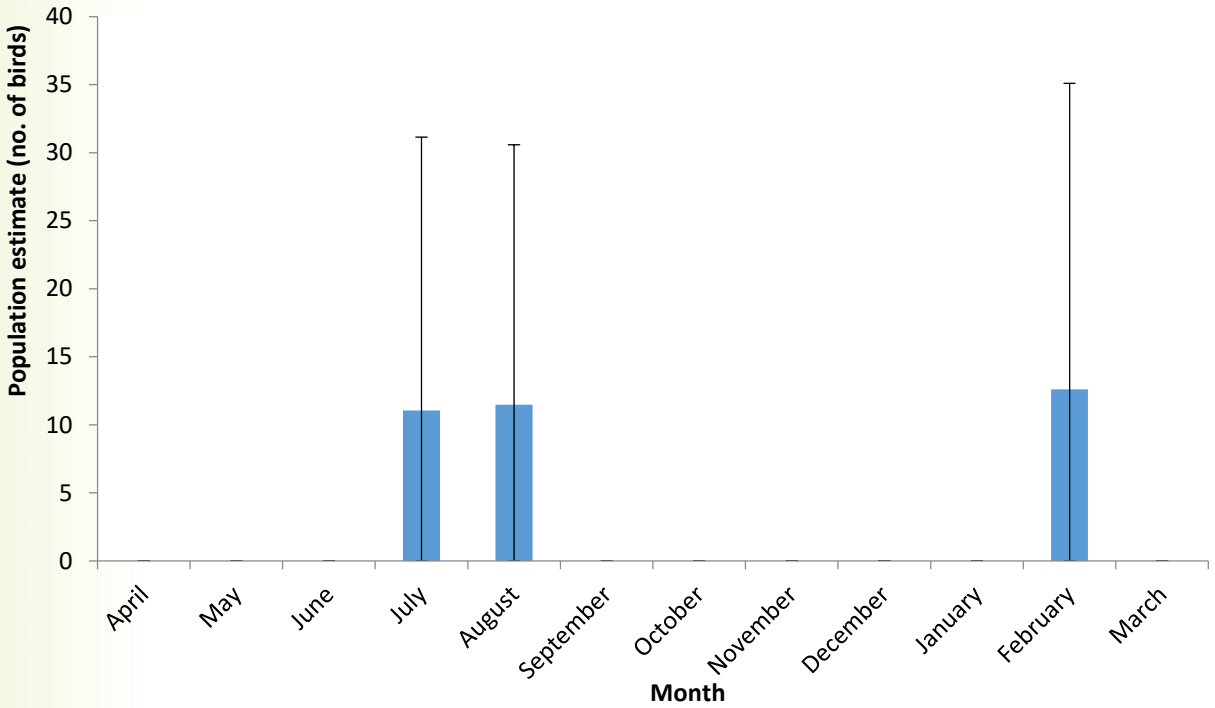
Common gull is listed as a qualifying interest species for two pSPAs in the breeding season in Scotland (Table 5.58).

Table 5.58: SPAs cited for wintering common gull in Scotland.

SPA	Distance to Moray West Site (km)	SPA population (individuals)	
		Citation	Standard Data Form
Outer Firth of Forth and St Andrews Bay Complex pSPA	165.2	14,647	-
Solway Firth pSPA	331.9	12,486	-

5.31.2 Seasonal Abundance and Distribution

Common gull were recorded in three of the aerial surveys undertaken across Moray West Site plus a 4 km buffer with peak abundance occurring in February (Graph 5.17 and Table 5.60).



Graph 5.17: Population estimates of common gull (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.31.3 Behaviour

Birds were only recorded in flight; one record of an easterly flight direction in the breeding season and one record of a south easterly flight direction in the non-breeding season (Table 5.59; Figure 5.10).

Table 5.59: Common gull behaviour recorded from aerial surveys over Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	N/A													
Breeding	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Post-breeding	N/A													
Non-breeding	0	0	0	1	0	0	0	0	0	0	0	0	0	0

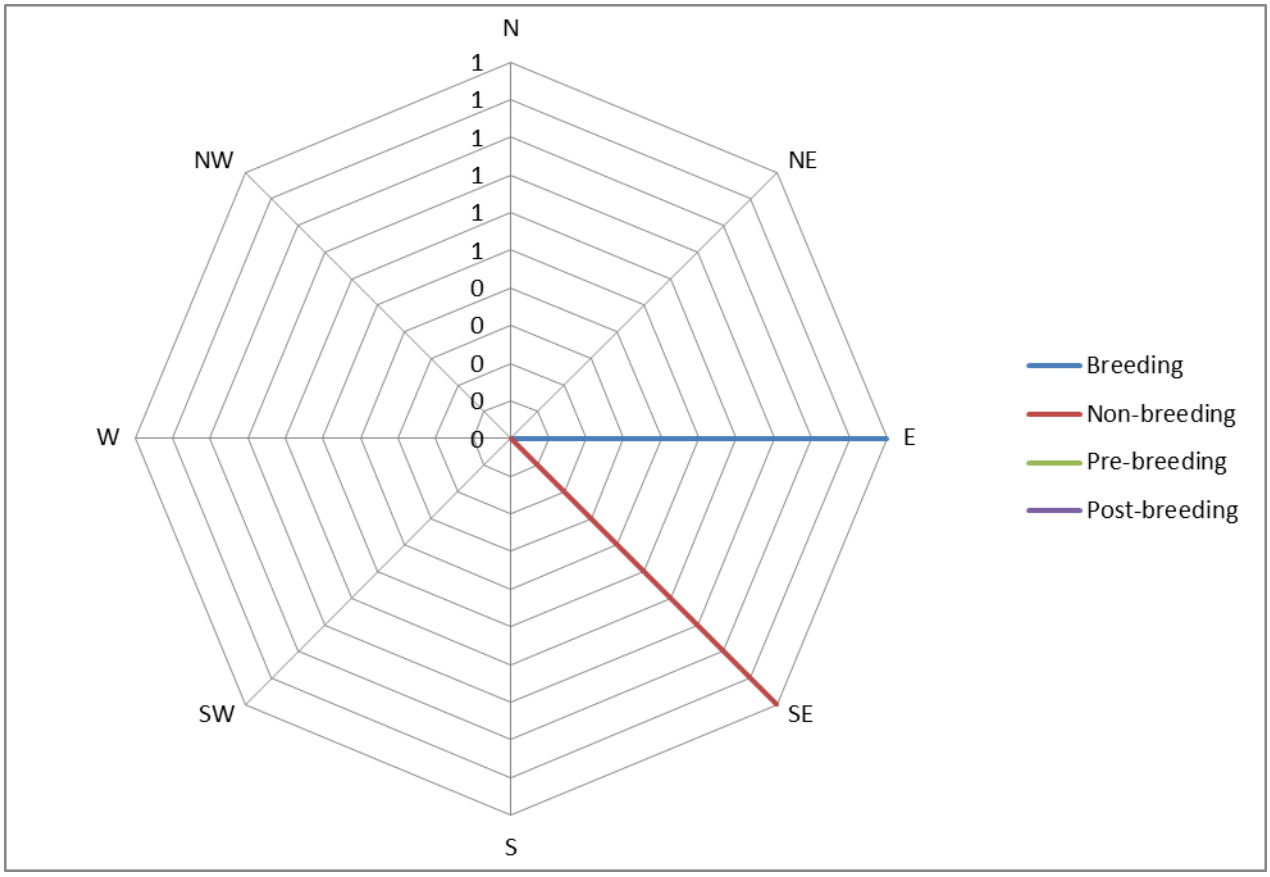


Figure 5.10: Common gull flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

Table 5.60: Monthly population estimates and densities of common gull in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
June	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
July	0	11	11	31	0	0.00	0.02	0.02	0.06	0.00
August	11	0	11	31	0	0.02	0.00	0.02	0.06	0.00
September	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	11	0	13	35	0	0.02	0.00	0.02	0.06	0.00
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

5.31.4 Conclusion

The peak population of common gull estimated during aerial surveys was 13 birds in February. This peak population estimate does not exceed the relevant 1% thresholds of the international or national populations.

Common gull is therefore not identified as a VOR and is therefore not considered for further assessment in the EIA.

The mean-maximum foraging range of common gull (Thaxter *et al.,* 2012) means there is no potential for interaction between birds from any (p)SPA breeding colony and the Moray West Site. Therefore common gull is not included in the Moray West Offshore Wind Farm HRA.

5.32 Lesser Black-backed Gull

5.32.1 Status Overview

Lesser black-backed gull is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). The species is currently amber-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

Lesser black-backed gulls are common and widespread in the UK in summer, and breed in colonies in coastal and inland locations. Seabird 2000 recorded 111,835 pairs in Britain (Mitchell *et al.,* 2004). In winter, many birds leave northern areas between November and March, although some remain all year, particularly in the south-west (Forrester *et al.,* 2007). The UK wintering population of lesser black-backed gull has been estimated at over 125,000 individuals (Burton *et al.,* 2012). Lesser black-backed gulls take a wide variety of prey and scavenged food, both at sea, and on farmland and refuse sites (Forrester *et al.,* 2007).

Wade *et al.,* (2016) assessed lesser black-backed gull as being at low risk of displacement from wind farms and very low risk of habitat loss due to the species ability to use a wide range of habitats. However, the species is assessed as being at very high risk of collision with turbines due to the relatively high proportion of birds at turbine height. Maclean *et al.,* (2009) assessed gulls as being at low risk of barrier effects at offshore wind farms (Table 3.1).

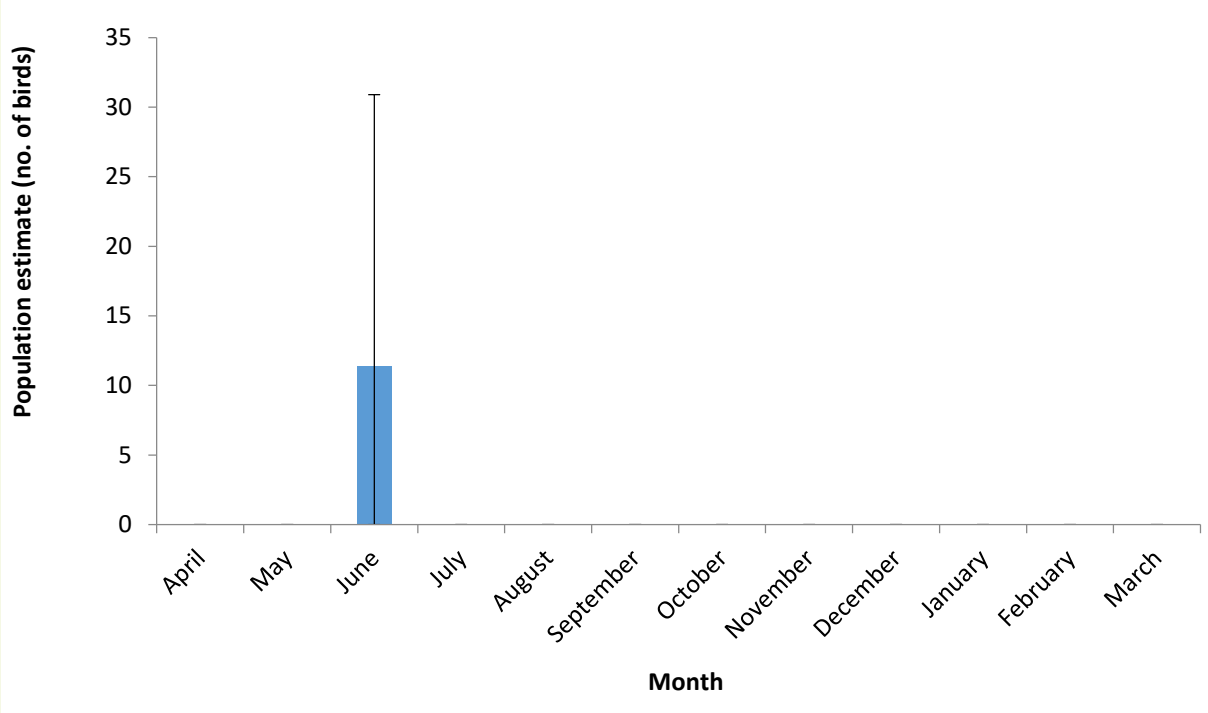
Lesser black-backed gull is listed as a qualifying interest species for two SPAs in the breeding season in Scotland (Table 5.61).

Table 5.61: SPAs cited for breeding lesser black-backed gull in Scotland. Moray West Site lies within the mean-maximum foraging range of lesser black-backed gull (141.0 km) from those sites in bold

SPA	Distance to Moray West Site (km)	SPA population (pairs)	
		Citation	Standard Data Form
Ailsa Craig	324.3	1,800	1,800
Forth Islands	202.9	1,500	1,500

5.32.2 Seasonal Abundance and Distribution

5.32.2.1 Lesser black-backed gull were recorded in one of the aerial surveys undertaken across Moray West Site plus a 4 km buffer with peak abundance occurring in June (Graph 5.18 and Table 5.62).



Graph 5.18: Population estimates of lesser black-backed gull (with 95% confidence intervals) estimated from aerial surveys undertaken across the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.32.3 Behaviour

The single record involved birds sitting on water.

Table 5.62: Monthly population estimates and densities of lesser black-backed gull in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
June	0	12	11	31	0	0.00	0.02	0.02	0.06	0.00
July	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
August	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
September	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
January	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
February	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

5.32.4 Conclusion

The peak population of lesser black-backed gull estimated during aerial surveys was 11 birds in June. This peak population estimate does not exceed the relevant 1% thresholds of the international or national populations.

Lesser black-backed gull is therefore not identified as a VOR and is therefore not considered for further assessment in the EIA.

The mean-maximum foraging range of lesser black-backed gull (Thaxter *et al.,* 2012) means there is no potential for interaction between birds from any (p)SPA breeding colony and the Moray West Site. Lesser black-backed gull is therefore not included in the Moray West Offshore Wind Farm HRA.

5.33 Herring Gull

5.33.1 Status Overview

Herring gull is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). The species is currently red-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

Herring gulls are resident, common and widespread, breeding in colonies in coastal and inland locations. Seabird 2000 recorded 142,942 pairs in Britain (Mitchell *et al.,* 2004). There is a general movement southwards in winter months (Forrester *et al.,* 2007) with the UK wintering population estimated at over 740,000 individuals (Burton *et al.,* 2012). Herring gulls exploit a wide range of food sources, including scraps and offal from trawlers, as well as on land at refuse dumps and farm land (Forrester *et al.,* 2007).

Wade *et al.,* (2016) has assessed herring gull as being low risk from displacement from wind farms and very low risk of habitat loss due to the species ability to use a wide range of habitats. The species is considered to be at very high risk of collision with turbines due to the relatively high proportion of birds at turbine height. Maclean *et al.,* (2009) assessed gulls as being at low risk of barrier effects at offshore wind farms (Table 3.1).

Herring gull is listed as a qualifying interest species for eight SPAs and two pSPAs in the breeding season in Scotland (Table 5.63).

Table 5.63: SPAs cited for breeding herring gull in Scotland. Moray West Site lies within the mean-maximum foraging range of herring gull (61.1 km) from those sites in bold

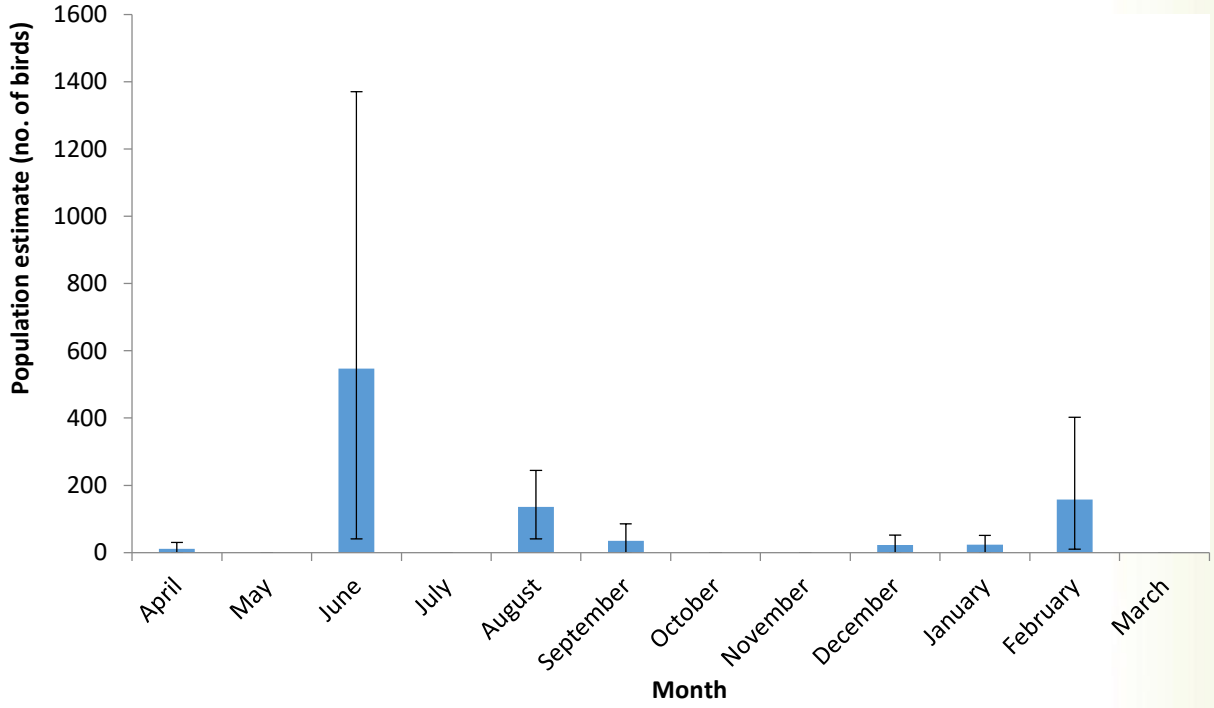
SPA	Distance to Moray West Site (km)	SPA population (pairs)	
		Citation	Standard Data Form
Ailsa Craig	324.3	2,250	2,250
Buchan Ness to Collieston Coast	92.7	4,292	4,292
Canna and Sanday	219.1	1,300	1,300
East Caithness Cliffs	**19.9**	**9,400**[35]	**9,400**
Forth Islands	202.9	6,600	6,600
Fowlsheugh	132.0	3,190	3,190
Outer Firth of Forth and St Andrews Bay Complex pSPA	165.2	3,044 individuals	-

[35] The most recent population count of herring gull at East Caithness Cliffs was of 3,267 pairs (2015)

Table 5.63: SPAs cited for breeding herring gull in Scotland. Moray West Site lies within the mean-maximum foraging range of herring gull (61.1 km) from those sites in bold			
SPA	**Distance to Moray West Site (km)**	**SPA population (pairs)**	
		Citation	**Standard Data Form**
Solway Firth pSPA	331.9	3,034	-
St Abb's Head to Fast Castle	237.1	1,160	1,160
Troup, Pennan and Lion's Heads	**52.5**	**4,200**	**4,200**

5.33.2 Seasonal Abundance and Distribution

Herring gull were recorded in seven of the aerial surveys undertaken across the Moray West Site plus a 4 km buffer with peak abundance occurring in June (Graph 5.19 and Table 5.65). Although MRSea analysis for herring gull was carried out, there were two few observations for modelling to provide appropriate outputs.



Graph 5.19: Population estimates of herring gull (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017.

5.33.3 Behaviour

The majority of the records were of birds sitting on water in the breeding season and of birds in flight in the non-breeding season (Table 5.64). A north westerly flight direction predominated in the breeding season forming a north west/south east flight axis (Table 5.64; Figure 5.11). A south easterly flight direction predominated in the non-breeding season also forming a north west/south east flight axis (Table 5.64; Figure 5.11).

Table 5.64: Herring gull behaviour recorded from aerial surveys over Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	N/A													
Breeding	2	1	2	4	0	1	1	15	0	40	0	1	0	0
Post-breeding	N/A													
Non-breeding	0	2	1	5	0	0	1	3	0	9	0	0	0	0

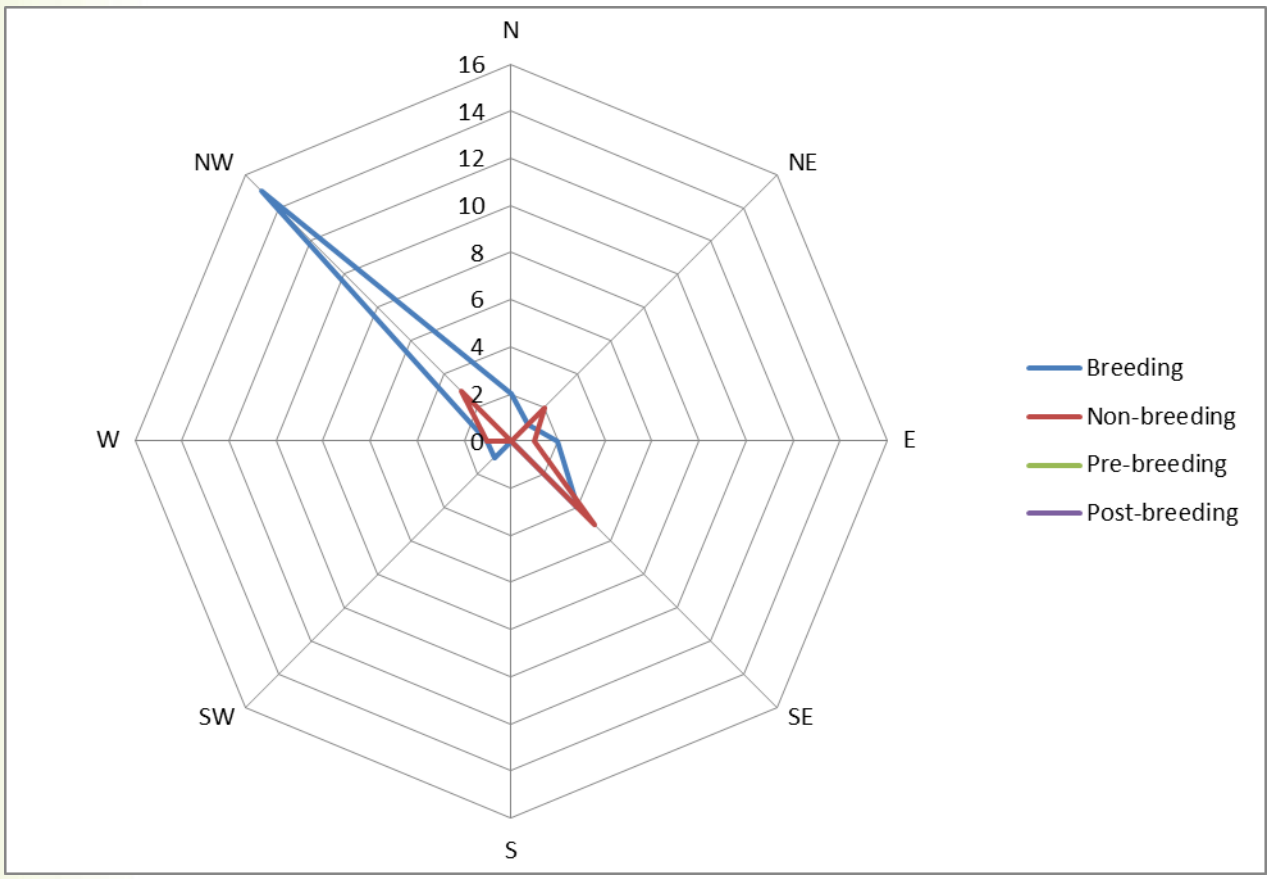


Figure 5.11: Herring gull flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

Table 5.65: Monthly population estimates and densities of herring gull in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	11	11	30	0	0.00	0.02	0.02	0.05	0.00
May	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
June	247	305	547	1370	41	0.45	0.55	0.99	2.47	0.07
July	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
August	23	112	136	244	41	0.04	0.20	0.24	0.44	0.07
September	0	36	35	85	0	0.00	0.07	0.06	0.15	0.00
October	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
November	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
December	23	0	23	52	0	0.04	0.00	0.04	0.09	0.00
January	23	0	23	52	0	0.04	0.00	0.04	0.09	0.00
February	56	100	158	402	10	0.10	0.18	0.28	0.72	0.02
March	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00

5.33.4 Conclusion

The peak population of herring gull estimated during aerial surveys exceeded the regional 1% threshold in June and August. The peak population estimate does not exceed the relevant 1% thresholds of the international or national populations in any month.

Herring gull is therefore identified as a VOR and considered for further assessment in the EIA as a species with a regional importance and international conservation value.

The mean-maximum foraging range of herring gull (Thaxter *et al.,* 2012) means is potential for interaction between birds from three SPAs and Moray West. Tracking of herring gulls at the East Caithness Cliffs SPA was carried out in 2014 through funding from Moray Offshore Renewables Ltd and Beatrice Offshore Wind Farm (Archibald *et al.,* 2014). A total of 10 herring gulls were tagged, with data being yielded from seven of these. All birds remained in coastal waters with no evidence of offshore trips. No overlap of foraging flights with the Moray West Site was noted.

Based on the potential SPA connectivity (albeit not confirmed through tracking studies) and the inclusion of herring gull in the Moray East Appropriate Assessment, herring gull is included in the Moray West Offshore Wind Farm Appropriate Assessment.

5.34 Great Black-backed Gull

5.34.1 Status Overview

Great black-backed gull is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). The species is currently amber-listed on the UK Birds of Conservation Concern (Eaton *et al.,* 2015).

Great black-backed gull is a common resident species in the UK, occurring in coastal areas. Seabird 2000 recorded 17,394 pairs in Britain, with largest numbers on western coasts (Mitchell *et al.,* 2004). Great black-backed gulls are omnivorous, foraging at sea, on estuaries and beaches, and less commonly at rubbish dumps (Forrester *et al.,* 2007).

Great black-backed gull is a relatively common breeding species in Great Britain. During the pre-breeding and breeding season their distribution tends to be limited to coastal areas. During the winter they are a much more widely dispersed species and often travel long distances in pursuit of discards from fishing vessels (Stone *et al.,* 1995). The UK wintering population of great black-backed gull has been estimated at over 76,000 individuals (Burton *et al.,* 2012). The flyway population in the North Sea is estimated at 480,000 birds with 5.2% of the biogeographic population flying over the southernmost part of this area (Stienen *et al.,* 2007).

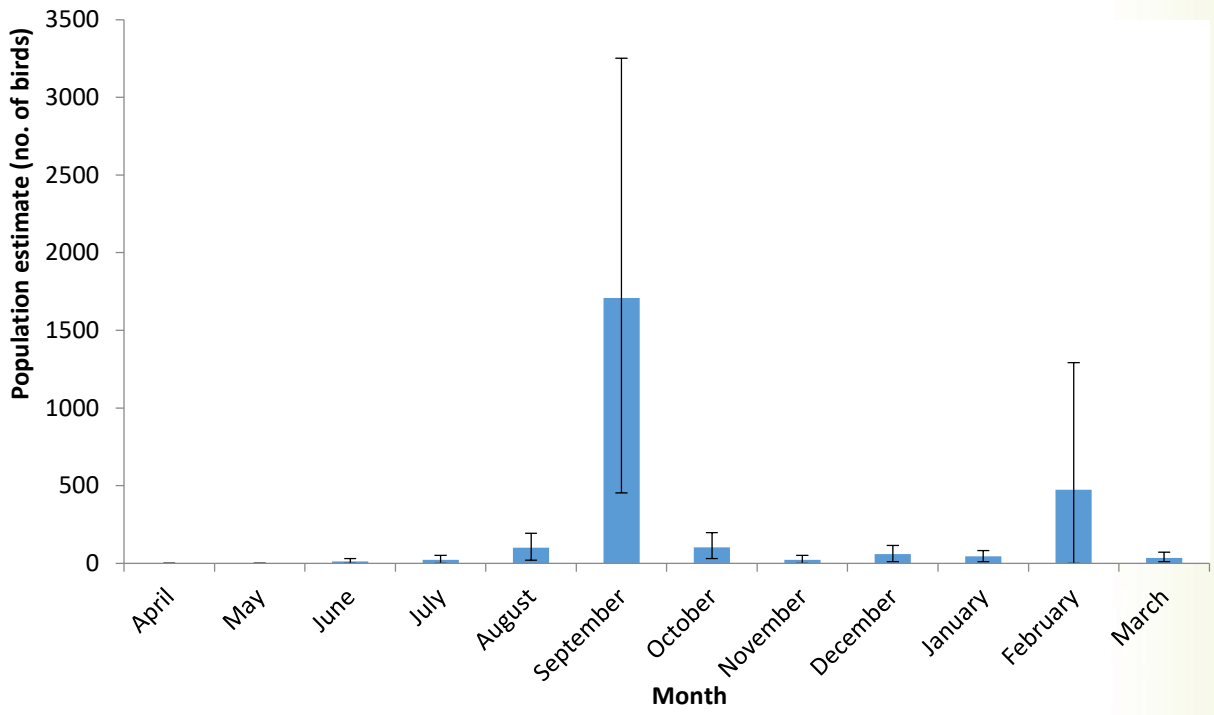
Wade *et al.,* (2016) assessed great black-backed gull as being at low risk of displacement from wind farms and very low risk of habitat loss due to the species ability to use a wide range of habitats. The species is considered to be at very high risk of collision with turbines due to the relatively high proportion of birds at turbine height. Maclean *et al.,* (2009) assessed gulls as being at low risk of barrier effects at offshore wind farms (Table 3.1).

Great black-backed gull is listed as a qualifying interest species for five SPAs in the breeding season in Scotland (Table 5.66).

Table 5.66: SPAs cited for breeding great black-backed gull in Scotland. Moray West Site lies within the maximum foraging range[36] of great black-backed gull from those sites in bold			
SPA	**Distance to Moray West Site (km)**	**SPA population (pairs)**	
		Citation	**Standard Data Form**
Calf of Eday	111.7	938	938
Copinsay	74.3	490	600
East Caithness Cliffs	**19.9**	**800[37]**	**850**
Hoy	64.9	570	570
North Rona and Sula Sgeir	188.7	730	730

5.34.2 Seasonal Abundance and Distribution

Great black-backed gull were recorded in 10 of the aerial surveys undertaken across the Moray West Site plus a 4 km buffer with peak abundance occurring in September followed by a secondary peak in February (Graph 5.20 and Table 5.68).



Graph 5.20: Population estimates of great black-backed gull (with 95% confidence intervals) estimated from aerial surveys undertaken across Moray West Site plus a 4 km buffer between April 2016 and March 2017.

[36] Based on tracking study results given in Archibald *et al.* (2014)
[37] The most recent population count from East Caithness Cliffs is 266 pairs (2015).

5.34.3 Behaviour

The majority of the records were of birds sitting on water in the breeding season and non-breeding season (Table 5.64). The only record of birds in flight in the breeding season was of birds moving in a north easterly direction (Figure 5.12). There was no clear pattern of flight direction in the non-breeding season although a south easterly flight direction predominated (Figure 5.12).

Table 5.67: Great black-backed gull behaviour recorded from aerial surveys over Moray West Site plus a 4 km buffer between April 2016 and March 2017 (number of records).

Season	Flying North	Flying North East	Flying East	Flying South East	Flying South	Flying South West	Flying West	Flying North West	Loafing	Sitting	Stationary	Taking off	Diving	Flying (direction unknown)
Pre-breeding	N/A													
Breeding	0	1	0	0	0	0	0	0	0	11	0	0	0	0
Post-breeding	N/A													
Non-breeding	1	5	7	10	4	8	2	2	0	160	0	1	0	1

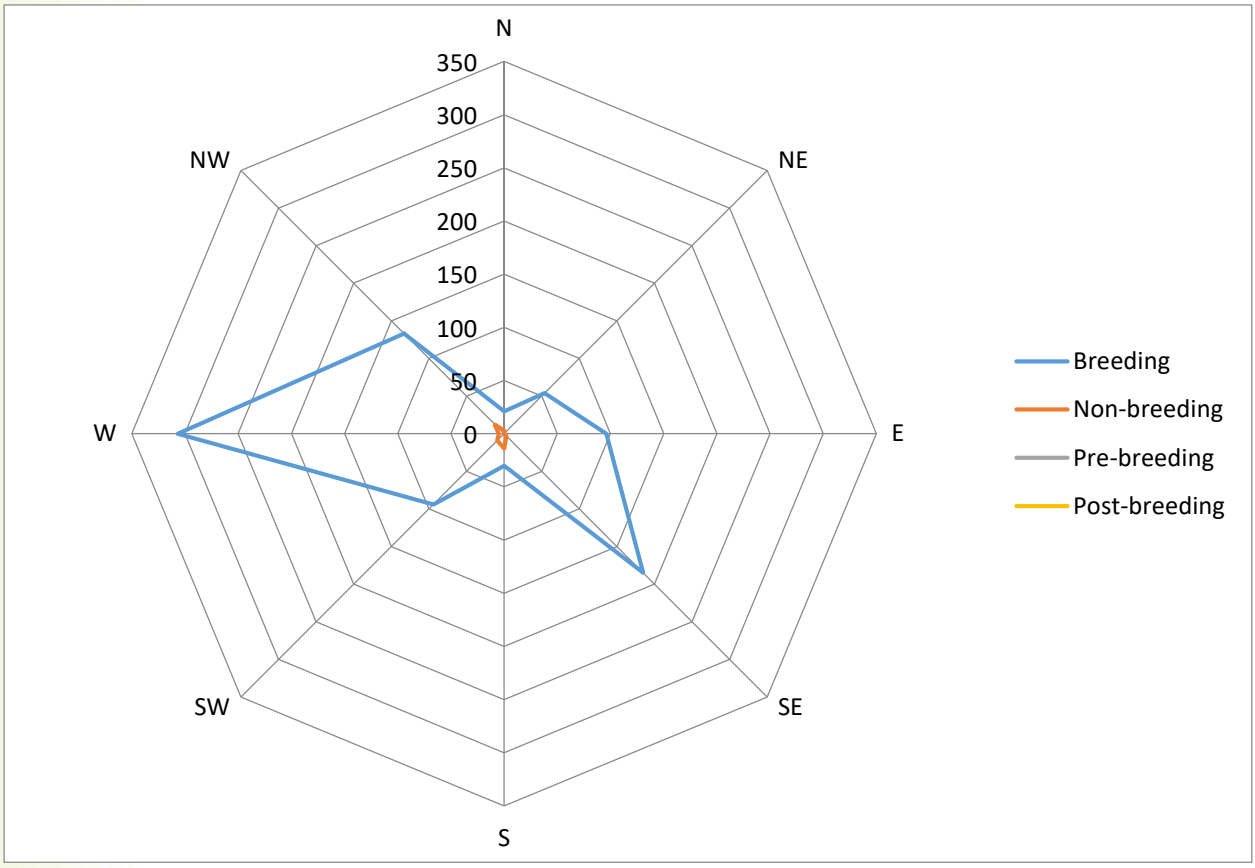


Figure 5.12: Great black-backed gull flight directions recorded from aerial surveys of the Moray West Site plus a 4 km buffer between April 2016 and March 2017.

Table 5.68: Monthly population estimates and densities of great black-backed gull in Moray West Site plus a 4 km buffer.

Month	Population estimates (Moray West Site plus 4 km buffer) (no. of birds)					Densities (Moray West Site plus 4 km buffer) (birds/km^2)				
	Flying	On water	Combined	Upper confidence limit	Lower confidence limit	Flying	On water	Combined	Upper confidence limit	Lower confidence limit
April	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
May	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
June	0	12	11	31	0	0.00	0.02	0.02	0.06	0.00
July	0	23	22	52	0	0.00	0.04	0.04	0.09	0.00
August	11	90	101	193	20	0.02	0.16	0.18	0.35	0.04
September	271	1,454	1,709	3,252	453	0.49	2.62	3.08	5.86	0.82
October	90	14	103	198	31	0.16	0.02	0.18	0.36	0.06
November	22	0	22	51	0	0.04	0.00	0.04	0.09	0.00
December	23	35	58	114	10	0.04	0.06	0.10	0.21	0.02
January	23	23	46	82	10	0.04	0.04	0.08	0.15	0.02
February	0	499	473	1,293	0	0.00	0.90	0.85	2.33	0.00
March	11	23	34	72	10	0.02	0.04	0.06	0.13	0.02

5.34.4 Conclusion

The peak population of great black-backed gull estimated during aerial surveys exceeded the regional 1% threshold in the breeding season in June, July and August. The peak population estimate in September exceed both the regional and national 1% thresholds.

Based on the presence of an important population, great black-backed gull is identified as a VOR and considered for further assessment in the EIA as a species of regional and national importance (breeding and non-breeding respectively) and international conservation value.

Tracking of great black-backed gulls at the East Caithness Cliffs SPA was carried out in 2014 through funding from Moray Offshore Renewables Ltd and Beatrice Offshore Wind Farm (Archibald *et al*., 2014). A total of 11 great black-backed gulls were tagged, with data being yielded from all individuals. All birds remained in coastal waters with no evidence of offshore trips. Based on great black-backed gull's maximum foraging range restricted to coastal waters (Archibald *et al.,* 2014) there is no potential for interaction between birds from SPAs and the Moray West Site. The maximum distance the individuals were recorded from the colony was 20 km. No overlap of foraging flights with the Moray West Offshore Wind Farm was noted.

In the absence of any (p)SPA connectivity and having been screened out of the Moray East HRA, great black-backed gull is not included in the Moray West Offshore Wind Farm HRA.

6 Identification of Valued Ornithological Receptors

Table 5.1 outlines the criteria used to determine the conservation value of all species relevant to the Moray West Offshore Wind Farm either due to their presence during site-specific aerial surveys or due to SPA connectivity. Based on the information in Section 1.4 regarding the sensitivity of different species' to recognised offshore wind farm impacts, and the results presented in each species account in Section 1.6, a group of key species has been identified for inclusion on the Impact Assessment for the Moray West Offshore Wind Farm:

- Fulmar;
- Gannet;
- Arctic skua;
- Puffin;
- Razorbill;
- Guillemot;
- Kittiwake;
- Herring gull; and
- Great black-backed gull (EIA only).

Results from the impact assessment are presented in Chapter 10 of the Offshore EIA Report.

In addition to the impacts associated with the Moray West Offshore Wind Farm that may affect birds at the Moray West Site, consideration has also been given to impacts associated with installation and maintenance of the OfTI. Based on the vulnerability of species to impacts associated with offshore wind farms (Table 3.1) and the overlap between the Moray Firth pSPA and the Offshore Export Cable Corridor (Table 4.1), 11 further species has been assigned an international conservation value in relation to impacts associated with the OfTI (Table 6.1) and therefore are also included in the Ornithology Assessment (Offshore EIA Report Chapter 10).

Table 6.1: Summary of the conservation importance and peak populations of all seabird species identified for consideration as part of the Moray West Offshore Wind Farm assessment in relation to national and regional thresholds. (Grey cells indicate seasons which are not applicable to the relevant species).

Species	Conservation status	SPA connectivity	Breeding season		Post-breeding/Pre-breeding season		Non-breeding season		Conservation value	Taken forward to impact assessment?
			Peak population estimate at Moray West[38] Site	Population importance	Peak population estimate at Moray West[33] Site	Population importance	Peak population estimate at Moray West[33] Site	Population importance		
Scaup	Red list	Yes	Not recorded	N/A	Not recorded	N/A	Not recorded but likely to be present in Offshore Export Cable Corridor	Uncertain – potentially regional[39]	International	Yes
Eider	Amber list	Yes	Not recorded	N/A	Not recorded	N/A	11 in Moray West Site and likely to be present in Offshore Export Cable Corridor	Uncertain – potentially regional[34]	International	Yes
Long-tailed duck	Red list	Yes	Not recorded	N/A	Not recorded	N/A	Not recorded but likely to be present in Offshore Export Cable Corridor	Uncertain – potentially regional[34]	International	Yes

[38] Based on digital aerial survey data without processing through MRSea. A full breakdown of population estimates and densities selected for impact assessment purposes are provided in Annex 10.1A.
[39] No baseline surveys of the offshore cable corridor have taken place – on a precautionary basis it is considered prudent to consider the possibility that regionally important populations may be present. The potential for this is further explored in Chapter 10: Offshore Ornithology.

Table 6.1: Summary of the conservation importance and peak populations of all seabird species identified for consideration as part of the Moray West Offshore Wind Farm assessment in relation to national and regional thresholds. (Grey cells indicate seasons which are not applicable to the relevant species).

Species	Conservation status	SPA connectivity	Breeding season		Post-breeding/Pre-breeding season		Non-breeding season		Conservation value	Taken forward to impact assessment?
			Peak population estimate at Moray West[38] Site	Population importance	Peak population estimate at Moray West[33] Site	Population importance	Peak population estimate at Moray West[33] Site	Population importance		
Common scoter	Red list	Yes	Not recorded	N/A	Not recorded	N/A	Not recorded but likely to be present in Offshore Export Cable Corridor	Uncertain – potentially regional[34]	International	Yes
Velvet scoter	Red list	Yes	Not recorded	N/A	Not recorded	N/A	Not recorded but likely to be present in Offshore Export Cable Corridor	Uncertain – potentially regional[34]	International	Yes
Goldeneye	Amber list	Yes	Not recorded	N/A	Not recorded	N/A	Not recorded but likely to be present in Offshore Export Cable Corridor	Uncertain – potentially regional[34]	International	Yes
Red-breasted merganser	Green	Yes	Not recorded	N/A	Not recorded	N/A	Not recorded but likely to be present in Offshore Export Cable Corridor	Uncertain – potentially regional[34]	International	Yes

Table 6.1: Summary of the conservation importance and peak populations of all seabird species identified for consideration as part of the Moray West Offshore Wind Farm assessment in relation to national and regional thresholds. (Grey cells indicate seasons which are not applicable to the relevant species).

Species	Conservation status	SPA connectivity	Breeding season		Post-breeding/Pre-breeding season		Non-breeding season		Conservation value	Taken forward to impact assessment?
			Peak population estimate at Moray West[38] Site	Population importance	Peak population estimate at Moray West[33] Site	Population importance	Peak population estimate at Moray West[33] Site	Population importance		
Red-throated diver	Annex 1	Yes	Not recorded	N/A	Not recorded	N/A	Not recorded but likely to be present in Offshore Export Cable Corridor	Uncertain – potentially regional[34]	International	Yes
Great northern diver	Annex 1	Yes	Not recorded	N/A	Not recorded	N/A	11 in Moray West Site and likely to be present in Offshore Export Cable Corridor	Uncertain – potentially regional[34]	International	Yes
Storm petrel	Annex 1	Yes	Not recorded	N/A	Not recorded	N/A	Not recorded	N/A	International	No
Fulmar	Amber list	Yes	1,042	Regional	127/2,336	Local	2,064	Local	International	Yes
Sooty shearwater	Green list	No	N/A	N/A	N/A	N/A	2,626	N/A	National	No
Manx shearwater	Amber list	Yes	35	Local	N/A	N/A	Not recorded	N/A	International	No
Gannet	Amber list	Yes	2,827	Regional	439/144	Local	N/A	N/A	International	Yes

Table 6.1: Summary of the conservation importance and peak populations of all seabird species identified for consideration as part of the Moray West Offshore Wind Farm assessment in relation to national and regional thresholds. (Grey cells indicate seasons which are not applicable to the relevant species).

Species	Conservation status	SPA connectivity	Breeding season		Post-breeding/Pre-breeding season		Non-breeding season		Conservation value	Taken forward to impact assessment?
			Peak population estimate at Moray West[38] Site	Population importance	Peak population estimate at Moray West[33] Site	Population importance	Peak population estimate at Moray West[33] Site	Population importance		
Cormorant	Green list	No	Not recorded	N/A	Not recorded	N/A	Not recorded but likely to be present in Offshore Export Cable Corridor	Uncertain – potentially regional[34]	International	No
Shag	Red list	Yes	Not recorded	N/A	Not recorded	N/A	Not recorded but likely to be present in Offshore Export Cable Corridor	Uncertain – potentially regional[34]	International	Yes
Slavonian grebe	Annex 1	Yes	Not recorded	N/A	Not recorded	N/A	Not recorded but likely to be present in Offshore Export Cable Corridor	Uncertain – potentially regional[34]	International	Yes
Pomarine skua	Green listed	No	Not recorded	N/A	11	Local	N/A	N/A	Local	No
Arctic skua	Red list	Yes	45	Regional	23	Local	N/A	N/A	International	Yes
Great skua	Amber list	No	68	Local	N/A	N/A	11	Local	Regional	No
Puffin	Red list	Yes	3,027	Regional	N/A	N/A	1,336	Local	International	Yes
Razorbill	Amber list	Yes	5,852	Regional	5,978	Regional	1,413	Regional	International	Yes

Table 6.1: Summary of the conservation importance and peak populations of all seabird species identified for consideration as part of the Moray West Offshore Wind Farm assessment in relation to national and regional thresholds. (Grey cells indicate seasons which are not applicable to the relevant species).

Species	Conservation status	SPA connectivity	Breeding season		Post-breeding/Pre-breeding season		Non-breeding season		Conservation value	Taken forward to impact assessment?
			Peak population estimate at Moray West[38] Site	Population importance	Peak population estimate at Moray West[33] Site	Population importance	Peak population estimate at Moray West[33] Site	Population importance		
Guillemot	Amber list	Yes	28,534	National	N/A	N/A	106,810	International	International	Yes
Sandwich tern	Annex 1	No	Not recorded	N/A	Not recorded	N/A	12	Local	National	No
Arctic tern	Annex 1	No	Not recorded	N/A	Not recorded	N/A	70	Local	National	No
Kittiwake	Red list	Yes	8,978	National	5,100/2,433	Local	N/A	N/A	International	Yes
Little gull	Annex 1	No	Not recorded	N/A	N/A	N/A	32	Local	National	No
Common gull	Amber list	No	11	Local	N/A	N/A	13	Local	Regional	No
Lesser black-backed gull	Amber list	No	12	Local	N/A	N/A	Not recorded	N/A	Regional	No
Herring gull	Red list	Yes	547	Regional	N/A	N/A	158	Local	International	Yes
Great black-backed gull	Amber list	Yes	101	Regional	N/A	N/A	1,709	National	International	Yes

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Annex 10.1A: Baseline Data Decision Support Flow Charts.

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Collision Risk Modelling (CRM)

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Technical Appendix 10.2

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Acronyms	
Acronym	**Expanded Term**
SNCBs	UK Statutory Nature Conservation Bodies
SNH	Scottish Natural Heritage
MSS	Marine Scotland Science
VORs	Valued Ornithological Receptors
JNCC	Joint Nature Conservation Committee
EIA	Environmental Impact Assessment
HRA	Habitats Regulation Appraisal
MW	Mega Watt
PCH	Potential Collision Height
CL	Confidence Limit
UCL	Upper Confidence Limit
LCL	Lower Confidence Limit
BTO	British Trust for Ornithology

1 Introduction

This Technical Appendix presents the collision risk modelling processes undertaken for the Moray West Offshore Wind Farm to inform the impact assessment presented in the Offshore EIA Report - Chapter 10: Offshore Ornithology.

The Technical Appendix provides a full overview of the methodologies, key parameters and results for each seabird species assessed. It is further supported by three annexes.

- Annex10.2A – Additional monthly breakdown of collision risk modelling results including outputs incorporating upper and lower confidence limits of parameters where available.
- Annex 10.2B – Collision risk modelling outputs using alternative sources of seabird flight speed data
- Annex 10.2C – A review of sensitivity of collision risk assessment to nocturnal activity factors used in the modelling process.

2 Background

2.1 Overview

Birds can collide with wind turbine rotor blades, which is almost certain to result in direct mortality. Most studies have found evidence of only low levels of bird mortality associated with operational onshore wind farms, as birds take avoiding action (Drewitt and Langston, 2006), although evidence of avoidance behaviour from offshore wind farms is limited. The actual risk of collision depends on a number of factors including the location of a wind farm, the bird species using the area, weather and visibility conditions, and the size and design of the wind farm, including the number and size of turbines.

The effect of mortality rates from collisions on a population is influenced by various characteristics, notably the populations size, density, recruitment rate (additions to the population through reproduction and immigration) and mortality rate (the natural rate of losses due to death and emigration). In general, the effect of an individual lost from the population will be greater for species that occur at low density, are relatively long-lived and reproduce at a low rate with most seabird species falling into this category. Conversely, the effect can be reduced for shorter-lived species with higher reproductive rates found at high densities, including some smaller gull species. Species that fly at night or during low light conditions at dawn and dusk are often assumed to be at increased risk from collisions, however, both eider and scoter have been shown to detect and avoid offshore turbines at night in both the Netherlands (Winkelman, 1995) and at offshore towers at Tuno Knob in Denmark (Tulp *et al*., 1999).

Wade *et al.* (2016), assigned cumulative vulnerability scores for a range of seabird species in relation to collision impacts although the authors did not categorise these for use in impact assessment. Table 2.1 provides an interpretation of these vulnerability scores; these are used alongside the size of the population occurring at the Moray West Site (see Appendix 10.1: Offshore Ornithology Technical Report and Section 3.1 below) in order to identify those Valued Ornithological Receptors (VORs) (identified in Appendix 10.1: Offshore Ornithology Technical Report) for which collision risk modelling was required.

Table 2.1: Vulnerability of Valued Ornithological Receptors to Collision with Offshore Wind Turbines (based on Wade *et al*. 2016)

Valued Ornithological Receptors	Vulnerability	Uncertainty Level (Wade *et al.*, 2016)
Fulmar	Very low	Low
Gannet	High	Very low
Arctic skua	High	Moderate
Great skua	High	Moderate
Puffin	Very low	Moderate
Razorbill	Very low	Low
Guillemot	Very low	Low
Kittiwake	High	Very low
Herring gull	Very high	Very low
Great black-backed gull	Very high	Low

In general, the effects of increased mortality on populations due to collisions with turbines are considered to be long-term (i.e., throughout the operational wind farm's lifespan) and the model assumes that the collision rate does not decrease over time in response to losses in the population causing a reduction in the density of flying birds in the wind farm. In reality, effects may change over time as birds, particularly those resident near the wind farm, may become habituated to the presence of turbines. External factors, such as changes in fishing activities, may alter the attractiveness of the wind farm area to birds, thereby changing activity levels within it.

2.2 Collision Risk Modelling

The most frequently used collision risk model in the UK is commonly referred to as 'the Band model'. This model was originally devised in 1995 and has since been through a number of iterations. Most recently it was adapted to facilitate application to offshore wind farms (Band, 2011) and to allow for the use of flight height distribution data and to include a methodology for considering birds on migration (Band, 2012).

Masden (2015) presents an update to Band (2012) which further develops the application of the offshore Band model using a simulation modelling approach to incorporate variability and uncertainty from the input data. The update provides for an improved understanding of uncertainty by pseudo-randomly sampling parameter values from distributions for each parameter, deriving average collision risk estimates with associated measures of variability. However, a recent review of Masden (2015) was undertaken by Trinder (2017), which raised some concerns about its use. As a result, Masden (2015) has not been used to calculate collision risk estimates for the Moray West Offshore Wind Farm.

Image 1.1 provides an overview of the information required for Band (2012) and the key outputs from the modelling process. The process to calculate the collision risk for a given species is a six stage process described as follows:

- Stage A: collate data on the number of flights which, in the absence of birds being displaced or taking other avoiding action, or being attracted to the wind farm, are potentially at risk from wind farm turbines;
- Stage B: use that flight activity data to estimate the potential number of bird transits through rotors of the wind farm;

- Stage C: calculate the probability of collision during a single bird transit;
- Stage D: multiply these to yield the potential collision mortality rate for the bird species under consideration, allowing for the proportion of time the turbines are not operational, assuming current bird use of the site and that no avoiding action is taken;
- Stage E: allow for the proportion of birds likely to avoid the wind farm or its turbines, either because they have been displaced from the site or because they take evasive action; and allow for any attraction by birds to the wind farm; and
- Stage F: express the uncertainty surrounding such a collision risk estimate.

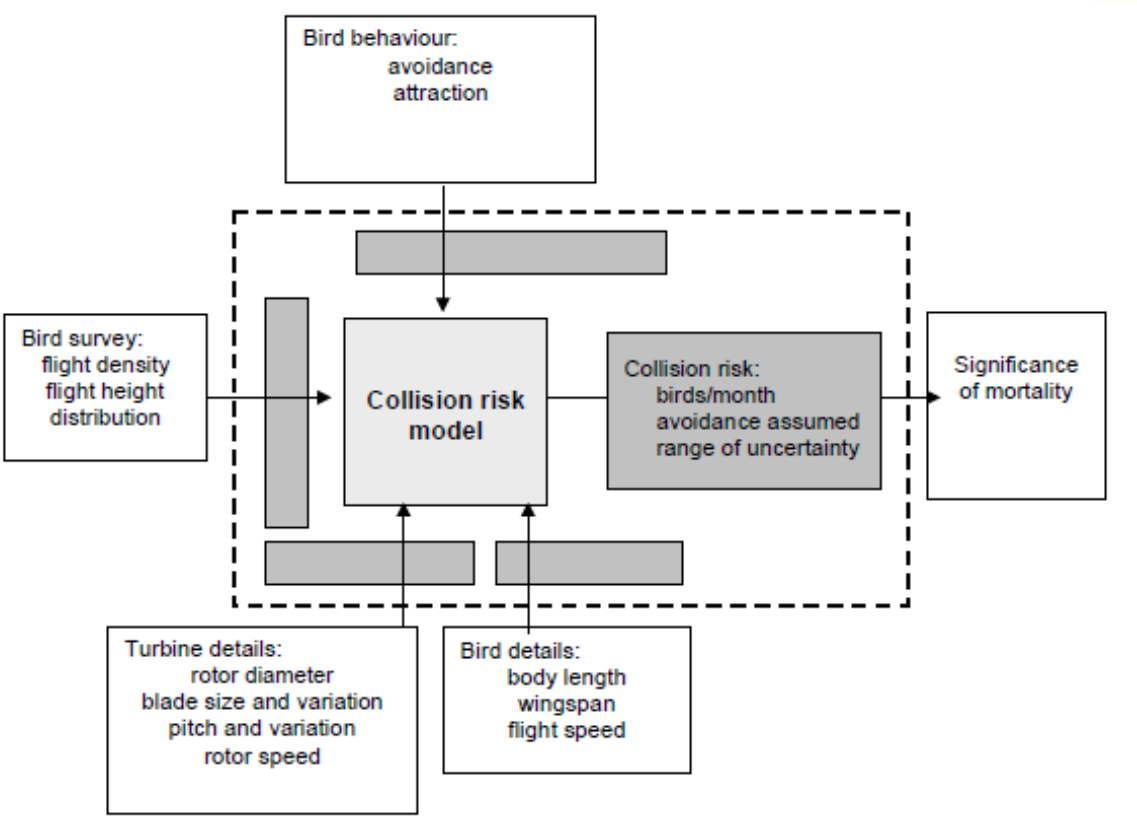

Image 2.1: Band (2012) collision risk model overview.

The Band (2012) model incorporates two approaches to calculating the risk of collision referred to as the 'Basic' and 'Extended' versions of the model. A key difference between these versions is the extent to which they account for the patterns of flight height data of seabirds (Band, 2012). The distribution of seabird flights across the sea is generally skewed towards lower altitudes. As stated by Band (2012) there are three consequences of a skewed flight height distribution:

- *"the proportion of birds flying at risk height decreases as the height of the rotor is increased;*
- *more birds miss the rotor, where flights lie close to the bottom of the circle presented by the rotor; and*
- *the collision risk, for birds passing through the lower parts of a rotor, is less than the average collision risk for the whole rotor."*

The Basic model assumes a uniform distribution of flights across the rotor with a consistent risk of collision across the whole rotor swept area. The Extended model of Band (2012) takes into account the distribution of birds in addition to the differential risk of collision across the rotor swept area.

2.2.1 Consideration of Uncertainty

2.2.1.1 The Band (2012) guidance states that "the output [from collision risk modelling] should convey the uncertainty in the collision risk estimate by indicating, in addition to a 'best estimate', a range of confidence around that estimate". The guidance further states that "the aim should be to express the range of uncertainty at around the 95% confidence level". The range of uncertainty should reflect uncertainty and/or variability associated with flight activity data, limitations of the collision risk model and turbine parameters that may not yet be finalised.

3 Methodology

3.1 Species for Consideration

The process to identify Valued Ornithological Receptors that may be affected by impacts associated with the Moray West Offshore Wind Farm is documented in the Offshore Ornithology Technical Report (Appendix 10.1). Those Valued Ornithological Receptors that are potentially affected by collision risk are those that are:

- Known to be vulnerable to collision risk (based on Wade *et al*., 2016; Bradbury *et al*., 2014) (Table 2.1); and
- Where the population of the species observed at the Moray West Site plus a 4 km buffer is considered to be of importance, when compared against relevant population scale thresholds (regional, national or international).

Table 3.1 identifies those Valued Ornithological Receptors for which collision risk modelling is required based on the above criteria. The following species were selected for collision risk modelling:

- Gannet;
- Kittiwake;
- Herring gull; and
- Great black-backed gull.

In addition to the species above, Arctic skua and great skua were also identified for collision risk modelling. These species were recorded in relatively low numbers at the Moray West Site. However, the survey methods used are considered unlikely to accurately capture the migratory movements of these species. Collision risk modelling for these species in relation to offshore wind farms in Scottish waters is presented in WWT Consulting and MacArthur Green (2014). The results presented in that report are therefore incorporated into the Offshore EIA Report - Chapter 10: Offshore Ornithology and no further collision risk modelling has been undertaken for Moray West.

Table 3.1: Identification of Valued Ornithological Receptors for Which Collision Risk Modelling is Required			
Valued Ornithological Receptors	**Vulnerability to Collision Risk Impacts**	**Importance of Population at the Moray West Site**	**Collision Risk Modelling Required (Yes/No)**
Fulmar	Very low	Regional	No – very low vulnerability to collision risk
Gannet	High	Regional	Yes – high vulnerability, species recorded in regionally important numbers
Arctic skua	High	Regional	Yes– high vulnerability, migratory species
Great skua	High	Local	Yes – high vulnerability, migratory species
Puffin	Very low	Regional	No – very low vulnerability to collision risk
Razorbill	Very low	Regional	No – very low vulnerability to collision risk
Guillemot	Very low	International	No – very low vulnerability to collision risk
Kittiwake	High	National	Yes – high vulnerability, species recorded in nationally important numbers
Herring gull	Very high	Regional	Yes – very high vulnerability, species recorded in regionally important numbers
Great black-backed gull	Very high	National	Yes – very high vulnerability, species recorded in nationally important numbers

3.2 Species Parameters

3.2.1 Bird Biometric and Behavioural Data

Table 3.3 presents the species-specific parameters for those species identified for collision risk modelling.

Bird flight speeds have been sourced from Skov *et al.* (2018). These flight speeds were estimated based on extensive work conducted at an operational wind farm in the UK and have associated large sample sizes (Table 3.2). In contrast, flight speeds that have previously been used to inform collision risk modelling (e.g. from Alerstam *et al.,* 2007 and, Pennycuick, 1987) have relatively small sample sizes. The flight speeds from Skov *et al.* (2018) are therefore the best available evidence to inform the collision risk assessment of Moray West. Collision risk estimates calculated using flight speeds from Alerstam *et al.* (2007) or Pennycuick (1987) are however also presented in Annex 10.2B.

Table 3.2: Flight Speeds and Sample Sizes Incorporated into Collision Risk Modelling for Relevant Valued Ornithological Receptors

Valued Ornithological Receptors	Flight Speeds (m/s) (sample size)	
	Skov *et al.* (2018)	**Alerstam *et al.* (2007) or Pennycuick (1987)**
Gannet	13.33 (683)	14.9 (32)
Kittiwake	8.71 (287)	13.1 (2)
Herring gull	9.80 (790)	12.8 (18)
Great black-backed gull	9.80 (790)	13.7 (4)

The avoidance rates presented in Table 3.3 are taken from Cook *et al.* (2014) which presents avoidance rates for all four species incorporated into this Annex. The report recommended avoidance rates for use with the Basic model for all four species and for the Extended model for herring gull and great black-backed gull. However, Cook *et al*. (2014) were unable to recommend an avoidance rate for use in the Extended model for gannet and kittiwake and as such, a default 98% avoidance rate is applied in the modelling conducted in this Annex. This approach is consistent with that recommended by the review of avoidance rates conducted in SMartWind and Forewind (2014).

In a joint response, the UK SNCBs supported the recommended avoidance rates of Cook *et al*. (2014) with the exception of those calculated for use with the Basic model for kittiwake (JNCC *et al*., 2014). The SNCBs did not agree with the application of avoidance rates calculated for the 'small gull' category to kittiwake and recommended that the avoidance rate calculated for the 'all gull' category should be applied instead. Modelling in this Annex is therefore conducted using the avoidance rates presented in Table 2.1: Vulnerability of Valued Ornithological Receptors to Collision with Offshore Wind Turbines (based on Wade *et al*. 2016)Table 3.3, taking into account the recommendations in both Cook *et al*. (2014) and JNCC *et al*. (2014).

Ongoing research is currently investigating the avoidance behaviour of seabirds at offshore wind farms. The results from Skov *et al.* (2018) suggests that the range of avoidance rates presented in are likely to be precautionary, including those given for the extended model for gannet and kittiwake.

The Band (2012) CRM requires the incorporation of a nocturnal activity parameter which describes the amount of flight activity at night in relation to the amount of flight activity in the day. In the absence of available empirical data, Band (2012) suggests that the subjectively-defined nocturnal activity factors presented in Garthe and Hüppop (2004) and King *et al*. (2009) be used to parameterise the CRM and so translating the rankings presented (1-5) into activity factors of 0, 25, 50, 75 and 100%. There now exists a body of empirical evidence from which nocturnal activity factors for gannet and kittiwake can be defined (see for example MacArthur Green, 2015).

A number of recent studies have deployed loggers on seabirds with the data collected providing empirical evidence of the nocturnal flight activity of a number of species (Hamer *et al*., 1993; Daunt *et al*., 2002; Kotzerka *et al*., 2010; Orben *et al*., 2015; Garthe *et al*., 1999; Hamer *et al*., 2000; Hamer *et al*., 2007; Garthe *et al*., 2012). These studies indicate that the nocturnal activity of gannet and kittiwake is lower than estimated by Garthe and Hüppop (2004) and King *et al.* (2009). For gannet these studies indicate a 2% nocturnal activity for non-breeding birds and no nocturnal activity by breeding birds. This translates to a nocturnal activity factor of 1 in the Band (2012) collision risk model. For kittiwake these studies indicate a 12% nocturnal activity for non-breeding birds and no nocturnal activity by breeding birds. This translates to a nocturnal activity factor of 1 (breeding) or 2 (non-breeding seasons) in the Band (2012) collision risk model. As part of their scoping advice to offshore wind farm projects located in the Firth of Forth, Marine

Scotland and SNH recommended the use of these nocturnal activity factors for gannet and kittiwake. In addition, a nocturnal activity factor of 2 was also recommended for herring gull, with this also considered relevant to great black-backed gull for the purposes of the modelling undertaken for the Moray West Offshore Wind Farm.

The nocturnal activity factors used in the collision risk modelling process for the Moray West Offshore Wind Farm are presented in Table 3.3 and are defined based on the empirical data and the advice of Marine Scotland and SNH to projects in the Firth of Forth. Further evidence and implications for the assessment of both Moray West Offshore Wind Farm alone and cumulatively with other projects is discussed in Annex 10.2C.

Table 3.3: Seabird Parameters Used for Collision Risk Modelling

Parameter	Source	Gannet	Kittiwake	Herring gull	Great black-backed gull
Bird length (m)	BTO Birdfacts	0.94	0.39	0.61	0.71
Wingspan (m)	BTO Birdfacts	1.72	1.08	1.44	1.58
Flight speed (m/s)	Skov *et al.* (2018)	13.33	8.71	9.80	9.80
Nocturnal activity factor	Empirically derived and/or MS/SNH advice	1	2	2	2
Flight type	N/A[1]	Flapping	Flapping	Flapping	Flapping
Proportion of flights upwind (%)	N/A[2]	50	50	50	50
Avoidance rate (Basic model) (%)	Cook *et al.* (2014) JNCC *et al.* (2014)	98.9 (±0.2)	98.9 (±0.2) 99.2 (±0.2)	99.5 (±0.1)	99.5 (±0.1)
Avoidance rate (Extended model) (%)	Cook *et al.* (2014)	98.0	98.0	99.0 (±0.2)	98.9 (±0.2)

3.2.2 Density Data

Project-specific data for the Moray West Offshore Wind Farm has been collected by twelve digital aerial surveys carried out between April 2016 and March 2017 encompassing the Moray West Site plus a 4 km buffer. From these data, in combination with data collected from adjacent projects (Moray East and Beatrice), monthly densities of birds in flight in the Moray West Site have been derived through a 'decision support' process to inform collision risk assessment.

Further information on the aerial surveys undertaken for Moray West is provided in the Appendix 10.1: Offshore Ornithology Technical Report. Detail on the decision support process and a full breakdown of monthly densities for each species applied to collision risk modelling is provided in Annex 10.1A.

[1] Based on expert opinion - the input parameters for flight type are either 'flapping' or 'gliding' with flapping representing the worst case scenario
[2] Assumed that there is a 50:50 split in flights upwind and downwind

3.3 Moray West Design and Turbine Parameters

A number of turbine scenarios were modelled for the Moray West Offshore Wind Farm in order to identify the worst case scenario for collision risk modelling. As a result of this process, two turbine scenarios were identified as the worst case scenario depending on whether the Basic or Extended version of Band (2012) was applied. The worst case scenario for collision risk when using the Basic model of Band (2012) was the development scenario comprising 85 x Model 2 (12 MW) turbines. For the Extended model, the worst case scenario was the development scenario comprising 85 x Model 1 (9.5 MW) turbines. The parameters for these turbine scenarios required by Band (2012) are presented in Table 3.4. The large array correction feature of Band (2012) was not applied at this stage, as this does not have a material effect on collision risk estimates (although if applied it would be expected to very slightly decrease collision estimates).

Table 3.4: Wind Farm and Turbine Parameters used for Collision Risk Modelling

Parameter	9.5 MW turbine scenario	12 MW turbine scenario
Wind farm		
Latitude (degrees)	58.10	
Number of turbines	85	85
Tidal offset (m)	2.24	
Turbines		
Rotor radius (m)	82	97.5
Hub height (m)	117	132.5
Max blade width (m)	5.4	6
Average pitch (°)	8	8
Monthly proportion of time operational (all months) (%)	85	85

3.3.1 Rotor Speed

The Band (2012) CRM requires information on the rotor speed for the turbine scenario under consideration with the Band (2012) guidance stating that the rotor speed should represent a time-averaged mean which takes account of different wind speeds and resulting operational rotor speeds. In order to ensure this approach is followed four rotor speed quartiles have been used to calculate collision risk estimates (Table 3.5). Collision risk estimates are calculated using each rotor speed quartile with the results for each quartile then weighted according to the proportion of time that each rotor speed will operate. A total collision risk estimate is then calculated by summing the resulting proportioned estimates for each rotor speed quartile. This approach has previously been applied as part of the application process for the consented Moray East offshore wind farm.

Table 3.5: Rotor Speed (rpm) Quartiles for Each Turbine Scenario and the Proportion of Time for Which Each Quartile will Operate at Moray West			
Rotor speed	**Proportion of time (%)**	**9.5 MW turbine scenario**	**12 MW turbine scenario**
Minimum	-	6.5	6.0
1st rotor quartile	8	7.3	6.5
2nd rotor quartile	6	8.9	7.4
3rd rotor quartile	9	10.4	8.4
4th rotor quartile	77	12.0	9.3
Maximum	-	12.8	9.8

3.3.2 Band Model Options

The Band (2012) model incorporates two approaches to calculating the risk of collision referred to as the 'Basic' and 'Extended' versions of the model. A key difference between these versions is the extent to which they account for the flight height patterns of seabirds (Band, 2012). The distribution of seabird flights across the sea is generally skewed towards lower altitudes. As stated by Band (2012) there are three consequences of a skewed flight height distribution:

- "the proportion of birds flying at risk height decreases as the height of the rotor is increased;
- more birds miss the rotor, where flights lie close to the bottom of the circle presented by the rotor; and
- the collision risk, for birds passing through the lower parts of a rotor, is less than the average collision risk for the whole rotor."

The Basic model assumes a uniform distribution of flights across the rotor with a consistent risk of collision across the whole rotor swept area. The Extended model of Band (2012) takes into account the distribution of birds in addition to the differential risk across the rotor swept area. It should be noted that the use of the basic model is precautionary as it does not take into account the variability in risk of collision that occurs across a rotor swept area, with the risk of collision decreasing as the distance from the hub of the turbine increases. If this were to be taken into account (as when using Option 3) it is likely that collision risk estimates would be lower as the vertical distribution of birds flying across water is skewed towards lower heights (i.e. those associated with a lower risk of collision within a rotor swept area).

Both the Basic and Extended models of Band (2012) allow for the use of two 'Options' termed Options 1-4. Options 1 and 2 use the Basic model with Options 3 and 4 utilising the Extended model. The difference between the two Options under each model is linked to the use of flight height data. Options 2 and 3 use generic data from Johnston et al. (2014) whereas Options 1 and 4 use site-specific data derived from site-specific surveys. It is standard practice to present collision risk estimates calculated using all Options in Band (2012) and this has been followed throughout this Appendix and associated assessments.

The flight height data collected during site-specific digital aerial surveys at the Moray West Site has been reviewed and is concluded to be of limited use for collision risk modelling. For the majority of species, there were fewer than 100 records, which has been recommended as required in order to calculate a representative proportion of birds at potential collision height (PCH) (Natural England, 2013). For the two species for which a representative PCH value is calculable, the resulting value falls considerably outside of the confidence limits associated with generic flight height information (Johnston *et al*., 2014) with no valid ecological reason as to why this should occur. It has been agreed with Marine Scotland and SNH that

the site-specific flight height data is not appropriate for use to inform the collision risk modelling undertaken for the Moray West Offshore Wind Farm.

A considerable amount of flight height data was collected during boat-based surveys conducted to support the application for the Moray East offshore wind farm. Surveys were conducted between April 2010 and March 2012 covering the Moray East offshore wind farm plus a 4 km buffer (which overlaps with the Moray West Site plus 4 km buffer) and were based on standard survey methodologies (Camphuysen *et al.,* 2004). A full description of the surveys conducted is presented in Natural Power (2012).

The boat-based surveys undertaken for Moray East categorised flying birds into one of six height bands (<5, 5-10, 10-20, 20-200, 200-300 and >300 m). The lower rotor tip height at Moray West is 35 m (HAT), therefore the 20-200 m flight height band has been used to calculate the proportion of birds at PCH. Although this is likely to represent a considerable over-estimate of the proportion of birds at collision risk height is not possible to identify those bird flying between 20 and 35 metres. The PCH values calculated using the 20-200 m height band for each species are presented in Table 3.6.

Table 3.6: Proportion of Birds at PCH Calculated from Boat-Based Survey Data Collected for the Moray East Offshore Wind Farm Between April 2010 and March 2012

Species	Proportion of Birds at PCH (%)
Gannet	11.64
Kittiwake	4.57
Herring gull	33.55
Great black-backed gull	29.95

In addition to Option 1, collision risk estimates have also been calculated using Options 2 and 3 of the Band (2012) model which make use of aggregated generic flight height data contained in Johnston *et al.* (2014).

It is highlighted that the use of the basic version of the model (Options 1 and 2 in this case) is precautionary as it does not take into account the variability in risk of collision that occurs across a rotor swept area, with the risk of collision decreasing as the distance from the hub of the turbine increases. If this were to be taken into account (as when using Option 3) it is likely that collision risk estimates would be of a lower magnitude as the vertical distribution of birds flying across water is skewed towards lower heights (i.e. those associated with a lower risk of collision within a rotor swept area).

3.3.3 Expressing Uncertainty

In order to express the uncertainty associated with the collision risk estimates presented in this Annex, modelling has been conducted incorporating confidence metrics associated with flight height distributions. The upper and lower 95% confidence limits associated with flight height distributions (Johnston *et al.,* 2014) are used within collision risk modelling to provide a range of collision risk estimates describing the variability around flight height distributions. The results obtained are presented on an annual basis in Section 4 and on a monthly basis in Annex 10.2A.

4 Results

The following section presents the results from the assessment for collision risk based on the worst case scenario as presented in Table 3.4

4.1 Gannet

The annual collision risk estimates (Options 1, 2 and 3) calculated for gannet using Band (2012) are shown in Table 4.1.

Table 4.1: Annual Collision Risk Estimates for Gannet Calculated using Options 1, 2 and 3 of the Band (2012) Collision Risk Model Using Best Estimate and Upper and Lower 95% Confidence Interval Flight Height Distributions.

Avoidance Rate (%)	Collision Risk Estimates (No. of Collisions/Annum)		
	Lower CL	Best Estimate	Upper CL
Option 1			
98.7		85	
98.9		72	
99.1		59	
Option 2			
98.7	4	15	36
98.9	3	12	30
99.1	3	10	25
Option 3			
98	1	6	19

4.2 Kittiwake

The annual collision risk estimates (Options 1, 2 and 3) calculated for kittiwake using Band (2012) are shown in Table 4.2.

Table 4.2: Annual Collision Risk Estimates for Kittiwake Calculated Using Options 1, 2 and 3 of the Band (2012) Collision Risk Model Using Best Estimate and Upper and Lower 95% Confidence Interval Flight Height Distributions

Avoidance Rate (%)	Collision Risk Estimates (no. of collisions/annum)		
	Lower CL	Best Estimate	Upper CL
Option 1			
98.7		211	
98.9		179	
99.1		146	
99.2		130	
99.5		81	
Option 2			
98.7	80	129	174
98.9	68	109	148
99.1	55	89	121
99.2	49	79	107
99.5	31	50	67
Option 3			
98	32	56	81

4.3 Herring Gull

The annual collision risk estimates (Options 1, 2 and 3) calculated for herring gull using Band (2012) are shown in Table 4.3.

Table 4.3: Annual Collision Risk Estimates for Herring Gull Calculated Using Options 1, 2 and 3 of the Band (2012) Collision Risk Model Using Best Estimate and Upper and Lower 95% Confidence Interval Flight Height Distributions

Avoidance Rate (%)	Collision Risk Estimates (No. of Collisions/Annum)		
	Lower CL	Best Estimate	Upper CL
Option 1			
99.4		44	
99.5		36	
99.6		29	
Option 2			
99.4	10	15	27
99.5	8	13	23
99.6	6	10	18
Option 3			
98.8	8	13	31
99.0	6	11	26
99.2	5	9	21

4.4 Great Black-Backed Gull

The annual collision risk estimates (Options 1, 2 and 3) calculated for herring gull using Band (2012) are shown in Table 4.4.

Table 4.4: Annual Collision Risk Estimates for Great Black-Backed Gull Calculated Using Options 1, 2 and 3 of the Band (2012) Collision Risk Model Using Best Estimate and Upper and Lower 95% Confidence Interval Flight Height Distributions

Avoidance Rate (%)	Collision Risk Estimates (No. of Collisions/Annum)		
	Lower CL	Best Estimate	Upper CL
Option 1			
99.4		27	
99.5		23	
99.6		18	
Option 2			
99.4	9	11	21
99.5	7	9	17
99.6	6	7	14
Option 3			
98.7	8	11	27
98.9	7	10	23
99.1	5	8	18

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6 Annex 10.2A: Additional Monthly Breakdown of Collision Risk Modelling Outputs

Table 6.1: Monthly collision risk estimates for gannet calculated using Option 1 of Band (2012)

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
98.7	0.00	0.00	4.18	0.00	7.81	20.34	3.00	5.63	32.83	5.12	5.43	0.59
98.9	0.00	0.00	3.54	0.00	6.61	17.21	2.54	4.76	27.78	4.33	4.59	0.50
99.1	0.00	0.00	2.89	0.00	5.41	14.08	2.08	3.89	22.73	3.54	3.76	0.41

Table 6.2: Monthly collision risk estimates for gannet calculated using Option 2 of Band (2012) using confidence intervals associated with flight height distribution.

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flight height distribution = Maximum Likelihood												
98.7	0.00	0.00	0.72	0.00	1.35	3.52	0.52	0.97	5.68	0.89	0.94	0.10
98.9	0.00	0.00	0.61	0.00	1.15	2.98	0.44	0.82	4.81	0.75	0.80	0.09
99.1	0.00	0.00	0.50	0.00	0.94	2.44	0.36	0.67	3.94	0.61	0.65	0.07
Flight height distribution = UCL												
98.7	0.00	0.00	1.77	0.00	3.31	8.62	1.27	2.38	13.91	2.17	2.30	0.25
98.9	0.00	0.00	1.50	0.00	2.80	7.29	1.08	2.02	11.77	1.84	1.95	0.21
99.1	0.00	0.00	1.23	0.00	2.29	5.97	0.88	1.65	9.63	1.50	1.59	0.17
Flight height distribution = LCL												
98.7	0.00	0.00	0.19	0.00	0.36	0.93	0.14	0.26	1.50	0.23	0.25	0.03
98.9	0.00	0.00	0.16	0.00	0.30	0.79	0.12	0.22	1.27	0.20	0.21	0.02
99.1	0.00	0.00	0.13	0.00	0.25	0.65	0.10	0.18	1.04	0.16	0.17	0.02

Table 6.3: Monthly collision risk estimates for gannet calculated using Option 3 of Band (2012) using confidence intervals associated with flight height distribution.

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flight height distribution = Maximum Likelihood												
98.0	0.00	0.00	0.32	0.00	0.60	1.56	0.23	0.43	2.51	0.39	0.42	0.05
Flight height distribution = UCL												
98.0	0.00	0.00	0.96	0.00	1.79	4.66	0.69	1.29	7.52	1.17	1.24	0.14
Flight height distribution = LCL												
98.0	0.00	0.00	0.07	0.00	0.13	0.33	0.05	0.09	0.53	0.08	0.09	0.01

Table 6.4: Monthly collision risk estimates for kittiwake calculated using Option 1 of Band (2012)

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
98.7	1.56	3.02	8.40	1.27	17.64	54.52	55.77	23.31	12.82	8.49	15.49	9.01
98.9	1.32	2.56	7.11	1.08	14.92	46.13	47.19	19.72	10.85	7.18	13.10	7.62
99.1	1.08	2.09	5.82	0.88	12.21	37.74	38.61	16.14	8.88	5.88	10.72	6.24
99.2	0.96	1.86	5.17	0.78	10.85	33.55	34.32	14.34	7.89	5.22	9.53	5.54
99.5	0.60	1.16	3.23	0.49	6.78	20.97	21.45	8.96	4.93	3.27	5.96	3.46

Table 6.5: Monthly collision risk estimates for kittiwake calculated using Option 2 of Band (2012) using confidence intervals associated with flight height distribution.

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flight height distribution = Maximum Likelihood												
98.7	0.95	1.84	5.12	0.78	10.75	33.24	34.00	14.21	7.82	5.18	9.44	5.49
98.9	0.81	1.56	4.34	0.66	9.10	28.13	28.77	12.03	6.62	4.38	7.99	4.65
99.1	0.66	1.28	3.55	0.54	7.45	23.01	23.54	9.84	5.41	3.58	6.54	3.80
99.2	0.59	1.13	3.15	0.48	6.62	20.46	20.92	8.75	4.81	3.19	5.81	3.38
99.5	0.37	0.71	1.97	0.30	4.14	12.78	13.08	5.47	3.01	1.99	3.63	2.11
Flight height distribution = UCL												
98.7	1.29	2.49	6.94	1.05	14.56	45.01	46.04	19.24	10.59	7.01	12.79	7.44
98.9	1.09	2.11	5.87	0.89	12.32	38.08	38.95	16.28	8.96	5.93	10.82	6.29
99.1	0.89	1.73	4.80	0.73	10.08	31.16	31.87	13.32	7.33	4.85	8.85	5.15
99.2	0.79	1.54	4.27	0.65	8.96	27.70	28.33	11.84	6.51	4.31	7.87	4.58
99.5	0.50	0.96	2.67	0.40	5.60	17.31	17.71	7.40	4.07	2.70	4.92	2.86

Table 6.5: Monthly collision risk estimates for kittiwake calculated using Option 2 of Band (2012) using confidence intervals associated with flight height distribution.

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flight height distribution = LCL												
98.7	0.59	1.15	3.18	0.48	6.68	20.66	21.13	8.83	4.86	3.22	5.87	3.41
98.9	0.50	0.97	2.69	0.41	5.66	17.48	17.88	7.47	4.11	2.72	4.97	2.89
99.1	0.41	0.79	2.20	0.33	4.63	14.30	14.63	6.12	3.36	2.23	4.06	2.36
99.2	0.36	0.70	1.96	0.30	4.11	12.71	13.01	5.44	2.99	1.98	3.61	2.10
99.5	0.23	0.44	1.22	0.19	2.57	7.95	8.13	3.40	1.87	1.24	2.26	1.31

Table 6.6: Monthly collision risk estimates for kittiwake calculated using Option 3 of Band (2012) using confidence intervals associated with flight height distribution.

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flight height distribution = Maximum Likelihood												
98.0	0.41	0.80	2.23	0.34	4.67	14.44	14.77	6.17	3.40	2.25	4.10	2.39
Flight height distribution = UCL												
98.0	0.60	1.16	3.23	0.49	6.78	20.96	21.44	8.96	4.93	3.26	5.95	3.46
Flight height distribution = LCL												
98.0	0.23	0.45	1.26	0.19	2.64	8.17	8.36	3.49	1.92	1.27	2.32	1.35

Table 6.7: Monthly collision risk estimates for herring gull calculated using Option 1 of Band (2012)

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
99.4	0.96	2.01	0.00	0.00	0.00	30.66	6.10	4.02	0.00	0.00	0.00	0.00
99.5	0.80	1.68	0.00	0.00	0.00	25.55	5.08	3.35	0.00	0.00	0.00	0.00
99.6	0.64	1.34	0.00	0.00	0.00	20.44	4.07	2.68	0.00	0.00	0.00	0.00

Table 6.8: Monthly collision risk estimates for herring gull calculated using Option 2 of Band (2012) using confidence intervals associated with flight height distribution.

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flight height distribution = Maximum Likelihood												
99.4	0.33	0.69	0.00	0.00	0.00	10.58	2.11	1.39	0.00	0.00	0.00	0.00
99.5	0.28	0.58	0.00	0.00	0.00	8.82	1.76	1.16	0.00	0.00	0.00	0.00
99.6	0.22	0.46	0.00	0.00	0.00	7.06	1.40	0.93	0.00	0.00	0.00	0.00
Flight height distribution = UCL												
99.4	0.59	1.25	0.00	0.00	0.00	19.02	3.78	2.49	0.00	0.00	0.00	0.00
99.5	0.50	1.04	0.00	0.00	0.00	15.85	3.15	2.08	0.00	0.00	0.00	0.00
99.6	0.40	0.83	0.00	0.00	0.00	12.68	2.52	1.66	0.00	0.00	0.00	0.00
Flight height distribution = LCL												
99.4	0.21	0.44	0.00	0.00	0.00	6.78	1.35	0.89	0.00	0.00	0.00	0.00
99.5	0.18	0.37	0.00	0.00	0.00	5.65	1.12	0.74	0.00	0.00	0.00	0.00
99.6	0.14	0.30	0.00	0.00	0.00	4.52	0.90	0.59	0.00	0.00	0.00	0.00

Table 6.9: Monthly collision risk estimates for herring gull calculated using Option 3 of Band (2012) using confidence intervals associated with flight height distribution.

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flight height distribution = Maximum Likelihood												
98.9	0.29	0.61	0.00	0.00	0.00	9.30	1.85	1.22	0.00	0.00	0.00	0.00
99.0	0.24	0.51	0.00	0.00	0.00	7.75	1.54	1.02	0.00	0.00	0.00	0.00
99.2	0.19	0.41	0.00	0.00	0.00	6.20	1.23	0.81	0.00	0.00	0.00	0.00
Flight height distribution = UCL												
98.9	0.68	1.42	0.00	0.00	0.00	21.64	4.31	2.84	0.00	0.00	0.00	0.00
99.0	0.56	1.18	0.00	0.00	0.00	18.04	3.59	2.36	0.00	0.00	0.00	0.00
99.2	0.45	0.95	0.00	0.00	0.00	14.43	2.87	1.89	0.00	0.00	0.00	0.00
Flight height distribution = LCL												
98.9	0.17	0.35	0.00	0.00	0.00	5.30	1.06	0.70	0.00	0.00	0.00	0.00
99.0	0.14	0.29	0.00	0.00	0.00	4.42	0.88	0.58	0.00	0.00	0.00	0.00
99.2	0.11	0.23	0.00	0.00	0.00	3.54	0.70	0.46	0.00	0.00	0.00	0.00

Table 6.10: Monthly collision risk estimates for great black-backed gull calculated using Option 1 of Band (2012)

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
99.4	0.00	0.00	0.00	0.00	0.00	1.92	1.94	7.94	12.33	3.30	0.00	0.00
99.5	0.00	0.00	0.00	0.00	0.00	1.60	1.62	6.62	10.28	2.75	0.00	0.00
99.6	0.00	0.00	0.00	0.00	0.00	1.28	1.29	5.29	8.22	2.20	0.00	0.00

Table 6.11: Monthly collision risk estimates for great black-backed gull calculated using Option 2 of Band (2012) using confidence intervals associated with flight height distribution.

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flight height distribution = Maximum Likelihood												
99.4	0.00	0.00	0.00	0.00	0.00	0.78	0.79	3.23	5.01	1.34	0.00	0.00
99.5	0.00	0.00	0.00	0.00	0.00	0.65	0.66	2.69	4.18	1.12	0.00	0.00
99.6	0.00	0.00	0.00	0.00	0.00	0.52	0.53	2.15	3.34	0.89	0.00	0.00
Flight height distribution = UCL												
99.4	0.00	0.00	0.00	0.00	0.00	1.44	1.45	5.95	9.24	2.47	0.00	0.00
99.5	0.00	0.00	0.00	0.00	0.00	1.20	1.21	4.96	7.70	2.06	0.00	0.00
99.6	0.00	0.00	0.00	0.00	0.00	0.96	0.97	3.97	6.16	1.65	0.00	0.00
Flight height distribution = LCL												
99.4	0.00	0.00	0.00	0.00	0.00	0.60	0.60	2.47	3.83	1.02	0.00	0.00
99.5	0.00	0.00	0.00	0.00	0.00	0.50	0.50	2.05	3.19	0.85	0.00	0.00
99.6	0.00	0.00	0.00	0.00	0.00	0.40	0.40	1.64	2.55	0.68	0.00	0.00

Table 6.12: Monthly collision risk estimates for great black-backed gull calculated using Option 3 of Band (2012) using confidence intervals associated with flight height distribution.

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flight height distribution = Maximum Likelihood												
98.7	0.00	0.00	0.00	0.00	0.00	0.80	0.81	3.31	5.15	1.38	0.00	0.00
98.9	0.00	0.00	0.00	0.00	0.00	0.68	0.68	2.80	4.35	1.17	0.00	0.00
99.1	0.00	0.00	0.00	0.00	0.00	0.56	0.56	2.29	3.56	0.95	0.00	0.00
Flight height distribution = UCL												
98.7	0.00	0.00	0.00	0.00	0.00	1.86	1.88	7.71	11.96	3.20	0.00	0.00
98.9	0.00	0.00	0.00	0.00	0.00	1.58	1.59	6.52	10.12	2.71	0.00	0.00
99.1	0.00	0.00	0.00	0.00	0.00	1.29	1.30	5.33	8.28	2.22	0.00	0.00

Table 6.12: Monthly collision risk estimates for great black-backed gull calculated using Option 3 of Band (2012) using confidence intervals associated with flight height distribution.

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flight height distribution = LCL												
98.7	0.00	0.00	0.00	0.00	0.00	0.55	0.56	2.28	3.55	0.95	0.00	0.00
98.9	0.00	0.00	0.00	0.00	0.00	0.47	0.47	1.93	3.00	0.80	0.00	0.00
99.1	0.00	0.00	0.00	0.00	0.00	0.38	0.39	1.58	2.46	0.66	0.00	0.00

7 Annex 10.2B – Collision Risk Estimates Using Flight Speed Data From Pennycuick (1987) or Alerstam (2007)

Table 7.1: Annual collision risk estimates for gannet calculated using Options 1, 2 and 3 of the Band (2012) collision risk model using best estimate and upper and lower 95% confidence interval flight height distributions.

Avoidance rate (%)	Collision risk estimates (no. of collisions/annum)		
	Lower CL	Best estimate	Upper CL
Option 1			
98.7		91	
98.9		77	
99.1		63	
Option 2			
98.7	4	16	39
98.9	4	13	33
99.1	3	11	27
Option 3			
98	1	7	20

Table 7.2: Annual collision risk estimates for kittiwake calculated using Options 1, 2 and 3 of the Band (2012) collision risk model using best estimate and upper and lower 95% confidence interval flight height distributions.			
Avoidance rate (%)	**Collision risk estimates (no. of collisions/annum)**		
	Lower CL	**Best estimate**	**Upper CL**
Option 1			
98.7		279	
98.9		236	
99.1		193	
99.2		172	
99.5		107	
Option 2			
98.7	106	170	231
98.9	90	144	195
99.1	73	118	160
99.2	65	105	142
99.5	41	65	89
Option 3			
98	34	60	88

Table 7.3: Annual collision risk estimates for herring gull calculated using Options 1, 2 and 3 of the Band (2012) collision risk model using best estimate and upper and lower 95% confidence interval flight height distributions.

Avoidance rate (%)	Collision risk estimates (no. of collisions/annum)		
	Lower CL	Best estimate	Upper CL
Option 1			
99.4		52	
99.5		43	
99.6		34	
Option 2			
99.4	11	18	32
99.5	10	15	27
99.6	8	12	21
Option 3			
98.8	8	14	34
99.0	7	12	28
99.2	5	9	23

Table 7.4: Annual collision risk estimates for great black-backed gull calculated using Options 1, 2 and 3 of the Band (2012) collision risk model using best estimate and upper and lower 95% confidence interval flight height distributions

Avoidance rate (%)	Collision risk estimates (no. of collisions/annum)		
	Lower CL	Best estimate	Upper CL
Option 1			
99.4		34	
99.5		28	
99.6		22	
Option 2			
99.4	10	14	25
99.5	9	11	21
99.6	7	9	17
Option 3			
98.7	9	13	30
98.9	7	11	26
99.1	6	9	21

8 Annex 10.2C – Sensitivity of Cumulative/In-Combination Projects to Changes in Nocturnal Activity Factors

8.1 Overview

In order to investigate the potential effect a change in nocturnal activity factor would have on in-combination and cumulative collision risk estimates a sensitivity analysis has been undertaken. The approach uses four hypothetical offshore wind farms that are located in the following geographic areas in the North Sea:

- East Anglia and English Channel (latitude = 51.64 degrees);
- Southern North Sea (latitude = 53.87 degrees);
- Firth of Forth (latitude = 56.18 degrees); and
- Moray Firth (latitude = 57.99 degrees).

These areas correspond with the main development areas for offshore wind farms in the North Sea.

The approach described is required due to the differences in the proportion of nocturnal hours that occurs at different latitudes across an annual cycle. For example, at more northerly latitudes (e.g. the Moray Firth), the number of nocturnal hours will be lower in the summer and higher in the winter when compared to more southerly latitudes (e.g. East Anglia). The Band (2012) CRM uses the Forsythe *et al.* (1995) model to calculate daylength as a function of latitude and each day in a year. The resulting daylength is then translated into the number of daylight and nocturnal hours in each month in the Band (2012) CRM. This calculation is triggered by the latitude input parameter in the Band (2012) CRM and therefore, as the amount of daylight and nocturnal hours are related to the latitude of a wind farm, four different hypothetical wind farms have been modelled to capture the change in collision risk estimates as a result of differing proportions of nocturnal hours throughout a year that occurs at different latitudes.

8.2 Collision risk modelling parameters

In order to model collision risk a number of assumptions are necessary. Throughout all modelling, the bird, wind farm, and turbine parameters used were consistent with those used for Moray West (Table 1.3, Table 1.4 and Table 1.5), with the exception of latitude which was changed to reflect the geographic area in which each hypothetical wind farm was located. Rotor speed was set at 10 r.p.m. and bird density was assumed to be constant in all geographic areas in all months. It is not necessary to use project-specific parameters for this sensitivity analysis as the aim of this analysis is to demonstrate the change that would occur if the nocturnal activity factors presented in Table 8.1 were used with the use of identical project parameters providing a consistent comparison across all geographic areas.

Table 8.1: Proposed changes to nocturnal activity factors for gannet, kittiwake, herring gull and great black-backed gull

Species	Nocturnal activity factor (from Garthe and Hüppop, 2004)	Nocturnal activity factor advised by Marine Scotland/SNH
Gannet	2	1
Kittiwake	3	2
Herring gull	3	2
Great black-backed gull	3	2

Two nocturnal activity scenarios have been used that correspond with the changes to the factors used for each species (Table 8.1). The 'gannet' scenario involves changing the nocturnal activity factor from 2 to 1 with the 'gull' scenario (considered applicable to kittiwake, herring gull and great black-backed gull) changing the nocturnal activity factor from 3 to 2.

8.3 Results

Graph 8.1 and Graph 8.2 show the effect of changing the nocturnal activity factor on monthly collision estimates for gannet and kittiwake respectively in the four defined geographic regions. Table 8.2 shows the minimum and maximum monthly changes that occur alongside the overall change in collision risk estimates for each of the four geographic areas.

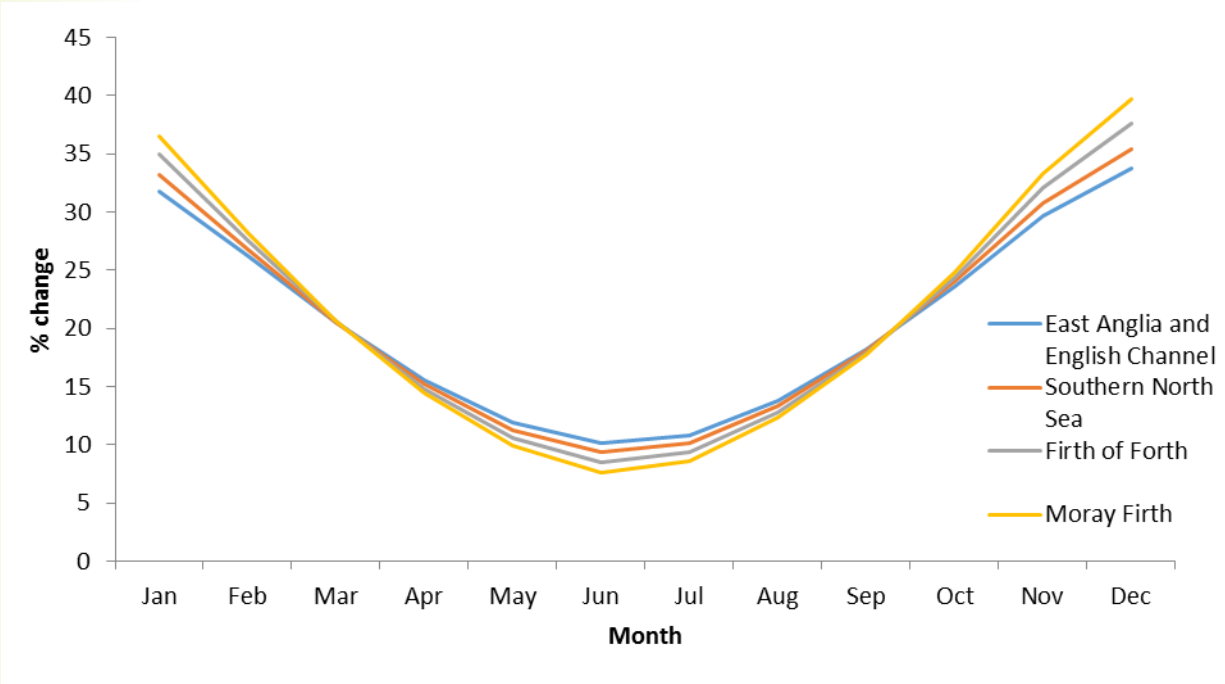
Table 8.2: Reductions in collision risk modelling in four geographic areas as a result of changes to the nocturnal activity factor used in CRM

Geographic area	Minimum (%)	Maximum (%)	Overall (%)
Gannet scenario			
East Anglia and English Channel	10.1	33.7	19.3
Southern North Sea	9.3	35.4	19.2
Firth of Forth	8.4	37.6	19.1
Moray Firth	7.6	39.7	19.1
Gull scenario			
East Anglia and English Channel	9.2	25.2	16.2
Southern North Sea	8.5	26.2	16.1
Firth of Forth	7.8	27.3	16.1
Moray Firth	7.1	28.4	16.0

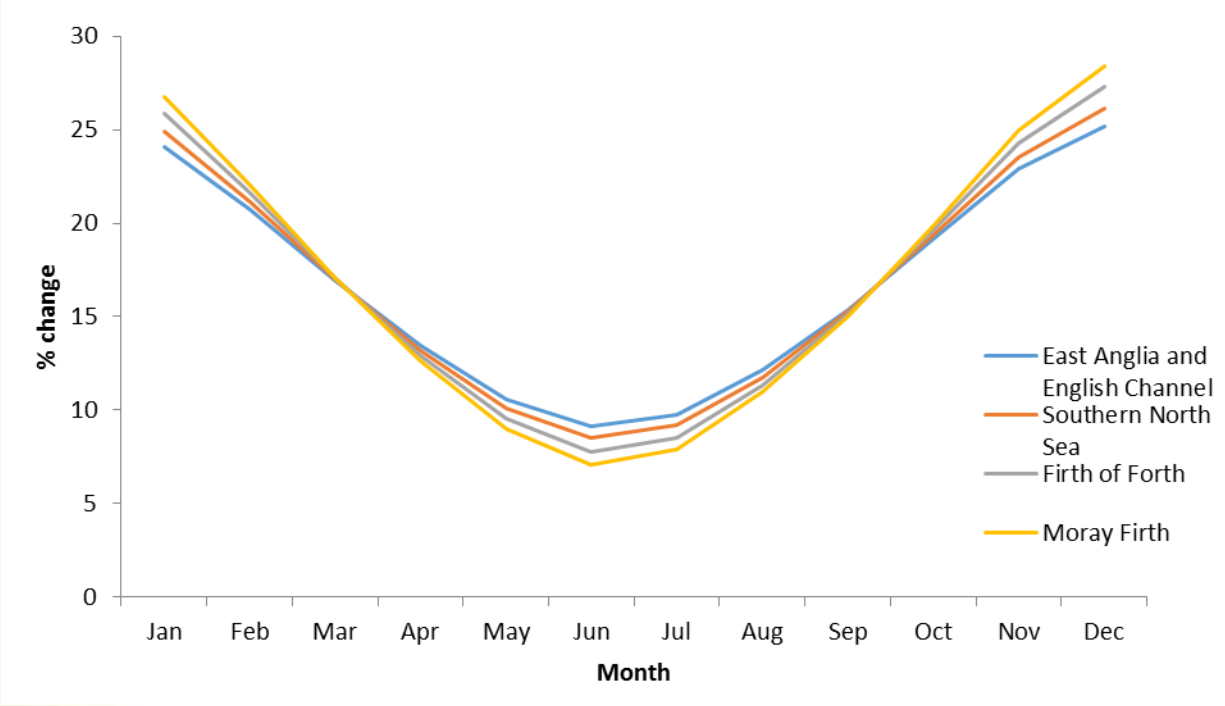
Reductions in the number of collisions occur in all months using both scenarios. These reductions occur due to the reduction in the proportion of time during which birds are at risk of collision. For the gannet scenario, birds were originally assumed to exhibit a nocturnal flight activity equivalent to 25% of daylight flight activity compared to no nocturnal flight activity whereas for the kittiwake scenario, birds were originally assumed to exhibit a nocturnal flight activity equivalent to 50% of daylight flight activity compared to an updated nocturnal flight activity equivalent to 25% of daylight flight activity. Identical changes would occur using both scenarios regardless of the species modelled as changes to the nocturnal flight activity have no influence on species-specific parameters within the Band (2012) CRM.

The effect of changing the nocturnal activity from 2 to 1 has a larger effect on resulting collision risk estimates than reducing the nocturnal activity factor from 3 to 2. This effect is more pronounced in winter months and is due to the monthly variation in the number of night-time hours when these are added to the number of daylight hours which remains constant in both scenarios.

The largest reductions in collision risk estimates using both scenarios occur in winter months across all latitudes with this linked to the relative durations of day and night. In winter months, the largest changes in both scenarios occur in the Moray Firth. This is due to there being more night-time hours at this latitude, meaning a reduction in the nocturnal flight activity of a species in this season has a greater effect than at more southerly latitudes. In summer months the opposite is true with larger changes occurring in the English Channel due to there being a greater proportion of night-time hours.



Graph 8.1: Reductions in collision risk estimates in each geographic region using the 'gannet' scenario – nocturnal activity factor changed from 2 (25%) to 1 (0%)



Graph 8.2: Reductions in collision risk estimates in each geographic region using the 'gull' scenario – nocturnal activity factor changed from 3 (50%) to 2 (25%)

8.4 Implications for Assessment

It is proposed that the changes to the nocturnal activity factors presented in Table 8.1 and applied in collision risk modelling for Moray West also be applied to the collision risk estimates used for projects considered in-combination/cumulatively.

In order to apply the changes in nocturnal activity factors presented in Table 8.1, it is necessary to have monthly collision risk estimates for projects considered in-combination/cumulatively. For many projects collision risk estimates at this temporal resolution are unavailable and therefore a precautionary approach has been adopted. Each project included in the in-combination and cumulative assessments for Moray West have been assigned to one of the four geographic regions used above (Table 8.3). As monthly collision risk estimates are not available for all projects the lowest monthly reduction has been applied for all projects in each of the four geographic regions (Table 8.3). This information will be incorporated into the EIA and HRA assessments for Moray West.

Table 8.3: Reductions to apply to collision risk estimates for projects in each geographic region

Geographic region	Projects within region	% reduction in collision risk estimates
East Anglia and English Channel	East Anglia One East Anglia Three Galloper Greater Gabbard Kentish Flats Extension London Array Thanet	Gannet = 10.1 Gull = 9.2
Southern North Sea	Dogger Bank Creyke Beck A & B Dogger Bank Teesside A & B Dudgeon Hornsea Project One Hornsea Project Two Humber Gateway Lincs Race Bank Sheringham Shoal Teesside Triton Knoll Westermost Rough	Gannet = 9.3 Gull = 8.5
Firth of Forth	Aberdeen (EOWDC) Inch Cape Kincardine[3] Methil Neart na Gaoithe Seagreen Alpha Seagreen Bravo	Gannet = 8.4 Gull = 7.8
Moray Firth	Beatrice Hywind Moray East	Gannet = 7.6 Gull = 7.1

[3] Collision risk modelling for Kincardine used a nocturnal activity factor of 1 for gannet and therefore only the gull correction factor has been applied

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Technical Appendix 10.3
Analysis of Displacement Effects on Seabirds

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Acronyms	
Acronym	**Expanded Term**
SNCBs	UK Statutory Nature Conservation Bodies
SNH	Scottish Natural Heritage
MSS	Marine Scotland Science
RSPB	Royal Society for the Protection of Birds
VORs	Valued Ornithological Receptors
MS-LOT	Marine Scotland Licencing and Operations Team
JNCC	Joint Nature Conservation Committee
DAS	Digital Aerial Surveys
EIA	Environmental Impact Assessment
HRA	Habitats Regulation Appraisal
MRSea	Marine Renewables Strategic Environmental Assessment
MORL	Moray Offshore Renewables Limited
EDA	Eastern Development Area
BDMPS	Biologically Defined Minimum Population Scales

1 Introduction

The physical presence of wind turbines has the potential to directly disturb and displace birds from within and around the Moray West Offshore Wind Farm. This in effect represents indirect habitat loss which would reduce the area available for feeding, loafing and moulting for seabird species that may occur at the Moray West Site.

This Technical Appendix presents data to inform the assessments presented in Chapter 10: Offshore Ornithology which determine the significance effects of displacement. The analyses presented in this Technical Appendix have been informed by recent guidance published jointly by the UK Statutory Nature Conservation Bodies (SNCBs) (JNCC *et al.,* 2017) and through consultation with Scottish Natural Heritage (SNH), Marine Scotland Science (MSS) and the Royal Society for the Protection of Birds (RSPB).

2 Background

Many groups of seabirds exhibit species-specific behavioural responses to operational offshore wind farms. These responses generally constitute an avoidance reaction in response to rotating turbines or vessel movements. Such a response can result in indirect habitat loss as species avoid areas in which operational wind farms are present (Maclean *et al*., 2009; Langston, 2010).

Displacement may impact bird populations by affecting site usage which may be for foraging, resting or moulting purposes. As a result of displacement an individual bird may experience a decrease in fitness, due to the effect of re-locating to alternative foraging grounds and/or changes to energy budgets due to the increased energy expenditure when avoiding a wind farm. These impacts, in turn, may have indirect effects on birds at areas that may be some distance from the wind farm including reduced energy acquisition as a result of increased competition at other foraging sites which can result in further reductions in fitness affecting reproductive success. However, due to limited empirical evidence quantifying the likely energetic consequences of displacement, Statutory Nature Conservation Bodies advice is to consider displacement impacts in terms of direct mortality on bird populations (JNCC *et al*., 2017). While this advice has been followed within this Annex it is noted that it represents an approach that is considerably precautionary.

The vulnerability of the seabirds identified as being present at Moray West Offshore Wind Farm in Technical Appendix 10.1: Offshore Ornithology Technical Report to displacement effects is shown in Table 2.1 with this information derived from Wade *et al*. (2016) or Garthe and Hüppop (2004).

Also included in Table 2.1: Vulnerability of Seabirds to Displacement from Structures (Wade et al., 2016; Garthe and Hüppop, 2004) is a 'uncertainty level' associated with the vulnerability scores from Wade *et al.* (2016). The uncertainty levels were defined by the quantity and quality of available data informing the respective vulnerability score. These uncertainty levels are considered as part of the process to identify Valued Ornithological Receptors (VORs) for inclusion in displacement analyses.

Table 2.1: Vulnerability of Seabirds to Displacement from Structures (Wade et al., 2016; Garthe and Hüppop, 2004)

Species	Vulnerability	Uncertainty level (Wade *et al.*, 2016)
Fulmar	Very Low	High
Gannet	High	Very low
Arctic skua	Very Low	Very High
Great skua	Very Low	High
Puffin	Moderate	Moderate
Razorbill	High	Very low
Guillemot	High	Very low
Common tern	Low	Low
Arctic tern	Low	Moderate
Kittiwake	Low	Very Low
Herring gull	Low	Very low
Lesser black-backed gull	Low	Very low
Great black-backed gull	Low	Very low

Displacement may impact bird populations by affecting site usage which may be for foraging, resting or moulting purposes. As a result of displacement an individual bird may experience a decrease in fitness, due to the effect of re-locating to alternative foraging grounds and/or changes to energy budgets due to the increased energy expenditure when avoiding a wind farm. These impacts, in turn, may have indirect effects on birds at areas that may be some distance from the wind farm including reduced energy acquisition as a result of increased competition at other foraging sites which can result in further reductions in fitness affecting reproductive success. However, due to limited empirical evidence quantifying the likely energetic consequences of displacement, Statutory Nature Conservation Bodies advice is to consider displacement impacts in terms of direct mortality on bird populations (JNCC *et al*., 2017). While this advice has been followed within this Annex it is noted that it represents an approach that is considerably precautionary.

JNCC *et al*., (2017) suggests a variety of factors can be used to determine an appropriate rate of mortality that's occurs as a result of displacement. These include the defined vulnerability of seabird species to displacement in combination with habitat use flexibility. Seabirds vary in the range of habitats they use, and whether they use these as specialists or generalists. Habitats at sea include a range of different oceanographic conditions, for example relating to water masses and frontal systems. The defined habitat use flexibility of a number of species/species groups is presented in Table 2.2.

Chapter 10: Offshore Ornithology presents further context on the assumptions relied upon when following the methodology proposed in JNCC *et al*., (2017) in particular from the results of Searle *et al*. (2014). This work presented models for certain key seabird species that were developed to estimate the population consequences of displacement (adult survival and breeding success) from the proposed Forth and Tay wind farms.

Table 2.2: Habitat Use Flexibility of Seabirds Considered for the Displacement Assessment of Moray West Offshore Wind Farm (Wade *et al*., 2016; Bradbury *et al.,* 2014).

Habitat use flexibility	Species / species group
Very High	Gannet, lesser black-backed gull, herring gull, fulmar
High	Kittiwake, great black-backed gull, Arctic skua, great skua
Medium	Guillemot, razorbill, puffin, Arctic tern, sandwich tern
Low	None
Very Low	None

Following guidance in JNCC *et al*., 2017, a 2 km buffer to the Moray West Site is applied to the assessment. Species where a 4 km buffer is considered appropriate (those with a Very High vulnerability to displacement such as divers and seaducks; Fox and Petersen, 2006; Percival, 2010) were not selected for inclusion in the analyses presented in this Annex due to insignificant observations (less than 10 birds) of these species during aerial surveys at the Moray West Site.

3 Methodology

3.1 Species for Consideration

The full process applied to identify Valued Ornithological Receptors (VORs) that may be affected by impacts associated with the Moray West Offshore Wind Farm is documented in the Technical Appendix 10.1: Offshore Ornithology Technical Report. Those Valued Ornithological Receptors that are potentially affected by displacement are those that are:

- Known to be vulnerable to displacement impacts (based on Wade *et al*., 2016; Bradbury *et al.,* 2014) (Table 2.2); and
- Where the population of the species observed at the development site plus a 4 km buffer is considered to be of importance, when compared against a relevant population scale thresholds (regional, national or international).

Table 3.1 identifies those VORs for which displacement analysis is required based on the above criteria. The following species were selected for displacement analysis:

- Fulmar;
- Razorbill;
- Guillemot;
- Puffin; and
- Kittiwake.

Table 3.1: Identification of Valued Ornithological Receptor for Which Analysis of Displacement for the Moray West Offshore Wind Farm is Required

Valued Ornithological Receptor	Vulnerability to displacement impacts	Importance of population at the Moray West Site	Displacement analysis required (Yes/No)
Fulmar	Very Low	Regional	Yes - species recorded in regionally important numbers, high uncertainty level associated with vulnerability score.
Gannet	High	Regional	No – Advice from Marine Scotland Licencing and Operations Team (MS-LOT) and Scottish Natural Heritage (SNH) suggests no likely implications of displacement on this species.
Arctic skua	Very Low	Regional	No – low vulnerability, recorded in only low numbers at the Moray West Site.
Great skua	Very Low	Local	No – low vulnerability, recorded in only low numbers at the Moray West Site.
Puffin	Moderate	Regional	Yes – moderate vulnerability, species recorded in regionally important numbers at the Moray West Site.
Razorbill	High	Regional	Yes –high vulnerability, species recorded in regionally important numbers at the Moray West Site.

Table 3.1: Identification of Valued Ornithological Receptor for Which Analysis of Displacement for the Moray West Offshore Wind Farm is Required			
Valued Ornithological Receptor	**Vulnerability to displacement impacts**	**Importance of population at the Moray West Site**	**Displacement analysis required (Yes/No)**
Guillemot	High	International	Yes – high vulnerability, species recorded in internationally important numbers at the Moray West Site.
Sandwich tern	Low	Local	No – low vulnerability, recorded in only low numbers at the Moray West Site.
Arctic tern	Low	Local	No – low vulnerability, recorded in only low numbers at the Moray West Site.
Kittiwake	Low	National	Yes - species recorded in nationally important numbers.
Herring gull	Low	Local	No – low vulnerability, recorded in only low numbers at the Moray West Site.
Lesser black-backed gull	Low	Local	No – low vulnerability, recorded in only low numbers at the Moray West Site.
Great black-backed gull	Low	National	No – low vulnerability, high habitat use flexibility

3.2 Population Estimates

Following guidance in JNCC *et al*., 2017, a 2 km buffer to the Moray West Site is applied to the assessment. Species where a 4 km buffer is considered appropriate (those with a Very High vulnerability to displacement such as divers and seaducks; Fox and Petersen, 2006; Percival, 2010) were not selected for inclusion in the analyses presented in this Annex due to insignificant observations (less than 10 birds) of these species during aerial surveys at the Moray West Site.

Project-specific data for the Moray West Offshore Wind Farm has been collected by twelve digital aerial surveys (DAS) carried out between April 2016 and March 2017 encompassing the Moray West Site plus a 4 km buffer. Further information on the aerial surveys undertaken for the Moray West Site and the methodologies used to derive population estimates is provided in the Technical Appendix 10.1 Offshore Ornithology Technical Report.

The primary data that informs the basis for the assessment are seasonal mean-peak population estimates (corrected for survey coverage and availability bias) including birds both on the water and in flight. For those species identified in Section 4.1, a 2 km buffer is considered appropriate to inform assessment of displacement. Seasonal definitions for each Valued Ornithological Receptor are based on advice from SNH and reference to Furness (2015).

It is recommended that two years of baseline survey data be collected in order to capture the inherent variability in seabird populations within assessments presented in an EIA/HRA including assessment of displacement (JNCC *et al.,* 2017). The Moray West Site aerial surveys have collected a single years of data through digital aerial survey. This has been supplemented by firstly the data being run through the MRSea package and then into a 'decision tree' process by which data is compared against overlapping data from

surveys of Beatrice Offshore wind Farm and MORL EDA (now Moray East) to select an appropriate population to inform the impact assessment (Technical Appendix 10.1 – Annex 10.1A).

The results of this analysis have been used to identify appropriate population estimates (Moray West Site and 2 km buffer) for use in displacement analyses (Table 2.1: Vulnerability of Seabirds to Displacement from Structures (Wade et al., 2016; Garthe and Hüppop, 2004) Table 3.2). These are populated for each defined season for each Valued Ornithological Receptor (noting that for some species some of the four definitions – breeding, post-breeding, non-breeding and pre-breeding do not apply).

Table 3.2: Seasonal Population Estimates (Moray West + 2 km buffer) for Species Under Consideration.

Species	Breeding	Post-breeding	Non-breeding	Pre-breeding
Fulmar	581 (Apr – Aug)	68 (Sep – Oct)	1,223 (Nov)	1,630 (Dec – Mar)
Guillemot	24,426 (Apr – Jul)	38,174(Aug – Sep)	8,217 (Oct – Mar)	
Razorbill	2,808 (Apr – Jul)	3,544 (Aug – Sep)	184 (Oct to Dec)	3,585 (Jan – Mar)
Puffin	1,115 (Apr – Jul)	3,966 (Aug – Sep)	12 (Oct – Mar)	
Kittiwake	6,902 (Apr – Aug)	1,470 (Sep to Dec)		1,074 (Jan to Mar)

3.3 Displacement and Mortality Rates

Displacement matrices are presented in Section 4.1 for each species and associated seasons identified in Section 3.2. Potential displacement impacts for each species are presented here based on a wide range of potential displacement (0-100%) and mortality rates (0-100%) following recent SNCB guidance (JNCC *et al*., 2017). Full consideration of the appropriate displacement and mortality rates to apply for assessment is provided in Chapter 10: Offshore Ornithology, with the appropriate displacement rates for each species included in Table 3.3 below.

Available published evidence for fulmar is limited and as such it is considered appropriate to consider a range of displacement rates from 10-30%. A 30% rate advised for kittiwake for Forth and Tay projects by MS-LOT (e.g. Scoping Opinion for Seagreen Offshore Wind Farm, 2017) and this is taken as being a precautionary guiding rate for the Moray West Offshore Wind Farm.

Monitoring studies have often recorded auks inside of wind farm areas and on the basis of the information presented in Chapter 10: Offshore Ornithology, a displacement value of 50% has been used for guillemots based on the conclusions of Vanerman *et al.,* (2016; 2017) and Nelson *et al.,* (2014), in particular. Razorbill appears to have a lower vulnerability to displacement impacts than guillemot (see studies summarised in Chapter 10: Offshore Ornithology), especially when considering the results obtained at Thortonbank (Vanerman *et al*., 2017), Blighbank (Vanerman *et al*., 2016) and Robin Rigg (Nelson *et al*., 2014) which show lower displacement rates than those calculated for guillemot. As such, a displacement rate of 40% is considered appropriate for razorbill. This is presented in addition to a 60% rate advised on all auk species for Forth and Tay projects by MS-LOT (e.g. Scoping Opinion for Seagreen Offshore Wind Farm, 2017).

There have been few studies which have included puffin as a separate species to assess displacement rates, with the majority combining all auks together. For assessment purposes, a displacement value of 50% from the Moray West Site plus 2 km buffer during the breeding and non-breeding seasons is considered appropriate for puffin, based on the rationale described for razorbill, but with an added degree of precaution due to a lower level of empirical evidence. The rates identified for the three auk species are presented in addition to a 60% rate advised on all auk species for Forth and Tay projects by MS-LOT (e.g. Scoping Opinion for Seagreen Offshore Wind Farm, 2017).

The mortality rates advised by MS-LOT as part of Scoping Opinions for a number of offshore wind farms are followed for the purposes of the assessment of the Moray West Offshore Wind Farm.

Table 3.3: Displacement and Mortality Rates Used in the Displacement Assessment for the Moray West Offshore Wind Farm for Relevant Species

Species	Displacement rate (%)	Mortality rate (%)
Fulmar	10-30	1
Razorbill	40-60	1
Guillemot	50-60	1
Puffin	50-60	2
Kittiwake	30	2

In Chapter 10: Offshore Ornithology the degree of change predicted to occur at the population level for a species is further explored by comparing the predicted displacement mortality to the relevant 1% of annual baseline mortality for each species. This approach has been used at other offshore wind farm projects (e.g. Hornsea Project Two) and is therefore considered applicable to the assessments conducted for the Moray West Offshore Wind Farm. As such, each matrix in the following species-specific sections is shaded to indicate where the displacement mortality surpasses the 1% of annual baseline mortality of the relevant regional or national population for each species. The relevant population against which displacement mortality is compared and the baseline mortality for each species (inverse of adult survival from Horswill and Robinson (2015)) are presented in each matrix.

The 1% value of annual baseline mortality provides guidance on the likely scale of impacts through displacement effects rather than being a definitive threshold. Considering that survival is likely to widely vary throughout the year and that information for all key species is only available on an annual basis, no attempt has been made to estimate seasonal baseline mortality. While the assessment of displacement impacts is undertaken on a seasonal basis it is considered most pragmatic to compare results with annual baseline mortality.

4 Results

4.1 Fulmar

Displacement matrices for each of the seasons relevant to fulmar, using the peak populations presented in Table 3.2 are presented in Table 4.1 to Table 4.4. The potential level of displacement mortality for fulmar is assessed in Chapter 10: Offshore Ornithology.

Table 4.1: Predicted Fulmar Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	1	3	6	12	17	23	29	35	41	46	52	58
20	1	2	6	12	23	35	46	58	70	81	93	105	116
30	2	3	9	17	35	52	70	87	105	122	139	157	174
40	2	5	12	23	46	70	93	116	139	163	186	209	232
50	3	6	15	29	58	87	116	145	174	203	232	261	290
60	3	7	17	35	70	105	139	174	209	244	279	314	348
70	4	8	20	41	81	122	163	203	244	285	325	366	406
80	5	9	23	46	93	139	186	232	279	325	372	418	465
90	5	10	26	52	105	157	209	261	314	366	418	470	523
100	6	12	29	58	116	174	232	290	348	406	465	523	581

Regional BDMPS population = 42,686 breeding individuals
Background mortality = 0.064

< 1% background mortality

> 1% background mortality

Table 4.2: Predicted Fulmar Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Post-Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	0	1	1	2	3	3	4	5	5	6	7
20	0	0	1	1	3	4	5	7	8	10	11	12	14
30	0	0	1	2	4	6	8	10	12	14	16	18	20
40	0	1	1	3	5	8	11	14	16	19	22	24	27
50	0	1	2	3	7	10	14	17	20	24	27	31	34
60	0	1	2	4	8	12	16	20	24	29	33	37	41
70	0	1	2	5	10	14	19	24	29	33	38	43	48
80	1	1	3	5	11	16	22	27	33	38	43	49	54
90	1	1	3	6	12	18	24	31	37	43	49	55	61
100	1	1	3	7	14	20	27	34	41	48	54	61	68
Regional BDMPS population = 957,702 individuals Background mortality = 0.064				< 1% background mortality					> 1% background mortality				

Table 4.3: Predicted Fulmar Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Non-Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	2	6	12	24	37	49	61	73	86	98	110	122
20	2	5	12	24	49	73	98	122	147	171	196	220	245
30	4	7	18	37	73	110	147	183	220	257	294	330	367
40	5	10	24	49	98	147	196	245	294	342	391	440	489
50	6	12	31	61	122	183	245	306	367	428	489	550	612
60	7	15	37	73	147	220	294	367	440	514	587	660	734
70	9	17	43	86	171	257	342	428	514	599	685	771	856
80	10	20	49	98	196	294	391	489	587	685	783	881	978
90	11	22	55	110	220	330	440	550	660	771	881	991	1101
100	12	24	61	122	245	367	489	612	734	856	978	1101	1223

Regional BDMPS population = 568,736 individuals
Background mortality = 0.064

< 1% background mortality

> 1% background mortality

Table 4.4: Predicted Fulmar Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Pre-Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	2	3	8	16	33	49	65	82	98	114	130	147	163
20	3	7	16	33	65	98	130	163	196	228	261	293	326
30	5	10	24	49	98	147	196	245	293	342	391	440	489
40	7	13	33	65	130	196	261	326	391	456	522	587	652
50	8	16	41	82	163	245	326	408	489	571	652	734	815
60	10	20	49	98	196	293	391	489	587	685	782	880	978
70	11	23	57	114	228	342	456	571	685	799	913	1027	1141
80	13	26	65	130	261	391	522	652	782	913	1043	1174	1304
90	15	29	73	147	293	440	587	734	880	1027	1174	1320	1467
100	16	33	82	163	326	489	652	815	978	1141	1304	1467	1630

Regional BDMPS population = 957,702 individuals
Background mortality = 0.064

< 1% background mortality

> 1% background mortality

4.2 Puffin

Displacement matrices for each of the seasons relevant to puffin, using the mean-peak populations presented in Table 3.2 are presented in Table 4.5 to Table 4.7. The potential level of displacement mortality for puffin is assessed in Chapter 10: Offshore Ornithology.

Table 4.5: Predicted Puffin Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	2	6	11	22	33	45	56	67	78	89	100	112
20	2	4	11	22	45	67	89	112	134	156	178	201	223
30	3	7	17	33	67	100	134	167	201	234	268	301	335
40	4	9	22	45	89	134	178	223	268	312	357	401	446
50	6	11	28	56	112	167	223	279	335	390	446	502	558
60	7	13	33	67	134	201	268	335	401	468	535	602	669
70	8	16	39	78	156	234	312	390	468	546	625	703	781
80	9	18	45	89	178	268	357	446	535	625	714	803	892
90	10	20	50	100	201	301	401	502	602	703	803	903	1004
100	11	22	56	112	223	335	446	558	669	781	892	1004	1115

Regional BDMPS population = 119,600 breeding individuals
Background mortality = 0.094

< 1% background mortality

> 1% background mortality

Table 4.6: Predicted Puffin Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Post-Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	4	8	20	40	79	119	159	198	238	278	317	357	397
20	8	16	40	79	159	238	317	397	476	555	634	714	793
30	12	24	59	119	238	357	476	595	714	833	952	1071	1190
40	16	32	79	159	317	476	634	793	952	1110	1269	1428	1586
50	20	40	99	198	397	595	793	991	1190	1388	1586	1785	1983
60	24	48	119	238	476	714	952	1190	1428	1666	1903	2141	2379
70	28	56	139	278	555	833	1110	1388	1666	1943	2221	2498	2776
80	32	63	159	317	634	952	1269	1586	1903	2221	2538	2855	3172
90	36	71	178	357	714	1071	1428	1785	2141	2498	2855	3212	3569
100	40	79	198	397	793	1190	1586	1983	2379	2776	3172	3569	3966

Regional BDMPS population = 119,600 breeding individuals
Background mortality = 0.094

< 1% background mortality

> 1% background mortality

Table 4.7: Predicted Puffin Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Non-Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	0	0	0	0	0	1	1	1	1	1	1
20	0	0	0	0	0	1	1	1	1	2	2	2	2
30	0	0	0	0	1	1	1	2	2	2	3	3	3
40	0	0	0	0	1	1	2	2	3	3	4	4	5
50	0	0	0	1	1	2	2	3	3	4	5	5	6
60	0	0	0	1	1	2	3	3	4	5	6	6	7
70	0	0	0	1	2	2	3	4	5	6	6	7	8
80	0	0	0	1	2	3	4	5	6	6	7	8	9
90	0	0	1	1	2	3	4	5	6	7	8	9	10
100	0	0	1	1	2	3	5	6	7	8	9	10	12

Regional BDMPS population = 231,957 individuals
Background mortality = 0.094

< 1% background mortality

> 1% background mortality

4.3 Razorbill

Displacement matrices for each of the seasons relevant to razorbill, using the mean-peak populations presented in Table 3.2 are presented in Table 4.8 to Table 4.11. The potential level of displacement mortality for razorbill is assessed in Chapter 10: Offshore Ornithology.

Table 4.8: Predicted Razorbill Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	3	6	14	28	56	84	112	140	168	197	225	253	281
20	6	11	28	56	112	168	225	281	337	393	449	505	562
30	8	17	42	84	168	253	337	421	505	590	674	758	842
40	11	22	56	112	225	337	449	562	674	786	898	1011	1123
50	14	28	70	140	281	421	562	702	842	983	1123	1263	1404
60	17	34	84	168	337	505	674	842	1011	1179	1348	1516	1685
70	20	39	98	197	393	590	786	983	1179	1376	1572	1769	1965
80	22	45	112	225	449	674	898	1123	1348	1572	1797	2022	2246
90	25	51	126	253	505	758	1011	1263	1516	1769	2022	2274	2527
100	28	56	140	281	562	842	1123	1404	1685	1965	2246	2527	2808

Regional BDMPS population = 107,711 breeding individuals
Background mortality = 0.105

< 1% background mortality

> 1% background mortality

Table 4.9: Predicted Razorbill Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Post-Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	4	7	18	35	71	106	142	177	213	248	284	319	354
20	7	14	35	71	142	213	284	354	425	496	567	638	709
30	11	21	53	106	213	319	425	532	638	744	851	957	1063
40	14	28	71	142	284	425	567	709	851	992	1134	1276	1418
50	18	35	89	177	354	532	709	886	1063	1240	1418	1595	1772
60	21	43	106	213	425	638	851	1063	1276	1488	1701	1914	2126
70	25	50	124	248	496	744	992	1240	1488	1737	1985	2233	2481
80	28	57	142	284	567	851	1134	1418	1701	1985	2268	2552	2835
90	32	64	159	319	638	957	1276	1595	1914	2233	2552	2871	3190
100	35	71	177	354	709	1063	1418	1772	2126	2481	2835	3190	3544

Regional BDMPS population = 591,874 individuals
Background mortality = 0.105

< 1% background mortality

> 1% background mortality

Table 4.10: Predicted Razorbill Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Non-Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	1	2	4	6	7	9	11	13	15	17	18
20	0	1	2	4	7	11	15	18	22	26	30	33	37
30	1	1	3	6	11	17	22	28	33	39	44	50	55
40	1	1	4	7	15	22	30	37	44	52	59	66	74
50	1	2	5	9	18	28	37	46	55	65	74	83	92
60	1	2	6	11	22	33	44	55	66	77	89	100	111
70	1	3	6	13	26	39	52	65	77	90	103	116	129
80	1	3	7	15	30	44	59	74	89	103	118	133	148
90	2	3	8	17	33	50	66	83	100	116	133	149	166
100	2	4	9	18	37	55	74	92	111	129	148	166	184

Regional BDMPS population = 218,622 individuals
Background mortality = 0.105

< 1% background mortality

> 1% background mortality

Table 4.11: Predicted Razorbill Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Pre-Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	4	7	18	36	72	108	143	179	215	251	287	323	359
20	7	14	36	72	143	215	287	359	430	502	574	645	717
30	11	22	54	108	215	323	430	538	645	753	860	968	1076
40	14	29	72	143	287	430	574	717	860	1004	1147	1291	1434
50	18	36	90	179	359	538	717	896	1076	1255	1434	1613	1793
60	22	43	108	215	430	645	860	1076	1291	1506	1721	1936	2151
70	25	50	125	251	502	753	1004	1255	1506	1757	2008	2259	2510
80	29	57	143	287	574	860	1147	1434	1721	2008	2294	2581	2868
90	32	65	161	323	645	968	1291	1613	1936	2259	2581	2904	3227
100	36	72	179	359	717	1076	1434	1793	2151	2510	2868	3227	3585

Regional BDMPS population = 591,874 individuals
Background mortality = 0.105

< 1% background mortality

> 1% background mortality

4.4 Guillemot

Displacement matrices for each of the seasons relevant to guillemot, using the mean-peak populations presented in Table 3.2 are presented in Table 4.12 to Table 4.14. The potential level of displacement mortality for guillemot is assessed in Chapter 10: Offshore Ornithology.

Table 4.12: Predicted Guillemot Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	24	49	122	244	489	733	977	1221	1466	1710	1954	2198	2443
20	49	98	244	489	977	1466	1954	2443	2931	3420	3908	4397	4885
30	73	147	366	733	1466	2198	2931	3664	4397	5129	5862	6595	7328
40	98	195	489	977	1954	2931	3908	4885	5862	6839	7816	8793	9770
50	122	244	611	1221	2443	3664	4885	6107	7328	8549	9770	10992	12213
60	147	293	733	1466	2931	4397	5862	7328	8793	10259	11724	13190	14656
70	171	342	855	1710	3420	5129	6839	8549	10259	11969	13679	15388	17098
80	195	391	977	1954	3908	5862	7816	9770	11724	13679	15633	17587	19541
90	220	440	1099	2198	4397	6595	8793	10992	13190	15388	17587	19785	21983
100	244	489	1221	2443	4885	7328	9770	12213	14656	17098	19541	21983	24426

Regional BDMPS population = 998,623 breeding individuals
Background mortality = 0.061

< 1% background mortality

> 1% background mortality

Table 4.13: Predicted Guillemot Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Post-Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	38	76	191	382	763	1145	1527	1909	2290	2672	3054	3436	3817
20	76	153	382	763	1527	2290	3054	3817	4581	5344	6108	6871	7635
30	115	229	573	1145	2290	3436	4581	5726	6871	8017	9162	10307	11452
40	153	305	763	1527	3054	4581	6108	7635	9162	10689	12216	13743	15270
50	191	382	954	1909	3817	5726	7635	9544	11452	13361	15270	17178	19087
60	229	458	1145	2290	4581	6871	9162	11452	13743	16033	18324	20614	22904
70	267	534	1336	2672	5344	8017	10689	13361	16033	18705	21377	24050	26722
80	305	611	1527	3054	6108	9162	12216	15270	18324	21377	24431	27485	30539
90	344	687	1718	3436	6871	10307	13743	17178	20614	24050	27485	30921	34357
100	382	763	1909	3817	7635	11452	15270	19087	22904	26722	30539	34357	38174

Regional BDMPS population = 998,623 breeding individuals
Background mortality = 0.061

< 1% background mortality

> 1% background mortality

Table 4.14: Predicted Guillemot Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Non-Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	8	16	41	82	164	247	329	411	493	575	657	740	822
20	16	33	82	164	329	493	657	822	986	1150	1315	1479	1643
30	25	49	123	247	493	740	986	1233	1479	1726	1972	2219	2465
40	33	66	164	329	657	986	1315	1643	1972	2301	2629	2958	3287
50	41	82	205	411	822	1233	1643	2054	2465	2876	3287	3698	4108
60	49	99	247	493	986	1479	1972	2465	2958	3451	3944	4437	4930
70	58	115	288	575	1150	1726	2301	2876	3451	4026	4601	5177	5752
80	66	131	329	657	1315	1972	2629	3287	3944	4601	5259	5916	6573
90	74	148	370	740	1479	2219	2958	3698	4437	5177	5916	6656	7395
100	82	164	411	822	1643	2465	3287	4108	4930	5752	6573	7395	8217

Regional BDMPS population = 1,617,306 individuals Background mortality = 0.061		< 1% background mortality		> 1% background mortality

4.5 Kittiwake

Displacement matrices for each of the seasons relevant to kittiwake, using the mean-peak populations presented in Table 3.2 are presented in Table 4.15 to Table 4.17. The potential level of displacement mortality for kittiwake is assessed in Chapter 10: Offshore Ornithology.

Table 4.15: Predicted Kittiwake Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	7	14	35	69	138	207	276	345	414	483	552	621	690
20	14	28	69	138	276	414	552	690	828	966	1104	1242	1380
30	21	41	104	207	414	621	828	1035	1242	1449	1656	1864	2071
40	28	55	138	276	552	828	1104	1380	1656	1933	2209	2485	2761
50	35	69	173	345	690	1035	1380	1726	2071	2416	2761	3106	3451
60	41	83	207	414	828	1242	1656	2071	2485	2899	3313	3727	4141
70	48	97	242	483	966	1449	1933	2416	2899	3382	3865	4348	4831
80	55	110	276	552	1104	1656	2209	2761	3313	3865	4417	4969	5522
90	62	124	311	621	1242	1864	2485	3106	3727	4348	4969	5591	6212
100	69	138	345	690	1380	2071	2761	3451	4141	4831	5522	6212	6902

Regional BDMPS population = 39,360 breeding individuals
Background mortality = 0.146

< 1% background mortality

> 1% background mortality

Table 4.16: Predicted Kittiwake Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Post-Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	3	7	15	29	44	59	74	88	103	118	132	147
20	3	6	15	29	59	88	118	147	176	206	235	265	294
30	4	9	22	44	88	132	176	221	265	309	353	397	441
40	6	12	29	59	118	176	235	294	353	412	470	529	588
50	7	15	37	74	147	221	294	368	441	515	588	662	735
60	9	18	44	88	176	265	353	441	529	617	706	794	882
70	10	21	51	103	206	309	412	515	617	720	823	926	1029
80	12	24	59	118	235	353	470	588	706	823	941	1059	1176
90	13	26	66	132	265	397	529	662	794	926	1059	1191	1323
100	15	29	74	147	294	441	588	735	882	1029	1176	1323	1470

Regional BDMPS population = 829,937 individuals
Background mortality = 0.146

< 1% background mortality

> 1% background mortality

Table 4.17: Predicted Kittiwake Mortality as a Result of Displacement from the Moray West Site and 2 km Buffer During the Pre-Breeding Season

Displacement Rate (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	2	5	11	21	32	43	54	64	75	86	97	107
20	2	4	11	21	43	64	86	107	129	150	172	193	215
30	3	6	16	32	64	97	129	161	193	225	258	290	322
40	4	9	21	43	86	129	172	215	258	301	344	386	429
50	5	11	27	54	107	161	215	268	322	376	429	483	537
60	6	13	32	64	129	193	258	322	386	451	515	580	644
70	8	15	38	75	150	225	301	376	451	526	601	676	751
80	9	17	43	86	172	258	344	429	515	601	687	773	859
90	10	19	48	97	193	290	386	483	580	676	773	870	966
100	11	21	54	107	215	322	429	537	644	751	859	966	1074

Regional BDMPS population = 627,816 individuals
Background mortality = 0.146

< 1% background mortality

> 1% background mortality

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MORAY WEST
OFFSHORE WINDFARM

Commercial Fisheries Technical Report

Moray Offshore Windfarm (West) Limited

Technical Appendix 11.1

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Acronyms	
Acronym	**Expanded Term**
AIS	Automatic Identification System
BMM	Brown and May Marine Ltd
CFP	Common Fisheries Policy
EC	European Commission
EDA	Eastern Development Area
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
GDP	Gross Domestic Product
ICES	International Council of the Exploration of the Sea
IFREMER	Institut Français de recherche pour l'exploitation de la Mer (English translation - French Research Institute for the Exploitation of the Sea)
MCZ	Marine Conservation Zone
MFIFA	Moray Firth Inshore Fishermen's Association
MLS	Marine Landing Size
MMO	Marine Management Organisation
RIFG	Regional Inshore Fisheries Group
SFF	Scottish Fishermen's Federation
SFSAG	Scottish Fisheries Sustainable Accreditation Group
UN	United Nations
VMS	Vessel Monitoring System

Executive Summary

The area of the Moray Firth in which the Moray West Offshore Windfarm and associated offshore transmission infrastructure (OfTI) ("the Development") is to be located is fished almost entirely by UK vessels with no significant activity by non-UK vessels observed over the past five years.

The five key fishing methods currently deployed in areas relevant to the Development are:

- Creel fishing for crabs and lobster;
- Jigging for principally mackerel;
- Demersal trawling for squid, *Nephrops* and whitefish species;
- Scallop dredging for king scallops; and
- Seine netting for whitefish.

The vessels engaged in creel fishing are, for the most part, under 10 metres in length, operating from a number of ports along the Moray Firth coast. The main fishing grounds of these vessels are understood to be inshore of the Moray West Site itself, with the grounds of some vessels overlapping the Offshore Export Cable Corridor. A number of the vessels engaged in creel fishing also practice jigging for mackerel, with the areas fished being similar to those where creel fishing occurs.

Demersal trawling by vessels deploying single and twin-rigged trawls occurs in the general area with squid and *Nephrops* being the principal target species and to a lesser extent, whitefish species. The information provided by the skippers consulted identified *Nephrops* grounds immediately to the south of the Moray West Site, extending along the majority of the south coast of the Moray Firth overlapping the Cable Corridor.

Two distinct squid fishing areas were derived from stakeholder consultation, namely inshore grounds extending along the south coast which overlap the Cable Corridor and further offshore grounds, a proportion of which overlap the Moray West Site.

The local scallop dredging grounds as defined by the scallop industry's Scottish Fishermen's Federation (SFF) representative are similar to the squid fishing grounds, comprising inshore grounds extending along the south coast and grounds further offshore overlapping the Moray West Site. Due to regulations limiting the number of dredges a vessel can deploy within the 12-mile limit, it is expected that the scallop dredging activity on the inshore grounds overlapping the Cable Corridor is by smaller locally-based vessels.

A significant proportion of the UK scallop dredging fleet is composed of larger nomadic vessels which seasonally fish extensive grounds in the North Sea, English Channel, off the Normandy coast, in the Irish Sea and off the Scottish West Coast. Whilst some of these vessels may occasionally fish in the Moray Firth, the grounds concerned represent a very small fraction of the overall grounds fished by the vessels.

Scallop fishing effort within a particular area is rarely constant year on year, as the normal pattern is for an area to be intensively fished for one to two years after which it is left to recover for periods varying from four to ten years.

Some Scottish seine netting landings values have been recorded by the Marine Management Organisation (MMO) within the International Council of the Exploration of the Sea (ICES) rectangle in which the Cable Corridor is located. This however is not reflected in the surveillance sightings or from the consultation undertaken, since seine netting in the area under consideration occurs to the north and north east of the Development.

Future patterns of fishing on national, regional and local scales are influenced by a number of unpredictable factors, most notably the imposition of quota changes and other measures, often implemented at short notice with limited industry consultation. Added to this is the uncertainty as to the policies to be implemented at the end of the Brexit transition period. However, whilst such uncertainty

exists, it is expected that the fisheries concerned are sufficiently stable to preclude dramatic changes to the baseline in the short and medium terms

1 Introduction

This document forms the Technical Report on commercial fisheries prepared as part of the Environmental Impact Assessment (EIA) Report for the Moray West Offshore Wind Farm ("Moray West Site") and Offshore Transmission Infrastructure (OfTI), considered together "the Development".

Commercial fishing is defined as the legitimate capture of finfish and shellfish to be sold for profit by a licensed fishing vessel. The following baseline focuses specifically on those fleets active in the vicinity of the Development. This includes the local inshore fleet and larger vessels which operate further offshore and have home ports in the UK and elsewhere in Europe.

There is currently no single data set, source or model which can determine patterns of commercial fishing activity within relatively small sea areas. As a consequence, the following baseline has been compiled using data and information derived from a number of sources.

Recorded fisheries statistics are presented by International Council of the Exploration of the Sea (ICES) rectangles. ICES statistical rectangles are the smallest spatial unit used for the collection and analysis of fisheries statistics by the European Commission (EC) and Member States. ICES rectangles cover approximately 900 nm^2 and align to 30' latitude by 1° longitude and it is recognised that the areas of ICES rectangles are greater than the footprint of the Development. Furthermore, it is acknowledged that activity within a rectangle may not be evenly distributed. Specific fishing grounds in the immediate vicinity of the Development have therefore been defined using information obtained from stakeholder consultation and using VMS and AIS records.

Commercial fishing is a diverse and constantly changing industry, subject to a wide variety of fishing legislation and regulations which can be altered and implemented at relatively short notice. Other factors, such as variations in target species, weather, fluctuations in market price and operating costs, can influence the commercial fisheries baseline both spatially and temporally. Any prediction of future baselines is therefore subject to a range of unpredictable factors of varying influence.

1.1 Study Area

The Development will be located in ICES Division IVa (Northern North Sea). Fisheries data are recorded, collated and analysed by ICES rectangles within each division. As previously mentioned ICES rectangles are the smallest available units for collation of fisheries data and are therefore used to define the analysis areas for the Development.

The landfall for the Cable is proposed for at a location along the Aberdeenshire coast, to the south of the Moray West Site.

The study area is shown in Figure 1.1. Overall, the Development is located within ICES rectangles 44E6, 44E7, 45E6 and 45E7. The Moray West Site is situated within 45E6 and 45E7 and the majority of the Cable Corridor is located in 44E7. Only a very small proportion of the Cable Corridor is located in ICES rectangle 44E6.

Within the study area, a range of fishing methods are undertaken by UK vessels as identified by surveillance sightings. The obtained data confirms that activity by non-UK vessels is so rare as to be considered negligible.

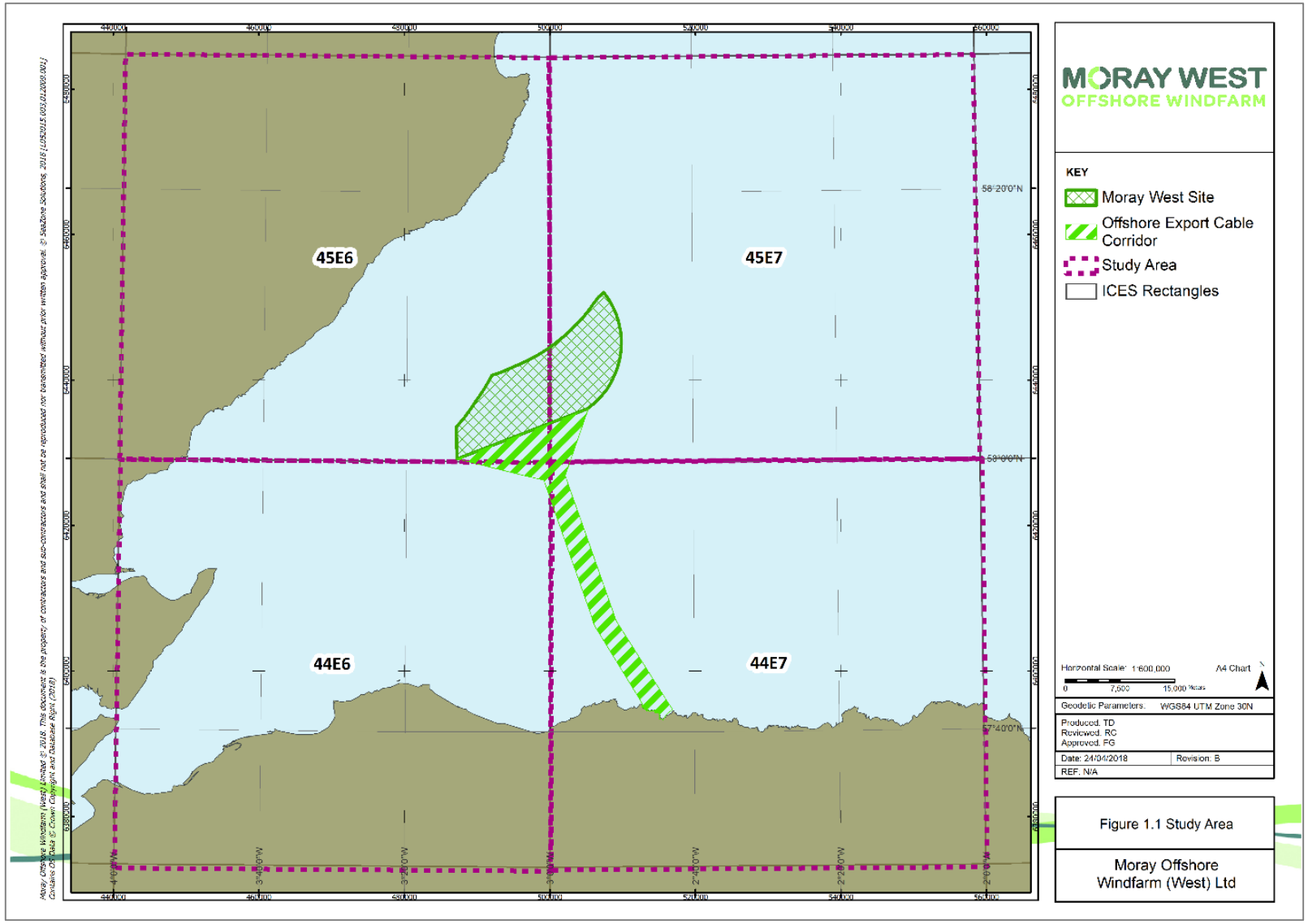


Figure 1.1 Commercial fisheries study area

2 Data Sources and Information Limitations

As previously stated, there is no single data source or model capable of establishing a commercial fisheries baseline within relatively small, discrete sea areas such as those occupied by offshore wind farms. Data and information has therefore been derived from a range of sources, namely:

- Marine Management Organisation (MMO), UK;
    - Surveillance sightings data (2012-2016);
    - Fisheries landings values and effort data (2012-2016); and
    - VMS data (2012-2016).
- Marine Scotland – vessel landing and Scottish fishing regulations (2017);
- Scottish Fishermen and Fishermen's Representatives – fishing vessels, gears, operating practices and fishing grounds (2017 consultation);
- BMM In-house databases; and
- A summary review of the available data on vessels of other nationalities, confirming the negligible levels of activity by non-UK vessels.

To more accurately illustrate trends when averaging annual data, the most recent five-year datasets (2012-2016) have been used. Where analysis of inter-annual trends has been undertaken, however, the past ten years' (2007-2016) data has been used.

Further details of the data sources used can be found in Annex 11.1A.

2.1 Consultation

Consultation was undertaken with both statutory and non-statutory stakeholders. This included the SFF and representatives of local associations and individual fishermen.

Direct consultation was undertaken with individual fishermen and fishermen's representative organisations (Table 2.1). In addition, questionnaires were distributed to fishermen via their organisations.

A meeting was held on 16th February 2018 with the SFF, during which the findings of this report were presented including the descriptions of the key fishing grounds and landings values by method and species. Also presented were details of the consultation undertaken.

In addition, non-UK stakeholder consultation was undertaken, summarised in Table 2.2 below, which supported the findings of the surveillance sightings discussed above.

Table 1.1 Summary of Local Fisheries Stakeholder Face-to-Face Consultation Undertaken by BMM Within the Moray Firth During 2017

Consultees	Port	Organisation/Role	Consultation date
Fisherman 1	Buckie	Creeler	9th January 2017
Fisherman 2	Buckie	Creeler (part time)	
Fisherman 3	Lossiemouth	Squid and *Nephrops* fisherman	
Fisherman 4	Buckie	Squid and *Nephrops* fisherman	
Fisherman 5	Buckie	Squid and *Nephrops* fisherman	
Fisherman 6	Buckie or Burgehead	Squid and *Nephrops* fisherman	

Table 1.1 Summary of Local Fisheries Stakeholder Face-to-Face Consultation Undertaken by BMM Within the Moray Firth During 2017

Consultees	Port	Organisation/Role	Consultation date
Fisherman 7	Fraserburgh	*Nephrops* and whitefish fisherman	
SFF	Aberdeen	Head of Policy Scallop Committee Industry Advisor	15th August 2017
Fisherman 8	Fraserburgh	*Nephrops* Skipper	16th August 2017
Fisherman 9	Cullen/Buckie	Moray Firth Inshore Fishermen's Association (MFIFA)	
Fisherman 10	Portknockie		
Fisherman 11	Portknockie		
Fisherman 12	Portknockie/Portsoy		
Fisherman 13	Whitehills		
John Cox	N/A	Aberdeenshire Councillor and Association Advisor	
Fisherman 14	Portsoy	Moray Firth Inshore Fishermen's Association (MFIFA)	
Fisherman 15	Portsoy		
Fisherman 16	Fidochty/Cullen		
Fisherman 17	Findochty		
Fisherman 18	Cullen		
Fisherman 19	Buckie	Moray Firth Inshore Fishermen's Association (MFIFA)	17th August 2017
Fisherman 20	Inverness	Inverness skipper	
Fisherman 21	Fraserburgh	Fraserburgh Whitefish Producers Organisation	23rd August 2017
Fisherman 22	Fraserburgh	Skipper - Denarius	23rd August 2017
SFF	Aberdeen	Head of Policy Industry Advisor	16th February 2018

Table 1.2 Consultation Undertaken with Non-UK Commercial Fishing Stakeholders			
Consultees	**Role/Organisation**	**Consultation date**	**Comments**
Antony Viera, Olivier Lepretre	Comité Régional des Pêches Maritimes (CRPMEM), Boulogne sur Mer	24/08/2017	The latest VMS data which has been received from CRPMEM, Boulogne sur Mer is from 2014. No issues raised.
-	Deutscher-fischerei-verband (Germany)	24/08/2017	Contacted regarding the Moray West development. No issues raised.
Jesper Espen	Fiskebat (Norway)	24/08/2017	Contacted regarding the Moray West development. No issues raised.

2.2 Fisheries Controls and Legislation

The UK's commercial fishing industry is subject to a range of constraints and legislation which are set by the European Commission (EC), the UK Government and Marine Scotland. The majority of such measures have a direct impact on fishing activity, and therefore on landings weights and values. Regulations are frequently implemented at short notice with limited consultation, reducing confidence in being able to predict future trends.

It should be noted that existing legislation is likely to be reviewed as part of the Brexit negotiations. It is currently unclear what changes are likely to be implemented. During the transition phase it is understood that policies under the CFP will continue to apply to the UK fleet.

Full details of fisheries legislation can be found in Annex 11.1B.

3 Overview of Fishing Activity

3.1 Surveillance Sightings

The distribution of surveillance sightings of fishing vessels recorded in the study area is shown by nationality in Figure 3.1 and by fishing method in Figure 3.2. It should be noted that surveillance sightings do not accurately describe the levels of fishing activity, but purely give an indication of vessel activity by gear and nationality.

The data show that the sightings throughout the area surrounding of the Development are of UK registered vessels (Figure 3.1). As previously stated, activity by non-UK vessels has been rarely observed.

The data indicates that the majority of sightings of the UK fleet are to the south of the Moray West Site, closer to the shore, although some activity does occur in the proposed site, albeit at significantly lower levels.

With regards to non-UK vessels, there are no historic rights for such vessels within the 12-mile limit along the Moray coast.

The UK fishing activities undertaken in the vicinity of the project identified through the initial data analysis and through consultation are:

- Creel fishing for shellfish
- Jigging for mackerel
- Demersal trawling for *Nephrops*, squid and whitefish
- Scallop dredging
- Scottish seine netting

Figure 3.2 shows the breakdown of surveillance sightings by method. This indicates a relatively high density of demersal trawlers across the Cable Corridor, concentrated more so in the middle section of the corridor. Some scallop dredgers are recorded within the Development but at lower densities than in other areas within the region. Creeling and whelking vessels have been observed in near shore waters all around the Moray Firth coastline, with very few observations beyond 12 miles from the coast. Surveillance sightings by nationality and gear type are shown in Table 3.1, Table 3.2 and Table 3.3.

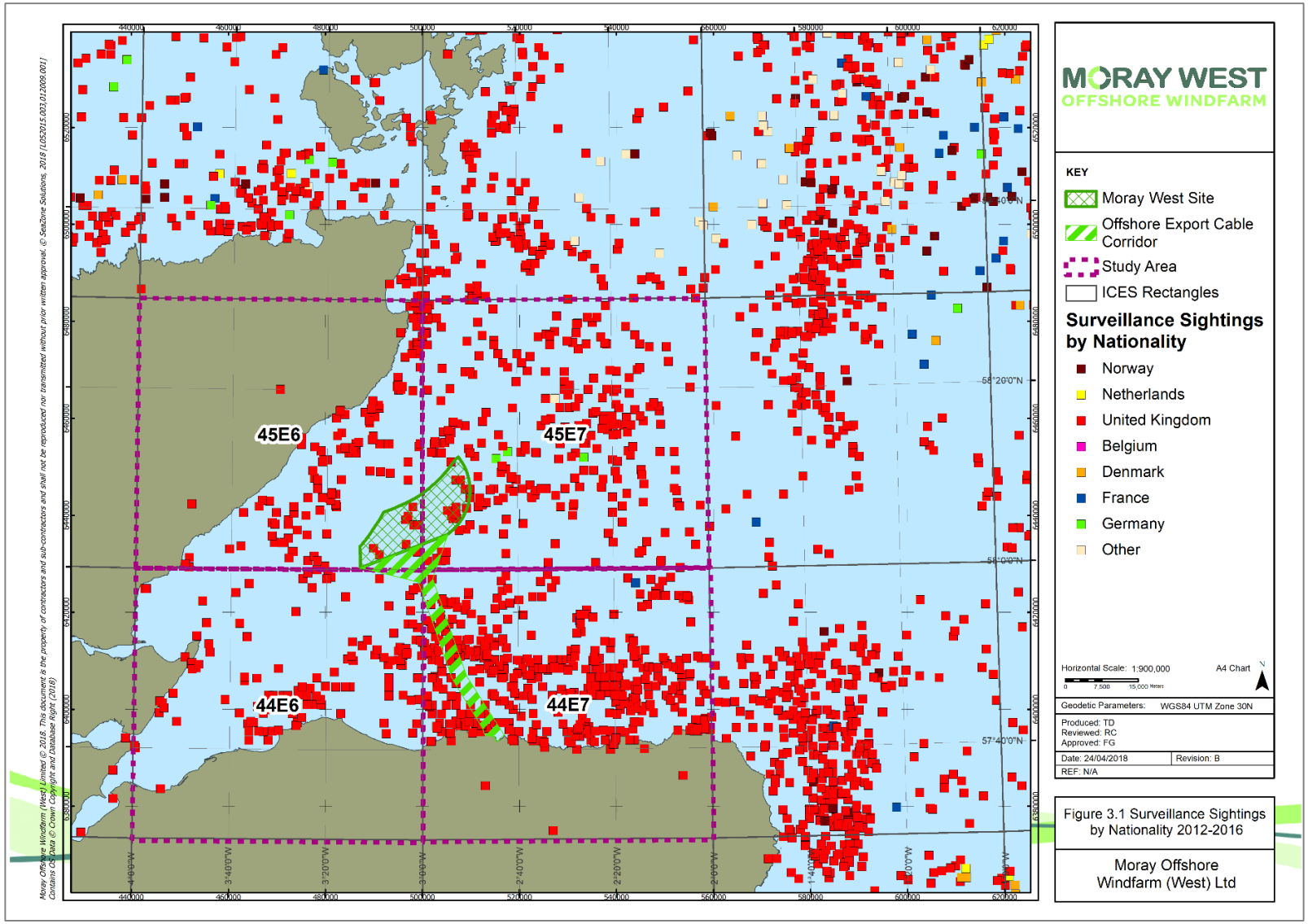


Figure 3.1 Surveillance sightings by nationality in the vicinity of the Development (2012-2016) (source: MMO, 2017)

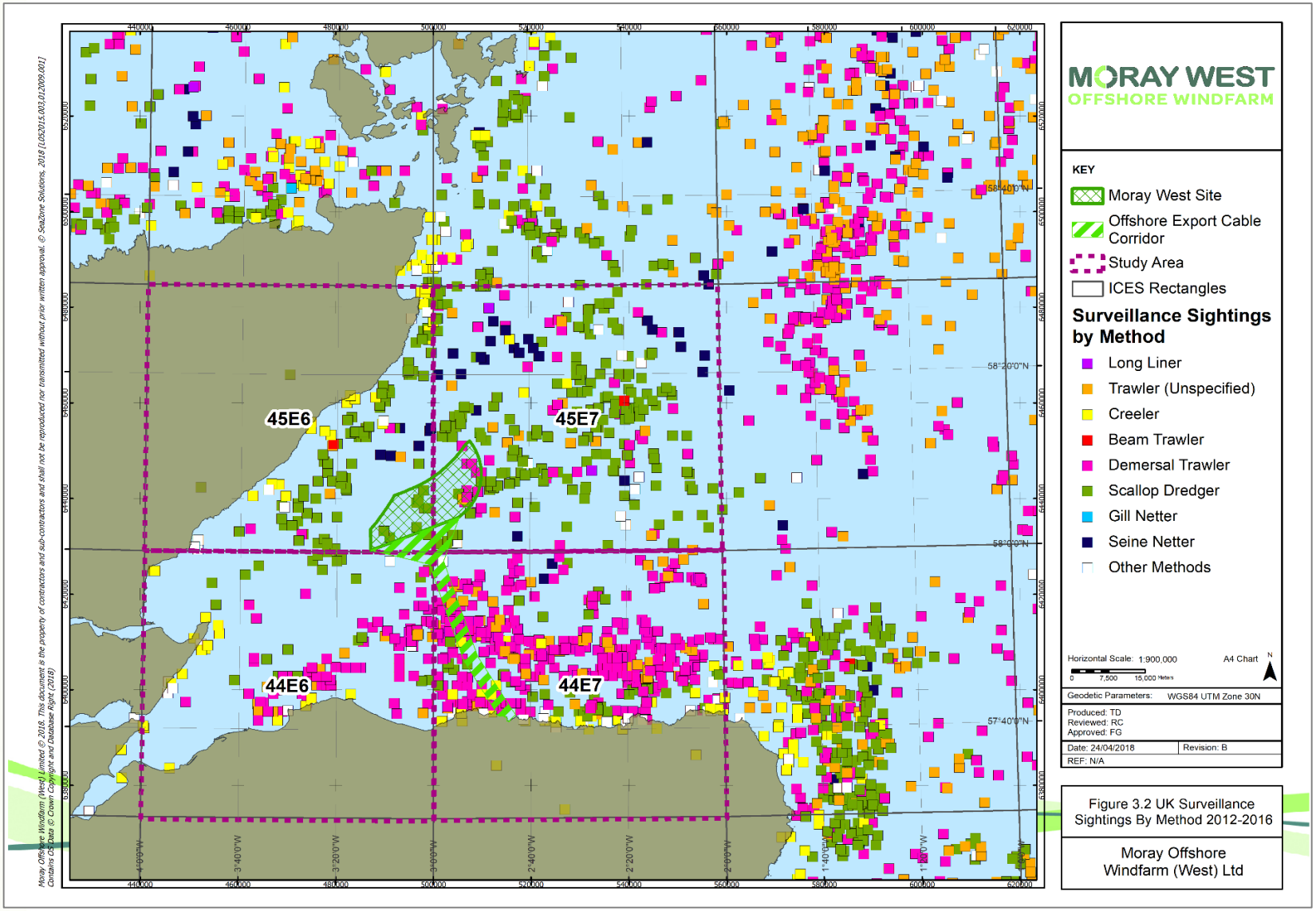


Figure 3.2 Surveillance sightings by method in the vicinity of the Development (2012-2016) (source: MMO, 2017)

Table 3.1 Surveillance Sightings (2012-2016) in ICES Rectangle 45E6 by Nationality and Method (source: MMO, 2017)

Nationality	Method	% of Total Sightings in 45E6
United Kingdom	Scallop Dredger (French/Newhaven)	44.0
	Potter/Whelker	30.2
	Demersal Stern Trawler	15.6
	Bottom Seiner (Anchor/Danish/Fly/Scots)	3.9
	Unknown	3.3
	Beam Trawler	0.6
	Demersal Side Trawler	0.6
	Pair Trawler (All)	0.6
	Pelagic Stern Trawler	0.6
	Side Trawler (Pelagic/Demersal)	0.3
	Trawler (All)	0.3
	United Kingdom % of total sightings (all gears)	100

Table 3.2 Surveillance Sightings (2012-2016) in ICES Rectangle 45E7 by Nationality and Method (source: MMO, 2017)

Nationality	Method	% of Total Sightings in 45E7
United Kingdom	Scallop Dredger (French/Newhaven)	38.2
	Demersal Stern Trawler	34.3
	Potter/Whelker	14.7
	Bottom Seiner (Anchor/Danish/Fly/Scots)	5.0
	Pelagic Stern Trawler	1.9
	Trawler (All)	1.8
	Null	1.2
	Unknown	1.2
	Demersal Side Trawler	0.3
	Long Liner	0.3
	Other Dredges (Including Mussel)	0.3
	Beam Trawler	0.1
	Industrial Trawler (Sandeeler)	0.1
	Pair Trawler (All)	0.1
	Rod and Line	0.1
	Side Trawler (Pelagic/Demersal)	0.1
	Stern Trawler (Pelagic/Demersal)	0.1
	United Kingdom % of total sightings (all gears)	**97.3**

Table 3.2 Surveillance Sightings (2012-2016) in ICES Rectangle 45E7 by Nationality and Method (source: MMO, 2017)

Nationality	Method	% of Total Sightings in 45E7
Norwegian	Trawler (All)	0.2
	Norwegian % of total sightings (all gears)	0.2
Netherlands	Trawler (All)	0.4
	German % of total sightings (all gears)	**0.4**
Ireland	Creeler/Whelker	0.1
	Trawler (All)	0.1
	Ireland % of total sightings (all gears)	**0.2**
Germany	Trawler (All)	0.9
	German % of total sightings (all gears)	**0.9**
Faroe Islands	Trawler (All)	0.1
	Potter/Whelker	0.1
	Faroe Islands % of total sightings (all gears)	**0.2**

Table 3.3 Surveillance Sightings (2012- 2016) in ICES Rectangle 44E7 by Nationality and Method (source: MMO, 2017)

Nationality	Method	% of Total Sightings in 44E7
United Kingdom	Demersal Stern Trawler	66.5
	Potter/Whelker	10.3
	Scallop Dredger (French/Newhaven)	7.7
	Trawler (All)	7.5
	Unknown	3.0
	Handliner	1.5
	Stern Trawler (Pelagic/Demersal)	1.3
	Pair Trawler (All)	0.6
	Pelagic Stern Trawler	0.6
	Bottom Seiner (Anchor/Danish/Fly/Scots)	0.4
	Demersal Side Trawler	0.4
	Other Dredges (Including Mussel)	0.2
	Rod and Line	0.2
	United Kingdom % of total sightings (all gears)	**100**

3.2 MMO Fisheries Statistics

Fisheries data for a five-year period from 2012-2016 was obtained from the MMO. The data includes landings (value) and VMS effort (days fished) data to assess:

- Species targeted
- Fishing methods used
- Vessel by length category (under 10 m, 10-15 m and over 15 m)
- Annual variations
- Seasonal variations
- Landings values and effort by port

As stated above, to more accurately illustrate trends when averaging annual data, the most recent five-year datasets (2012-2016) have been used. Where analysis of inter-annual trends has been undertaken, however, the past ten years' (2007-2016) data has been used.

Figure 3.3 gives an overview the landings values by species caught, by ICES rectangle, within the study area and Figure 3.4 the landings values by method. Figure 3.5, Figure 3.6 and Figure 3.7 show in more detail the landings value by method for each of the rectangles in which infrastructure is to be located.

The highest average annual landings occur within rectangle 44E7, in which the Cable Corridor is located, with *Nephrops*, squid and haddock caught by trawls representing the major proportion of the values.

Although comparatively lower in value than the trawl landings, landings of crabs and lobsters from creels also make a significant contribution to the value of landings within 44E7.

As shown by Figure 3.3 and Figure 3.4, a substantial proportion of the landings values in 45E7, in which the eastern section of the Moray West Site is located, are derived from scallop dredging. In terms of value, haddock and squid are the second and third most important species after which there are modest landing values for other species. There have been no significant recordings of creel fishing values between 2012 and 2016 in rectangle 45E7.

With regards to 45E6 (Figure 3.3, Figure 3.4 and Figure 3.7) in which the western section of the Moray West Site is located, creel fishing for crabs and lobsters and dredging for scallops are responsible for all but a very small proportion of the value of landings in the rectangle. The only other species of any significance is haddock caught by trawls and seine nets and a small amount from whelk potting. From the surveillance sightings and VMS discussed below, it appears that creel fishing is, for the most part, concentrated in the west of the rectangle in near shore waters whereas the scallop dredging activity is focused in the east of the rectangle.

The overview of landings values by vessel length is given in Figure 3.8 and for each rectangle in Figure 3.9 (44E7), Figure 3.10 (45E7) and Figure 3.11 (45E6).

In the case of 44E7, the majority of the activity, which is from trawlers and scallop dredgers, is by vessels of over 15 m in length. For 45E7, the activity is almost entirely by over 15 m scallop dredgers and to a lesser extent trawlers.

In rectangle 45E6, the pattern is reversed, whereby the highest proportion of landings values are from under 10 m vessels. Also of note is that a significant proportion of the landings values from scallop dredgers are the smaller class of vessels of between 10 and 15 m in length.

Figure 3.12 illustrates the overall pattern of landings values by species for the 10-year period between 2007 and 2016. In the case of scallops there appears to be a six to seven-year cycle of peak landings values and a five-year pattern for *Nephrops*. Squid landings values also appear to have six to seven-year cycles.

The seasonality of landings values by rectangle by species are given in Figure 3.13, Figure 3.14 and Figure 3.15.

In rectangle 44E7 (Figure 3.13), there are notable seasonal patterns for the landings of *Nephrops* and squid. In the case of *Nephrops,* there are pronounced peaks of activity in June and July, whilst the majority of the squid landings occur between July and November.

As shown by Figure 3.14, in rectangle 45E7, higher scallop landings values occur in the summer months of June, July and August, with very low values being recorded from November to February. Squid landings appear to be mainly confined to the four months from July to October, with peak landings occurring in August and September.

Figure 3.15 shows a marked pattern of substantially higher lobster landings values between July and October, whereas crab values are more consistent throughout the year. The scallop fishery exhibits a pattern of higher landings values between June and September.

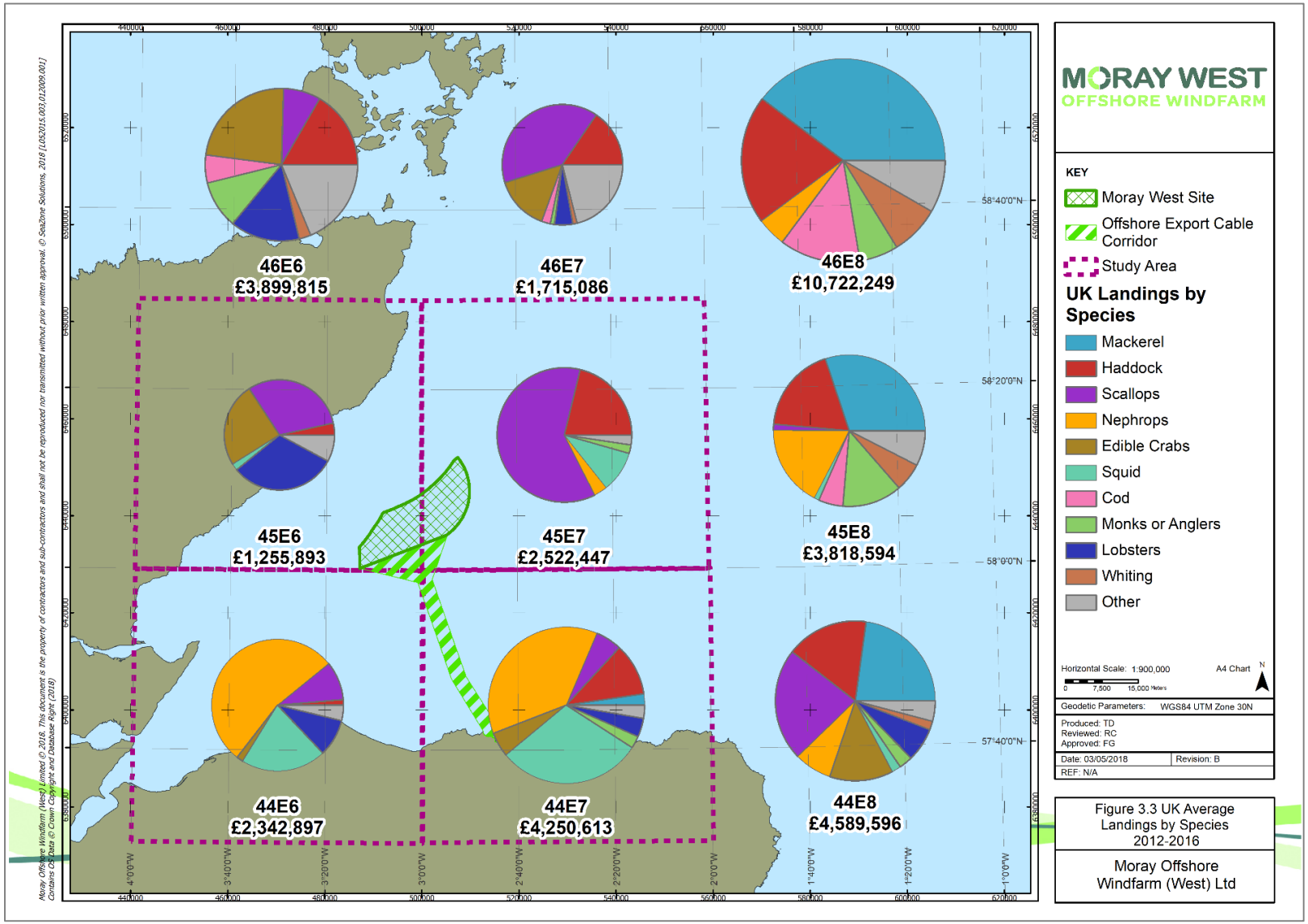


Figure 3.3 UK average annual landings values (2012-2016) by species (source: MMO, 2017)

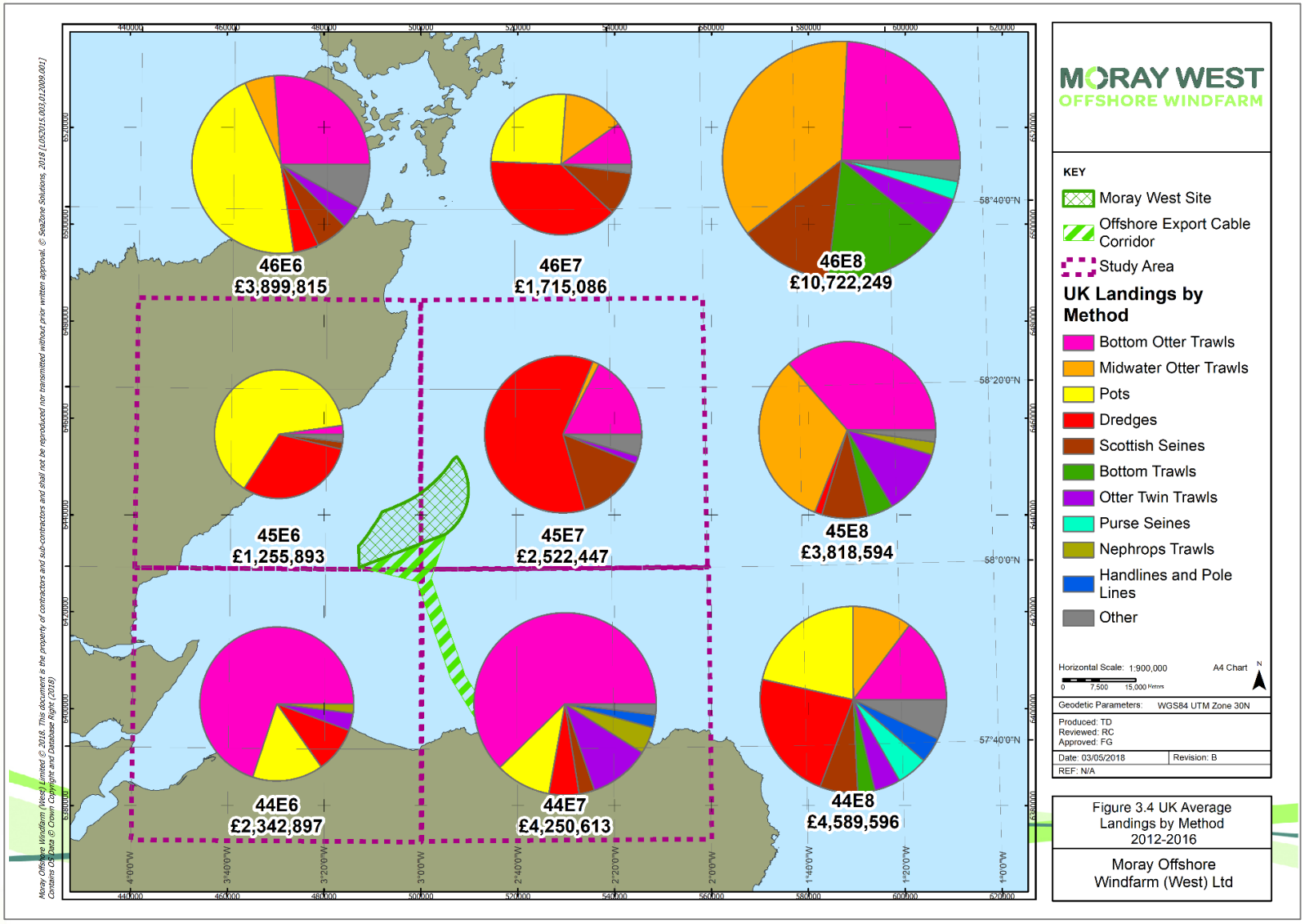
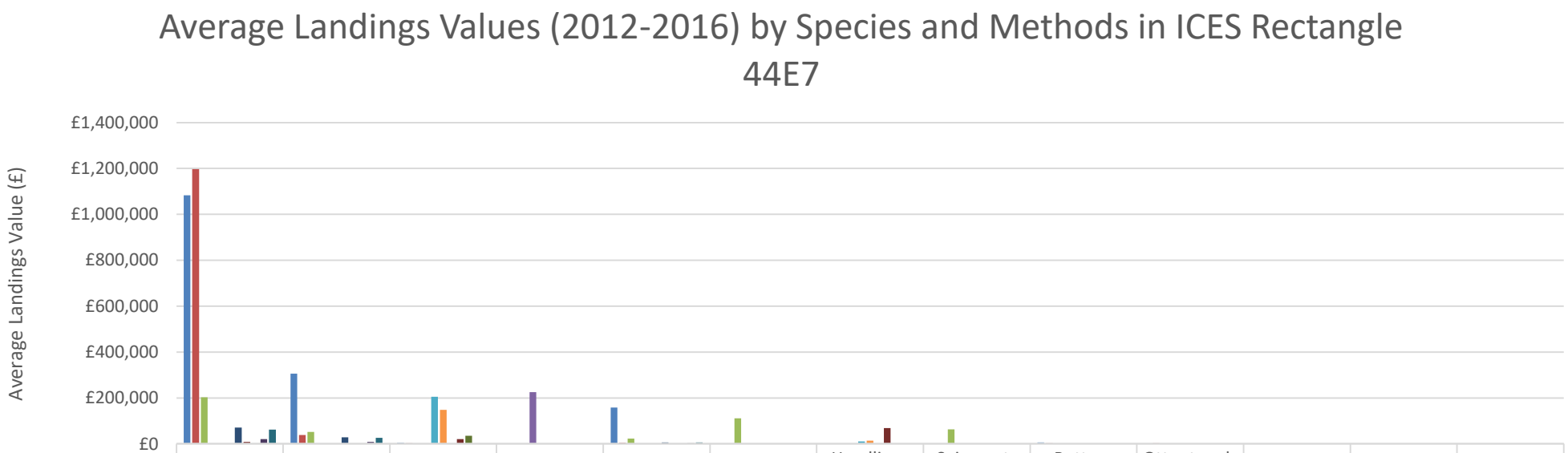
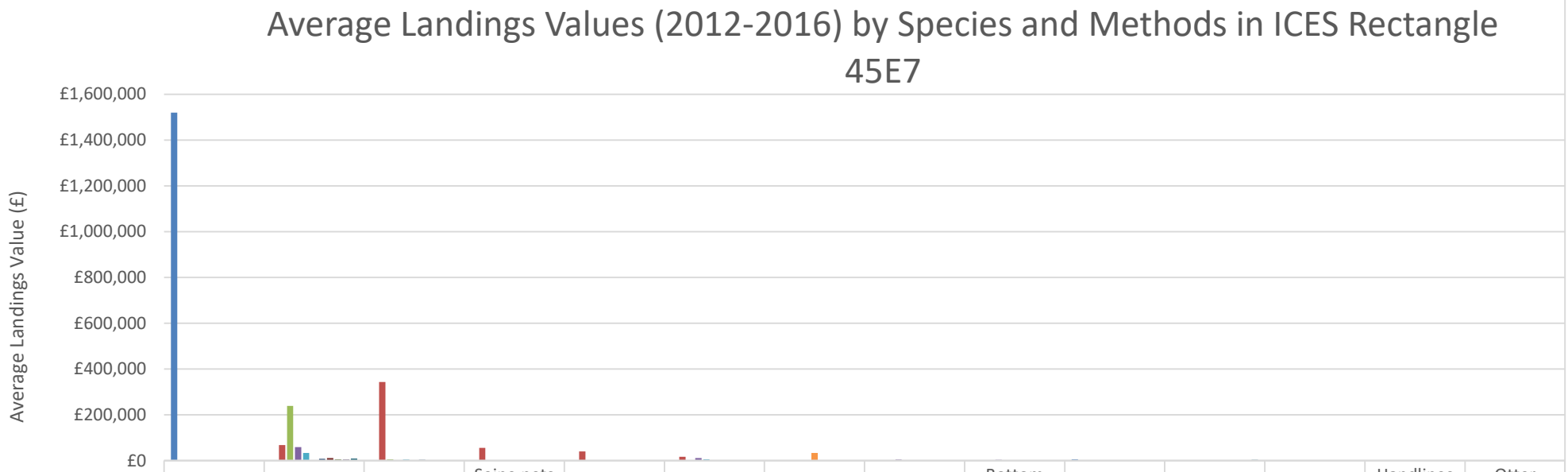


Figure 3.4 UK average annual landings values (2012-2016) by method (source: MMO, 2017)



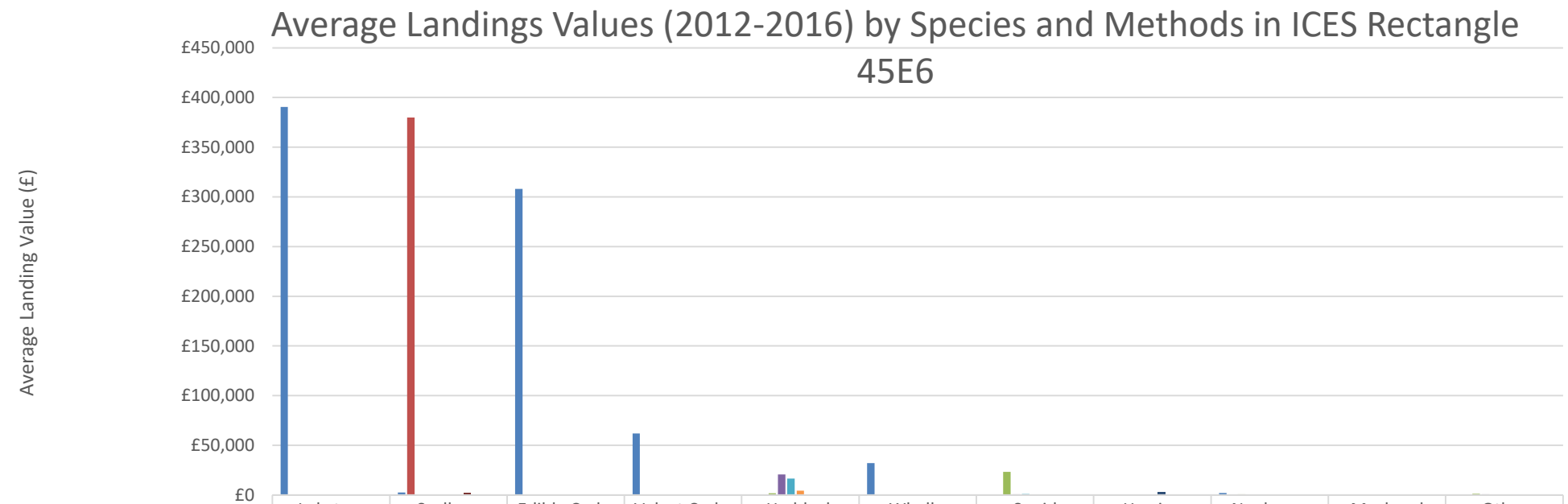
	Bottom otter trawls	Otter twin trawls	Pots	Boat dredges	Nephrops trawls	Scottish seines	Handlines and pole-lines	Seine nets (not specified)	Bottom trawls (not specified)	Otter trawls (not specified)	Bottom pair trawls	Mechanized dredges	Midwater otter trawls
Nephrops	£1,083,098	£306,367	£5,506	£266	£158,661	£20	£591	£4	£6,415	£900	£0	£0	£0
Squid	£1,197,482	£38,942	£2,364	£0	£4,604	£2,198	£837	£1,086	£2,545	£2,213	£5	£0	£455
Haddock	£202,859	£51,733	£17	£0	£22,984	£110,690	£0	£62,777	£1,776	£79	£765	£0	£0
Scallops	£0	£0	£0	£225,662	£0	£0	£0	£0	£0	£0	£0	£1,679	£0
Edible Crabs	£84	£0	£205,210	£0	£15	£0	£10,501	£0	£0	£0	£0	£0	£0
Lobsters	£462	£0	£148,105	£0	£4	£0	£13,839	£0	£0	£0	£0	£0	£0
Monks or Anglers	£70,758	£28,021	£1	£94	£6,534	£1,255	£1	£277	£629	£35	£0	£0	£0
Mackerel	£8,501	£119	£20,384	£0	£3	£2	£69,262	£3	£0	£0	£0	£0	£5
Velvet Crabs	£25	£0	£35,358	£0	£0	£0	£2,058	£0	£0	£0	£0	£0	£0
Whiting	£20,144	£8,309	£0	£0	£2,483	£1,535	£0	£207	£263	£15	£21	£0	£0
Other	£62,489	£26,032	£1,128	£8	£6,629	£1,560	£145	£296	£465	£23	£1,734	£0	£0

Figure 3.5 Average annual landings values (2012-2016) by species and methods in ICES rectangle 44E7 (source: MMO, 2017)



	Boat dredges	Bottom otter trawls	Scottish seines	Seine nets (not specified)	Danish seines	Otter twin trawls	Midwater otter trawls	Nephrops trawls	Bottom trawls (not specified)	Mechanized dredges	Pots	Midwater pair trawls	Handlines and pole-lines	Otter trawls (not specified)
Scallops	£1,519,641	£1	£0	£0	£0	£0	£0	£0	£0	£5,190	£0	£0	£0	£0
Haddock	£0	£68,351	£343,782	£55,662	£40,046	£16,508	£0	£1,026	£1,648	£0	£0	£0	£0	£0
Squid	£0	£239,027	£5,384	£1,443	£538	£876	£0	£235	£24	£0	£0	£0	£0	£0
Nephrops	£0	£58,745	£457	£22	£0	£11,357	£0	£4,597	£3,032	£0	£0	£0	£0	£0
Monks or Anglers	£2,447	£33,983	£4,380	£180	£896	£5,767	£0	£1,000	£993	£0	£0	£0	£0	£0
Herring	£0	£342	£0	£0	£0	£0	£32,953	£0	£0	£0	£0	£1,118	£0	£0
Whiting	£0	£7,570	£3,869	£781	£236	£1,209	£0	£28	£472	£0	£0	£0	£0	£0
Cod	£1	£10,974	£1,883	£2	£26	£694	£0	£6	£0	£0	£0	£0	£0	£0
Megrim	£0	£5,543	£226	£0	£63	£709	£0	£17	£89	£0	£0	£0	£0	£0
Mackerel	£0	£4,194	£15	£94	£0	£0	£116	£0	£0	£0	£0	£0	£992	£10
Other	£2,148	£9,211	£2,723	£283	£269	£2,002	£0	£242	£689	£0	£3,413	£0	£0	£0

Figure 3.6 Average annual landings values (2012-2016) by species and methods in ICES rectangle 45E7 (source: MMO, 2017)



	Lobsters	Scallops	Edible Crabs	Velvet Crabs	Haddock	Whelks	Squid	Herring	Nephrops	Mackerel	Other
Pots	£390,487	£2,468	£307,910	£61,924	£0	£32,121	£0	£0	£1,960	£355	£428
Boat dredges	£0	£379,914	£0	£0	£0	£0	£0	£0	£0	£0	£14
Bottom otter trawls	£149	£0	£253	£3	£1,899	£0	£23,344	£16	£705	£113	£1,272
Scottish seines	£0	£0	£0	£0	£20,658	£0	£762	£0	£0	£0	£817
Seine nets (not specified)	£0	£0	£0	£0	£16,553	£0	£884	£0	£0	£0	£310
Danish seines	£0	£0	£0	£0	£4,267	£0	£42	£0	£0	£0	£71
Midwater otter trawls	£0	£0	£0	£0	£0	£0	£0	£2,830	£0	£0	£0
Mechanized dredges	£0	£2,187	£0	£0	£0	£0	£0	£0	£0	£0	£0
Handlines and pole-lines	£150	£0	£201	£18	£0	£0	£0	£0	£0	£513	£0
Hand fishing	£39	£0	£2	£33	£0	£0	£0	£0	£0	£0	£101
Hooks and lines (not specified)	£20	£0	£52	£9	£0	£0	£0	£0	£0	£38	£0

Figure 3.7 Average annual landings values (2012-2016) by species and methods in ICES rectangle 45E6 (source: MMO, 2017)

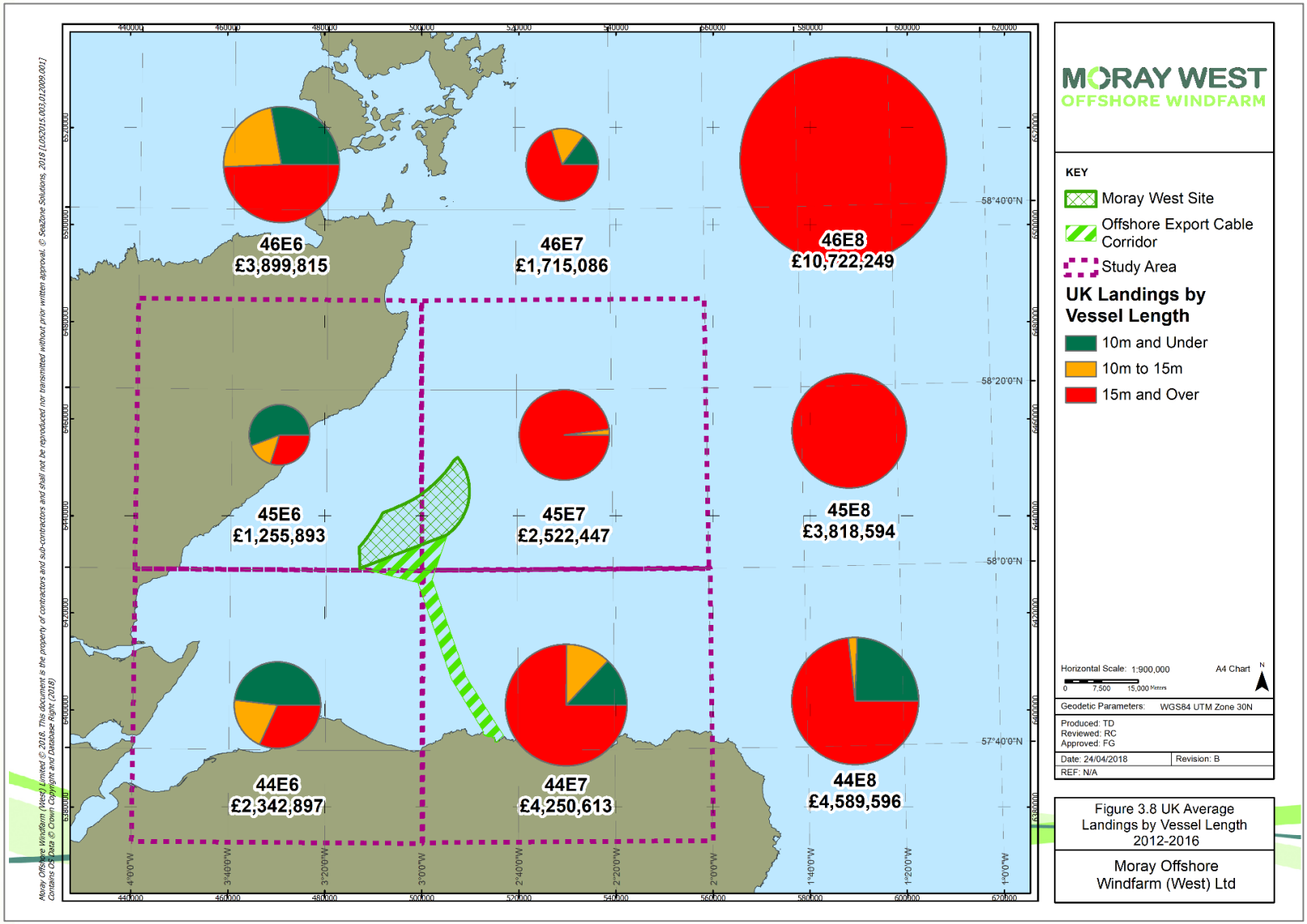
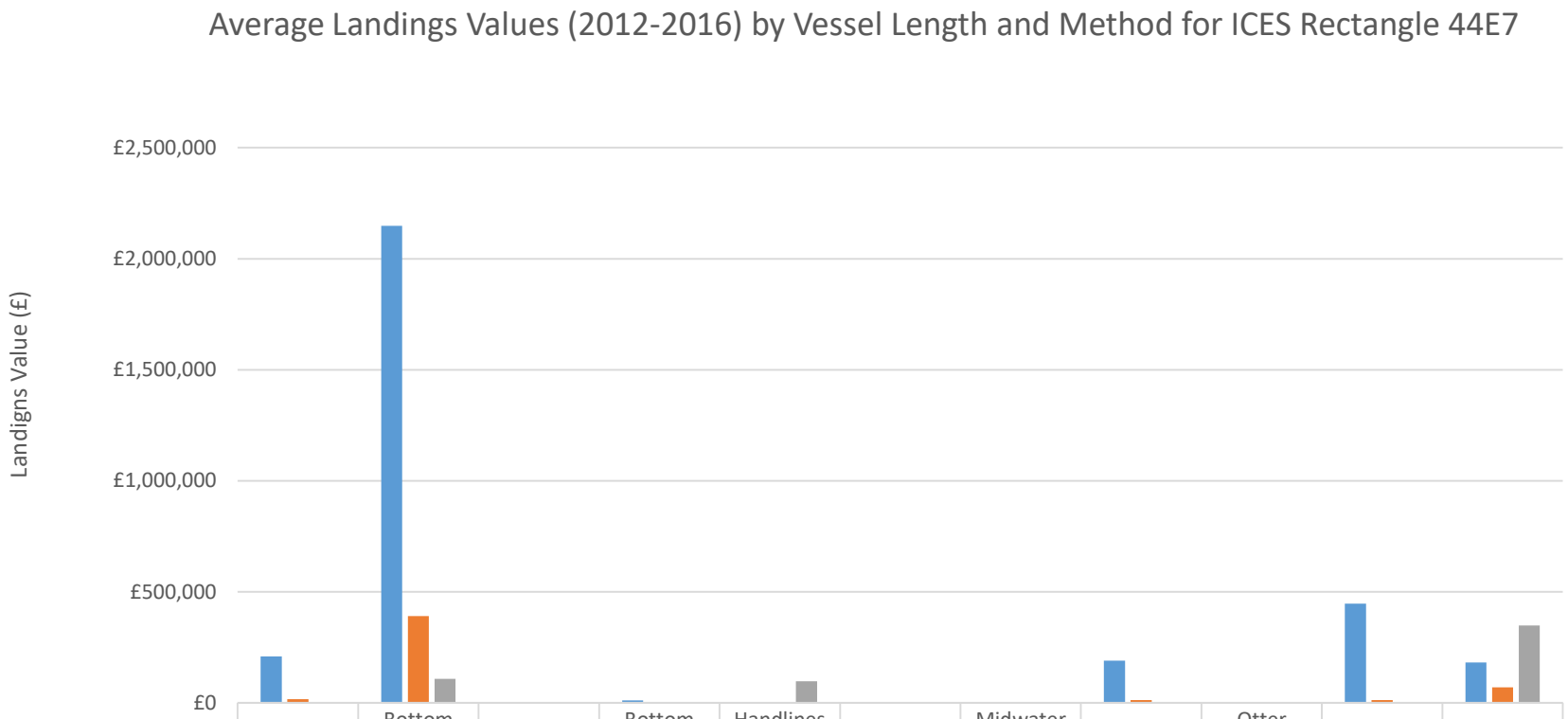
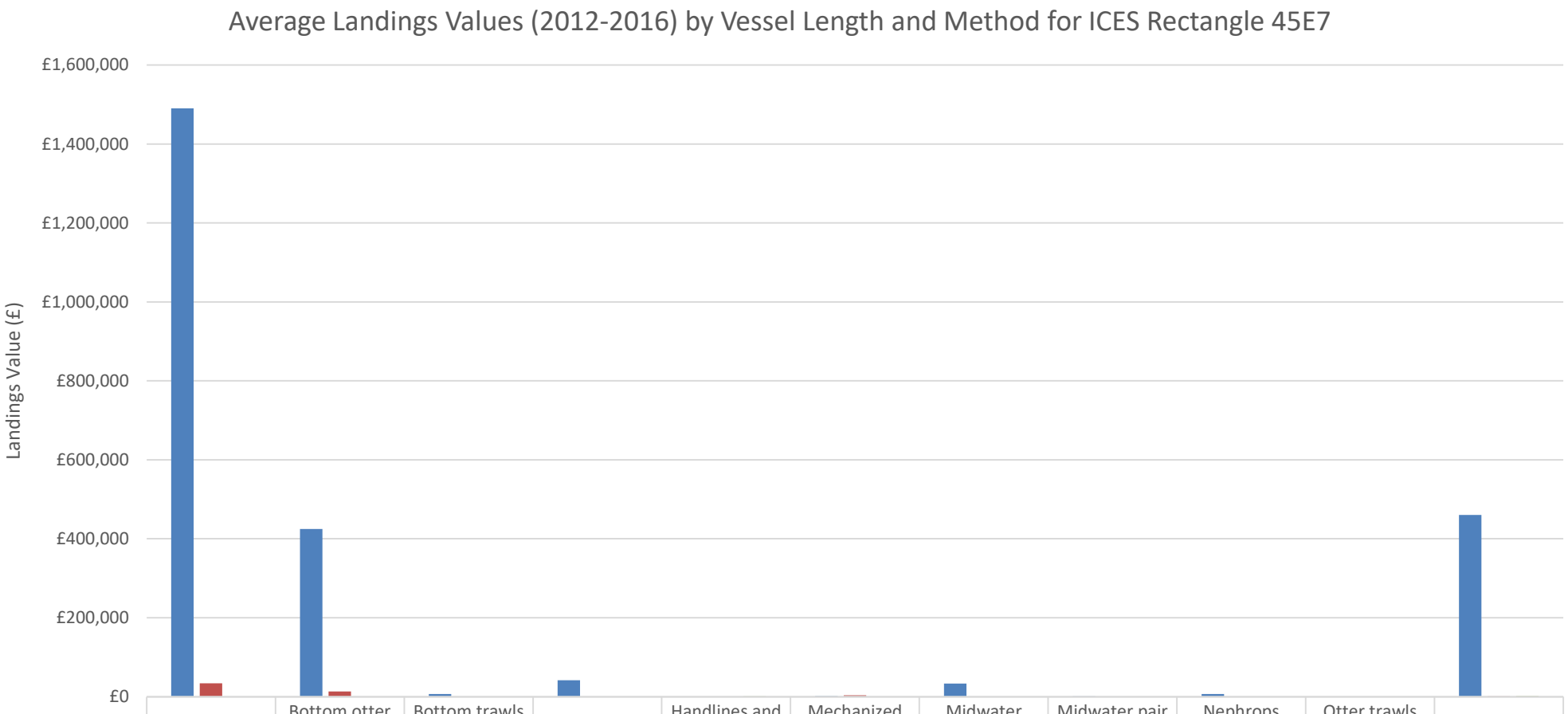


Figure 3.8 Average annual landings values (2012-2016) by vessel length (source: MMO, 2017)



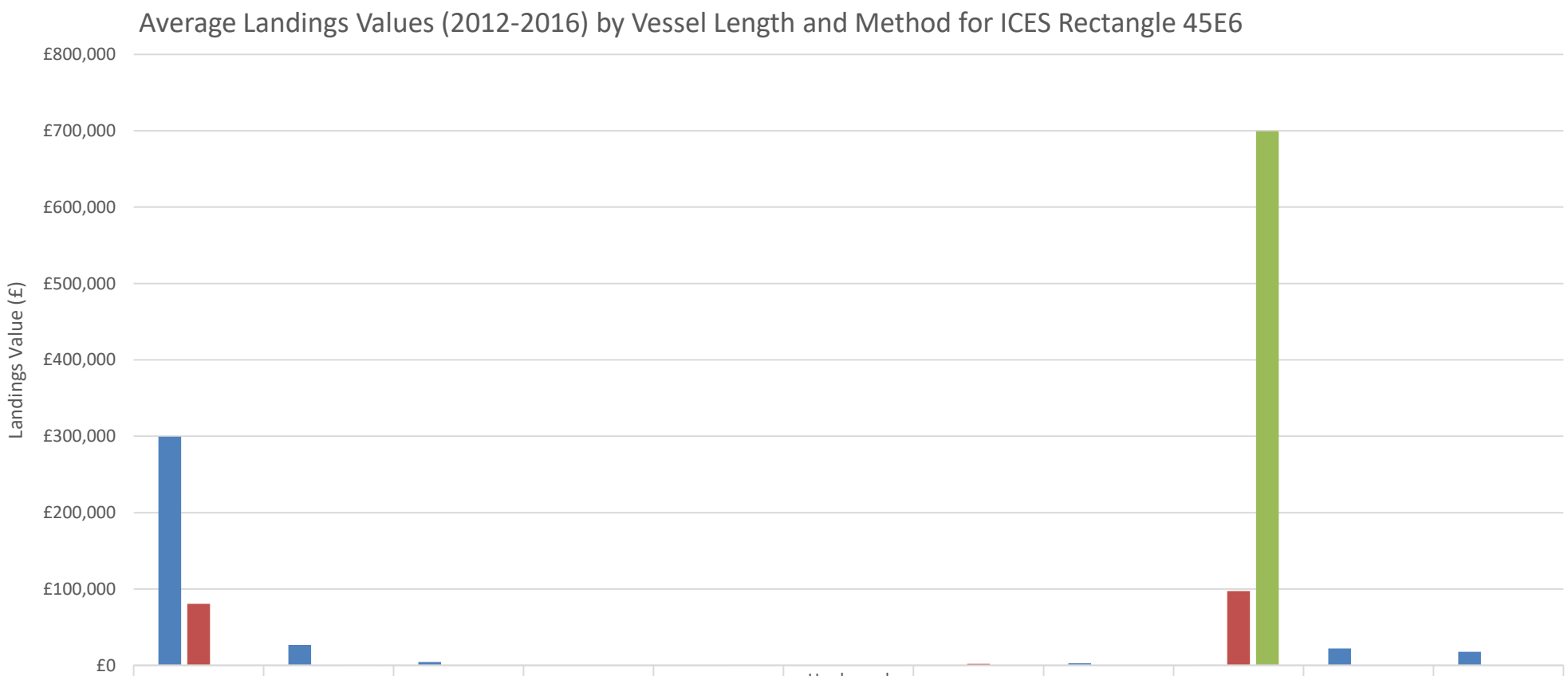
	Boat dredges	Bottom otter trawls	Bottom pair trawls	Bottom trawls (not specified)	Handlines and pole-lines	Mechanized dredges	Midwater otter trawls	Nephrops trawls	Otter trawls (not specified)	Otter twin trawls	Other
15m and Over	£208,918	£2,147,737	£2,525	£11,679	£0	£0	£460	£189,794	£3,042	£446,165	£181,912
10 to 15m	£16,544	£390,339	£0	£414	£0	£1,679	£0	£12,122	£221	£13,136	£70,287
Under 10	£569	£107,827	£0	£0	£97,234	£0	£0	£0	£0	£224	£347,785

Figure 3.9 Average annual landings values (2012-2016) by vessel length and method for ICES rectangle 44E7 (source: MMO, 2017)



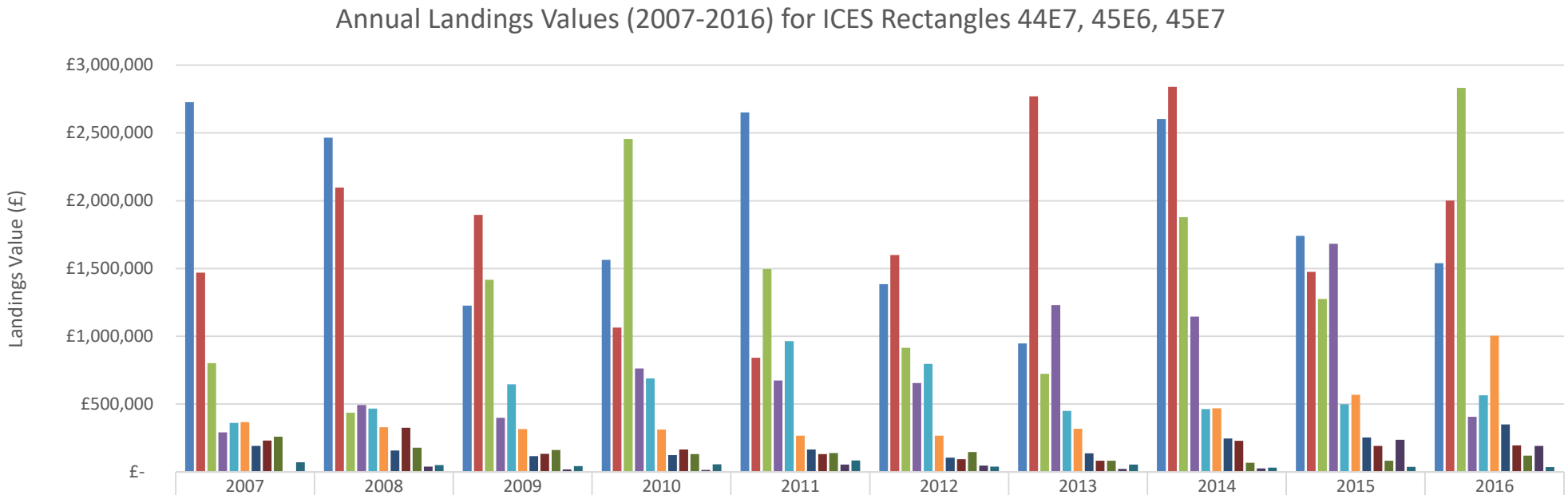
	Boat dredges	Bottom otter trawls	Bottom trawls (not specified)	Danish seines	Handlines and pole-lines	Mechanized dredges	Midwater otter trawls	Midwater pair trawls	Nephrops trawls	Otter trawls (not specified)	Other
15m and Over	£1,490,052	£424,870	£6,947	£42,074	£0	£1,840	£33,069	£1,118	£7,023	£10	£460,598
10m to 15m	£34,184	£13,070	£0	£0	£0	£3,350	£0	£0	£127	£0	£1,356
Under 10	£0	£0	£0	£0	£992	£0	£0	£0	£0	£0	£1,764

Figure 3.10 Average annual landings values (2012-2016) by vessel length and method for ICES rectangle 45E7 (source: MMO, 2017)



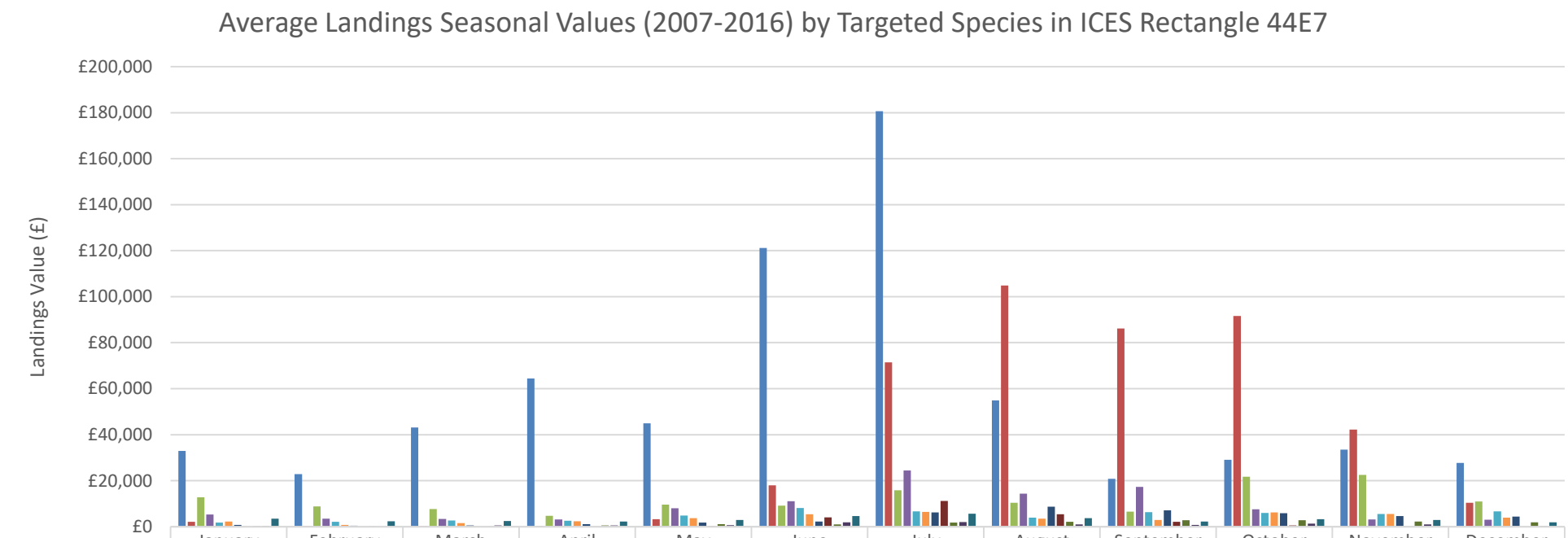
	Boat dredges	Bottom otter trawls	Danish seines	Hand fishing	Handlines and pole-lines	Hooks and lines (not specified)	Mechanized dredges	Midwater otter trawls	Pots	Scottish seines	Seine nets (not specified)
Over 15m	£299,315	£26,733	£4,380	£0	£0	£0	£0	£2,830	£674	£22,237	£17,748
10m to 15m	£80,613	£172	£0	£0	£0	£0	£2,187	£0	£97,507	£0	£0
Under 10m	£0	£849	£0	£175	£881	£119	£0	£0	£699,473	£0	£0

Figure 3.11 Average annual landings values (2012-2016) by vessel length and method for ICES rectangle 45E6 (source: MMO, 2017)



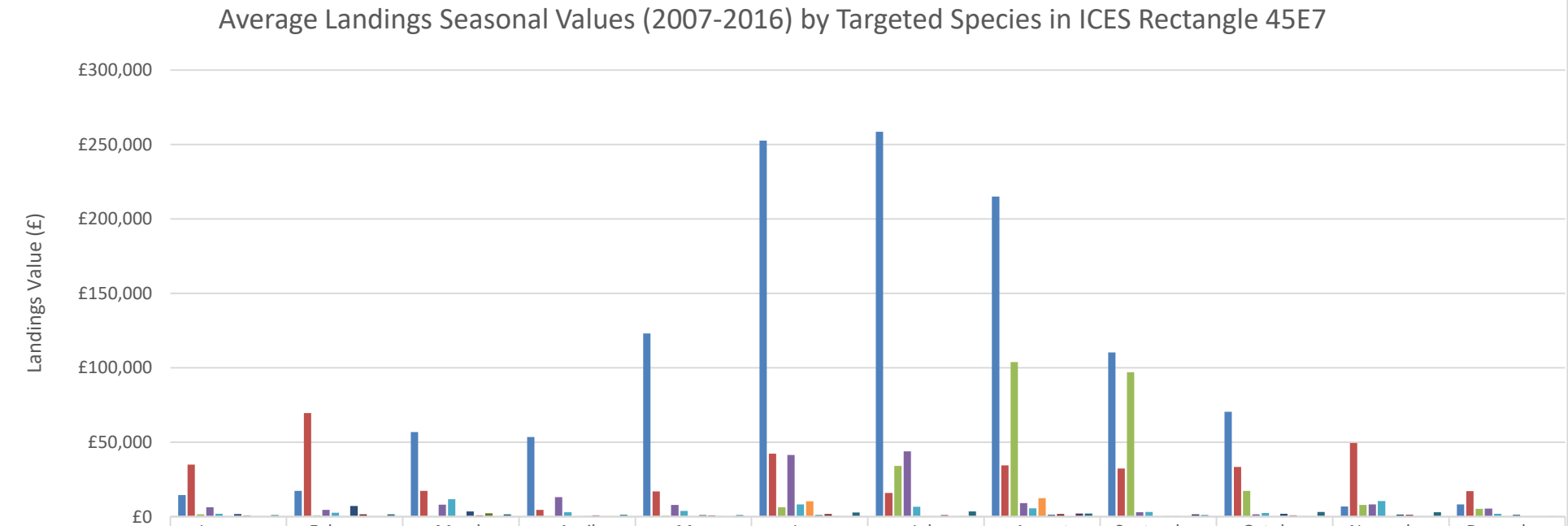
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Nephrops	£2,727,338	£2,465,509	£1,225,650	£1,563,715	£2,650,628	£1,384,130	£946,521	£2,603,109	£1,741,223	£1,538,535
Scallops	£1,469,684	£2,096,197	£1,894,632	£1,065,042	£841,467	£1,599,168	£2,769,584	£2,839,047	£1,474,433	£2,001,475
Squid	£801,362	£436,097	£1,416,119	£2,454,389	£1,496,718	£915,529	£723,609	£1,878,807	£1,275,928	£2,832,580
Haddock	£291,911	£493,026	£399,389	£761,820	£673,670	£656,063	£1,230,422	£1,146,060	£1,681,597	£406,258
Lobsters	£361,935	£467,170	£646,562	£690,070	£965,104	£796,584	£449,182	£463,106	£499,272	£563,970
Edible Crabs	£367,053	£328,763	£315,696	£312,407	£267,347	£267,791	£318,826	£468,760	£568,696	£1,003,153
Other	£190,727	£156,936	£116,039	£124,577	£165,307	£105,799	£136,167	£245,546	£254,202	£350,451
Monks or Anglers	£232,048	£325,438	£132,741	£165,532	£132,024	£93,077	£81,683	£228,515	£191,316	£195,456
Velvet Crabs	£258,774	£179,018	£160,560	£130,641	£138,641	£146,904	£83,139	£66,961	£82,994	£119,546
Mackerel	£504	£38,555	£18,586	£13,560	£54,443	£46,499	£22,157	£25,938	£237,580	£191,426
Cod	£70,163	£50,435	£43,655	£55,858	£83,494	£38,750	£53,260	£31,595	£37,604	£34,779

Figure 3.12 Annual landings values (2007-2016) for ICES rectangles 44E7, 45E6, 45E7 (source: MMO, 2017)



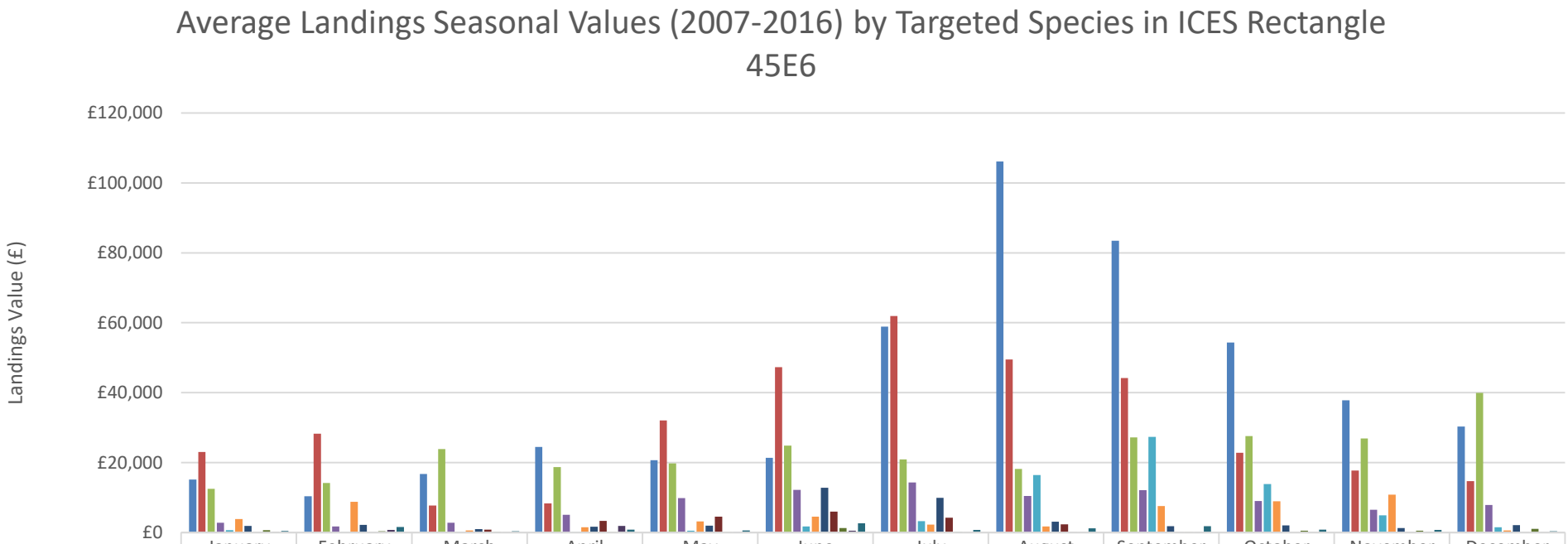
	January	February	March	April	May	June	July	August	September	October	November	December
Nephrops	£32,938	£22,869	£43,075	£64,418	£44,906	£121,222	£180,631	£54,875	£20,760	£29,056	£33,493	£27,742
Squid	£2,087	£290	£297	£343	£3,252	£17,927	£71,454	£104,901	£86,179	£91,578	£42,229	£10,335
Haddock	£12,710	£8,758	£7,627	£4,740	£9,596	£9,167	£15,846	£10,350	£6,540	£21,690	£22,455	£10,997
Scallops	£5,317	£3,480	£3,387	£3,143	£7,990	£11,025	£24,405	£14,318	£17,246	£7,541	£3,126	£3,063
Edible Crabs	£1,826	£2,112	£2,734	£2,617	£4,873	£8,132	£6,605	£3,959	£6,272	£5,978	£5,480	£6,700
Monks or Anglers	£2,231	£813	£1,506	£2,319	£3,650	£5,362	£6,379	£3,530	£2,857	£6,201	£5,532	£3,943
Lobsters	£797	£459	£545	£1,142	£1,740	£2,246	£6,152	£8,667	£7,051	£5,844	£4,629	£4,364
Mackerel	£3	£0	£0	£0	£285	£4,008	£11,131	£5,387	£2,113	£490	£51	£0
Velvet Crabs	£327	£154	£114	£512	£1,044	£985	£1,741	£2,149	£2,831	£2,810	£2,184	£1,877
Whiting	£299	£130	£499	£583	£651	£1,913	£1,979	£1,001	£766	£1,274	£943	£281
Other	£3,450	£2,353	£2,506	£2,260	£2,947	£4,558	£5,635	£3,751	£2,222	£3,268	£2,922	£1,893

Figure 3.13 Average landings seasonal values (2007-2016) by targeted species in ICES rectangle 44E7 (source: MMO, 2017)



	January	February	March	April	May	June	July	August	September	October	November	December
Scallops	£14,461	£17,398	£56,829	£53,469	£123,054	£252,664	£258,555	£215,052	£110,342	£70,575	£6,867	£8,318
Haddock	£34,929	£69,678	£17,310	£4,540	£16,980	£42,301	£15,917	£34,507	£32,365	£33,422	£49,483	£17,179
Squid	£1,662	£989	£287	£134	£769	£6,378	£34,104	£103,839	£97,050	£17,339	£7,914	£5,234
Nephrops	£6,331	£4,598	£8,125	£13,207	£7,833	£41,423	£43,973	£9,058	£3,069	£1,675	£8,194	£5,526
Monks or Anglers	£1,922	£2,649	£11,829	£3,015	£3,882	£8,203	£6,655	£5,547	£3,262	£2,502	£10,506	£2,002
Herring	£0	£0	£0	£0	£0	£10,390	£0	£12,462	£221	£0	£0	£0
Cod	£1,810	£7,158	£3,485	£409	£1,092	£1,128	£258	£1,238	£472	£2,044	£1,412	£1,174
Whiting	£683	£1,671	£862	£922	£826	£1,781	£1,020	£1,804	£417	£938	£1,240	£180
Megrim	£130	£161	£2,384	£291	£327	£457	£94	£58	£64	£451	£430	£3
Mackerel	£0	£0	£0	£0	£175	£279	£402	£2,048	£1,629	£198	£0	£0
Other	£1,068	£1,653	£1,633	£1,215	£1,018	£2,770	£3,516	£2,106	£1,048	£3,114	£3,081	£443

Figure 3.14 Average landings seasonal values (2007-2016) by targeted species in ICES rectangle 45E7 (source: MMO, 2017)



	January	February	March	April	May	June	July	August	September	October	November	December
Lobsters	£15,113	£10,389	£16,731	£24,507	£20,714	£21,367	£58,870	£106,143	£83,480	£54,351	£37,795	£30,325
Scallops	£23,063	£28,256	£7,681	£8,335	£32,026	£47,271	£61,915	£49,510	£44,154	£22,788	£17,690	£14,703
Edible Crabs	£12,514	£14,178	£23,830	£18,710	£19,805	£24,838	£20,877	£18,207	£27,236	£27,575	£26,878	£39,930
Velvet Crabs	£2,781	£1,686	£2,772	£5,080	£9,803	£12,160	£14,316	£10,446	£12,119	£9,028	£6,520	£7,862
Squid	£643	£68	£21	£56	£501	£1,687	£3,202	£16,436	£27,345	£13,819	£4,942	£1,515
Haddock	£3,847	£8,763	£602	£1,519	£3,165	£4,503	£2,230	£1,699	£7,595	£8,932	£10,791	£571
Nephrops	£1,872	£2,196	£986	£1,650	£1,967	£12,811	£9,900	£3,095	£1,778	£2,028	£1,245	£2,136
Whelks	£4	£62	£819	£3,297	£4,503	£5,971	£4,191	£2,364	£43	£0	£85	£2
Monks or Anglers	£662	£350	£169	£105	£128	£1,267	£166	£42	£158	£471	£483	£1,002
Cod	£231	£698	£40	£1,898	£141	£493	£38	£25	£18	£23	£167	£14
Other	£400	£1,539	£347	£811	£582	£2,614	£714	£1,188	£1,828	£785	£710	£388

Figure 3.15 Average landings seasonal values (2007-2016) by targeted species in ICES rectangle 45E6 (source: MMO, 2017)

4 Fishing Grounds

The following description of the fishing grounds local to the development is based on the following:

- Fishing grounds drawn by fishermen on paper charts provided;
- Questionnaires completed by local fishermen and statements made by fishermen and their representatives during consultation meetings in 2017 are summarised in Table 4.1 below; and
- VMS and AIS records, recognising that at present VMS data from the MMO is only available for vessels of over 15 m in length and that transmitting AIS is not universal amongst fishing vessels.

4.1 Creel Fishing Grounds

The creel fishing grounds as drawn on paper charts by local fishermen are depicted in Figure 4.1. It is appreciated, as confirmed by the statements summarised in Table 4.1, that the grounds depicted in Figure 4.1 do not represent the full extent of creel fishing grounds along the Moray coast, but rather those in the immediate vicinity of the Cable Corridor.

4.2 Mackerel Jigging Grounds

The mackerel jigging grounds (Figure 4.2) drawn by local fishermen are similarly focused over a relatively small, nearshore section of the Cable Corridor. The similarity between the jigging and creeling grounds suggests that, in many cases, vessels alternate between the two methods, and that as with the creel grounds, the jigging grounds depicted do not represent the full extent of the jigging grounds along the Moray coast.

4.3 *Nephrops* Grounds

Figure 4.3 illustrates the *Nephrops* grounds and indicates approximately two thirds of the area of the Cable Corridor is overlapped by the *Nephrops* trawlers.

The grounds identified are supported by Figure 3.3 and Figure 3.4 which show the majority of *Nephrops* landings values are derived from fishing activity south of the Moray West Site in rectangle 44E7.

It was stated that a number of the larger trawlers targeting *Nephrops* have mixed nationality crews and those with crew members who are not EU nationals are not permitted to fish within the UK's 12-mile limit. It is therefore likely that much of *Nephrops* activity over the Cable Corridor may be from the smaller class of trawler.

4.4 Squid Fishing Grounds

The squid fishing grounds as shown in Figure 4.4 extend along the coast from Burghead to Fraserburgh, crossing parts of the Cable Corridor and into the Moray West Site. The number of vessels undertaking this activity is understood to vary from year to year as does the duration of the fishing season.

Figure 4.5 shows the VMS value data for demersal mobile nets which along with whitefish grounds, encompasses *Nephrops* trawling grounds and squid trawling grounds. As is apparent, the trawling grounds around the Scottish coast are extensive.

4.5 Scallop Fishing Grounds

Figure 4.6 depicts the regional grounds as provided by the scallop fishing sectors SFF representative. This shows a wide area along the south Moray Firth coast as well as an overlap of part of the Moray West Site.

The AIS tracks of 19 known scallop dredgers during the period of May to November 2017 obtained from Marine Traffic are shown in Figure 4.7. This shows comparatively low activity over most of the Cable Corridor and a small number of the tracks in the centre of the Moray West Site.

The MMO VMS effort data for dredges in the Moray Firth indicates only moderate scallop fishing effort within the Moray West Site and over the export cable when compared to the levels of effort immediately to the north east of the site and off the Aberdeenshire coast (Figure 4.8).

Figure 4.9 illustrates the wide extent of scallop dredging around the Scottish coast and Figure 4.10 shows the full extent of the scallop grounds fished by nomadic scallop UK scallop dredgers. This is further illustrated by the sample of AIS tracks of UK scallop dredgers shown in Figure 4.11.

Table 4.1 Summary of Information Provided by Local Fisheries Stakeholders

Fisherman	Port	Gear Type	Target Species	Notes on Grounds
A	Portsoy/Portknockie	Creel fishing and mackerel trolling lines	Lobster, Brown Crab, Velvet Crab (creels) Mackerel	Inshore area to 6 nm between Buckie and Whitehills – lines for mackerel, haddock and cod. Pots are deployed along the coast along the nearshore from Buckie to Portsoy.
B	Fraserburgh	Twin rig	*Nephrops* – all year Whitefish (Mar – May)	UK crew target Lossiemouth to Fraserburgh inside the 12 nm limit, working up to the 3 nm limit and along the Southern Trench. Mixed crew (UK and Filipino crew) worked Lossiemouth to Fraserburgh and a smaller area to the east of Smith Bank outside the 12 nm.
C	Portsoy	Handlines, long lines and nets	Mackerel (June – Oct) and cod	Buckie to Macduff.
D	Whitehills	Creels and mackerel jigging	Brown crab, velvet crab, lobster (Mar – Dec) and mackerel (May – Oct)	Mackerel – Buckie to Roseheath, out to 6 nm. Creels from Portsoy in West to Macduff in the East.
E	Cullen	Creel fishing and mackerel trolling lines	Creels and mackerel, haddock and cod	Inshore area to 6 nm between Buckie and Whitehills – lines for mackerel, haddock and cod. Pots are deployed along the coast along the nearshore from Buckie to Portsoy.
F	Buckie	Creels and rigging for mackerel	Creels – lobster (Jun – Dec), crabs and velvet crabs (all year) Rigging for mackerel (Jun – Oct)	Key creel areas – Findochty to Kingston but fishing also occurs from Lossiemouth to Whitehills.
G	Buckie	Single rig and scallop dredge	*Nephrops* (all year) and squid (Aug – Oct) and scallop (starting in Jan)	Between 6 to 12 nm. East of Buckie June to Aug and West of Buckie Aug – Dec (prawn grounds). Nearshore from Burghead to Portknockie (Sept – Oct).
H	Buckie	Creels and rigging	Lobster (June – Dec), Crab (all year) and velvet crab Mackerel (June – Oct)	Key areas – Buckie to Kingston. Also, creels from Lossiemouth to Fraserburgh.
I	Cullen	Creels and Handline	Brown Crab and Velvet Crab and lobster (Mar – Oct) Mackerel (June – Sept)	Creels in the nearshore around Cullen. Mackerel fishing from Buckie to Whitehills out to just past the 12 nm.
J	Lybster	Creels	Brown crab, lobster, velvet crabs	Between 6 to 12 nm out of Lybster.

Table 4.1 Summary of Information Provided by Local Fisheries Stakeholders

Fisherman	Port	Gear Type	Target Species	Notes on Grounds
K	Wick	Creels and jigging for mackerel	Crab and lobster and mackerel	Sites north east and south east of Wick around the 12 nm limit. Creel all year and summer for mackerel.
L	Buckie	Twin rig	*Nephrops* and squid	Squid is targeted from Burghead to Gardenstown up to 6 nm, with prawns targeted in the same areas but between 6 to 12 nm. Squid is also targeted from Lossiemouth to Banff offshore.
M	Fraserburgh	Twin rig	*Nephrops*	*Nephrops* from Buckie to Gardenstown along the 12 nm limit and offshore of Macduff.
N	Buckie	Single rig	*Nephrops* and squid	Squid (from Aug – Nov) around the 6 nm limit from Buckie to Lossiemouth. *Nephrops* from Lossiemouth to Banff from the 6 nm limit.
O	Lossie	Single rig	Squid and *Nephrops*	Squid grounds within the 6 nm from Burghead to Pennan, and a small area offshore of Buckie. *Nephrops* are targeted from Whitehills to Burghead from the 6 nm to offshore.
P	Buckie	Single rig	*Nephrops* and squid	Squid is targeted in 2 areas offshore of Buckie. *Nephrops* grounds are between 6 to 12 nm between Lossiemouth and Gardenstown with key grounds between Portknockie and Lossiemouth.

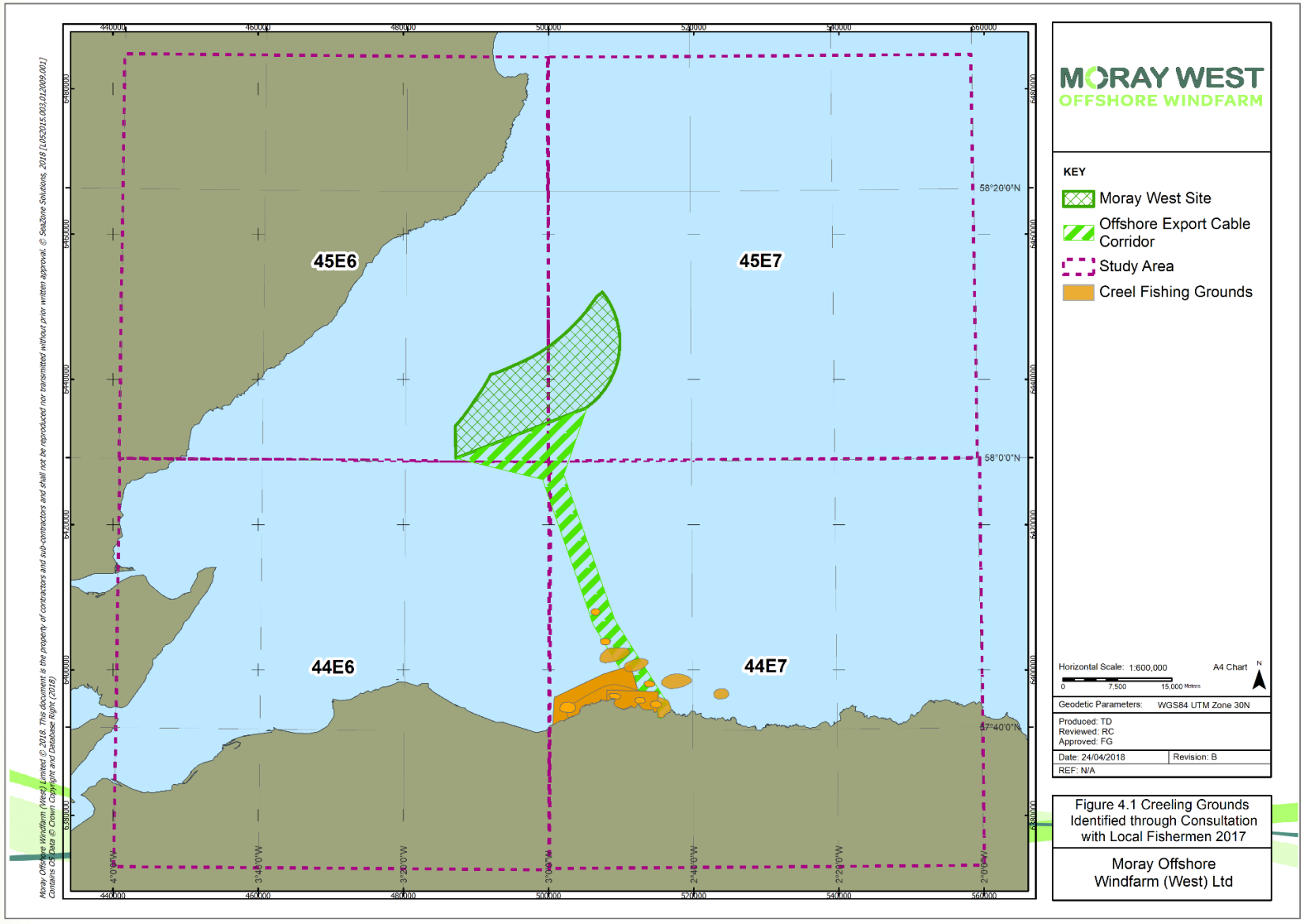


Figure 4.1 Creeling grounds identified through consultation with local fisherman (source: BMM, 2017)

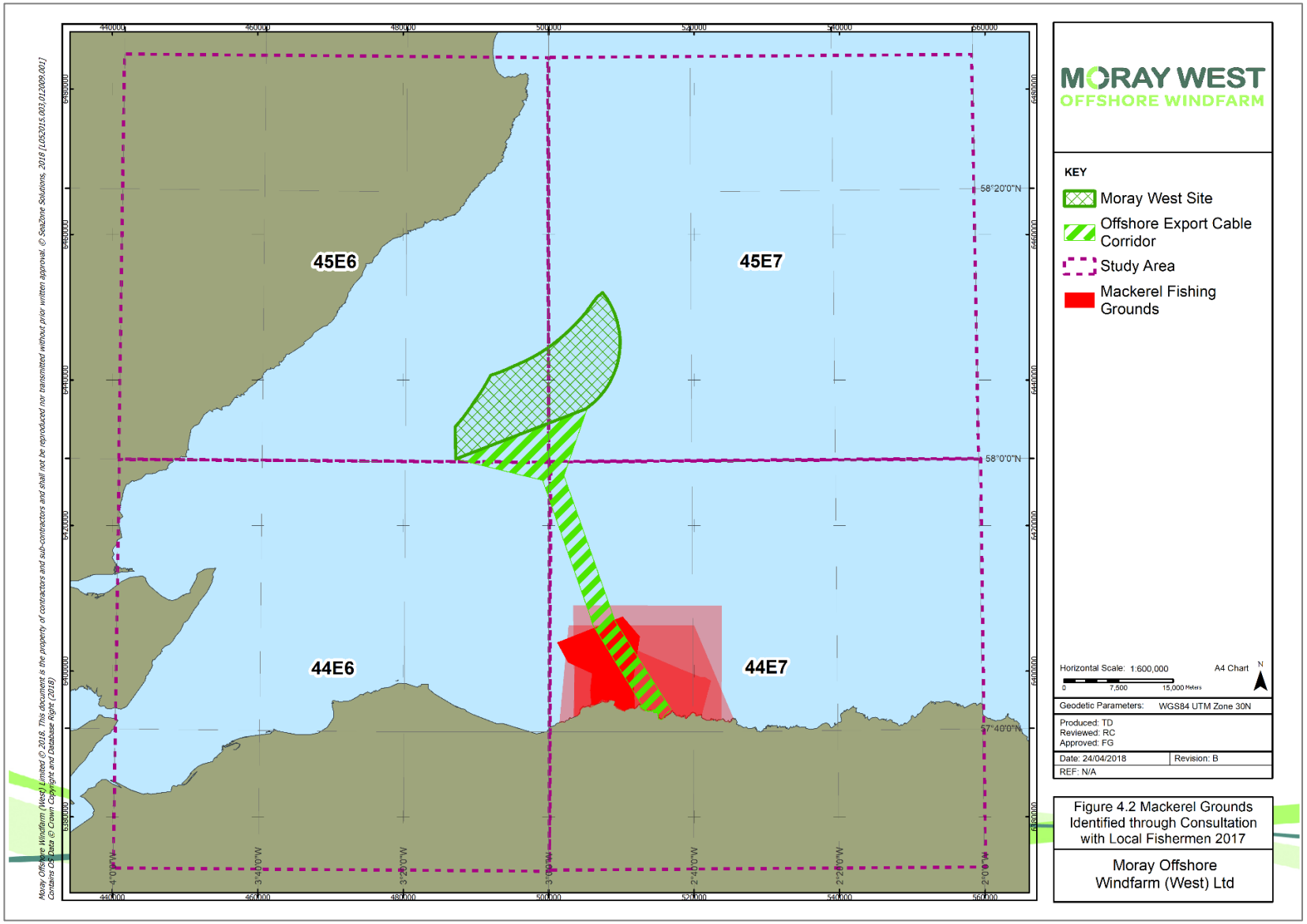


Figure 4.2 Mackerel fishing (jigging) grounds identified through consultation with local fisherman (source: BMM, 2017)

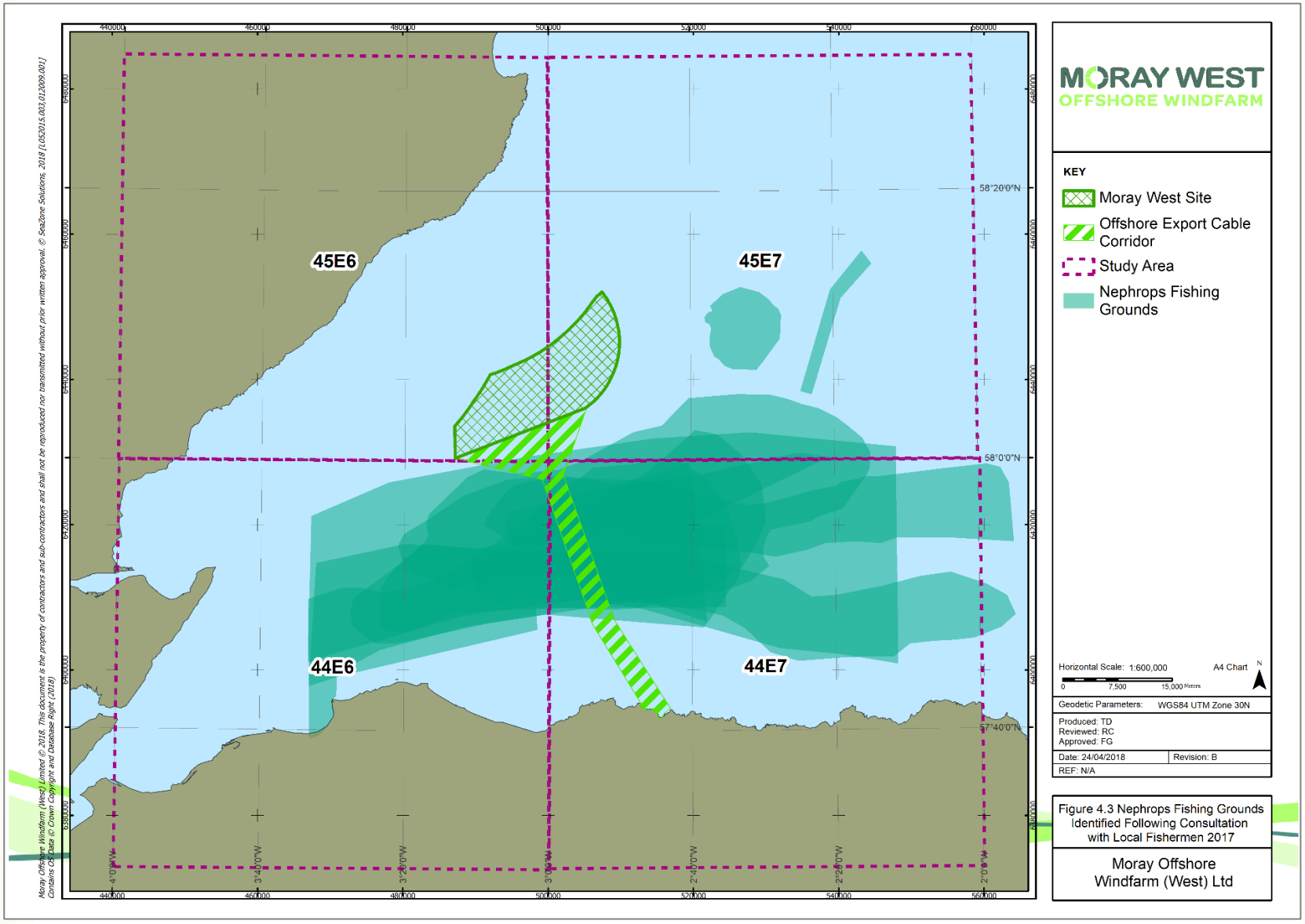


Figure 4.3 Nephrops grounds identified by local fisherman during consultation (source: BMM, 2017)

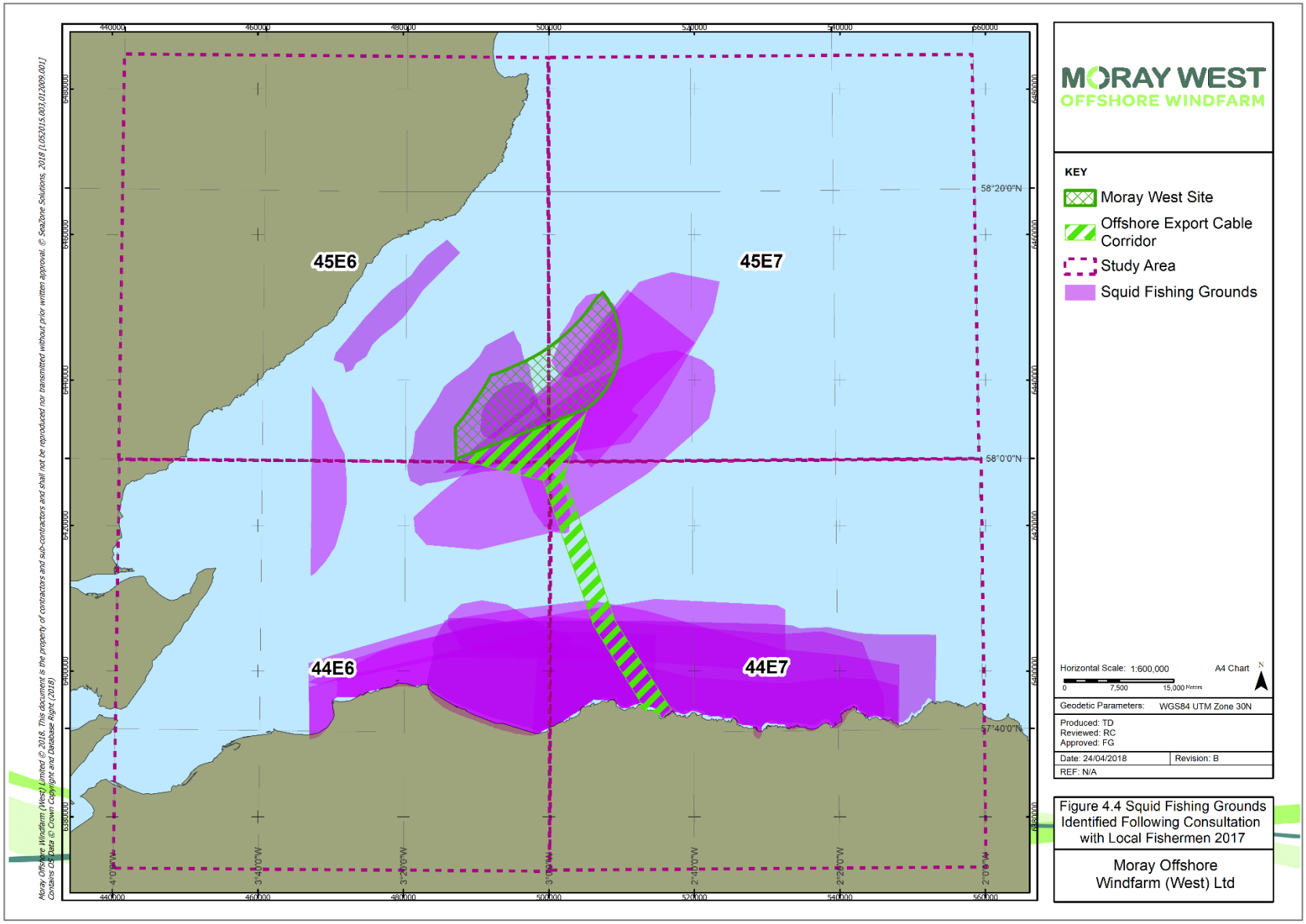


Figure 4.4 Squid fishing grounds identified through consultation with local fisherman 2017 (source: BMM, 2017)

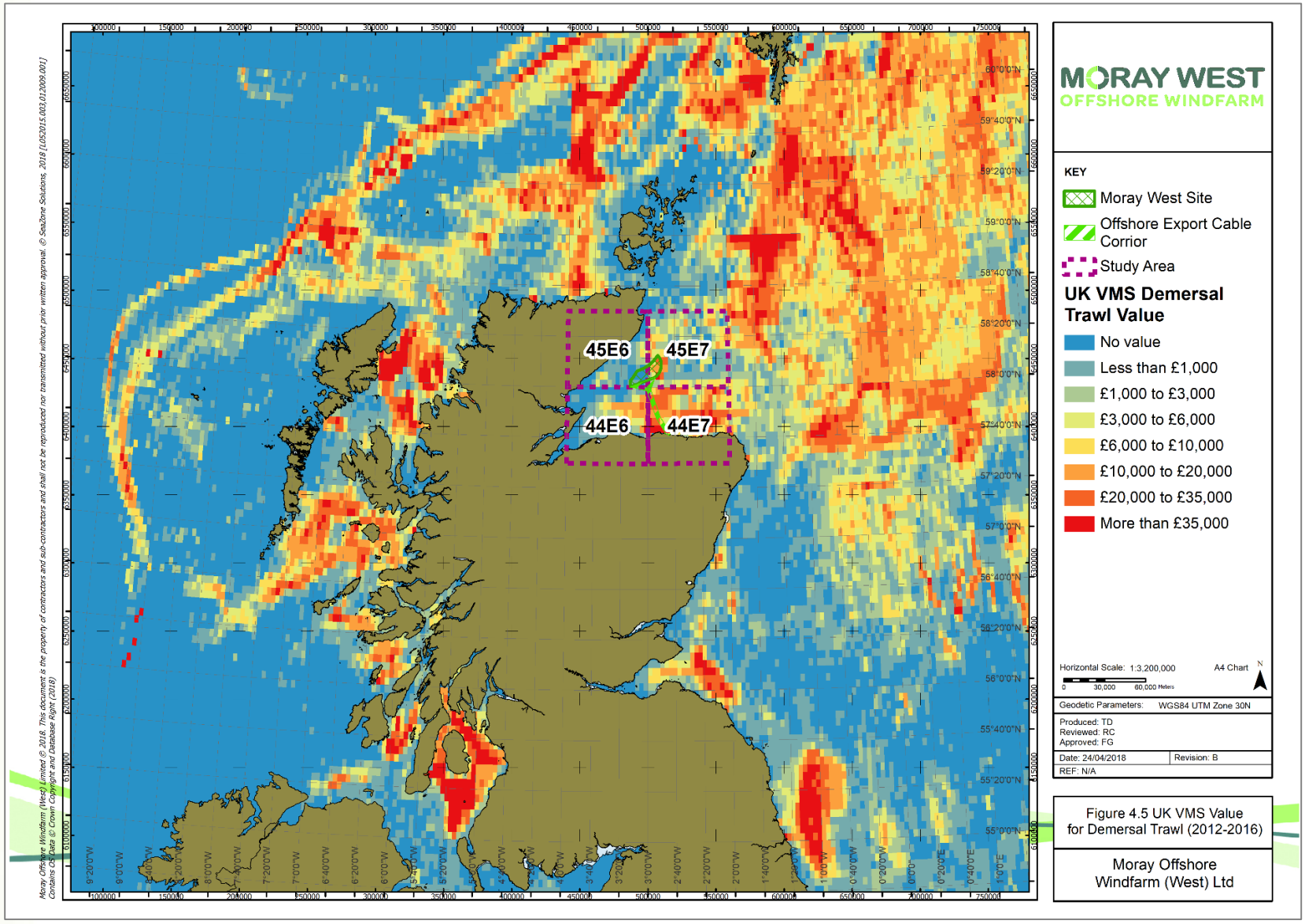


Figure 4.5 UK VMS value data for demersal mobile nets (average 2012-2016) (source: MMO, 2017)

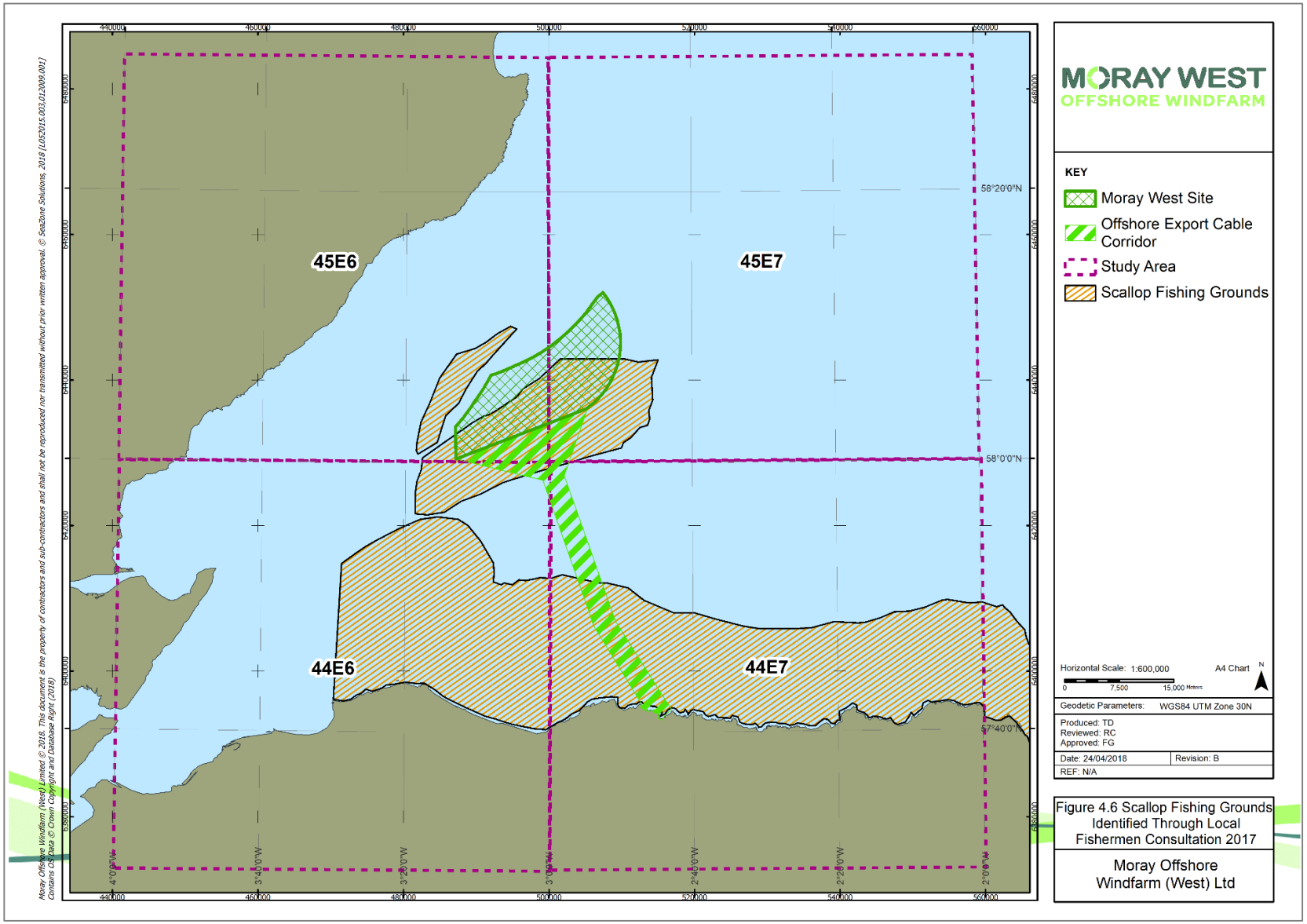


Figure 4.6 Scallop fishing grounds identified through local fisherman consultation (source: BMM 2017)

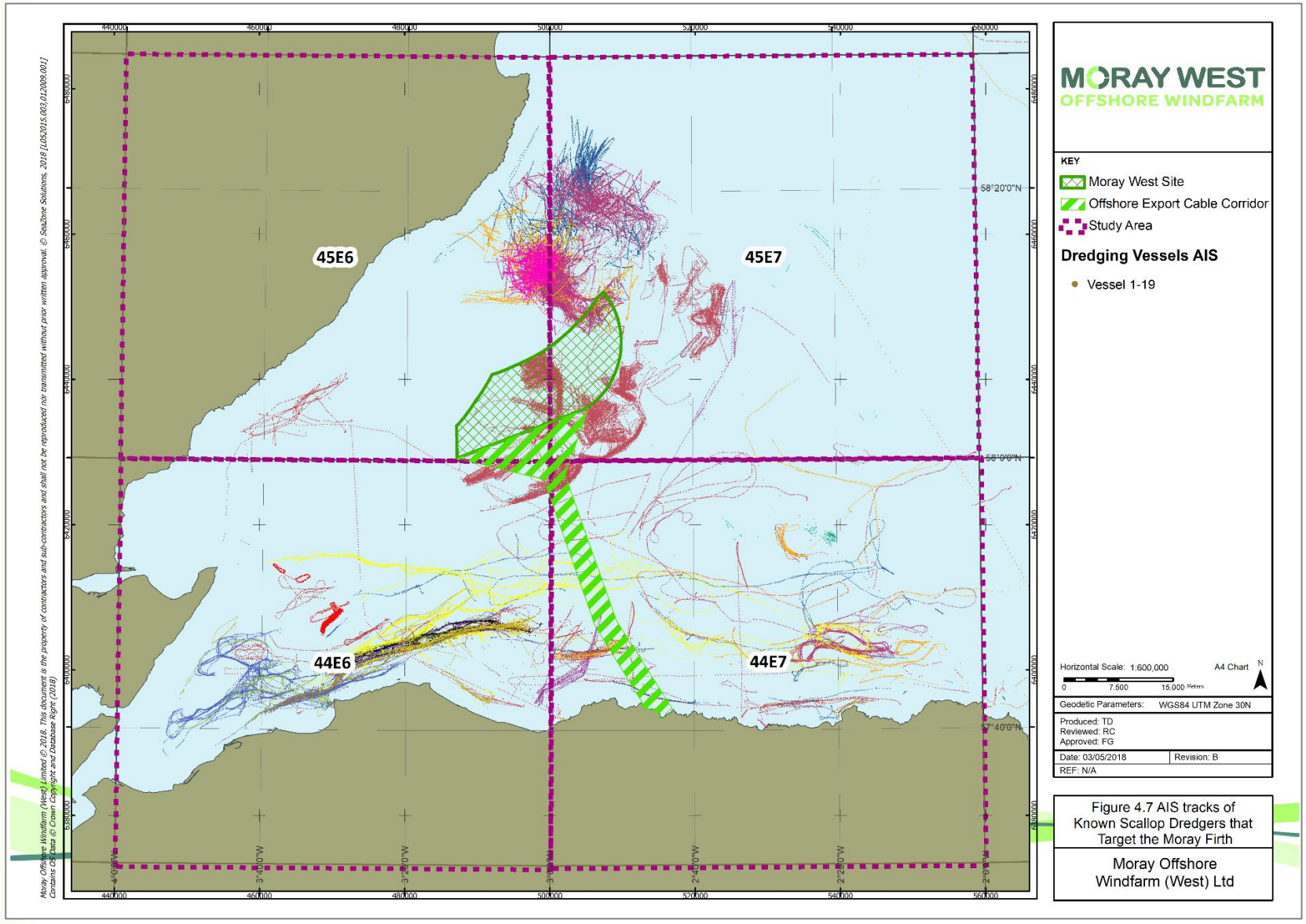


Figure 4.7 AIS tracks of known scallop dredgers in the Moray Firth (source: BMM, 2017)

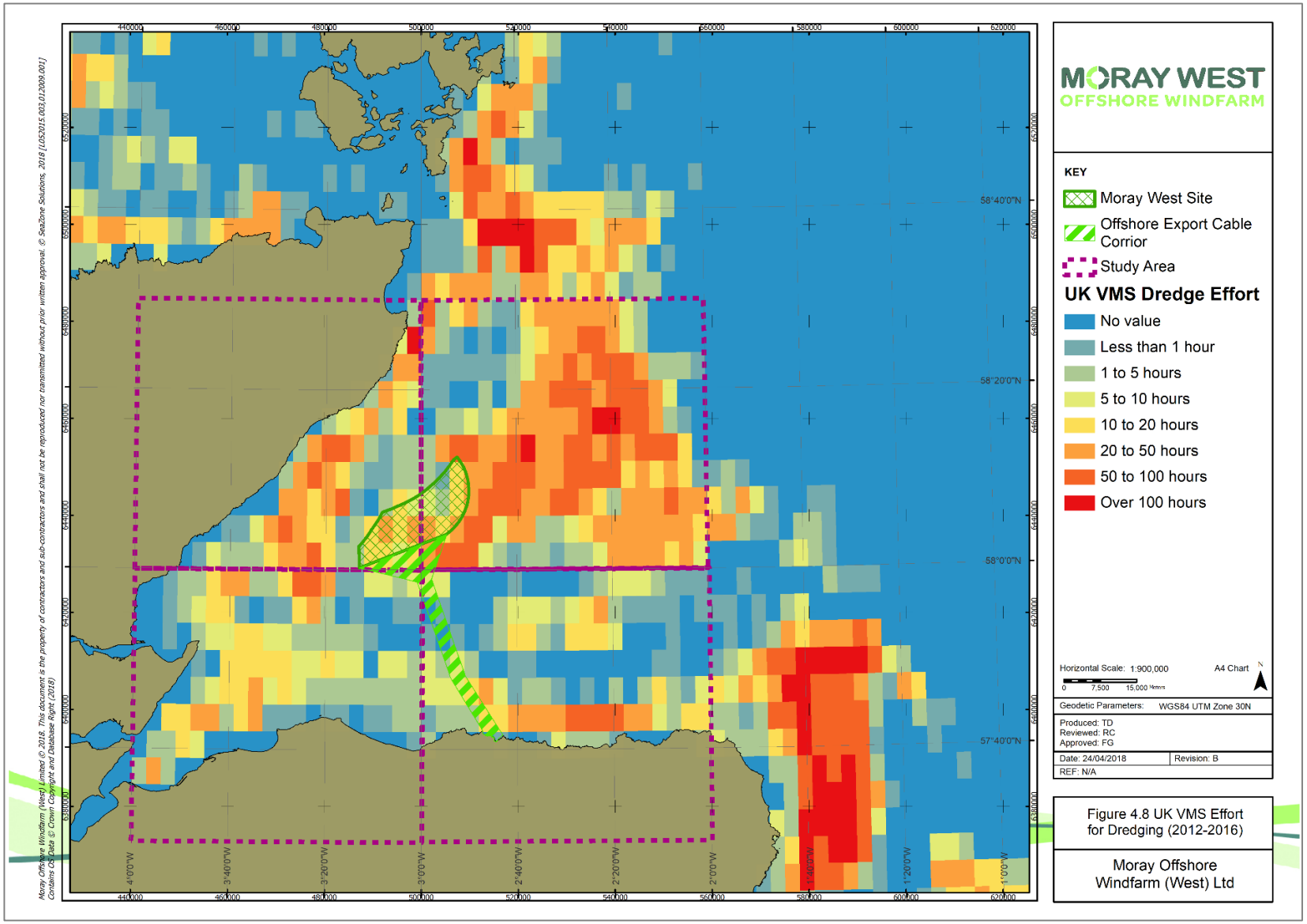


Figure 4.8 UK VMS effort data for dredges in the Moray Firth (average 2012-2016) (source: MMO, 2017)

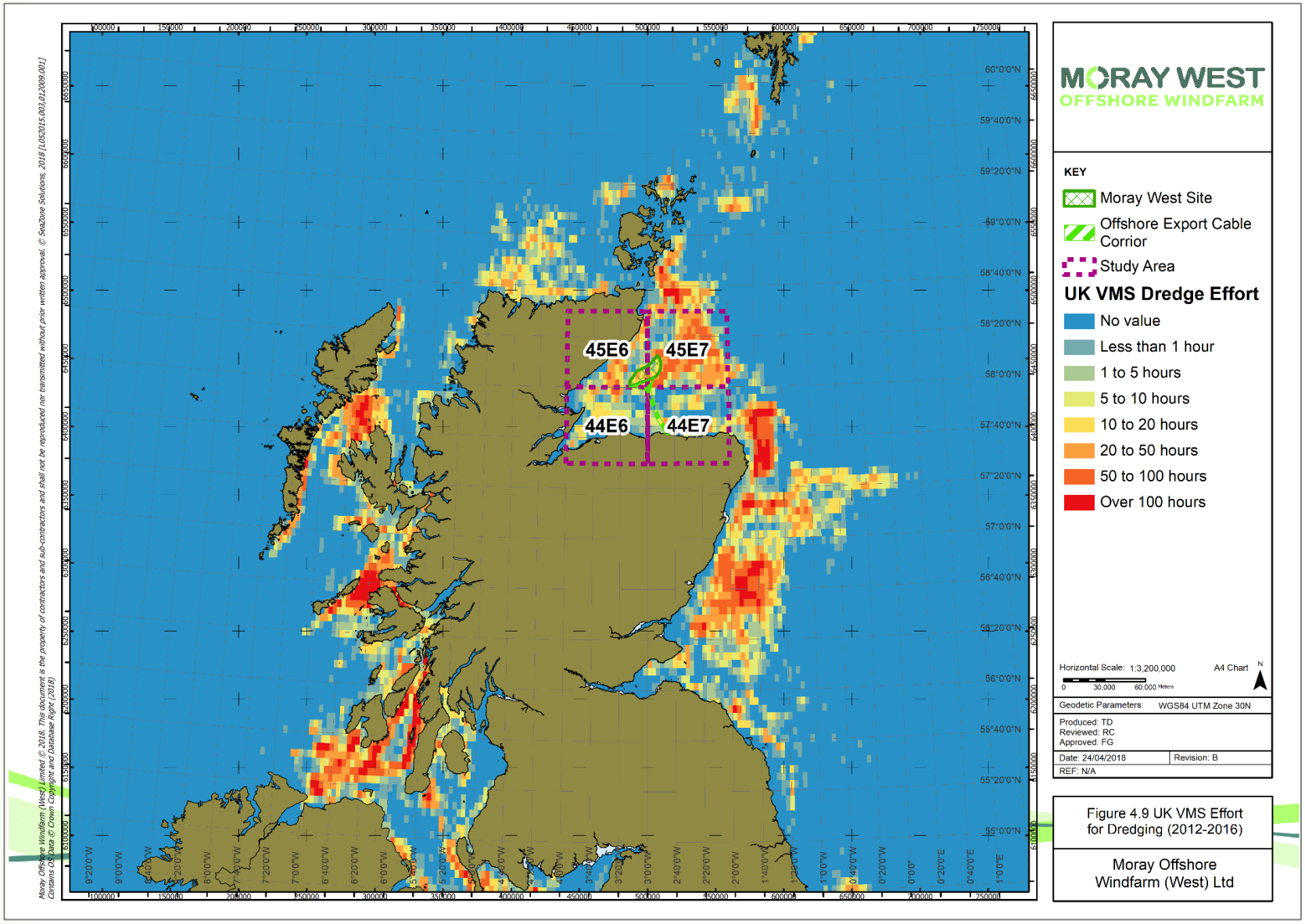


Figure 4.9 UK VMS effort data for dredges around Scotland (average 2012-2016) (source: MMO, 2017)

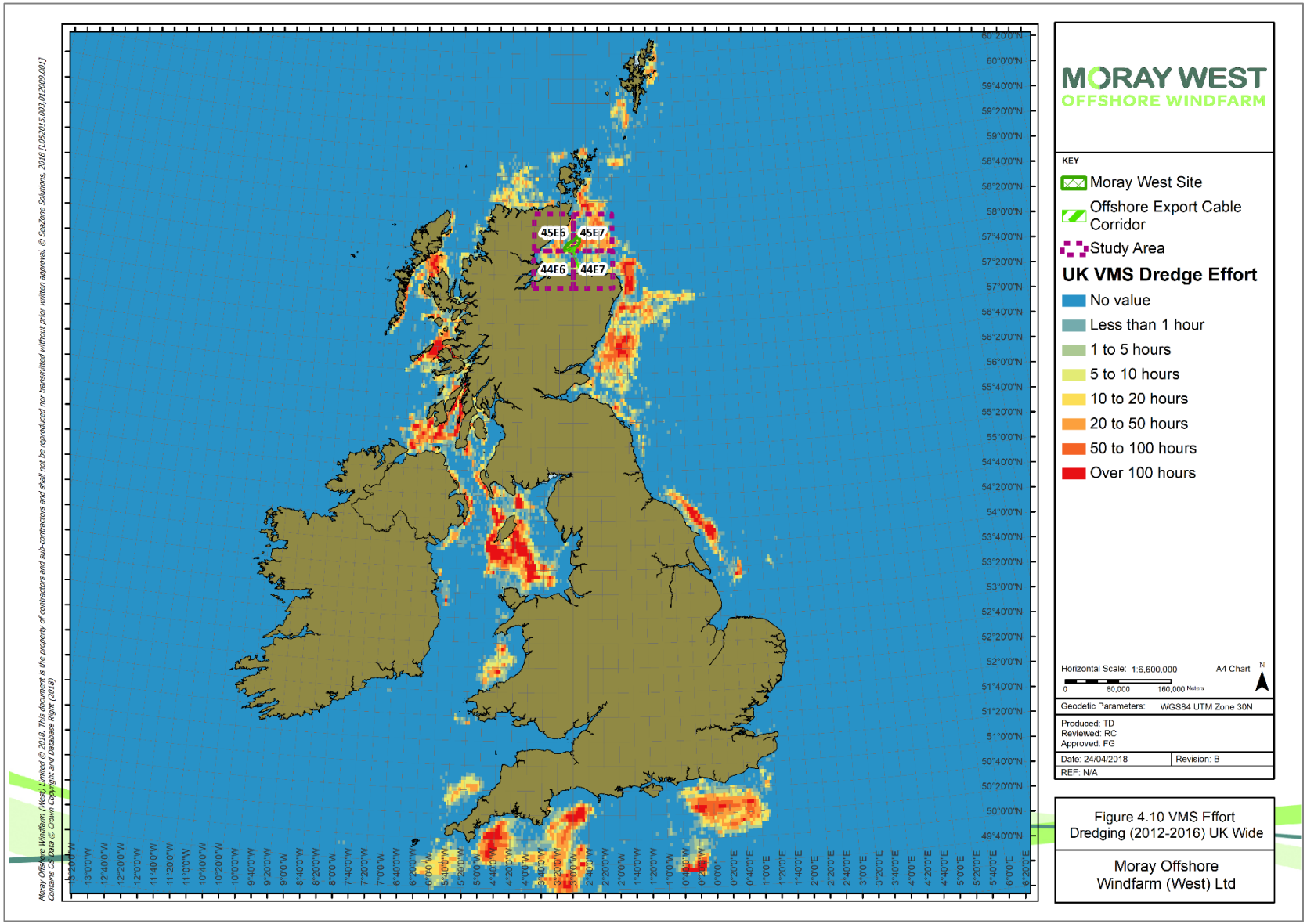


Figure 4.10 UK VMS effort data for dredges (average 2012-2016) (source: MMO, 2017)

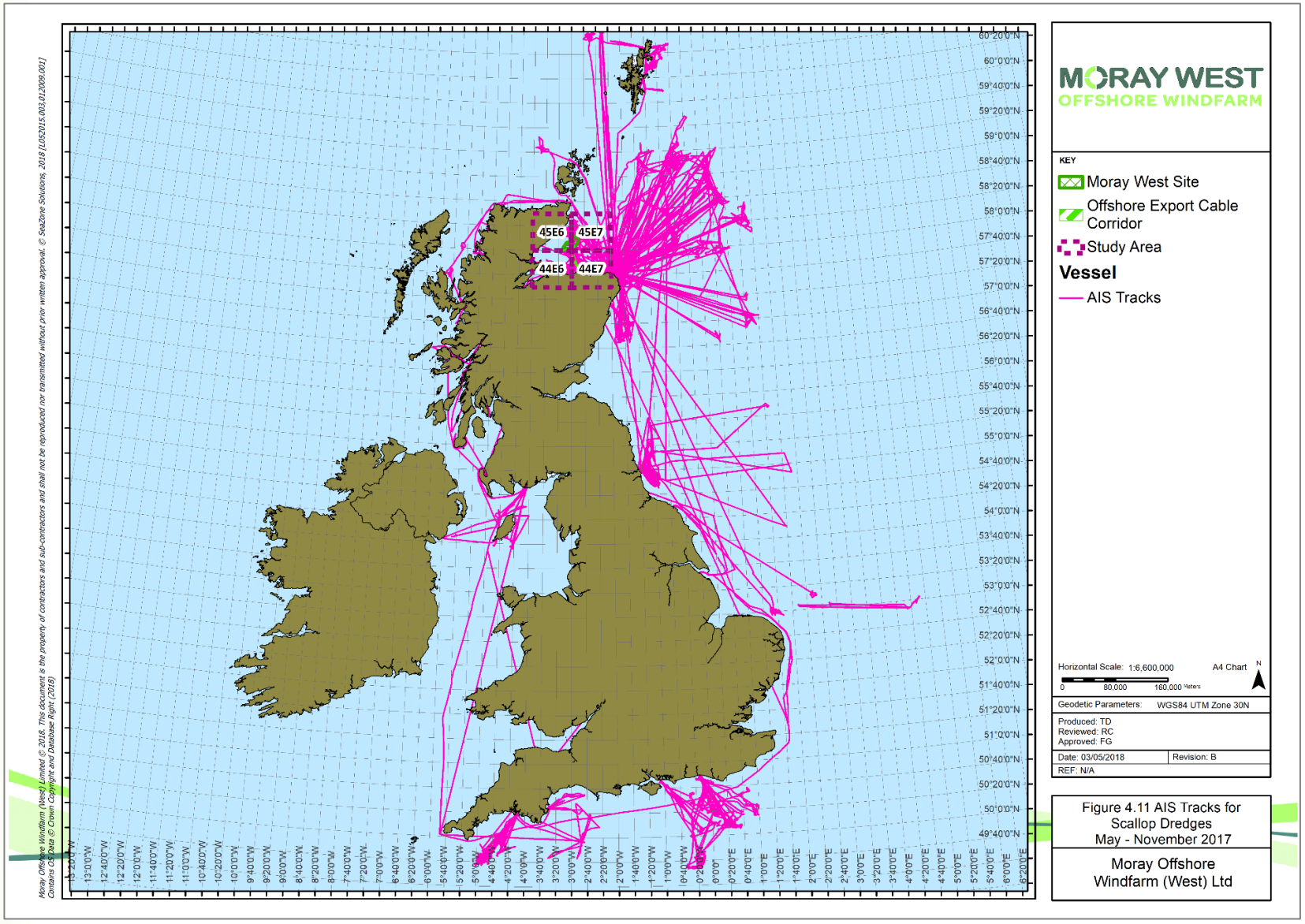


Figure 4.11 AIS tracks for scallop dredgers (May – November 2017)

5 Vessels, Gear and Operating Practices

Table 5.1 below shows the numbers of under and over 10 m vessels by home port within the study area as given in the MMO March 2018 monthly vessel list. It should be noted that the MMO lists do not always fully reflect the numbers of vessels actually operating from a port.

The list does, however, broadly reflect the information obtained during consultation, in that the larger vessels are concentrated in the ports of Peterhead, Fraserburgh and Buckie, whereas the smaller vessels also operate from a variety of smaller ports along the coast such as Portsoy, Portknockie, Whitehills and Gardenstown.

With regards to the nomadic scallop dredging fleet, it should be noted that the MMO lists may not fully represent the operating ports of the nomadic scallop dredging vessels as these change depending upon the time of year.

Table 5.1 List of Fishing Vessels by Home Port Relevant to the Moray West Development Area (source: MMO, 2017)

Port	Number of <10 m Vessels Registered	Number of >10 m Vessels Registered	Methods Used
Fraserburgh	70	56	Demersal trawling, pelagic trawling, creeling, netting, scallop dredging
Peterhead	44	34	Demersal trawling, pelagic trawling, creeling, netting, scallop dredging
Buckie	40	9	Demersal trawling, scallop dredging, creeling, netting, scallop dredging
Wick	4	2	Creeling and scallop dredging
MacDuff	4	15	Demersal trawling, scallop dredging, creeling, netting
Portsoy	4	1	Creeling, netting
Portknockie	3	-	Creeling, netting
Gardenstown	2	8	Creeling, netting
Helmsdale	3	-	Creeling, netting
Lybster	2	-	Creeling, netting
Whitehills	2	3	Creeling, netting
Lossiemouth	1	1	Creeling, netting

Table 5.2 summarises average annual port landings values from the three ICES rectangles in which Moray West infrastructure will be located. As shown, the majority of the landings by value are into the ports of Fraserburgh, Buckie, Peterhead and Macduff. It should however be noted that not all of the ports along the Moray coast are designated as landing ports for administrative purposes.

Table 5.2 Average Port Landing Values by ICES Rectangle for 2012-2016 (source: MMO, 2017)

Port	44E7	45E7	45E6
Fraserburgh	£2,674,374	£1,108,829	£440,198
Buckie	£955,205	£615,672	£577,216

Table 5.2 Average Port Landing Values by ICES Rectangle for 2012-2016 (source: MMO, 2017)			
Port	**44E7**	**45E7**	**45E6**
Burghead	£16,831	£1,113	£806,625
Peterhead	£193,281	£413,905	£23,691
Macduff	£244,493	£109,709	£33,561
Wick	£2,368	£183,925	£3,901
Scrabster	£14,758	£56,213	£3,332
Lerwick	£3,532	£6,212	£0
ICES Rectangle Total	£4,250,613	£2,522,447	£2,342,897

5.1 Creeling

Creeling for crab and lobster occurs throughout Scottish waters, although the design of creels and the rigging configurations may vary depending on region and target species.

Fleets are rigged with between 10 and 50 creels per fleet depending upon the vessel size and the area to be fished. Fleet lengths generally range from 100 to 500 m, anchored at each end. A variety of surface markers are used including flagged dahns[1], buoys and cans (Figure 5.1). Soak times (the time between setting and hauling) is understood to vary from approximately 12 hours to two days, although this can be longer during periods of adverse weather.

Due to the limited operational ranges of some of the smaller, inshore vessels, their creels are generally deployed closer to the coast and also in areas which are unsuitable for trawling. As previously stated, the vessels engaged in creeling are generally <10 m in length, with crews of one to three (Plate 5.1).

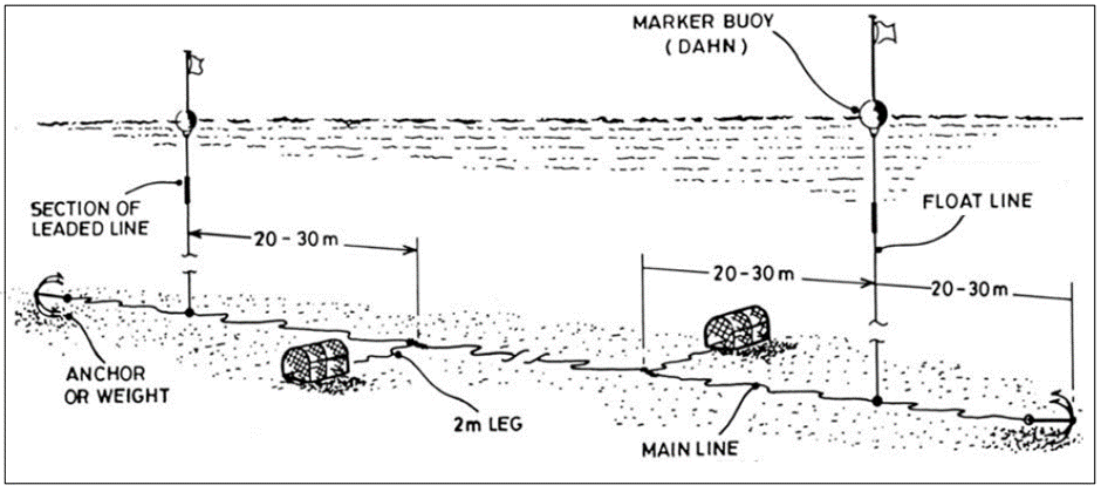


Figure 5.1 Illustration of a fleet of creels (Source: Seafish, 2005)

Over the past few years however, there have been instances of older creel boats being replaced with modern glass reinforced plastic (GRP) mono-hull or catamaran boats capable of steaming speeds of up to 25 knots allowing extended operational ranges, reported to be up to 50 miles from base port.

[1] A dahn/dhan is a bamboo pole with a flag attached, positioned on top of a marker buoy (see Figure 5.1).

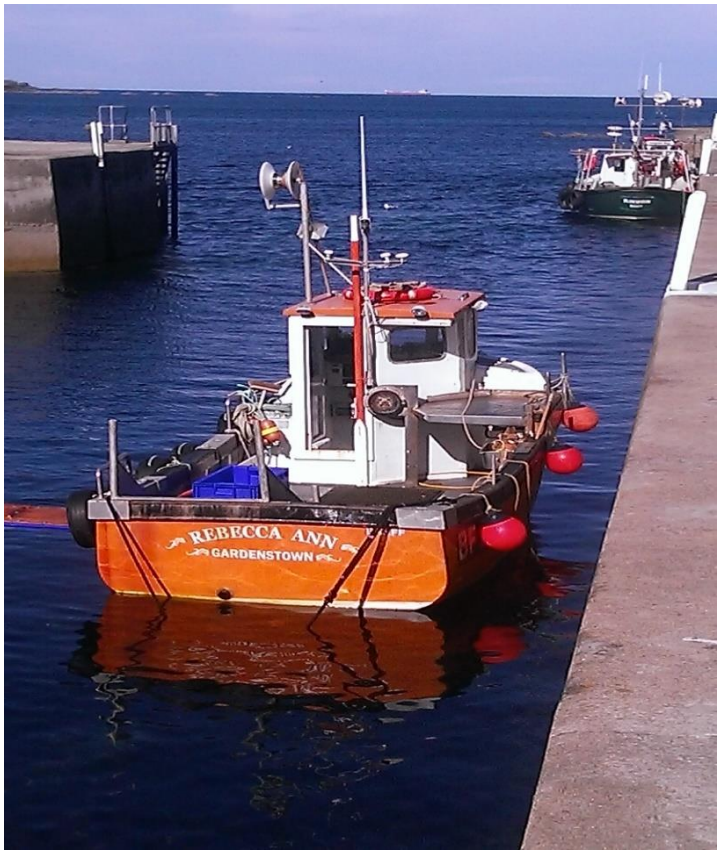


Plate 5.1 Under 10 m creel fishing vessel based at Gardenstown (source: BMM, August 2017)

5.2 Mackerel Jigging

Mackerel jigging gear comprises a number of hooked lures attached to drop lines (Figure 5.2). In the Moray Firth, this method is deployed by under 10 m vessels mainly targeting mackerel (Plate 5.2). Jigging fisheries operate on a seasonal basis and normally in inshore areas. As the species targeted are pelagic, the equipment does not normally contact the seabed.

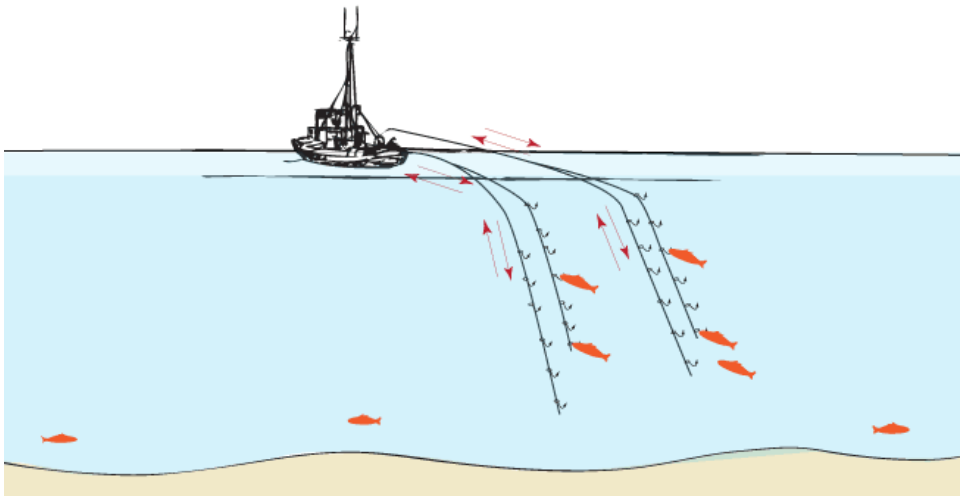


Figure 5.2 Illustration of pelagic jigging (source: Monterey Fish Market, 2011)

Plate 5.2 Under 10 m vessel rigged for mackerel jigging at Portknockie (source: BMM, August 2017)

5.3 Demersal Otter Trawling

With demersal otter trawling the lateral opening of the net is achieved by ground sheer and hydrodynamic forces acting on the trawl doors and the vertical opening by a series of spherical floats attached along the headline of the net (Figure 5.3). The seabed substrate penetration of otter boards can vary between 50 to 300 mm depending on substrate type. The ground lines of trawl nets vary in type depending upon the species targeted and the nature of the seabed fished. For rocky seabeds, “rockhopper” ground lines are used, comprising a series of rubber discs fixed along the along the ground line. For softer substrates such as those occupied by *Nephrops*, simpler, smaller diameter ground lines tend to be used.

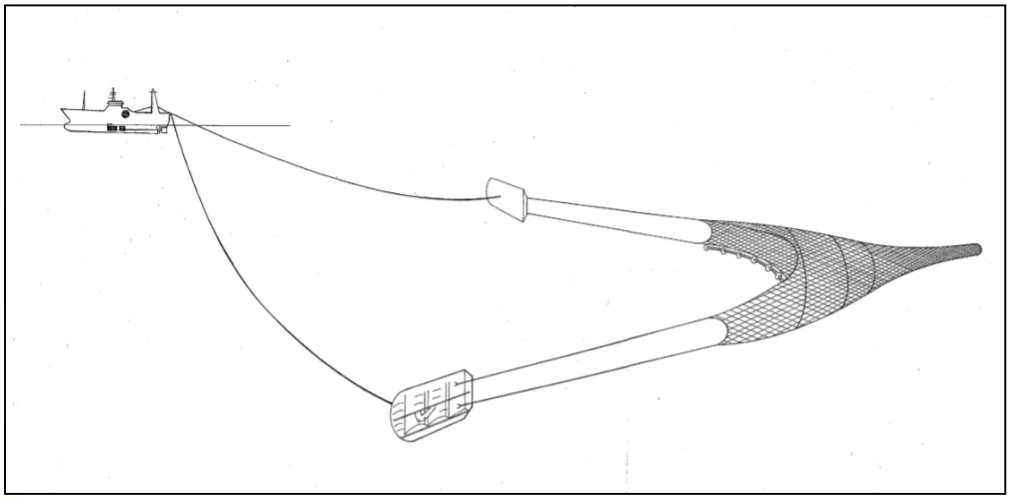


Figure 5.3 Single net otter trawling (source: BMM, 2017)

5.4 Otter Trawling – Twin Rig

The past 25 years have seen the progressive use of twin rigged trawls, whereby two nets are towed side by side Figure 5.4. As with single net trawling, two otter boards are used to maintain the lateral opening of the nets. A third towing warp is attached to a central clump weight. Twin rigged vessels are used to target *Nephrops*, whitefish species and squid.

The main advantage of twin rigged trawling is the increased swept area. With both methods of otter trawling, the mesh size of the cod-end can range between 70 and 110 mm, dictated by regulations regarding target species and the area fished.

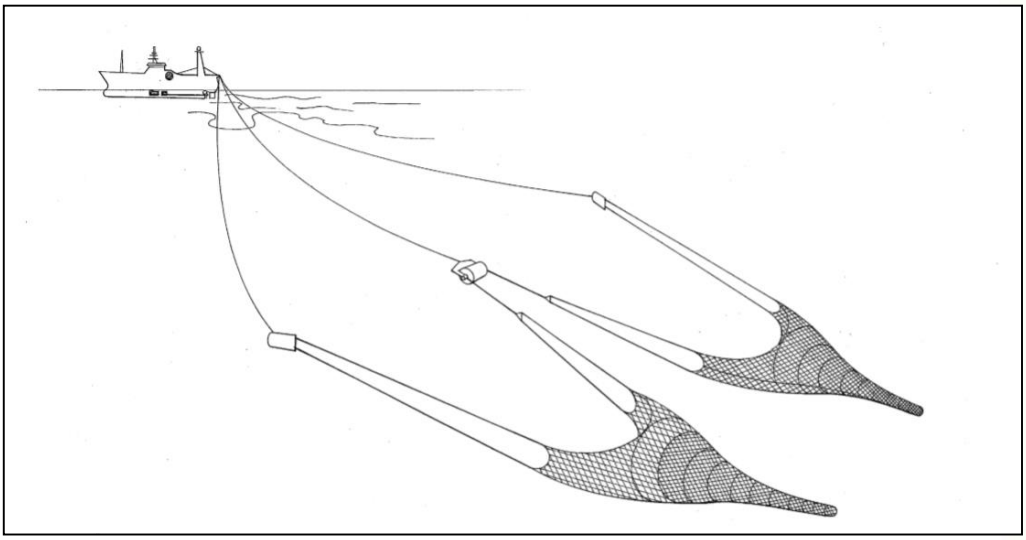


Figure 5.4 Twin rig trawl (source: BMM, 2017)

Within the Moray Firth demersal otter trawlers target a variety of whitefish species as well as *Nephrops* and squid. The vessels involved are for the most part over 15 m in length with a significant proportion being over 20 m (Plate 5.3).

There has been a directed squid fishery in the Moray Firth since 2004, although prior to this squid was caught as a by-catch. The importance of this fishery to the demersal trawler fleet has increased, partly as a consequence of restrictions on whitefish and *Nephrops* fishing. The fishery is usually of short duration, being dependent on the arrival of squid in the area to spawn. Vessels targeting squid generally arrive in the area during June with the fishery lasting up to 5 or 6 months in some years. In peak periods, up to 30 vessels may be targeting squid in the Moray Firth although it appears to have been at a lower level during 2017 (personal communication, MFIFA, 2017).

The number of vessels targeting *Nephrops* is dependent upon the local productivity of the fishery and this fluctuates on an annual basis. *Nephrops* are one of the more valuable species landed in Scotland with most *Nephrops* caught by trawlers although some are caught by creels. The larger vessels operate out of Fraserburgh, Buckie, Macduff, Inverness and Wick.

Plate 5.3 Examples of Scottish demersal trawlers in Fraserburgh Harbour (source: BMM, 2016)

5.5 Scallop Dredging

With scallop dredging, a series of dredges are attached to steel beams supported at each end by rubber wheels (Figure 5.5). The local vessels fishing the area have a typical set up of five to eight dredges and are typically towed each side.

In addition to the smaller local vessels, the area also sustains scallop dredging by larger nomadic vessels. These are either purpose built or are converted Dutch beam trawlers. With these larger vessels, up to 14 dredges are towed each side of the vessels.

An example of a medium-sized Scottish scallop dredger is shown in Plate 5.4 below.

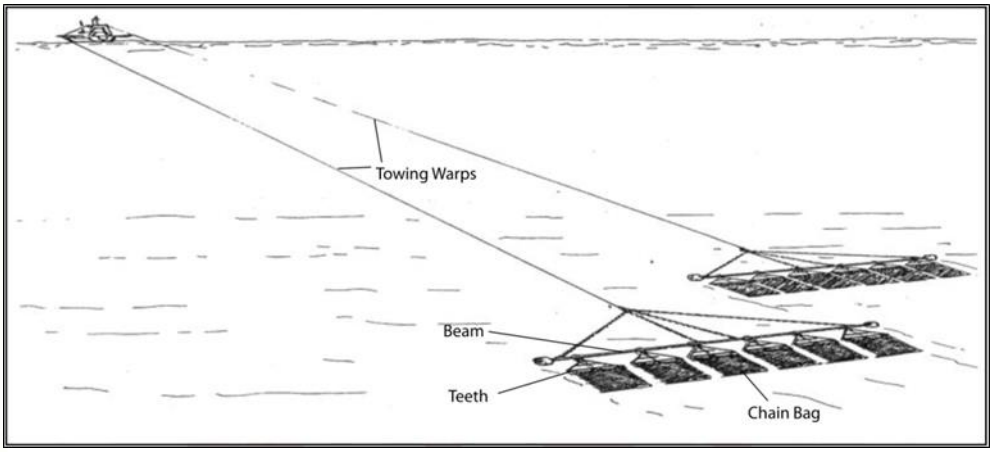


Figure 5.5 Scallop dredging configuration (source: BMM, 2017)

Plate 5.4 Example of a scallop dredger in Buckie Harbour (source: BMM, August 2017)

The scallop dredges currently used in the area under consideration are the "Newhaven" type, also known as "Springer" dredges. Attached to the leading edges of these dredges are hinged, spring retained "tooth bars", the purpose of which is to rake the scallops off the seabed and into the dredge bag. The typical towing speeds of scallop dredgers was reported to be 3.5 knots with tow durations varying from 1 to 3.5 hours depending upon the grounds fished and catch rates.

There are a series of measures which control the number of dredges a vessel may deploy within Scottish waters. Vessels have to ensure that any tow bar deployed is no more than 7.5 m in length and is capable of carrying no more than eight dredges per side or have a monitoring system installed by Marine Scotland to inspect the number of dredges being used. Vessels with a system will be able to fish with up to eight dredges per side in the 0-6 nm area, and with up to 10 dredges per side in the 6-12 nm area.

However, if the vessel has a remote electronic monitoring system installed that allows Marine Scotland Compliance to inspect the number of dredges, eight dredges per side between 0 to 6 nm and up to 10 dredges per side in the 6-12 nm area are allowed. As a consequence of these measures, the scallop dredging activity over the section of the export cable within the 12-mile limit is expected to be by the smaller class of dredgers.

From the consultation undertaken (October 2017), it is understood that, in addition to east coast-based vessels, there are between 10 and 20 scallopers based at west coast Scottish ports which will occasionally fish in the Moray Firth area on a seasonal basis, between February and August. The number of non-local scallopers seen in the Moray Firth and the time they spend in the area will depend on the productivity of grounds, which varies on an annual basis. Consultation with the scallop industry representatives confirmed that the scallops' fishing cycles can be up to 10 years (SFF 2017, personal communication, October 2017).

5.6 Scottish Seine Netting

Scottish seine nets (flydragging) are deployed over clean seabeds, free of obstacles, to target demersal species such as cod and haddock. The seine ropes are laid on the seabed in a triangular pattern with the net set in the middle of the base of the triangle. As the seine ropes are hauled they initially come towards each other, herding the fish into the path of the net. The final stage of the process is a faster winding of the seine ropes to haul the net over the section of the seabed in which the fish have been herded.

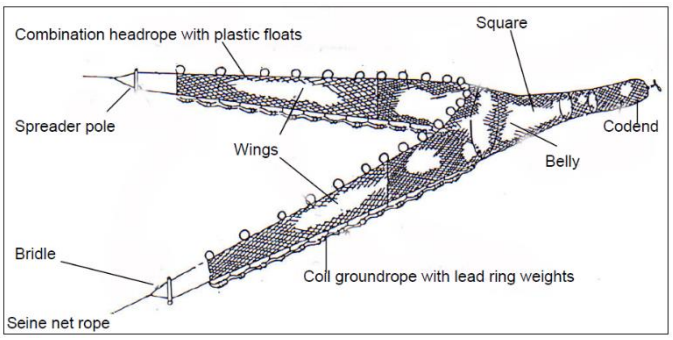


Figure 5.6 Scottish seine net (Source: Seafish, 2005)

6 Future Fisheries

Changes to quota and effort allocation, fishing areas and gear restrictions make predicting future fishing activity difficult and subjective. Fishing activity may not remain constant year on year due to fluctuations in fish stocks, changes in legislation and alterations in the economy. The following section outlines the factors potentially influencing changes to current fishing activity and practices.

6.1 Future Activity and Regulations

6.1.1 Reform of the Common Fisheries Policy (CFP)

Due to the EU referendum result, and the following Brexit negotiations, fisheries policy and international fishing rights in UK waters are under review and will form part of these negotiations. As a result, it is currently difficult to predict future fisheries policy changes and the impact of ongoing negotiations and decision making on the UK fishing industry. Currently it is understood that, at least until December 2020, UK fishing will continue to be bound by the policies and regulation of the EU Common Fisheries Policy.

The CFP was reviewed most recently in 2014. The latest CFP changes placed an emphasis on achieving long-term environmental sustainability. These policy changes included a ban on discarding (phased in to all EU fisheries by 2019) and new mandatory rules on the labelling of fisheries products on sale to consumers. There were also measures implemented to reduce overcapacity, with an obligation to report on the balance between fleet capacity and fishing opportunities and implement plans to address imbalances.

6.1.1.1 Vessel Licences

In order to fish commercially (using a vessel and to land a catch for profit), a UK fishing vessel licence is required. In Scotland fishing vessel licences are issued by Marine Scotland, on behalf of Scottish Ministers. Scottish fishing vessel licenses are issued to vessels registered in Scotland, and licenses are split into length category; 10 m and under and 10 m and over. Since 1st July 2017, licenses provide a general authority to fish.

Prior to the recent changes in fishing licenses, the licenses were split into the following 3 categories and the available fish stocks which can be fished are categorised as:

- Category A (formerly "pressure stocks");
- Category B (formerly “non-pressure stocks”); or
- Category C (formerly "miscellaneous species").

This categorisation of stocks provides the basis of licence categories, as follows:

- Category A (formerly “Pressure Stock”) Licence:
  - Authorises fishing vessels >10 m overall length to fish for all available stocks, including “pressure stocks” and up to 500 tonnes per calendar year of combined “pelagic species” stocks.
- Category A (Pelagic) Licence:
  - There are separate licences for pelagic trawlers, pelagic pursers and pelagic freezers;
  - Full fishing entitlement for all available Category A stocks, including demersal species and with the authority to fish for pelagic species stocks in excess of 500 tonnes per calendar year.
- Category A (10 m and Under) Licence
  - Authorises fishing vessels of 10 m and under overall length to fish for all available (as for over 10 m vessels) stocks.

- Category B (formerly "Non-pressure Stock") Licence:
    - Authorises fishing vessels over 10 m overall length to fish for all available stocks, including "non-pressure stocks" but excluding "pressure stocks" (as previously defined).
- Category C (formerly "Miscellaneous Species") Licence:
    - Authorises fishing vessels over 10 m overall length to fish for all available stocks, except "pressure stocks" and "non-pressure stocks".

It should be noted that depending on the location for which a species is caught a stock can fall into different categories. For example, no UK vessel may fish whiting in Area VIIIc, but it is considered a pressure stock in Area IV and a non-pressure stock in another area (Area VIIa).

6.1.2 Quotas

As quotas are an integral part of fisheries management within the EU Common Fisheries Policy (CFP) it is expected that they will continue at least until the end of the Brexit transition phase in 2020.

6.1.3 Changes in Fleet Structure

The current national fleet is considered to be proportionate with sustainable stock levels by those in the fishing industry and it is therefore considered that fishing practices will not alter considerably in the future.

In summary, whilst there are a number of uncertainties surrounding the future regulations and policies to be apply to the UK fishing industry, in the short and probably medium term, the overall future structure of fishing in the Moray Forth may not differ dramatically from the present structure.

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8 Annex 11.1A – Data Sources

8.1 Surveillance Sightings Data

As a component of fisheries protection and to ensure the fishing industry complies with UK and EU law, aircraft and surface vessels are used to compile surveillance sightings of fishing vessels in UK waters. The data has been used to give a relative spatial distribution of fishing activity by method and nationality within a given area. It should be noted that, due to the low frequency of flights in an area, which are generally weekly and only occur during daylight hours, the sightings data should not be used to give a quantitative assessment of fishing activity. The MMO has provided sightings of all fishing vessels in UK waters by nationality and method between 2010 and 2015.

8.2 Fisheries Statistics

UK fisheries statistical data for a five-year period between 2012 and 2016 has been collected by the MMO by ICES rectangle for all UK and non-UK fishing vessels landing into UK ports. The data includes landings by value and effort (days fished). This data set has been analysed to identify:

- Species targeted;
- Fishing methods used;
- Vessel categories (under 10 m, 10 m-15 m, over 15 m);
- Annual variations;
- Seasonal variations; and
- Landings values and effort by port.

The main source of fisheries landing data is the EC daily log sheets that all vessels over 10 m must complete and submit. Fishing vessels under 10 m in length are not required to submit daily log sheets, although skippers can choose to do so. Dockside inspections are made on the under 10 m fleet by local fisheries officers. The Shellfish Entitlement Scheme (2004) and the Registration of Buyers and Sellers of First Sale Fish and Designation Auction Site Scheme (2005) further facilitate collection of fisheries data from the under 10 m fleet. It should be noted that data collected prior to the introduction of these schemes may underestimate the true levels of activity from the under 10 m fleet. It should also be recognised that under these schemes, fishermen are required only to identify the ICES sub-area within which catch was taken and not the specific ICES rectangle.

8.3 Satellite Tracking (VMS) Data

8.3.1 MMO VMS Data

VMS data is the most comprehensive fisheries data set currently available which shows the intensity of over 15 m fishing vessel activity in the vicinity of Moray West. Since January 2005, all EC vessels over 15 m in length have been fitted with satellite tracking equipment which transmits the vessels' position at a minimum of every two hours to the relevant Member States' fisheries authority. The MMO monitors all UK vessels irrespective of location, and all foreign vessels within the UK Exclusive Economic Zone (EEZ). Information regarding non-UK vessels cannot be disclosed by the MMO without prior permission from the vessels national regulating body.

The satellite data has been cross-referenced with landings and effort data to give values in a 0.05° by 0.05° grid for the years 2011 to 2015. The disclosure of independent UK vessels' identities is restricted under the Data Protection Act (1998) and the coordinates of individual vessels are only available at the request of the vessels skipper/owner. Any rectangles that record less than five transmissions are not included in the data set and specific fishing methods have been identified. All vessels that are stationary in port have

not been included in the data set and the VMS data does not differentiate between vessels fishing and steaming. As a result, the data has been filtered by speed, with vessels travelling at speeds of between 1 and 6 knots included (Lee *et al.*, 2010).

Due to VMS only applying to vessels over 15 m in length, activity by vessels under 15 m will not be represented in the analysis. As of 2012, EU legislation required all Member State vessels over 12 m in length to have VMS installed. Due to delays in the release of this data by MMO, however, this is not included in this assessment.

9 Annex 11.1B – Fisheries Legislation

9.1 Fishing Vessel Licences

For a vessel to commercially fish (to catch and sell fish for profit) it must hold a valid licence. The current vessel licensing scheme was introduced to stabilise fleet numbers and reduce catching capacity through the use of vessel capacity units (VCUs). Successive decommissioning schemes have also reduced the size of UK and several other Member States' fleets over the past 20 years.

9.2 Territorial Limits and Fishing Rights

Under the United Nations (UN) Convention on the Law of the Sea (UNCLOS, 1982), the UK's territorial sea extends out to 12 nm from the mean low water mark. With a few exceptions, access within 6 nm of the coast is restricted to the vessels of that country. As part of its Brexit negotiations, the UK government has indicated it will be withdrawing from this convention effective 2019 or upon Brexit completion.

9.3 Regional and Local Fishing Restrictions

Scottish ministers are responsible for the regulation of sea fishing around Scotland and within 12 nm of Scottish coasts. Inshore fisheries in the Scotland are regulated primarily through the Inshore Fishing (Scotland) Act 1984.

Moray West falls within the jurisdiction of the North and East Coast Regional Inshore Fisheries Groups (RIFG, a non-statutory body that aim to improve the management of Scottish inshore fisheries up to 6 nm) which enforces the local byelaws within 6 nm of the coast. Byelaws include:

- Minimum Landing Sizes (MLS) for fish and shellfish species
- Maximum number of dredges (scallop dredging)
- Fishing permits for shellfish species

9.4 Quota Restrictions

In European waters, quota in the form of Total Allowable Catches (TACs) is allocated to EU Member States by ICES sub-area based on historic fishing rights. A quota is a permission to catch quota stocks that are allocated between non-sector vessels (those who own quota), Producer Organisations (who manage quota for their members) and the inshore fleet. The UK quota management system aims to ensure that the quota is shared fairly amongst the UK fishing industry and that fishing activity is managed to ensure that these quotas are not exceeded.

Following heavy criticism of the quantity of discards under the quota system (due to the catch being undersized or over-quota), this was addressed in the reform of the Common Fisheries Policy (CFP) and has led to the introduction of discard ban regulation for pelagic fleet from 2015 and demersal ones from 2016.

9.4.1 Over 10 Metre Fleet

National, regional and individual quotas for the over 10 m fleet are assigned on the basis of historic rights. Vessel quotas are tangible assets which are eligible to be sold or leased, and national quotas may be exchanged between Member States.

9.4.2 Under 10 Metre Fleet

Vessels under 10 m in length represent 77% of the UK's fishing fleet but are allocated 4% of the UK's fishing quota. Half of the under 10 m fleet have uncapped licences allowing them to catch more than 300 kg of quota species per year. This inshore fleet represents over 50% of full time employment across the UK fleet, with majority of landings being non-quota stocks, particularly shellfish (NUFTA, 2017).

9.5 The Common Fisheries Policy (CFP)

The main method the European Union (EU) utilises to manage fishing activity in European waters is the CFP. The CFP provides a management strategy for fishing activities in order to prevent overfishing and provide economic and social stability to fishing communities.

The UK government remains a reserved power with regard to European fisheries negotiations, such as the setting of quotas. The implementation of fisheries regulations is undertaken by the Scottish Government in Scottish waters.

Changes to the CFP came into legislation in 2014. The changes were wide-ranging and cover all aspects of fisheries management and objectives. The key priorities of the reform were to ban discards, fish at sustainable levels and decentralise decision making, allowing Member States to agree the measures appropriate to their fisheries. A ban on discarding pelagic fisheries (such as mackerel and herring) started on 1st January 2015, with a ban on discards in all other fisheries to be phased in between January 2016 and 2019.

Due to the EU referendum and subsequent Brexit negotiations it is not possible to predict at the time of writing the future changes to fishing regulation and international rights which will be made as part of the Brexit negotiations. Until the end of the Brexit negotiations the CFP will still be enforced.

9.6 Shellfish Entitlements

National shellfish entitlement licences were introduced in 2004 for vessels targeting crabs and lobsters. The licence allows an unrestricted quantity of crab and lobster to be caught by vessels which have a historic record in the fishery. Vessels that are under 10 m and have a valid shellfish licence must submit weekly log sheets for crab and lobster to the local Fishery Officer. Licenced vessel owners who do not hold the shellfish entitlement are allowed to land up to five lobsters and 25 crabs per day.

9.7 Marine Protected Areas

The aims of Marine Protected Areas (MPAs) are to protect species and habitats of EU and national importance through the management of sea areas. In the UK, there are various types of MPAs, which include in the area of the project:

- Special Areas of Conservation (SACs) – designated to protect species and habitats under the EC Habitats Directive both inshore and offshore.
- Special Protection Areas (SPAs) – areas where birds and their habitats are given protection under the EC Wild Bird and Habitat Directive. SPAs have little or no impacts on the commercial fisheries sector.
- Marine Conservation Zones (MCZs) – designed to protect species and habitats of national importance under the Marine and Coastal Access Act (2009).

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MORAY WEST
OFFSHORE WINDFARM

Draft Commercial Fisheries Mitigation Strategy

Moray Offshore Windfarm (West) Limited

Technical Appendix 11.2

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1 Draft Commercial Fisheries Mitigation Strategy

1.1 Introduction

Moray Offshore Windfarm (West) Limited (known as 'Moray West') is promoting the development of the Moray West Offshore Wind Farm and associated Moray West Offshore Transmission Infrastructure (OfTI) (referred to jointly as 'the Development').

This draft Commercial Fisheries Mitigation Strategy (CFMS) has been prepared following pre-application discussions with the Scottish Fishermen's Federation (SFF) on the initial findings from the commercial fisheries impact assessment (presented in Chapter 11 of this EIA Report). This assessment (which has now been finalised) concludes no significant effects on any of the commercial fisheries fleets known to be active in the Moray West Site or along the Offshore Export Cable Corridor.

These conclusions are based on the implementation of embedded mitigation (described in Section 11.6.2 of the Commercial Fisheries Chapter). Embedded mitigation comprises a series of safety measures and plans for the preparation of a CFMS.

This document comprises a draft version of the CFMS.

1.2 Purpose of the Draft Commercial Fisheries Mitigation Strategy (CFMS)

Although it was concluded in the assessment that there would be no significant effects on any commercial fisheries fleets in accordance with the EIA Regulations, Moray West does acknowledge that there will be some temporary and long-term loss of, or restricted, access to certain grounds that are affected by the Development.

The aim of this draft CFMS is to therefore develop a draft framework of possible additional mitigation measures, actions or initiatives that could be implemented to further reduce the effect that temporary and long-term loss of, or restricted, access to certain grounds may have on certain commercial fisheries. The CFMS will also be used to set out how certain safety measures identified as embedded mitigation in Chapter 11 of the EIA Report will be implemented.

1.2.1 Basis for Preparation of a Draft CFMS

As discussed with the SFF, Moray West has adopted a Design Envelope approach to the assessment of likely significant effects of the Development on all receptors. As such, at this stage in the process it is not possible to define a final layout for the offshore wind farm on the basis that the size and number of turbines to be installed is not known as this will depend on the design parameters and generating capacity of turbines available at the time of construction. The final layout for the offshore wind farm, along with other details such as the type of substructures / foundations required to support the turbines (e.g. monopiles, jacket foundations, gravity base structure or suction cassions), number and position of OSPs will therefore only be determined post-consent. Similarly, final cable routes (inter-array, OSP interconnector and export cable circuits) will also only be determined post consent.

Given that the layout and design of the offshore wind farm will only be finalised post consent, it is not possible at this stage to produce a final CFMS on the basis that a number of the measures included in the CFMS will be influenced by the final design of the Development. However, it is acknowledged that there is a requirement to set out (even at a high level) the type of mitigation and safety measures that Moray West will be looking to include in the final CFMS which will be prepared post-consent prior to construction commencing

1.3 Overview of the Commercial Fisheries Mitigation Strategy

Moray West has undertaken a significant programme of early engagement with the fishing industry and is committed to continuing to explore and develop practical coexistence and mitigation options in consultation with the industry. Moray West, as part of the implementation of the CFMS, will continue ongoing dialogue throughout the determination, pre-construction, construction and operational phases of the Development. The CFMS will be finalised post consent prior to construction commencing.

The following information is currently provided in this draft CFMS:

- Measures for facilitating on-going dialogue with the fishing community throughout all phases of the Development;
- Outline measures for managing and mitigating potential effects on key fisheries associated with a loss of, or restriction in access to, traditional fishing grounds during pre-construction, construction, operations and maintenance and decommissioning;
- Outline measures and procedures for minimising interactions (navigation conflict) between wind farm construction and fishing activities;
- Procedures to be implemented in the event of interactions (navigation conflict) between wind farm construction and fishing activities (i.e. claims for lost / and or damaged gear);
- Protocols and procedures for ensuring compliance with standard offshore policies such as the Dropped Objects Policy. These policies prohibit the discarding of objects or materials overboard and require rapid recovery of any accidentally dropped objects; and
- Supplementary industry wide initiatives.

Moray West, where appropriate, in preparing this draft CFMS has taken into account best practice and industry defined standards such as the following procedures in communicating with the industry as well implementation of measures:

- FLOWW Best Practice Guidance for Offshore Renewables Developments: Recommendations for Fisheries Disruption Settlements and Community Funds;
- FLOWW Best Practice Guidance for Offshore Renewables Developments: Recommendations for Fisheries Liaison; and
- SFF Terms of Reference (TOR) for Fishing Industry Representatives (FIRs) to Wind Farms & Commercial Fisheries Working Groups.

2 Suggested Measures for Inclusion into the CFMS

2.1 Introduction

The following section of this draft CFMS sets out proposed measures and actions that Moray West would seek to develop further through consultation with SFF and other key fisheries stakeholders as part of the final CFMS. This includes information on the implementation of some of the industry best practice and standard safety measures and procedures that have been identified as part of the embedded mitigation presented in Chapter 11 of the EIA Report.

2.2 On-going Dialogue with the Fisheries Community

Moray West will engage in on-going dialogue with the fishing industry throughout all phases of the Development. This will involve regular communications with the fishing industry through the following mechanisms:

- Regular meetings/communications with the SFF and other key fisheries stakeholders as required. These meetings/communications will relate to the following:
    - Review and finalisation of the CFMS – regular quarterly to bi-annual meetings depending on stage in CFWS development and level of input required. Meetings will focus on the post consent and pre-construction period to ensure that the CFMS is finalised prior to the commencement of construction; and
    - On-going meetings/communications carried out as part of implementation of the CFMS (or draft CFMS if the Design Specification and Layout Plan (DSLP) is still in preparation). These will focus specifically on Development activities. The frequency of these meetings will depend on the phase of the Development and planned activities. For example:
        - The post-consent period is likely to be relatively quiet as it is usually a period of limited activity offshore;
        - Communications with fisheries stakeholders in relation to pre-construction surveys are likely to occur on an ad hoc basis occurring over weeks or months depending on the schedule for and duration of the survey; and
        - Once the Development moves into the construction phase where there will be a clearly defined programme of works, it is expected that consultation will occur on a more regular basis (e.g. quarterly).
- Dissemination of Notice to Mariners (NtMs), issue of Radio Navigation Warnings and a notice in the Kingfisher Fortnightly Bulletin for activities taking place on site;
- Appointment of a suitably experienced Fisheries Liaison Officer (FLO) who will be responsible for liaising with Fisheries Industry Representatives (FIRs) and local fishermen as part of any pre-construction surveys, prior to, during and post construction, and to maintain communications during O&M phase of the Development;
- Appointment of suitable Fisheries Industry Representatives (FIRs) for key fisheries who will be responsible for liaising with the wider fishing industry. The Terms of Reference for Fishing Industry Representatives to Windfarms & Commercial Fisheries Working Groups (issued by the SFF) will be used, in conjunction with Moray West policies, as a basis for appointing FIRs as well as defining activities and terms. Specific roles and responsibilities of the FIR and how they operate will be defined within the CFMS;
- Alternative methods of communication for example email or similar communication platforms (to be discussed and agreed as part the preparation of the final CFMS); and
- Issue of regular newsletters or bulletins providing updates on progress of the Development.

2.2.1 Communications Protocol and Log

Moray West proposes establishing a communications protocol and log. The purpose of this would be to provide guidance on approaches to consultation relating to different matters during the Development, including identifying key lines of communication, and to maintain a log of all communication activities undertaken. This will be developed as part of discussions with the SFF and other fisheries stakeholders on the final CFMS and will also involve input from the FLO. The precise content of this protocol would need to be agreed as part of the ongoing engagement on the preparation of the final CFMS but it is likely to comprise a simple Excel spreadsheet (or similar) which includes information on the following (note this is indicative only):

- Requirement for consultation / communications e.g. survey planning, communications on preparation of the DSLP, dissemination of information on proposed works etc.;
- Main point of contact (depending on activity / requirement for the communications);
- Method of engagement / communications with key point of contact (meeting / email / phone call etc.);
- Responsibility for communications e.g. FLO, FIRs or Moray West;
- Record of communications (time, date, location etc.);
- Any issues raised during communication;
- Actions taken to address these issues; and
- Action tracker to record whether actions remain open / have been closed out.

2.3 Managing effects associated with loss of, or restricted access to traditional fishing grounds

As discussed in the previous section, although it was concluded that there would be no significant effects on any of the fisheries fleets in terms of both temporary and long-term loss or, or restricted access to key fishing grounds. However, Moray West does acknowledge that there will be some temporary and long-term loss of, or restricted, access to, certain grounds that are affected by the Development.

The measures outlined in Table 2.1 below will not necessarily change this outcome (e.g. it is expected that there will still be some temporary and long-term access restrictions to certain fisheries grounds). However, Moray West is keen to explore options that will further reduce the effect that these access restrictions will have on certain fleets. The measures proposed are based on a combination of compensatory payments (for potential direct effects occurring during construction or as a result of specific maintenance activities), measures for coexistence and other industry wide measures. These measures do not include standard industry best practice safety measures which are outlined in Section 11.6.2 of the EIA Report Chapter and referred to in Sections 2.4 and 2.5 below where relevant.

Table 2.1: Fleet Specific Mitigation Measures

Fleet	Nature of effect	Mitigation
Creel fishery	Direct temporary loss of, or restricted access to, creel grounds (crab and lobster) during installation of the offshore export cable circuits and activities at the landfall. *There are currently no creel grounds in the Moray West Site.*	Disruption payments (see Section 2.3.1 below).

Table 2.1: Fleet Specific Mitigation Measures		
Fleet	**Nature of effect**	**Mitigation**
	No long-term effects are expected other than temporary displacement due to presence of maintenance vessels involved in cable repair works. This is on the basis these fisheries can resume activities along the export cable corridor once the cables are installed.	Disruption payments (for direct effects associated with maintenance activities within the creel grounds only) Industry wide fishing initiatives (see Section 2.8)
Nephrops	Temporary loss or restricted access to grounds along the Offshore Export Cable Corridor. Given that there are no Nephrops grounds in the Moray West Site, potential effects are limited to the installation of the offshore export cable circuits. These have been assessed to be not significant due to short term duration of the construction activities and extent of alternative grounds available to this fishery in the surrounding area.	Industry wide fishing initiatives (see Section 2.8)
	Long term loss or restricted access to grounds along the Offshore Export Cable Corridor.	Cable burial to at least 1 m depth along at least 80% of offshore export cables. Where burial is not possible, additional cable protection will be required. Cable burial methods and requirements for additional cable burial will be determined as part of a Cable Burial Risk Assessment (CBRA). This will be carried out by Moray West in consultation with the SFF and other key fisheries stakeholders (see Section 2.3.4). Industry wide fishing initiatives (see Section 2.8)
Squid fishery	Temporary loss or restricted access to squid grounds located within the Moray West Site. Although there is some squid fishing in the Moray West Site, it is not a major ground for this fishery. Potential effects during construction will therefore be limited.	Temporary safety zones around unburied cables (see Section 2.3.2). Industry wide fishing initiatives (see Section 2.8)
	Long term loss or restricted access to squid grounds located within the Moray West Site.	Industry wide fishing initiatives (see Section 2.8)
	Temporary loss or restricted access to squid grounds located along the Export Cable Corridor. Potential effects will be limited due to short term nature of construction activities and extent of alternative grounds that can be targeted for squid.	Temporary safety zones around unburied cables (see Section 2.3.2). CBRA (see Section 2.3.4). Industry wide fishing initiatives (see Section 2.8)
	Long term loss or restricted access to squid grounds located within the Moray West Site. Assessment concluded that given preference for fishermen to target rocky grounds, once operational even where additional cable protection has been installed, squid fishing will be able to resume along the Offshore Export Cable Corridor. Long term effects are therefore limited.	CBRA (see Section 2.3.4). Industry wide fishing initiatives (see Section 2.8)

Table 2.1: Fleet Specific Mitigation Measures		
Fleet	**Nature of effect**	**Mitigation**
Scallop dredge fishery (local and nomadic)	Temporary loss or restricted access to scallop grounds located within the Moray West Site.	Construction planning (see Section 2.3.4)
	Long term loss or restricted access to scallop grounds located within the Moray West Site.	CBRA (see Section 2.3.4). Overtrawlablity surveys (see Section 2.7) Re-seeding scheme (See Section 2.3.4) Review progress with gear trials for Moray East (See Section 2.3.4)
Whitefish	Temporary loss or restricted access to scallop grounds located within the Moray West Site.	Industry wide fishing initiatives (see Section 2.8)
	Long term loss or restricted access to scallop grounds located within the Moray West Site.	CBRA (see Section 2.3.4) Industry wide fishing initiatives (see Section 2.8)

2.3.1 Disruption payments (construction phase impacts and localised maintenance activities only)

Moray West is committed to making disruption payments to creel fisheries where there is clear evidence activities during construction will result in direct temporary displacement of these fisheries from certain grounds. The process and procedures that will be put in place to manage disruption payments will be developed in consultation with key stakeholders, the FLO and FIR. Further detail on the proposed approach to managing disruption payments will be included in the Final CFMS.

Disruption payments will also be made where there is a direct effect on creel activities along the export cable route due to the presence of maintenance vessels involved in cable repair works. The process and procedures for managing these payments will be as agreed for payments made during the construction phase.

2.3.2 Temporary safety zones around unburied cables

During installation of the offshore export cables there is potential for the cables to be temporarily laid on the seabed while awaiting burial. Where this is required Moray West will implement temporary safety zones around the areas where exposed sections of the offshore export cables are present. These will be in addition to the 500 m safety zones that will put in place during installation around construction vessels within the Moray West Site and along the Offshore Export Cable Corridor. If required, an FLO will be positioned onboard a guard vessel to notify fishing vessels in the area of the presence of the safety zone and the area affected. Coordinates of the safety zones and locations of exposed sections of cable will also be provided through recognised communications channels (e.g. Notice to Mariners (NtMs), issue of Radio Navigation Warnings and a notice in the Kingfisher Fortnightly Bulletin).

2.3.3 Cable Burial Risk Assessment (CBRA)

Moray West will use information obtained from post-consent geophysical and geotechnical surveys of the Moray West Site and Offshore Export Cable Corridor to inform a Cable Burial Risk Assessment (CBRA). The main aims of the CBRA are to:

- Identify where the cables (inter-array, OSP interconnector and offshore export cable circuits) can be buried and likely depth of burial that will be achievable along the buried sections of cable;
- Identify areas where cable burial is not achievable (due to seabed conditions or other constraints);
- Identify cable sections where additional protection will be required (either where burial is not possible (cables have to be surface laid) or where it is not possible to achieve target burial depths);

- Determine methods for cable installation and burial (based on seabed conditions); and
- Where additional cable protection is required, determine appropriate methods of additional protection. This will take into account the principal type of fishing gear deployed in the area where additional protection is required, seabed and metocean conditions (e.g. tidal currents) and other technical constraints such as other activities / third party assets in the area.

The CBRA will also provide information on cable crossings including locations, cable protection methods to be used, dimensions of crossings etc.

The CBRA will also identify areas at risk for creation of berms and identify likely level of effort and intensity of overtrawling required for breaking up berms. It will also identify requirements for boulder clearance along to the cable routes and set out methods for minimising the displacement of boulders into new areas of seabed where possible.

Findings from the CBRA will be used to inform the preparation of a Cable Plan for the Development.

Moray West will consult with the SFF and other key fisheries stakeholders as part of the CBRA process and on the preparation of the Cable Plan. In particular with regard to cable installation and burial techniques and additional cable protection measures (location and total length of cable affected).

2.3.4 Measures relating to the scallop dredge fleet

It is acknowledged that one of the principal fisheries within the Moray West Site is the scallop dredge fleet. This section therefore presents some options that Moray West would be keen to explore in more detail with the SFF and key fisheries stakeholders in order to try and further reduce or offset potential effects on the scallop dredge fleet associated with potential temporary and longer-term access restrictions within the Moray West Site.

2.3.4.1 Construction Planning

Moray West will see to engage with the scallop fishery (local and nomadic) as part of post consent and pre-construction communications to determine the status of the scallop fishery (based on cyclic nature of scallop fishing practices) within the Moray West Site prior to commencement of construction. This would enable Moray West to take the expected status of the scallop fishery in the Moray West Site into account in the preparation of construction plans for the Development. These plans will be clearly communicated to the to the scallop fishery in order to give the fishery the opportunity target certain areas of importance prior to the commencement of construction in those areas.

2.3.4.2 Scallop Re-Seeding Scheme

Moray West is keen to explore options for implementing a scallop re-seeding scheme within the Moray West Site. Details of this scheme would be developed in full post-consent should this be of interest to the scallop fisheries.

2.3.4.3 Review of Moray East Scallop Dredge Gear Trials

In finalising this CFMS, Moray West will review progress and, subject to availability, results from the Moray East scallop gear trials. Moray West will then seek further engagement with SFF and other fisheries stakeholders to establish how best the findings from the trials can be applied also to the Moray West Offshore Wind Farm.

2.4 Safety Issues for Fishing Vessels

2.4.1 Implementation of Safety Zones

At the time of construction Moray West will be able to take advantage of previous experience gained from other projects and implement the lessons learned. It is expected that the fishing industry will also be in a better position to offer constructive input to how best to phase advisory safety zones during construction after other offshore wind farms in the areas have been built out.

Specific processes and procedures for engaging with fishermen on the phasing of advisory safety zones during construction will be developed once final design of the Development has been agreed (post consent).

Moray West will develop with the SFF and relevant fisheries stakeholders a construction method plan. The plan will be developed in close co-ordination with the commercial fisheries industry and Moray West recognises the valuable role SFF will provide in supporting that.

Moray West will also appoint a FLO to ensure close co-ordination between Moray West and the commercial fisheries affected during the works. The plan will also recognise the need to re-open distinct areas to fishing as quickly as possible.

2.4.2 Overtrawlability Surveys

Moray West will undertake post construction surveys. The main objectives of these surveys will be:

- Verify cable burial depths;
- Where additional cable protection is required, verify that this has been installed in the correct locations and in accordance with methods agreed in the cable burial and protection strategy; and
- Identify the presence of any construction related seabed obstacles such as:
    - Mounds;
    - Boulders (increased quantities and/or presence in locations where boulders previously were not present and therefore have not been charted by fishermen); and
    - Berms that could have the potential to interfere with fishing.

Where required remedial action will be taken to reduce or remove significant obstructions. This could include physical remedial work, for example, to reduce the size of berms or improve cable burial where target burial depths have not been achieved; or charting the presence of berms and boulders and notifying fishermen of the presence of the seabed obstacles through recognized channels (NtMs etc.). The type and level of remedial action required will be determined through consultation with the SFF and other fisheries stakeholders and agreed with MSLOT prior to any remedial works being carried out.

2.5 Interference with Fishing Activities (Navigational Conflict)

The following measures / actions will be implemented to manage any potential navigational conflict between survey, construction or maintenance vessels and fishing gear.

- Project briefings to all survey, construction and maintenance contractors;
- Preparation of protocols and procedures for avoiding navigation conflict to be adhered to by all survey, construction and maintenance contractors and vessel skippers;
- Agreement on lines of communication between survey, construction and maintenance contractors and vessel skippers and the FLO;
- Delineation of construction zones with approved Aids to Navigation (AtNs);
- Application of advisory safety zones around construction vessels during construction;

- Incorporation of fisheries activities into risk assessments and identification of emergency response procedures (ERPs); and
- Identification of preferred transit routes for construction traffic (subject to weather conditions etc.) and refuge areas / anchorages for vessels in the event of bad weather.

2.6 Procedures in the Event of Interactions During Construction

This section relates specifically to procedures that will be put in place in the event that an interaction occurs between any vessels involved in surveys, construction or maintenance and fishing gear.

It is proposed that Moray West proforma will be produced that will be supplied to all survey, construction and maintenance vessels and the FLO. This will enable the nature of the incident to be recorded and other details such as location, timing, notifications issued prior to vessel operations etc.

Specific procedures and processes to be followed when dealing with any subsequent compensation claims (where applicable) will be developed in more detail as part of the preparation of the final CFMS.

2.7 Offshore Policies

Moray West will ensure compliance with standard offshore policies such as the International Convention for the Prevention of Collisions at Sea (COLREGs) (IMO, 1972) and Dropped Objects Policy (specific policy on dropped objects to be identified through further consultation with SFF).

2.8 Supplementary Industry Wide Initiatives

Moray West is committed to working with the SFF and the fishing industry to enhance opportunities for the fishing industry to benefit from training and employment opportunities associated with offshore wind developments. This includes, for example, the use of SFF members' vessel and crews as support and guard vessels. It is expected that there will be a range of potential opportunities for SFF members to provide vessel and crew support throughout the life cycles of the Development, in particular during construction and any pre-construction survey works. Moray West will work with SFF to explore options for maximising these opportunities.

Moray West will work with the SFF to align safety standards adopted by the renewables industry with those of the commercial fisheries industry to ensure that vessels selected are fit for the purpose for which they are required and avoid unnecessary barriers being introduced which would prevent the commercial fisheries industry accessing offshore wind opportunities. Further, Moray West will work with the SFF to ensure that the industry is aware of renewables industry standards for use of vessels and crews to ensure that that access to the opportunities can be taken.

Another area Moray West will investigate is with establishing Fisheries Community Funds. Examples of the kind of initiatives that could benefit from this include:

- Projects for community benefit such as ice plants, fuel storage facilities, or safety equipment (any medium to large scale projects must be supported by a viable business case);
- Research initiatives aimed at supporting fisheries e.g. stocks assessment surveys or better understanding marine renewable – fishery interactions e.g. gear trials;
- Resource enhancement or conservation initiatives e.g. lobster v-notching, reseeding;
- Support industry in advancing efforts towards attaining accreditation that certifies sustainable fisheries and seafood products e.g. through initiatives such as Fisheries Improvement Projects (FIPs); and
- Build on award winning skills work.

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MORAY WEST
OFFSHORE WINDFARM

Navigation Risk Assessment

Moray Offshore Windfarm (West) Limited

Technical Appendix 12.1

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Acronyms	
Acronym	**Expanded Term**
AC	Alternating Current
AIS	Automatic Identification System
ALB	All Weather Lifeboat
ARPA	Automatic Radar Plotting Aid
AtoN	Aid to Navigation
BEIS	Department of Business, Energy, and Industrial Strategy
BOWL	Beatrice Offshore Wind Farm
BOWL	Beatrice Offshore Windfarm Ltd
CA	Cruising Association
CAA	Civil Aviation Authority
CGOC	Coastguard Operation Centre
CIA	Cumulative Impact Assessment
COLREGS	International Regulations for Preventing Collisions at Sea 1972
CoS	Chamber of Shipping
CRO	Coastguard Rescue Officer
CRT	Coastguard Rescue Team
dB	Decibel
DC	Direct Current
DfT	Department for Transport
DSC	Digital Selective Calling
DSLP	Development Specification and Layout Plan
EIA	Environmental Impact Assessment
ERCoP	Emergency Response and Cooperation Plan
EU	European Union
FSA	Formal Safety Assessment
GPS	Global Positioning System
GRT	Gross Registered Tonnage
HSC	High Speed Craft
HSE	Health and Safety Executive
IALA	International Association of Lighthouse Authorities
ILB	Inshore Lifeboat
IMO	International Maritime Organization
ITOPF	International Tanker Owners Pollution Federation
kHZ	Kilo-hertz

Acronyms	
Acronym	**Expanded Term**
km	Kilometre
LCD	Liquid Crystal Display
LIDAR	Light Detection and Ranging
LOA	Length overall
m	Metre
MAIB	Maritime Accident Investigation Branch
MCA	Maritime and Coastguard Agency
MHWS	Mean High Water Springs
MEHRA	Marine Environmental High Risk Area
Met	Meteorological
MGN	Marine Guidance Note
MOD	Ministry of Defence
MSC	Maritime Safety Council
MSI	Maritime Safety Information
MW	Megawatt
NAVTEX	Navigational Telex
N	North
NLB	Northern Lighthouse Board
nm	Nautical Mile
nm2	Nautical Mile Square
NMOC	National Maritime Operations Centre
NOREL	Nautical and Offshore Renewable Energy Liaison
NOTAM	Notice to Airmen
NRA	Navigation Risk Assessment
NSP	Navigational Safety Plan
NUC	Not Under Command
OfTI	Offshore Transmission Infrastructure
OREI	Offshore Renewable Energy Installation
OSP	Offshore Substation Platform
PEXA	Practise and Exercise Area
PLA	Port of London Authority
REZ	Renewable Energy Zone
RNLI	Royal National Lifeboat Institution
Ro-Ro	Roll-on/roll-off

Acronyms	
Acronym	**Expanded Term**
RYA	Royal Yachting Association
SAR	Search and Rescue
SFF	Scottish Fishermen's Association
SOLAS	International Regulation for the Safety of Life at Sea
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
UKHO	United Kingdom Hydrographic Office
UK	United Kingdom
US	United States
VHF	Very High Frequency
VTS	Vessel Traffic Services
W	West
WTG	Wind Turbine Generator

Glossary of Terms	
Term	**Definition**
The Development	The Moray West Offshore Wind Farm and the associated Moray West OfTI.
The Moray Firth Zone	UK offshore wind Round 3 Zone 1 area held under a Zone Development Agreement by Moray Offshore Renewable Power Limited which is comprised of the Moray East Site and the Moray West Site.
Moray West	Moray Offshore Windfarm (West) Limited.
Moray West Offshore Transmission Infrastructure (OfTI)	The Offshore Transmission Infrastructure associated with the Moray West Offshore Wind Farm.
Moray West Offshore Wind Farm	The wind farm to be developed in the Moray West Site.
Moray West Onshore Transmission Infrastructure (OnTI)	The Offshore Transmission Infrastructure associated with the Moray West Offshore Wind Farm.
Moray West Site	The area of the Moray Firth Zone in which the Moray West Offshore Wind Farm will be located, previously known as the Western Development Area.
The Project	The Development (Moray West Offshore Wind Farm and Moray West OfTI) and the Moray West OnTI.

1 Introduction

1.1 Background

Anatec were commissioned by Moray Offshore Windfarm (West) Limited (Moray West) (the Applicant) to undertake a Navigation Risk Assessment (NRA) for the proposed Moray West Offshore Wind Farm. The report presents information on the Development relative to the existing and future case navigational activity and forms the Technical Appendix to the Shipping and Navigation Chapter (Chapter 12) of the Offshore Environmental Impact Assessment (EIA) Report, within which the impact assessment is undertaken.

1.2 Environmental Impact Assessment

Impacts on shipping and navigation during the construction, operation, and decommissioning phases are informed by an NRA. Following the Maritime and Coastguard Agency (MCA) methodology for assessing marine navigational risk of offshore wind farms (MCA, 2015) and Marine Guidance Note (MGN) 543 (MCA, 2016), the NRA includes:

- Overview of base case environment;
- Marine traffic survey data and analysis;
- Assessment of navigational risk pre and post development of the Development;
- Implications on marine navigation and communication equipment;
- Emergency response;
- Technical assessment for the Formal Safety Assessment (FSA) being undertaken as part of the EIA;
- Identification of mitigation measures; and
- Through life safety management.

Results from the NRA are then used to inform the EIA, a process which identifies the environmental effects of a project, both negative and positive, in accordance with European Union (EU) Directives.

2 Regulations and Guidance

2.1 Primary Guidance

The primary guidance documents used to inform this NRA are as follows:

- MCA MGN 543 (Merchant and Fishing) Safety of Navigation Offshore Renewable Energy Installations (OREIs) and annexes – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response (MCA, 2016);
- MCA Methodology for Assessing Marine Navigational Safety Risks of Offshore Wind Farms (2015); and
- Guidelines for FSA – Maritime Safety Council (MSC)/Circular 1023/MEPC/Circular 392 (International Maritime Organization (IMO), 2002).

MGN 543 highlights issues that shall be taken into consideration when assessing the effect on navigational safety from offshore renewable energy developments, proposed in UK internal waters, territorial sea or Renewable Energy Zone (REZ).

The MCA require that their methodology is used as a template for preparing NRAs, including the completion of an FSA. The methodology is centred on risk management and requires a submission that shows that sufficient controls are, or will be, in place for the assessed risk (base case and future case) to be judged as broadly acceptable or tolerable with mitigation. An MGN 543 checklist referencing the sections in this report which address all MCA requirements is presented in Annex B – MGN 543 Checklist.

2.2 Other Guidance

Other (secondary) guidance documents used during the NRA are listed below:

- MCA MGN 372 (merchant and fishing) OREIs Guidance to Mariners Operating in the Vicinity of UK OREIs (MCA, 2008);
- International Association of Marine Aids to Navigation (AtoN) and Lighthouse Authorities (IALA) Recommendation O-139 on The Marking of Man-Made Offshore Structures, Edition Two (IALA, 2013);
- Royal Yachting Association (RYA) – The RYA's Position on Offshore Renewable Energy Developments Paper One– Wind Energy (RYA, 2015); and
- Department for Business, Energy and Industrial Strategy (BEIS) Standard Marking Schedule for Offshore Installations (2011).

3 Navigation Risk Assessment Methodology

3.1 Methodology for Assessing the Development in Isolation

As per the primary guidance listed in Section 2.1, shipping and navigation impacts are assessed within the EIA based on an FSA approach. The NRA forms the technical workings of, and primary input to, the FSA. The results of the FSA are presented in Chapter 12: Shipping and Navigation of the EIA report.

The NRA has evaluated all required effects as detailed within MGN 543 (listed in Annex B) and as required by the MCA. Those effects with an effective pathway to shipping and navigation receptors have then been carried forward to Chapter 12: Shipping & Navigation as impacts requiring assessment.

Where an impact has been identified the overall severity of consequence to the receptor and likely frequency of occurrence of the impact have been determined. As this process incorporates a degree of subjectivity both screening of significant impacts from the NRA process and the consequent assessment within the EIA report have used the following sources:

- Scoping responses;
- Baseline data and assessment (including marine traffic survey data);
- Expert opinion;
- Outputs of the Hazard Workshop (Annex A);
- Level of stakeholder concern;
- Significance of any deviation;
- Number of transits of specific vessel and / or vessel type;
- Outputs of modelling where undertaken; and
- Lessons learnt from existing offshore projects.

The definitions used within the FSA for severity of consequence and frequency of occurrence are presented in Table 3.1 and Table 3.2 respectively. These rankings assume the embedded mitigation measures listed in Section 21 will be in place. It should be noted that the primary concern of the NRA and subsequent FSA is navigational safety (risk to the safety of vessels and / or crew) however financial and reputation consequences have also been considered from a cost benefit approach as per the methodology (MCA, 2015).

Table 3.1: Severity of Consequence Definitions

Rank	Description	Definition			
		People	Property	Environment	Business
1	Negligible	No injury	< £10k	< £10k	< £10k
2	Minor	Slight injury (s)	£10k-£100k	Tier 1 Pollution Incident[1] Local assistance required	£10k-£100k

[1] Response to incident within the capability of one local authority, offshore installation operator or harbour authority. Tiers defined in the National Contingency Plan (Marine Pollution), (MCA, 2014).

Table 3.1: Severity of Consequence Definitions					
Rank	**Description**	**Definition**			
		People	**Property**	**Environment**	**Business**
3	Moderate	Multiple moderate or single serious injury	£100k-£1M	Tier 2[2] Pollution Incident Limited external assistance required	£100k-£1M Local publicity
4	Serious	Serious injury or single fatality	£1M-£10M	Tier 2[2] Pollution Incident Regional assistance required	£1M-£10M National publicity
5	Major	More than 1 fatality	>£10M	Tier 3[3] Pollution Incident National assistance required	>£10M International publicity

Table 3.2: Frequency of Occurrence Definitions		
Rank	**Description**	**Definition**
1	Negligible	< 1 occurrence per 10,000 years
2	Extremely Unlikely	1 per 100 to 10,000 years
3	Remote	1 per 10 to 100 years
4	Reasonably Probable	1 per 1 to 10 years
5	Frequent	Yearly

The significance of each impact is then assessed as either "**Broadly Acceptable**", "**Tolerable**", or "**Unacceptable**" based on the tolerability risk matrix presented in Table 3.3. Definitions of these significance rankings are presented in Table 3.4. Where an impact is assessed as being of **Unacceptable** significance, additional mitigation is required to reduce the significance of the impact to within the "**Broadly Acceptable**" or "**Tolerable**" ranges. The impact is then considered to be As Low as is Reasonably Practicable (ALARP).

[2] Response to incident beyond the capability of one local authority or requires additional contracted response from offshore operator or from ports or harbours. Tiers defined in the National Contingency Plan (Marine Pollution), (MCA, 2014).
[3] Incident response requires national resources coordinated by the MCA for a shipping incident and the operator for an offshore installation incident. Tiers defined in the National Contingency Plan (Marine Pollution), (MCA, 2014).

Table 3.3: Tolerability Risk Matrix

Consequence	**Major (5)**	Tolerable	Tolerable	Unacceptable	Unacceptable	Unacceptable
	Serious (4)	Broadly Acceptable	Tolerable	Tolerable	Unacceptable	Unacceptable
	Moderate (3)	Broadly Acceptable	Broadly Acceptable	Tolerable	Tolerable	Unacceptable
	Minor (2)	Broadly Acceptable	Broadly Acceptable	Broadly Acceptable	Tolerable	Tolerable
	Negligible (1)	Broadly Acceptable	Broadly Acceptable	Broadly Acceptable	Broadly Acceptable	Tolerable
		1	**2**	3	4	5
		Frequency				

Table 3.4: Significance Ranking Definitions

	Broadly Acceptable	Risk ALARP with no additional mitigations or monitoring required above embedded mitigations.
	Tolerable	Risk acceptable but may require additional mitigation measures and monitoring in place to control and reduce to ALARP.
	Unacceptable	Significant risk mitigation or design modification required to reduce to ALARP.

3.2 Methodology for Assessing Cumulative Effects

Cumulative effects have been considered for shipping and navigation within this NRA; this includes impacts of other offshore developments, as well as activities associated with other marine operations. Fishing, recreation and marine aggregate dredging transits have been considered as part of the baseline assessment. Other developments and relevant marine activities have been identified within Section 8 (Navigational Features) and Section 12 (Marine Traffic), and summarised in the baseline assessment in Volume 1, Chapter 12: Shipping and Navigation of the EIA report.

A list of screened in cumulative developments and activities is presented in Section 18. Associated cumulative effects are then assessed within the Cumulative Impact Assessment (CIA) within, Volume 1, Chapter 12: Shipping and Navigation of the EIA report.

3.3 Methodology of Assessing Transboundary Effects

Given the location of the Moray West Site within the Moray Firth, no transboundary effects on vessel routeing are identified (see Section 18.3). It is noted that vessels within the Moray Firth have the potential to be internationally owned or based. The movements of these vessels are captured within the baseline assessment, and associated impacts are listed in Table 22.1.

3.4 Assumptions

The shipping and navigation baseline and impact assessment has been carried out based on the information available, and consultation responses received (including to the Scoping Report for both the wind farm and the OfTI) at the time of preparation. This includes design parameters of the Development (as set out in the Design Envelope), and the anticipated Development schedule.

Assessment has considered a worst case scenario (from a shipping and navigation perspective) from the proposed design envelope noting the final locations of structures will not be finalised until post consent.

3.5 Study Areas

The analysis within this NRA has largely been undertaken within a 10 nautical mile (nm) buffer of the Moray West Site (hereafter referred to as the offshore wind farm study area). This ensured all relevant traffic passing the Moray West Site was included within the assessment (i.e., traffic which may be effected by the wind farm structures), while still remaining site specific to the Development.

In addition, analysis of marine traffic data and relevant navigational features has been undertaken within a 2nm buffer of the Offshore Export Cable Corridor (hereafter referred to as the OfTI study area). Both study areas are presented in Figure 4-1.

Cumulative impacts have been considered within a 10 nm buffer around the Moray West Site (as per the offshore wind farm study area) but where applicable vessel routes which transit through this area have been considered outside of this study area where they intersect another cumulative site.

4 Development Description

4.1 Development Timeline

Construction is anticipated to begin in 2022, with final commissioning anticipated for 2024, beginning the Development's operational phase. Plans for the Decommissioning of the Development are presented in the Decommissioning Programme. The detail of the Decommissioning Programme will be finalised and agreed post consent.

4.2 Boundaries and Layouts

The Moray West Site is located within the Moray Firth, covering an area if approximately 66 square nautical miles (nm^2), and is, approximately 12 nm from the Caithness coast. The key corner coordinates of the Moray West Site are presented in Table 3.1 below, with the corresponding corner points then plotted in Figure 4-1.

Table 4.1: Moray West Site Coordinates

Corner	Latitude	Longitude
C1	58° 06' 24.88" North (N)	003° 08' 14.16" West (W)
C2	58° 12' 34.55" N	002° 52' 26.17" W
C3	58° 03' 58.74" N	002° 54' 40.04" W
C4	58° 00' 18.49" N	003° 12' 52.82" W
C5	58° 02' 37.64" N	003° 13' 06.48" W

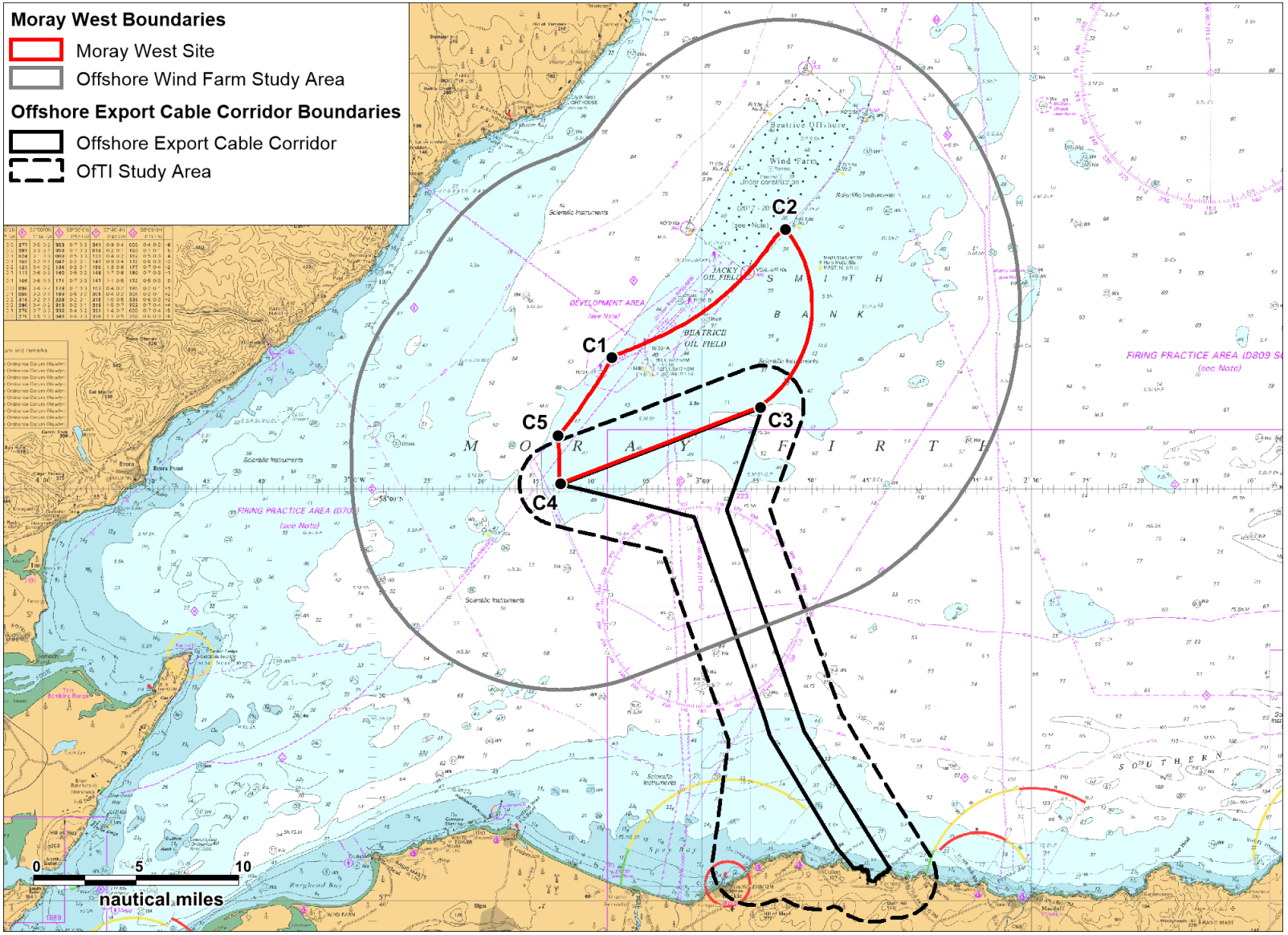


Figure 4-1 Development Coordinates and Shipping and Navigation Study Area Overview

The Development will comprise up to 85 wind turbine generators (WTGs). From a shipping and navigation perspective, the maximum number of WTGs covering the widest area is considered to represent the worst case, based on the assumption that this will displace the most vessels, and present the greatest number of allision[4] targets for passing traffic.

4.3 Development Details

4.3.1 WTGs

Four potential turbine models are under consideration, key parameters of which are summarised in Table 4.2.

Table 4.2: WTG Parameters

Model	Maximum Hub Height (m)	Maximum Rotor Diameter (m)	Maximum Tip Height (m)	Minimum Air Blade Clearance (m)	At HAT Surface Dimensions (Jacket - Worst Case)	Maximum WTG Numbers
Model 1	117	164	199	22	35 x 35m	85
Model 2	132.5	195	230	22	Between 35 x 35m and 40 x 40m	85
Model 3	150	230	265	22	Between 35 x 35m and 40 x 40m	72
Model 4	160	250	285	22	40 x 40m	62

WTGs will be installed on one of the following foundation types. It is considered unlikely that more than one of the foundation types listed will be used:

- Jacket;
- Monopiles;
- Gravity base structure (GBS) foundations; or
- Suction caissons.

4.3.2 Offshore Substation Platforms (OSPs)

There will be up to two OSPs installed within the Moray West Site, with the foundation types listed above in Section 4.3.1 all under consideration. Platforms will be of dimension 100 x 100m.

4.3.3 Cables

4.3.3.1 Inter-array

The WTGs will be linked via an inter-array cable network installed within the Moray West Site. Wherever possible, cables will be protected via burial, with required depths (in the range of 1 m to 3 m trench depth) to be assessed post consent by a risk assessment process (as per the embedded mitigation listed in Section 21). Where burial is not feasible, cables will be protected using a combination of rock placement, concrete mattresses, polymer or steel sleeves, and grout bags. In the event of the installation of two OSPs, these will be linked via an Interconnector cable.

[4] Act of a moving object striking a stationary object.

4.3.3.2 Offshore Export Cables

The Offshore Export Cable Corridor is presented in Figure 4-1 relative to the Moray West Site. As with the inter-array cables, cables will be protected via burial, with required depths to be assessed post consent within the Cable Burial Risk Assessment (as per the embedded mitigation listed in Section 21). Where burial is not feasible, cables will be protected using a combination of rock placement, concrete mattresses, polymer or steel sleeves, and grout bags.

4.4 Worst Case Layout

For the purpose of this NRA, the worst case layout (from a shipping and navigation perspective) has been chosen from those layouts currently under consideration to use as input to the modelling process (see Section 15). The worst case layout from a shipping and navigation perspective is represented by the maximum number of structures covering the maximum area. Following a review of the potential layouts, Layout 1a (using Model 1 turbines) has been selected as the worst case based on the following:

- Maximum number of WTGs (85 Model 1); and
- Maximum total footprint.

Layout 1a is presented in Figure 4-2.

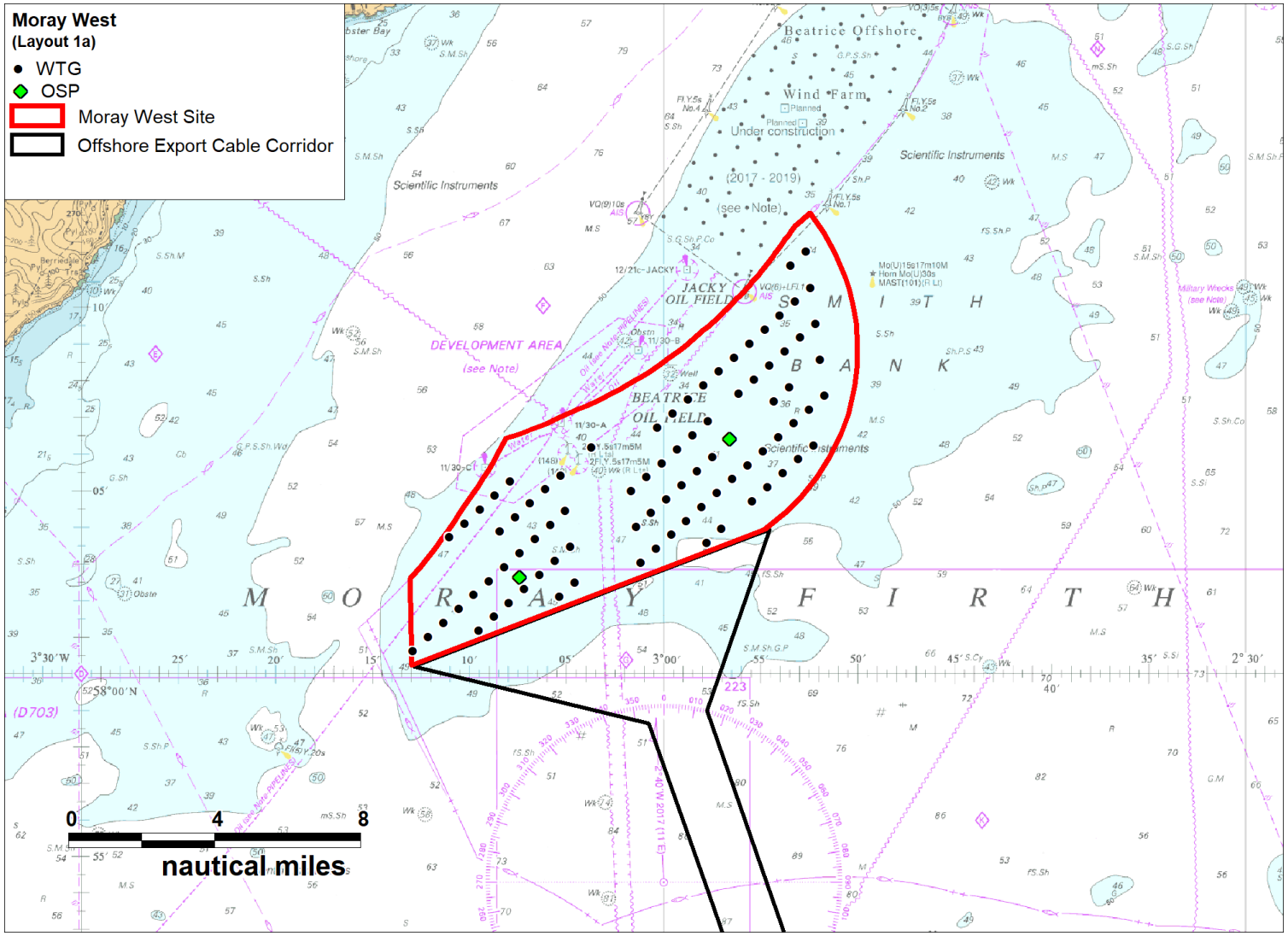


Figure 4-2 Worst Case Layout 1A

5 Consultation

5.1 Introduction

A key input to the NRA and subsequent FSA were responses received from key statutory and non-statutory stakeholders relevant to Shipping and Navigation. This included consideration of responses received within the Scoping Opinion in response to the Scoping Reports issued for the Wind Farm (Moray West Wind Farm Scoping Report, 2016) and the Moray West Offshore Transmission Infrastructure (OfTI) (Moray West, OfTI Scoping Report, 2017), regular operator responses, and consultation undertaken via a Hazard Workshop.

The marine traffic survey data presented in Section 12 was used to identify any regular operators utilizing the area. Regular operator responses received are included in Table 5.3, and key consultation output from the Hazard Workshop (see Section 20.2) is summarised in Table 5.4.

5.2 Scoping and Subsequent Statutory Stakeholder Responses

Key consultation responses arising from the scoping process and from subsequent meetings held with statutory stakeholders are provided in Table 5.1 and Table 5.2, with an explanation of how the points raised have been addressed, or a reference to where they have been addressed, included.

Table 5.1: Consultation – Scoping Opinion

Consultee	Comment	Moray West Approach
MCA	EIA should include commercial and recreational vessel impacts.	Impacts to both considered within Chapter 12: Shipping and Navigation.
	NRA must be submitted in line with MGN 543 (MCA, 2016) and required OREI assessment methodology (MCA, 2015).	This NRA is in line with the guidance referenced (Section 2).
	Consideration must be given to potential navigable water depth reduction (noting MGN 543 requirement that depth reductions of greater than 5% of chart datum require MCA consultation).	Assessment of Cable Protection will be undertaken post consent (Section 21), with the MCA consulted as necessary.
	Cumulative effects with Moray East and BOWL must be considered.	Cumulative effects are considered in Chapter 12: Shipping and Navigation.
	Final layout must consider safe passage of Search and Rescue (SAR) helicopters and vessels during SAR operations. OSPs must be in line with WTG row/columns. Implications on ERCoP must be considered.	Final layout will be agreed with the MCA post consent (Section 21).
	Principle of Rochdale[5] Envelope approach should be used in EIA.	Impact assessment in Chapter 12: Shipping and Navigation assumes the worst case envelope parameters.
	Inclusion of Radar and visual observations in marine traffic analysis to ensure capture of non-AIS traffic.	Approach to marine traffic collection agreed with the MCA and NLB.
	Automatic granting of safety zones should not be assumed.	Application for safety zones (rather than safety zones themselves)

[5] Meaning the 'Design Envelope'.

Table 5.1: Consultation – Scoping Opinion		
Consultee	**Comment**	**Moray West Approach**
		assumed as embedded mitigation (Section 21).
Moray Council	Seeks early engagement on likely impacts to Moray Harbours.	Invite to Hazard Workshop (Section 20.2) was extended to Moray Council. Ports used to be decided post consent – impacts assessed in Chapter 12: Shipping and Navigation.
NLB	Lighting and marking should be in line with IALA O-139, and in continuity with Moray East. Marking of cable landfall may be necessary.	All lighting and marking will be agreed with NLB post consent (Section 21) and will be in line with IALA O-139.
	NRA submitted in line with MGN 543 (MCA, 2016). NRA informed by bland observations, local user consultation, and desktop study.	This NRA is in line with MGN 543 (Section 2). Marine traffic data approach agreed with MCA and NLB.
Civil Aviation Authority (CAA)	Any WTG of height 60 m or more above Highest Astronomical Tide (HAT) in United Kingdom (UK) waters must be lit/marked in line with the Air Navigation Order.	All lighting and marking will be agreed in consultation with the CAA (Section 21) and will be in line with the Air Navigation Order.
	Issue of Notice to Airmen while aviation charts are being updated.	Promulgation of information (which includes Notice to Airmen) assumed embedded mitigation (Section 21).
CoS	Traffic data required updating (noting Moray East data used within Moray West Scoping Process), including recording of non-AIS traffic.	Approach to marine traffic data collection agreed with the MCA and NLB.
	Adverse weather routeing and anchorages must be considered.	Adverse weather considered in Section 13.4. Anchorages shown in Section 8.4.
	Layout must consider MGN 543 (MCA, 2016) guidelines.	MGN 543 checklist provided in Annex B. Layout to be agreed with MCA post consent (Section 21).
RYA	Mitigation must include publicity of timing and location of construction. RYA objects to use of operational safety zones.	Promulgation of information counted as embedded mitigation. Moray West do not intend to apply for operational safety zones, however this will be assessed prior to the safety zone application.
	The proposal of no-anchor zones in waters of less than 10m depth would require RYA consultation.	Cable protection will be agreed post consent (Section 21).
	Data sources should include updated RYA Coastal Atlas (RYA, 2016).	Updated Coastal Atlas considered (see Section 6).
BOWL	BOWL should be treated as part of the baseline.	BOWL has been considered as part of the baseline assessment (Section 8.2).

Table 5.2: Post Scoping Stakeholder Meetings			
Meeting	**Stakeholder**	**Comment**	**Moray West Approach**
20/04/2017 with MCA and NLB	MCA	Agreed AIS only winter survey based on data already collected, however summer survey must include non AIS traffic.	Moray West have complied with the approach agreed with the MCA and NLB for marine traffic survey data collection.
	NLB	Potential increases in traffic associated with BOWL construction and Beatrice Field decommissioning should be accounted for.	Potential traffic increases have been accounted for within the future case routing and modelling assessment (Section 15.2).
May 2017 with Cruising Association (CA) and CoS	CA	OSPs should be internal within Moray West Site and in line with WTG row/columns.	Layout to be agreed with MCA post consent (Section 21).
		Cable burial should exceed 1.5m in areas where recreational vessels may anchor if possible, with preservation of a smooth seabed ideal. Burial of 1m may be acceptable depending on location, but beacon marker may be required.	Assessment of Cable Protection will be undertaken post consent (Section 21).
		Requested coordinated lighting between the Development, Moray East, and BOWL.	Lighting and marking will be agreed post consent with NLB (Section 21).
		Requested use of an OSP to operate a relay service improving mobile phone reception of the area.	Given the complexity of installing additional hardware and licensing it is unlikely that a mobile phone mast would be considered. Noted that marine VHF remains the primary method of communication for offshore vessels.
		Request consideration of horizontal black band for corner wind turbines and possibly some intermediate wind turbines to indicate Mean High Water Springs (MHWS) level.	Given the uniform and standardised requirements for offshore lighting and marking this request is not considered feasible.
		Under-tip clearance of WTG blades should be at least 22m above HAT.	MGN 543 requires 22 m from MHWS – this would be complied with as a minimum (Section 21).
	CoS	Queried as to if final layout would align with Moray East.	Layout will be agreed with MCA post consent.
23/10/2017 with MCA and NLB	MCA and NLB	Agreed NRA and EIA methodology, worst case envelope and marine traffic survey data.	NRA/EIA undertaken in line with agreed approach.
14/11/2017	RYA Scotland	Mitigation required by law is “embedded”, any further mitigation is therefore “additional” and should be presented as such.	Embedded mitigation measures are listed in Section 21.

Table 5.2: Post Scoping Stakeholder Meetings			
Meeting	**Stakeholder**	**Comment**	**Moray West Approach**
		Requested more publicity related to the Development and its progress.	Promulgation of information (including with local recreational stakeholders) assumed as embedded mitigation (Section 21).
16/01/2018 with CoS, CA, and BP Shipping	BP Shipping	Raised concern over impact of cables on shuttle tanker anchorage within Moray Firth.	Anchoring impacts assessed in Chapter12: Shipping and Navigation.
	CoS	Noted that marine traffic is specific to market conditions of the period and may not capture all relevant shipping movements.	Marine traffic data approach agreed with MCA and NLB. Data validated against Anatec's long term shipping database.
	CA	It was raised that small local sailing vessels may not be on AIS.	The summer marine traffic survey utilised radar and visual observations to record non-AIS vessel movements. Additionally, the latest RYA Coastal Atlas (RYA, 2016) has been used as input to the assessment.

5.3 Regular Operator

Regular commercial operators were identified from the marine traffic survey data (see Section 12), and each were subsequently sent information regarding the Development, and a request for a consultation response.

A summary of the operators contacted, and the responses received are provided in Table 5.3. Further details (including a template of the communication sent to each operator) are provided in Annex D to this NRA.

Table 5.3: Consultation – Regular Operators			
Date Sent	**Consultee**	**Response**	**Where Addressed**
07/11/2017	Arklow Shipping	No Response	n/a
07/11/2017	BP Shipping Offshore	Response on 21/11/2017. More detail about the cable corridor routes between the Moray West, Moray East and Beatrice Farms to shore was requested to determine what impact (if any) they will have with regards to anchorages that have traditionally been used by North Sea Shuttle tankers and could potentially be utilised to provide safe anchorage for floating storage	Consideration to anchorage locations (including those identified via consultation) has been given in Section 8.4.

Table 5.3: Consultation – Regular Operators			
Date Sent	**Consultee**	**Response**	**Where Addressed**
		operations when demand for tanker volume is low, oil prices are low and contango[6].	
07/11/2017	Briggs Marine	No Response	n/a
07/11/2017	Cruise & Maritime Voyages	No Response	n/a
09/11/2017		No Response	n/a
07/11/2017	Faversham Ships	No Response	n/a
07/11/2017	Green Marine UK	No Response	n/a
07/11/2017	Hagland Shipping	No Response	n/a
07/11/2017	Hapag-Lloyd	No Response	n/a
07/11/2017	Hebridean Island Cruises	No Response	n/a
07/11/2017	James Fisher Everard	No Response	n/a
07/11/2017	Norwegian Cruise Line	No Response	n/a
07/11/2017	Peak Group	No Response	n/a
07/11/2017	Princess Cruises	No Response	n/a
07/11/2017	Scotline	No Response	n/a
07/11/2017	Solstad Farstad	No Response	n/a
07/11/2017	Subsea 7	Response on 06/12/2017 No comments to make. Vessels working within the area where carrying out project work therefore not specifically transiting.	n/a
07/11/2017	Teekay Shipping Norway AS	No Response	n/a
07/11/2017	Vadero Shipping	No Response	n/a
07/11/2017	Viking Supply Ships	No Response	n/a

[6] The normal situation in which the spot or cash price of a commodity is lower than the forward price.

Table 5.3: Consultation – Regular Operators			
Date Sent	**Consultee**	**Response**	**Where Addressed**
07/11/2017	Vroon Offshore Services	Response on 16/11/2017 The VOS Master transit was for a port call for a crew change in Invergordon which is a rare occasion as her normal port is Aberdeen. As an initial overview with regards to Vroon traffic for the area, it would have very little impact on the fleet. The only perceived impact would be for the VOS Master for traffic monitoring at her assigned location at the Captain Field and if any traffic flow would be diverted to pass closer to the Captain Field and VOS Master once Moray West and Moray East complete installation.	Displacement impacts are assessed within Chapter 12: Shipping and Navigation.
07/11/2017	Wijnne Barends	No Response	n/a
07/11/2017	Windstar Cruises	No Response	n/a
08/11/2017	AIDA Cruises	No Response	n/a
20/11/2017	Fred Olsen Cruise Lines	No Response	n/a
20/11/2017	MSC Cruises	No Response	n/a

5.4 Hazard Workshop

Relevant consultation outputs of the Hazard Workshop held in September 2017 are summarised in Table 5.4, which includes reference to where the points raised have been addressed. The main output of the Hazard Workshop was the Hazard Log, which is provided in Annex A, with a summary also available in Section 20 of this NRA.

Table 5.4: Consultation - Hazard Workshop			
Date / Document	**Consultee**	**Comment**	**Moray West Approach**
21/09/2017	NLB	Queried if the Shetland HVDC Link would be included in the analysis.	This cable lies outside of the area studied and therefore represents no baseline or cumulative impacts (landfall is at Noss Head, approximately 7nm north of the offshore wind farm study area). However the Caithness Moray Transmission Link (also making landfall at Noss Head) has been included within the baseline assessment in Section 8, given that it crosses the Offshore Export Cable Corridor.

Table 5.4: Consultation - Hazard Workshop			
Date / Document	**Consultee**	**Comment**	**Moray West Approach**
21/09/2017	Repsol Sinopec	It would be useful to include traffic associated with the Beatrice and Jacky platforms in analysis, as decommissioning was unlikely to start until 2024. At this point, marine vessel traffic will likely increase from levels currently observed.	The traffic has been considered as part of the baseline, and has been included in the modelling undertaken in Section 16 and 17.

6 Data Sources

This section lists the data sources that have been used as input to this NRA, and hence the subsequent FSA. The primary input was the marine traffic surveys, undertaken to assess the baseline traffic patterns within the vicinity of the Moray West Site. Further details of the marine traffic surveys are presented in Section 12 (which establishes the marine traffic baseline), with other relevant data sources considered listed below (used to supplement the marine traffic baseline, and to establish the navigational feature baseline in Section 8 of this NRA):

- Maritime incident data from the MAIB (2005 to 2014) and maritime incident data from the Royal National Lifeboat Institute (RNLI) (2005 to 2014). Although all UK commercial vessels are required to report accidents to the MAIB, non-UK vessels do not have to report unless they are in a UK port or within 12 nm territorial waters and carrying passengers to a UK port. There are also no requirements for non-commercial recreational craft to report accidents to the MAIB;
- The Crown Estate UK offshore wind farm boundaries (2017);
- Admiralty Sailing Directions – North Coast of Scotland Pilot, NP 52 United Kingdom Hydrographic Office (UKHO), 2015);
- UKHO Admiralty Charts;
- RYA UK Coastal Atlas of Recreational Boating (2016), Cruising Routes (2010), recreational AIS (summers of 2011-2013) and Geographic Information System (GIS) Shape Files (2016); and
- Metocean Data (see Section 9 for further details) - the probability of poor visibility has been estimated based on information given in the Admiralty Sailing Directions (UKHO, 2015), average statistics for the North Sea, and data collected from onshore receivers. Based on the available data, the UK North Sea average was assumed to be representative of the Moray Firth. Tidal stream information has been taken from UK Admiralty Charts, and it has been assumed that the provided details are accurate.

7 Lessons Learned

There is considerable benefit to developers in the sharing of lessons learned within the offshore industry. The NRA, and in particular the hazard assessment, includes general consideration for lessons learned and expert opinion from previous offshore wind farm projects and other sea users.

These include:

- *Moray East Offshore Wind Farm NRA (Anatec, 2012).* Establishment of baseline Moray Firth characteristics have been carried forward (and validated as appropriate) to the Moray West NRA.
- *DfT (2004) Results of the electromagnetic investigations 2nd edition, Southampton, MCA and QinetiQ.* The results of this study have informed the Communications and Position Fixing Equipment Fixing impact assessment in Section 19.
- *MCA (2005) Offshore Wind Farm Helicopter Search and Rescue – Trials Undertaken at the North Hoyle Wind Farm Report of helicopter Search and Rescue (SAR) trials undertaken with Royal Air Force Valley C Flight 22 Squadron on March 22nd 2005, Southampton, MCA.* The results of these trials have informed the Communications and Position Fixing Equipment Fixing impact assessment in Section 19.
- *Nautical Offshore Renewable Energy Liaison (NOREL Group) (unknown) A Report compiled by the Port of London Authority based on experience of the Kentish Flats Wind Farm Development, NOREL Work Paper, WP4 (2nd NOREL).* The results of these trials have informed the Communications and Position Fixing Equipment Fixing impact assessment in Section 19.
- *Renewables UK (2014 issue 2) Guidelines for Health and Safety in the Wind Energy Industry.* These guidelines have informed the impact assessment undertaken in Chapter 12: Shipping and Navigation.
- *RYA and CA (2004) Sharing the Wind – Identification of recreational boating interests in the Thames Estuary, Greater Wash and North West (Liverpool Bay), Southampton, RYA.* This study has informed the impacts assessed relevant to recreational vessels.
- *The Crown Estate (2012) Strategic Assessment of Impacts on Navigation of Shipping and Related Effects on Other Marine Activities Arising from the Development of Offshore Wind Farms in the UK REZ.* This study has informed the impact assessment in relation to vessel routeing, and informs cumulative assessment.

8 Existing Environment – Navigational Features

8.1 Introduction

This section presents the navigational baseline assumed within this NRA which has been established based on the data sources outlined in Section 6. This is primarily based on assessment of the Pilot Book (UKHO, 2015) and Admiralty Charts covering the Moray Firth area.

An overview plot of the navigational features assessed is presented in Figure 8-1.

8.2 Other Wind Farm Developments

One of key navigational features in the immediate vicinity of the Development is the project, Beatrice Offshore Wind Farm (referred to as BOWL), as shown in Figure 8-1. BOWL lies directly northwest of the Moray West Site. BOWL is currently under construction and will consist of 84 WTGs, with final commissioning expected by 2019. For context, the Moray East Site is included in the figure (noting that the Moray East Offshore Wind Farm is not considered baseline, and is considered cumulatively in Section 8.2).

8.3 Aids to Navigation

There are a number of pre-existing Aids to Navigation (AtoNs) located in proximity to the development, as presented in Figure 8-1. Positions and details of the presented AtoNs are based on assessment of UKHO Admiralty Charts. It is noted that the figure includes temporary AtoNs (cardinal and special mark buoys) placed to mark the buoyed construction area surrounding the BOWL (likely to be removed in 2019).

No additional buoyage is to be used to mark the BOWL during its operational phase; however, the WTGs will be marked and lit as agreed with the relevant stakeholders.

8.4 Anchorage Areas

Figure 8-2 includes charted and uncharted anchorages listed as providing suitable anchoring conditions within the Admiralty Sailing Directions (UKHO 2015). These are as follows:

- Wick Bay, outer anchorage on sandy bottom of bay;
- Helmsdale, anchorage five cables south east of harbour entrance in 12m;
- Loch Fleet, south east of village noting submarine cables are laid between disused piers;
- Spey Bay, anchorage anywhere but advised to remain in depths of not less than 10m;
- Wilkhaven jetty, five cables East of Wilkhaven jetty in 13-14m; and
- Rockfield, five cables east of Rockfield in 15m.

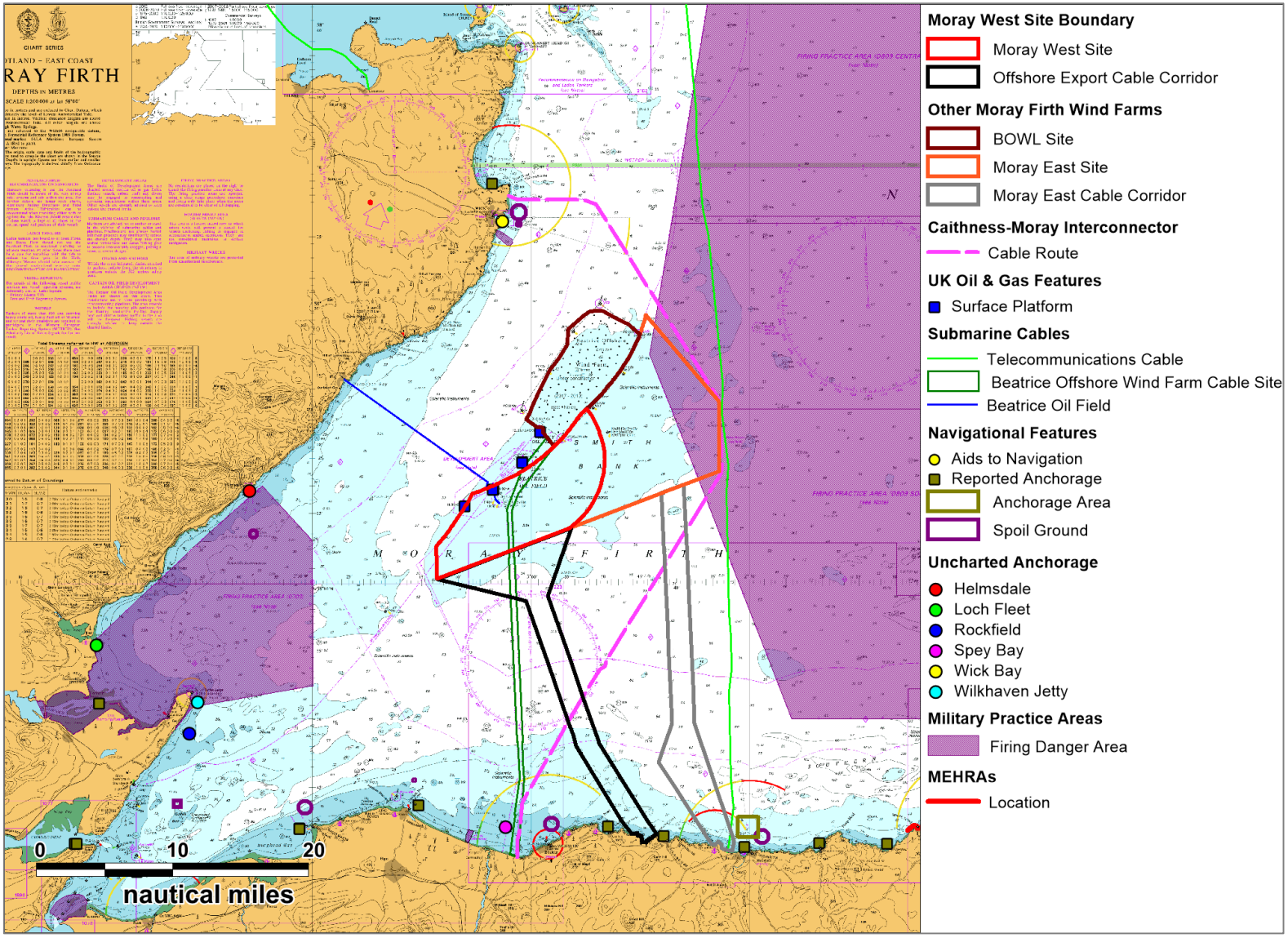


Figure 8-1 Navigational Features Overview

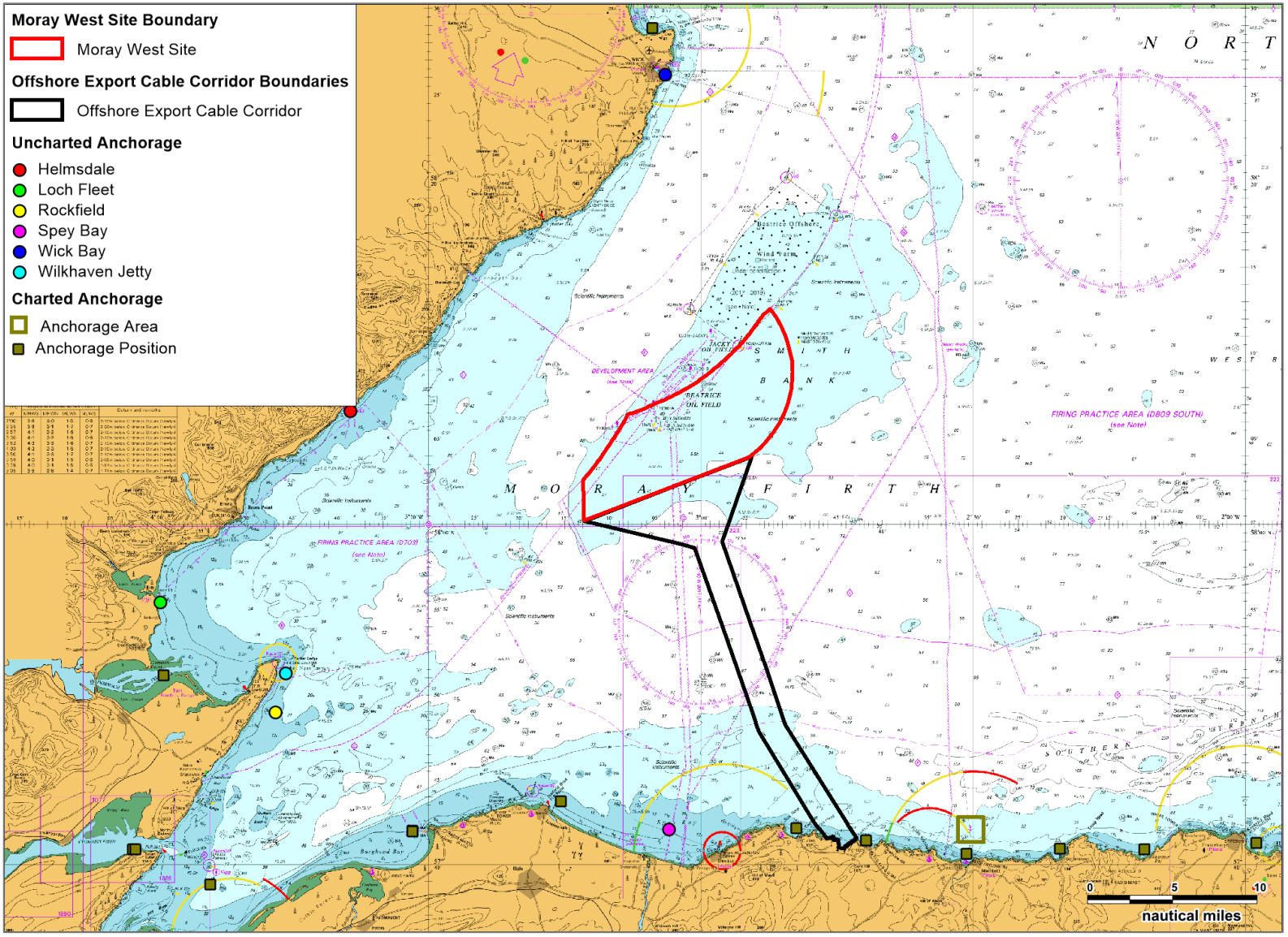
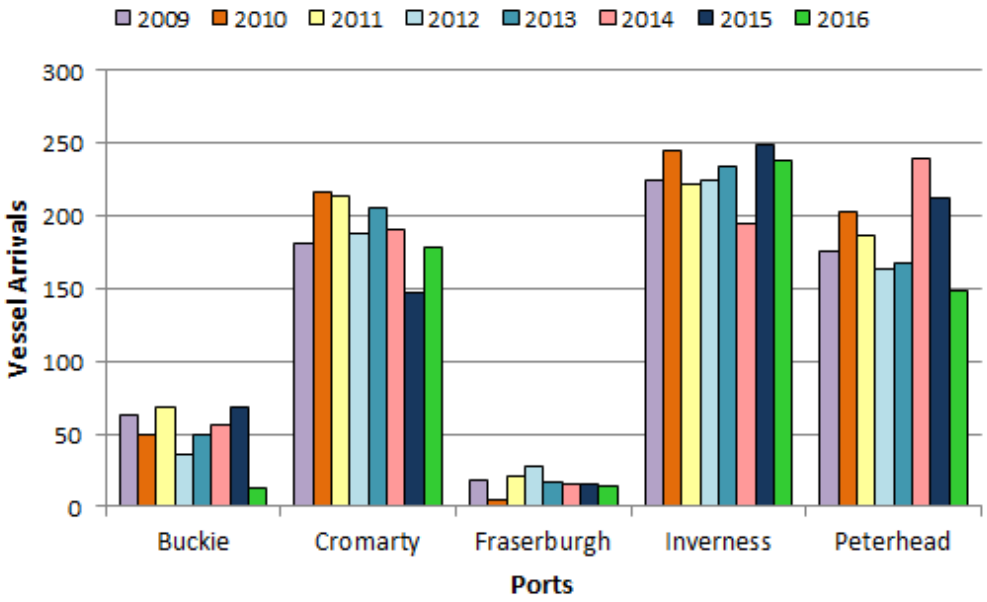


Figure 8-2 Charted and Uncharted Anchorage Areas

8.5 Ports

Major ports and harbours in the vicinity of the Development are Buckie, Cromarty (including Invergordon), Fraserburgh, Wick, Peterhead and Inverness. The number of vessel arrivals to the principal ports in the Moray Firth (Department of Transport, 2017) are presented in Graph 8-1. It should be noted that Wick harbour does not have large volumes of commercial cargo but recently has been used by BOWL for its wind farm transfer vessels, these types of movements are not reflected in the DfT Statistics. These statistics exclude some movements which occur within the port or harbour limits, however they are considered to provide a good indication of the relative traffic levels and trends.

Wick is the closest harbour to the Moray West Site and is located approximately 15 nm to the north of the Moray West Site. Buckie is the closest port to the Offshore Export Cable Corridor landfall area, approximately 5 nm west.



Graph 8-1 Vessel Arrivals to Principal Ports (2009 to 2016) (DfT, 2017)

8.6 Pilot Boarding

Pilot boarding points identified within the Moray Firth are provided in Table 8.1.

Table 8.1: Pilotage Boarding Areas

Port/Harbour	Compulsory?	Further Details
Buckie	No, but advised.	Should be requested from the Harbour Office 24 hours in advance.
Burghead	For vessels greater than 40 GT.	Vessels should arrive between two hours before and one hour after High Water (HW).
Inverness & Caledonian Canal	For vessels above 50 m in length.	Harbour Office maintains a listening watch during normal working hours, and prior to HW or when a vessel is expected outside of working hours.
Nigg	Vessels above 60 m LOA (inc fishing vessels);	Service available 24 hours a day.

Table 8.1: Pilotage Boarding Areas		
Port/Harbour	**Compulsory?**	**Further Details**
	Vessels above 20 m LOA carrying 12 or more passengers; and Vessels over 40 m LOA carrying hazardous, dangerous, or polluting goods.	
Wick	For vessels over 90 GT, excluding fishing vessels and yachts.	n/a

8.7 Ministry of Defence (MoD) Practice and Exercise Areas (PEXAs)

There are three designated firing danger areas within the Moray Firth with the nearest area located approximately 5.4 nm to the east of the Moray West Site. A note on UKHO Admiralty Charts states of the PEXAs, that *"No restrictions are placed on the right to transit the firing practice areas at any time. The firing practice areas are operated using a clear range procedure; exercises and firing only take place when the areas are considered to be clear of all shipping".*

8.8 Oil and Gas Infrastructure

Figure 8-3 presents an overview of the nearby oil and gas infrastructure in the vicinity of the Development. There are six oil & gas surface platforms located within the vicinity, five of which are located on the northern boundary of the Moray West Site (each associated with the Beatrice Oil Field). The Beatrice Oil Field is undergoing initial decommissioning at the time of writing (well plugging). These activities will comprise two months of work at Beatrice Charlie and 15 months at Beatrice Bravo, scheduled to be completed in 2018. The sixth platform is associated with the Jacky Oil Field, which is currently inactive.

Final decommissioning of the platforms is expected to begin in 2024, and be completed by 2027.

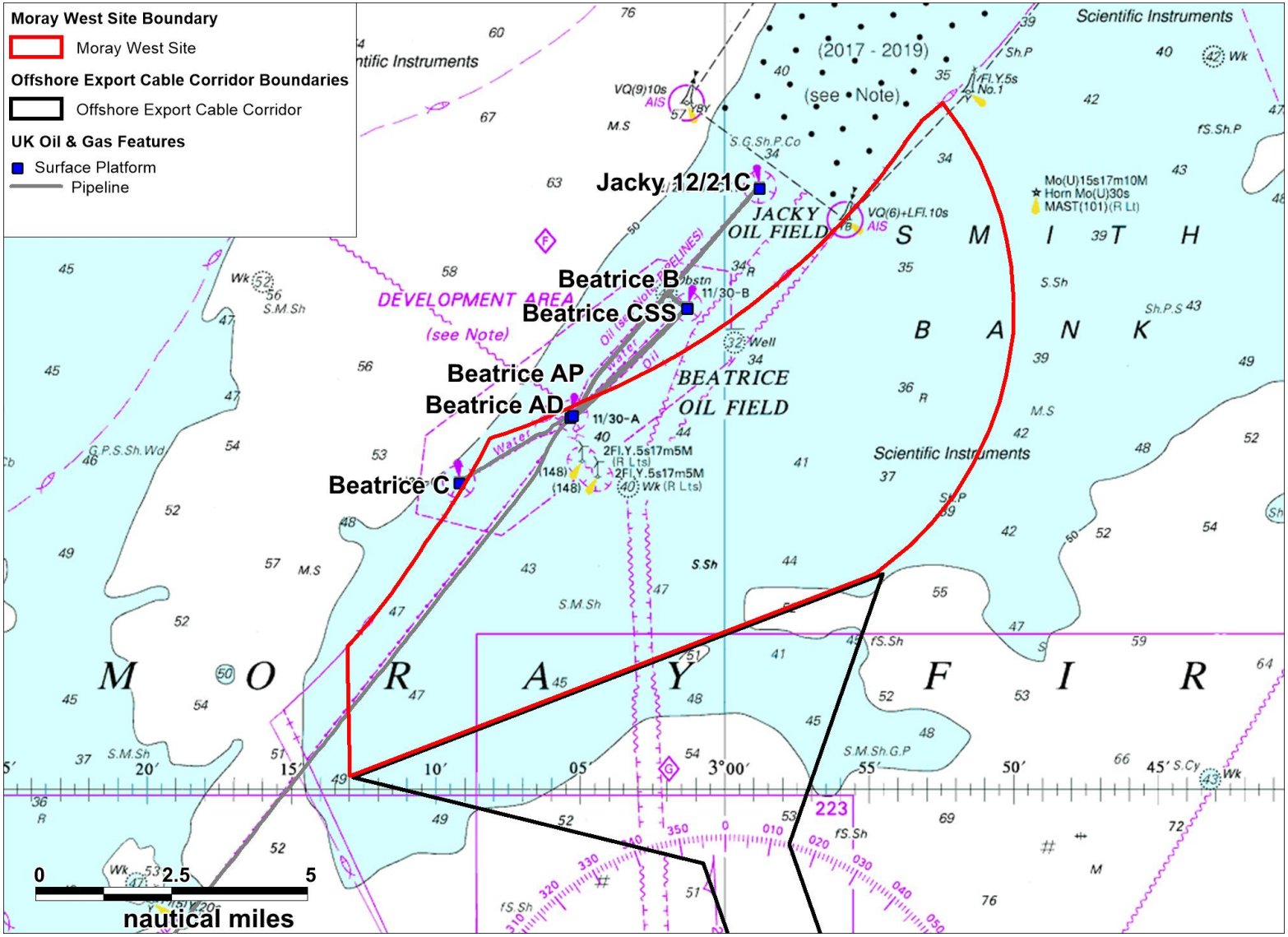


Figure 8-3 Oil and Gas Infrastructure Relative to the Moray West Site

8.9 Marine Aggregate Dredging Areas

There are no licensed marine aggregate dredging areas in proximity to the Development.

8.10 Submarine Cables

The submarine cables in the vicinity of the Development are presented in Figure 8-4.

The BOWL export cables, which are installed but not yet commissioned at the time of writing, intersect the Moray West Site and Offshore Export Cable Corridor. The Caithness Moray Transmission Link (which makes landfall alongside the BOWL cables) also crosses the offshore export cable corridor, and is expected to be commissioned by the end of 2018.

For context the Moray East offshore export cable corridor is included in Figure 8-4, however this is not considered as part of the baseline, and is instead considered cumulatively in Section 18.

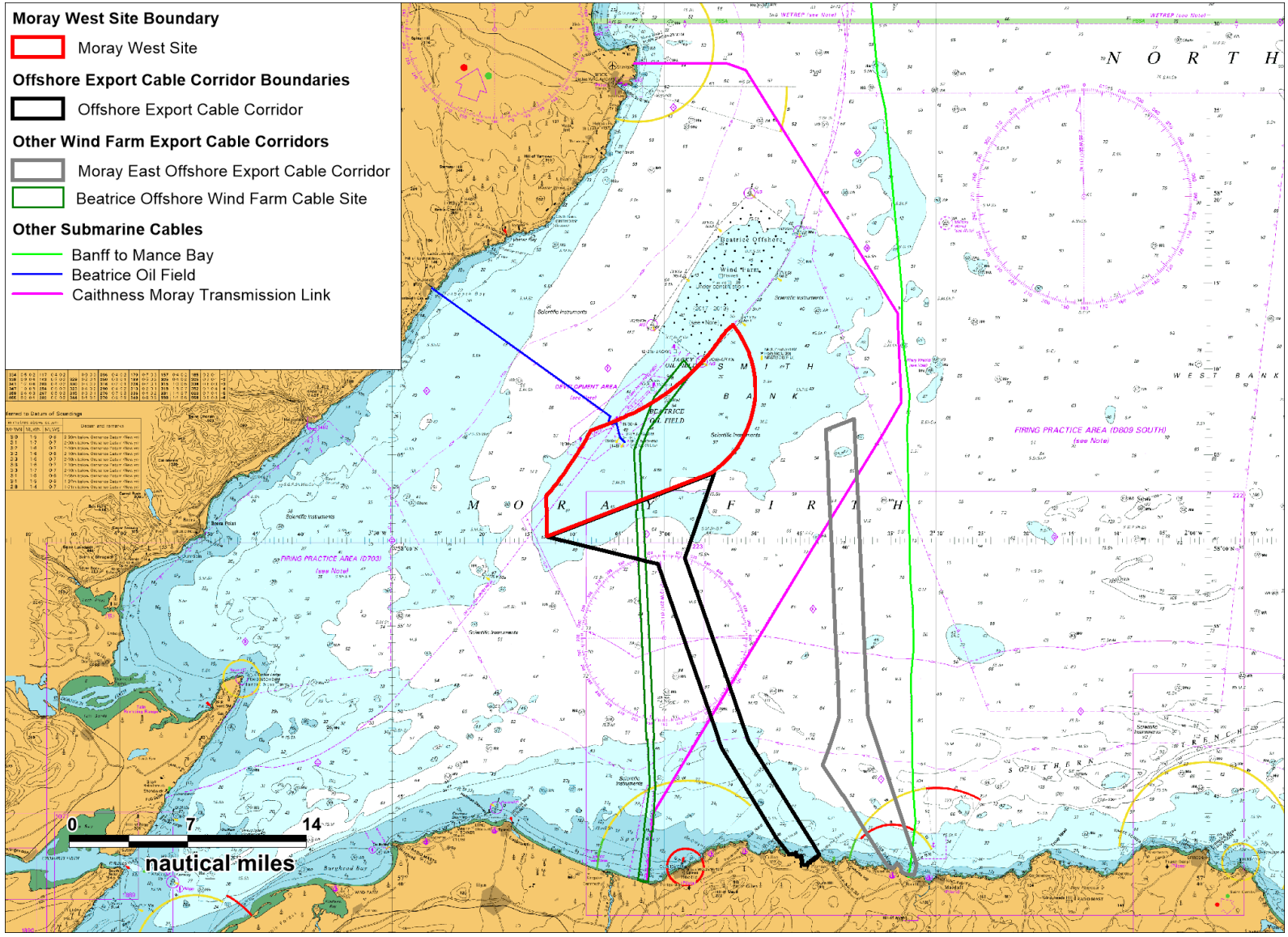


Figure 8-4 Submarine Cables Relative to the Development

8.11 Marine Environmental High Risk Areas (MEHRAs)

There are no MEHRAs in the immediate vicinity of the Development; with the nearest being Kinnaird Head MEHRA located approximately 18.9 nm east of the Offshore Export Cable Corridor, on the north east coast of Scotland. Kinnaird Head consists of a high concentration of vulnerable seabird species due to the extensive intertidal mud and sandflats with low rocky outcrops as well as a range of fishing and economic activity. No routeing measures are in place however due to passing traffic and fishing vessels leaving Fraserburgh, transiting distances should be considered.

8.12 Marine Wrecks

There are 12 charted wrecks within the offshore wind farm study area with one charted wreck within the Moray West Site itself. There is also one charted wreck within the Offshore Export Cable Corridor. There are not anticipated to be any navigational safety risks associated with these wrecks.

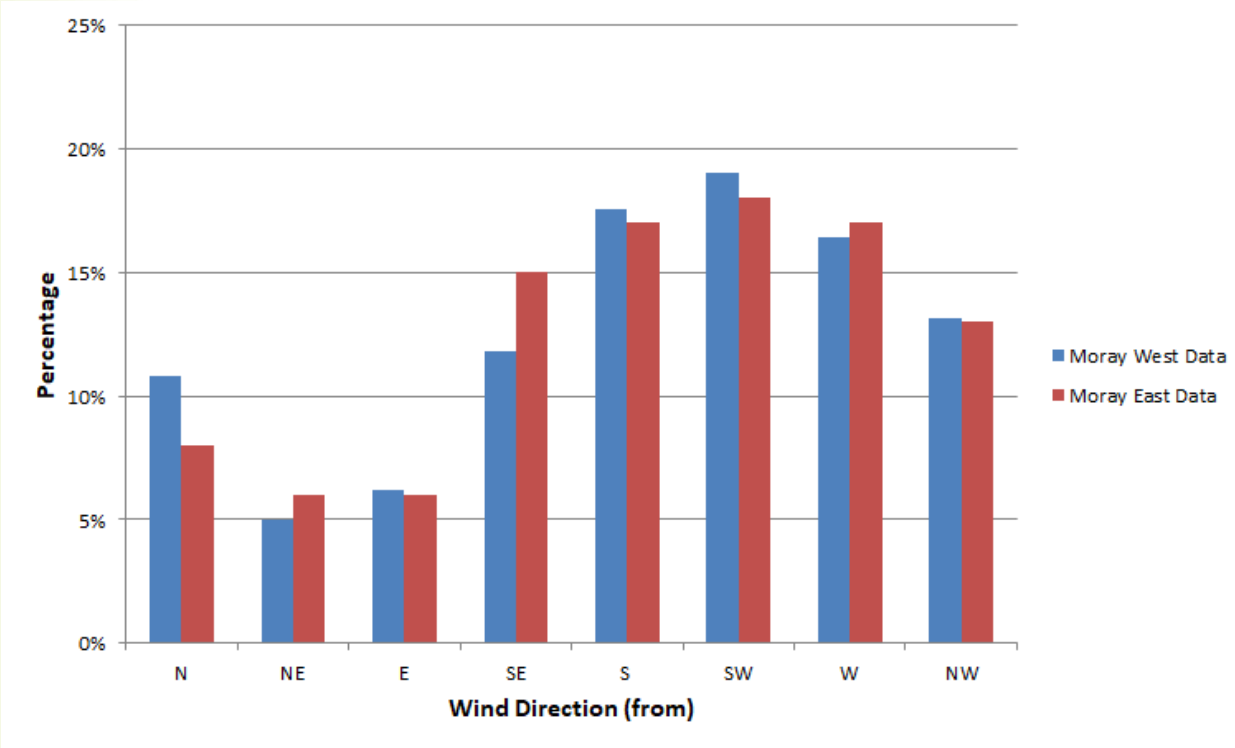
9 Metocean Data

9.1 Introduction

This section provides a summary of the available meteorological and oceanographic conditions and statistics within the Moray Firth area, relative to the Development. This is based on an assessment of in-house weather data, information provided in the Pilot Book (UKHO 2015), and a review of UKHO Admiralty charts.

9.2 Wind Direction Data

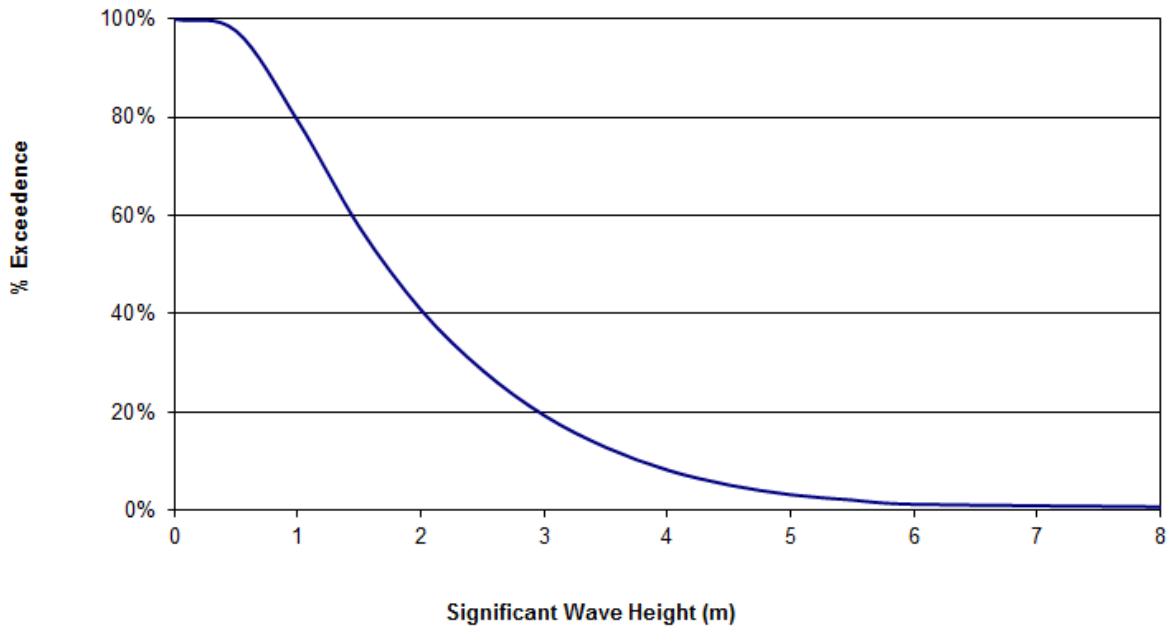
Indicative wind direction probabilities for the area are presented in Graph 9-1. The prevalent wind direction was from the southwest, which is in line with the UK average. For the purposes of validation, the corresponding wind data assessed within the NRA undertaken for the Moray East offshore wind farm is included in the figure.



Graph 9-1 Wind Direction Probabilities

9.3 Wave Height

The significant wave height exceedance curve obtained from the collected data is presented in Graph 9-2. Wave height data has been used to assess likely drift speeds within the allision modelling process, and to assess the probabilities of various seas states. It is noted that as the wave data was recorded offshore, the values ensure a conservative assessment.



Graph 9-2 Significant Wave Height

9.4 Visibility

Visibility data was available from the Pilot Book (UKHO, 2015) and from onshore weather stations located at Wick Airport and at Lossiemouth. The percentage likelihood of poor visibility derived from these sources is provided in Table 9.1. It should be noted that the definition of poor visibility varies by source, however the values are considered as providing good indication of the visibility conditions.

Table 9.1: Probability of Poor Visibility

Source		Percentage
Pilot Book (UKHO 2015) – percentage frequency	February	0-1%
	May	4-5%
	August	3-4%
	November	0-1%
Onshore Stations – average over 3 years	Lossiemouth	1%
	Wick	2%
Typical UK[7]		3%

[7] Estimated based on All Year Weather Data - Central North Sea (Forties), 1 Jan 1975 to 31 Dec 1994, Norwegian Meteorological Institute, Weather Data Recorded at the Frigg Field from Jan 1981 to Dec 1997, and Met Office Data for Sea Area 52.7-54.3° N, 001-003° E, Oct 1854 to Oct 1992.

The Pilot Book indicated the percentage of poor visibility ranged from 0 to 5%, with poor visibility most likely during May. The readings from onshore stations at Lossiemouth and Wick estimated the percentage of poor visibility to be between 1 and 2% (noting that as these are onshore readings, the likelihood of poor visibility in the vicinity of the Moray West Site is likely to be higher).

Based on the available information, the typical UK value of 3% was considered appropriate for the purposes of the modelling.

9.5 Tidal Streams

Tidal data has been taken from Admiralty Chart 115-0, which covers the Moray Firth.

10 Emergency Response

This section summaries the existing search and rescue (SAR) resources in proximity to the Development. It is noted that Moray West will be required to consider self-help capabilities for its own personnel and vessels.

10.1 Search and Rescue Helicopters

In March 2013, the Bristow Group were awarded the contract by the MCA (as an executive agency of DfT) to provide helicopter SAR operations in the UK over a ten-year period. Bristow have now been operating the service since April 2015. There are ten base locations for the SAR helicopter service. The nearest SAR helicopter base to the offshore cable corridor is the Inverness base which is approximately 47 nm from the centre of the Moray West Site and has been in operation since April 2015. This base operates two Agusta Westland AW189 aircraft.

10.2 RNLI

The RNLI is organised into six divisions, with the relevant region for the Development being the Scotland Division. Based out of more than 230 stations, there are more than 350 lifeboats across the RNLI fleet, including both all-weather lifeboats (ALBs) and inshore lifeboats (ILBs). Based on the offshore position of the Moray West Site it is likely that ALBs from Buckie would respond to an incident in proximity to the Development. Locations of RNLI lifeboat stations along the east coast of Scotland and details of the types of lifeboats operating out of these stations are given in Table 10-1. At each station, lifeboats are available on a 24-hour basis throughout the year.

Table 10.1: UK Lifeboats Operated from Northern North Sea RNLI Stations

Station	Lifeboats	ALB Class	ILB Class	Approximate Distance to Central Point Moray West Site (nm)
Buckie	ALB	Severn	-	25
Macduff	ILB	-	B Class	30
Fraserburgh	ALB	Trent	-	41
Invergordon	ALB	Trent	-	44
Kessock	ILB	-	B Class	53
Wick	ALB	Trent	-	21

10.3 Emergency Towing

In 2016, the Scottish Government awarded a new emergency towing contract to the *Levoli Black*, replacing the existing tug, the *Herakles.* The vessel primarily patrols the north and north-west Scottish coasts (including the Moray Firth area) where commercial towage is not always readily available. It should be noted that due to the wide area the vessel is responsible for, response times may vary depending on the vessel's position relative to an incident.

Emergency tug provision may also be provided by local operators via a contracted agreement between the owner of the vessel requiring emergency towage and the tug operators. A Coastguard Agreement on Salvage and Towage will be invoked when owners are either unable or unwilling to engage in a commercial tow contract. MCA will pursue costs through arbitrators on a cost recovery basis.

10.4 HM Coastguard Stations

HM Coastguard, a division of the MCA, is responsible for requesting and tasking SAR resources made available to other authorities and for coordinating the subsequent SAR operations (unless they fall within military jurisdiction).

The HM Coastguard coordinates SAR through a network of 11 Coastguard Operations Centres (CGOC), including a National Maritime Operations Centre (NMOC) based in Hampshire. A corps of over 3,500 volunteer Coastguard Rescue Officers (CROs) around the UK form over 352 local Coastguard Rescue Teams (CRT) involved in coastal rescue, searches and surveillance.

All of the MCA's operations, including SAR, are divided into three geographical regions. The Scotland and Northern Ireland Region covers the north east coast of Scotland, and therefore cover the area around the Moray West Site.

Each region is divided into four districts with its own CGOC, which coordinates the SAR response for maritime and coastal emergencies within its district boundaries. The nearest rescue coordination centre to the Development is the Aberdeen CGOC based in Aberdeen, located approximately 65 nm (120 km) from the Moray West Site.

10.5 Third Party Assistance

Companies operating offshore typically have resources of vessels, helicopters and other equipment available for normal operations that can assist with emergencies offshore. Alongside that all vessels under IMO obligations set out in the International Convention for the Safety of Life at Sea convention (SOLAS) (IMO, 1974) as amended, are required to render assistance to any person or vessel in distress if safely able to do so.

Notably, vessels associated with BOWL, and the Beatrice Oil Field complex will therefore be able to offer assistance to vessels in trouble within the area.

11 Maritime Incidents

11.1 Introduction

This section provides details of marine incidents that have occurred within the vicinity of the Development over the latest available ten year period data (between 2005 and 2014). The analysis is intended to provide an indication as to the baseline level of incidents within the general area and show the common causes and vessel types involved. Incident data has been collected and reviewed from two sources:

- The Marine Accident Investigation Branch (MAIB); and
- RNLI.

It is noted that the same incidents may be recorded by both sources.

11.2 MAIB

All UK commercial vessels are required to report accidents they are involved in to the MAIB. Non-UK vessels do not have to report unless they are in a UK port, or within 12 nm territorial waters and carrying passengers to a UK port. There are also no requirements for non-commercial recreational craft to report accidents to the MAIB.

11.2.1 Moray West Site

The MAIB recorded two incidents occurring within the offshore wind farm study area between 2005 and 2014, both detailed as “Hazardous Incidents”. The first occurred on the 24th May 2005, and involved two fishing vessels. The second was recorded as occurring on the 17th January 2010, and involved an oil & gas supply vessel. Neither incident resulted in casualties or damage based on the available information. The positions of the incidents are plotted in Figure 11-1, colour coded by vessel type. As shown in the figure, neither incident occurred within the Moray West Site boundary.

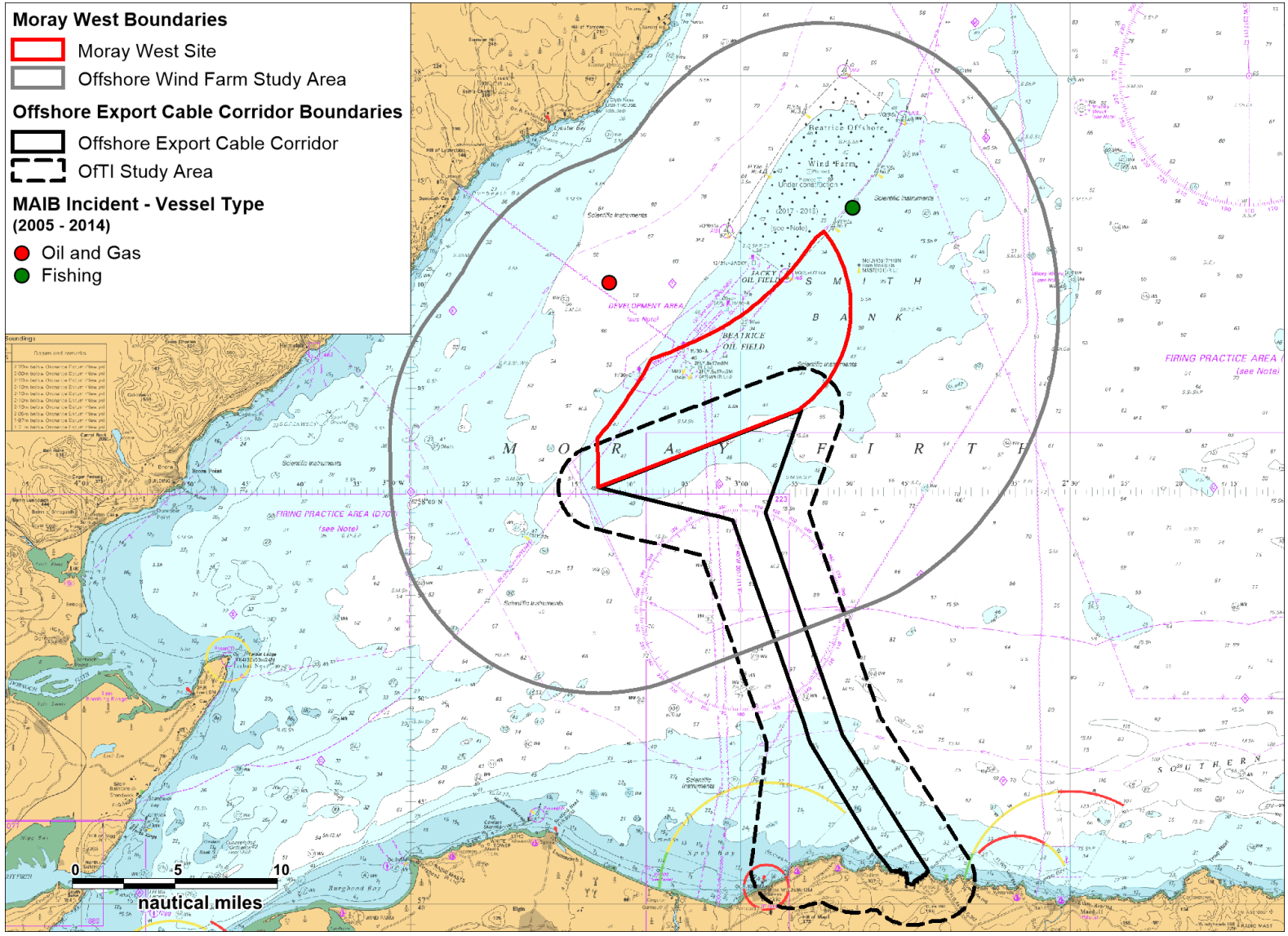


Figure 11-1 MAIB Incident Data (2005 to 2014) – Moray West Site

11.2.2 Offshore Export Cable Corridor

Between 2005 and 2014, a total of 17 incidents were recorded by the MAIB as occurring within the OfTI study area, as shown in Figure 11-2. Of the 17, four were recorded within the Offshore Export Cable Corridor (two “Hazardous Incidents”, and two “Machinery Failures”). The majority of incidents occurred coastally (15 of the 17 were within 3 nm of the coast), with two incidents (both classed as “Accident to Person” incidents) occurring within a port or harbour area. The majority of incidents (14 of the 17) involved a fishing vessel, with the remaining three involving small commercial vessels.

It is noted that the MAIB group certain port incidents geographically. Three incidents occurring at Buckie were grouped in this way, and therefore two of these incidents are not visible in the figure (an accident to person, and a machinery failure).

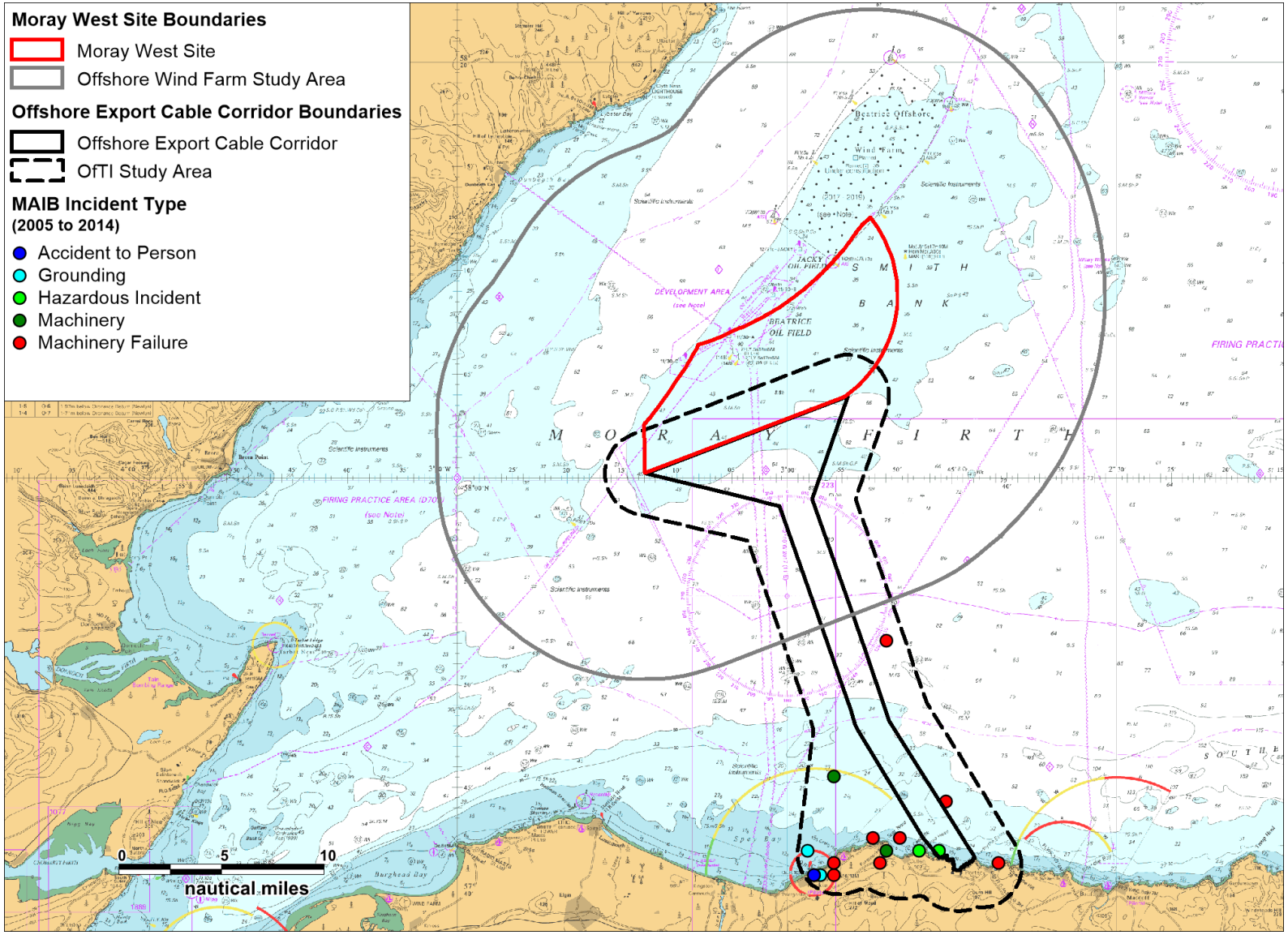


Figure 11-2 MAIB Incident Data (2005 to 2014) – Offshore Export Cable Corridor

11.3 RNLI

Data on RNLI lifeboat responses within the offshore wind farm and OfTI study areas for the ten year period between 2005 and 2014 were analysed, with cases of a hoax or false alarm excluded. The results are presented below. It should be noted that this analysis only includes incidents to which the RNLI were alerted of, and subsequently responded to.

11.3.1 Moray West Site

A total of 15 lifeboat responses to 13 incidents were recorded by the RNLI between 2005 and 2014 within the offshore wind farm study area surrounding the Moray West Site, as shown in Figure 11-3. No incidents were recorded within the Moray West Site itself. Lifeboats were most often sent from either Wick or Buckie, however lifeboats responses from Invergordon and Macduff were also noted (see Section 10.2 for details of RNLI resources within the area).

The RNLI incidents colour-coded by casualty type are presented in Figure 11-4.

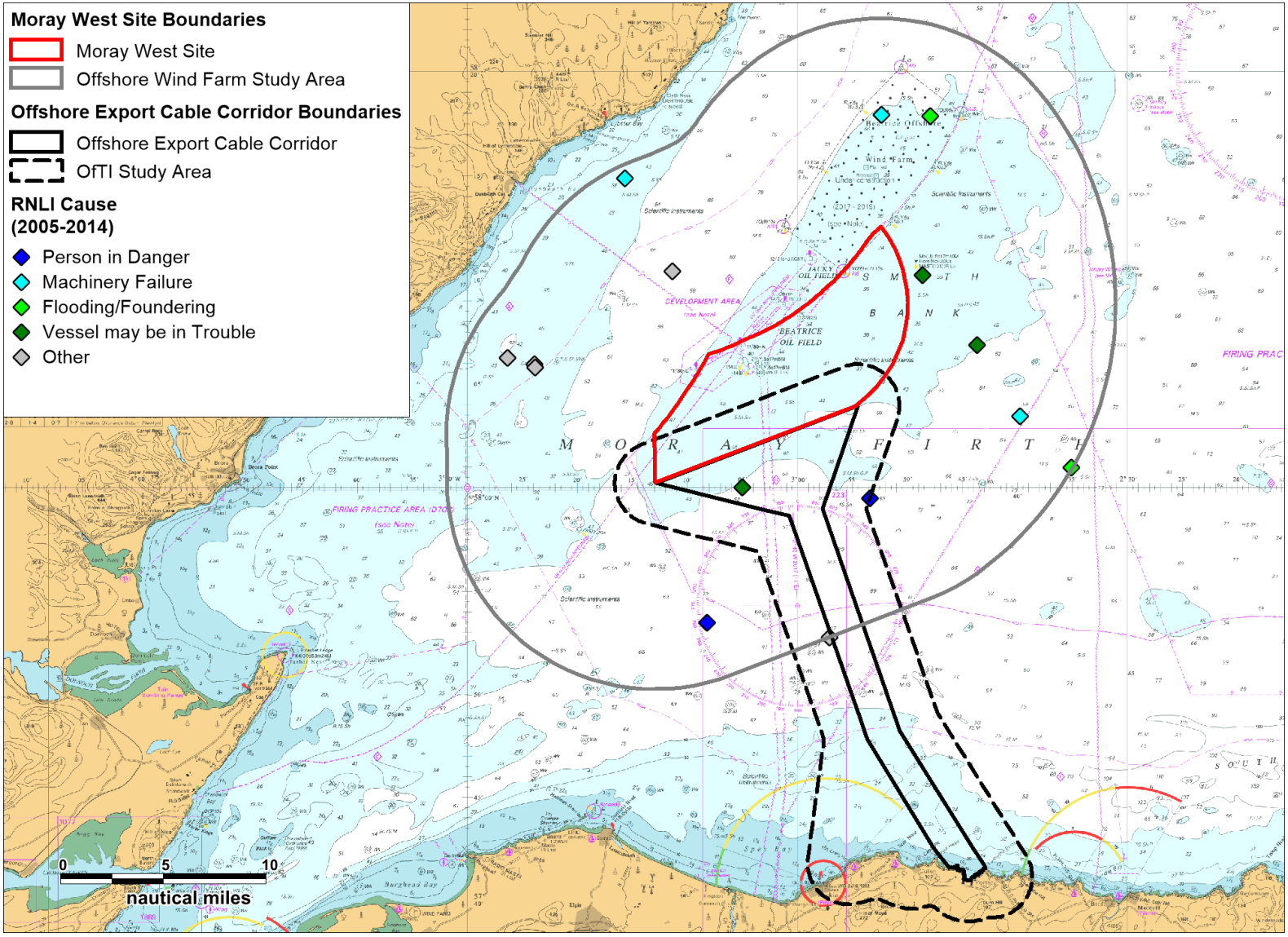


Figure 11-3 RNLI Incident Data by Cause (2005 to 2014) – Moray West Site

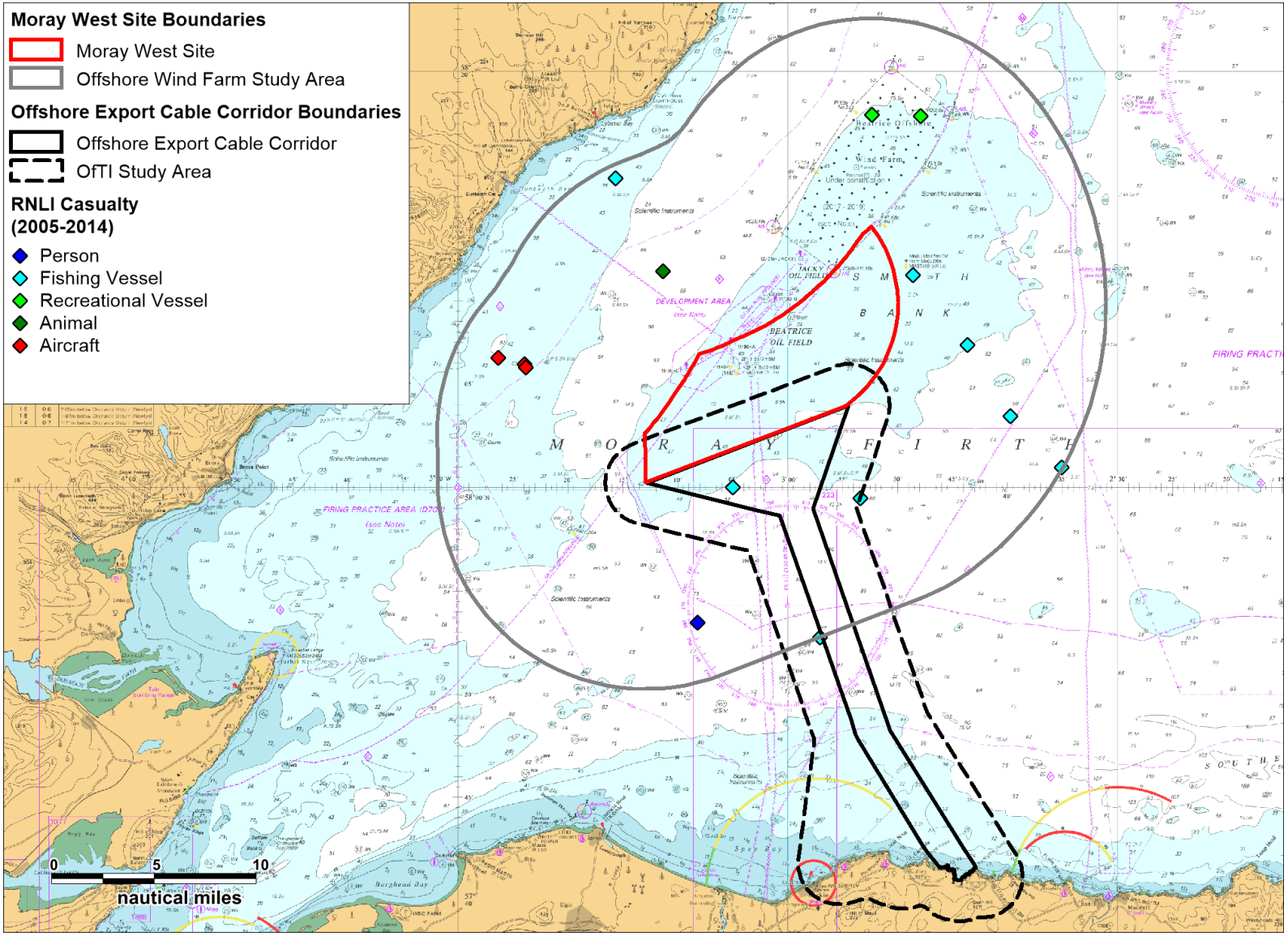


Figure 11-4 RNLI Incident Data by Casualty (2005 to 2014) – Moray West Site

11.3.2 Offshore Export Cable Corridor

A total of 90 incidents were recorded within the OfTI study area between 2005 and 2014 by the RNLI, with 40 occurring within the offshore export cable corridor itself. The majority of incidents occurred coastally, with 92% of incidents recorded as being within 2 nm of the coastline. The positions of incidents colour-coded by cause are presented in Figure 11-5. A corresponding plot of incidents by casualty is presented in Figure 11-6.

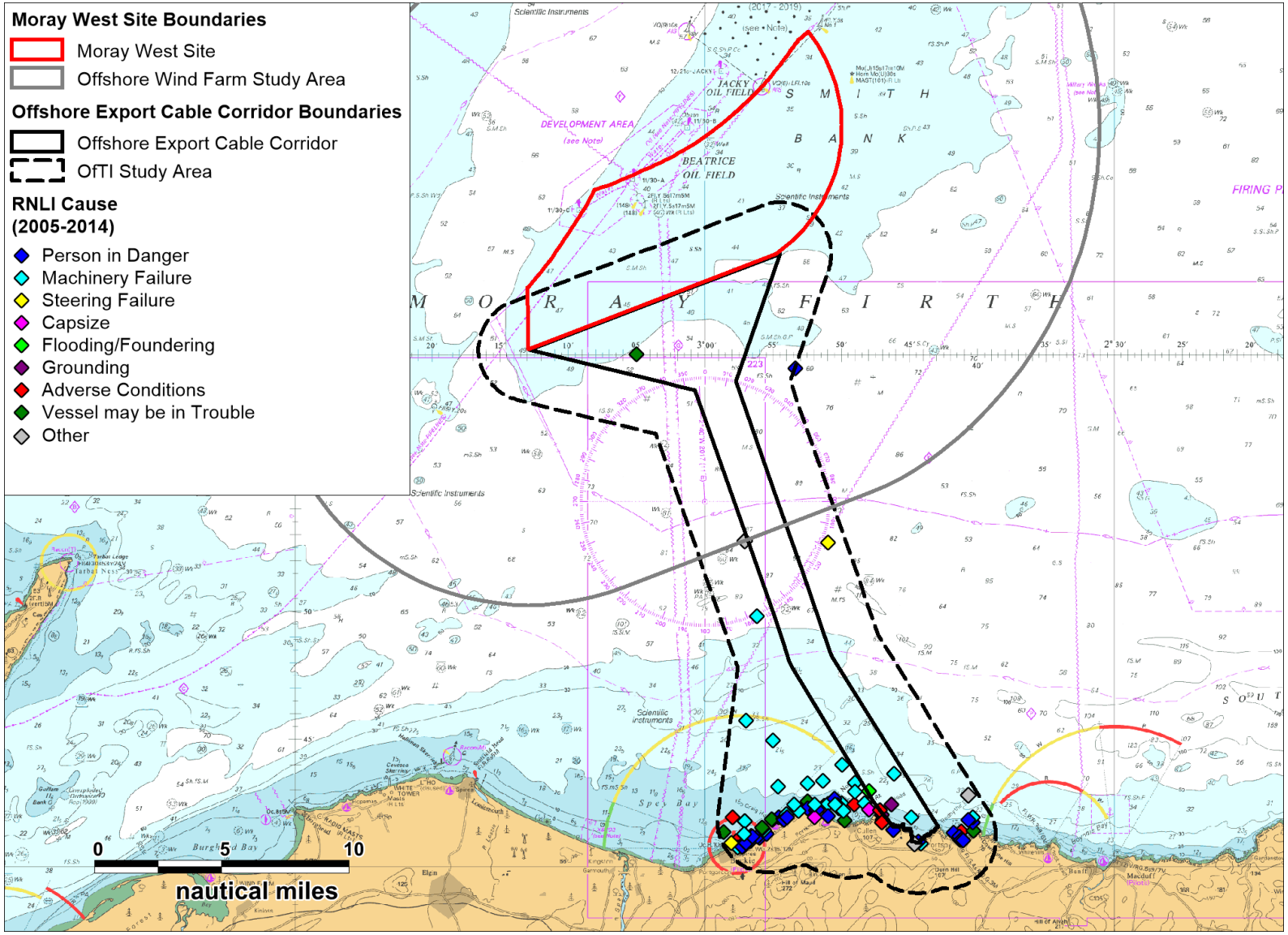


Figure 11-5 RNLI Incident Data by Cause (2005 to 2014) – Offshore Export Cable Corridor

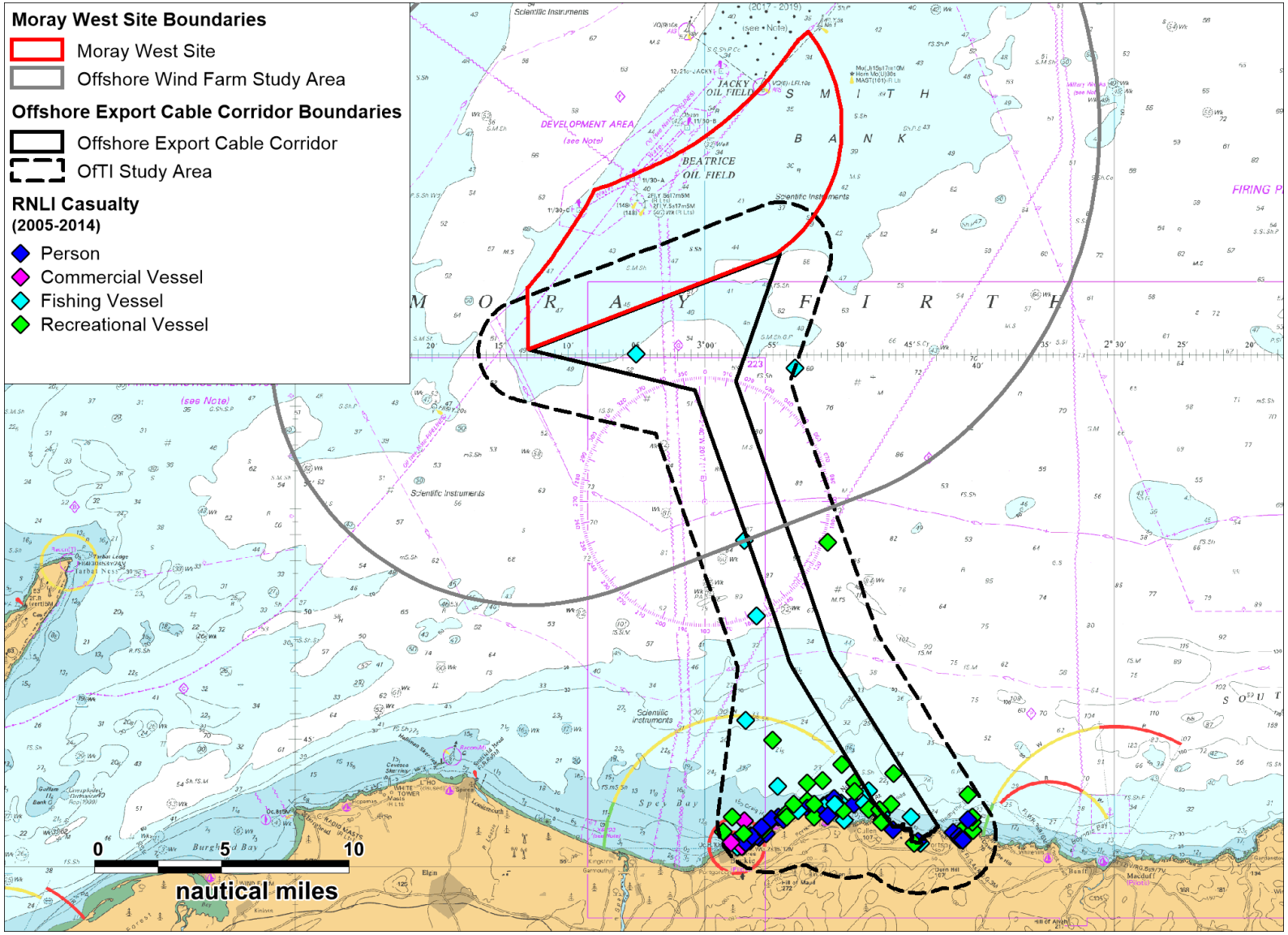


Figure 11-6 RNLI Incident Data by Casualty (2005 to 2014) – Offshore Export Cable Corridor

12 Marine Traffic Survey

12.1 Introduction

This section presents shipping data in relation to the Development.

The summer survey was undertaken by a survey vessel, which recorded traffic via AIS, radar, and visual observations. Additionally, shored-based AIS data was utilised during a winter period to account for seasonal variations. This approach was agreed with the MCA and NLB (see Section 5).

The analysis periods are as follows:

- 4th November to 22nd December 2016 (winter period at Moray West Site); and
- 15th August to 13th September 2017 (summer period at Moray West Site).

Throughout both periods, the majority of vessels were recorded via AIS. AIS is now fitted on all commercial vessels operating in UK waters over 300 Gross Register Tonnage (GRT) engaged on international voyages, over 500 GRT on domestic voyages, passenger vessels irrespective of size built on or after 1st July 2002 and fishing vessels over 15 m. During the summer survey period, vessels not broadcasting via AIS were captured by Radar and visual observation wherever possible.

The winter survey utilised shore-based AIS data collected over 28 days while the summer survey was carried out by the *Horizon Geobay* survey vessel. The summer data was combined with shored-based AIS data to ensure comprehensive coverage of the offshore wind farm and OfTI study areas, with the final summer data set consisting of 25 full days of AIS and Radar data within a 30 day survey period.

12.2 Moray West Site

A plot of all the survey vessel tracks recorded within the offshore wind farm study area during the 25 full days of survey recorded between the 15th August and the 13th September 2017 (summer) colour-coded by vessel type, is presented in Figure 12-1. A plot of all the tracks recorded within the offshore wind farm study area during the further 28 day survey between the 4th November and the 22nd December 2016 (winter) is presented in Figure 12-2.

These figures include tracks for the survey vessel *Horizon Geobay* as well as offshore support vessels operating at nearby installations such as those at the Beatrice Oil Field and wind farm related vessels associated with construction of the BOWL project.

A number of tracks recorded during the summer and winter surveys were classified as temporary (non-routine), such as the tracks of the survey vessel and traffic associated with BOWL. These have therefore been excluded from further analysis. Oil and gas affiliated vessels supporting the decommissioning of Beatrice Oil Field as well as permanent installations were retained in the analysis, based on the results of the consultation process (see Section 5).

Plots of vessel tracks recorded during each respective survey period, colour-coded by vessel type and excluding temporary traffic (as defined above), are presented in Figure 12-3 and Figure 12-4 respectively, with corresponding density grids then presented in Figure 12-5 and Figure 12-6.

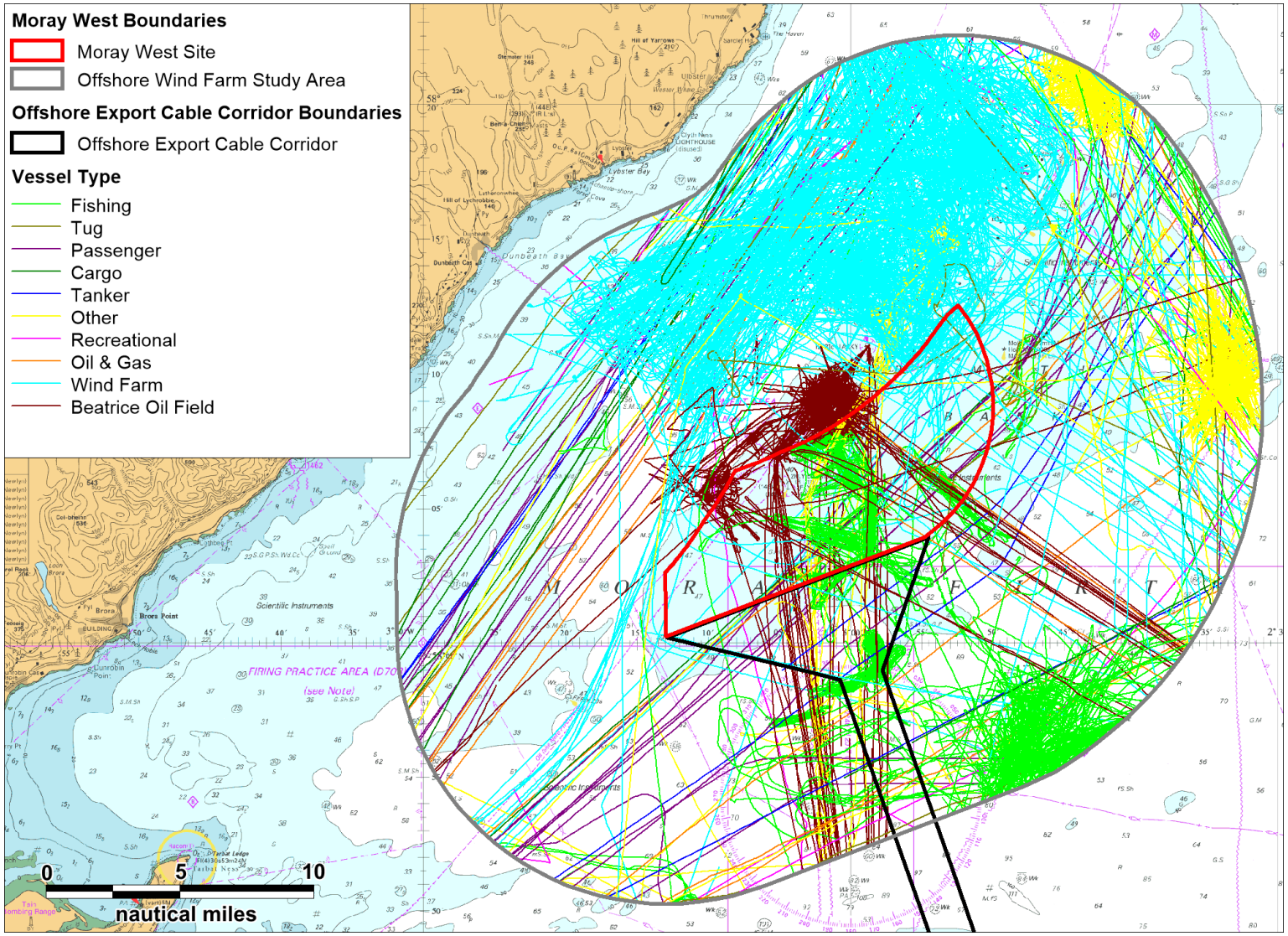


Figure 12-1 AIS, Visual and Radar Data within Offshore Wind Farm Study Area (25 Days Summer 2017)

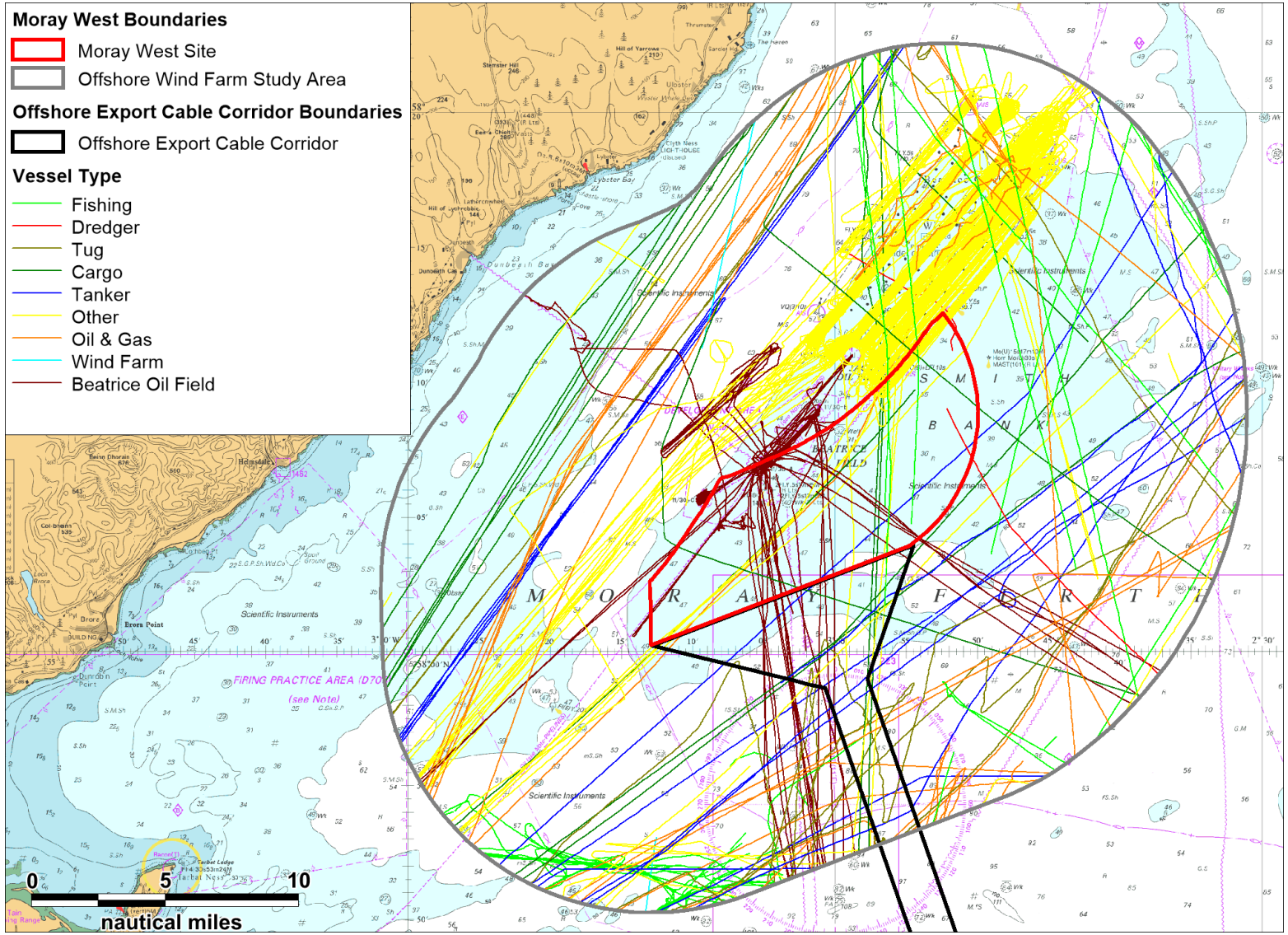


Figure 12-2 AIS Data within Offshore Wind Farm Study Area (28 Days Winter 2016)

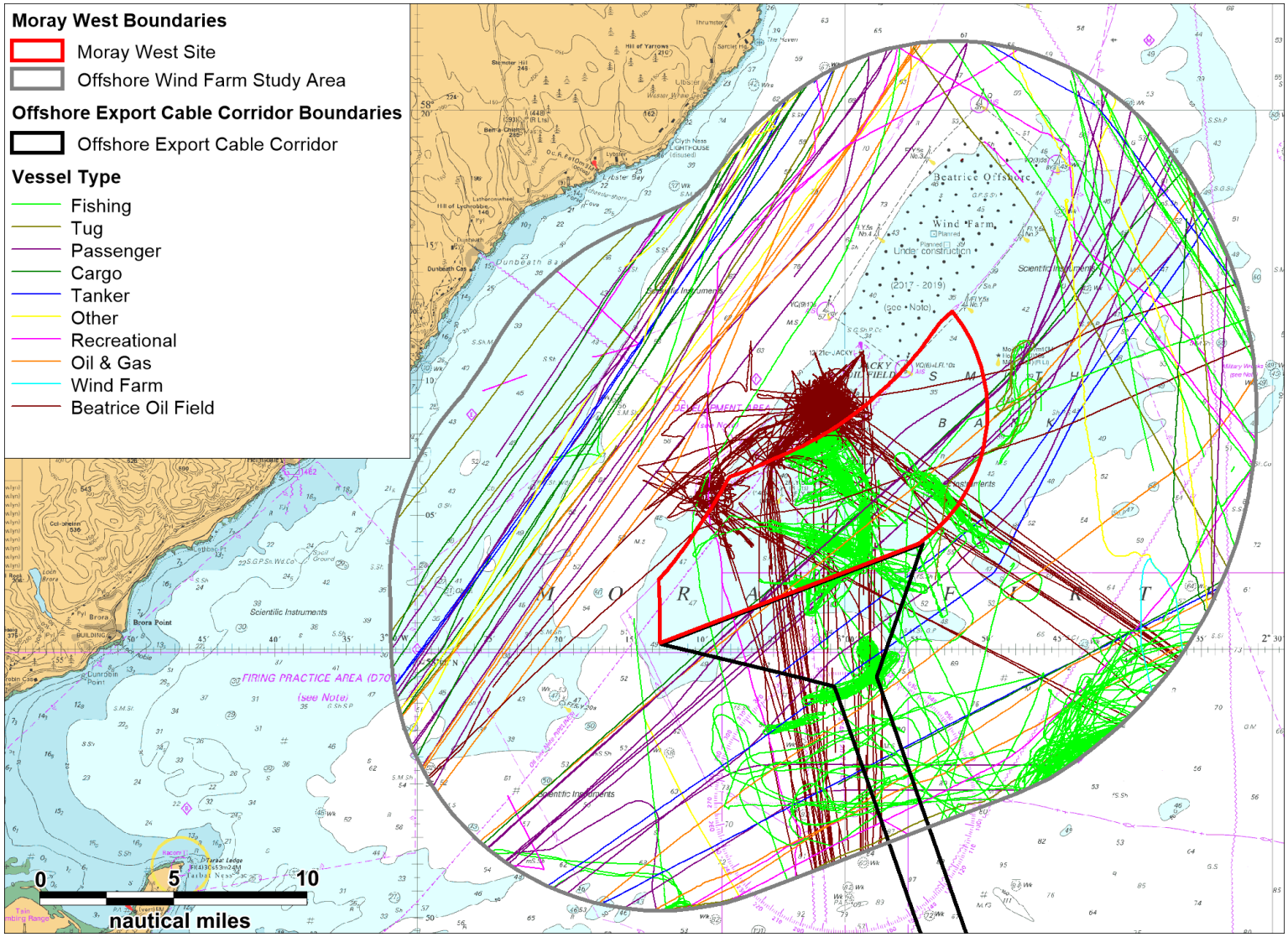


Figure 12-3 **AIS, Visual and Radar Data within the Offshore Wind Farm Study Area Excluding Temporary Traffic (25 Days Summer 2017)**

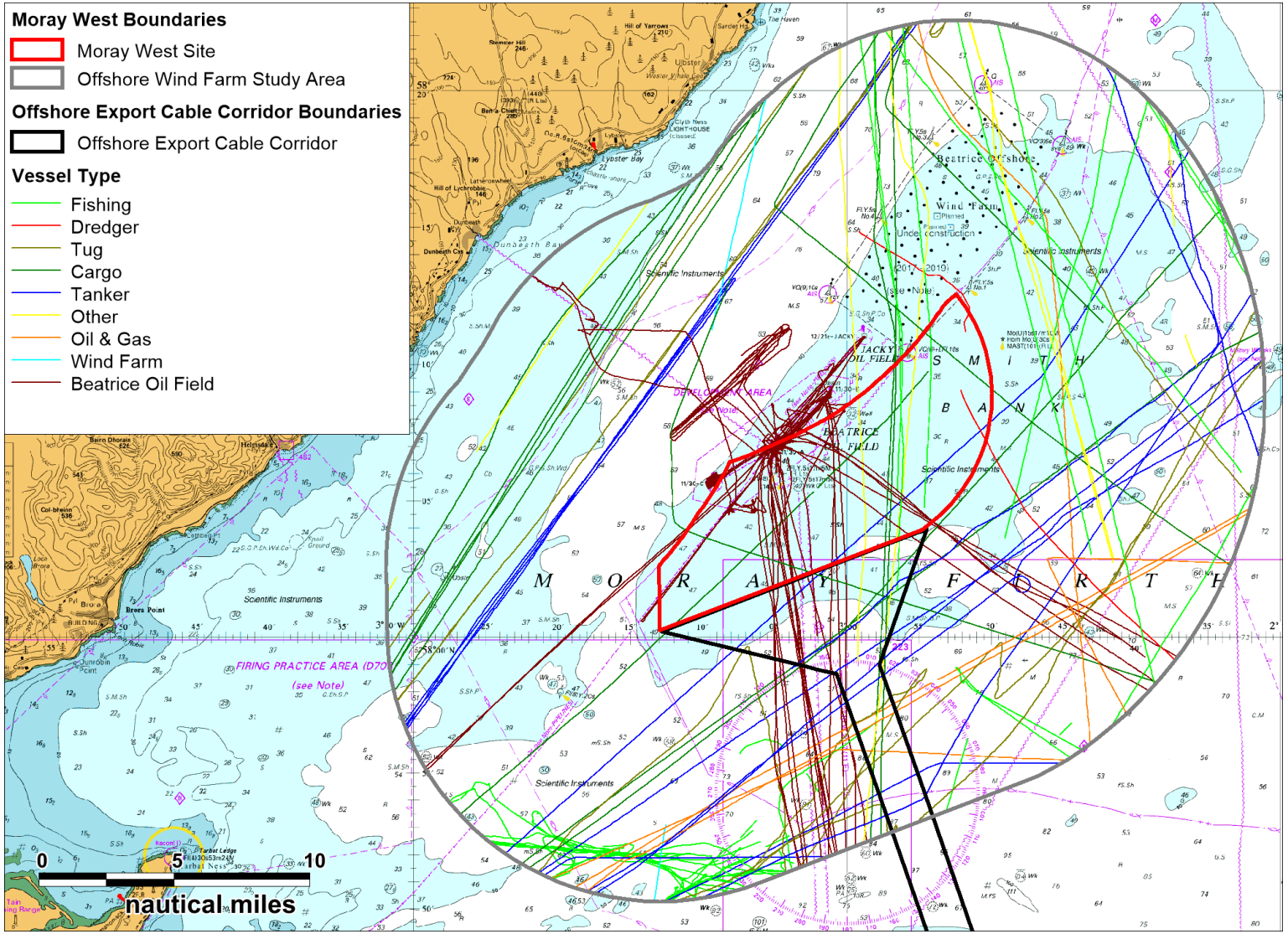


Figure 12-4 AIS Data within the Offshore Wind Farm Study Area Excluding Temporary Traffic (28 Days Winter 2016)

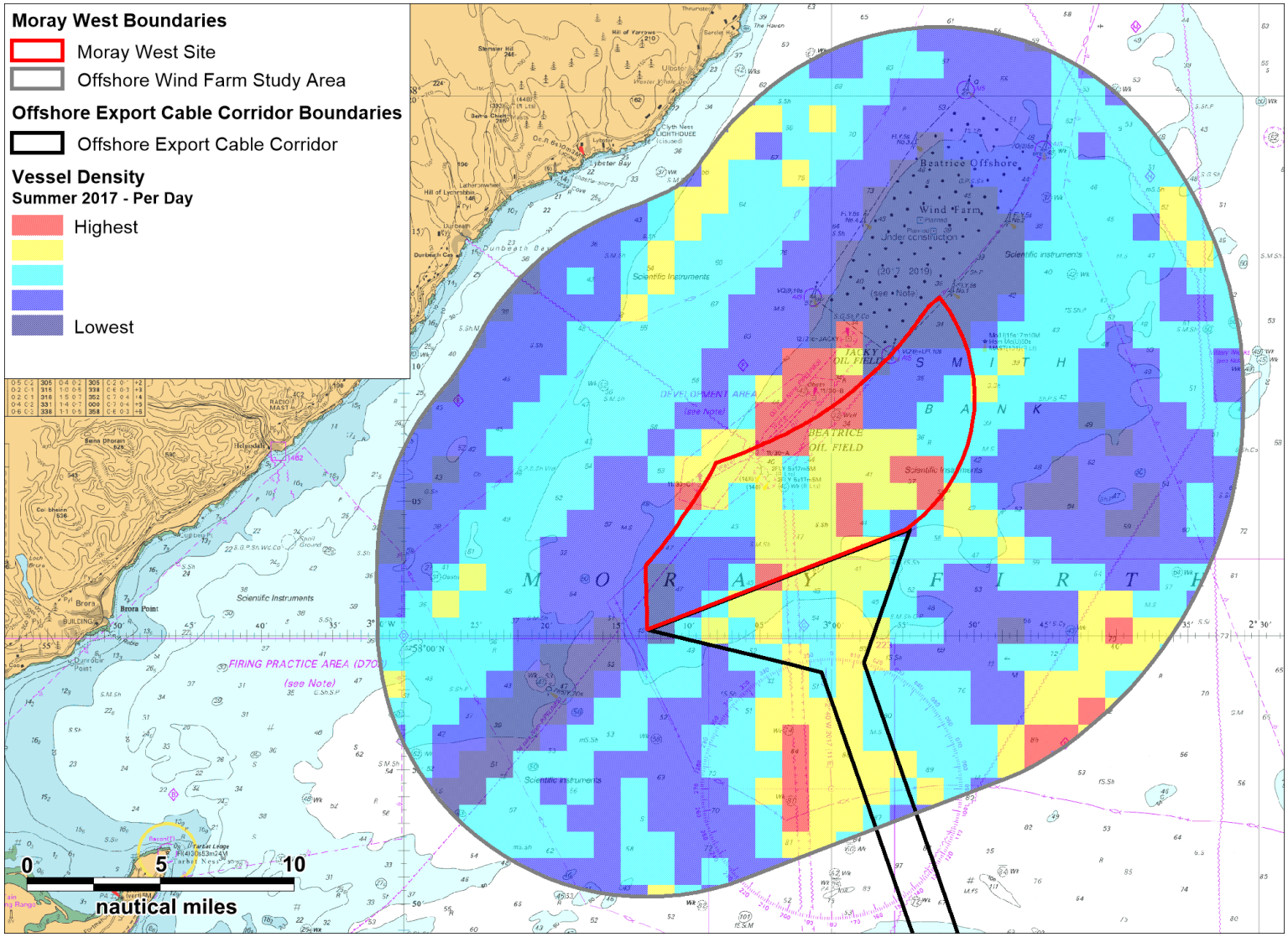


Figure 12-5 **Vessel Density from AIS, Visual and Radar within the Offshore Wind Farm Study Area Excluding Temporary Tracks (25 Days Summer 2017)**

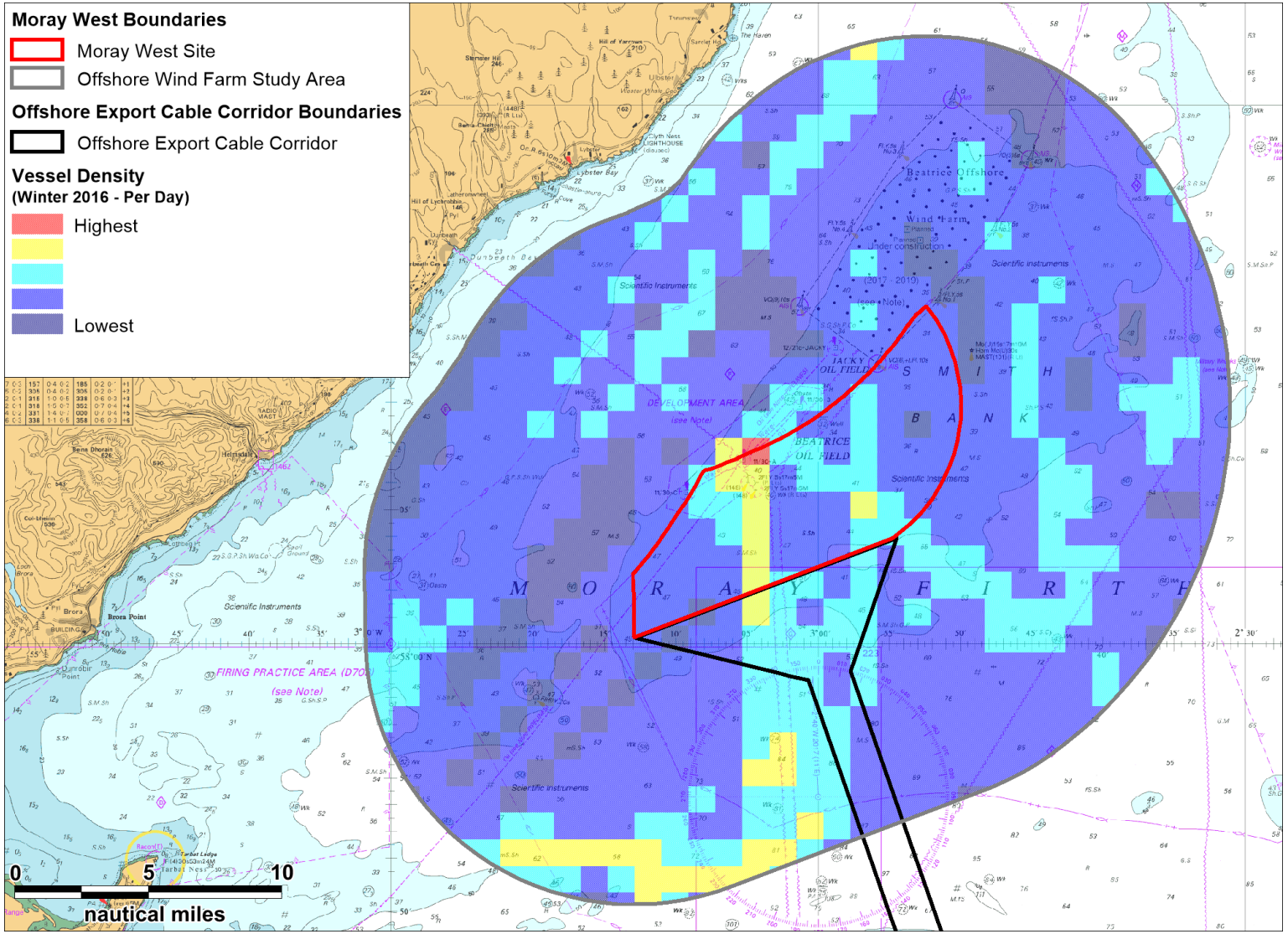


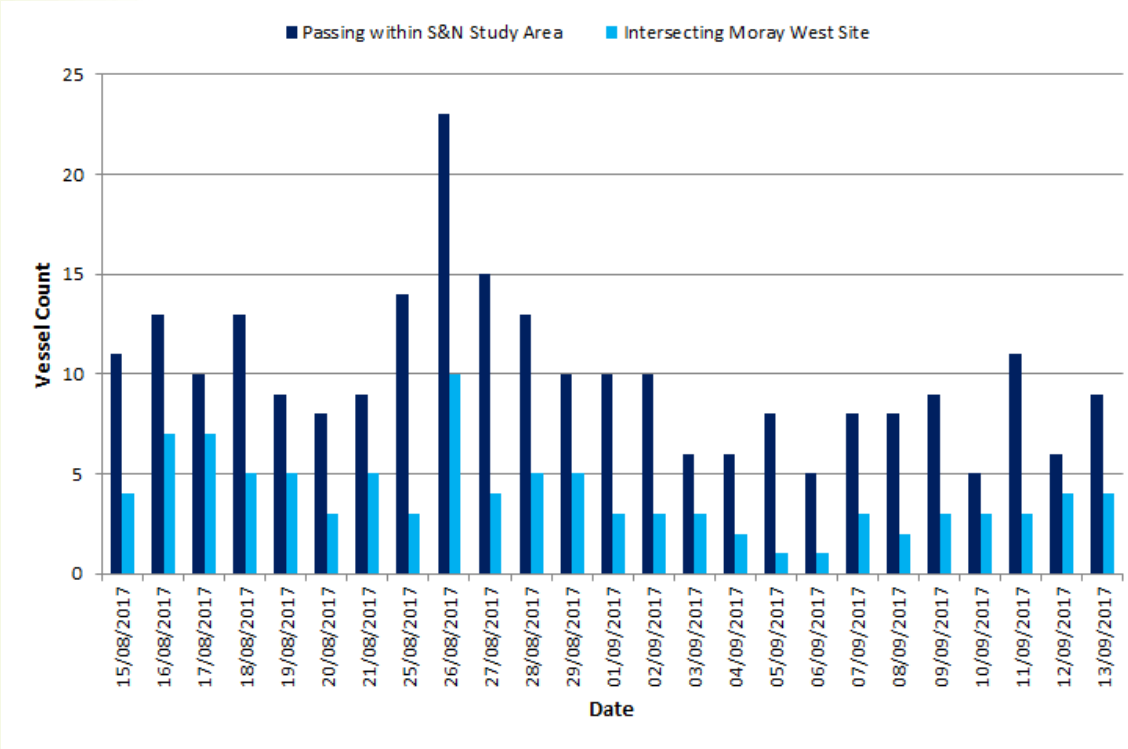
Figure 12-6 **Vessel Density from AIS within the Offshore Wind Farm Study Area Excluding Temporary Tracks (28 Days Winter 2016)**

12.2.1 Vessel Counts

For the 25 days analysed in summer 2017, there were an average of ten unique vessels per day passing within the offshore wind farm study area, recorded on AIS, visual and radar. In terms of vessels intersecting the Moray West Site, there was an average of four unique vessels per day.

Graph 12-1 illustrates the daily number of unique vessels passing through the offshore wind farm study area and intersecting the Moray West Site during summer 2017. The busiest day recorded throughout the survey period was 26th August 2017 when 23 unique vessels were recorded within the offshore wind farm study area. The quietest days recorded throughout the survey period were the 6th September and 10th September 2017 when five unique vessels were recorded within offshore wind farm study area.

Throughout the summer survey period approximately 32% of traffic recorded within the offshore wind farm study area also intersected the Moray West Site. This activity was largely from fishing vessels, and from vessels associated with the Beatrice Oil Field complex.

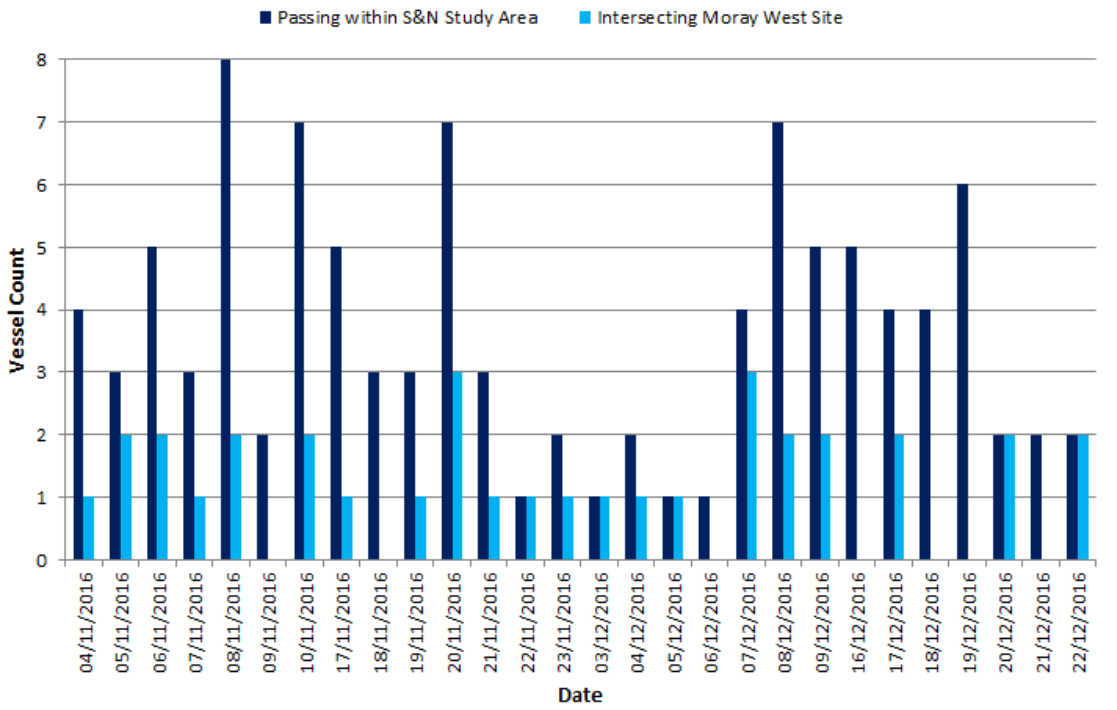


Graph 12-1 Unique Vessels per Day within the Offshore Wind Farm Study Area during 25 Days Summer 2017 (AIS, Visual and Radar)

For the 28 days analysed in winter 2016, there was an average of four unique vessels per day passing within the offshore wind farm study area, recorded on AIS. In terms of vessels intersecting the Moray West Site, there was an average of two unique vessels per day.

Graph 12-2 illustrates the daily number of unique vessels passing through the offshore wind farm study area and intersecting the Moray West Site itself during the winter survey period in 2016. The busiest day recorded throughout the survey period was the 8th November when eight unique vessels were recorded within the offshore wind farm study area.

The quietest days recorded throughout the survey period were the 22nd November, 3rd December, 5th December and 6th December 2016 when just one unique vessel was recorded within the offshore wind farm study area. Throughout the winter survey period approximately 33% of traffic recorded within the offshore wind farm study area intersected the Moray West Site.

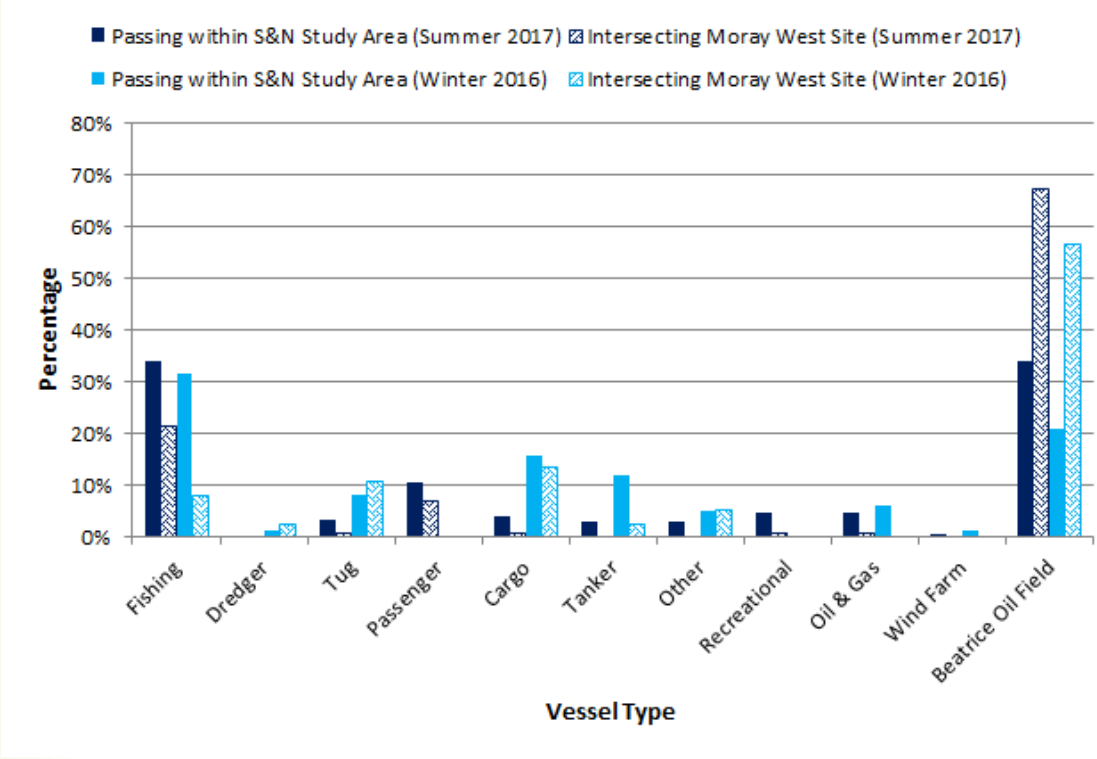


Graph 12-2 Unique Vessels per Day within the Offshore Wind Farm Study Area during 28 Days Winter 2016 (AIS)

12.2.2 Vessel Types

Analyses of the vessel types recorded passing within the offshore wind farm study area and intersecting the Moray West Site throughout both survey periods are presented in Graph 12-3. The category of "other" vessels includes those that are not large enough in quantities (i.e. less than 5%) to mention on their own. This includes dive support vessel, RNLI lifeboats, a buoy-laying vessel, a fishing feed vessel, a utility vessel and two training vessels.

Throughout the summer period, the majority of tracks were fishing vessels (34%) and Beatrice oil field vessels (34%), with the majority of vessels within the Moray West Site itself being Beatrice oil field vessels (67%). Throughout the winter period the majority of tracks were fishing vessels (31%) and Beatrice oil field vessels (21%), with the majority of vessels within the Moray West Site itself being Beatrice oil field vessels (57%). It should be noted that the cargo vessel category includes commercial ferries (Northlink Ferries) operating on route to winter maintenance periods within the Moray Firth, which generally broadcast their vessel types on AIS as cargo.



Graph 12-3 Distribution of Vessel Types within the Offshore Wind Farm Study Area during 53 Days Summer 2017 and Winter 2016 (AIS, Visual and Radar)

Figure 12-7 presents a plot of cargo vessels, including Ro-Ro cargo vessels, recorded within the offshore wind farm study area on AIS, visual and Radar during both the summer and winter survey periods. Equivalent plots of tankers and oil & gas affiliated vessels are presented in Figure 12-8 and Figure 12-9 respectively.

Throughout the combined summer and winter period, an average of one unique cargo vessel every three days passed within the offshore wind farm study area.

Regular cargo vessels operating in the vicinity of the offshore wind farm study area include Northlink Ferries Ro-Ro cargo vessels operating routes between Orkney (UK) and Aberdeen (UK). Two Ro-Ro cargo vessels were recorded during the winter survey period (18% of total cargo traffic) while no Ro-Ro cargo vessels were recorded during the summer survey period. Throughout the combined summer and winter survey period, an average of one unique tanker every four days passed within the offshore wind farm study area.

Tankers recorded throughout the combined survey period were transiting towards Moray Firth ports (Cromarty, Nigg, Invergordon, Scrabster and Macduff), other UK ports (Wick, Lerwick, Immingham and Dunbar). Other destinations included Glen Lyon and Foinaven Floating Production Storage and Offloading vessels, Vedde (Denmark) and the United States (US).

Throughout the combined summer and winter survey period, an average of one unique oil & gas affiliated vessel every four days passed within the offshore wind farm study area. These vessels were either on passage to / from offshore oil & gas installations outside of the offshore wind farm study area or transiting to UK ports (Peterhead, Invergordon and Nigg). The 93 m offshore supply vessel *Caledonian Victory* was recorded transiting north through the study area towards Orkney for shelter on the 9th December 2016.

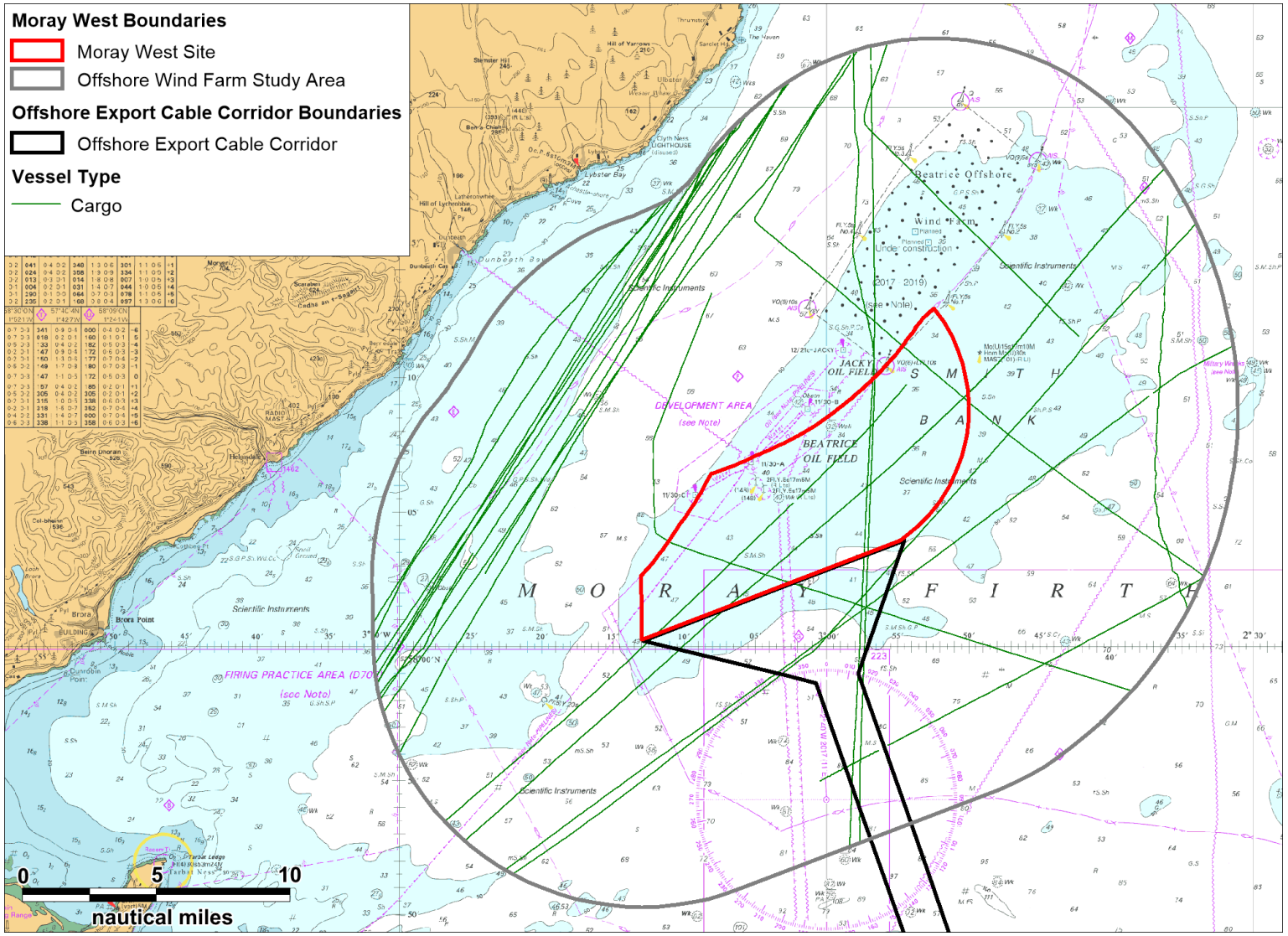


Figure 12-7 **AIS, visual and Radar Cargo Vessels within the Offshore Wind Farm Study Area (53 Days Summer 2017 and Winter 2016)**

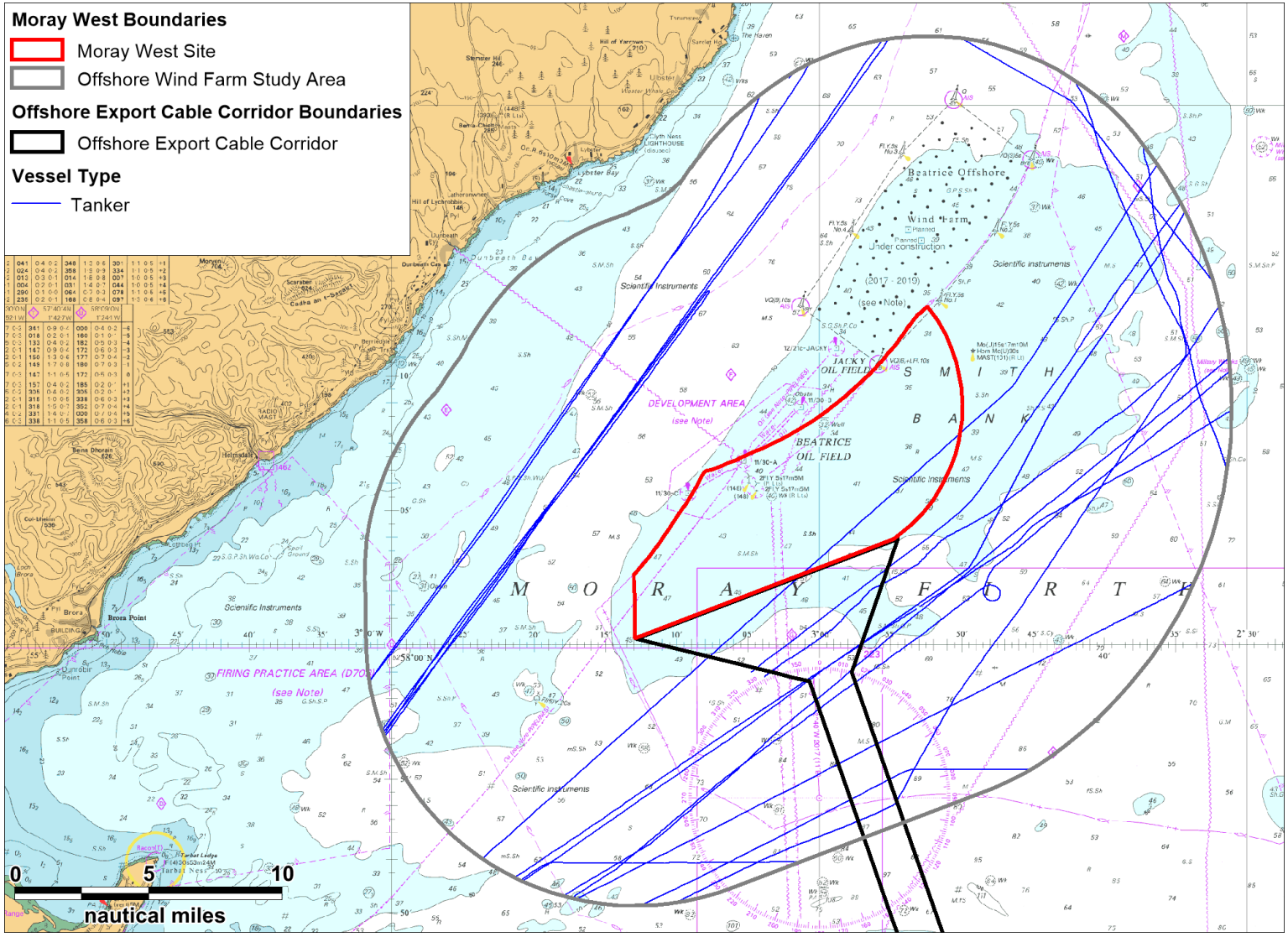


Figure 12-8 AIS, visual and Radar Tankers within the Offshore Wind Farm Study Area (53 Days Summer 2017 and Winter 2016)

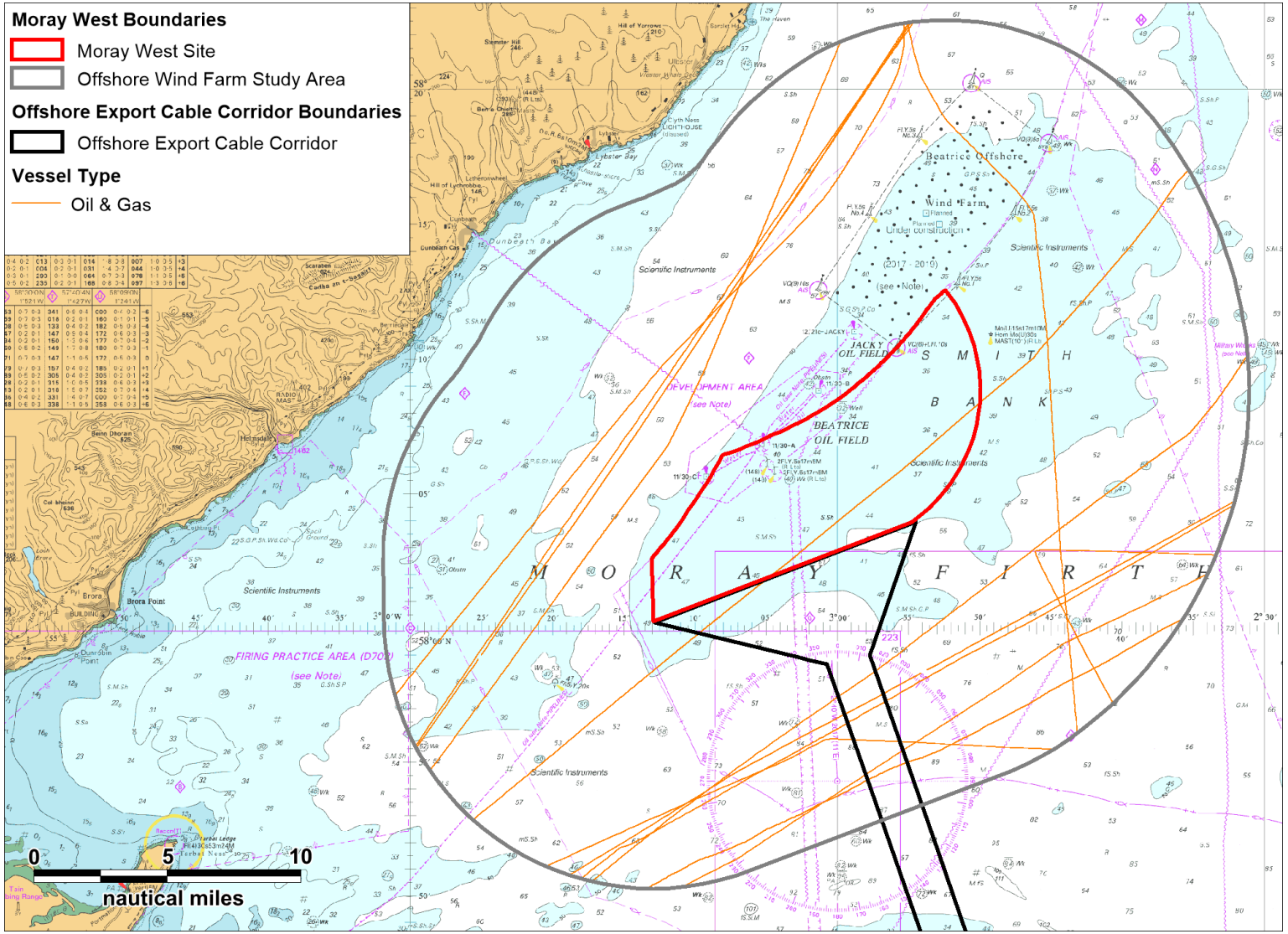


Figure 12-9 AIS, visual and Radar Oil & Gas Vessels within the Offshore Wind Farm Study Area (53 Days Summer 2017 and Winter 2016)

12.2.3 Vessel Size Distribution

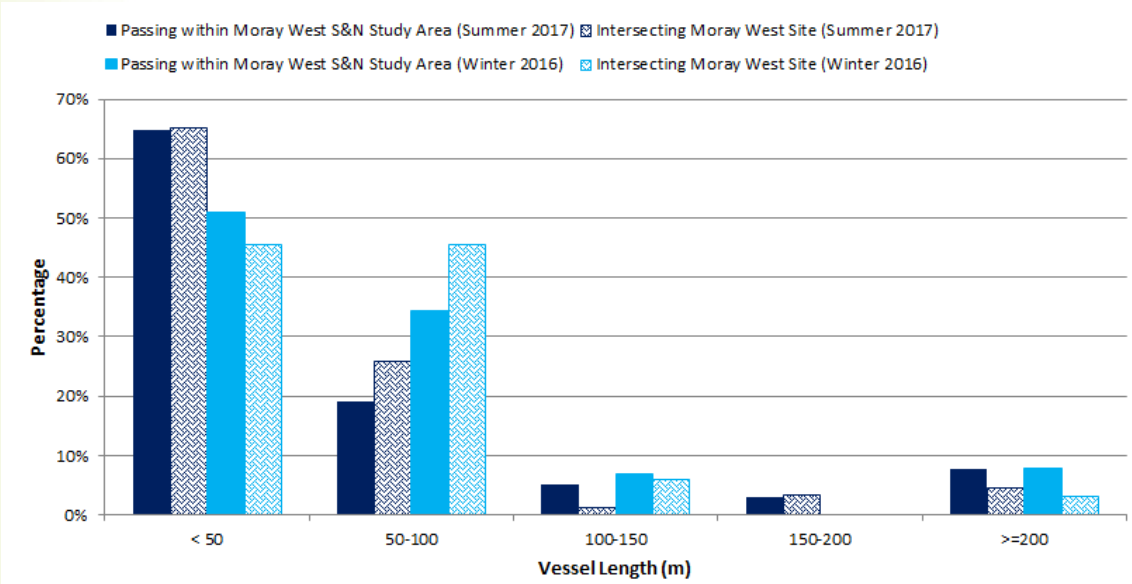
12.2.3.1 Vessel Length

Vessel length overall (LOA) recorded throughout the survey periods ranged from 7 m (Search and Rescue (SAR) vessel *Esvagt FRB 11*) to a maximum of 333 m (cruise ship *MSC Preziosa*). Graph 12-4 illustrates the distribution of vessel lengths recorded throughout both survey periods.

It should be noted that 8% of the total number of unique vessels recorded within the offshore wind farm study area during the summer period did not broadcast a length on AIS or were recorded via Radar (and hence no length was recorded). These tracks have therefore been excluded from the following length analysis. The data is considered to provide a good indication of the types of lengths likely to be recorded in the area, however it should be considered that smaller vessels may be underrepresented.

The average lengths of vessels within the offshore wind farm study area throughout the summer and winter survey periods were 62 m and 66 m, respectively. There was a greater proportion of small vessels (<50 m) recorded throughout the summer survey within the offshore wind farm study area. This is likely due to smaller vessels being recorded on radar during the summer survey, and it should also be considered that activity from smaller vessels would be expected to be less during winter than in summer (due to the potential for adverse weather).

Figure 12-10 provides an overview of AIS, visual and Radar vessel tracks (excluding temporary traffic) recorded within the offshore wind farm study area throughout the combined 53 day summer and winter survey periods, colour-coded by vessel length.



Graph 12-4 Vessel Length Distribution within the Offshore Wind Farm Study Area during 53 Days Summer 2017 and Winter 2016 (AIS, visual and Radar)

12.2.3.2 Vessel Draught

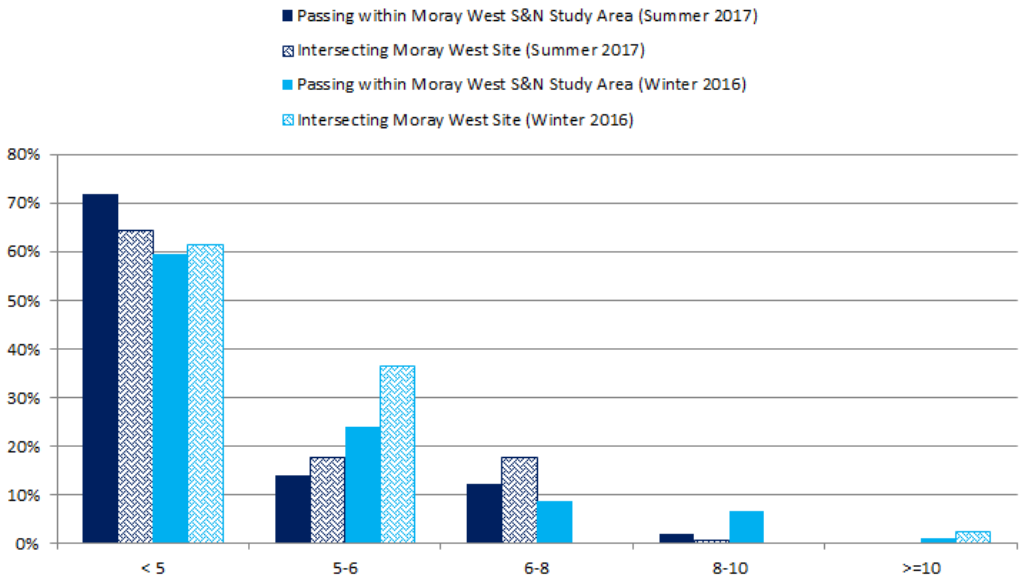
Vessel draughts recorded through the survey periods ranged from 1.4 m (lifeboat vessel *RNLI Lifeboat 14-20*) to a maximum of 13.5 m (crude oil tanker *Hilda Knutsen*). Graph 12-5 illustrates the distribution of vessel draughts recorded throughout each survey period.

It should be noted that 14% of the total number of unique vessels recorded within the offshore wind farm study area during the summer period and 28% during the winter period did not broadcast a draught via AIS or were recorded via Radar (and hence no draught was recorded). These tracks have therefore been

excluded from the following draught analysis. The data is considered to provide a good indication of the types of lengths likely to be recorded in the area, however it should be considered that smaller vessel draughts are likely to be underrepresented.

The average draughts of vessels within the offshore wind farm study area throughout the summer and winter survey periods were 4 m and 5 m respectively. There was a greater proportion of small-draught vessels (< 5m) recorded throughout the summer survey within the offshore wind farm study area, for reasons similar to those discussed within the corresponding length analysis.

Figure 12-11 provides an overview of AIS, visual and Radar vessel tracks (excluding temporary traffic) recorded within the offshore wind farm study area throughout the combined 53 day summer and winter survey periods, colour-coded by vessel draught.



Graph 12-5 Vessel Draught Distribution within the Offshore Wind Farm Study Area during 53 Days Summer 2017 and Winter 2016 (AIS, visual and Radar)

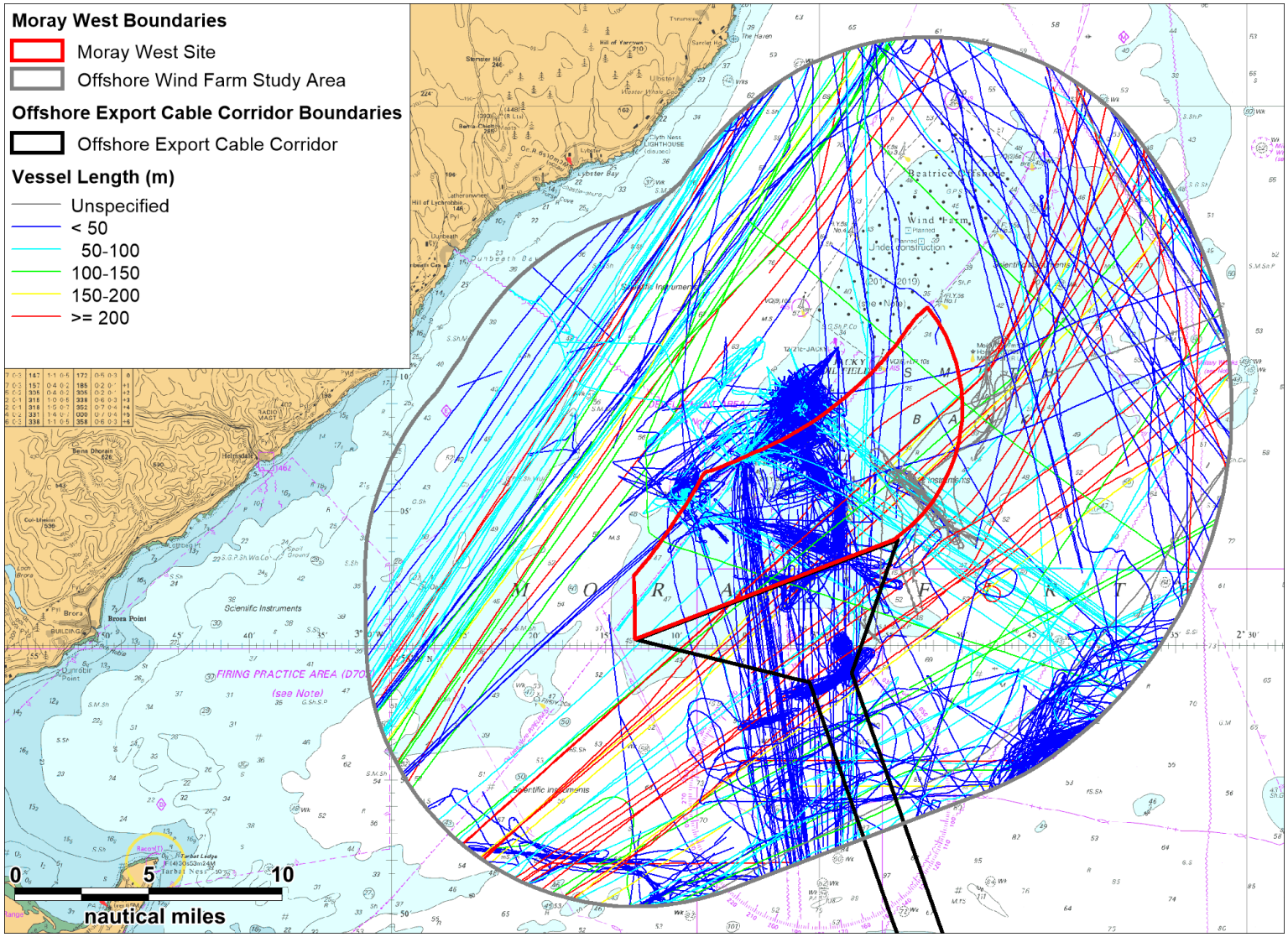


Figure 12-10 AIS, visual and Radar data within Offshore Wind Farm Study Area Colour-Coded by Vessel Length (53 Days Summer 2017 and Winter 2016)

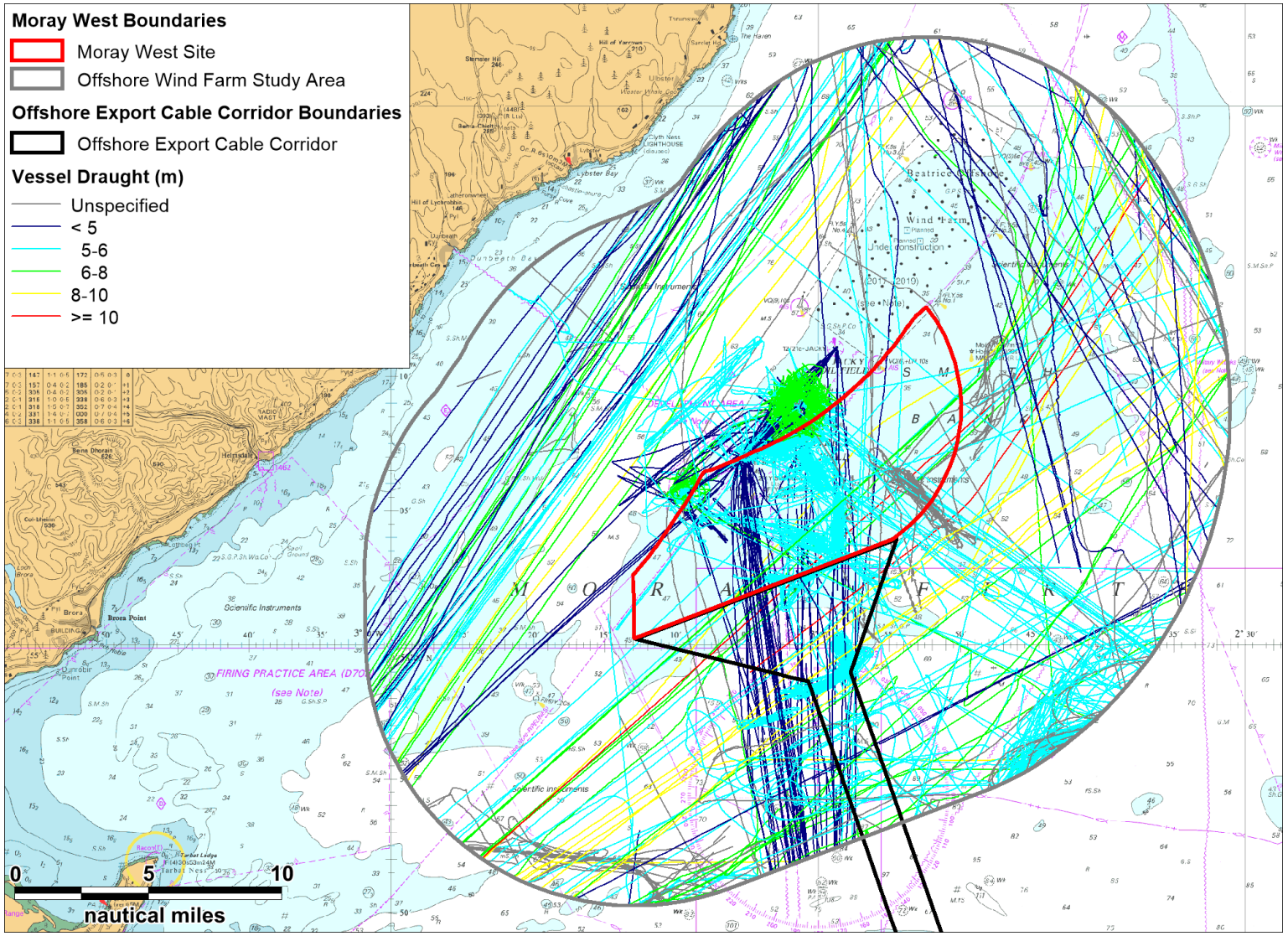


Figure 12-11 AIS, visual and Radar data within Offshore Wind Farm Study Area Colour-Coded by Vessel Draught (53 Days Summer 2017 and Winter 2016)

12.2.4 Beatrice Oil Field Vessels

This section reviews the vessels associated with the Beatrice Oil Field recorded during the marine traffic surveys.

Throughout the combined summer and winter period, an average of three unique Beatrice oil field vessels per day passed within the offshore wind farm study area. Figure 12-12 presents a plot of Beatrice oil field vessels recorded within the offshore wind farm study area on AIS, visual and Radar throughout the combined survey periods.

These vessels consisted of oil and gas vessels as well as High Speed Craft (HSC) transfer vessels transiting between Buckie and Beatrice Oil Field. It is noted that this crew transfer activity was also observed at the Jacky Field platform (which has been included in Figure 12-12).

Based on the output of the consultation process, Beatrice oil field vessels have been designated as being baseline activity. However, it should be noted that the associated activity will end upon completion of the decommissioning process (anticipated to be 2028).

12.2.5 Tugs (including Towing Operations)

The tracks recorded from tugs during the marine traffic surveys are presented in Figure 12-13. It is noted that operation where two vessels were operating in close vicinity were identified, with the behaviours of the two vessels involved suggesting it was a towing operation. Based on the information transmitted via AIS, the vessels were bound for Wick. The corresponding tracks have been highlighted in the figure.

12.2.6 Passenger Vessels

This section reviews the passenger vessels in the offshore wind farm study area based on the marine traffic surveys.

There was an average of two unique vessels per day during the summer period. Figure 12-14 presents a plot of passenger vessels recorded within the offshore wind farm study area on AIS, visual and Radar throughout the summer survey period.

No passenger vessels were recorded during winter. This is likely due to lessened cruise activity during winter periods (noting that all but one of the passenger vessels recorded during summer were cruise liners).

Table 12.1 presents details of the passenger vessels recorded within the offshore wind farm study area throughout the summer period.

Table 12.1: Passenger Vessel Details (25 Days Summer 2017)

Vessel Name	Vessel Type	Destination	Location	Operator
Thalassa	Tall Ship	Invergordon	North Offshore Wind Farm Study Area	N/A
Hebridean Princess	Cruise Ship	Wick		Hebridean Island Cruises
Europa 2		Kirkwall		Hapag-Lloyd Cruises

Table 12.1: Passenger Vessel Details (25 Days Summer 2017)

Vessel Name	Vessel Type	Destination	Location	Operator
Aidavita		Invergordon		AIDA Cruises
Wind Surf		Kirkwall		Windstar Cruises
Magellan		Invergordon		Cruise & Maritime Voyages
Columbus		Invergordon		
Vision of the Seas		Reykjavik	South Offshore Wind Farm Study Area	Royal Caribbean
Prinsendam		Invergordon	Intersecting Moray West Site	Holland America
Aidacara		Invergordon		AIDA Cruises
Norwegian Jade		Invergordon		Norwegian Cruise Line
Star Pride		Kirkwall	North Offshore Wind Farm Study Area	Windstar Cruises
		Invergordon	South Offshore Wind Farm Study Area	
MSC Preziosa		Reykjavik	North Offshore Wind Farm Study Area	MSC Cruises
		Greenock	Intersecting Moray West Site	
MS Braemar		Invergordon	South Offshore Wind Farm Study Area	Fred. Olsen Cruises Lines
		Scrabster	Intersecting Moray West Site	
Black Watch		Invergordon Lerwick Ullapool	Intersecting Moray West Site	
Caribbean Princess		Invergordon	North / South / West Offshore Wind Farm Study Area	Princess Cruises

The majority of passenger vessels were transiting to UK ports with Invergordon the most common destination. Reykjavik (Iceland) was also a recorded destination.

12.2.7 Recreational Vessel Activity

This section reviews recreational activity in the offshore wind farm study area based on cruising route information published by the RYA, as well as AIS, visual and Radar tracking of recreational vessels during the marine traffic surveys.

For the purposes of the NRA, recreational activity includes sailing and motor craft (including those undertaking dive and fishing charter trips) of between 2.4 and 24 m as per the RYA preference and European Union classifications.

12.2.7.1 Survey Data

Figure 12-15 presents the recreational tracks recorded during the summer marine traffic survey.

There were no recreational vessels recorded throughout the winter survey period and an average of one unique vessel every three days during the summer survey period within the offshore wind farm study area. It is noted that all recreational tracks were recorded on AIS, with no tracks recorded on Radar.

12.2.7.2 RYA Coastal Atlas

The RYA Coastal Atlas (RYA, 2016) shows the estimated direction of offshore cruising routes, and approximate densities of recreational vessel density within the UK 12 nm limit. A plot of this data is shown in Figure 12-16, which has been overlaid with the recreational tracks recorded during the marine traffic surveys (noting that no activity was recorded during the winter survey period).

It can be seen that recreational density within the offshore wind farm study area is low when compared to the coastal areas. This correlates well with the marine traffic data.

The highest recreational AIS densities are located along Moray coast and approaches to the Cromarty Firth. The Moray West Site is located outside of the UK coastal waters 12 nm limits therefore no AIS density is available for within Moray West Site but it can be deduced that density is low.

A general boating area intersects the Offshore Export Cable Corridor at the nearshore area and an estimated five offshore routes intersect the OfTI study area.

12.2.8 Fishing Vessel Activity

12.2.8.1 Marine Traffic Survey

This section reviews the fishing activity in proximity to the Moray West Site based on the marine traffic surveys.

Fishing vessel activity was recorded using AIS, visual and Radar and is presented in Figure 12-17. It can be seen that fishing activity was recorded within the offshore wind farm study area, with the majority of vessels tracked within the Moray West Site actively engaged in fishing rather than transiting.

Throughout the combined summer and winter survey periods there was an average of two unique fishing vessels per day within the offshore wind farm study area.

Fishing method information was available for approximately 85% of fishing vessels recorded on AIS, visual and Radar within the offshore wind farm study area. Of the fishing methods identified, the most common were demersal trawling (51%) and dredgers (15%).

Flag state (nationality) information was available for approximately 86% of fishing vessels recorded on AIS, visual and Radar within the offshore wind farm study area. All of the fishing vessels with available nationality information were UK registered (85%). The remaining 15% of tracks were recorded on Radar and therefore their nationalities could not be identified.

12.2.8.2 Sightings Data

Fishing vessel sightings (over flight and/or vessel based) recorded between 2015 and 2016 were analysed for the offshore wind farm study area.

The only nationality identified was the UK (100%) while the most common fishing methods were scallop dredgers (51%) and demersal trawlers (27%). Other fishing methods recorded included trawlers (12%), potter/whelkers (2%), other dredgers (2%), pelagic trawlers (2%) and seiners (2%).

Of the traffic recorded, 89% of fishing vessels were travelling at less than 6 knots and were therefore potentially engaged in fishing activity. This shows good agreement with the fishing vessel tracks shown in Figure 12-17.

12.2.8.3 Satellite Data

Satellite data (from Marine Scotland and collected for fishing vessels of 12m length and over) recorded throughout 2015 and 2016 was analysed for the offshore wind farm study area.

The majority of fishing vessels were UK registered (99.9%). Other nationalities identified were the Netherlands, Ireland, France, Greenland and the Faroe Islands (all less than 0.05%). Fishing method details and vessel identifiers were not provided with the satellite data (for the purposes of data protection), and further analysis into gear types was therefore not possible.

Of the traffic recorded, 83% of fishing vessels broadcasted their activity as engaged in fishing. Transiting vessels accounted for 12% traffic and 5% laid stationary. As with the sightings data, the nationality and speed distributions show good agreement with the corresponding distributions for the survey data.

12.2.9 Anchored Vessels

Anchored vessels can be identified based on the AIS navigational status which is programmed on the AIS transmitter on board a vessel. No vessels were broadcasting as “at anchor” within the offshore wind farm study area during the 53 day survey period. However, information is manually entered into the AIS; and therefore it is common for vessels not to update the navigational status if they are anchored for only a short period of time.

For this reason, vessels which travelled at a speed of less than one knot for more than 30 minutes checked for, on the basis that they may be at anchor. After applying these criteria, no vessels were identified as being at anchor. This result can be attributed to the moderate water depth and varied seabed type within the study area.

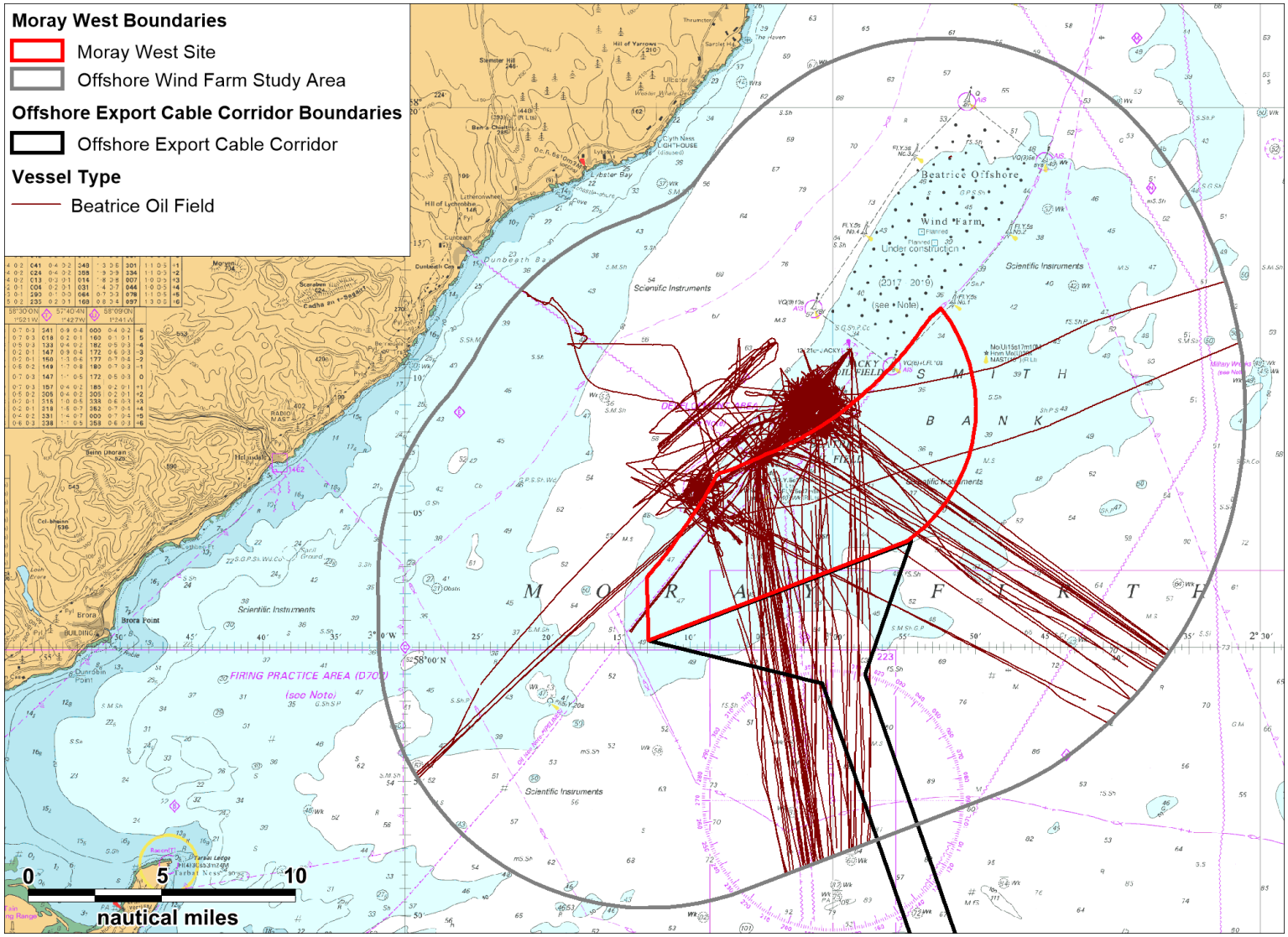


Figure 12-12 **AIS, visual and Radar Beatrice Oil & Gas Vessels within the Offshore Wind Farm study Area (53 Days Summer 2017 and Winter 2016)**

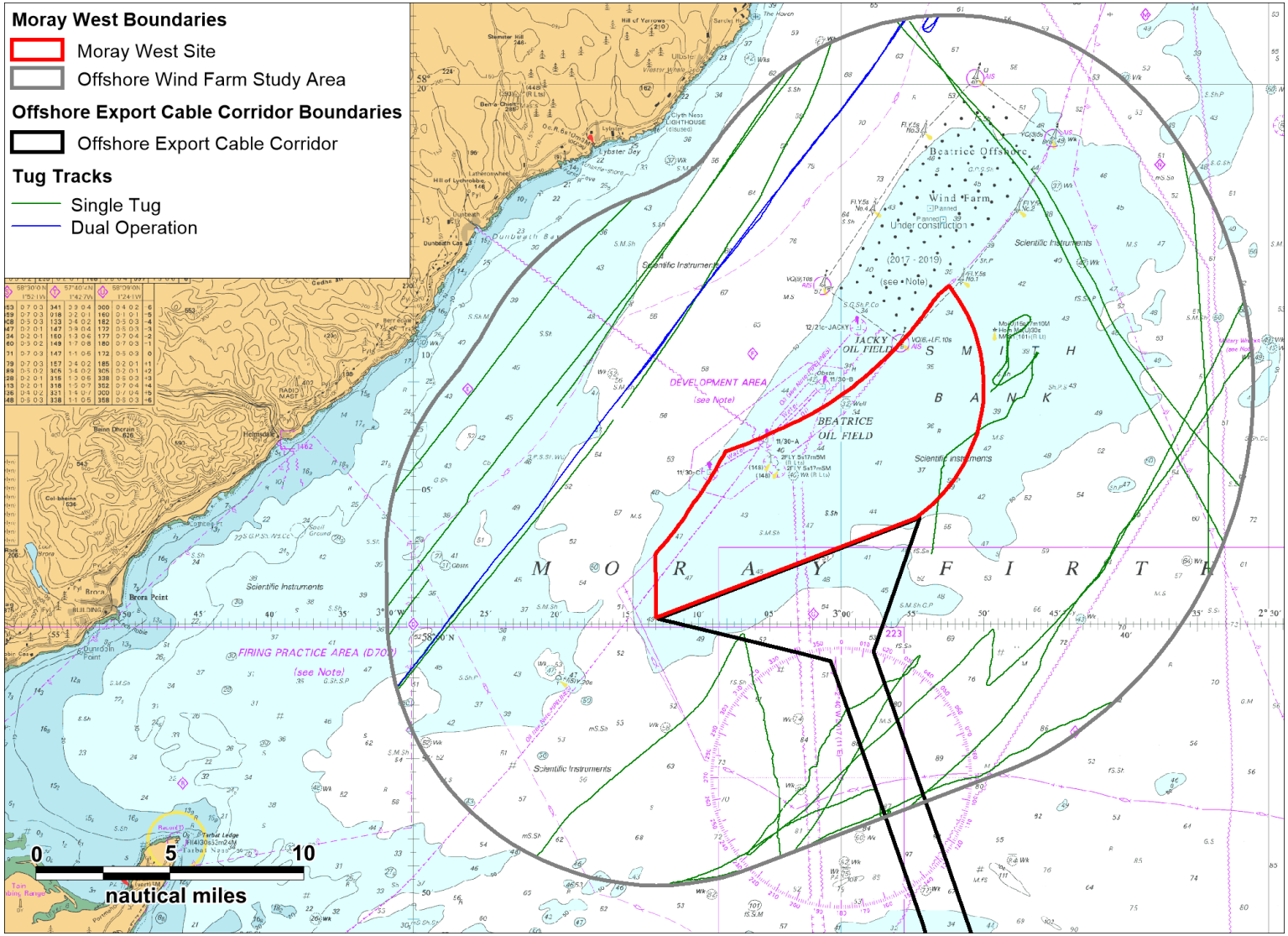


Figure 12-13 AIS, Visual and Radar Tugs within the Offshore Wind Farm study Area (25 Days Summer 2017)

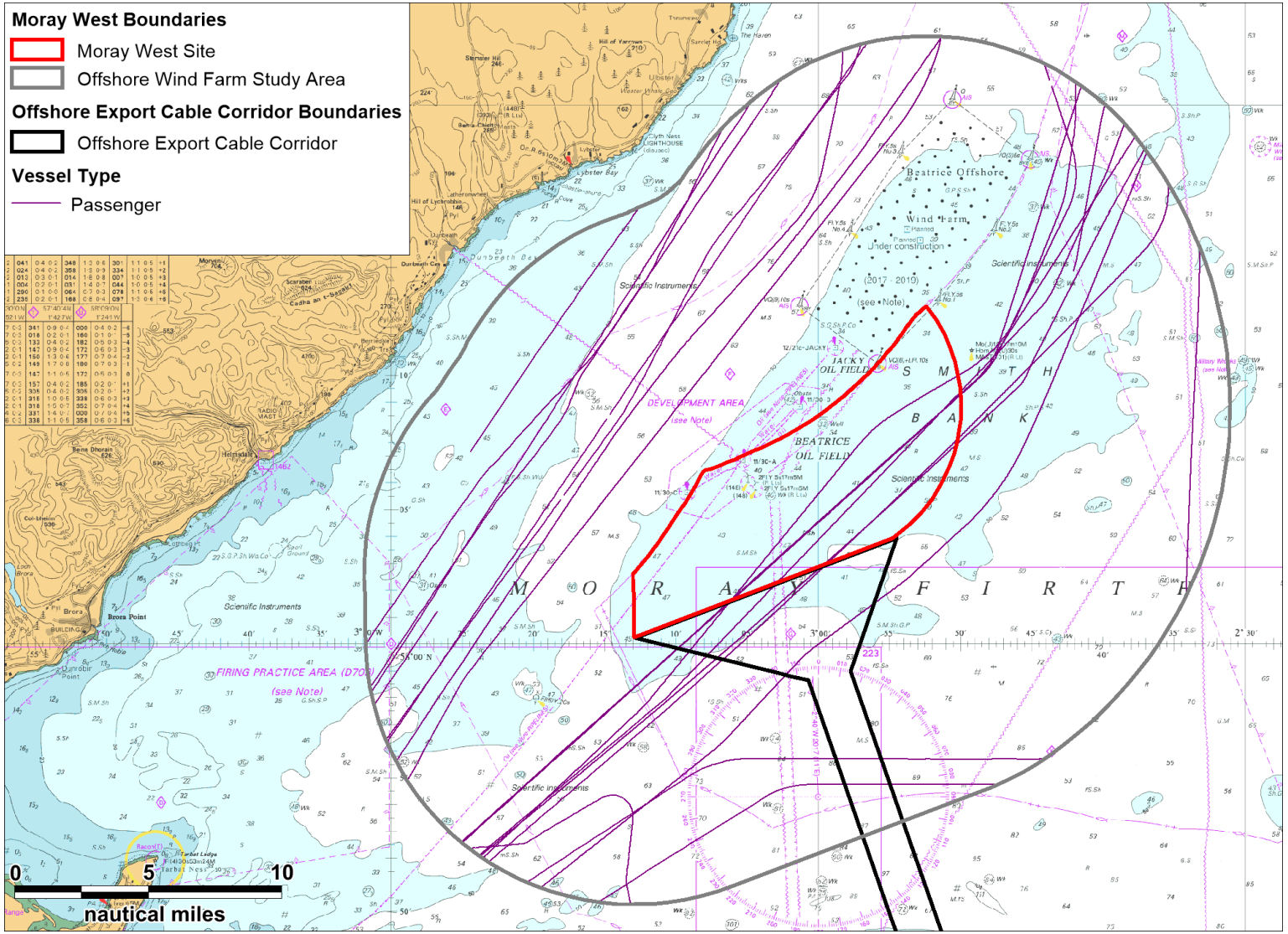


Figure 12-14 AIS, Visual and Radar Passenger Vessels within the Offshore Wind Farm study Area (25 Days Summer 2017

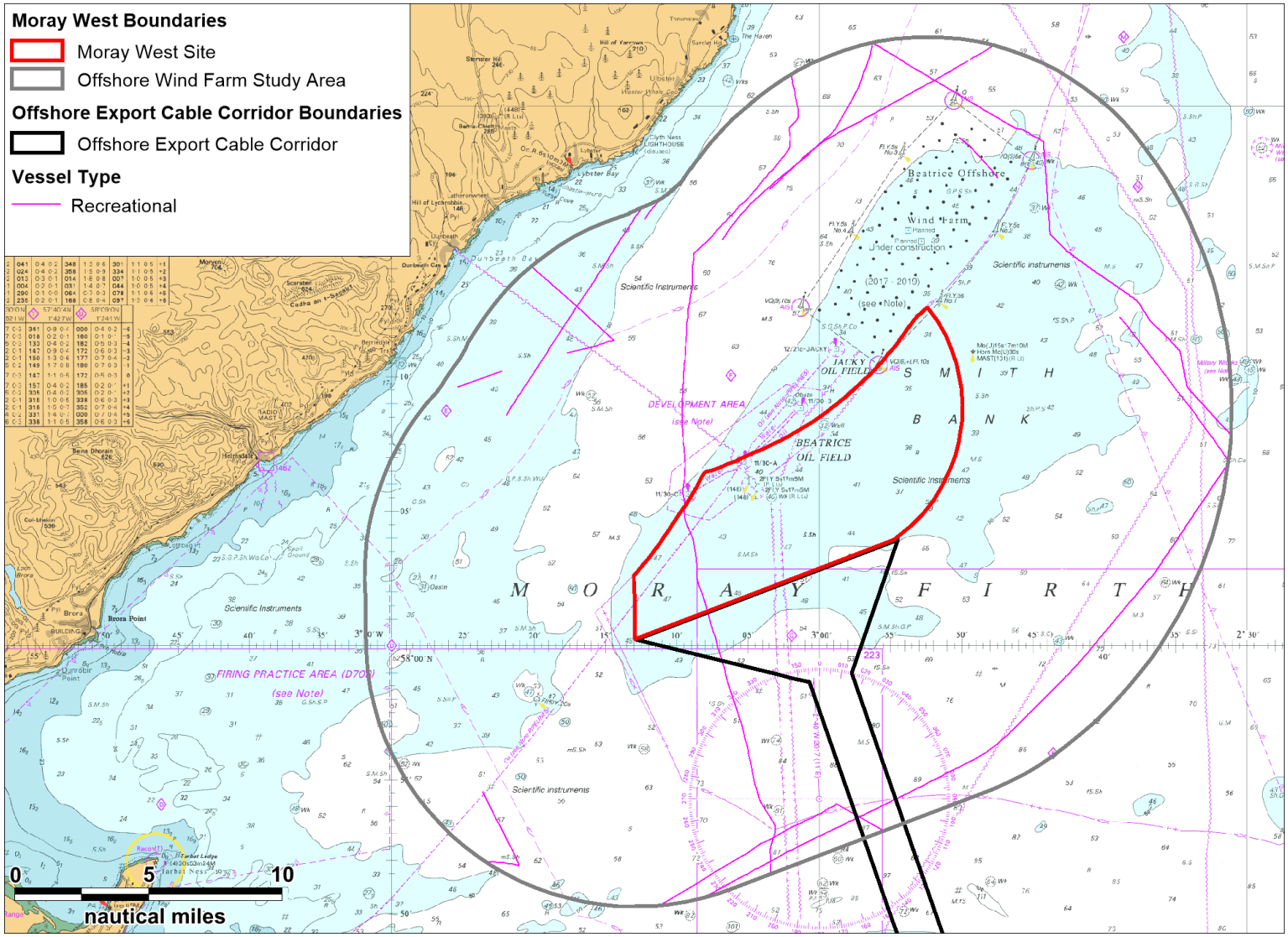


Figure 12-15 AIS, Visual and Radar Recreational Vessels within the Offshore Wind Farm study Area (25 Days Summer 2017)

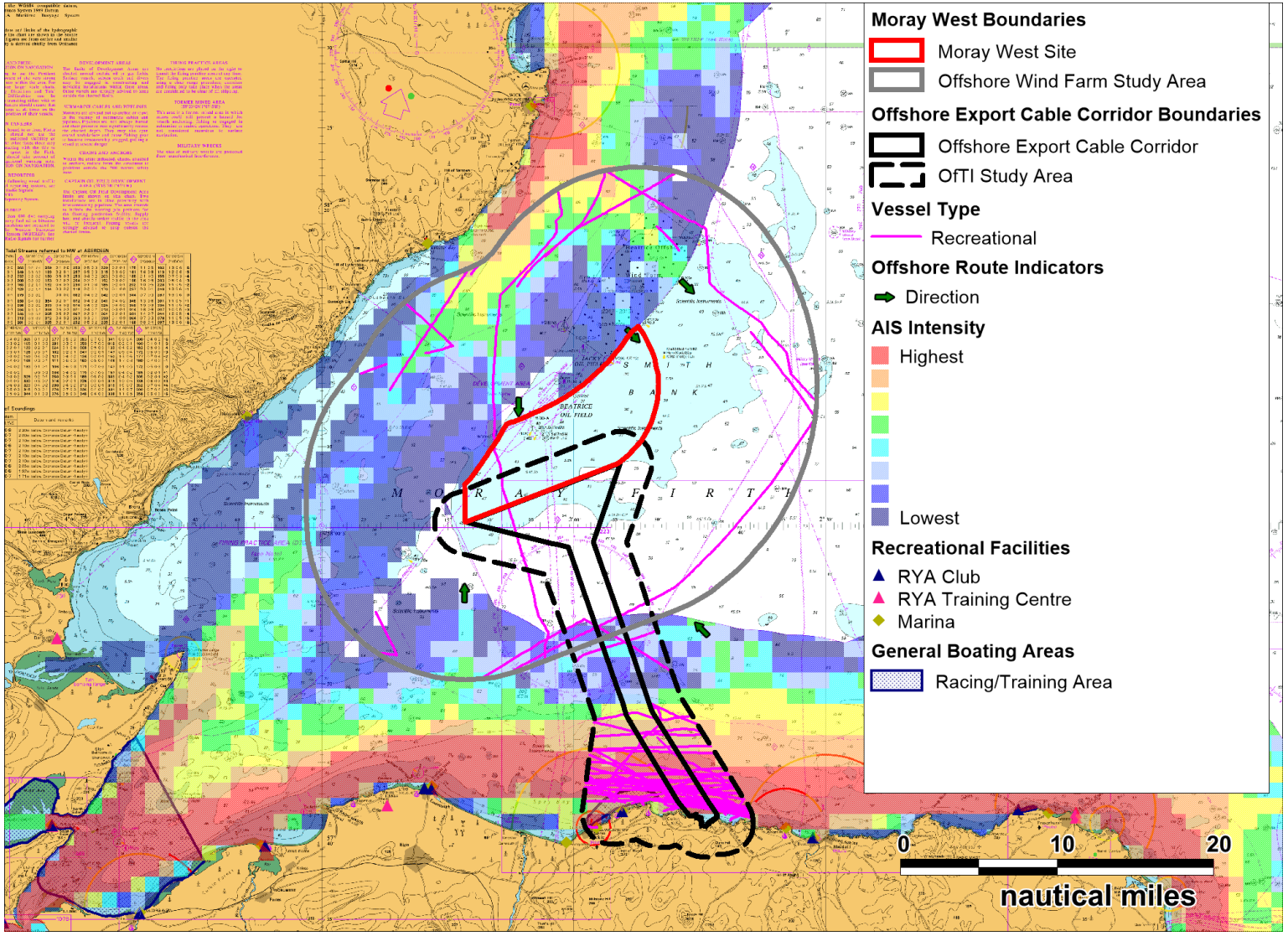


Figure 12-16 RYA Cruising Routes in Proximity to Moray West Site

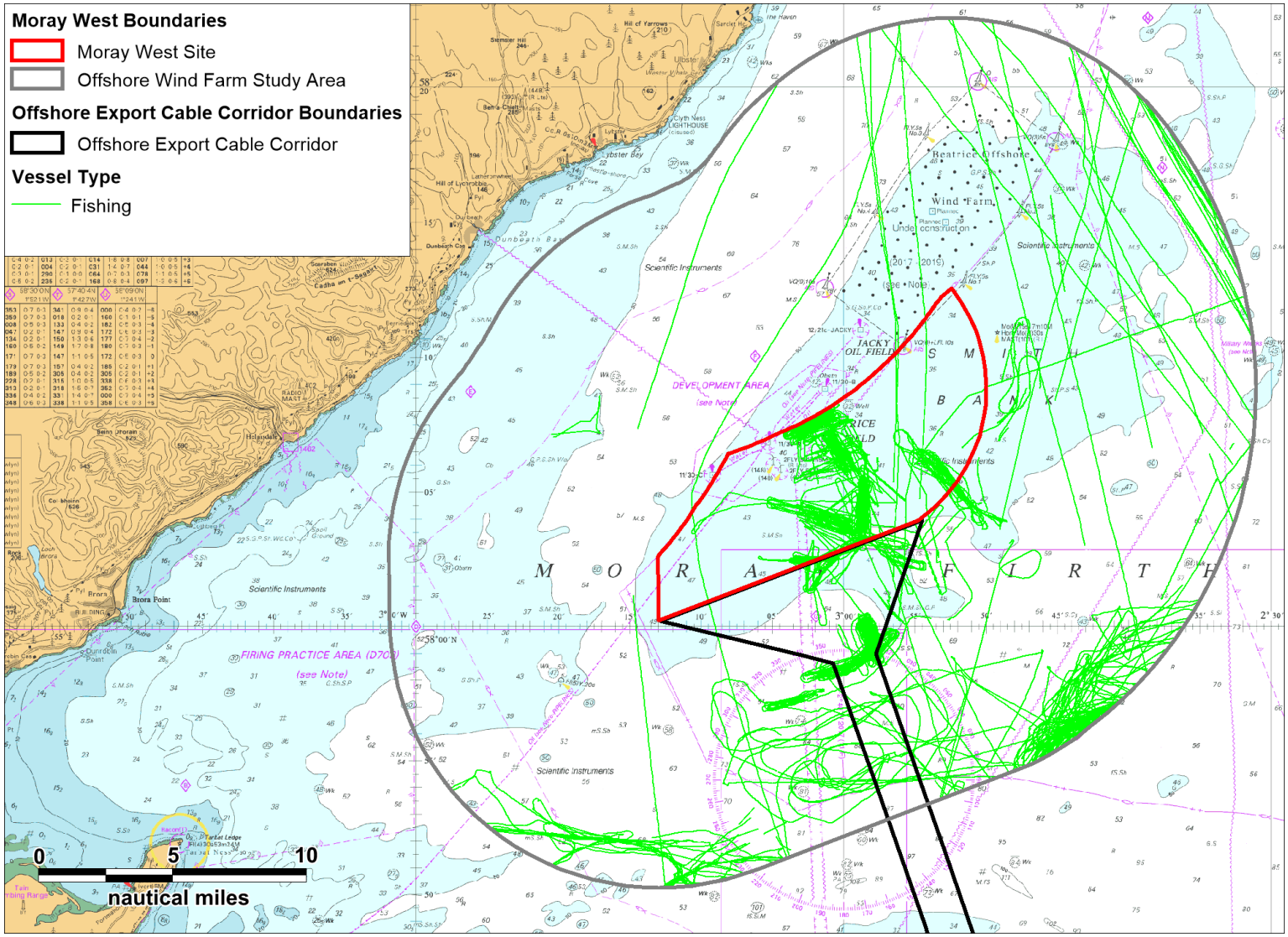


Figure 12-17 **AIS, Visual and Radar Fishing Vessels within the Offshore Wind Farm Study Area (53 Days Summer 2017 and Winter 2016)**

12.3 Offshore Export Cable Corridor

AIS data collected for the OfTI study area between 4th November to 22nd December 2016 and AIS, visual and Radar data collected between 15th August and 13th September 2017 has been analysed (i.e., the same marine traffic data sources/periods have been used for both the analysis of the Moray West Site and the Offshore Export Cable Corridor, within the relevant geographical extents).

Figure 12-18 presents the 53 days (25 days summer AIS, visual and Radar and 28 days winter AIS) of all tracks recorded during the seasonal periods studied, colour-coded by vessel type, within the OfTI study area.

A number of tracks recorded during the summer and winter surveys were classified as temporary (non-routine), such as the tracks of the survey vessel and traffic associated with BOWL. These have therefore been excluded from further analysis. Oil and gas affiliated vessels supporting the decommissioning of Beatrice Oil Field as well as permanent installations were retained in the analysis.

A plot of vessel tracks recorded during the combined 53 day summer and winter survey period, colour-coded by vessel type and excluding temporary traffic (as defined above) are presented in Figure 12-19.

12.3.1 Vessel Counts

Graph 12-6 illustrates the daily number of unique vessels passing through the OfTI study area and intersecting the Offshore Export Cable Corridor during the 25 days from August to September 2017.

For the 25 days analysed in summer 2017, there were an average of 15 unique vessels per day passing within the OfTI study area, recorded on AIS, visual and Radar. In terms of vessels intersecting the Offshore Export Cable Corridor itself, there was an average of eight unique vessels per day.

The busiest day recorded throughout the survey period was the 10th September 2017 when 19 unique vessels were recorded within the OfTI study area. The busiest day if just the Offshore Export Cable Corridor was considered was the 17th August 2017 when 13 unique vessels were recorded.

The quietest day recorded during the summer survey period was the 18th August 2017 when 10 unique vessels were recorded within the OfTI study area. The quietest day within the Offshore Export Cable Corridor was the 8th September 2017 when five vessels were recorded.

Throughout the summer survey period 45% of traffic recorded within the OfTI study area intersected the Offshore Export Cable Corridor.

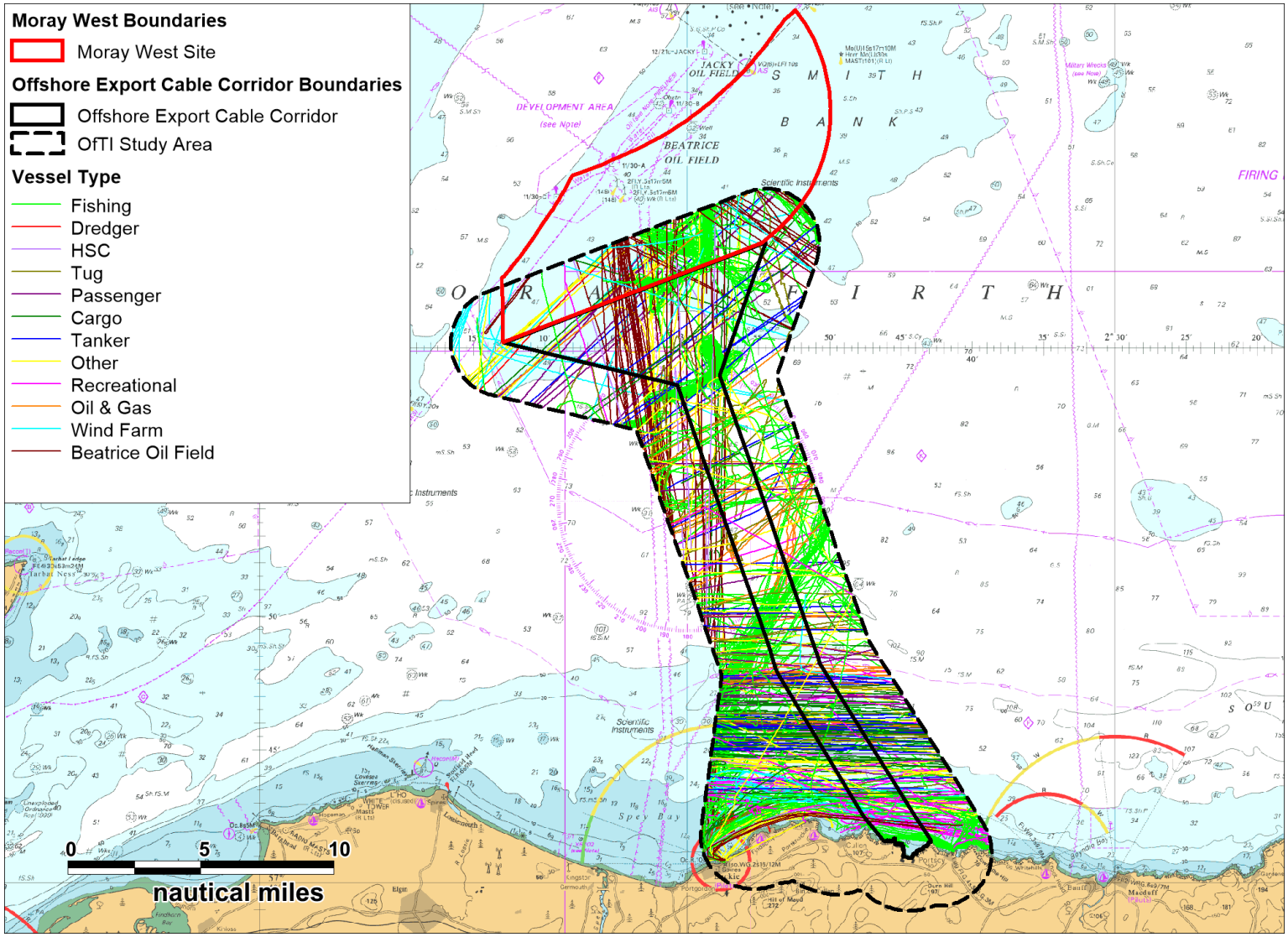


Figure 12-18 **Overview of all AIS, Visual and Radar Data within the Shipping and Navigation OfTI Study Area (53 Days Summer 2017 and Winter 2016)**

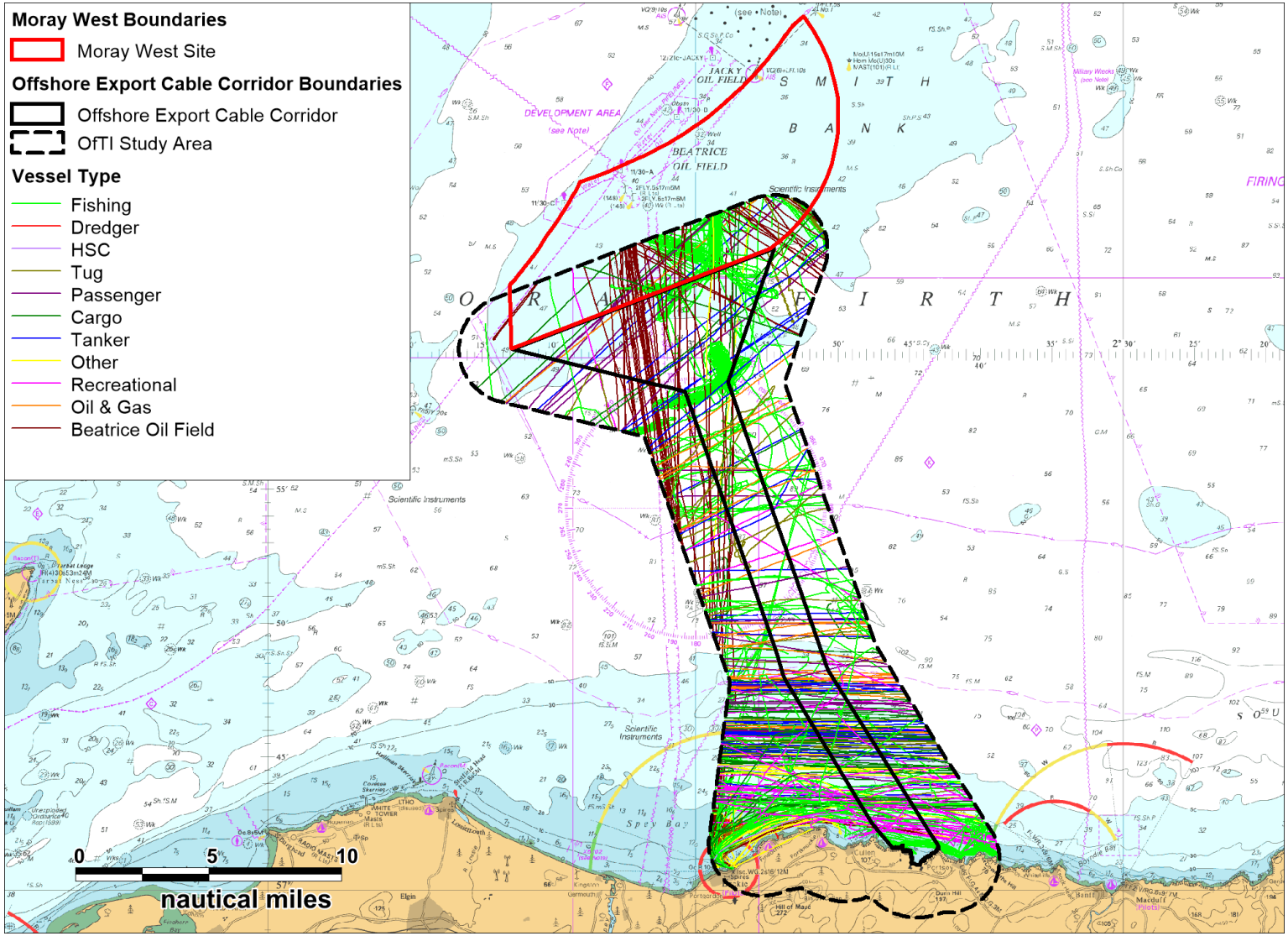
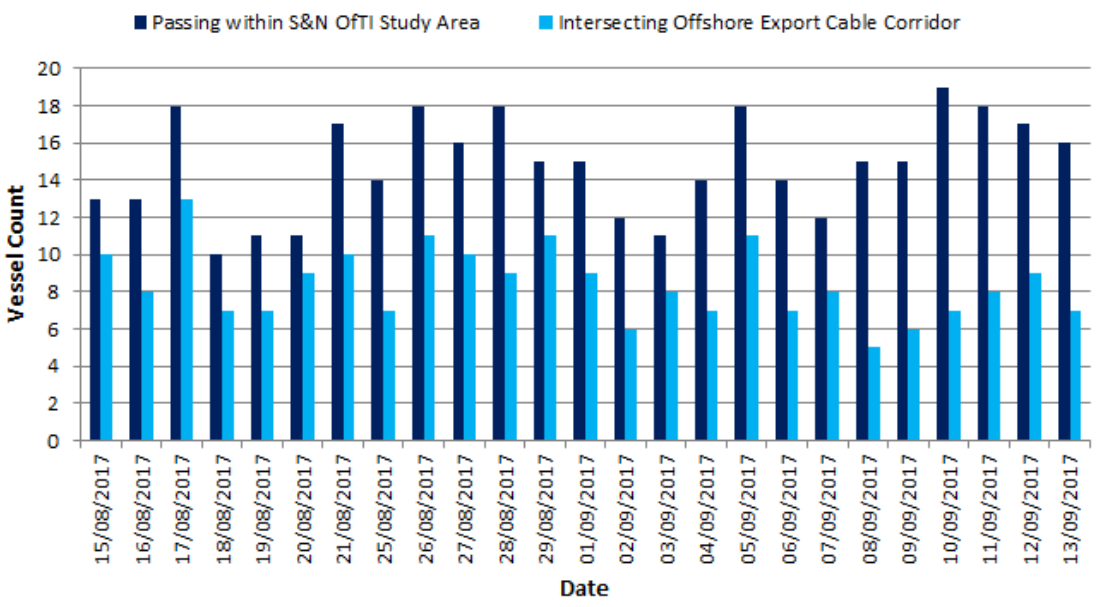


Figure 12-19 **Overview of all AIS, visual and Radar Data within the Shipping and Navigation OfTI Study Area Excluding Temporary Tracks (53 Days Summer 2017 and Winter 2016)**



Graph 12-6 Unique Vessels per Day within the Shipping and Navigation OfTI Study Area during 25 Days Summer 2017 (AIS, Visual and Radar)

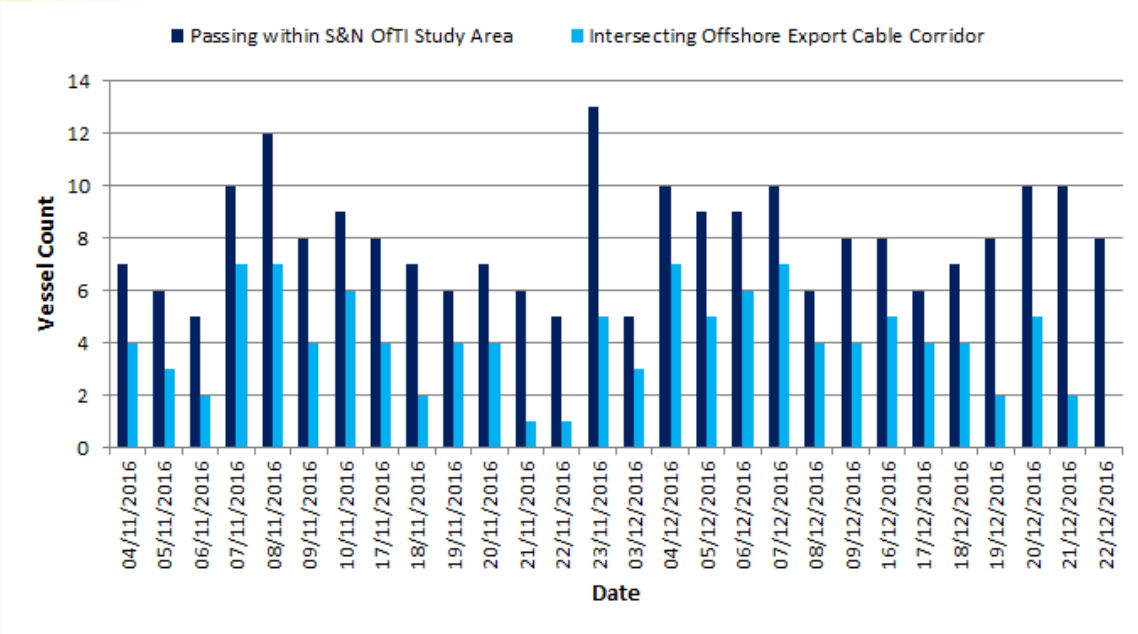
Graph 12-7 illustrates the daily number of unique vessels passing within the OfTI study area and intersecting the Offshore Export Cable corridor, during the 28 days from November to December 2016.

For the 28 days analysed in winter 2016, there were an average of eight unique vessels per day passing within the OfTI study area, recorded on AIS, visual and Radar. In terms of vessels intersecting the Offshore Export Cable Corridor, there was an average of four unique vessels per day.

The busiest day recorded throughout the survey period was the 23rd November 2016 when 13 unique vessels were recorded within the OfTI study area. The busiest days within the Offshore Export Cable Corridor were the 7th November, 8th November, 4th December and 7th December 2016 when seven unique vessels were recorded.

The quietest days recorded throughout the survey period were the 6th November, 22nd November and 3rd December 2016 when five unique vessels were recorded within the OfTI study area. The quietest days within the Offshore Export Cable Corridor were the 21st November and 22nd November 2016 when just one vessel was recorded.

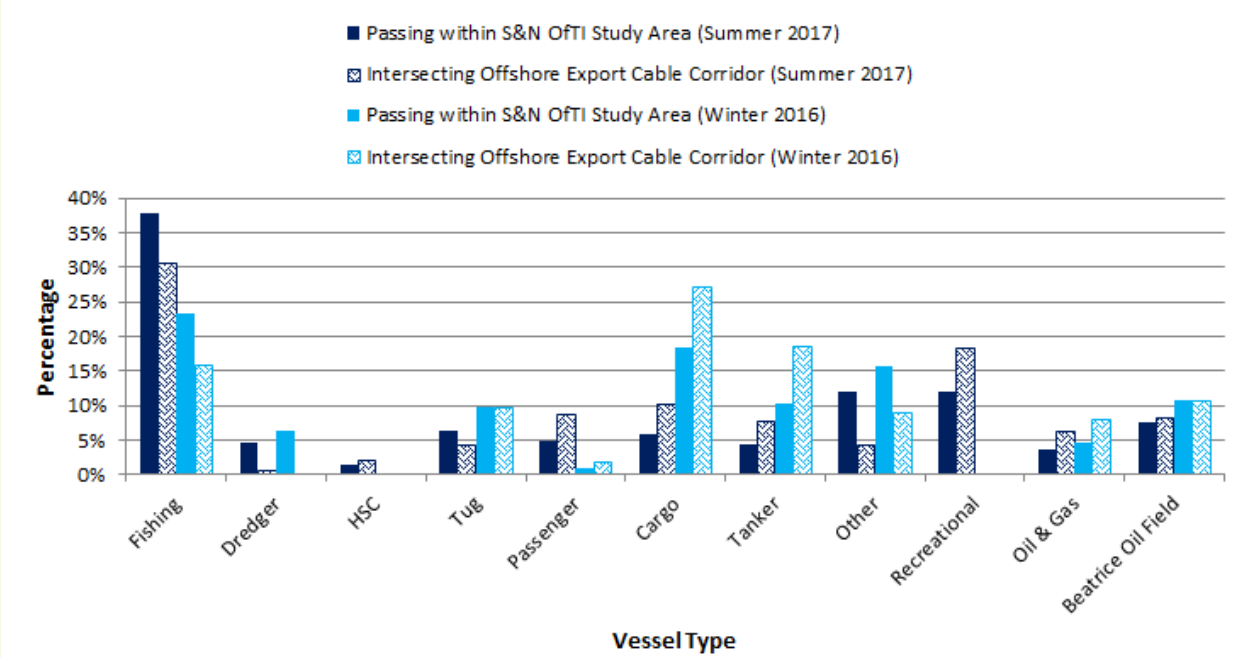
Throughout the winter survey period 27% of traffic recorded within the OfTI study area intersected the Offshore Export Cable Corridor.



Graph 12-7 Unique Vessels per Day within the Shipping and Navigation OfTI Study Area during 28 Days Winter 2016 (AIS)

12.3.2 Vessel Types

Analyses of the vessel types recorded passing within the OfTI study area and intersecting the Offshore Export Cable Corridor throughout both the survey periods are presented in Graph 12-8.



Graph 12-8 Distribution of Vessel Types within the Shipping and Navigation OfTI Study Area during 53 Days Summer 2017 and Winter 2016 (AIS, Visual and Radar)

Throughout August and September 2017 (summer) the majority of tracks were fishing vessels (38%), "other" vessels and recreational vessels (both 12%). The majority of vessels within the Offshore Export Cable Corridor were fishing vessels (30%), recreational (18%) and cargo vessels (10%). Throughout November and December 2016 (winter) the majority of tracks were fishing vessels (23%), cargo vessels (18%) and other vessels (16%). The majority of vessels within the Offshore Export Cable Corridor were

cargo vessels (27%), tankers (18%) and fishing vessels (16%). It should be noted that the cargo vessel category includes commercial ferries (Northlink Ferries) operating in the OfTI study area which generally broadcast their vessel types on AIS as cargo.

Figure 12-20 presents a plot of cargo vessels, including Ro-Ro cargo vessels, recorded within the OfTI study area on AIS, visual and Radar throughout both the summer and winter survey periods. Equivalent plots of tankers and oil & gas affiliated vessels are presented in Figure 12-21 and Figure 12-22 respectively.

Throughout the combined summer and winter period, an average of one unique cargo vessel per day passed within the OfTI Study Area.

Regular cargo vessels operating in the vicinity of the OfTI Study Area include a Northlink Ferries Ro-Ro cargo vessel operating between Orkney (UK) and Aberdeen (UK). The Ro-Ro cargo vessel was recorded during the winter survey period (2% of total cargo traffic). There was no Ro-Ro cargo vessels recorded during the summer survey period.

Throughout the combined summer and winter survey period, an average of one unique tanker per day passed within the OfTI Study Area.

Tankers recorded throughout the combined survey period were transiting towards Moray Firth ports (Cromarty, Nigg, Inverness and Invergordon), other UK ports (St. Andrews, Immingham and Dunbar). Other European ports were also recorded (Amsterdam, Brofjorden, Vedde and Skagen).

Throughout the combined summer and winter survey period, an average of one unique oil & gas affiliated vessel every two days passed within the OfTI Study Area. These vessels were either on passage to / from offshore oil & gas installations outside of the OfTI Study Area or transiting to UK ports (Aberdeen, Peterhead, Invergordon and Nigg). One oil & gas affiliated vessel was transiting to Rotterdam (the Netherlands).

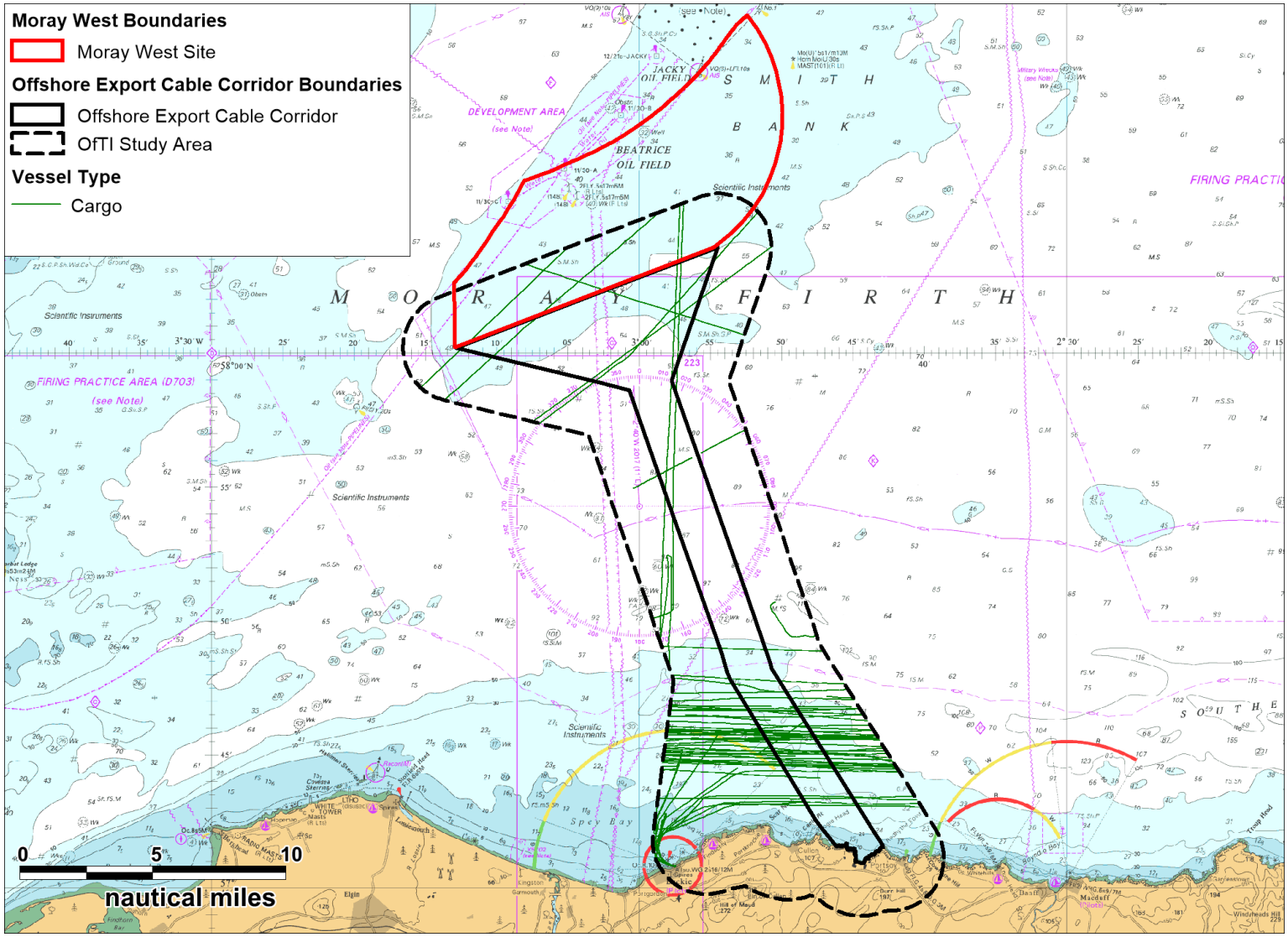


Figure 12-20 AIS, visual and Radar Cargo Vessels within the Shipping and Navigation OfTI Study Area (53 Days Summer 2017 and Winter 2016)

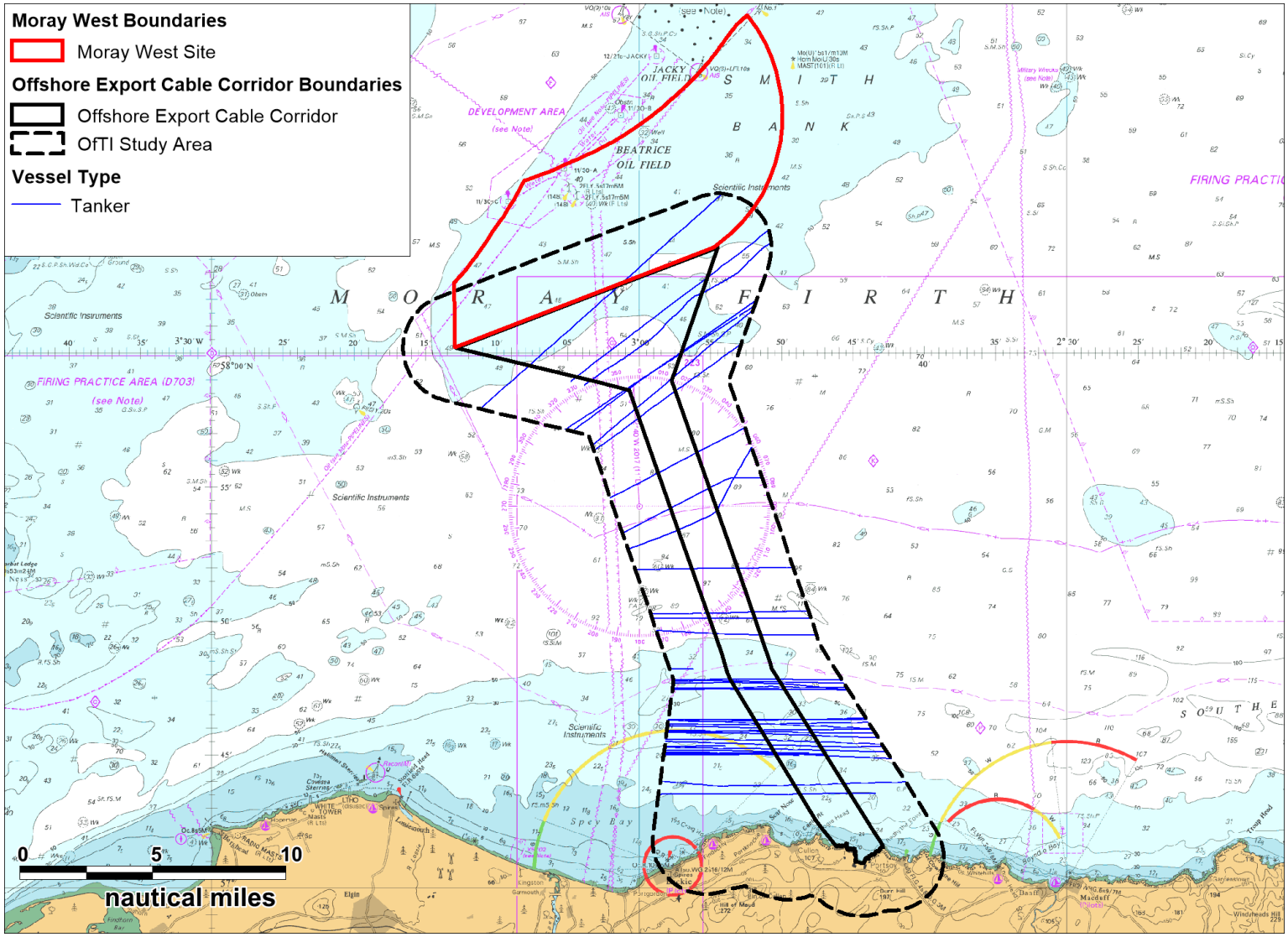


Figure 12-21 AIS, visual and Radar Tankers within the OfTI Study Area (53 Days Summer 2017 and Winter 2016)

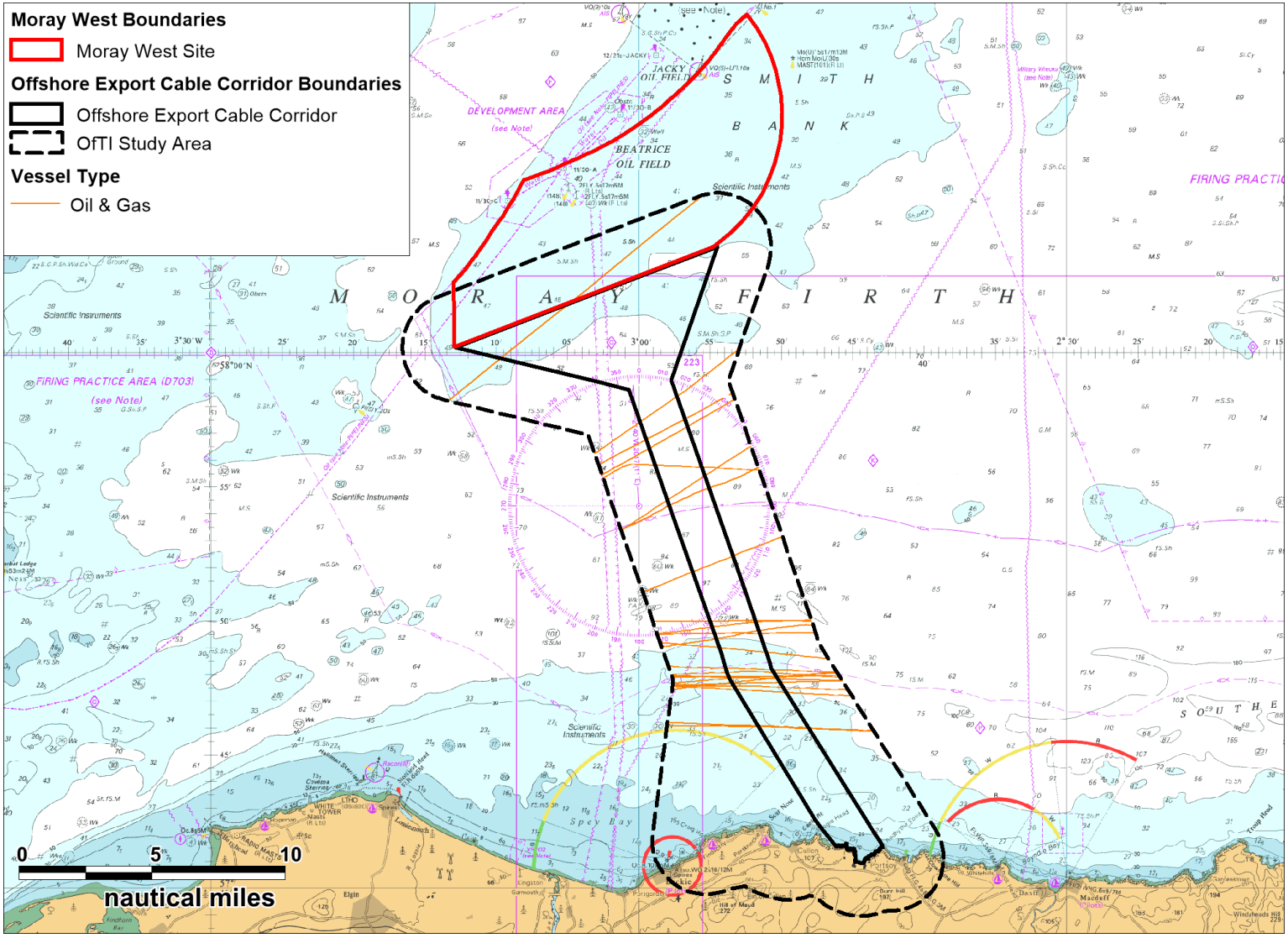


Figure 12-22 AIS, visual and Radar Oil & Gas Vessels within the OfTI Study Area (53 Days Summer 2017 and Winter 2016)

12.3.3 Vessel Size Distribution

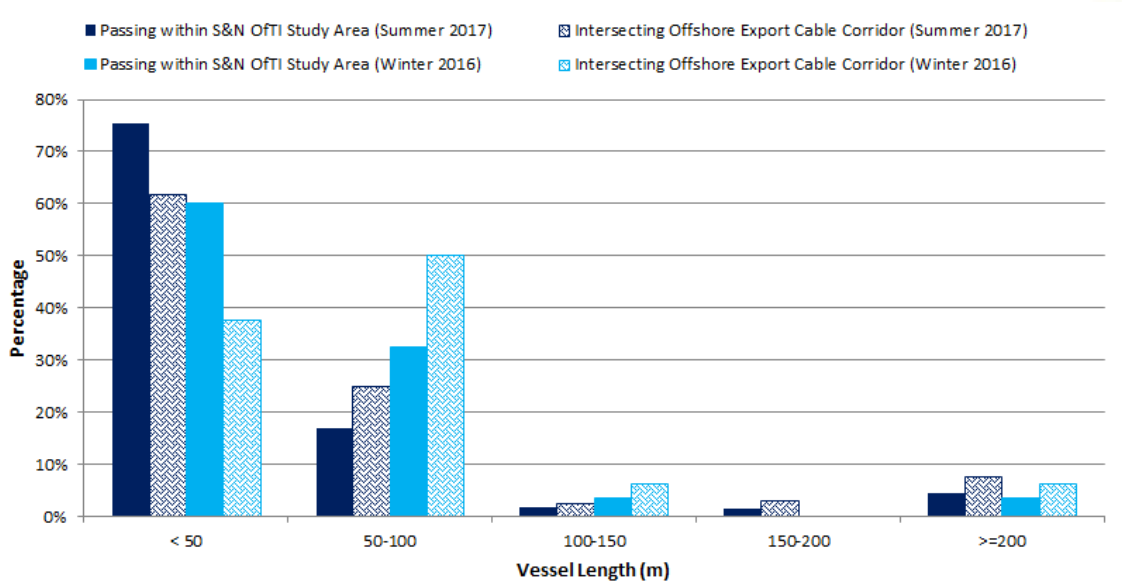
12.3.3.1 Vessel Length

Vessel length recorded throughout the survey periods ranged from 6m (fishing vessel *Lawret*) to a maximum of 333 m (cruise ship *MSC Preziosa*). Graph 12-9 illustrates the distribution of vessel lengths recorded throughout both survey periods.

It should be noted that 8% of the total number of unique vessels recorded within the OfTI study area during the summer period and 1% during the winter period did not broadcast a length on AIS or were recorded via Radar (and hence no length was recorded). These tracks have therefore been excluded from the following length analysis. The data is considered to provide a good indication of the types of lengths likely to be recorded in the area, however it should be considered that smaller vessels may be underrepresented.

The average lengths of vessels within the OfTI study area throughout the summer and winter survey periods were 44 m and 54 m, respectively. There was a greater proportion of small vessels (<50m) recorded throughout the summer survey within the OfTI study area. This is likely due to smaller vessels being recorded on Radar during the summer survey, and it should also be considered that activity from smaller vessels would be expected to be less during winter than in summer (due to the potential for adverse weather).

Figure 12-23 provides an overview of AIS, visual and Radar vessel tracks (excluding temporary traffic) recorded within the OfTI study area throughout the combined 53 day summer and winter survey periods, colour-coded by vessel length.



Graph 12-9 Vessel Length Distribution within the OfTI Study Area during 53 Days Summer 2017 and Winter 2016 (AIS, visual and Radar)

12.3.3.2 Vessel Draught

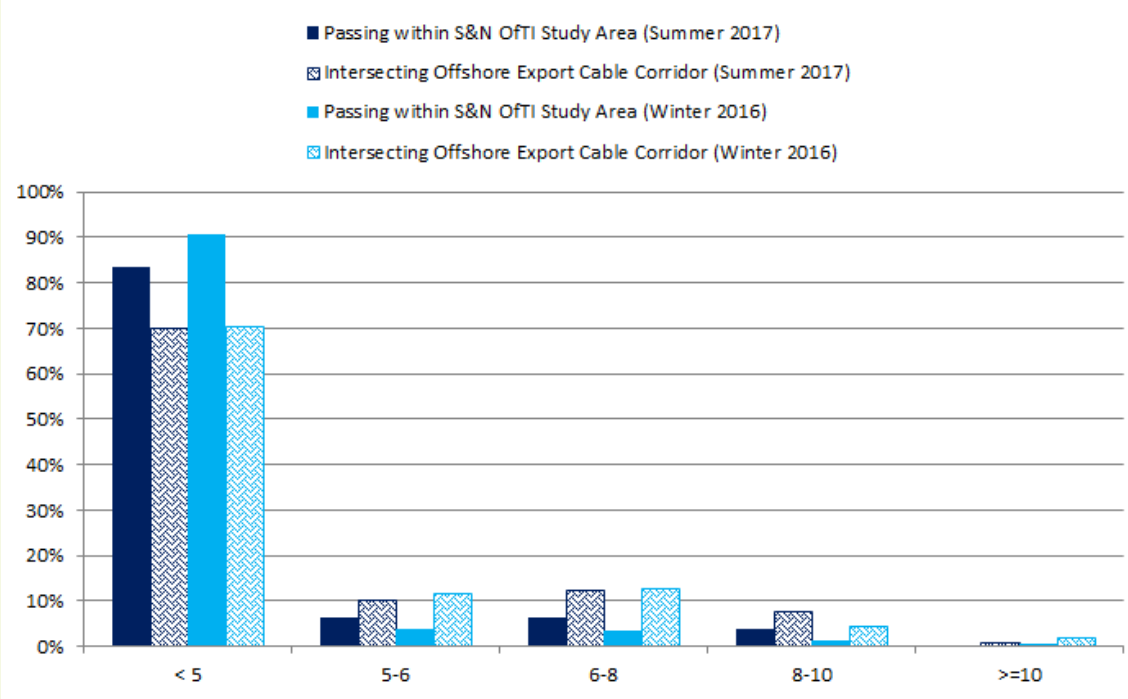
Vessel draughts recorded through the survey periods ranged from 1.2 m (cruise/tour ship *RNLI Jacobite Revel*) to a maximum of 13.5 m (crude oil tanker *Hilda Knutsen*). Graph 12-10 illustrates the distribution of vessel draughts recorded throughout each survey period.

It should be noted that 36% of the total number of unique vessels recorded within the OfTI study area during the summer period and 9% during the winter period did not broadcast a draught via AIS, or were recorded via Radar (and hence no draught was recorded). These tracks have therefore been excluded from the following draught analysis. The data is considered to provide a good indication of the types of

lengths likely to be recorded in the area, however it should be considered that smaller vessel draughts are likely to be underrepresented.

The average draughts of vessels within OfTI study area throughout the summer and winter survey periods were both 4 m. There was a greater proportion of small-draught vessels (< 5 m) recorded throughout the winter survey within the OfTI study area.

Figure 12-24 provides an overview of AIS, visual and Radar vessel tracks (excluding temporary traffic) recorded within the OfTI study area throughout the combined 53 day summer and winter survey periods, colour-coded by vessel draught.



Graph 12-10 Vessel Draught Distribution within the OfTI Study Area during 53 Days Summer 2017 and Winter 2016 (AIS, visual and Radar)

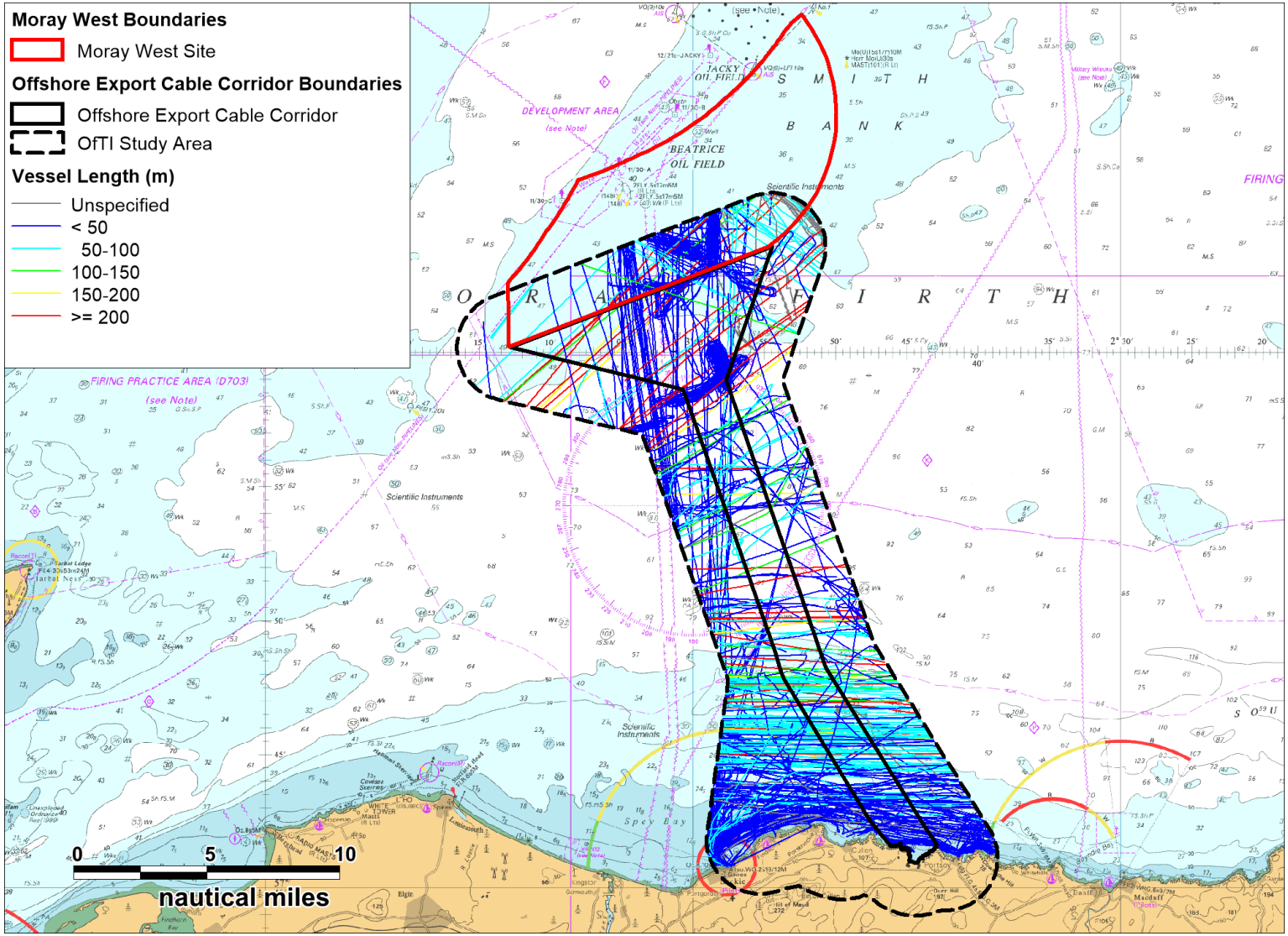


Figure 12-23 AIS, visual and Radar data within OfTI Study Area Colour-Coded by Vessel Length (53 Days Summer 2017 and Winter 2016)

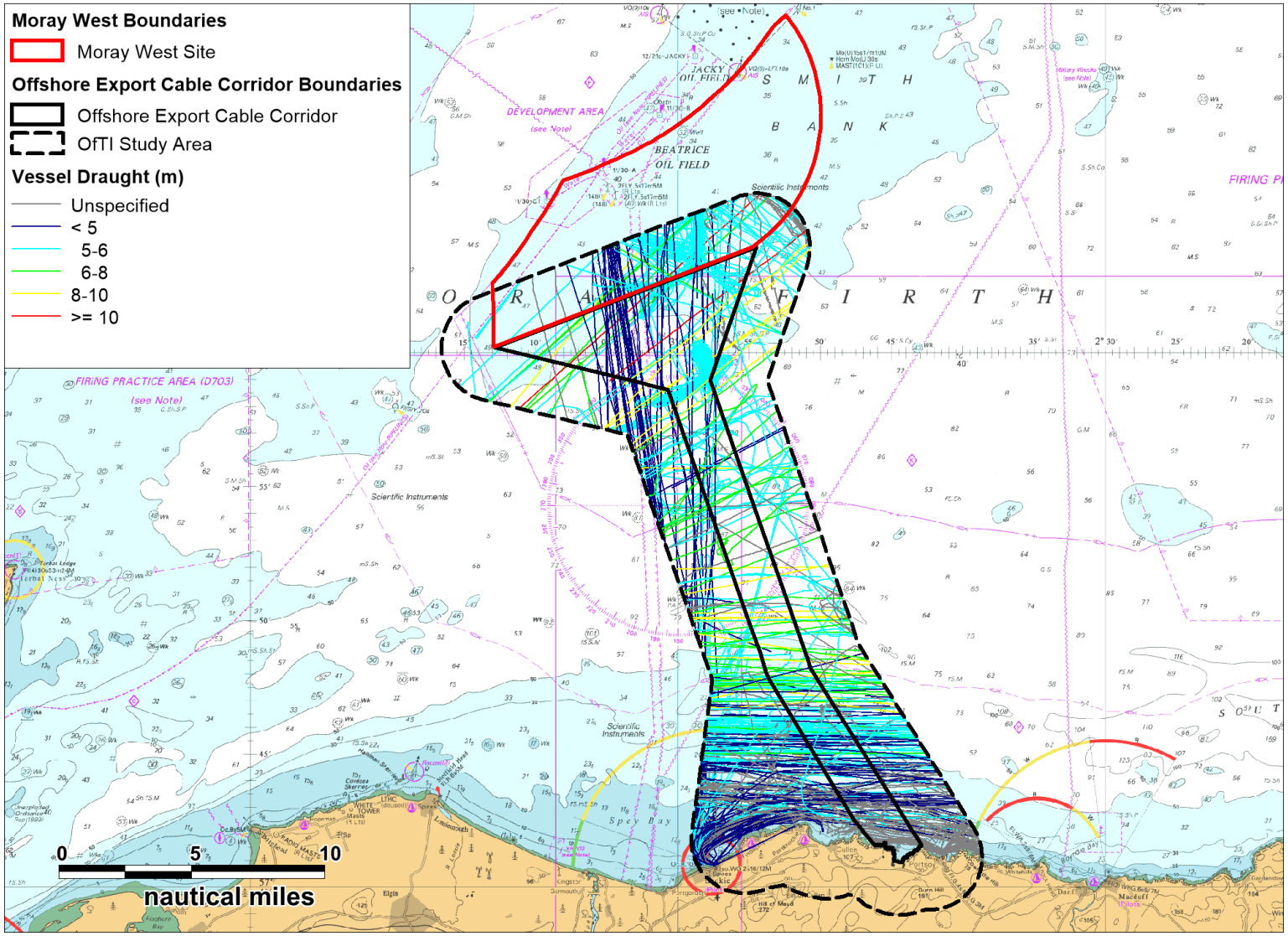


Figure 12-24 AIS, visual and Radar data within OfTI Study Area Colour-Coded by Vessel Draught (53 Days Summer 2017 and Winter 2016)

12.3.4 Anchored Vessels

Anchored vessels can be identified based on the AIS navigational status which is programmed on the AIS transmitter on board a vessel. No vessels were broadcasting as "at anchor" within the OfTI study area during the 53 day survey period. However, information is manually entered into the AIS; and therefore it is common for vessels not to update the navigational status is they are anchored for only a short period of time.

For this reason, vessels which travelled at a speed of less than one knot for more than 30 minutes checked for, on the basis that they may be at anchor. After applying these criteria, no vessels were identified as being at anchor.

12.3.5 Beatrice Oil Field Vessels

This section reviews the vessels associated with the Beatrice Oil Field recorded during the marine traffic surveys.

Throughout the combined summer and winter period, an average of one unique Beatrice field vessel per day passed within the OfTI study area. Figure 12-25 presents a plot of Beatrice oil field vessels recorded within the OfTI study area on AIS, visual and Radar throughout the combined survey periods.

These vessels consisted of oil & gas vessels as well as HSC transfer vessels transiting between Buckie and Beatrice Oil Field (noting that these vessels were also observed to visit the Jacky Field platform).

12.3.6 Passenger Vessels

This section reviews the passenger vessels in the OfTI study area based on the marine traffic surveys.

Throughout the winter survey period, only two unique passenger vessels were recorded within the 28 day period. There was an average of two unique passenger vessels every two days during the 25 day summer survey period. Figure 12-26 presents a plot of passenger vessels recorded within the OfTI study area on AIS, visual and Radar throughout the combined survey periods.

Table 12.2 presents details of the passenger vessels recorded within the OfTI study area throughout the combined survey period.

Table 12.2: Passenger Vessel Details (Corridor) (53 Days Summer 2017 and Winter 2016)

Vessel Name	Vessel Type	Destination	Operator	Survey Period
Jacobite Rebel	Cruise/Tour Vessel	Dochgarroch	Jacobite	Winter
Rover	Local Cruise Vessel	N/A	Clyde Cruises	
Thalassa	Tall Ship	Leith	N/A	Summer
Hebridean Princess	Cruise Vessel	Invergordon	Hebridean Island Cruises	
Europa 2		Invergordon	Hapag-Lloyd Cruises	
Aidavita		Aarhus	AIDA Cruises	
Wind Surf		Invergordon	Windstar Cruises	

Table 12.2: Passenger Vessel Details (Corridor) (53 Days Summer 2017 and Winter 2016)				
Vessel Name	**Vessel Type**	**Destination**	**Operator**	**Survey Period**
Star Pride		Invergordon		
Magellan		Newcastle	Cruise & Maritime Voyages	
Vision of the Seas		Reykjavik	Royal Caribbean	
		Invergordon	Royal Caribbean	
Prinsendam		Rosyth	Holland America	
		Invergordon		
Aidacara		Invergordon	AIDA Cruises	
		Hamburg		
Thomson Celebration		Invergordon	Thomson Cruises	
		Dundee		
MSC Preziosa		Greenock	MSC Cruises	
		Invergordon		
MS Braemar		Scrabster	Fred. Olsen Cruises Lines	
		Invergordon		
Black Watch		Invergordon		
		Ullapool		
		Lerwick		
Caribbean Princess		Invergordon	Princess Cruises	
		South Queensferry		

The majority of passenger vessels were transiting to UK ports with Invergordon the most common destination. Reykjavik (Iceland), Hamburg (Germany) and Aarhus (Denmark) were also recorded destinations.

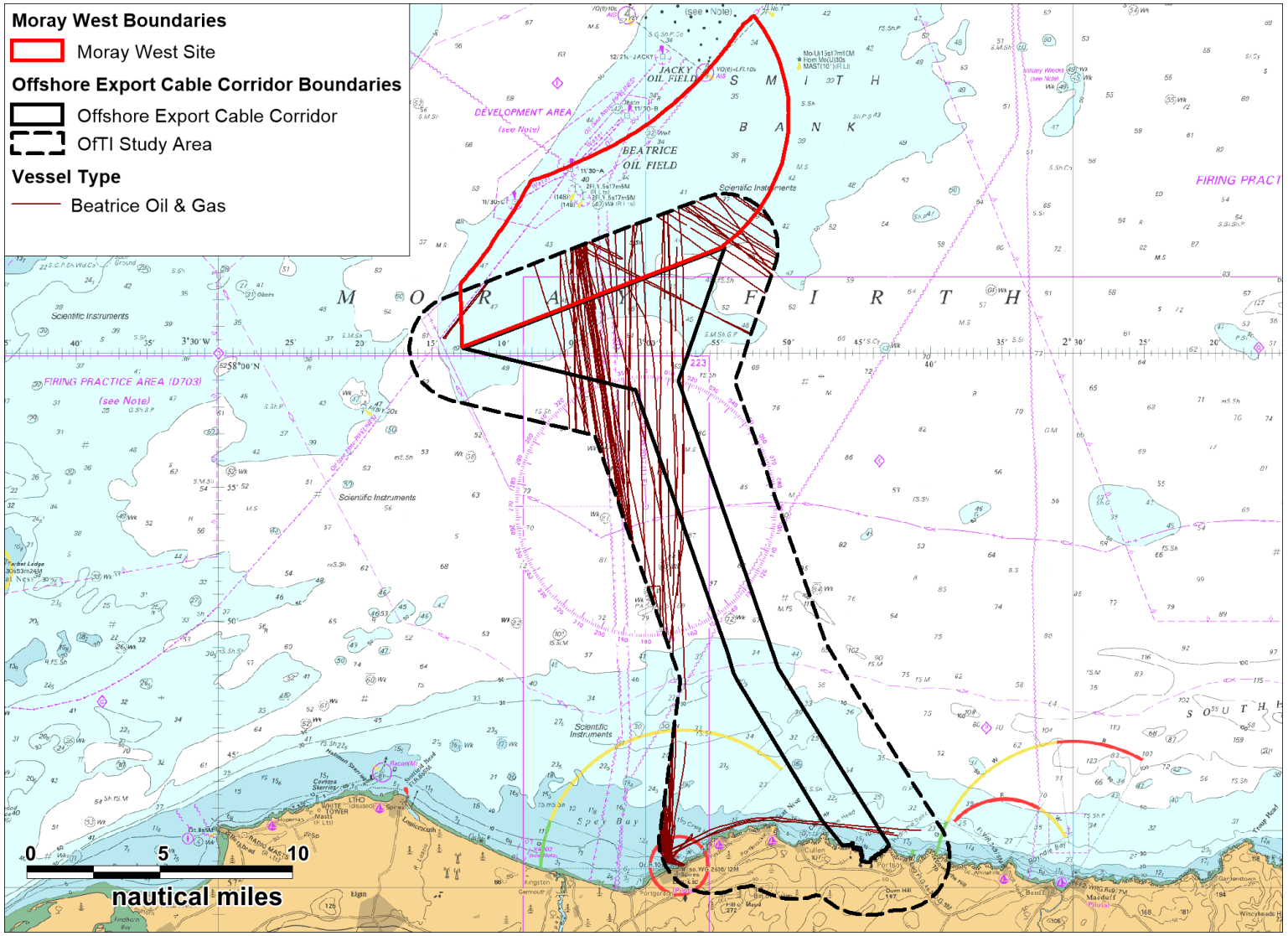


Figure 12-25 **AIS, visual and Radar Beatrice Oil Field Vessels within the OfTI Study Area (53 Days Summer 2017 and Winter 2016)**

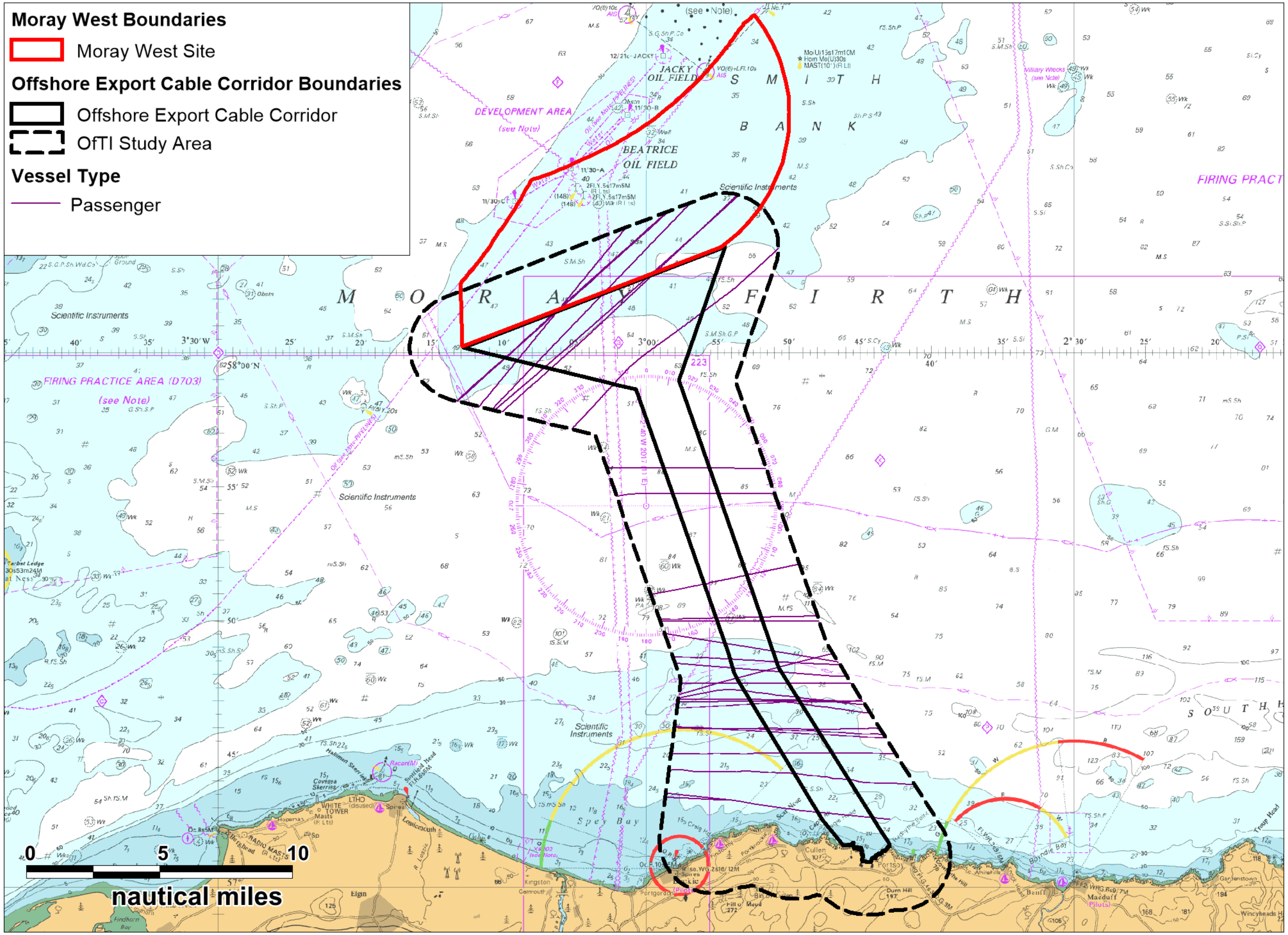


Figure 12-26 AIS, Visual and Radar Passenger Vessels within the OfTI Study Area (53 Days Summer 2017 and Winter 2016)

12.3.7 Recreational Vessels

This section reviews recreational activity in the OfTI study area based on the marine traffic surveys, with Figure 12-28 presenting the recreational tracks recorded during the summer marine traffic survey (no recreational tracks were recorded during winter).

An average of two unique vessels per day were recorded within the OfTI study area during summer. It is noted that all these recreational tracks were recorded on AIS, with no tracks recorded on Radar.

12.3.8 Fishing Vessels

12.3.8.1 Marine Traffic Survey

This section reviews the fishing activity in proximity to the Offshore Export Cable Corridor based on the marine traffic surveys. Fishing vessel activity was recorded using AIS, visual and Radar, with the tracks recorded presented in Figure 12-27. It can be seen that fishing activity was recorded within the OfTI Study Area, with the majority of vessels tracked within the Offshore Export Cable Corridor actively engaged in fishing rather than transiting.

Throughout the combined summer and winter survey periods there was an average of four unique fishing vessels per day within the OfTI study area.

Fishing method information was available for approximately 90% of fishing vessels recorded on AIS, visual and Radar within the OfTI study area. Of the fishing methods identified, the most common were demersal trawling (32%) and dredgers (13%).

Flag state (nationality) information was available for approximately 98% of fishing vessels recorded on AIS, visual and Radar within the OfTI study area. All of the fishing vessels with available nationality information were UK registered (96%). The remaining 4% of tracks were recorded on Radar and therefore their nationalities could not be identified.

12.3.8.2 Sightings Data

Fishing vessel sightings (over flight and/or vessel based) recorded between 2015 and 2016 were analysed for the OfTI study area. The only nationality identified was the UK (100%) while the most common fishing methods identified was demersal trawlers (68%). Other fishing methods recorded included scallop dredgers (17%), unspecified trawlers (9%), potter/whelkers (4%) and other dredgers (2%).

Of the traffic recorded, 95% of fishing vessels were travelling at less than 6 knots therefore was assumed to be actively engaged in fishing activity. This shows good agreement with the fishing vessel tracks shown in Figure 12-27.

12.3.8.3 Satellite Data

Satellite data (from Marine Scotland and collected for fishing vessels of 12m length and over) recorded throughout 2015 and 2016 were analysed for the OfTI study area. The most common nationality identified was the UK (99.98%) followed by French and Dutch registered vessels (both 0.01%). Fishing methods were not available for satellite data.

Of the traffic recorded, 92% of fishing vessels broadcasted their activity as engaged in fishing. Transiting vessels accounted for 8% traffic. As with the sightings data, the nationality and speed distributions show good agreement with the corresponding distributions for the survey data.

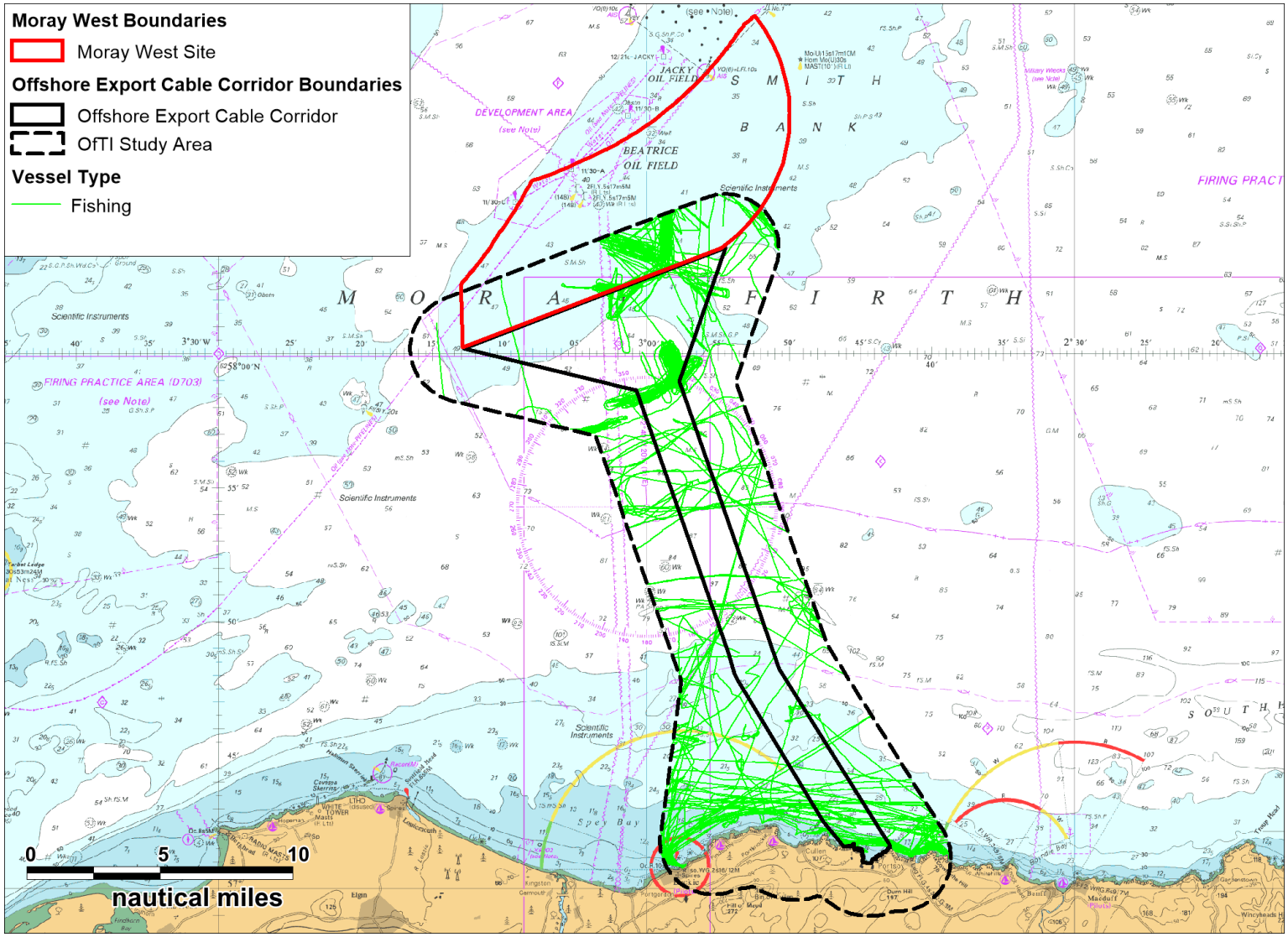


Figure 12-27 AIS, Visual and Radar Fishing Vessels within the OfTI Study Area (53 Days Summer 2017 and Winter 2016)

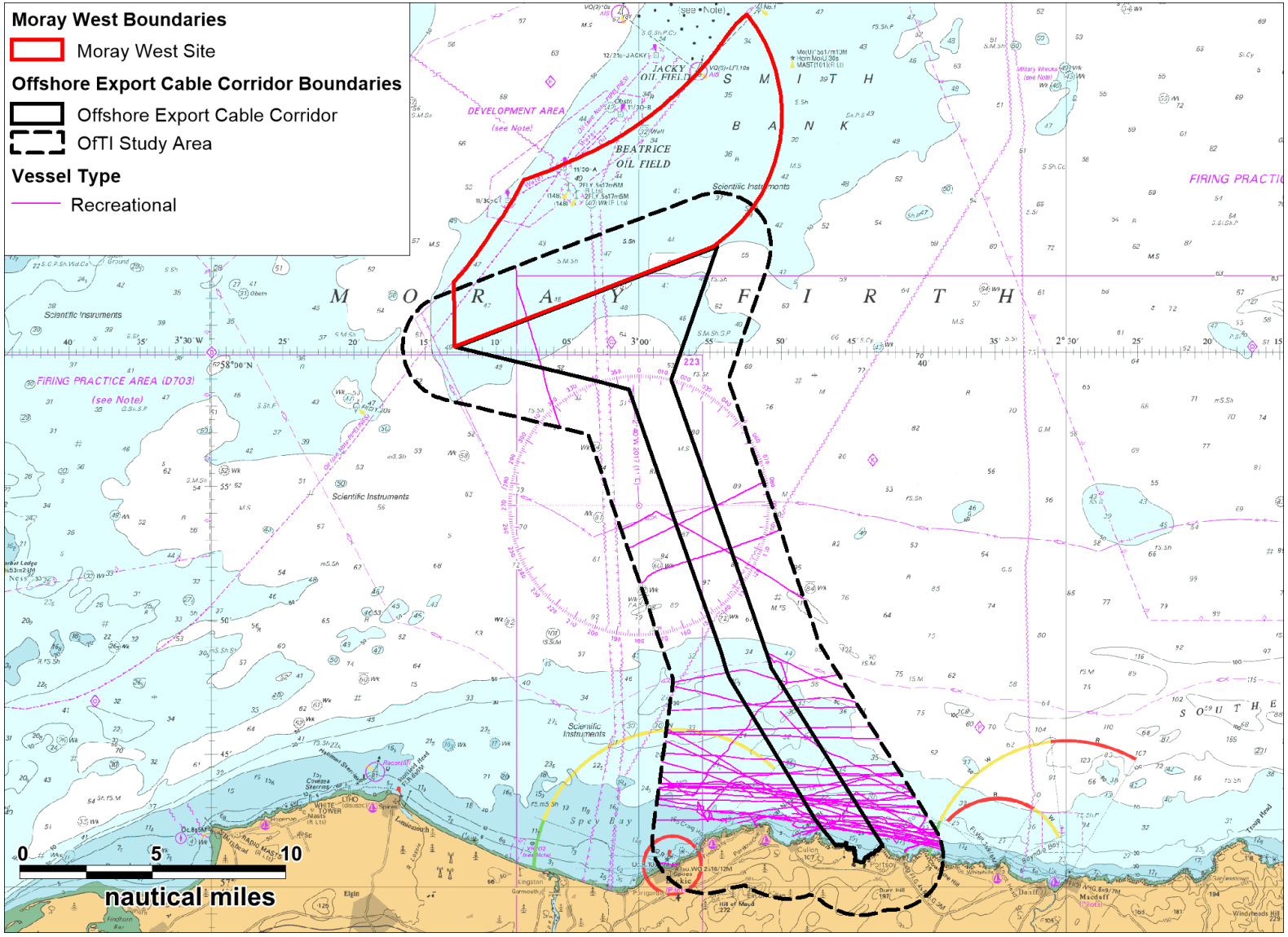


Figure 12-28 AIS, Visual and Radar Recreational Vessels within the OfTI Study Area (25 Days Summer 2017)

13 Base Case Routeing Analysis (Pre-Wind Farm)

13.1 Methodology

13.1.1 Marine Traffic

This section provides an assessment of the base case regular vessel routeing within the vicinity of the Moray West Site. This assessment has been primarily based on the marine traffic survey data (see Section 12), however Anatec's internal UK route database has been used for validation purposes.

13.1.2 Beatrice Oil Field Traffic

Based on consultation responses (see Section 5.2) and on the current understanding of decommissioning programmes, traffic associated with the Beatrice Oil Field has been retained in this routeing analysis. It should be considered that actual numbers of vessels associated with the Beatrice field may fluctuate depending on the stage of decommissioning; however base case numbers have been estimated based on the marine traffic data to provide an indication of current levels (the potential for future traffic growth has been accounted for within the modelling process).

13.1.3 Beatrice Offshore Wind Farm

As the marine traffic data (section 12) was recorded prior to the commencement of construction of BOWL, the traffic patterns observed did not reflect potential deviations arising from the BOWL buoyed construction area.

Two routes were identified as likely to have deviated to avoid the BOWL buoyed construction area (Routes 4 and 6 in the proceeding sections). As BOWL has been considered as part of the baseline (see Section 8.2 and Section 12), these routes have been deviated to represent the likely passage that the associated vessels will take during the BOWL construction phase (noting that the corresponding deviations during the operational phase are considered likely to be similar).

13.2 Routes

The marine traffic data presented in Section 12 was used to identify the main vessel routes within the vicinity of the Moray West Site. The routes identified are presented in Figure 13-1, with details per route then provided in Table 13.1, including the most common destinations of vessels on that route.

The destinations provided per route represent the most common destinations identified from vessels using that route (based on the marine traffic survey data), and a vessel on a given route will therefore not necessarily be associated with either destination listed.

As discussed in Section 13.1.3, the mean route position presented for Route 6[8] has been deviated to account for the BOWL.

[8] Note that rather than deviating the mean route position of Route 4, the width of the percentile has been reduced to account for the BOWL as would be typical in this type of scenario.

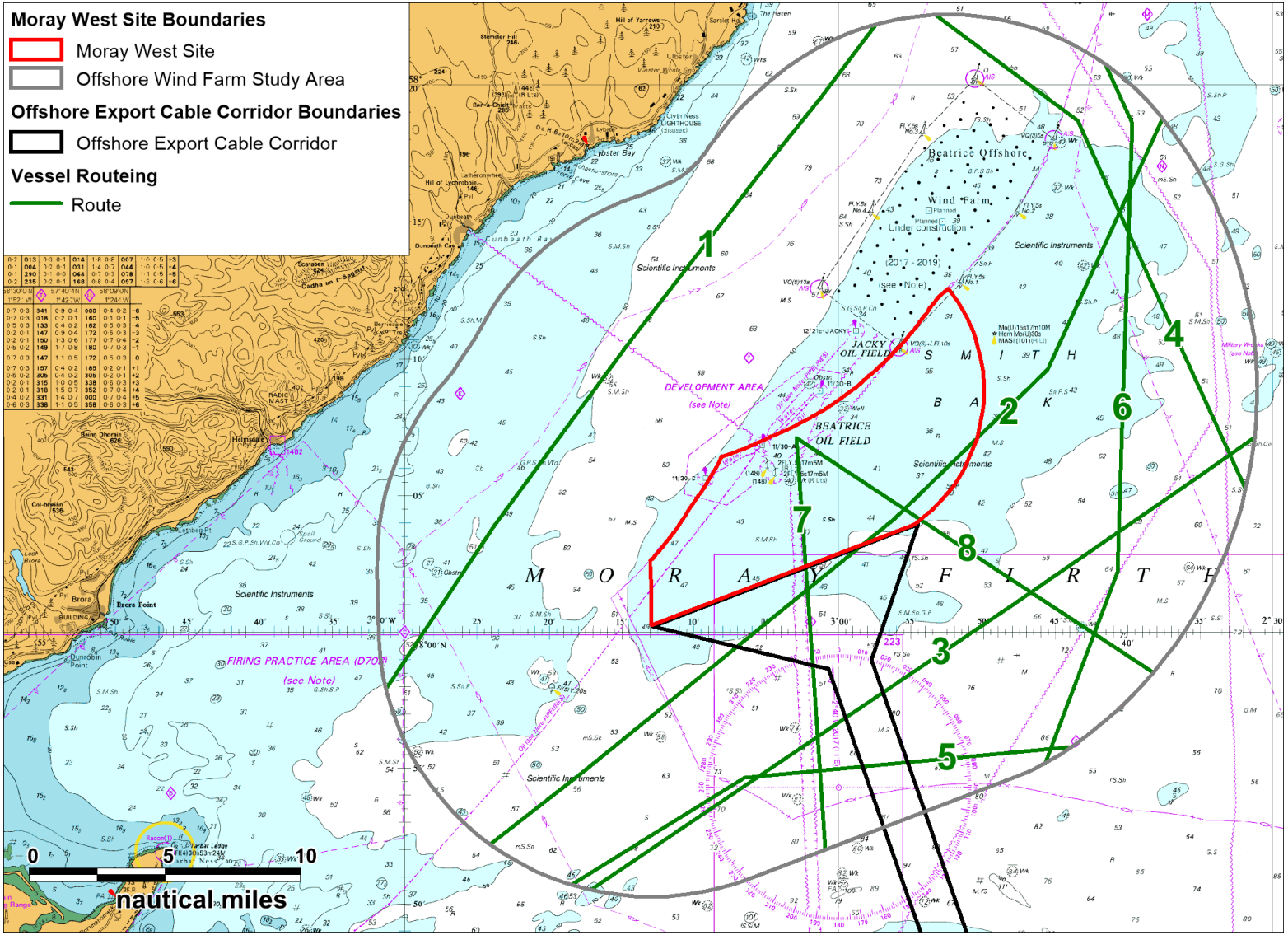


Figure 13-1 Base Case Vessel Routeing

Table 13.1: Main Routes

Route ID	Ports	Approximate Vessels per Year	Summary
1	Cromarty or Inverness Firth – Kirkwall or Lerwick	350	Route used by cargo vessels, tankers, passenger vessels and oil and gas vessels
2	Invergordon - Lerwick	145	Mainly used by passenger vessels
3	Invergordon – Captain Field	100	Mainly used by vessels associated with the Captain Field
4	Wick – Immingham	30	Used by tankers, passenger vessels and "other" vessels
5	Invergordon - Dunbar	40	Used mainly by cargo vessels and passenger vessels
6	Buckie - Orkney	30	Used mainly by cargo vessels.
7	Buckie – Beatrice Field	370	Crew transfer to the Beatrice Oil Field
8	Aberdeen / Peterhead – Beatrice Field	140	Supply vessel traffic to Beatrice Field

13.3 Percentiles

The 90th percentile lanes, which have been estimated from the mean route positions and marine traffic survey data, are presented in Figure 13-2, colour coded by vessel density. The corresponding routes (as summarised in Table 13.1) are included in the figure.

As discussed in Section 13.1.3, the percentiles for Routes 4 and 6 take account for the BOWL project.

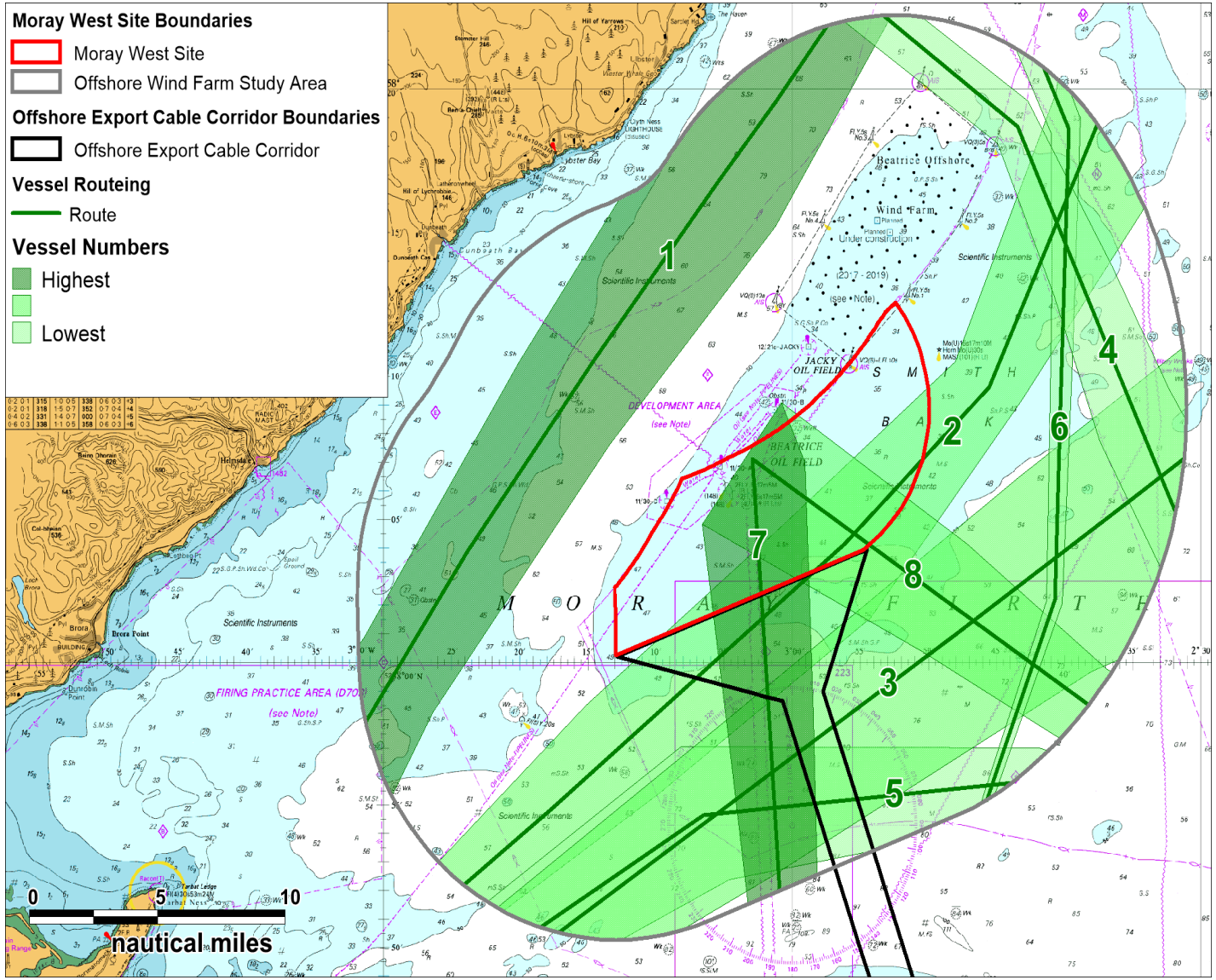


Figure 13-2 Base Case 90th Percentiles

13.4 Adverse Weather Routeing

Adverse weather includes wind, wave and tidal conditions as well as reduced visibility due to fog that can hinder a vessel's normal route and / or speed of navigation. Adverse weather routes are assessed to be significant course adjustments to mitigate vessel movement in adverse weather conditions. When transiting in adverse weather conditions, a vessel is likely to encounter various kinds of weather and tidal phenomena, which may lead to severe roll motions, potentially causing damage to cargo, equipment and / or danger to persons on board. The sensitivity of a vessel to these phenomena will depend on the actual stability parameters, hull geometry, vessel type, vessel size and speed.

The probability of occurrence in a particular sea state may differ for each vessel. Adverse weather is considered most significant for passenger vessels, due to the potential health and safety risks (as well as the effect on passenger comfort) to people on board (such as sea sickness and difficulty moving around the vessel). This can also have implications for regular timetabled vessels, due to increases in journey time and potential cancellations. Mitigations for vessels include adjusting their heading to position themselves 45° to the wind, altering or delaying sailing times, reducing speed and potentially cancelling journeys.

Minimal adverse weather routeing was observed within the marine traffic survey data as shown in Figure 13-3 where by Ro-Ro vessels, Helliar and Hildasay (Northlink Ferries) amend their course to enter the Moray Firth area to minimise the impacts on strong wind in the area on both the 6th (Helliar track passing through BOWL) and 17th November (Helliar track passing through Moray West and Hildasay passing through BOWL). It is noted that these tracks were recorded pre-construction of BOWL, and it is likely that vessels would take adverse weather courses passing to the east of BOWL and thus meaning there are no impacts associated with Moray West. However in extreme weather conditions, vessels may still enter the Moray Firth area and transit west and north or west and south of the Moray West and BOWL sites.

Vessels may also enter the Moray Firth to seek sheltered waters in the event of adverse weather; either to anchor or to stem the tide. However there is considered to be ample sea area for this purpose out with the Moray West Site (and other installations) for the purposes of sheltering.

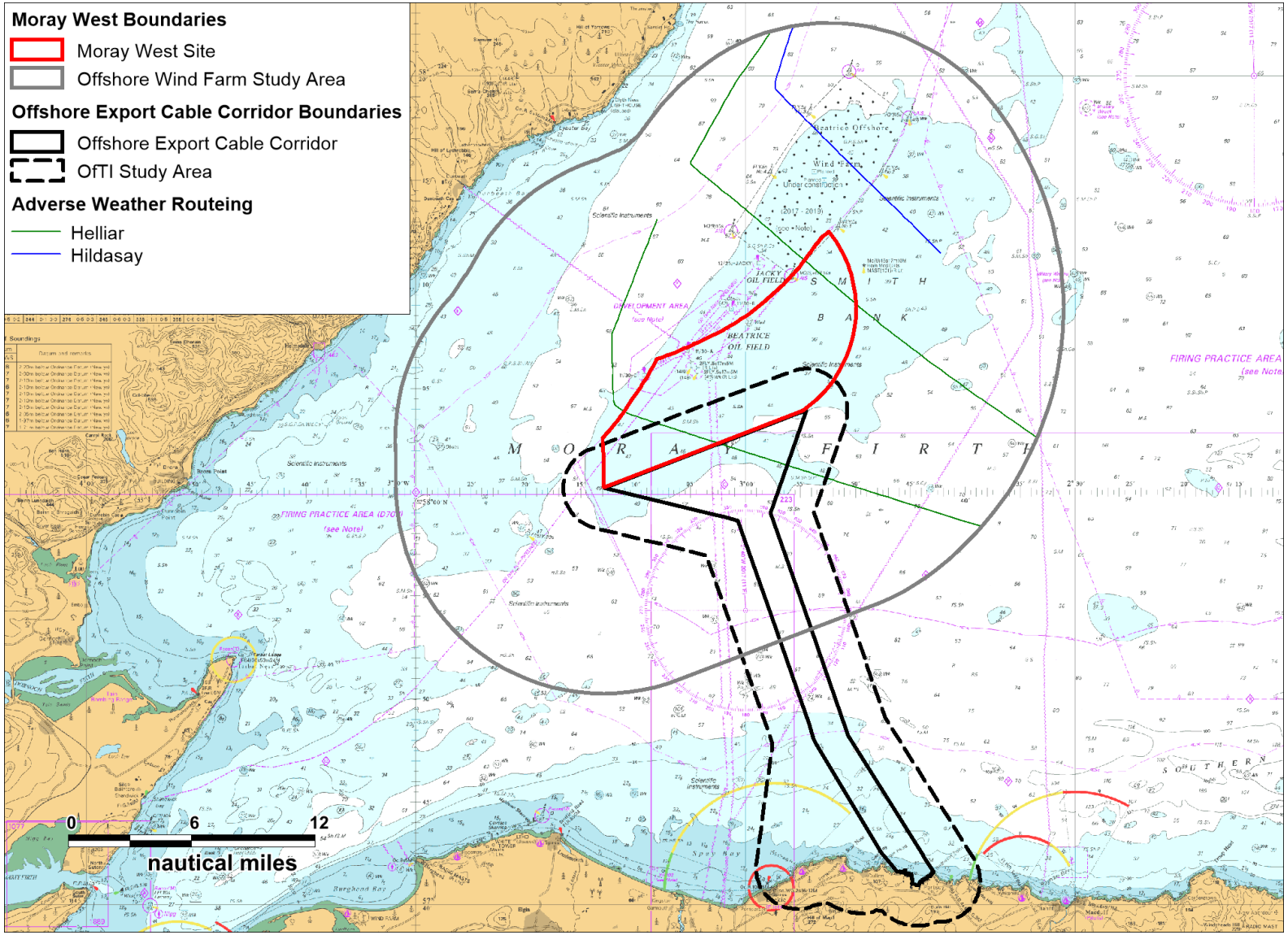


Figure 13-3 Adverse Weather Routeing

14 Post Wind Farm Routeing Analysis

14.1 Introduction

This section provides likely route deviations that will arise during the operational phase of the Moray West Site (noting that deviations are likely to be similar around the buoyed construction area during the construction phase). As shown in Section 13.2, three of the eight identified routes intersect the Moray West Site, and will therefore require deviation (routes 2, 7, and 8).

It has been assumed that deviated vessels will keep a distance of at least one nautical mile from the Moray West Site. The anticipated future case routes are presented in Figure 14-1 on that basis, with detailed views of the three deviated routes then presented in Sections 14.2, 14.3, and 14.4.

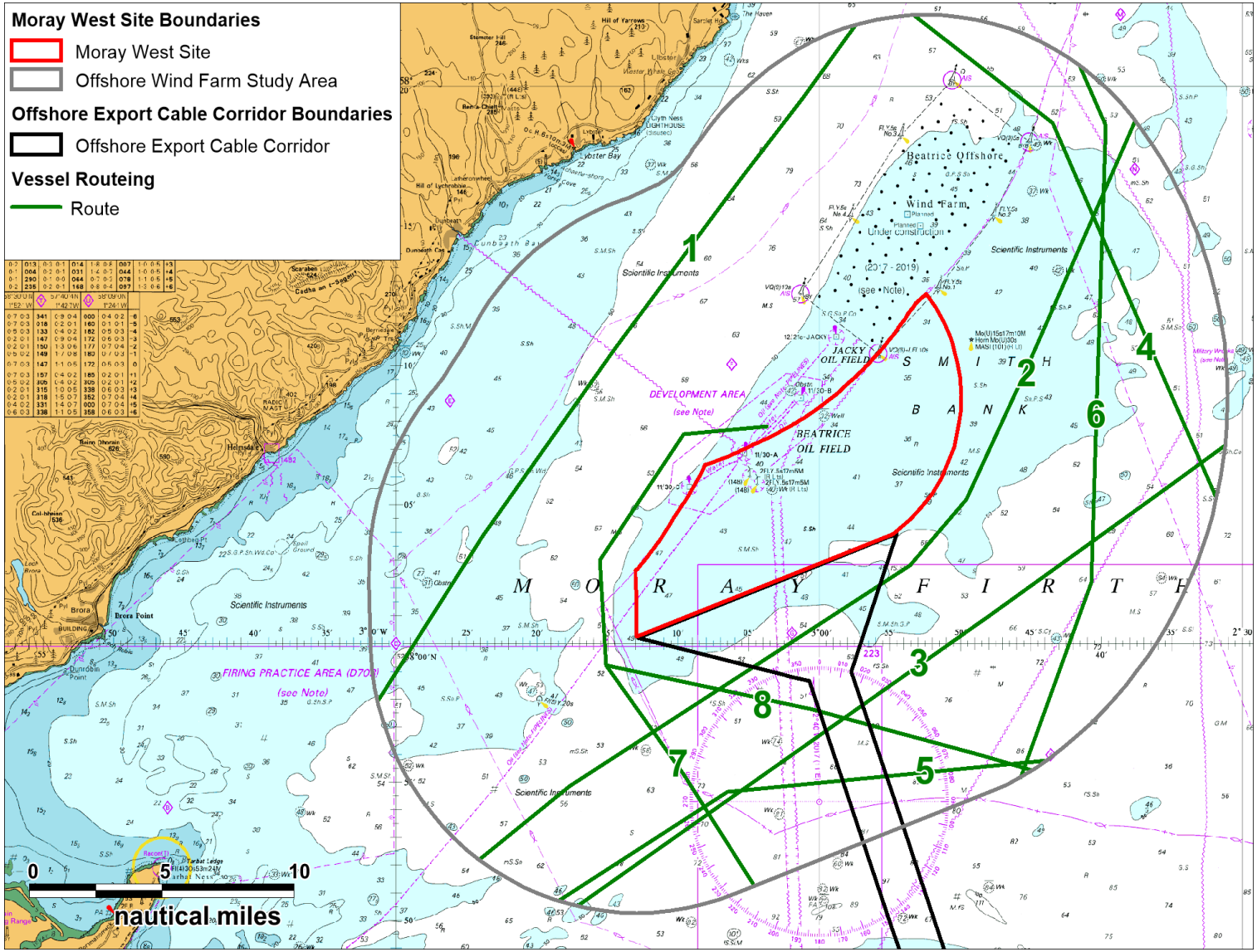


Figure 14-1 Future Case Vessel Roueting

14.2 Route 2 Deviation

The anticipated deviation of Route 2 is shown in Figure 14-2. This route is largely used by passenger vessels running between Invergordon and Lerwick, and it is considered unlikely that such vessels would transit through the Moray West Site. It has therefore been assumed that (based on the position of the original route) that these vessels will pass south of the Moray West Site, as shown in Figure 14-2. It should be noted that, in reality, vessels on Route 2 may also choose to pass inshore of the Moray West Site.

It was estimated that the deviation assessed for Route 2 will result in an increase in journey distance of less than 1% when compared to the pre-wind farm case.

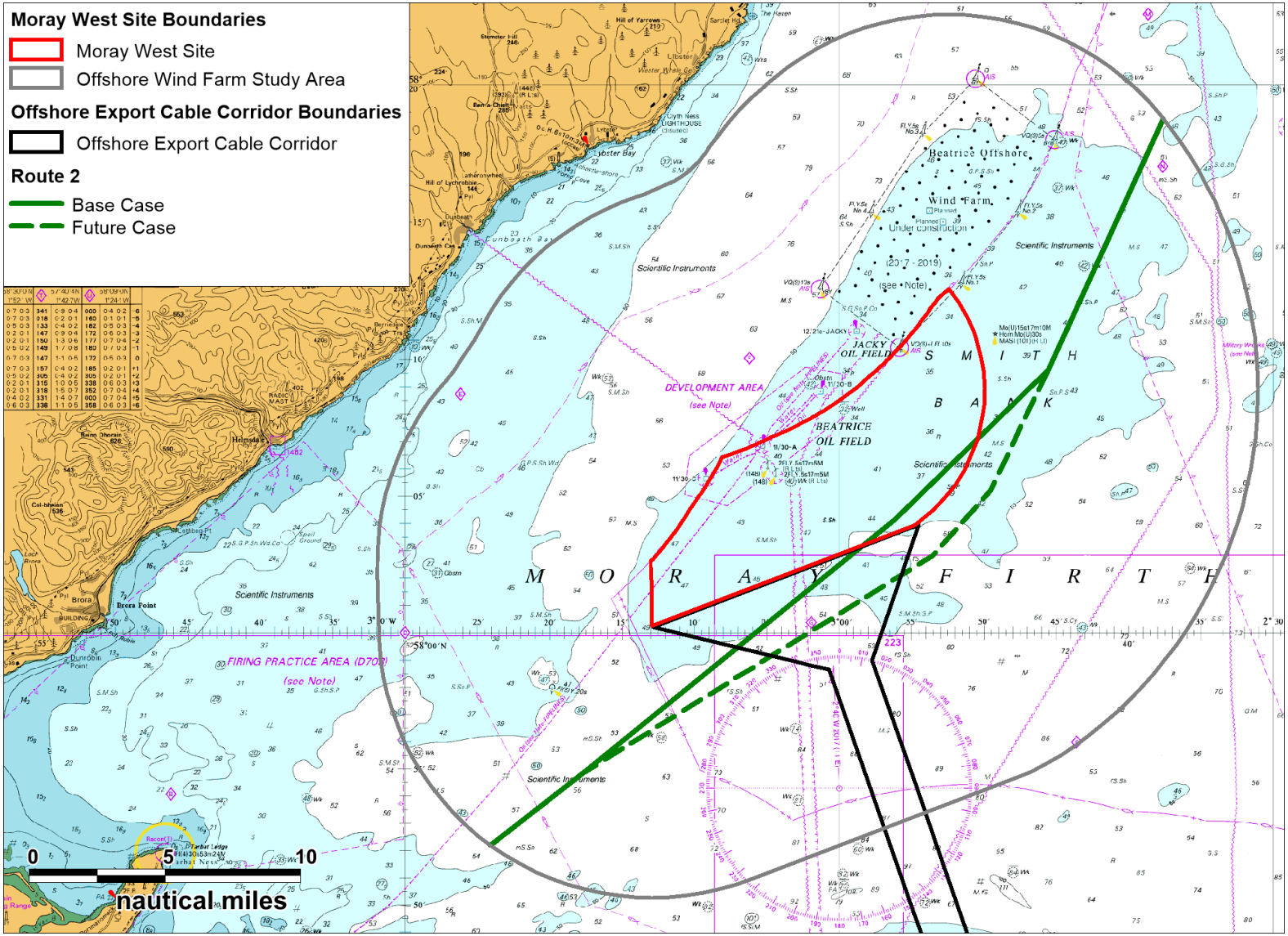


Figure 14-2 Route 2 Deviation

14.3 Route 7 Deviation

Route 7 defines the crew transfer route between Buckie and the Beatrice oil field (see Table 13.1). Due to the size of crew transfer vessels, there is the potential for such vessels to transit through the Moray West Site during the operational phase (i.e., resulting in no deviation following the completion of Moray West construction). However, for the purpose of assessing the worst case (in terms of deviation), it has been assumed that they will continue to deviate around the Moray West Site, as shown in Figure 14-3.

It was estimated that the deviation assessed for Route 7 will result in an increase in journey distance of approximately 27% when compared to the base case (from 26nm to 33nm).

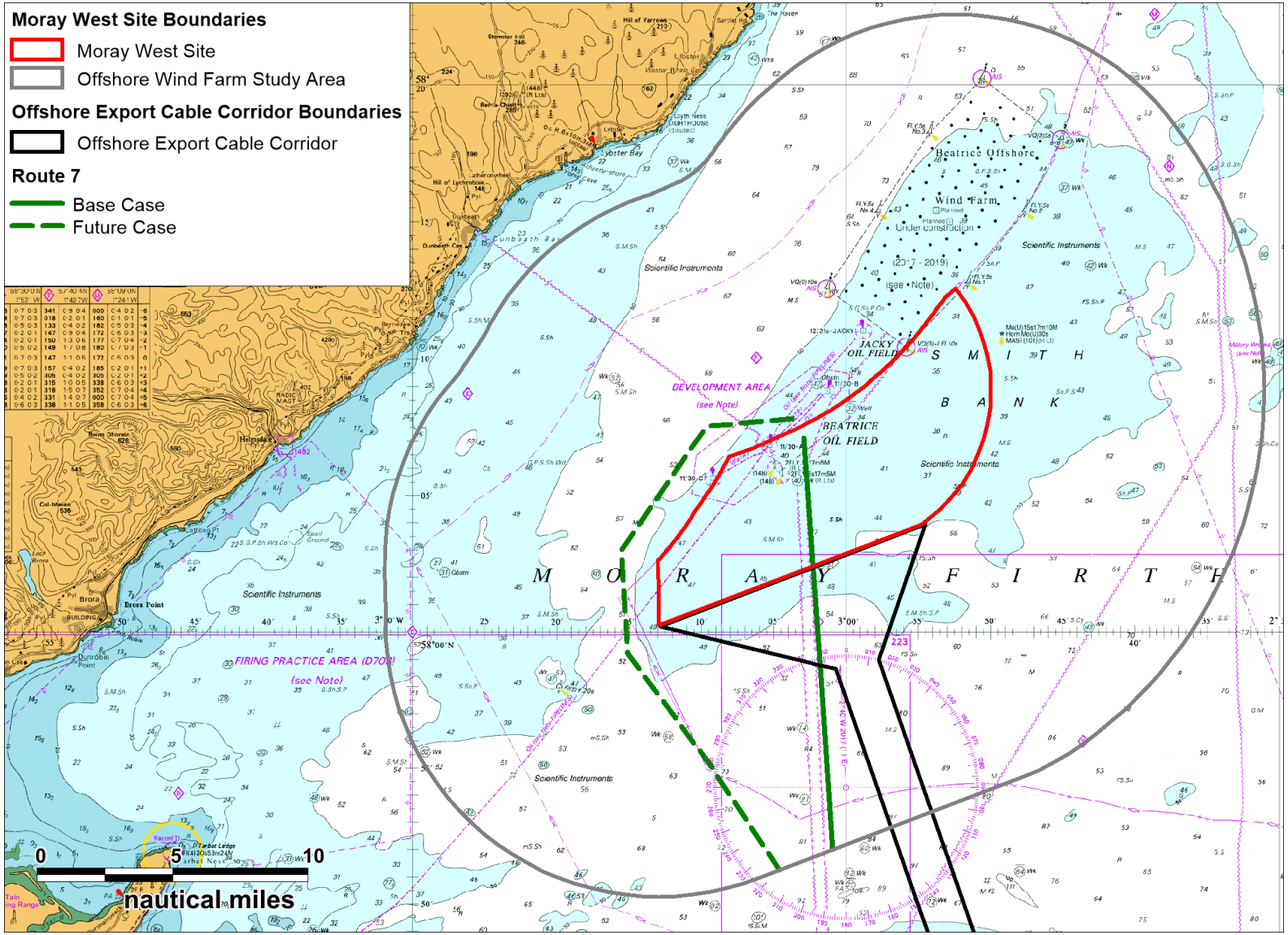


Figure 14-3 Route 7 Deviation

14.4 Route 8 Deviation

Route 8 is used by oil and gas supply traffic, running between Peterhead and the Beatrice field. These vessels are likely to avoid transiting through the Moray West Site (they are larger than the crew transfer vessels discussed in Section 14.3). As shown in Figure 14-4, it is considered likely that the associated vessels will pass south of the Moray West Site, as the presence of the BOWL would cause a larger deviation to the north.

It was estimated that the deviation assessed for Route 8 will result in an increase in journey distance of approximately 25% when compared to the base case (from 60 nm to 76 nm).

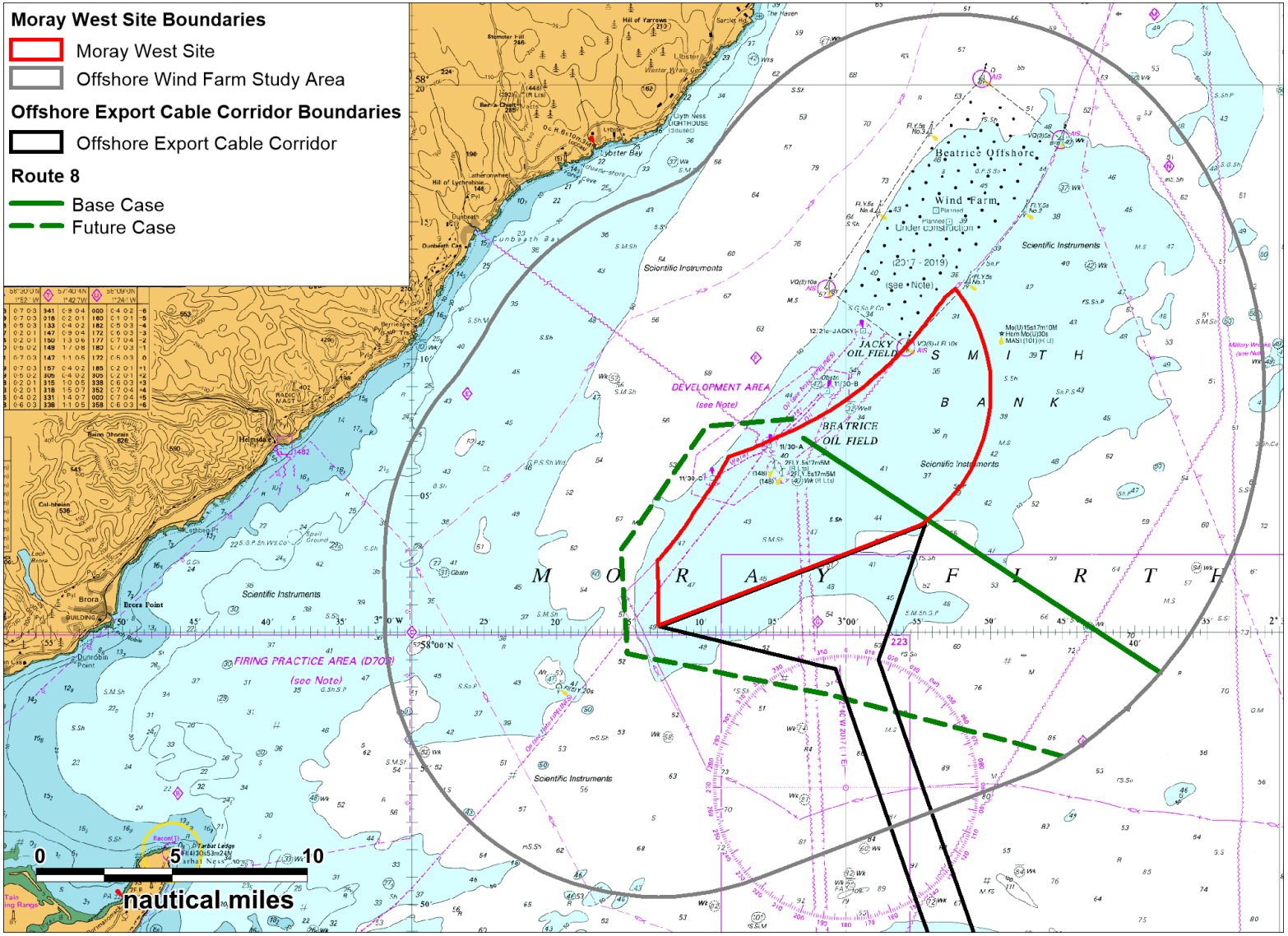


Figure 14-4 Route 8 Deviation

14.5 Simulated AIS – Future Case

To illustrate the anticipated vessel activity from regular routed traffic, the deviated routes presented in Figure 14-1 were used as input to Anatec's AIS simulator. This program creates randomised AIS tracks on each input route based on the mean route positions, standard deviations, and vessel numbers. The results are presented in Figure 14-5. It is noted that deviations are presented as realistic worst case and in reality vessels would distance themselves appropriately from the Moray West Site in line with MGN 372 (MCA, 2008) depending on weather (notable visibility) and sea state.

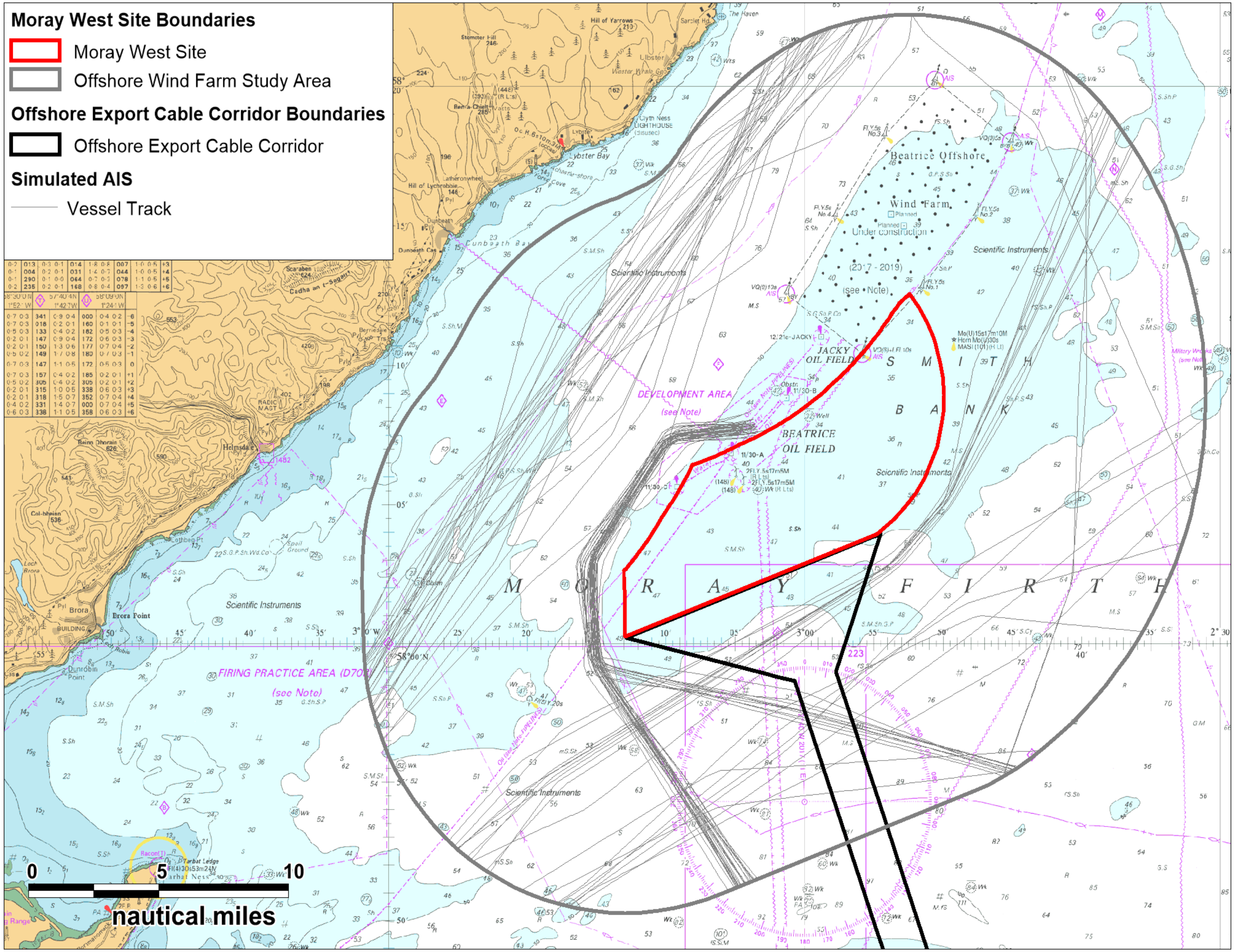


Figure 14-5 Simulated AIS – Future Case

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15 Collision and Allision Risk Modelling Overview

15.1 Introduction

This section provides an overview of the allision and collision risk modelling process which has been undertaken for the Moray West Site. The following allision and collision risks have been assessed within this NRA:

- Increased vessel to vessel collision;
- Additional vessel to structure allision from a vessel under power (regular routed traffic);
- Additional vessel to structure allision from a drifting vessel (regular routed traffic); and
- Additional vessel to structure allision (fishing vessels).

A pre wind farm assessment is provided in Section 16, with the post wind farm then assessed in Section 17.

15.2 Potential Traffic Increases (Future Case)

There is the potential for traffic levels to increase during the lifespan of the Moray West Site, which may lead to increases in allision and collision risk within the area. Accurate forecasts of traffic increases are difficult, as a large number of variables require consideration. For this reason, an indicative value of a 10% increase of all vessel types has been assessed within this NRA, in addition to an assessment of risk should traffic levels remain constant. This increase is in line with the assessments undertaken for other UK wind farms, and therefore ensures a consistent approach with existing assessments. It is noted that this value relates to number of vessels rather than increases in overall tonnage.

The increase was implemented by increasing the total vessel numbers per route shown in Table 13.1 by 10%, maintaining the breakdowns by vessel type and size. The updated vessel numbers were then rounded to the nearest whole number[9].

It should be noted that with ongoing decommissioning of various North Sea fields (and the Beatrice Field within the Moray Firth), UK oil and gas traffic is expected to decline in the long term. However, on the basis that an accurate timeframe within which this decline will occur cannot be accurately predicted, the 10% increase has been applied to oil and gas traffic, which represents a conservative approach.

On this basis, the following scenarios have been assessed:

- Base Case Allision[10] and Collision Risk – pre wind farm;
- Base Case Allision and Collision Risk – post wind farm;
- Future Case Allision[10] and Collision Risk – pre wind farm; and
- Future Case Allision and Collision Risk – post wind farm.

15.3 Modelled Layout and Structure Dimensions

The worst case layout which has been used as input to the modelling process is presented in Figure 4-2 (within Section 4.4). Justification for this choice is provided within the same section. The WTG and OSP dimensions which have been modelled are presented in Table 15.1. It should be noted that neither set of dimensions presented in Table 15.1 are the largest under consideration, however as the worst case layout

[9] Rounding means that in certain instances updated traffic volumes are not precisely a 10% increase, however any resultant discrepancies are considered minor.
[10] Note that allision risk is zero pre-wind farm.

represents the maximum number of WTGs and OSPs, the corresponding dimensions have been chosen for the purposes of the modelling.

Table 15.1: Modelled Dimensions

Structure	Shape	Dimensions
WTG	Rectangle	35 x 35m
OSP	Rectangle	50 x 50m

15.4 Metocean Data

The following Metocean data has been used as input to the modelling process. Further details on each are provided in Section 9:

- Wind direction;
- Wave height;
- Tidal streams; and
- Visibility.

16 Moray West Site in Isolation Assessment – Base Case

16.1 Introduction

This section provides an assessment of the base case collision risk within the vicinity of the Moray West Site (i.e., the vessel to vessel collision rates pre wind farm). The marine traffic survey data has been used to run an encounters assessment, which provides an indication of how often vessels pass in close proximity within the area. The base case collision rates of regular routed traffic have then been estimated, using the routes presented in Section 13.

16.2 Encounters

16.2.1 Introduction

The marine traffic survey data was used to identify all case of vessel "encounters" recorded during the survey periods. An encounter is defined as two (or more) vessels passing within one nautical mile of each other. This helps to illustrate where existing shipping congestion is highest and therefore where offshore developments, such as windfarms, could potentially increase congestion and therefore also increase the risk of encounters / collisions.

The following should be considered when viewing the encounters analysis:

- As the winter survey was AIS only, any encounters including a non-AIS vessel (e.g., fishing vessels less than 15 m, recreational vessels) are not accounted for during the winter survey period.
- During summer, not all radar vessels were able to be identified, meaning there were cases where it was unclear as to if encounters were genuine, or simply a vessel encountering itself. Such cases have been retained in the assessment.
- Cases of vessels engaged in towing operations, or other dual-vessel operations have been excluded, on the basis that they are not genuine encounters. However, encounters between vessels associated with the Beatrice field have been retained, on the basis that it could not be confirmed as to if the vessels involved were engaged in independent activities.

16.2.2 Encounters Overview

An overview plot of the tracks identified as being involved in an encounter are presented in Figure 16-1, colour-coded by vessel type. Where only one transmitted data point from a vessel was recorded within an encounter zone, only the single point has been shown. Otherwise, the track created by joining the points transmitted within the zone has been shown.

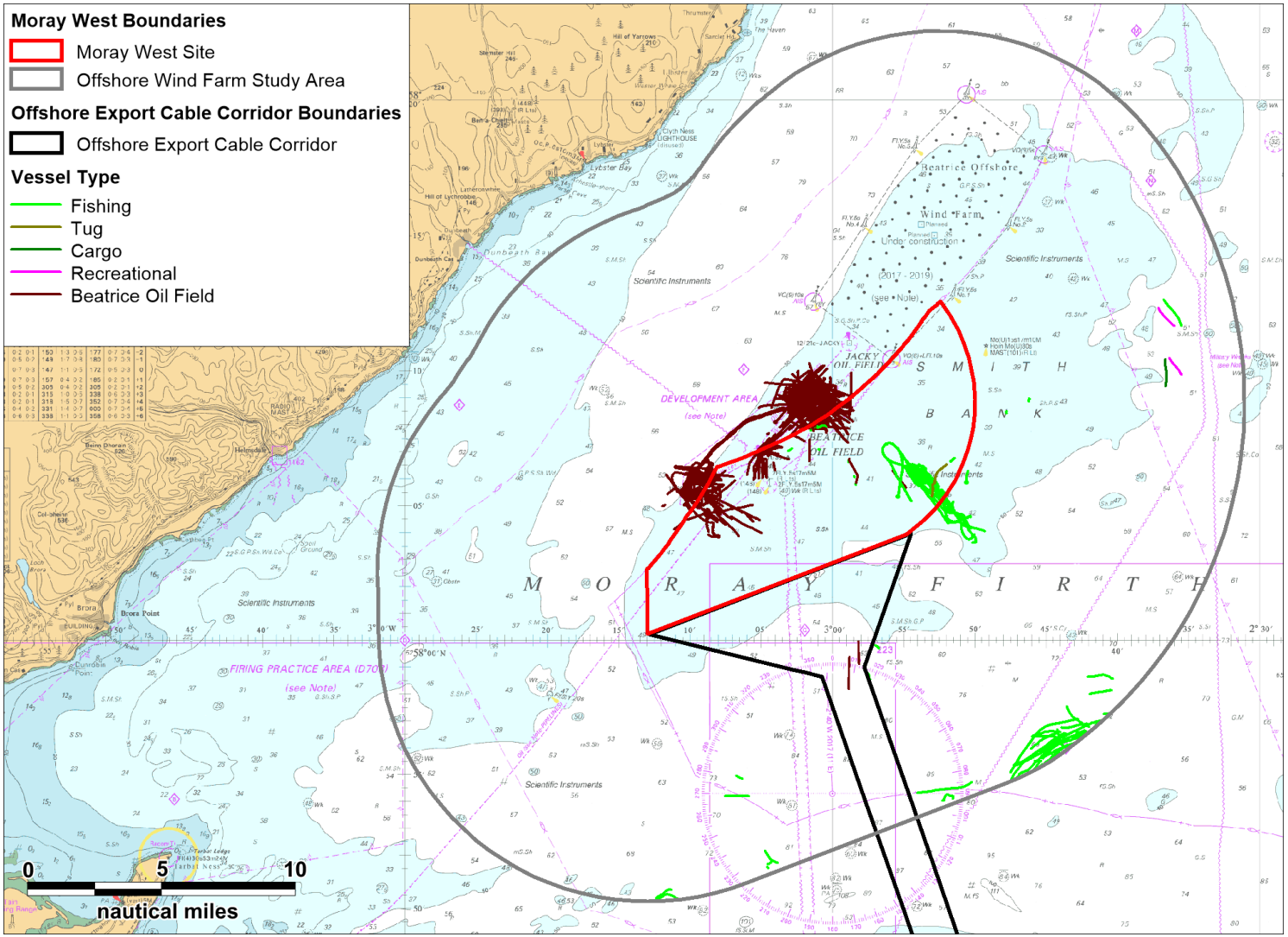
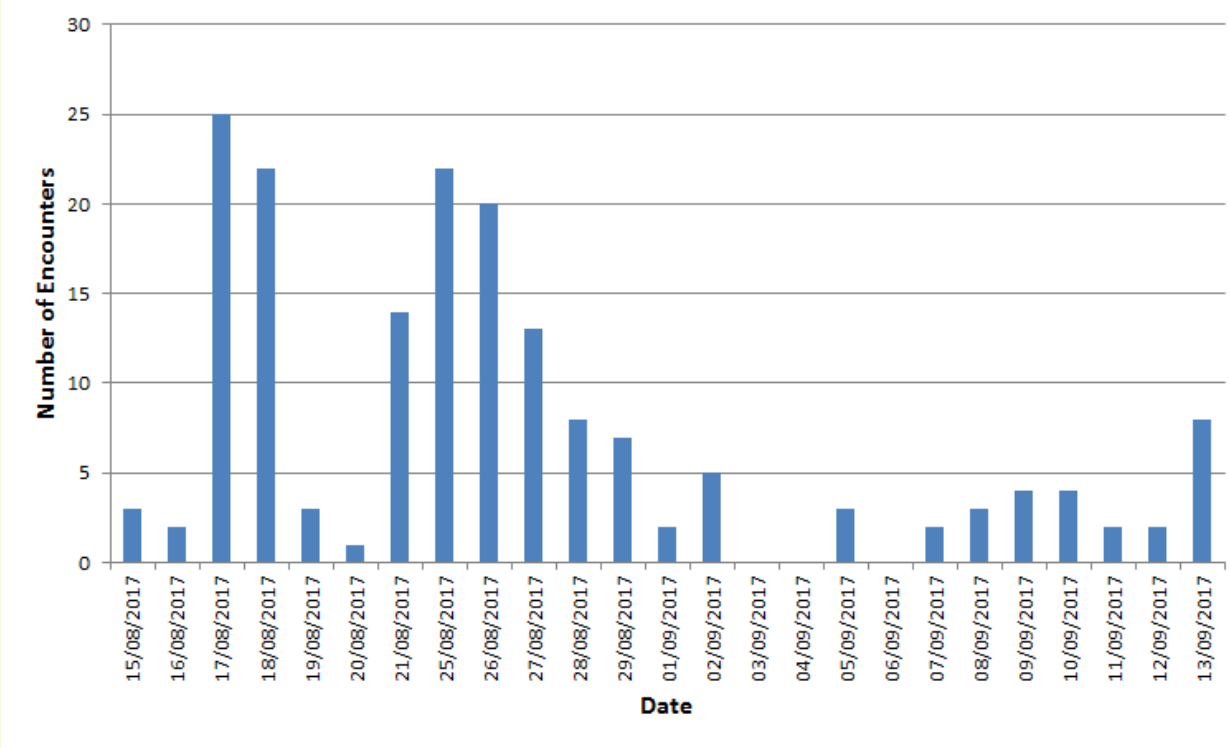


Figure 16-1 Encounters Overview

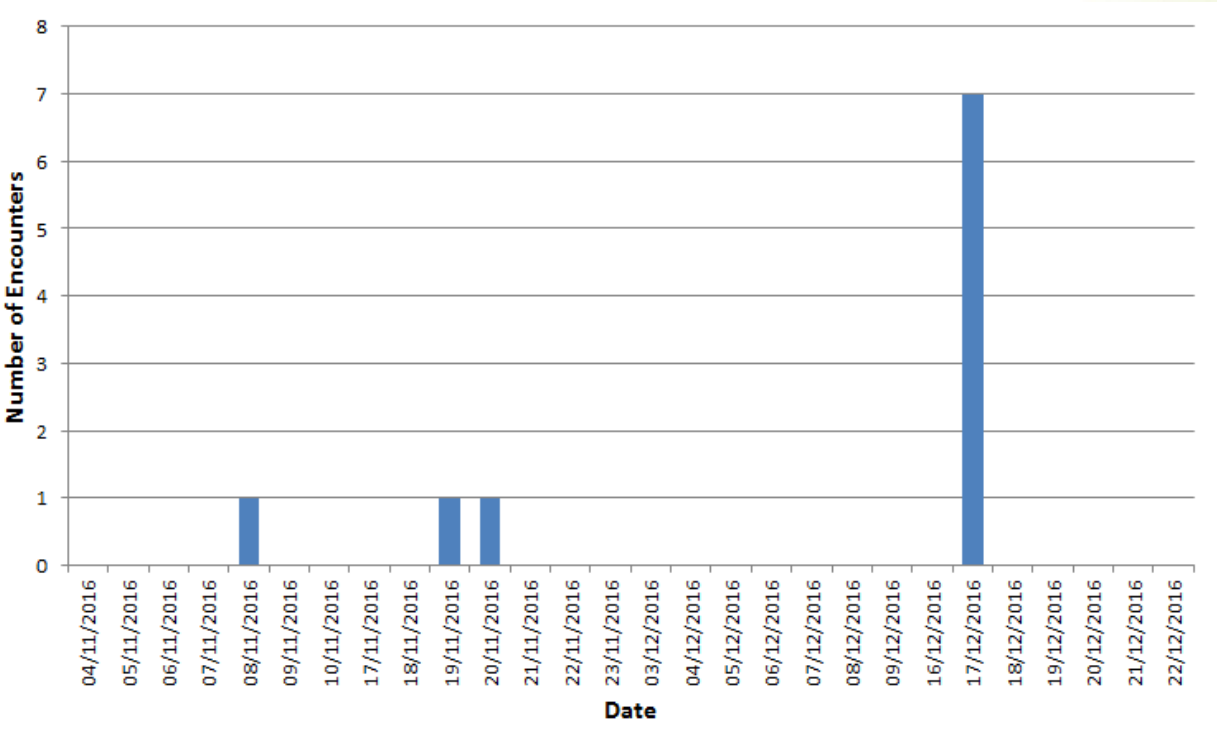
The majority of encounters were recorded between vessels associated with the Beatrice oil field, or between vessels engaged in fishing activities. This included encounters occurring within the Moray West Site. No encounters were recorded between regular routed commercial vessels (the identified routes are presented in Section 13). This is likely due to there being enough sea room either side of the Beatrice oil field for such vessels to pass each other at a safe distance, and routes used by not more than one vessel a day on average.

16.2.3 Daily Counts

The number of encounters recorded during the summer and winter survey periods are presented in Graph 16-1 and Graph 16-2 respectively. As discussed in Section 16.2.1, it should be considered when viewing these figures that encounters involving a non-AIS vessel are not accounted for in the winter assessment.



Graph 16-1 Number of Encounters – Summer Period (AIS and Radar)



Graph 16-2 Number of Encounters – Winter Period (AIS Only)

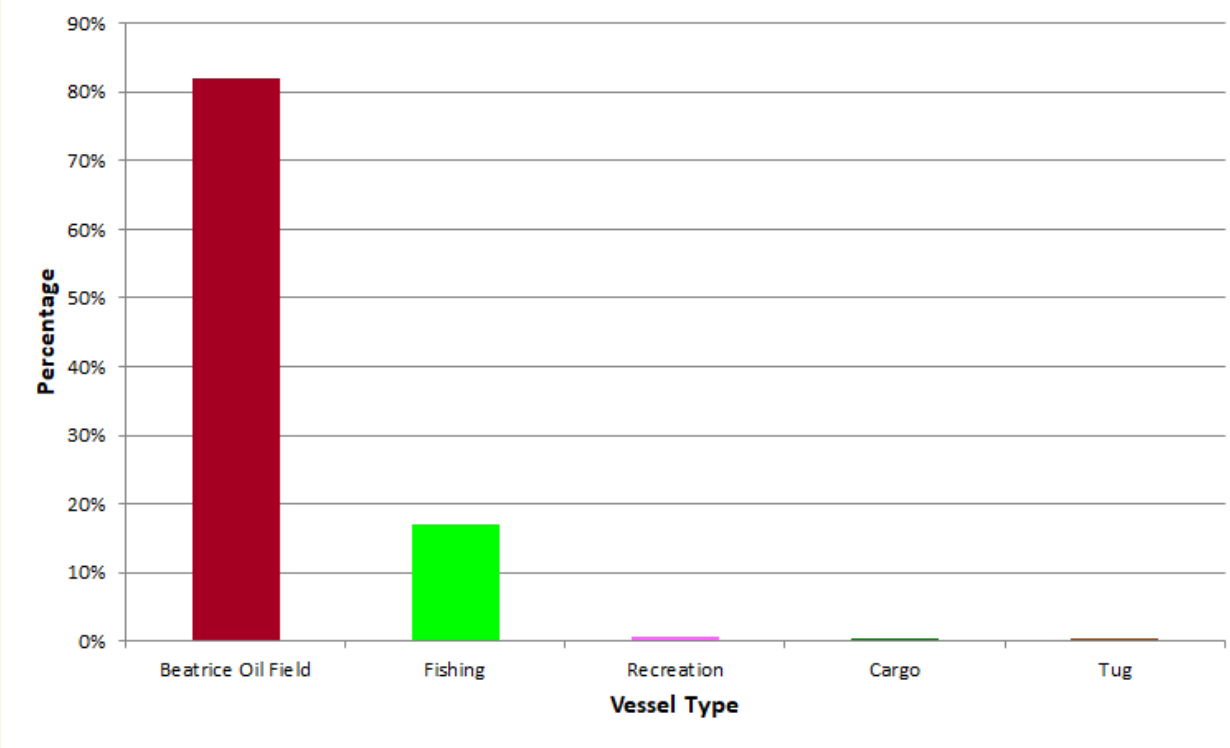
The busiest day in terms of encounters was the 17th August 2017, when 25 encounters were identified within the marine traffic survey data, 23 of which were encounters between vessels associated with the Beatrice field, with the remaining two both being between a fishing vessel and a Beatrice oil field vessel. The maximum during the winter period was the 17th December 2016, when seven encounters were recorded. Six of these were between vessels associated with the Beatrice field, with the remaining encounter being between two fishing vessels.

It is noted that encounter levels were significantly lower in winter than in summer (an average of seven per day during summer compared to one during winter). There were two main contributing factors to this:

- The winter period was AIS only, meaning encounters between non-AIS vessels (most notably fishing) are not accounted for; and
- Activity at the Beatrice oil field was notably less during winter than in summer (less than one vessel per day in winter compared to three in summer).

16.2.4 Vessel Type Distribution

The distribution of vessel types involved in the identified encounters is presented in Graph 16-3.



Graph 16-3 Encounter Vessel Type Distribution

More than 80% of the vessels involved in the identified encounters were associated with the Beatrice field, with a further 17% being fishing vessels. As previously discussed, the winter survey was AIS only, and so it is likely that encounters involving a non-AIS vessel (fishing, recreational) are underrepresented in this distribution.

16.2.5 Encounter Density

The encounter results were used as input to Anatec's ShipDensity calculator. The resultant density grid is presented in Figure 16-2. As expected based on the identified encounters, the majority of density was associated with vessels at the Beatrice field, and from fishing vessels within, and south of the Moray West Site.

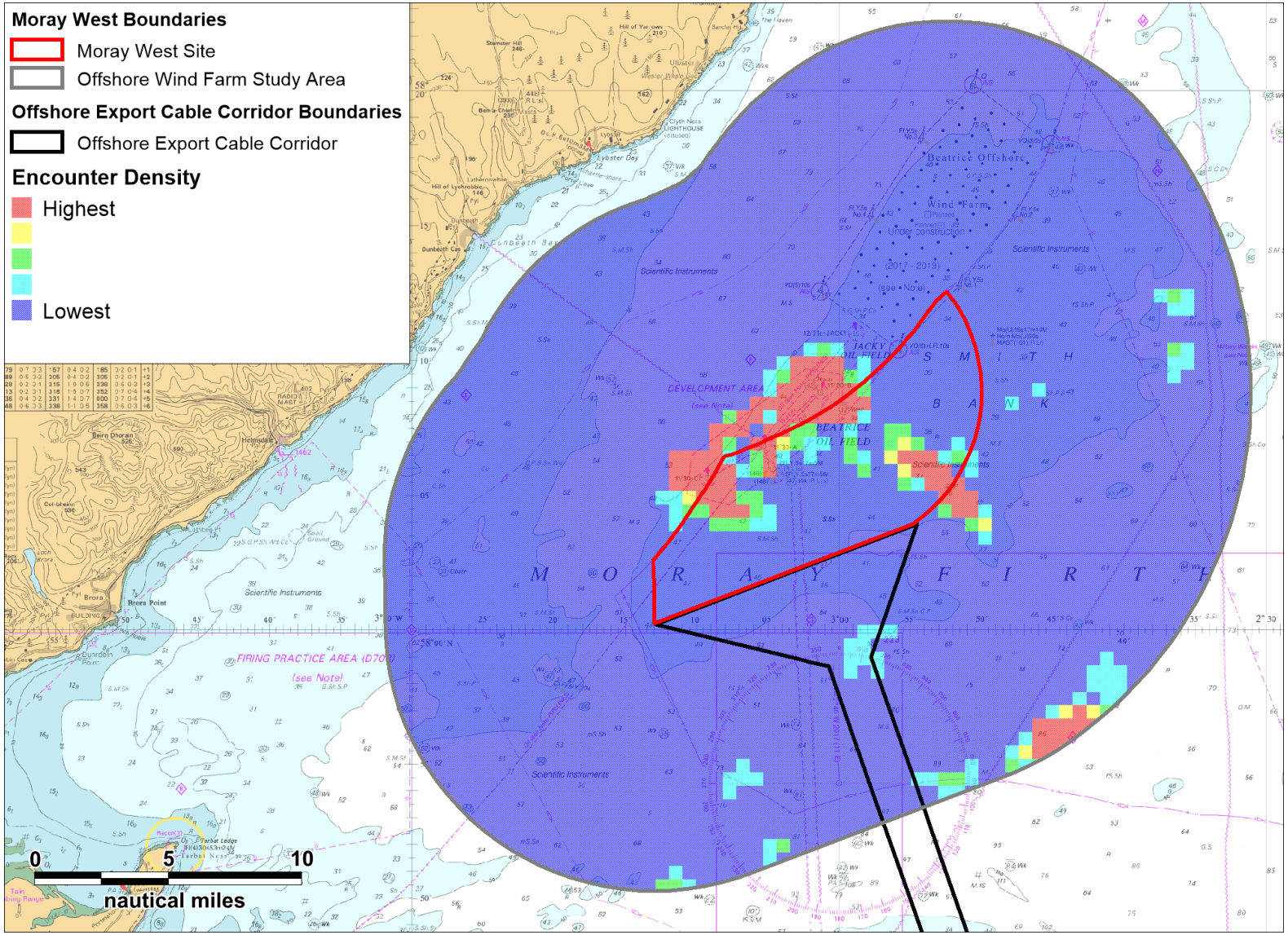


Figure 16-2 Encounter Density

16.3 Vessel to Vessel Collisions

The base case routes presented in Section 13 were used as input to the vessel to vessel collision model included in Anatec's CollRisk model suite to estimate the vessel to vessel collision rates in the vicinity of the Moray West Site pre wind farm (note that it has been assumed in the routeing analysis that BOWL is included in the baseline).

It was estimated that a vessel would be involved in a collision once every 28,600 years pre wind farm. The results of the model are summarised in Figure 16-3, which shows the results in grid form, with each cell colour coded according to collision frequency.

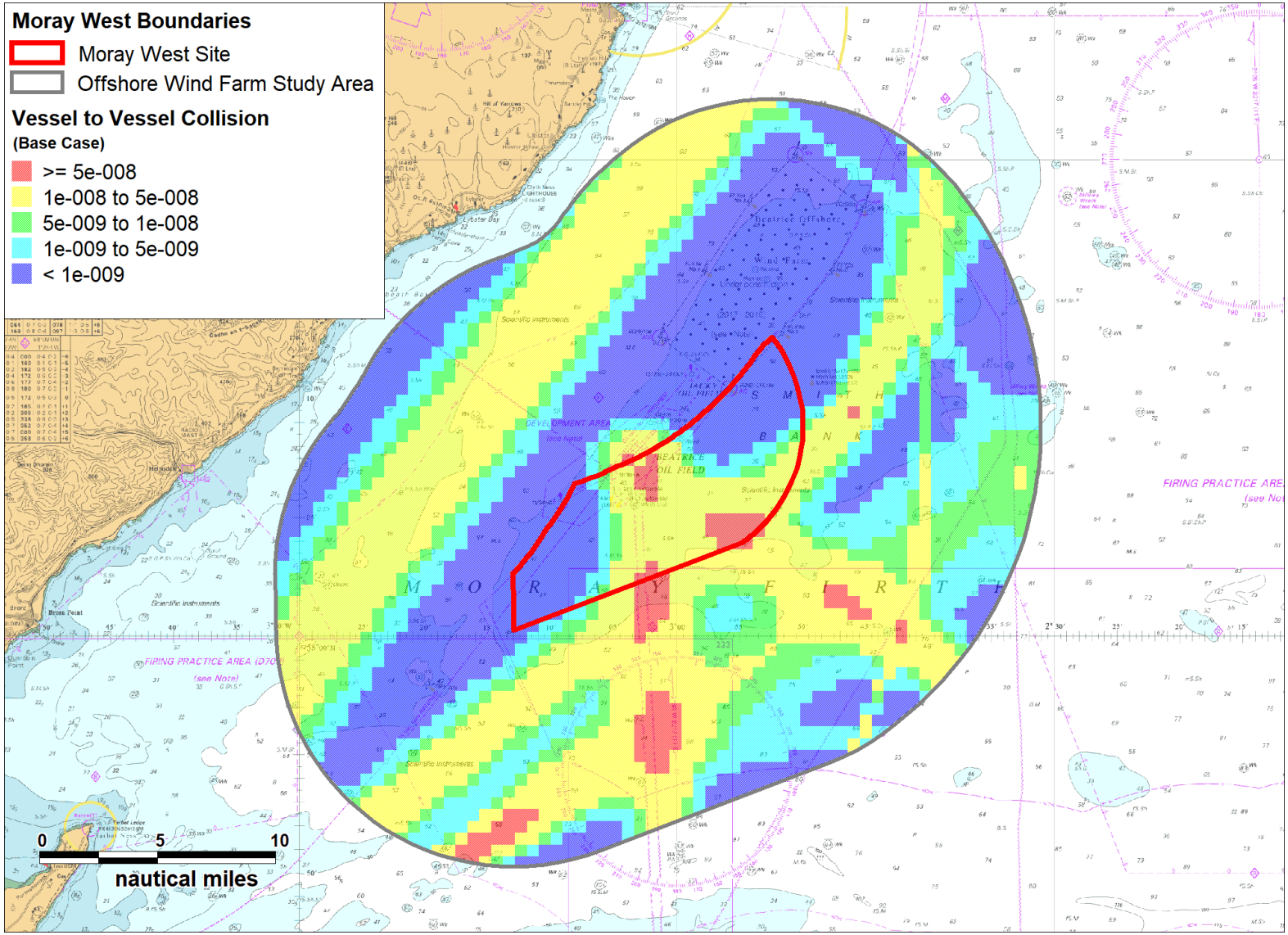


Figure 16-3 Vessel to Vessel Collision Frequency – Base Case

The most significant areas of risk were observed to be the points where the two routes associated with the Beatrice oil fields crossed other intersecting routes, and at the Beatrice complex itself. Collision rates inshore (west) of the Beatrice complex were less, as the busy route here was not crossed by any other routes.

It is emphasised that the model is calibrated based on major incident data at sea which allows for benchmarking but does not cover all incidents, such as minor impacts. Other incident data, which includes minor incidents, is presented in Section 11.

16.4 Vessel to Structure Allisions

There is no vessel to structure allision risk pre wind farm (as there are no structures that could be hit). Section 17.3 provides an assessment of vessel to structure allision post wind farm.

17 Moray West Site in Isolation Assessment – Future Case

17.1 Introduction

This section provides an assessment of estimated collision and allision rates post wind farm, based on the future case routes presented in Section 14. As discussed in Section 15, two post wind farm scenarios have been assessed; one assuming vessel numbers will remain level with the base case, and one assuming a 10% increase in traffic.

17.2 Vessel to Vessel Collisions

17.2.1 Results Summary

Grid plots of the results of the future case vessel to vessel collision assessments are presented in Figure 17-1 and Figure 17-2 for the 0% traffic growth and 10% traffic growth scenarios respectively. The results are then summarised in Table 17.1, with base case results included for comparison.

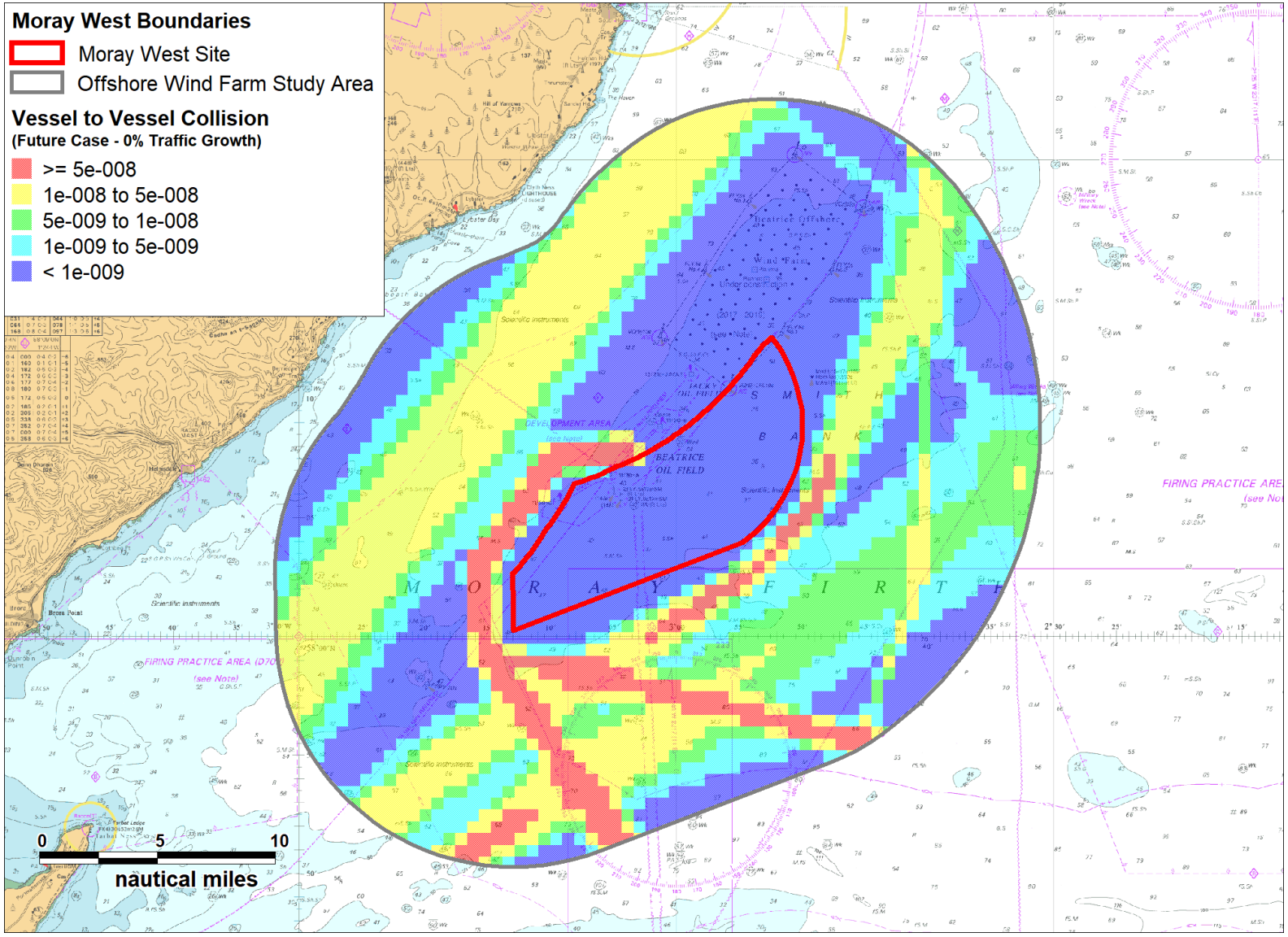


Figure 17-1 Vessel to Vessel Collision Frequency – Future Case – 0% Traffic Growth

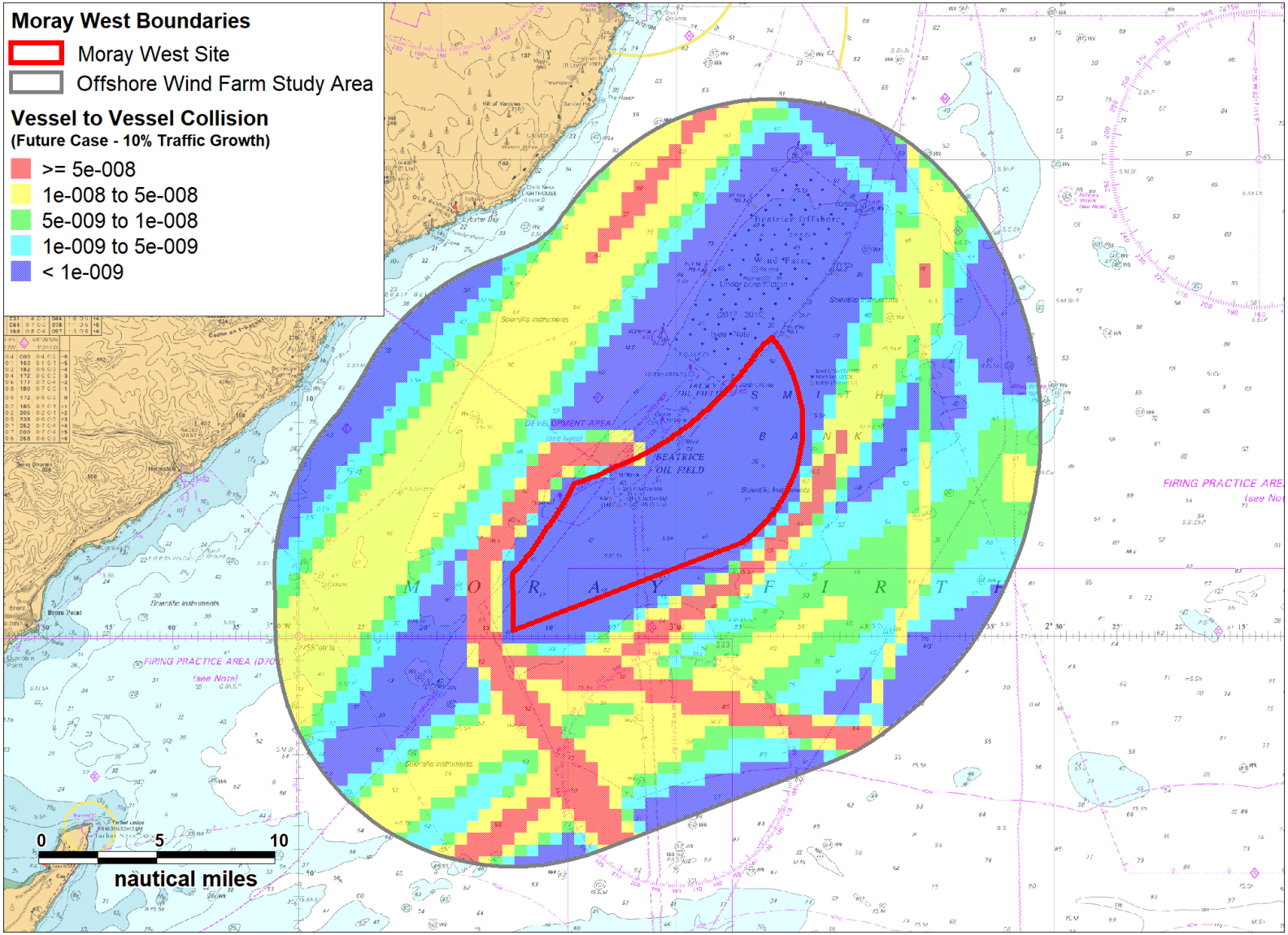


Figure 17-2 Vessel to Vessel Collision Frequency – Future Case – 10% Traffic Growth

Table 17.1: Vessel to Vessel Collision Rates – Future Case			
Scenario	**Annual Frequency**	**Return Period (Years)**	**Increase from Base Case – Pre Wind Farm**
Base Case - Pre Wind Farm	3.50×10^{-5}	28,600	n/a
Base Case - Post Wind Farm	6.03×10^{-5}	16,600	72%
Future Case – Pre Wind Farm	4.19×10^{-5}	23,900	20%
Future Case – Post Wind Farm	7.23×10^{-5}	13,800	107%

Assuming no growth in traffic, it was estimated that post wind farm a vessel will be involved in a collision once every 16,600 years. This represents an increase of 72% from the base case. If traffic levels were to increase by 10%, it was estimated that collision rates would increase by approximately 107% from the base case pre wind farm results.

The majority of the post wind farm collision risk was observed to be associated with the deviated Beatrice oil field routes (rerunning the post wind farm case model without the Beatrice oil field routes reduced the frequency to approximately once every 38,800 years, which was less than the base case pre wind farm). These routes were both deviated to the south of the Moray West Site (on a worst case basis), and the resulting increase in vessel density on the southern and western boundaries of the site were the main cause of the increase in risk.

As the majority of risk is from Beatrice oil field associated vessels, the following should be considered when viewing the results in Table 17.1:

- The deviations assessed are worst case. In reality, it is likely that the vessels on routes to the Beatrice field will transit through the wind farm (based on their size).
- Vessels associated with the Beatrice field are likely to be familiar with their associated routes and vessels, which has not been factored into the modelling.
- Beatrice oil field decommissioning is expected to end in 2028 (i.e., the associated impact is temporary within the operational phase of the Development).

It is also noted that even with the inclusion of Beatrice oil field vessels, and the 10% increase in traffic, future case collision frequency is still negligible under the definition used in the FSA (see Table 3.2).

17.2.2 Change in Collision Risk

The change in collision risk observed between the base case pre and post wind farm is presented in Figure 17-3. This figure is provided to highlight the areas where collision rates are expected to increase and decrease as a result of the presence of the Moray West Site. The 0% traffic growth scenario has been used to illustrate the change arising from the expected deviations only.

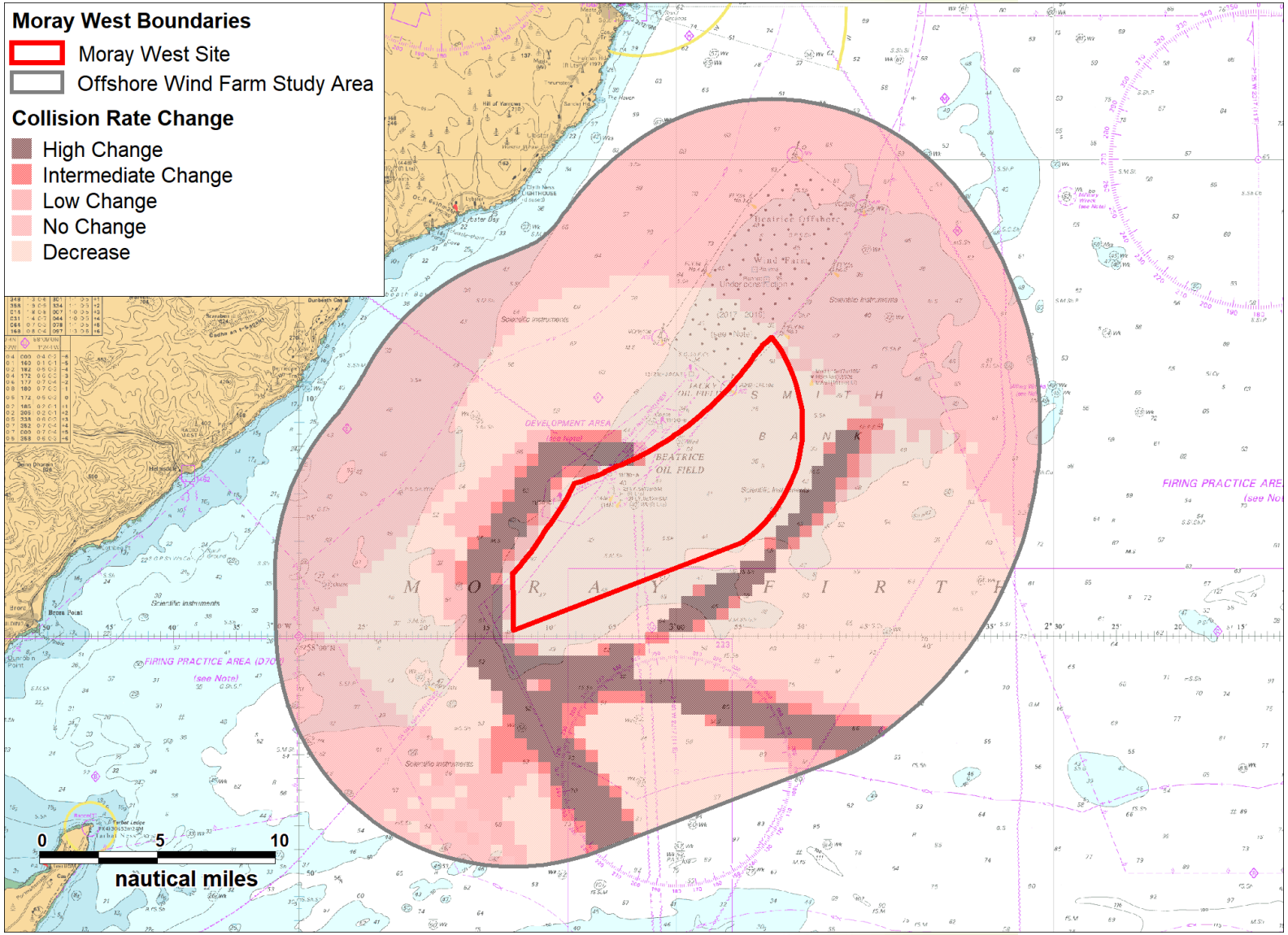


Figure 17-3 Change in Collision Risk – Base Case vs Future Case (0% Traffic Growth)

As previously discussed, the majority of the increase in risk was associated with the worst case deviations of the Beatrice oil field routes around the southern and western boundaries of the Moray West Site (and which already existed within the base case densities shown in Figure 16-3). The other route requiring deviation (Route 2 in Section 14) also contributed. As the worst case deviation is a focus of traffic at the Moray West Site boundary, collision risk in the areas surrounding the deviated routes was observed to decrease (though only to a minor degree).

17.3 Vessel to Structure Allisions

17.3.1 Powered

A powered allision is defined as a vessel making contact with a structure whilst under power. Based on the vessel routeing identified for the area, the anticipated change in routeing due to the Development, and assumptions that effective mitigation measures are in place, the frequency of an errant vessel under power deviating from its route to the extent that it comes into proximity with a structure is not considered to be a probable outcome.

From consultation with the shipping industry it is also assumed that merchant vessels would not navigate between wind turbine rows due to the restricted sea room and would be directed by the navigational aids in the area.

The deviated routes presented in Section 14 were used as input to the powered allision function of Anatec's CollRisk modelling suite. This model estimates the likelihood that a vessel will allide with one of the wind farm structures whilst under power. It is noted that the model does not take account for the possibility of one structure shielding another.

The results are summarised in Table 17.2 for both the 0% (base case) and 10% (future case) traffic growth scenarios.

Table 17.2: Vessel to Structure Allision Results - Powered

Scenario	Annual Frequency	Return Period (Years)
Base Case – Post Wind Farm	5.21×10^{-5}	19,200
Future Case – Post Wind Farm	5.73×10^{-5}	17,400

It was estimated that a vessel will allide under power with a structure within the Moray West Site once every 19,200 years assuming no growth in traffic, and once every 17,400 years should traffic increase by 10%. The structures most at risk were observed to be the periphery WTGs on the south and west of the Moray West Site, as a result of the traffic passing south, and west of the Moray West Site. Traffic passing to the north (inshore), passed at a distance large enough to avoid significant risk to the northernmost WTGs. This is illustrated in Figure 17-4, which shows a graduated plot by risk of the WTGs, based on the 0% traffic growth scenario.

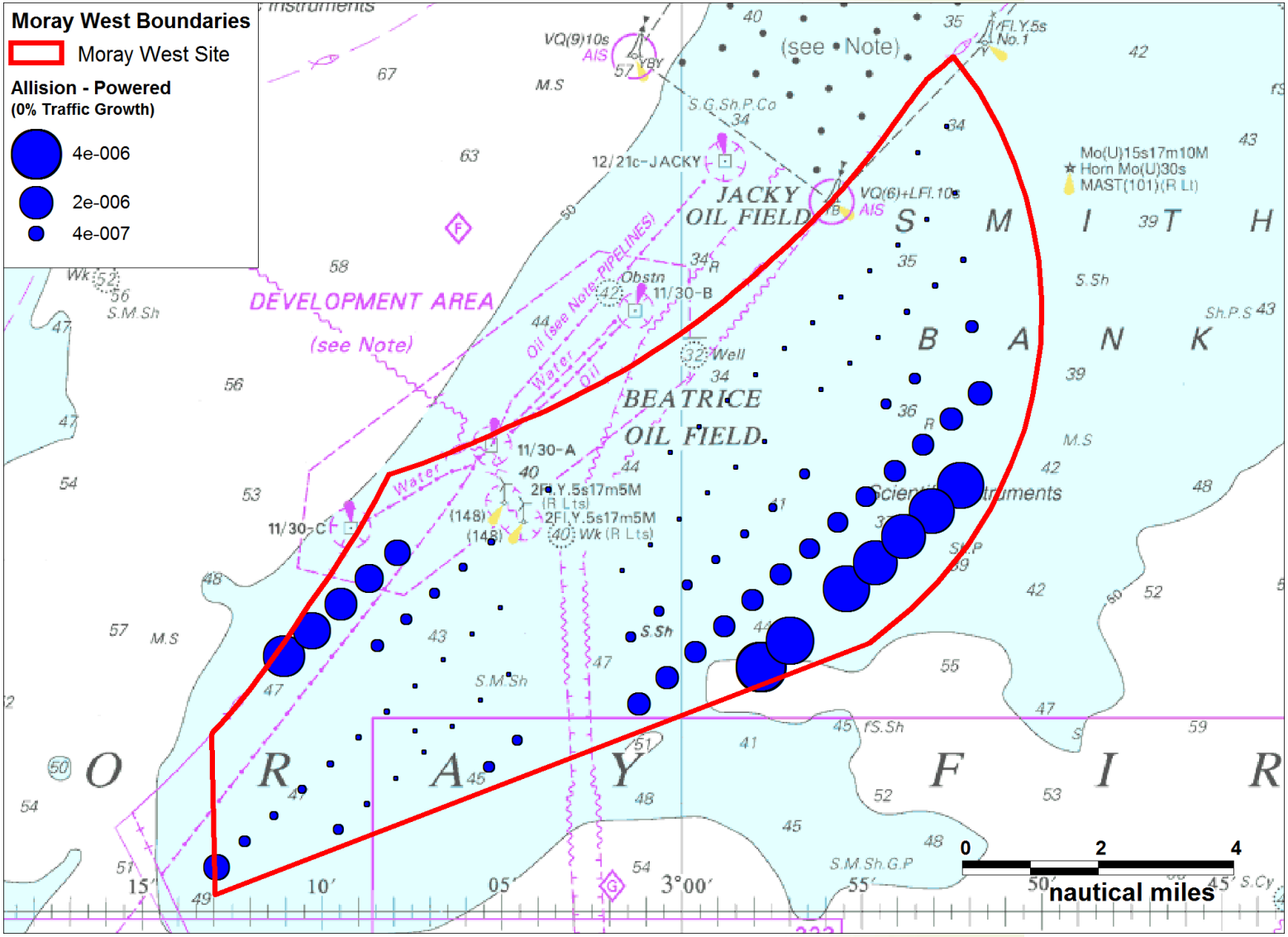


Figure 17-4 Powered Allision – Future Case – 0% Traffic Growth

17.3.2 Drifting

The deviated routes presented in Section 14 were used as input to the Not Under Command (NUC) allision function of Anatec's CollRisk modelling suite. This model is based on the premise that propulsion on a vessel must fail before a vessel would drift, takes account of the type and size of the vessel, number of engines, average time to repair, and differing weather conditions.

The exposure times for a drifting scenario are based on the vessel-hours spent in proximity to the Moray West Site (up to 10 nm from perimeter). These have been estimated based on the traffic levels, speeds and revised routeing pattern. The exposure is divided by vessel type and size to ensure these factors, which based on analysis of historical accident data have been shown to influence accident rates, are taken into account within the modelling.

Using this information the overall rate of breakdown within the area surrounding the Moray West Site was estimated. The probability of a vessel drifting towards a structure and the drift speed are dependent on the prevailing wind, wave and tide conditions at the time of the accident.

The following drift scenarios were modelled:

- Wind;
- Peak spring flood tide; and
- Peak spring ebb tide.

The probability of vessel recovery from drift is estimated based on the speed of drift and hence the time available before reaching the wind farm structure. Vessels that do not recover within this time are assumed to allide.

The wind based scenario was observed to produce the worst case results, and this scenario was therefore chosen for assessment. The results for the 0% (base case) and 10% (future case) traffic increase cases are presented in Table 17.3.

Table 17.3: Vessel to Structure Allision Results - Drifting

Scenario	Annual Frequency	Return Period (Years)
Base Case – Post Wind Farm	6.81×10^{-6}	146,900
Future Case – Post Wind Farm	7.39×10^{-6}	135,300

It was estimated that, if traffic levels remain as they are, that a vessel will drift into a Moray West structure once every 146,900 years, with this rising to once every 135,300 years if traffic were to grow by 10%.

Risk distribution across the structures was observed to be similar to that observed in the powered allision assessment, with the southern and western periphery structures most at risk. This is illustrated in Figure 17-5, which shows drifting allision risk per structure. It should be noted that the risk bands differ from those used to illustrate the powered allision results shown in Figure 17-4 (and direct comparison between the figures is therefore not appropriate).

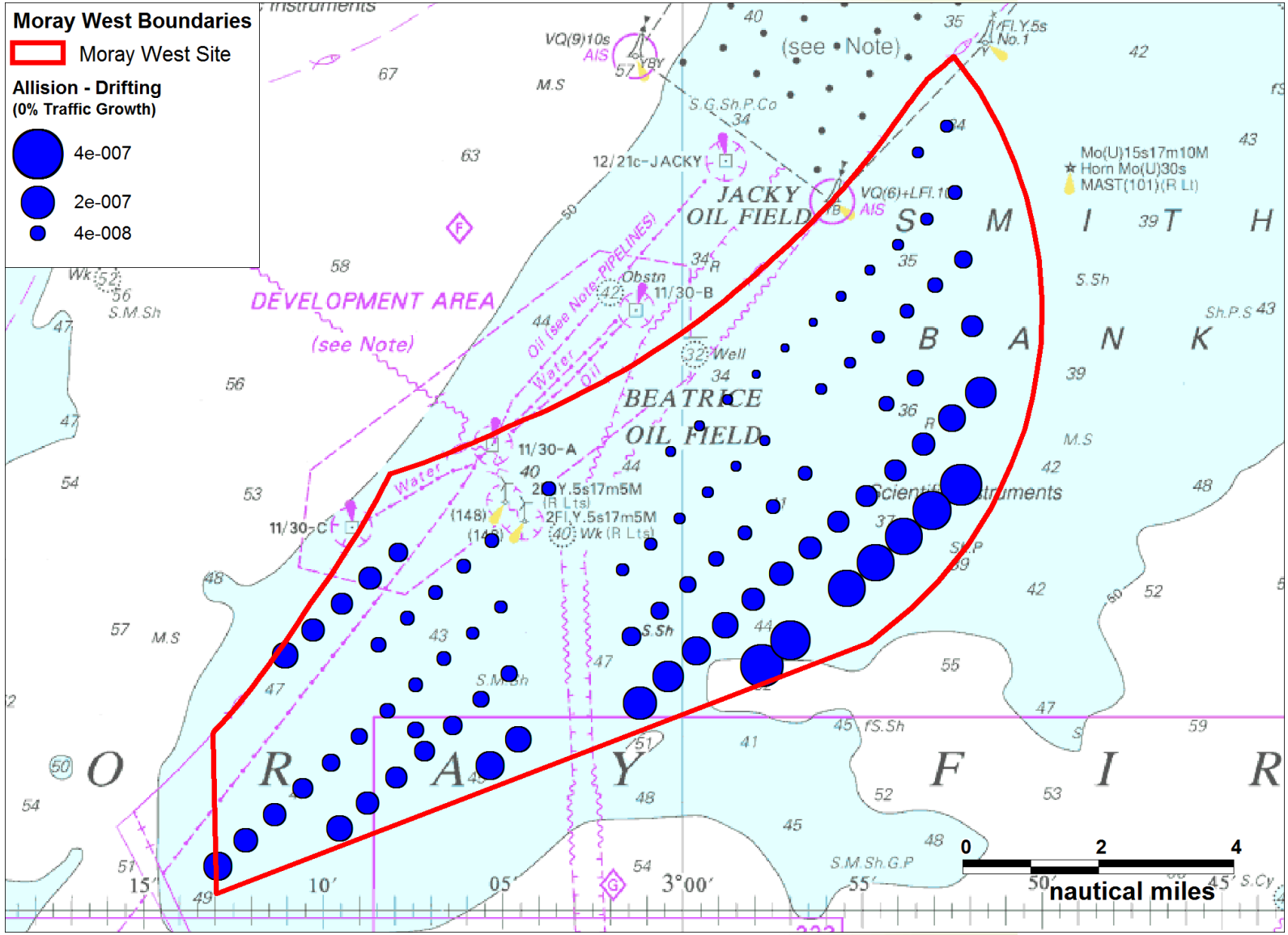


Figure 17-5 Drifting Allision – Future Case – 0% Traffic Growth

17.4 Fishing Vessel Allision

Anatec's CollRisk fishing vessel risk model has been calibrated using fishing vessel activity data along with offshore installation operating experience in the UK (oil and gas) and the experience of allisions between fishing vessels and UKCS offshore installations (published by the Health and Safety Executive (HSE)).

The two main inputs to the model are the fishing vessel density for the area and the structure details including the number and dimensions of the structures. The fishing vessel density in the Moray West Site was based upon the marine traffic survey collected from the Moray West Site during summer (as the winter data did not include radar data, and non-AIS activity was therefore underrepresented).

The results are summarised in Table 17.4.

Table 17.4: Vessel to Structure Allision Results - Fishing

Scenario	Annual Frequency	Return Period (Years)
Base Case – Post Wind Farm	1.40×10^{-1}	7
Future Case – Post Wind Farm	1.54×10^{-1}	6

The fishing allision results are high when compared to the results of the allision assessment of regular routed vessels provided in Section 17.3. This reflects the assumption that the presence of the structures within the Moray West Site will have no impact on current fishing levels (i.e., takes no account of vessels deviating around the structures, whereas it has been assumed that regular routed commercial traffic will deviate to avoid the Moray West Site). It is also noted that any allision from a fishing vessel within the site is expected to be low speed (the estimated average speed of fishing vessels within the Moray West Site was approximately 3 knots), and therefore lower risk to the crew, vessel, and structure.

17.5 Modelling Results Summary

A summary of the collision and allision risk frequency modelling results for the Moray West Site is provided in Table 17.5. The corresponding return periods are included in the table.

Table 17.5: Allision and Collision Risk Results Summary				
Scenario	**Base Case**		**Future Case**	
	Pre Wind Farm	**Post Wind Farm**	**Pre Wind Farm**	**Post Wind Farm**
Vessel to Vessel	3.50×10^{-5} (28,600 years)	6.03×10^{-5} (16,600 years)	4.19×10^{-5} (24,900 years)	7.23×10^{-5} (13,800 years)
Allision – Powered	n/a	5.21×10^{-5} (19,200 years)	n/a	5.73×10^{-5} (17,400 years)
Allision - Drifting	n/a	6.81×10^{-6} (146,900 years)	n/a	7.39×10^{-6} (135,300 years)
Allision - Fishing	n/a	1.40×10^{-1} (7 years)	n/a	1.54×10^{-1} (6 years)
Total	**3.50×10^{-5} (28,600 years)**	**1.40×10^{-1} (7 years)**	**4.19×10^{-5} (24,900 years)**	**1.54×10^{-1} (6 years)**

17.6 Consequences

The consequences associated with the probable outcomes of a collision or allision are expected to be minor. However, the worst case outcomes could have severe consequences, including events with the potential for multiple fatalities.

An allision involving a larger vessel may result in the collapse of a WTG with limited damage to the vessel. Breach of a vessel's fuel tank is considered unlikely and in the case of vessels carrying hazardous cargoes, e.g., tanker or gas carrier, the additional safety features associated with these vessels would further mitigate the risk of pollution (for example mandatory double hulls). Similarly, in a drifting allision the proposed wind farm structures are likely to absorb the majority of the impact energy, with some energy also being retained by the vessel in terms of rotational movement (glancing blow).

In terms of smaller vessels such as fishing and recreational craft, the worst case scenario would be risk of vessel damage leading to foundering of the vessel and Potential Loss of Life (PLL).

A quantitative assessment of the potential consequences of collision / allision for each of the scenarios is presented in Annex C. This applies the site-specific collision / allision frequency results presented in Table 17.5 with estimated outcomes in terms of fatalities on-board and oil pollution from the vessel based on research into historical collision incidents (MAIB, Internal Tanker Owners Pollution Federation (ITOPF), etc.).

The overall increase in PLL estimated due to the Development is 5.69×10^{-4} fatalities per year (base case), which equates to one fatality per 1,700 years. This is a very small change in comparison to MAIB statistics which indicate an average of 20 fatalities per year in UK territorial waters.

In terms of individual risk to people, the incremental increase for commercial vessels (approximately 9.37×10^{-10}) is very low compared to the background risk level for the UK sea transport industry of 2.9×10^{-4} per year.

Similarly for fishing vessels, whilst the change in individual risk attributed to the Development is higher than for commercial vessels (approximately 1.98×10^{-5}, compared to 9.37×10^{-10} for commercial vessels), it is relatively low compared to the background risk level for the UK sea fishing industry of 1.2×10^{-3} per year.

The overall increase in oil spilled due to the Development is 0.35 tonnes of oil per year (base case). From research undertaken as part of the DfT MEHRA project (DfT, 2005) the average annual tonnes of oil spilled in the waters around the British Isles due to marine accidents in the 10-year period from 1989 to 1998 was 16,111 tonnes. Therefore, the overall increase in pollution estimated for the Development is very low compared to the historical average pollution quantities from marine accidents in the UK waters.

Therefore, the incremental increase in risk to both people and the environment caused by the Development is estimated to be low.

Impacts associated with the allision and collision modelling are considered within Chapter 12 of the EIA Report: Shipping and Navigation.

18 Moray West Site Cumulative Assessment

18.1 Introduction

This section provides an assessment of likely cumulative vessel routeing in the vicinity of the Moray West Site, if other developments within the Moray Firth were taken into consideration. This assessment feeds into the cumulative impact assessment undertaken in Chapter 12 Shipping and Navigation of the EIA Report.

18.2 Cumulative Screening

The projects that have been considered within the cumulative assessment are listed below:

- Moray West offshore wind farm (including OfTI);
- Moray East offshore wind farm (including OfTI);
- BOWL (including OfTI);
- Beatrice Oil Field complex; and
- Caithness Moray Transmission Link.

BOWL is assumed as baseline, however for the purposes of cumulative routeing it will be considered given the subsequent effects (due to BOWL) associated with vessels that are deviating for Moray West and Moray East.

18.3 Cumulative Deviations

The anticipated cumulative vessel routes (obtained by deviating the base case routes from Section 13 to account for the developments considered) are presented in Figure 18-1. The route ID numbering shown in the figure corresponds to that presented in Sections 13 and 14. It is noted that the OfTI associated with the Development and Moray East, and the Caithness Moray transmission cable have not been considered within this deviation assessment on the basis that they will have no impact upon vessel routeing during normal operations. Cable installation or maintenance vessels will cause some minor re routeing, however the associated deviations will be temporary, and limited to a small geographical area as the vessels move along the cable routes.

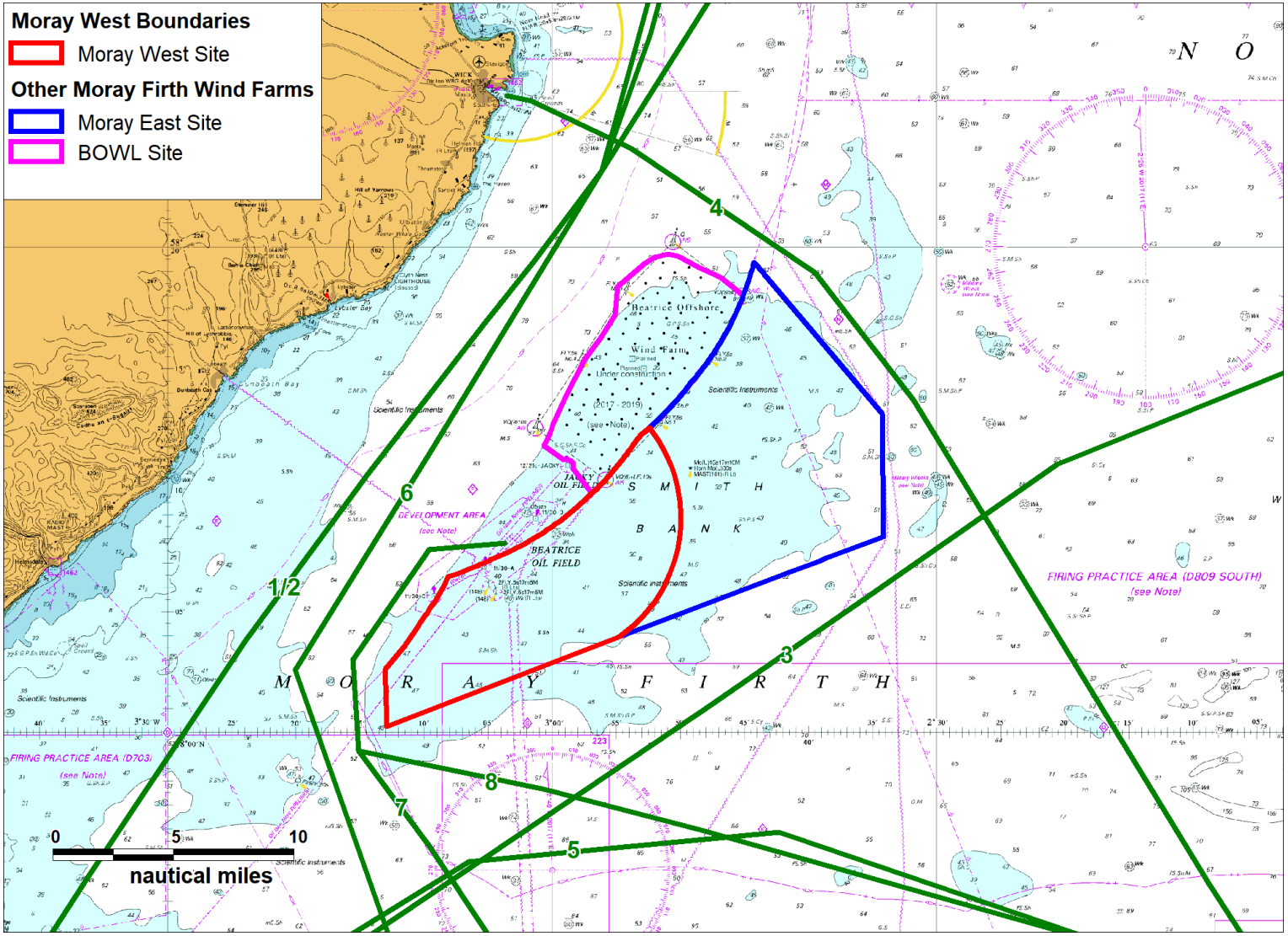


Figure 18-1 Anticipated Cumulative Routeing

18.4 Cumulative Impact Assessment Methodology

Each impact assessed for the Development in isolation within Chapter 12: Shipping and Navigation has also been assessed on a cumulative basis, taking the projects listed in Section 18.2 into account. Cumulative impacts have been assessed within the construction, operational, and decommissioning phases of the Development, with the other projects assessed as being within their likely coinciding phases. Impacts screened into the in-isolation assessment within the EIA are presented in Section 22.2.

19 Communication and Position Fixing

19.1 Introduction

This section provides assessment of potentials impacts that the Development may have on communication and position fixing devices installed on vessels navigation with the area.

19.2 Very High Frequency (VHF) Communications (including Digital Selective Calling (DSC))

As part of the 2004 SAR provider (MCA and QinetiQ, 2004) trials at North Hoyle wind farm, tests were undertaken to evaluate the operational use of typical small vessel Very High Frequency (VHF) transceivers when operated close to wind farm structures.

The wind farm structures had no noticeable effect on voice communications within the wind farm or ashore. It was noted that if small craft vessel to vessel and vessel to shore communications were not affected significantly by the presence of WTGs, then it is reasonable to assume that larger vessels with higher powered and more efficient systems would also be unaffected.

During this trial a number of mobile telephone calls were made from ashore, within the wind farm, and on its seawards side. No effects were recorded using any system provider (MCA and QinetiQ, 2004).

Furthermore, as part of the SAR trials carried out at North Hoyle wind farm in 2005, radio checks were undertaken between the Sea King helicopter and both Holyhead and Liverpool coastguards. The aircraft was positioned to the seaward side of the wind farm and communications were reported as very clear, with no apparent degradation of performance. Communications with the service vessel located within the wind farm were also fully satisfactory throughout the trial (MCA, 2005).

Following consideration of these independent reports, the Development is anticipated to have no significant impact upon VHF communications as demonstrated at other operational sites.

19.3 VHF Direction Finding

During the 2004 trials at North Hoyle wind farm, the VHF direction equipment carried in the trial boats did not function correctly when very close to WTGs (within approximately 50 m). This is deemed to be a relatively small scale impact due to the limited use of VHF direction finding equipment and will not impact operational or SAR activities, especially as the effect is now recognised by the MCA (MCA and QinetiQ, 2004).

Throughout the 2005 SAR trials carried out at North Hoyle wind farm, the Sea King radio homer system was tested. The sea king radio homer system utilises the lateral displacement of a vertical bar on an instrument to indicate the sense of a target relative to the aircraft heading. With the aircraft and the target vessel within the wind farm, at a range of approximately 1 nm, the homer system operated as expected with no apparent degradation.

19.4 AIS

In theory there could be interference when there is a structure located between the transmitting and receiving antennas (i.e. blocking line of sight) of the AIS. This was not evident in the trials carried out at the North Hoyle offshore wind farm site and no significant impact is anticipated for any AIS signals being transmitted and received within the Moray West Site (MCA and QinetiQ, 2004).

19.5 Navtex Systems

The Navigational Telex (NAVTEX) system is used for the automatic broadcast of localised Maritime Safety Information (MSI) and either prints it out in hard copy or displays it on a Liquid Crystal Display (LCD)LCD screen, depending on the model.

There are two NAVTEX frequencies. All transmissions on NAVTEX 518 Kilo-hertz (kHz), the international channel, are in English. NAVTEX 518 kHz provides the mariner (both recreational and commercial) with weather forecasts, severe weather warnings and navigation warnings such as obstructions or buoys off station. Depending on the users' location other information options may be available such as ice warnings for high latitude sailing.

The 490 kHz national NAVTEX service may be transmitted in the local language. In the UK full use is made of this second frequency including useful information for smaller craft, such as the inshore waters forecast and actual weather observations from weather stations around the coast.

Although no specific trials have been undertaken, no significant effect has been noted at operational sites and therefore no effects are expected to arise from the Development.

19.6 Global Positioning System (GPS)

Global Positioning System (GPS) is a satellite based navigational system. GPS trials formed part of the 2004 trials at North Hoyle wind farm and it was concluded that "no problems with basic GPS reception or positional accuracy were reported during the trials".

The additional tests showed that "even with a very close proximity of a wind turbine to the GPS antenna, there were always enough satellites elsewhere in the sky to cover for any that might be shadowed by the wind turbine tower" (MCA and QinetiQ, 2004).

Therefore there are not expected to be any significant impacts associated with the use of GPS systems within or in proximity to the Moray West Site.

19.7 Electromagnetic Interference (from Wind Turbines or Cables) on Navigation Equipment

A compass, magnetic compass or mariner's compass is a navigational instrument for determining direction relative to the earth's magnetic poles. It consists of a magnetised pointer (usually marked on the north end) free to align itself with the earth's magnetic field. A compass can be used to calculate heading, used with a sextant to calculate latitude, and with a marine chronometer to calculate longitude.

Like any magnetic device, compasses are affected by nearby ferrous materials as well as by strong local electromagnetic forces, such as magnetic fields emitted from power cables. As the compass still serves as an essential means of navigation in the advent of power loss or a secondary source, it should not be allowed to be affected to the extent that safe navigation is prohibited. The important factors that affect the resultant deviation are:

- Water and burial depth;
- Current (whether alternating or direct) running through the cables;
- Spacing or separation of the two cables in a pair (balanced monopole and Bipolar designs); and / or
- Cable route alignment relative to the earth's magnetic field.

The Moray West export and array cables are intended to be alternating current (AC). Studies indicating that AC does not emit an electromagnetic field significant enough to impact marine magnetic compasses (OSPAR, 2008).

No problems with respect to magnetic compasses have been reported to date in any of the trials carried out (inclusive of SAR helicopters). However, small vessels with simple magnetic steering and hand bearing compasses should be wary of using these close to WTGs as with any structure in which there is a large amount of ferrous material (MCA and QinetiQ, 2004).

19.8 Impact on Marine Radar Systems

The 2004 MCA North Hoyle wind farm trials identified areas of concern with regard to the potential impact on marine and shore based Radar systems. This is due to the large vertical extent of the WTGs returning Radar responses strong enough to produce interfering side lobes, multiple and reflected echoes (ghosts). This has also been raised as a major concern by the maritime industry with further evidence of the problems being identified by the Port of London Authority around the Kentish Flats offshore wind farm in the Thames Estuary. Based on the results of the North Hoyle trial, the MCA produced a wind farm / shipping route template to give guidance on the distances which should be established between shipping routes and offshore wind farms.

A second trial was conducted at Kentish Flats between 30 April 2006 and 27 June 2006 on behalf of the Renewables UK (RUK) (RUK, 2007). The project steering group had members from the MCA and the Port of London Authority. This trial was conducted in pilotage waters and in an area covered by the Port of London Vessel Traffic Services (VTS). It therefore had the benefit of pilot advice and experience but was also able to assess the impact of the generated effects on VTS Radars.

The trial concluded that:

- The phenomena referred to above detected on marine Radar displays in the vicinity of wind farms can be produced by other strong echoes close to the observing vessel although not necessarily to the same extent;
- Reflections and distortions by vessels' structures and fittings created many of the effects and the effects vary from vessel to vessel and Radar to Radar;
- VTS scanner static Radars can be subject to similar phenomena as above if passing vessels provide a suitable reflecting surface but the effect did not seem to present a significant problem for the Port of London VTS; and
- Small vessels operating in or near the wind farm would be detectable by Radars located on vessels operating near the Moray West Site but would be less detectable when the vessel was operating within the Moray West Site.

Throughout the 2005 MCA SAR helicopter trials at the North Hoyle wind farm, side lobe returns were found to extend approximately 100 m to either side of each wind turbine, with side lobe depth estimated at less than 50 m. The Radar target, which was moving between the WTGs within the wind farm, was tracked from an aircraft positioned in the 50 foot hover position between 0.25 to 0.5 nm clear of the wind farm boundary. The target could be tracked to a distance of approximately 100 m from each wind turbine. Beyond this point the target could be recognised at a slightly closer range to the wind turbine, but only if it had been previously identified at a greater separation and Radar processing continuously adjusted (MCA, 2005).

Theoretical modelling of the composite effects of the development of the Atlantic Array offshore wind farm on marine Radar systems was carried out by Ledwood Technology in October 2011 (Atlantic Array, 2012). The main outcomes of the modelling were as follows:

- "Multipath effects (false targets) were detected under all modelled parameters. The main effects noticed were stretching of targets in azimuth and appearance of more ghost targets due to multipath energy arriving through the side lobes. However, it was concluded that there was a significant amount of clear space amongst the returns to ensure recognition of vessels moving amongst the wind farm structures and safe navigation.

- Even in the worst case with Radar operator settings set artificially bad there is significant clear space around each wind turbine that does not contain any multipath or side lobe ambiguities to ensure safe navigation and allow differentiation between false and real (both static and moving) targets.
- Overall it can be concluded that the amount of shadowing observed was very little. However, it should be noted that this was modelled on lattice-type base structures which are sufficiently sparse to allow Radar energy to pass through. The lower the density of structures the easier it is to interpret the Radar returns and fewer multipath ambiguities are present.
- In dense, target rich environments S-Band Radar scanners suffer more severely from multipath effects in comparison to X-Band scanners.
- It is important for passing vessels to keep a reasonable separation distance between the wind farm structures in order to minimise the effect of multipath and other ambiguities.
- The potential Radar interference is mainly a problem during periods of reduced visibility when mariners may not be able to visually confirm the presence of other vessels in the vicinity (i.e. those without AIS installed which are usually fishing and recreational craft)".

Based on the trials carried out to date, the onset range from the WYGS of false returns is approximately 1.5 nm, with progressive deterioration in the Radar display as the range closes. If interfering echoes develop, the requirements of the COLREGS (1972) Rule 6 Safe speed are particularly applicable and must be observed with due regard to the prevailing circumstances. In restricted visibility, Rule 19 Conduct of vessels in restricted visibility applies and compliance with Rule 6 becomes especially relevant. In such conditions mariners are required, under Rule 5 Lookout to take into account information from other sources which may include sound signals and VHF information, for example from a VTS, or AIS (MCA, 2016).

It is noted that upon development of the Development, commercial vessels are likely to pass over 1 nm from the Moray West Site, and thereby potentially be subject to a minor level of Radar interference. There is sufficient sea room around the proposed wind farm for vessels to increase their clearance further (if they consider it necessary) to greater than 2 nm and outwith the potential range of Radar interference.

For reference, Figure 19-1 shows 500 m, 1.5 nm, and 2 nm buffers of the Moray West Site relative to the anticipated future case routes (see Section 14) to illustrate the potential radar interference impact. Simulated AIS of the worst case route deviations (see Section 14) have been included in the figure. It noted that the routeing scenario used is worst case and shows support vessels for Beatrice Oil Field passing in close proximity to the Moray West Site; in reality these vessels will passage plan in line with MGN 372 (MCA, 2008) mitigating any effects; with even the possibility of them navigating through the Moray West Site in good weather and sea conditions.

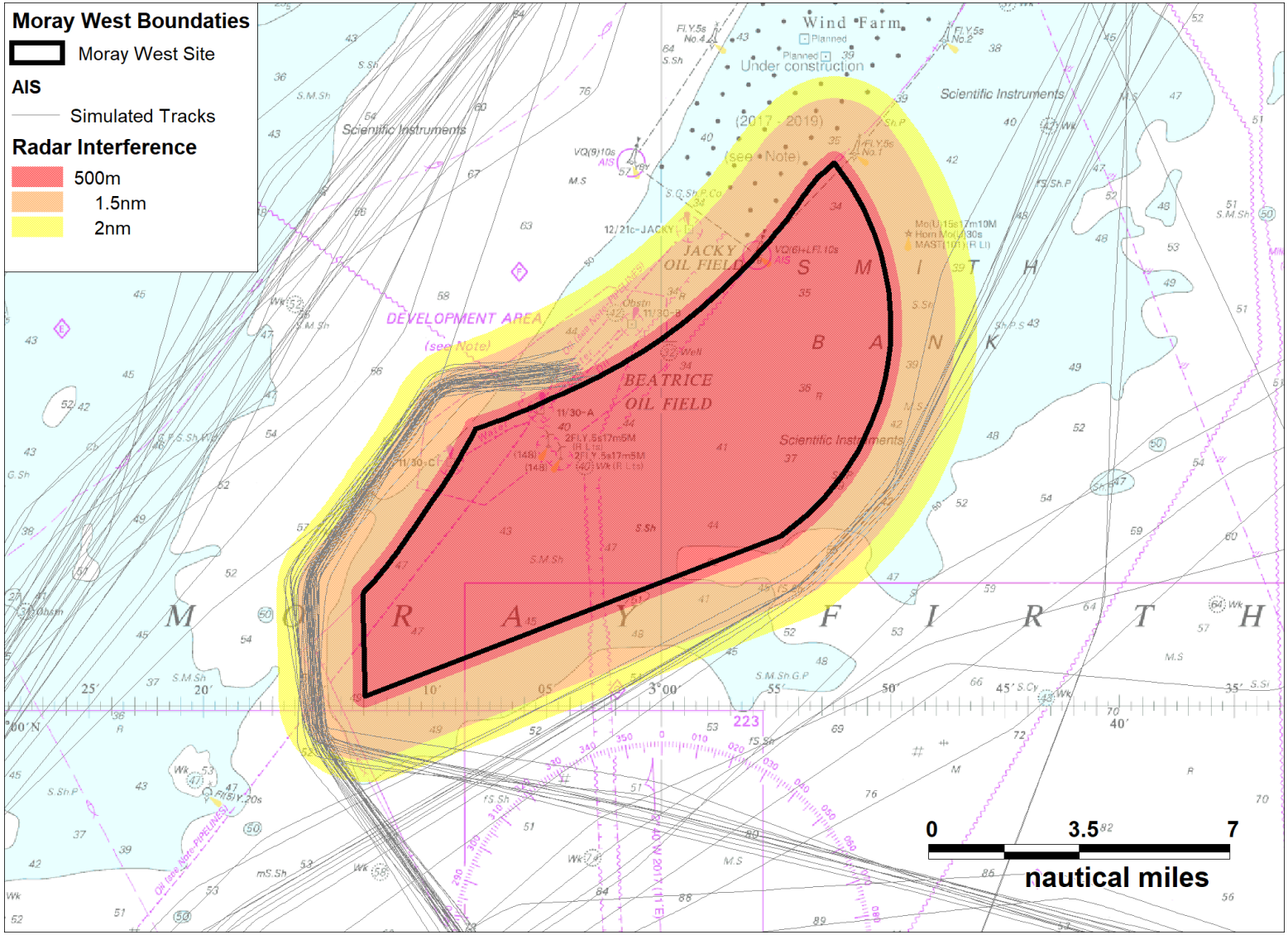


Figure 19-1 Moray West Site Radar Interference

Experienced mariners should be able to suppress the observed problems to an extent and for short periods (a few sweeps) by careful adjustment of the receiver amplification (gain), sea clutter and range settings of the Radar. However, there is a consequential risk of losing targets with a small Radar cross section, which may include buoys or small craft, particularly yachts or Glass Reinforced Plastic (GRP) constructed craft, therefore due care is needed in making such adjustments. The Kentish Flats study observed that the use of an easily identifiable reference target (a small buoy) can help the operator select the optimum Radar settings.

The performance of a vessel's ARPA could also be affected when tracking targets in or near the Moray West Site. However, although greater vigilance is required, it appears that during the Kentish Flats trials, false targets were quickly identified as such by the mariners and then by the equipment itself.

The evidence from mariners operating in the vicinity of existing wind farms is that they quickly learn to work with and around the effects. The MCA has produced guidance to mariners operating in the vicinity of UK OREIs which highlights Radar issues amongst others to be taken into account when planning and undertaking voyages in the vicinity of renewable energy installations off the UK coast (MCA, 2008).

AIS information can also be used to verify the targets of larger vessels (generally vessels above 300 tonnes) and fishing vessels of 15 m length and over which are required to carry AIS. Since May 2014 the updated carriage requirements require all fishing vessels of 15 m length and over to carry and broadcast AIS. It is noted that an increasing number of small fishing vessels (currently not required to carry AIS) and recreational craft are voluntarily utilising Class B AIS units thus enabling verification of these small craft when in proximity to a wind farm.

19.8.1 Increased Wind Turbine Size

Following analysis of Radar interference studies and general Radar principles the following impacts associated with the use of the largest WTGs (maximum hub height of 160m and rotor tip of 285 m Highest Astronomical Tides) which could be used in the Moray West Site have been identified. This is specifically to identify potential impacts with the increasing size of WTGs due to the operation of marine Radar beam widths and does not consider impacts associated with the total number of WTGs or amount of exposure for transiting vessels passing within 2nm.

Figure 19-2 shows an example of how Radar range is determined – the curve of the earth plus the sum of the scanner and target height. A higher target height (point B in Figure 19-2) will result in a greater range of detection (point C) of the target, especially for larger vessels with a higher antenna (point A). However the increased distance would result in a weaker Radar return and therefore the effects recorded whilst operating in close proximity to a wind farm (e.g. interfering side lobes, multiple and reflected echoes), are not likely to occur at this increased range. Therefore the increased range of detection of larger WTGs will not impact on a vessels' ability to navigate safely.

Increased wind turbine size would mean that small craft transiting within the Moray West Site would be able to identify WTGs targets at a greater distance, especially if they are not in rows. Consequently, the Moray West structures, ahead of the vessel, would be clear on the Radar screen.

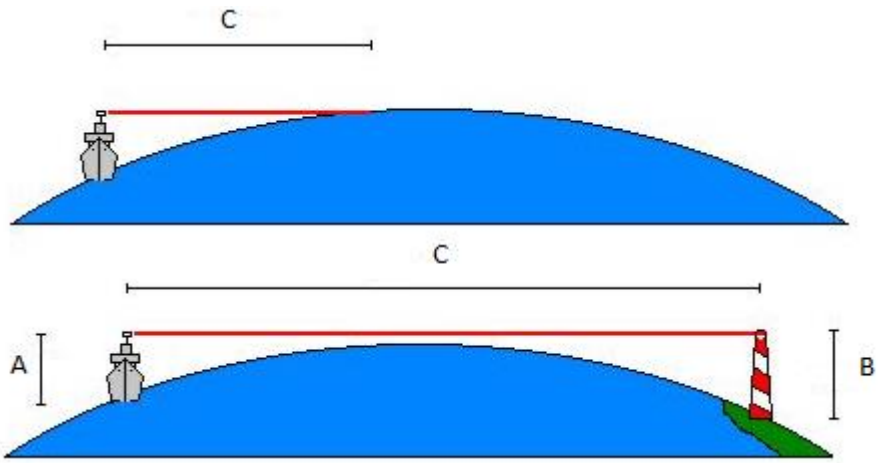


Figure 19-2 Determining Radar Range

19.8.2 Increased Target Returns

Beam width is the angular width, horizontal or vertical, of the path taken by the Radar pulse. Horizontal beam width ranges from 0.75 to 5°, and vertical beam width from 20 to 25°. How well an object reflects energy back towards the Radar depends on its size, shape and aspect angle.

The larger WTGs (either in height or width) will return a greater target size or stronger false targets. However there is a limit to which the vertical beam width would be affected (20 to 25°) dependent on the distance from the target. Therefore increased wind turbine height at the Moray West Site will not create any effects in addition to those already identified from existing operational wind farms (e.g. interfering side lobes, multiple and reflected echoes).

The most likely occurrence will be a greater target return due to increased width of WTGs and foundations resulting in similar effects to those previously described (e.g. interfering side lobes, multiple and reflected echoes). Again when taking into consideration the potential options available to marine users (e.g. reducing gain to remove false returns) and feedback from trials carried out to date that the effects of increased returns can be managed effectively, this effect is expected to be negligible and not further impact on navigational safety.

19.9 Structures Affecting Sonar Systems

No evidence has been found to date with regard to existing wind farms to suggest that they produce any kind of sonar interference which is detrimental to the fishing industry, or to military systems. No impact is therefore anticipated for the Moray West Site or OfTI.

19.10 Noise Impact

19.10.1 Surface Noise

The concern in relation to noise impact which must be addressed under MGN 543 is whether acoustic noise from the wind farm could mask prescribed sound signals.

The sound level from a wind farm at a distance of 350 m has been predicted to be 51 (decibels) dB to 54 dB (A). Furthermore recent predictions of noise levels have been carried out throughout the consenting process of the Atlantic Array offshore wind farm. Modelling shows that the highest predicted level due to operational wind turbine noise (for a 125 m tall eight megawatt (MW) WTGs) is around 60 dB (Atlantic Array Offshore Wind Farm, 2012).

A vessel's whistle for a vessel of 7 m should generate in the order of 138 dB and be audible at a range of 1.5 nm (IMO, 1972/77); hence this should be heard above the background noise of the WTGs. Similarly, foghorns will also be audible over the background noise of the Development.

There are therefore no indications that the sound level of the Development will have a significant influence on marine safety.

19.10.2 Underwater Noise

Underwater noise radiated from 110 m tall, 2 MW capacity WTGs during the operation of the Horns Rev offshore wind farm (Denmark) was measured in November 2005. The maximum levels recorded at 100 m from the WTGs were a sound pressure of 122 dB re 1µ pascals (Pa) (ITAP, 2006).

During the operational phase of the Development, the subsea noise levels generated by WTGs are not anticipated to have any significant impact on sonar systems as they are designed to work in pre-existing noisy environments.

19.11 Effects on Visual Collision / Allision Avoidance

19.11.1 Visual Impact (Other Vessels)

Consideration has been given to the alignment of WTGs within the Moray West Site with regards to visual navigation (noting that the final layout will not be agreed until post consent). Based on the intended alignment, number of WTG and minimum spacing (1,200 m downwind x 1.050 m crosswind) it is not considered there would be any significant effects associated with visual "blind spots" between vessels on the main commercial shipping routes in the area, this also includes small craft navigating within the Moray West Site.

Both fishing and recreational activity was recorded within the Moray West Site during the marine traffic surveys. In the event of a small vessel emerging from the wind farm towards shipping traffic, the vessel should be visible for the vast majority of the time, due to the size of the WTGs and the spacing between them.

19.11.2 Visual Impact (AtoNs or Landmarks)

The Moray West Site will form a significant AtoN once constructed, with marine navigation lighting ensuring visibility to passing traffic (lighting of the Moray West Site will be agreed with NLB post consent). It is therefore considered that the Development will not degrade the ability of vessels to navigate within the area through visual impairment (though it is noted that there is potential for the view of existing AtoNs to be briefly obscured by the Moray West structures without significant effect of a vessels ability to navigate).

20 Hazard Log

20.1 Introduction

As per the required MCA methodology (MCA, 2015), a Hazard Log has been created detailing the potential hazards to shipping and navigation receptors that may arise from the construction, operation, and decommissioning of the Moray West Site and OfTI. The Hazard Log itself is included in Annex A, with this section providing an overview of the methodology used to create the log, and a summary of the results.

20.2 Hazard Workshop

Key to the creation of a Hazard Log is the incorporation of comment and experience of both local and national shipping and navigation stakeholders relevant to the Development. For this reason a Hazard Workshop was held in Inverness on the 21st September 2017 for the purpose of gathering the knowledge and experience of the attendees to use as input to the final Hazard Log. The workshop invitees are listed in Table 20.1, including those parties invited but who were unable to attend.

Table 20.1: Hazard Workshop Invitees

Stakeholder	Attended
Brown and May (Commercial Fisheries Consultees)	Yes
Moray Firth Partnership	Yes
Northern Lighthouse Board	Yes
Repsol Sinopec (Beatrice Oil Field Operator)	Yes
SFF	Yes
RYA Scotland	Yes
Beatrice Offshore Windfarm Ltd	No
CA	No
CoS	No
Cromarty Firth Port Authority	No
Fraserburgh Harbour	No
Ithaca Energy (Jackie Oil Field Operator)	No
Lossiemouth Marina	No
Marine Scotland	No
MCA	No
Moray Council Harbours and Marinas	No
Peterhead Port Authority	No
RNLI	No
The Crown Estate	No
Wick Harbour	No

The attendees were provided with an overview of the Development, including the intended timeline, and the key relevant parameters. Following this, potential hazards to shipping and navigation receptors associated with the Development were identified and discussed. This included discussion of potential mitigation measures that could be implemented to reduce risk to ALARP where appropriate.

Post-workshop, the Hazard Log was drafted and distributed to all attendees, with the final version incorporating the feedback received. The final, agreed version of the Hazard Log is presented in Annex B.

20.3 Results

A total of 14 hazards were identified and included in the Hazard Log. These are listed below (noting that construction and decommissioning impacts were grouped on the basis that these phases presented similar scenarios):

- Displacement of commercial vessel routeing (construction/decommissioning and operation);
- Displacement of third party marine activity (construction/decommissioning and operation);
- Allision with a Development structure (construction/decommissioning and operation);
- Increased collision risk associated with the Development (construction/decommissioning and operation);
- Reduction in SAR resources arising from increased vessel activity associated with the Development (construction/decommissioning and operation);
- Allision (or near miss) associated with towing operations within the Moray Firth (operation);
- Interference with marine navigational equipment (operation);
- Snagging of fishing gear or anchors on cable (operation); and
- Reduction in underkeel clearance impacting on navigational safety (operation).

Each hazard was placed into a tolerability region based on an FSA approach (as described in Section 3). In both the “most likely” and “worst case” scenarios considered, all hazards identified were considered to be of “broadly acceptable” significance based on the output of the Hazard Workshop, and the embedded mitigation in place.

21 Embedded Mitigation Measures

Those measures assumed to be embedded mitigation are listed in Table 21.1. The EIA has been undertaken on the understanding that these measures will be in place.

Table 21.1: Embedded Mitigation Measures

Mitigation	Description
Safety Zones	Moray West will apply for 500 m rolling safety zones during construction, for periods of major maintenance during operation, and for during decommissioning. Smaller 50 m "pre-commissioning" safety zones will also be applied for.
Buoyed Construction Area	During construction, the extents of the Moray West Site will be marked with buoyage to indicate the area within which construction is being undertaken (noting navigation will only be restricted within active safety zones). This will be undertaken following NLB consultation and approval.
Blade Clearance	Blade clearance will be at least 22 m above MHWS in line with MGN543 and RYA requirements.
Cable Burial Risk Assessment	A Cable Burial Risk Assessment will be undertaken post consent. The assessment will provide detail of cable protection to be implemented, including the highlighting of any areas where cable protection may reduce navigable water depths.
Compliance with international maritime regulations	It will be ensured that all vessels associated with the Development are familiar with, and will comply with, international maritime regulations as adopted by the flag state. This includes compliance with COLREGS (IMO, 1972).
Development and Specification Layout Plan (DSLP)	Post consent, Moray West will create a DSLP, which will include the final layout of the Development. This layout will be agreed with Marine Scotland, who will consult with the MCA, NLB and CoS through their approval of the DSLP.
Emergency Response and Cooperation Plan (ERCoP)	Post consent, Moray West will provide an ERCoP to the MCA for approval. The ERCoP will provide details of emergency response plans in place for the Development.
Fisheries Liaison Officer	Moray West will assign a Fisheries Liaison Officer who will be responsible for providing fishing stakeholders with Development information, and for providing fishing stakeholder feedback to Moray West.
Vessel health and safety requirements including competency assessments and audits	Moray West will ensure suitable procedures are in place to check Development associated vessel's compliance with health and safety requirements.
Lighting and Marking	Post consent, a Lighting and Marking Plan will be created presenting the lighting/marking that will be implemented during the construction and operation of the Development. This plan will be agreed with the NLB, MCA, CAA, and MoD.
Marine Coordination	Development vessel movements during construction and operation will be managed via a Marine Coordination Centre.
Marine Pollution Contingency Planning	Measures will be adopted to ensure that the potential for release of pollutants from construction and operation and maintenance activities is minimised, which will include planning for accidental spills and responding to all potential contaminant releases.
MGN543	The Development will be designed in line with applicable recommendations set out in MGN543 (MCA 2016), including the SAR annex.

Table 21.1: Embedded Mitigation Measures	
Mitigation	**Description**
AIS Monitoring	Vessel traffic passing the Development will be monitored via AIS during the construction phase.
Navigational Safety Plan (NSP)	An NSP will be created post consent detailing the navigational safety measures Moray West will have in place during the construction and operation of the Development.
Permanent AtoNs	Permanent AtoNs will be established based on the requirements set out in IALA O-139 (IALA 2013). This will be agreed with the NLB, CAA, MCA and MoD.
Promulgation of information	Development information will be promulgated to relevant stakeholders, including through the means of Notice to Mariners and Kingfisher bulletins.
	The positions of all OSPs and cables will be provided to the Clyde Cruising Club, for inclusion in the "Clyde Cruising Club Sailing Directions and Anchorages".
Guard vessels	Guard vessels will be used during construction and decommissioning where appropriate (as determined through risk assessment).
Marking on Admiralty Charts	The positions of WTGs, OSPs, and cables will be provided to the UKHO, who will add the information to Admiralty Charts as appropriate.

22 Next Steps

22.1 EIA Summary

Following identification of both future case impacts and the outcomes of the FSA an impact assessment in line with EIA guidance has been undertaken. The impact assessment screens the identified impacts from the NRA with effective pathways to shipping and navigation receptors, and assumes the mitigation measures listed in Section 21 will be in place. This EIA is presented in Chapter 12: Shipping and Navigation.

The EIA takes in to consideration the baseline assessment including the marine traffic survey analysis in addition to the other contents of this NRA. This input is used to rank each impact identified for the construction, operation, and decommissioning phases of the Development in terms of significance as per the FSA process described in Section 3.

22.2 Impact Screening

Table 22.1 presents the impacts that have been identified during the scoping stage, and any additional impacts identified within the NRA process (including the baseline assessment, consultation, and hazard workshop). The table indicates whether each impact has been screened out within this NRA stage (with justification), or whether further assessment is required within the EIA, Chapter 12: Shipping and Navigation.

Table 22.1: Impact Screening

Impact	Scoped into EIA	Receptors	Justification
Construction Phase			
Vessel displacement	Yes	All third party vessels	During construction, it is anticipated that the majority of vessels will choose to avoid the buoyed construction area. As the marine traffic analysis (Section 12) showed third party vessel activity within the Moray West Site (including from regular routed vessels as per Section 13), assessment of displacement impact is necessary.
Increased vessel to vessel collision	Yes	All third party vessels Moray West vessels	Changes in collision rates will depend on the levels of displacement, and the sea areas into which vessels are displaced. Further assessment is therefore required.
Vessel to structure (partially completed or pre-commissioned) allision risk	Yes	All third party vessels	During the construction phase, structures may be in a partially constructed state (and therefore potentially less visible than when completed) within a previously open sea area. Further assessment is therefore required.
Anchor interaction or snagging	Yes	All third party vessels	Anchorage areas were noted within the vicinity of the offshore export cable corridor (see Section 8.4) and it is noted that cable protection may not be implemented during the construction phase.

Table 22.1: Impact Screening			
Impact	**Scoped into EIA**	**Receptors**	**Justification**
Marine Radar Interference	No	All third party vessels	Provided in Section 19.8; no safety related effects are anticipated.
Diminishment of Emergency Response Resources	No	SAR Resources	The anticipated rise in incidents requiring response during the construction phase is considered negligible when compared against the baseline (see Section 11).
Operational Phase			
Vessel displacement	Yes	All third party vessels	During the operational phase, some vessels (most likely recreational and fishing) may choose to transit through the Moray West Site, and assessment beyond that undertaken within the corresponding construction phase impact is therefore required. The operational lifespan of the Development also needs to be considered.
Increased vessel to vessel collision	Yes	All third party vessels Moray West vessels	The change to vessel to vessel collision risk is dependent on the levels and locations of displacement, which will differ during the operational phase compared to the construction phase. The operational lifespan of the Development also needs to be considered.
Vessel to structure allision	Yes	All third party vessels	Construction phase measures used to mitigate against allision (e.g., safety zones, guard vessels, promulgation of information) will no longer be present during the operational phase, and further assessment is therefore required. The operational lifespan of the Development also needs to be considered.
Anchor interaction or snagging	Yes	All third party vessels	Cable protection will be implemented during the operational phase; however the operational lifespan of the Development needs to be considered.
Allision scenario associated with towing operation within the Moray Firth	No	All vessels	It assumed that towing operations will be undertaken and managed in line with COLREGS, and that passing traffic will also comply with the regulations. There are no remaining safety related impacts and therefore no further assessment is considered necessary on this basis.
Marine Radar Interference	No	All third party vessels	Provided in Section 19.8, no safety related effects are anticipated.

Table 22.1: Impact Screening			
Impact	**Scoped into EIA**	**Receptors**	**Justification**
Diminishment of Emergency Response Resources	Yes	SAR Resources	Further assessment is considered necessary given the operational lifespan of the Development and the varying levels of vessels and personnel on site.
Reduction in underkeel clearance	Yes	All third party vessels	Further assessment is required, given that cable protection may reduce safe navigable water depths in the landfall approach where water depths are less than 20 m.
Decommissioning Phase			
Vessel displacement	Yes	All third party vessels	Significance of vessel displacement will be dependent on structures left in situ. Further assessment is therefore considered necessary.
Increased vessel to vessel collision	No	All third party vessels Moray West vessels	As a worst case, collision rates are anticipated to remain consistent with operational levels.
Vessel to structure allision	Yes	All third party vessels	Structures left in situ may no longer have operational lighting and marking, and there is the potential for structures to reduce in height to subsurface levels over time. Further assessment is therefore considered necessary.
Anchor interaction or snagging	Yes	All third party vessels	Cable protection may no longer be monitored/maintained post decommissioning, increasing the snagging risk. Further assessment is therefore considered necessary.
Marine Radar Interference	No	All third party vessels	Provided in Section 19.8, no safety related effects are anticipated.
Diminishment of Emergency Response Resources	No	SAR Resources	The anticipated rise in incidents (noting there is anticipated to be negligible need for SAR response during the decommissioning phase) requiring response during the decommissioning phase is considered negligible when compared against the baseline (see Section 11).
Reduction in underkeel clearance	No	All third party vessels	There are considered to be no additional changes to water depths during decommissioning beyond that observed during the operational phase. Water depths observed during decommissioning will therefore be established during the operational phase, and no additional decommissioning impact is anticipated.

23 Future Monitoring

23.1 Safety Management System (SMS) and Emergency Response Planning

Health and safety documentation, including a policy statement, SMS and emergency response plans (including the ERCoP would be in place for the Development post consent and prior to construction. These would then be continually updated throughout the operational and decommissioning process.

Monitoring, reviewing and auditing would be carried out on all procedures and activities and feedback actively sought. Any designated person, managers and supervisors are to maintain continuous monitoring of all marine operations and determine if all required procedures and processes are being correctly implemented.

23.2 Subsea Cables

The subsea cables will be subject to periodic inspection to monitor the cable protection (including burial depths) during the operational phase. This will include the export cables, inter array cables, and, in the event of two OSPs, the interconnector cable.

23.3 Hydrographic Surveys

As required by MGN 543, detailed and accurate hydrographic surveys will be undertaken periodically at agreed intervals.

23.4 Decommissioning Programme

A decommissioning programme will be developed post consent. With regards to impacts on shipping and navigation this will also include consideration of the scenario where on decommissioning and on completion of removal operations, an obstruction is left on site (attributable to Moray West) which is considered to be a danger to navigation and which it has not proved possible to remove. Such an obstruction may require marking until such time as it is either removed or no longer considered a danger to navigation, the continuing cost of which would need to be met by the operator.

24 Summary

24.1 Marine Traffic

As agreed with the MCA and NLB, Moray West collected a total of 53 days of marine traffic survey data during 2016 and 2017, recorded during summer (via AIS, Radar, and visual observations) and winter (AIS only). During the summer survey, an average of approximately ten unique vessels were recorded within 10 nm of the Moray West Site, four of which intersected the site itself. Traffic levels dropped during winter (noting that non-AIS vessels will be underrepresented during winter), with an average of four unique vessels per day recorded within 10 nm of the Moray West Site, two per day of which intersected the site itself.

The most commonly recorded traffic recorded during both seasonal periods was from fishing vessels, and from vessels associated with the Beatrice oil field vessels.

Based on existing vessel routeing patterns, and the available sea room inshore of the Moray West Site, there are not anticipated to be any impacts on adverse weather routeing.

24.2 Vessel Routeing

The marine traffic survey data was used to identify the regular vessel routes within the offshore wind farm study area. A total of eight routes were identified, three of which were observed to intersect the Moray West Site. Worst case deviations (on the assumption that the affected vessels would not transit through the Moray West Site) were then assessed for these three routes; in reality vessels are likely to passage plan in line with MGN 372 (MCA, 2008) depending on weather and sea state further reducing the level of impact that has been identified within this NRA.

24.3 Allision and Collision Modelling

The baseline traffic data and estimated vessel deviations were used to estimate the change in allision and collision frequencies expected to arise as a result of the Development, taking into account the potential for future traffic growth within the Moray Firth.

It was estimated that vessel collision rates would rise from one collision every 28,600 years pre wind farm, to one every 13,800 years post wind farm. The majority of this risk was observed to be associated with Beatrice oil field vessels.

The frequencies of a commercial vessel (including passenger, and oil field traffic) alliding with a structure within the Moray West Site was estimated at one powered allision per 17,400 years, and one drifting allision per 135,300 years.

The frequency of a fishing vessel alliding with a structure within the Moray West Site was estimated at one allision per six years. It is noted that while this value is high when compared to the commercial vessel assessment, the majority of fishing vessel allisions within a wind farm would be expected to be low speed (and therefore low consequence). It is also noted that this value was estimated on the assumption that fishing levels within the Moray West Site would be unaffected by the finished structures (i.e., a worst case allision case of no displacement) and that fishing vessels would not alter their navigational behaviour to account for the WTGs. This would not be the case and fishing vessels would learn and amend their behaviour to navigate and fish within the Moray West Site (as demonstrated in existing wind farms within the UK REZ).

24.4 Emergency Response

Under national and international law the operators of the Development would be required to comply with existing emergency response requirements as well as giving consideration to other response groups within the area. Owing to the increased level of activity in and around the Development there are expected to be some increased demands on search and rescue facilities within the area. The Development could also increase traffic and activity to a level that self-help emergency response would be required and consideration in the ERCoP should be given to what resources would be required to provide a level of response that would ensure that response time and resources aren't impacted.

24.5 Hazard Log

A Hazard Log was drafted by Anatec, which detailed the potential hazards associated with the Development that were identified during the baseline assessment. The Hazard Log was informed by the outputs of a Hazard Workshop attended by various marine stakeholders (both statutory and non-statutory) and was subsequently agreed with key shipping and navigation stakeholders. The approved Hazard Log was then used to inform the significance rankings used within the impact assessment undertaken in Chapter 12: Shipping and Navigation, in addition to the modelling results and expert opinion. No significant concerns were raised during the Hazard Workshop.

24.6 Impact Screening

The main output of the NRA is a list of impacts considered as requiring further assessment within the EIA undertaken in Chapter 12: Shipping and Navigation. The following impacts are therefore carried forward to the EIA:

- Vessel displacement (all phases);
- Increased vessel to vessel collision risk (construction and operational phases);
- Vessel to structure allision risk (all phases);
- Anchor interaction or snagging (all phases);
- Diminishment of emergency response Resources (operational phase); and
- Reduction in underkeel clearance (operational phase).

Each of the above impacts will also be considered on a cumulative basis within the EIA.

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26 Annex 12.1A Hazards Log

26.1 Introduction

26.1.1 Overview

This annex to Chapter 12: Shipping and Navigation of the Moray West Environmental Impact Assessment (EIA) Report presents the Hazard Log(see Table 26.1), which was created to identify and provisionally assess impacts to shipping and Navigation receptors which may arise as a result of the Project.

26.1.2 Methodology

The Hazard Log was drafted following a Hazard Workshop undertaken in September 2017, which gathered marine stakeholders for the purpose of validating the results of the baseline assessment, and to identify and discuss impacts specific to the Project. Further details of the Hazard Workshop are presented in Section 20 of Appendix 12.1: Navigation Risk Assessment.

Each impact was assigned a severity of consequence ranking and frequency of occurrence ranking as per the definition provided in Section 3 of the NRA. These were used to assess significance of each impact, as per the defined risk matrix, also provided in Section 3 of the NRA.

It is emphasized that the rankings provided in the Hazard Log have been designed to reflect the discussions of the Hazard Workshop, and do not necessarily represent the final EIA rankings. While the Hazard Log forms a key input to the impact assessment undertaken in Chapter 12: Shipping and Navigation, the final rankings also take into consideration other outputs of the NRA, including modelling results, the baseline assessment, and statutory consultation results.

Table 26.1 Hazards Log

Phase	Hazard Type	Hazard Title	Hazard Detail	Possible Causes	Most Likely Consequence	Worst Case Consequence	Embedded Mitigations	Most Likely							Worst Case							Potential Additional Mitigation	Remarks / Questions
								People	Property	Environment	Business	Consequence	Frequency	Risk with Embedded Mitigation	People	Property	Environment	Business	Consequence	Frequency	Risk with Embedded Mitigation		
Construction (and Decommissioning)	Displacement	Displacement of commercial vessel routeing	The construction of Moray West may lead to a displacement of established commercial vessel routes.	Buoyed construction (or decommissioning) area intersecting or in proximity to pre-existing commercial vessel routes.	Increased journey time and distance for vessels using affected routes.	Increased journey time and distance for vessels using affected routes, leading to delays in operator schedules.	Promulgation of information including notice to mariners, charting and marine coordination.	1	1	1	1	1	2	Broadly Acceptable	1	1	1	3	2	1	Broadly Acceptable	No further mitigation required.	Effects on commercial vessels limited, no time sensitive ferry operations present.
Construction (and Decommissioning)	Displacement	Displacement of third party marine activity (navigational)	The construction of Moray West leading to a displacement of third party marine activity (e.g., recreational, fishing).	Buoyed construction (or decommissioning) area intersecting or in proximity to pre-existing third party marine activity.	Minor reduction in sea space / fishing grounds for existing recreational or fishing activity.	Loss of area used by third party marine activity - temporary.	Promulgation of information including notice to mariners, charting and marine coordination.	1	1	1	1	1	2	Broadly Acceptable	2	1	1	2	2	1	Broadly Acceptable	No further mitigation required.	Limited third party navigational activity present (compared to other UK areas) and cohabitation likely.
Construction (and Decommissioning)	Allision	Allision with pre-commissioned structures	A passing vessel alliding with one of the precommissioned wind farm structures.	Lack or failure of lighting / marking, human error, mechanical failure of vessel, adverse weather, navigational error.	Near miss of vessel with periphery structure, or entry into a safety zone.	Allision of small vessel with structure leading to capsize, or large vessel leading to damage or pollution spill.	Promulgation of information, lighting and marking, safety zones, buoyed construction area, marine coordination and guard vessel as required.	1	1	1	1	1	2	Broadly Acceptable	4	3	3	3	4	1	Broadly Acceptable	No further mitigation recommended; given the frequency of occurrence.	Standard industry practice has effectively mitigated this impact at other developments.
Construction (and Decommissioning)	Impacts on SAR	Reduction of SAR Resources due to increased activity associated with the construction of Moray West	The increase of activity associated with the construction of Moray West leading to an increase in SAR incidents, reducing overall SAR resources in the Moray Firth area.	Increased vessel activity associated with the construction of Moray West.	Limited reduction to SAR Resources	Multiple incidents occurring within the Moray Firth over a short period of time, leading to a deficit of required SAR resources.	Presence of development will provided increased on site resources during construction, ERPs and ERCoP in place.	2	1	1	1	2	1	Broadly Acceptable	4	4	4	4	4	1	Broadly Acceptable	No further mitigation recommended; given the frequency of occurrence.	
Construction (and Decommissioning)	Collision	Increased collision risk arising from the construction of Moray West.	An increase in collision risk arising from the following scenarios: - third party vessel with a construction vessel - between two third party vessels as a result of displacement into limited sea room	Human error, adverse weather, mechanical failure of vessel, navigational error, vessel displacement	A near miss scenario outside of the wind farm area	Collision between two vessels leading to loss of stability and possible capsize, with the potential for loss of lives, or pollution spill	Marine coordination, charting and marking of the site, site location considered against existing vessel activity (at site design stage).	1	1	1	1	1	1	Broadly Acceptable	5	4	3	3	4	1	Broadly Acceptable	No further mitigation recommended; given the frequency of occurrence.	Standard industry practice has effectively mitigated this impact at other developments.
Operation and Maintenance	Displacement	Displacement of commercial vessel routeing	The wind farm structures, or safety zones during major maintenance, displacing commercial traffic.	Wind farm structures in proximity to pre-existing commercial vessel routes.	Increased journey time and distance for vessels using affected routes.	Increased journey time and distance for vessels using affected routes, leading to delays in operator schedules.	Promulgation of information including notice to mariners, charting and marine coordination.	1	1	1	1	1	2	Broadly Acceptable	1	1	1	2	2	1	Broadly Acceptable	No further mitigation required.	It is expected that commercial vessels will adapt to the presence of the wind farm during the construction phase, and will continue to use deviated routes during the operational phase.
Operation	Displacement	Displacement of third party marine activity (navigational)	The wind farm structures, or safety zones during major maintenance, displacing third party marine traffic.	Wind farm structures in proximity to pre-existing third party marine activity.	Minor reduction in sea space / fishing grounds for existing recreational or fishing activity.	Loss of area used by third party marine activity .	Promulgation of information including notice to mariners, charting and marine coordination.	1	1	1	2	2	1	Broadly Acceptable	1	1	1	3	2	1	Broadly Acceptable	No further mitigation required.	Recreational or fishing vessels may choose to transit through the wind farm during the operational phase (except if safety zones are used during periods of major maintenance).
Operation	Allision	Allision with a wind farm structure	A passing vessel alliding with one of the wind farm structures.	Failure of lighting / marking, human error, mechanical failure of vessel, adverse weather, navigational error.	Near miss of vessel with periphery structure	Allision of small vessel with structure leading to capsize, or large vessel leading to damage or pollution spill.	Promulgation of information, lighting and marking, marine coordination	1	1	1	1	1	2	Broadly Acceptable	4	3	3	3	4	1	Broadly Acceptable	No further mitigation recommended; given the frequency of occurrence.	Standard industry practice has effectively mitigated this impact at other developments.
Operation	Allision	Allision or near miss associated with a structure being towed within the Moray Firth	Increase in allision risk associated with structures being towed within the Moray Firth, either to a Moray West vessel, or to a third party vessel displaced into limited sea space by the wind farm.	Failure or lack or lighting / marking of towed structure, tow line failure / break, human error, adverse weather, navigational error	A near miss scenario outside of the wind farm area	Allision of small vessel with structure leading to capsize, or large vessel leading to damage or pollution spill.	Promulgation of information, marine coordination, ERCoP, compliance with international and flag regulations (SOLAS and COLREGS)	1	1	1	1	1	1	Broadly Acceptable	4	3	3	3	4	1	Broadly Acceptable	No further mitigation recommended; given the frequency of occurrence.	
Operation	Impacts on SAR	Reduction of SAR Resources due to increased activity associated with the construction of Moray West	The increase of activity associated with the operation of Moray West leading to an increase in SAR incidents, reducing overall SAR resources in the Moray Firth area.	Increased vessel activity associated with the operation of Moray West.	Limited reduction to SAR Resources	Multiple incidents occurring within the Moray Firth over a short period of time, leading to a deficit of required SAR resources.	Presence of development will provided increased on site resources during construction, ERPs and ERCoP in place.	2	1	1	1	2	1	Broadly Acceptable	4	4	4	4	4	1	Broadly Acceptable	No further mitigation required.	Considered lower than during construction and decommissioning due to decreased numbers of vessels/personnel
Operation	Collision	Increased collision risk arising from the operation of Moray West.	An increase in collision risk arising from the following scenarios: - third party vessel with a maintenance vessel - between two third party vessels as a result of displacement into limited sea room	Human error, adverse weather, mechanical failure of vessel, navigational error, vessel displacement.	A near miss scenario outside of the wind farm area	Collision between two vessels leading to loss of stability and possible capsize, with the potential for loss of lives, or pollution spill	Marine coordination, charting and marking of the site, site location considered against existing vessel activity (at site design stage).	1	1	1	1	1	1	Broadly Acceptable	5	4	3	3	4	1	Broadly Acceptable	No further mitigation recommended; given the frequency of occurrence.	Standard industry practice has effectively mitigated this impact at other developments.
Operation	Interference	interference with marine navigational equipment.	Wind farm structures interfering with vessel marine radar capabilities (e.g., shadowing)	Vessels passing in close proximity to wind farm structures.	No notable effect.	Some minor radar interference	Consideration of MGN 543 and consideration of lessons learnt.	1	1	1	1	1	1	Broadly Acceptable	1	1	1	1	1	1	Broadly Acceptable	No further mitigation required.	Operational projects and research have shown not significant impacts for marine navigational equipment.
Operation	Snagging	Snagging of gear or anchors on cable	The cables or protection method creates a snagging risk	Failure of cable protection leading to exposed cable, human error, mechanical anchor failure	A minor snagging which the vessel frees itself from, leading to very minor cable / gear / anchor damage	Snagging from a small vessel, leading to capsize with the potential for loss of life, or from a large vessel leading to significant damage to the cable	Cable burial risk assessment, ERCoP, Fisheries liaison officer, promulgation of information including charting of the cables	1	2	1	1	2	1	Broadly Acceptable	4	2	1	3	3	1	Broadly Acceptable	No further mitigation recommended; given the frequency of occurrence.	
Operation	Under keel Clearance	Reduction in under keel clearance	The cables or cable protection leading to a reduction in under keel clearance	Cable protection required in areas of shallow water depth	Not significant changes to water depths in coastal areas	Changes to water depths to a degree affecting navigational transits.	Cable burial risk assessment, promulgation of information	1	1	1	1	1	3	Broadly Acceptable	2	1	1	1	2	1	Broadly Acceptable	No further mitigation required.	

26.3 References

IMO (1972) Convention on the International regulations for Preventing Collisions at Sea – Annex 3. London: IMO.

IMO (1974) Convention on the Safety of Life at Sea (SOLAS). London: IMO.

MCA (2016) MGN 543 (Merchant and Fishing) Safety of Navigation Offshore Renewable Energy Installations (OREIs) – Guidance on UK Navigational Practice, Safety and Emergency Response. Southampton: MCA

27 Annex 12.1B: Marine Guidance Note 543 Guidance

27.1 Introduction

This annex to Chapter 12: Shipping and Navigation of the Moray West Offshore Wind Farm Environmental Impact Assessment (EIA) Report provides the Maritime and Coastguard Agency (MCA) Marine Guidance Note (MGN) 543 (MCA, 2016a) checklist, which demonstrates that the NRA (Appendix 12.1) and subsequent impact assessment in Chapter 12: Shipping and Navigation meets the MCA requirements for Offshore Renewable Energy Installations (OREIs).

A template checklist is provided by the MCA (2016b), which has been used as the basis of this document. The template provides tables containing the requirements of MGN 543, and the requirements of the MCA Methodology for Assessing Navigational Safety and Emergency Response Risks of OREIs (MCA, 2015). These are provided in Table 27.1 and Table 27.2 of this annex respectively.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
Annex 1: Considerations on Site Position, Structures and Safety Zones		
1. Site and Installation Co-ordinates		
Developers are responsible for ensuring that formally agreed co-ordinates and subsequent variations of site perimeters and individual OREI structures are made available, on request, to interested parties at relevant project stages, including application for consent, development, array variation, operation and decommissioning. This should be supplied as authoritative Geographical Information System (GIS) data, preferably in Environmental Systems Research Institute (ESRI) format. Metadata should facilitate the identification of the data creator, its date and purpose, and the geodetic datum used. For mariners' use, appropriate data should also be provided with latitude and longitude coordinates in WGS84 (ETRS89) datum.	✓	Moray West will make the formally agreed coordinates, and any subsequent variations, available to interested parties at the relevant project stages.
Traffic Survey – includes:		
All vessel types	✓	The marine traffic analysis undertaken within the NRA includes all vessel types recorded during the summer and winter surveys. As agreed with the MCA, the winter survey was Automatic Identification System (AIS) only. Based on consultation, vessels working at (or transiting to/from) the Beatrice field have been

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
		retained within the baseline; however other traffic counted as temporary has been excluded.
At least 28 days duration, within either 12 or 24 months prior to submission of the Environmental Statement	✓	As agreed with the MCA, marine traffic data spans 53 days, split as follows: 25 days summer (AIS and radar); and 28 days winter (AIS only). Data was collected within 24 months of intended submission date of the EIA Report.
Multiple data sources	✓	In addition to the marine traffic survey data (consisting of both AIS and radar), additional data sources have also been considered, as per Section 6 of the NRA. These include: Royal Yachting Association (RYA) Coastal Atlas (2016); Fishing sightings surveillance data; and Fishing satellite monitoring data.
Seasonal variations	✓	Marine traffic analysis (Section 12 of the NRA) has utilised data recorded to account for both summer (Aug/Sept 2017) and winter (Nov/Dec 2016) months.
MCA consultation	✓	The approach to marine traffic data collection was agreed with the MCA. MCA response to the Scoping Report, and key issues arising from consultation meetings undertaken directly with the MCA are provided in Section 5 of the NRA, and in Chapter 12: Shipping and Navigation.
General Lighthouse Authority (GLA) consultation	✓	The approach to marine traffic data collection was agreed with the Northern Lighthouse Board (NLB). NLB response to the Scoping Report, and key issues arising from consultation meetings undertaken directly with the NLB are provided in Section 5 of the NRA, and in Chapter 12: Shipping and Navigation.
Chamber of Shipping (CoS) consultation	✓	CoS responses to the Scoping Report, and key issues arising from consultation meetings undertaken directly with the CoS are provided in Section 5 of the NRA, and in Chapter 12: Shipping and Navigation.
Recreational and fishing vessel organisations consultation	✓	RYA Scotland, Cruising Association (CA), and Scottish Fishermen's Federation (SFF) responses to the Scoping Report are provided in Section 5 of the NRA, and in Chapter 12: Shipping and Navigation. The same section also provides output of direct consultation meetings held with RYA Scotland and the CA.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
		RYA Scotland and SFF representatives were present at the Hazard Workshop (see Section 20 of the NRA). Further relevant consultation with fishing stakeholders is provided in Chapter 11: Commercial Fisheries.
Port and navigation authorities consultation, as appropriate	✓	Moray Council response to the Scoping Report is provided in Section 5 of the NRA, and in Chapter 12: Shipping and Navigation. A representative of the Moray Firth partnership was present at the Hazard Workshop (see Section 20 of the NRA).
Assessment of the cumulative and individual effects of (as appropriate):		
i. Proposed OREI site relative to areas used by any type of marine craft.	✓	The study area used to assess marine traffic was defined to encompass all relevant passing traffic while still remaining site specific to the Moray West Site (see Section 3.5 of the NRA).
ii. Numbers, types and sizes of vessels presently using such areas	✓	Marine traffic analysis (Section 12 of the NRA) includes assessment of vessel numbers, types, and sizes within the area.
iii. Non-transit uses of the areas, e.g. fishing, day cruising of leisure craft, racing, aggregate dredging, etc.	✓	Recreational and fishing vessel activities have been assessed in Sections 12.2.8 and 12.2.9 of the NRA respectively. Oil and gas activity has also been assessed on Section 12.2.6.
iv. Whether these areas contain transit routes used by coastal or deep-draught vessels on passage.	✓	Vessel draughts have been assessed in Section 12.2.4 of the NRA. Vessel routeing has been assessed in Section 13.
v. Alignment and proximity of the site relative to adjacent shipping lanes	✓	Vessel routeing has been assessed in Section 13, which includes estimated 90th percentile lanes relative to the Moray West Site.
vi. Whether the nearby area contains prescribed routeing schemes or precautionary areas	✓	Navigational features relevant to the Moray West Site and the Moray Firth in general have been assessed in Section 8 of the NRA.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
vii. Whether the site lies on or near a prescribed or conventionally accepted separation zone between two opposing routes	✓	Navigational features relevant to the Moray West Site and the Moray Firth in general have been assessed in Section 8 of the NRA.
viii. Proximity of the site to areas used for anchorage, safe haven, port approaches and pilot boarding or landing areas.	✓	Navigational features relevant to the Moray West Site and the Moray Firth in general have been assessed in Section 8 of the NRA.
ix. Whether the site lies within the jurisdiction of a port and/or navigation authority.	✓	Navigational features relevant to the Moray West Site and the Moray Firth in general have been assessed in Section 8 of the NRA, which includes nearby ports (Section 8.5).
x. Proximity of the site to existing fishing grounds, or to routes used by fishing vessels to such grounds.	✓	Fishing vessel activity has been assessed in Section 12.2.9 of the NRA, including assessment of fishing vessels in transit.
xi. Proximity of the site to offshore firing/bombing ranges and areas used for any marine military purposes.	✓	Navigational features relevant to the Moray West Site and the Moray Firth in general have been assessed in Section 8 of the NRA, which includes military practice areas (Section 8.6).
xii. Proximity of the site to existing or proposed offshore oil / gas platform, marine aggregate dredging, marine archaeological sites or wrecks, Marine Protected Area or other exploration/exploitation sites	✓	Navigational features relevant to the Moray West Site and the Moray Firth in general have been assessed in Section 8 of the NRA, which includes: Oil/gas platforms (Section 8.7); Dredging areas (Section 8.8); Wrecks (Section 8.11); and Marine Environmental High Risk Areas (Section 8.10).
xiii. Proximity of the site to existing or proposed OREI developments, in co-operation with other relevant developers, within each round of lease awards.	✓	The Moray West Site is shown relative to other developments in Sections 8.2 of the NRA. Cumulative assessment has been undertaken in Section 12.20 of Chapter 12 Shipping and Navigation.
xiv. Proximity of the site relative to any designated areas for the disposal of dredging spoil or other dumping ground	✓	The navigational feature baseline is established in Section 8 of the NRA.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
xv. Proximity of the site to Aids to Navigation (AtoNs) and/or Vessel Traffic Services (VTS) in or adjacent to the area and any impact thereon.	✓	AtoNs within the vicinity of the Moray West Site are presented in Section 8.3 of the NRA. Pilotage requirements are shown in Section 8.6 of the NRA.
xvi. Researched opinion using computer simulation techniques with respect to the displacement of traffic and, in particular, the creation of 'choke points' in areas of high traffic density and nearby or consented OREI sites not yet constructed.	✓	Collision rates pre and post wind farm (i.e., taking into account displacement arising from Moray West) have been modelled within Sections 16 and 17.
xvii. With reference to xvi. above, the number and type of incidents to vessels which have taken place in or near to the proposed site of the OREI to assess the likelihood of such events in the future and the potential impact of such a situation.	✓	Historic maritime incidents recorded within the vicinity of Moray West are presented in Section 11 of the NRA. Future collision and allision rates have been modelled, with the results presented in Section 17 of the NRA.
3. OREI Structures – the following should be determined:		
a. Whether any feature of the OREI, including auxiliary platforms outside the main generator site, mooring and anchoring systems, inter-device and export cabling could pose any type of difficulty or danger to vessels underway, performing normal operations, including fishing, anchoring and emergency response.	✓	Impacts to commercial vessels, fishing vessels, recreational vessels, and Search and Rescue (SAR) resources are assessed within Chapter 12: Shipping and Navigation.
b. Clearances of wind turbine blades above the sea surface are *not less than 22 metres* above Mean High Water Springs (MHWS).	✓	As per the embedded mitigation listed in Section 21 of the NRA, blade clearance will be at least 22m above MHWS.
c. Underwater devices i. changes to charted depth ii. maximum height above seabed iii. Under Keel Clearance	✓ ✓ ✓	Impacts associated with reductions in water depth from the subsea cabling are assessed in Chapter 12 Shipping and Navigation.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
d. The burial depth of cabling and changes to charted depths associated with any protection measures.	✓	Impacts associated with reductions in water depth from the subsea cabling are assessed in Chapter 12 Shipping and Navigation.
4. Assessment of Access to and Navigation Within, or Close to , an OREI		
To determine the extent to which navigation would be feasible within the OREI site itself by assessing whether:		
a. Navigation within or close to the site would be safe:		
by all vessels, or by specified vessel types, operations and/or sizes. in all directions or areas, or in specified directions or areas. in specified tidal, weather or other conditions	✓ ✓ ✓ ✓ ✓	During the construction phase, vessels will be advised against entry into the buoyed construction area, however navigation will not be restricted other than through active safety zones. During the operational phase, Moray West will not restrict navigation on any type or size of vessel, with the exception of during periods of major maintenance, where safety zones may be utilised around the structures being worked on.
b. Navigation in and/or near the site should be:		
i) prohibited by specified vessels types, operations and/or sizes. ii) prohibited in respect of specific activities, iii) prohibited in all areas or directions, or iv) prohibited in specified areas or directions, or v) prohibited in specified tidal or weather conditions, or simply vi) recommended to be avoided.	✓ ✓ ✓ ✓ ✓ ✓	i) There will be no restrictions on navigation to any vessel type during normal operations of the Development (noting that safety zones may be employed during the construction phase, and during periods of major maintenance). ii) There will be no formal restrictions put in place by Moray West on any marine activity. However, it has been assumed that vessels seeking anchorage or engaged in fishing will take the charted presence of infrastructure into consideration. iii) There will be no restrictions on navigation to any vessel type during normal operations of the Development (noting that safety zones may be employed during the construction phase, and during periods of major maintenance). iv) There will be no restrictions on navigation to any vessel type during normal operations of the Development (noting that safety zones may be employed during the construction phase, and during periods of major maintenance).

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
		v) There will be no restrictions on navigation to any vessel type during normal operations of the Development (noting that safety zones may be employed during the construction phase, and during periods of major maintenance). Adverse weather routeing within the Moray Firth has been assessed within Section 13.4 of the NRA. vi) Moray West will put no formal restrictions on navigation in place (noting that safety zones may be employed during the construction phase, and during periods of major maintenance). However, recommended safe passing distances from Development vessels will be promulgated via Notice to Mariners.
c. Exclusion from the site could cause navigational, safety or routeing problems for vessels operating in the area e.g. by preventing vessels from responding to calls for assistance from persons in distress	✓	Displacement impacts are assessed in Chapter 12 Shipping and Navigation. Marine Scotland will consult with the MCA on the final layout post consent prior to approval. The MCA will assess the layout in terms of emergency response.
Relevant information concerning a decision to seek a safety zone for a particular site during any point in its construction, extension, operation or decommissioning should be specified in the Environmental Statement accompanying the development application	✓	As per the embedded mitigation listed in Section 21 of the NRA, Moray West intends to apply for safety zones during the construction and operational phases (during periods of major maintenance).
Annex 2: Navigation, collision avoidance and communications		
The Effect of Tides and Tidal Streams: It should be determined whether:		
a. Current maritime traffic flows and operations in the general area are affected by the depth of water in which the proposed installation is situated at various states of the tide i.e. whether the installation could pose problems at high water which do not exist at low water conditions, and vice versa.	✓	The marine traffic data (Section 12 of the NRA) was collected to account for seasonal (and therefore tidal level) variations. Given the distance offshore, the design of the WTGs and OSPs and the tidal range at the Moray West Site no additional impacts at high water which do not exist at lower water (and vice versa) are anticipated.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
b. The set and rate of the tidal stream, at any state of the tide, has a significant effect on vessels in the area of the OREI site.	✓	Tidal data for the area is assessed within the NRA (Section 9). The drifting model (forming part of the allision modelling process undertaken in Section 17.3.2 of the NRA) takes tidal information into account. Tidal data has been taken from Admiralty Chart 115, as per Section 9.5 of the NRA.
c. The maximum rate tidal stream runs parallel to the major axis of the proposed site layout, and, if so, its effect.	✓	Tidal data for the area is assessed within the NRA (Section 9). The drifting model (forming part of the allision modelling process undertaken in Section 17.3.2 of the NRA) takes tidal information into account. Tidal data has been taken from Admiralty Chart 115, as per Section 9.5 of the NRA.
d. The set is across the major axis of the layout at any time, and, if so, at what rate.	✓	Tidal data for the area is assessed within the NRA (Section 9). The drifting model (forming part of the allision modelling process undertaken in Section 17.3.2 of the NRA) takes tidal information into account. Tidal data has been taken from Admiralty Chart 115, as per Section 9.5 of the NRA.
e. In general, whether engine failure or other circumstance could cause vessels to be set into danger by the tidal stream.	✓	The drifting model (forming part of the allision modelling process undertaken in Section 17.3.2 of the NRA) takes probabilities of engine failure into account.
f. The structures themselves could cause changes in the set and rate of the tidal stream.	✓	No such changes are anticipated.
g. The structures in the tidal stream could be such as to produce siltation, deposition of sediment or scouring, affecting navigable water depths in the wind farm area or adjacent to the area	✓	Under keel clearance is assessed within Chapter 12 Shipping and Navigation.
2. Weather: It should be determined whether:		
a. The site, in normal, bad weather, or restricted visibility conditions, could present difficulties or dangers to craft, including	✓	Varying sea states and visibility conditions are accounted for within the allision and collision modelling undertaken in Sections 16 and 17 of the NRA.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
sailing vessels, which might pass in close proximity to it.		
b. The structures could create problems in the area for vessels under sail, such as wind masking, turbulence or sheer.	✓	Based on experience at constructed windfarms (with smaller turbines than proposed at Moray West) impacts associated with wind masking, turbulence or sheer are known not cause issue for vessel under sail.
c. In general, taking into account the prevailing winds for the area, whether engine failure or other circumstances could cause vessels to drift into danger, particularly if in conjunction with a tidal set such as referred to above.	✓	The drifting modelling process (see Section 17.3.2 of the NRA) takes wind direction, tidal streams, and engine failure into account.
3. Collision Avoidance and Visual Navigation: It should be determined whether:		
a. The layout design will allow safe transit through the OREI by SAR helicopters and vessels.	✓	Marine Scotland will consult with the MCA on the final layout post consent prior to approval. The MCA will assess the layout in terms of emergency response access.
b. The MCA's Navigation Safety Branch and Maritime Operations branch will be consulted on the layout design and agreement will be sought.	✓	Marine Scotland will consult with the MCA on the final layout post consent prior to approval. The MCA will assess the layout in terms of emergency response access.
c. The layout design has been or will be determined with due regard to safety of navigation and Search and Rescue.	✓	Marine Scotland will consult with the MCA on the final layout post consent prior to approval. The MCA will assess the layout in terms of emergency response access.
d.i. The structures could block or hinder the view of other vessels under way on any route.	✓	As per Section 19.11.1 of the NRA, no such impact is anticipated.
d.ii. The structures could block or hinder the view of the coastline or of any other navigational feature such as aids to navigation, landmarks, promontories, etc	✓	As per Section 19.11.2 of the NRA, no significant visual obstructions to AtoNs are anticipated.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
4. Communications, Radar and Positioning Systems - To provide researched opinion of a generic and, where appropriate, site specific nature concerning whether:		
a. The structures could produce radio interference such as shadowing, reflections or phase changes, and emissions with respect to any frequencies used for marine positioning, navigation and timing or communications, including Global Maritime Distress and Safety System, and AIS, whether ship borne, ashore or fitted to any of the proposed structures, to: i. Vessels operating at a safe navigational distance ii. Vessels by the nature of their work necessarily operating at less than the safe navigational distance to the OREI, e.g. support vessels, survey vessels, SAR assets. iii. Vessels by the nature of their work necessarily operating within the OREI.	✓ ✓ ✓ ✓	Impacts on marine radar and other forms of position fixing and communications are assessed within Section 19 of the NRA.
b. The structures could produce radar reflections, blind spots, shadow areas or other adverse effects: i. Vessel to vessel; ii. Vessel to shore; iii. VTS radar to vessel; iv. Racon to/from vessel.	✓ ✓ ✓ ✓	Impacts on marine radar are assessed within Section 19 of the NRA.
c. The structures and generators might produce sonar interference affecting fishing, industrial or military systems used in the area.	✓	As per Section 19.9 of the NRA, no such impacts are anticipated.
	✓	As per Section 19.10 of the NRA, no such impacts are anticipated.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
d. The site might produce acoustic noise which could mask prescribed sound signals.		
e. Generators and the seabed cabling within the site and onshore might produce electro-magnetic fields affecting compasses and other navigation systems.	✓	Impacts associated with electromagnetic interference are assessed within Section 19.7 of the NRA.
5. Marine Navigational Marking : It should be determined:		
a. How the overall site would be marked by day and by night throughout construction, operation and decommissioning phases, taking into account that there may be an ongoing requirement for marking on completion of decommissioning, depending on individual circumstances.	✓	Lighting and marking of Moray West will be agreed post consent with the NLB, MCA and the Civil Aviation Authority (CAA), and will be in line with International Association of Lighthouse Authorities (IALA) -O139.
b. How individual structures on the perimeter of and within the site, both above and below the sea surface, would be marked by day and by night.	✓	Lighting and marking of Moray West will be agreed post consent with the NLB, MCA and CAA, and will be in line with IALA-O139.
c. If the specific OREI structure would be inherently radar conspicuous from all seaward directions (and for SAR and maritime surveillance aviation purposes) or would require passive enhancers.	✓	Any associated marking requirements will be agreed with the NLB and MCA post consent, as per Section 21 of the NRA (embedded mitigation).
d. If the site would be marked by additional electronic means e.g. Racons	✓	Lighting and marking of Moray West will be agreed post consent with the NLB, MCA and CAA, and will be in line with IALA-O139.
e. If the site would be marked by an AIS transceiver, and if so, the data it would transmit.	✓	Lighting and marking of Moray West will be agreed post consent with the NLB, MCA and CAA, and will be in line with IALA-O139.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
f. If the site would be fitted with audible hazard warning in accordance with IALA recommendations	✓	Lighting and marking of Moray West will be agreed post consent with the NLB, MCA and CAA, and will be in line with IALA-O139.
g. If the structure(s) would be fitted with aviation lighting, and if so, how these would be screened from mariners or guarded against potential confusion with other navigational marks and lights.	✓	Lighting and marking (including aviation lighting) of Moray West will be agreed post consent with the NLB, MCA and CAA, and will be in line with IALA-O139.
h. Whether the proposed site and/or its individual generators complies in general with markings for such structures, as required by the relevant GLA in consideration of IALA guidelines and recommendations.	✓	Lighting and marking of Moray West will be agreed post consent with the NLB, MCA and CAA, and will be in line with IALA-O139.
i. The AtoNs specified by the GLAs are being maintained such that the 'availability criteria', as laid down and applied by the GLAs, is met at all times.	✓	All AtoNs will be monitored and maintained to ensure the required availability criteria are met. The monitoring and response procedures will be agreed with the NLB post consent.
j. The procedures that need to be put in place to respond to casualties to the aids to navigation specified by the GLA, within the timescales laid down and specified by the GLA.	✓	Monitoring and response procedures will be agreed with the NLB post consent.
k. The ID marking will conform to a spreadsheet layout, sequential, aligned with SAR lanes and avoid the letters O and I.	✓	The ID marking system used will be agreed with the MCA, NLB, and CAA post consent, once a layout has been chosen.
l. Working lights will not interfere with AtoN or create confusion for the Mariner navigating in or near the OREI.	✓	The potential for light confusion will be taken into account as part of the lighting and marking plan, which will be agreed with the NLB, MCA and CAA post consent.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
6. Hydrography - In order to establish a baseline, confirm the safe navigable depth, monitor seabed mobility and to identify underwater hazards, detailed and accurate hydrographic surveys are included or acknowledged for the following stages and to MCA specifications:		
i. Pre-consent: The site and its immediate environs extending to 500m outside of the development area shall be undertaken as part of the licence and/or consent application. The survey shall include all proposed cable route(s).	✓	Survey results will be provided by the Applicant.
ii. Post-construction: Cable route(s)	✓	Survey results will be provided by the Applicant.
iii. Post-decommissioning of all or part of the development: Cable route(s) and the area extending to 500m from the installed generating assets area.	✓	Survey results will be provided by the Applicant.
Annex 3: MCA template for assessing distances between wind farm boundaries and shipping routes		
"Shipping Route" template and Interactive Boundaries – where appropriate, the following should be determined:		
a. The safe distance between a shipping route and turbine boundaries.	✓	Section 14 of the NRA provides assessment of likely deviated vessel routeing arising from construction of the Development.
b. The width of a corridor between sites or OREIs to allow safe passage of shipping.	✓	There are no designated navigational corridors between the Moray Firth Developments.
Annex 4: Safety and mitigation measures recommended for OREI during construction, operation and decommissioning.		
Mitigation and safety measures will be applied to the OREI development appropriate to the level and type of risk determined during the EIA. The specific measures to be employed will be selected in consultation with the Maritime and Coastguard Agency and will be listed in the	✓	Embedded mitigation is listed in Section 21 of the NRA.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
developer's EIA Report. These will be consistent with international standards contained in, for example, the Safety of Life at Sea (SOLAS) Convention (International Maritime Organisation (IMO), 1974) - Chapter V, IMO Resolution A.572 (14)3 and Resolution A.671(16)4 and could include any or all of the following:		
i. Promulgation of information and warnings through notices to mariners and other appropriate maritime safety information (MSI) dissemination methods.	✓	Promulgation of information is included in the embedded mitigation listed in Section 21 of the NRA.
ii. Continuous watch by multi-channel Very High Frequency (VHF), including Digital Selective Calling (DSC).	✓	Marine coordination (which will be responsible for site monitoring) is included in the embedded mitigation listed in Section 21 of the NRA,
iii. Safety zones of appropriate configuration, extent and application to specified vessels[11]	✓	The application for safety zones is included in the embedded mitigation listed in Section 21 of the NRA.
iv. Designation of the site as an area to be avoided (ATBA).	✓	It is not intended that the Moray West Site will be designated as an ATBA.
v. Provision of AtoN as determined by the GLA	✓	Lighting and marking of the site in consultation with NLB, MCA, and the CAA is included in the embedded mitigation listed in Section 21 of the NRA.
vi. Implementation of routeing measures within or near to the development.	✓	It is not intended that routeing measures will be implemented within or near Moray West.
vii. Monitoring by radar, AIS, Closed Circuit Television or other agreed means	✓	Marine coordination (which will be responsible for site monitoring) is included in the embedded mitigation listed in Section 21 of the NRA.

[11] As per SI 2007 No 1948 "The Electricity (Offshore Generating Stations) (Safety Zones) (Application Procedures and Control of Access) Regulations 2007.

Table 27.1: Safety of Navigation: OREIs – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response		
Issue: OREI Response	**Yes/No**	**Comments**
viii. Appropriate means for OREI operators to notify, and provide evidence of, the infringement of safety zones.	✓	The safety zone application (to be submitted post consent) will include Moray West plans for monitoring and policing of safety zones (as stated in Section 21 of the NRA).
ix. Creation of an Emergency Response Cooperation Plan (ERCoP) with the MCA's Search and Rescue Branch for the construction phase onwards.	✓	The creation of an ERCoP is included in the embedded mitigation listed in Section 21 of the NRA.
x. Use of guard vessels, where appropriate	✓	The use of guard vessels (with need to be identified via risk assessment) is included in the embedded mitigation listed in Section 21 of the NRA.
xi. Any other measures and procedures considered appropriate in consultation with other stakeholders.	✓	The list of embedded mitigation provided in Section 21 of the NRA includes input from relevant marine stakeholders.
Annex 5: Standards, procedures and operational requirements in the event of search and rescue, maritime assistance service counter pollution or salvage incident in or around an OREI, including generator/installation control and shutdown.		
The MCA, through HM Coastguard, is required to provide Search and Rescue and emergency response within the sea area occupied by all OREIs in UK waters. To ensure that such operations can be safely and effectively conducted, certain requirements must be met by developers and operators.		
a. An ERCoP will be developed for the construction, operation and decommissioning phases of the OREI.	✓	The creation of an ERCoP is included in the embedded mitigation listed in Section 21 of the NRA.
b. The MCA's guidance document *Offshore Renewable Energy Installation: Requirements, Advice and Guidance for Search and Rescue and Emergency Response* for the design, equipment and operation requirements will be followed.	✓	Moray West confirms this guidance has been followed.

Table 27.2: Methodology for Assessing the Marine Navigational Safety & Emergency Response Risks of OREIs		
Section	**Compliant (Yes/No)**	**Comments**
A1: Reference Sources - Lessons learned.	✓	Lessons learnt are provided in Section 7 of the NRA.
B1: Base case traffic densities and types.	✓	Marine traffic (Section 12 of the NRA) was agreed with the MCA and NLB.
B2: Future traffic densities and types.	✓	Likely future case vessel routeing is provided in Section 14 of the NRA. The potential for traffic growth has been accounted for in the post wind farm modelling process (Section 17 of the NRA).
B3: The marine environment:		
B3.1 Technical & operational analysis (TOA)	✓	NRA, Section 4 (Project Description) EIA, Chapter 4 – Description of the Development
B3.2 Generic TOA	✓	See impact assessment undertaken in Chapter 12 – Shipping and Navigation.
B3.3 Potential Accidents	✓	Potential impacts are identified within the Hazard Log (Annex A), and within Section 22.2 of the NRA. All screened in impacts are then assessed in Chapter 12 – Shipping and Navigation.
B3.4 Affected navigational activities	✓	Shipping and navigation receptors are identified within the existing environment baseline assessment (Section 8 of the NRA) and within the marine traffic analysis (Section 12 of the NRA).
B3.5 Effects of OREI Structures	✓	Impacts are screened within the NRA (Section 22.2), with assessment then undertaken in Chapter 12 – Shipping and Navigation.
B3.6 Development phases	✓	Impacts have been assessed separately for the construction, operational, and decommissioning phases of the Development in Chapter 12 – Shipping and Navigation.
B3.7 Other structures and features	✓	Preexisting structures and features are assessed in Section 8 of the NRA.
B3.8 Vessel types involved	✓	Vessel types within the area are identified in Section 12 of the NRA.
B3.9 Conditions affecting navigation	✓	Local metocean conditions are assessed in Section 9 of the NRA, which have been taken into account within the collision and allision modelling (NRA, Sections 15, 16, and 17). The existing environment is assessed in Section 8 of the NRA. Impacts are then assessed in Chapter 12 – Shipping and Navigation.

Table 27.2: Methodology for Assessing the Marine Navigational Safety & Emergency Response Risks of OREIs		
Section	**Compliant (Yes/No)**	**Comments**
B3.10 Human Actions	✓	Regular vessel routeing is assessed in Sections 13 and 14 of the NRA, with other vessel activity assessed in Section 12.
C1: Hazard Identification	✓	Hazards were identified within the Hazard Log (Annex A), with screening undertaken in Section 22.2 of the NRA.
C2: Risk Assessment	✓	All identified impacts are assessed in Chapter 12 – Shipping and Navigation.
C3: Influences on level of risk	✓	Risk influences have been considered as part of the creation of the hazard log (Annex A), and during the impact screening process (Section 22.2 of the NRA). Impacts are assessed in Chapter 12 – Shipping and Navigation, taking risk influencers identified during the NRA process into account.
C4: Tolerability of Risk	✓	Tolerability definitions (using a Formal Safety Assessment (FSA) approach) are provided in Chapter 12 – Shipping and Navigation, and Section 3 of the NRA.
D1: Appropriate risk assessment	✓	Impacts are assessed in Chapter 12 – Shipping and Navigation, as per the methodology described in Section 3 of the NRA (using the FSA approach, the standard for shipping risk assessments).
D2 : MCA acceptance for assessment techniques and tools	✓	The approach to impact assessment (Section 3 of the NRA) is the standard methodology used for shipping risk assessments, and has been agreed with the MCA.
D3: Demonstration of Results	✓	The results of the impact assessment are presented in Chapter 12 – Shipping and Navigation. The inputs to this assessment are provided in the NRA.
D4: Area traffic assessment	✓	Marine traffic analysis within the study area is provided in Section 12 of the NRA.
D5: Specific traffic assessment	✓	The marine traffic analysis undertaken in Section 12 of the NRA includes analysis specific to the Moray West Site.
E1: Risk control log	✓	The Hazard Log is provided in Annex A.
E2: Marine stakeholders	✓	Consultation processes associated with the Scoping Report, the Hazard Workshop, regular operators, and stakeholder meetings are provided in Section 5 of the NRA, with key responses provided in Chapter 12 – Shipping and Navigation.

Table 27.2: Methodology for Assessing the Marine Navigational Safety & Emergency Response Risks of OREIs		
Section	**Compliant (Yes/No)**	**Comments**
F1: Hazard identification checklist	✓	Hazards were initially identified within the Hazard Log (Annex A), with impact screening then undertaken in Section 22.2 of the NRA.
F2: Risk control checklist	✓	Risk control measures are identified within Chapter 12 – Shipping and Navigation where required.

27.2 References

IMO (1974) Convention on the Safety of Life at Sea (SOLAS). London: IMO.

MCA (2015) Methodology for Assessing the Marine Navigational Safety Risks of Offshore Wind Farms. Southampton: MCA.

MCA (2016) MGN 543 (Merchant and Fishing) Safety of Navigation Offshore Renewable Energy Installations (OREIs) – Guidance on UK Navigational Practice, Safety and Emergency Response. Southampton: MCA.

MCA (2016a) OREI MGN543 Checklist.

RYA (2016) UK Coastal Atlas of Recreational Boating. Southampton.

28 Annex 12.1C: Consequence Assessment

28.1 Introduction

This Annex to the Moray West Offshore Wind Farm Navigation Risk Assessment (NRA) (Appendix 12.1 to Chapter 12: Shipping and Navigation) provides an assessment of the potential consequences of an allision or collision incident associated with the Development in terms of fatalities and oil spill. The significance of impact of the potential consequences is also assessed based on risk evaluation criteria and comparison with historical accident data within United Kingdom (UK) waters[12].

The assessment undertaken within this Annex is primarily based on the results of the allision and collision modelling undertaken within the NRA. Sections 15, 16, and 17 of the NRA can be viewed for further discussion of the methodology used and assumptions made within the modelling assessment.

28.1.1 Risk Evaluation Criteria

28.1.1.1 Risk to People

With regards to the assessment of risk to people two measures are considered, as presented in the following sections:

- Individual risk; and
- Societal risk.

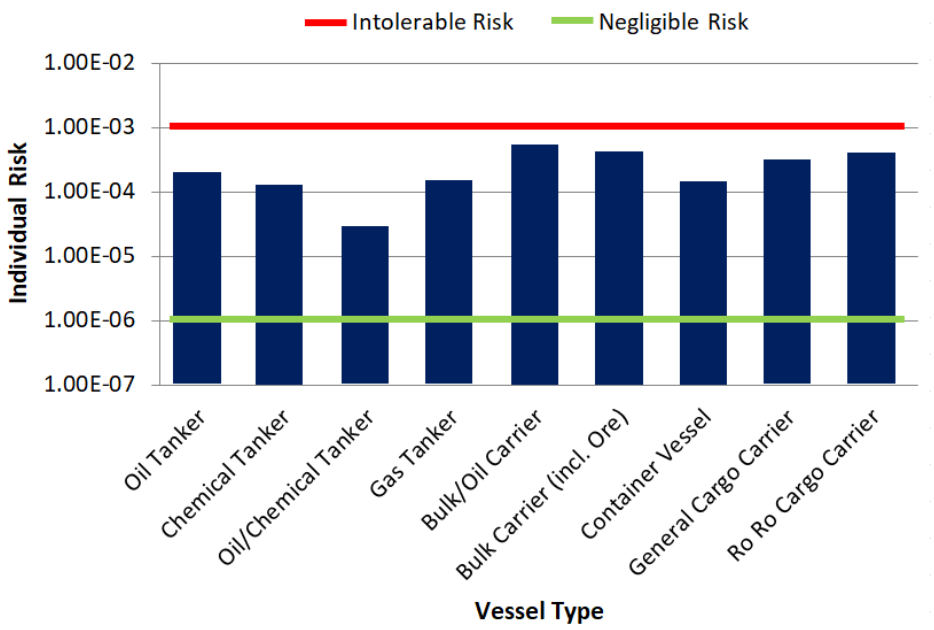
Individual Risk (per Year)

This measure considers whether the risk from an accident to a particular individual changes significantly due to the presence of the wind farm structures. Individual risk considers not only the frequency of the accident and the consequence (likelihood of death), but also the individual's fractional exposure to that risk, i.e. the probability of the individual of being in the given location at the time of the accident.

The purpose of estimating the individual risk is to ensure that individuals who may be affected by the presence of the wind farm structures are not exposed to excessive risks. This is achieved by considering the significance of the change in individual risk resulting from the presence of the wind farm relative to the background individual risk levels.

Annual individual risk levels to crew (the annual fatality risk of an average crew member) for different vessel types are presented in Graph 28-1 (International Maritime Organisation (IMO), 2001). The graph also highlights the upper and lower bounds for risk acceptance criteria as suggested in IMO Maritime Safety Committee (MSC) 72/16. The annual individual risk level to crew falls within the As Low as Reasonably Practicable (ALARP) region for each of the vessel types presented.

[12] Within this Annex, UK waters means the UK Exclusive Economic Zone and UK territorial waters means within the 12 nautical miles limit.



Graph 28-1 Individual Risk Levels and Acceptance Criteria per Vessel Type

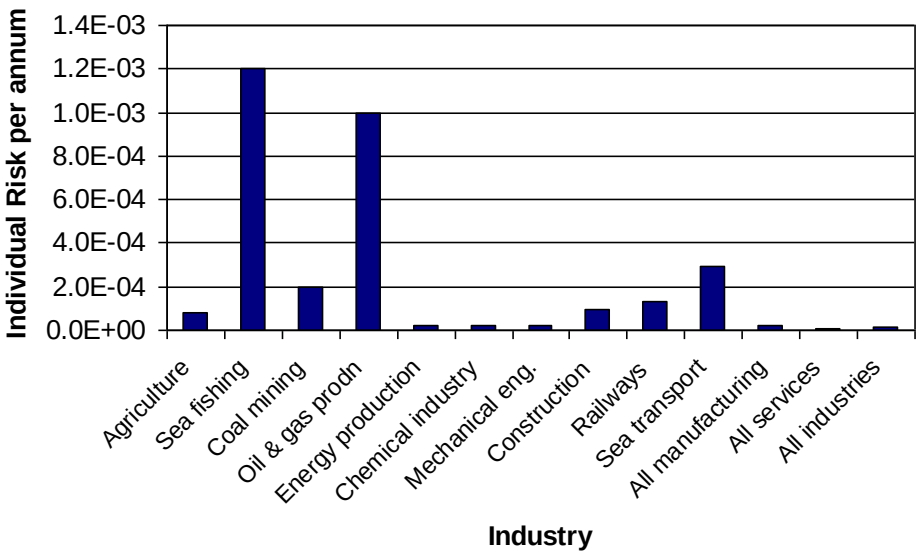
Typical bounds defining ALARP regions for decision making within shipping are presented in Table 28.1.

Table 28.1: Individual Risk ALARP Criteria

Individual	Lower Bound for ALARP	Upper Bound for ALARP
To crew member	10^{-6}	10^{-3}
To passenger	10^{-6}	10^{-4}
Third party	10^{-6}	10^{-4}
New vessel target	10^{-6}	Above values are reduced by one order of magnitude

On a UK basis, the Maritime Coastguard Agency (MCA) website provides individual risks for various UK industries based on the Health and Safety Executive data for 1987 to 1991. The risks for different industries are presented in Graph 28-2.

The individual risk for sea transport of 2.9 x 10^{-4} per year is consistent with the worldwide data presented in Graph 28-1, whilst the individual risk for sea fishing of 1.2 x 10^{-3} per year is the highest across all of the industries listed.



Graph 28-2 Individual Risk per Year for various UK Industries

Societal Risk

Societal risk is used to estimate risks of accidents affecting many persons, e.g., catastrophes, and acknowledging risk averse or neutral attitudes. Societal risk includes the risk to every person, even if a person is only exposed on one brief occasion to that risk. For assessing the risk to a large number of affected people, societal risk is desirable because individual risk is insufficient in evaluating risks imposed on large numbers of people.

Within this assessment societal risk (navigational based) can be assessed for the Development, giving account to the change in risk associated with each accident scenario caused by the introduction of the wind farm structures. Societal risk may be expressed as:

- Annual fatality rate where frequency and fatality are combined into a convenient one-dimensional measure of societal risk. This is also known as Potential Loss of Life (PLL); and
- FN-diagrams showing explicitly the relationship between the cumulative frequency of an accident and the number of fatalities in a multi-dimensional diagram.

When assessing societal risk this study focuses on PLL, which takes into account the number of people likely to be involved in an incident (which is higher for certain vessel types), and assesses the significance of the change in risk compared to background risk levels for the UK.

28.1.2 Risk to Environment

For risk to the environment the key criteria considered in terms of the effect of the Development is the potential amount of oil spilled from the vessel involved in an incident.

It is recognised there will be other potential pollution, e.g. hazardous containerised cargoes; however oil is considered the most likely pollutant and the extent of predicted oil spills will provide an indication of the significance of pollution risk due to the Development compared to background pollution risk levels for the UK.

28.2 Marine Accident Investigation Branch Data Analysis

28.2.1 All Incidents

All UK-flagged commercial vessels are required to report accidents to the Marine Accident Investigation Branch (MAIB). Non-UK flagged vessels do not have to report unless they are in a UK port or are within 12 nm territorial waters and carrying passengers to a UK port. There are no requirements for non-commercial recreational craft to report accidents to the MAIB; however a significant proportion of these incidents are reported to and investigated by the MAIB.

The MCA, harbour authorities and inland waterway authorities also have a duty to report accidents to MAIB. Therefore, whilst there may be a degree of under-reporting of accidents with minor consequences, those resulting in more serious consequences, such as fatalities, are likely to be reported.

Only incidents occurring in UK waters have been considered within this assessment for which the MAIB data is most comprehensive. It is also noted that incidents occurring in ports/harbours and rivers/canals have been excluded since the causes and consequences may differ from an accident occurring offshore, which is the location of most relevance to the Development.

Taking into account these criteria, a total of 13,374 accidents, injuries and hazardous incidents were reported to the MAIB between 1994 and 2014 involving 15,212 vessels (some incidents such as collisions involved more than one vessel).

The locations[13] of incidents reported in the vicinity of the UK are presented in Figure 28.1, colour-coded by type. It can be seen that most incidents occurred in coastal waters.

[13] MAIB aim for 97% accuracy in reporting the locations of incidents.

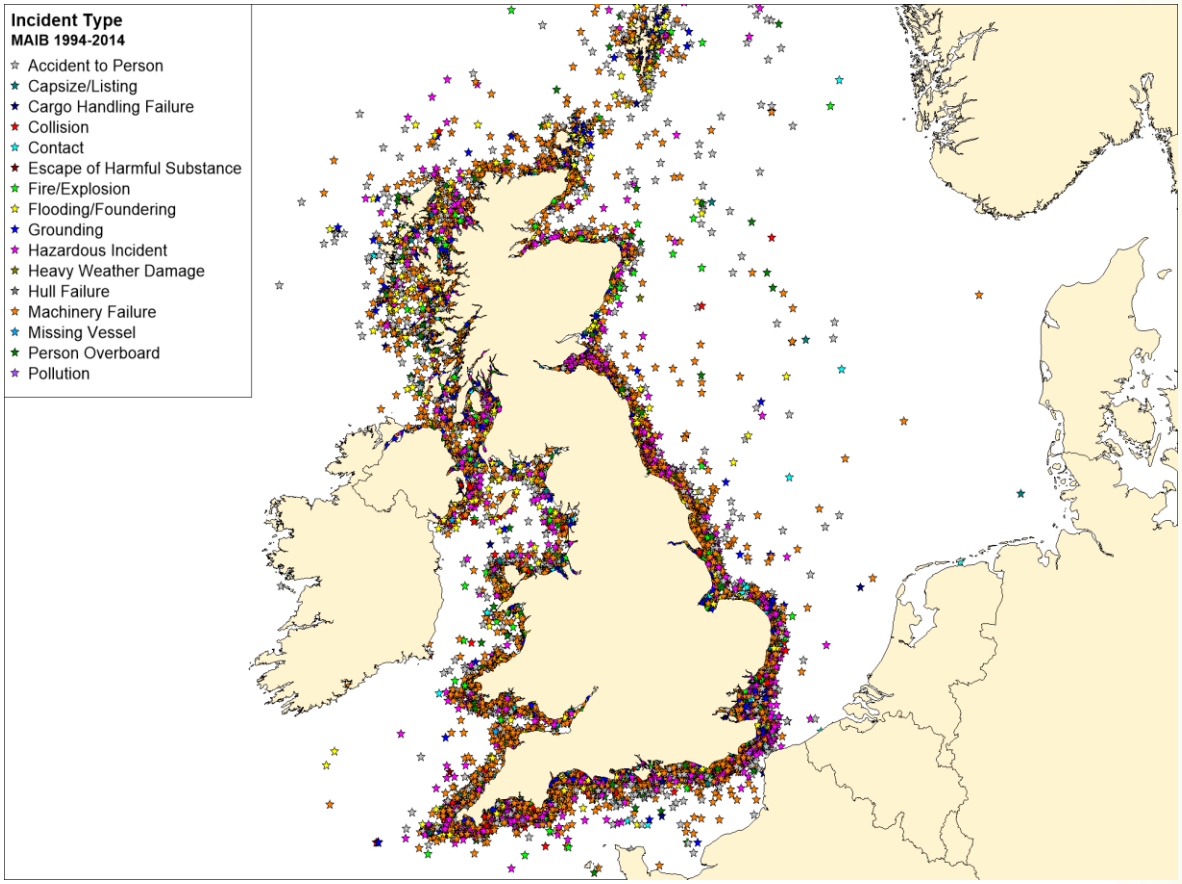
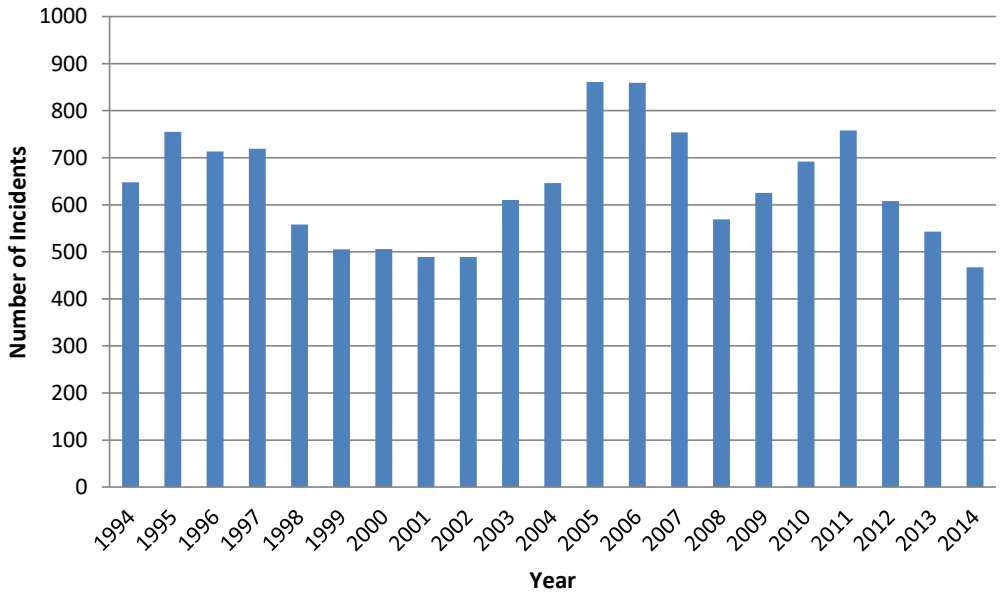


Figure 28.1 Incident Locations by Type within UK Waters (MAIB 1994-2014)

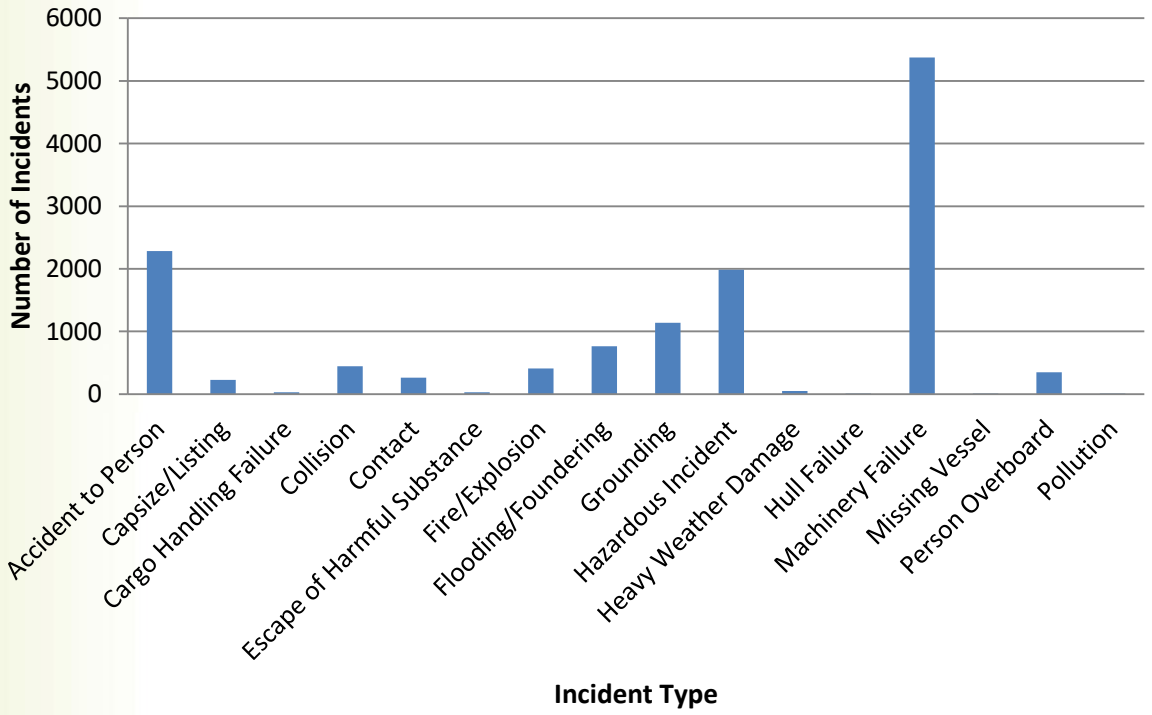
The distribution of incidents by year is presented in Graph 28-3.



Graph 28-3 Incidents per Year within UK Waters (MAIB 1994-2014)

The average number of incidents per year was 637. There has generally been a fluctuating trend in incidents over the 21 year period.

The distribution of incidents by incident type is presented in Graph 28-4.

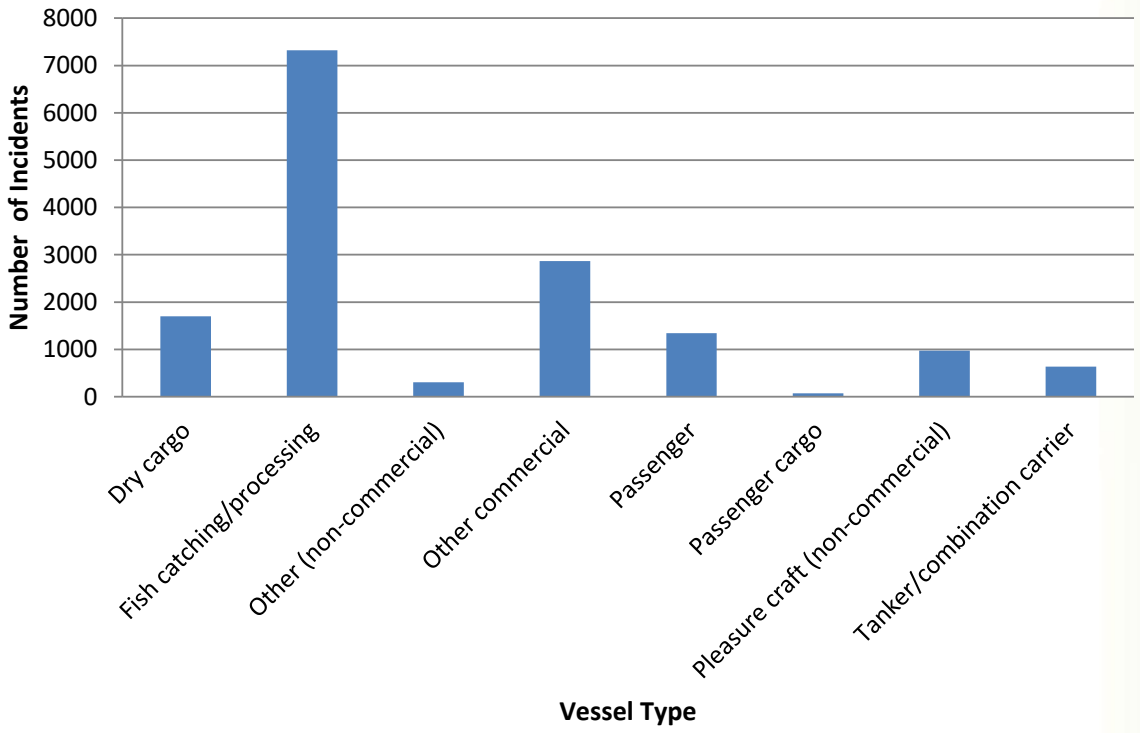


Graph 28-4 Incidents by Incident Type within UK Waters (MAIB 1994-2014)

The most common incident types were "Machinery Failure" (40%), "Accident to Person"[14] (17%) and "Hazardous Incident" (15%). "Collisions" and "Contacts" represented 3% and 2% of the total incidents, respectively.

The distribution of incidents by vessel type is presented in Graph 28-5.

[14] Where the incident is an accident to a vessel, e.g., collision or machinery failure, it would be reported under the vessel accident category.

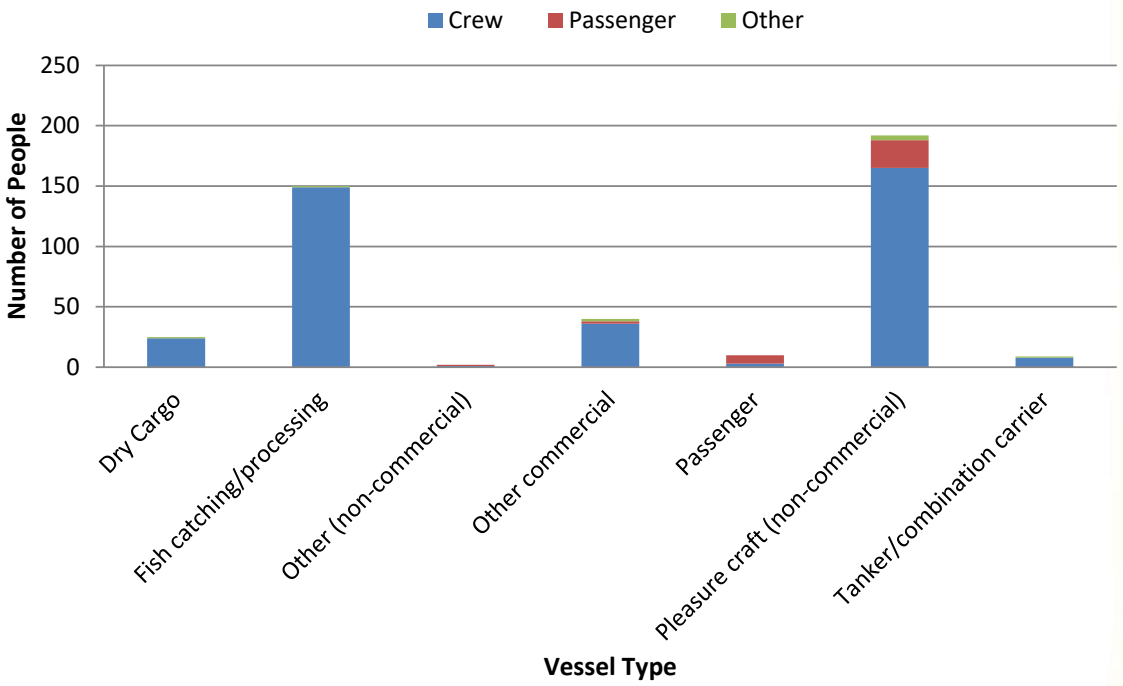


Graph 28-5 Incidents by Vessel Type within UK Waters (MAIB 1994-2014)

The most common vessel types involved in incidents were fishing vessels (48%), "other" commercial vessels (17%) (which include offshore industry vessels, tugs, workboats and pilot vessels) and dry cargo vessels (11%).

The total number of fatalities reported in the MAIB incidents from 1994 to 2014 was 428, giving an average of 20 fatalities per year.

The distribution of fatalities in UK waters by vessel type and person category (namely crew, passenger, and other) is presented in Graph 28-6.



Graph 28-6 Fatalities by Vessel Type for Incidents within UK Waters (MAIB 1994-2014)

It can be seen that the majority of fatalities occurred to crew members of pleasure craft and fishing vessels.

28.2.2 Collision Incidents

MAIB define a collision incident as "vessel hits another vessel that is floating freely or is anchored (as opposed to being tied up alongside)."

A total of 447 collision incidents were reported to MAIB in UK waters (excluding ports, etc.) between the 1st January 1994 and the 31st December 2014 involving 889 vessels (in a small number of cases the other vessel involved was not logged).

The locations of collision incidents reported in the vicinity of the UK are presented in Figure 28.2.

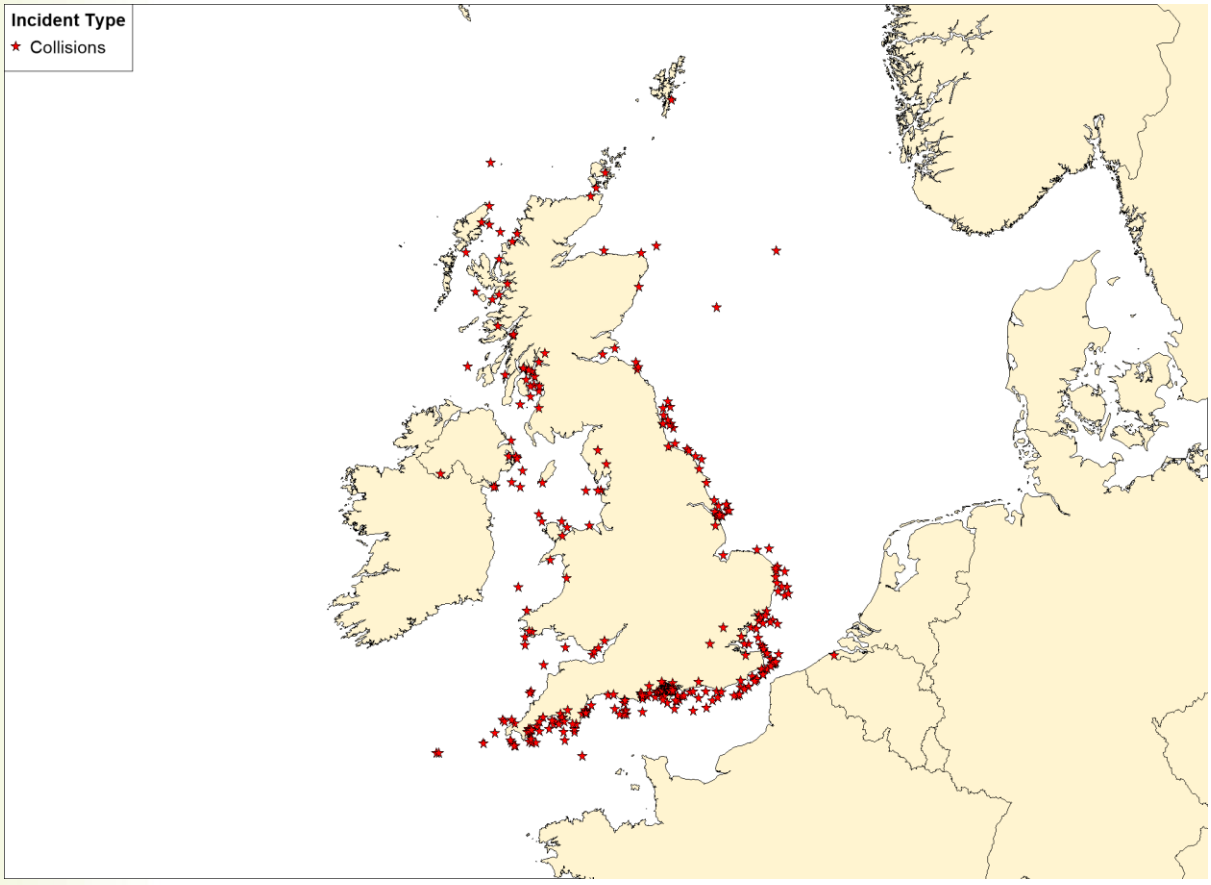
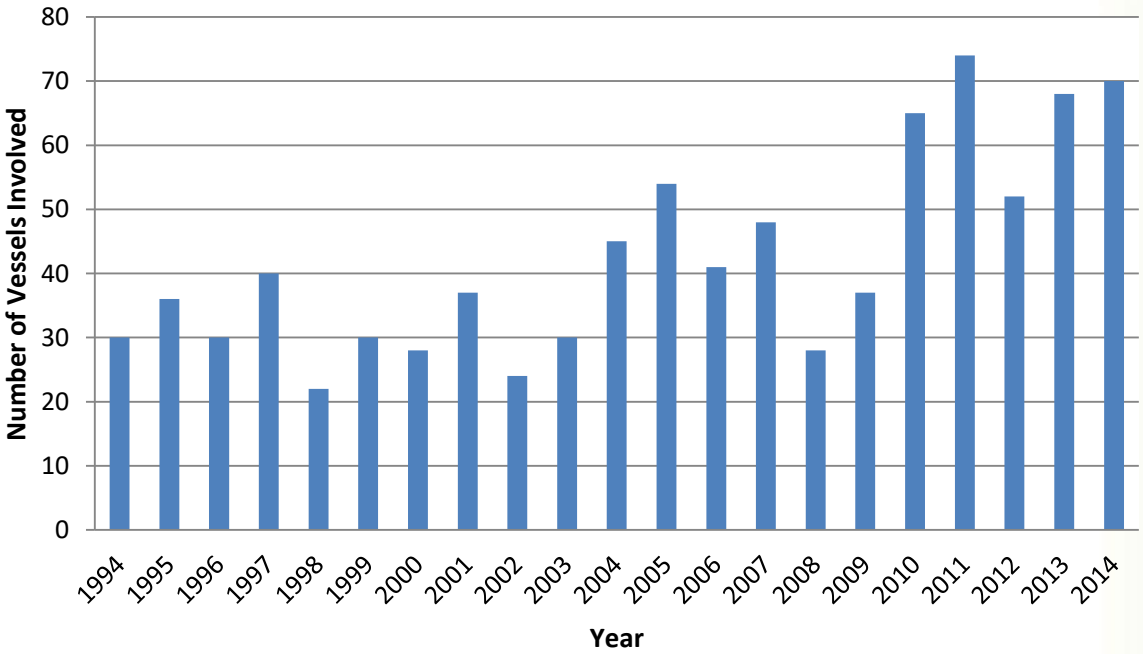


Figure 28.2 Collision Incident Locations within UK Waters (MAIB 1994-2014)

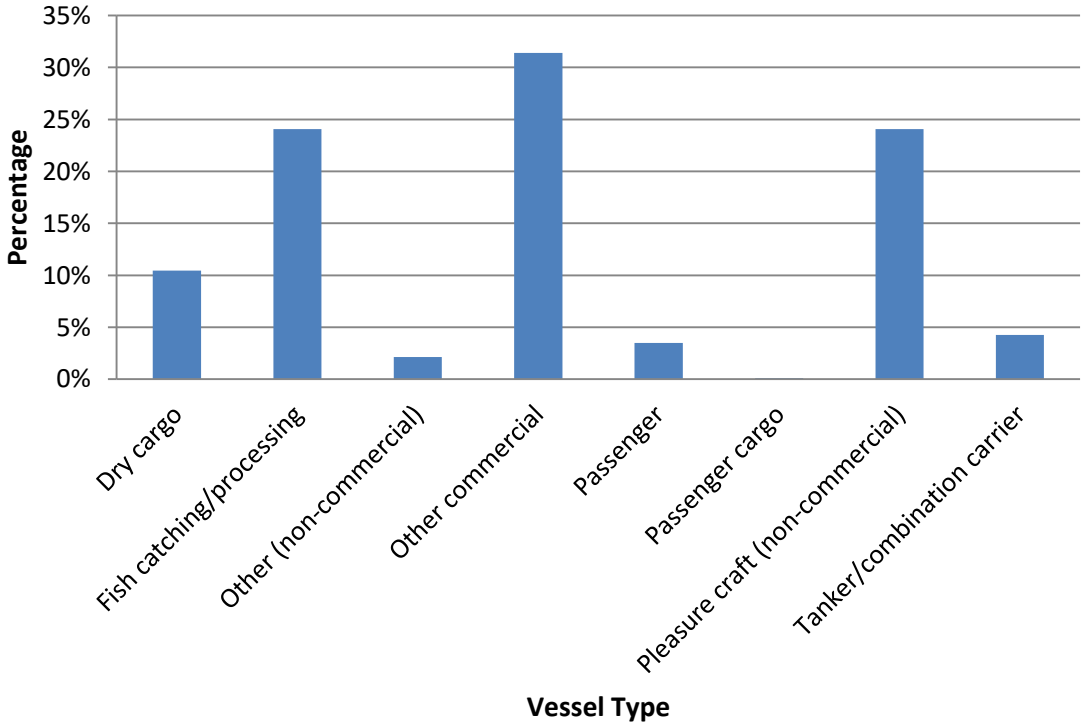
The number of vessels involved in a collision incident by year is presented in Graph 28-7.



Graph 28-7 Collision Incidents per Year within UK Waters (MAIB 1994-2014)

The average number of vessels involved in a collision per year was 42. There has been an overall increasing trend in collisions over the study period, which may be due to better reporting of less serious incidents in recent years.

The distribution of collision incidents by vessel type is presented in Graph 28-8.



Graph 28-8 Collision Incidents by Vessel Type within UK Waters (MAIB 1994-2014)

The most common vessel types involved in collision incidents were “other” commercial vessels (31%), fishing vessels (24%), non-commercial pleasure craft (24%) and dry cargo vessels (10%).

The total number of fatalities reported in MAIB collision incidents within UK waters between 1994 and 2014 when excluding incidents occurring in ports and harbours was four. Details of each of these fatal incidents reported by the MAIB are presented in Table 28.2.

Table 28.2: Fatal Collision Incidents (MAIB 1994-2014)

Date	Description	Fatalities
October 2001	A dry cargo vessel and a chemical tanker collided in the south-west traffic lane of the Dover Strait Traffic Separation Scheme to the south-east of Hastings. Although the weather and visibility were good, both watchkeepers were too late to take effective avoiding action. The collision resulted in the sinking of the dry cargo vessel from which five out of six crew members were rescued.	1
August 2002	Two speedboats collided resulting in one fatality and one injury. The visibility was good and the weather was calm. Police were called to the scene and both drivers were arrested.	1
July 2005	A collision between two powerboats near Castle Point, St. Mawes resulted in the death of one of the helmsmen. The incident occurred during the night with both vessels unlit whilst transiting through the area. Both helmsmen had consumed alcohol prior to the incident which is suspected to have caused reduced peripheral vision, deterioration of judgment and slower reaction times from both helmsmen, resulting in the collision.	1
August 2010	An Italian registered Ro Ro passenger ferry collided with a UK registered fishing vessel around four miles off St Abb's Head. As a result of the collision, the fishing vessel sank. The skipper was recovered from the sea but, despite an extensive search by the rescue services and a large number of local fishing vessels, the remaining crew member was lost.	1

28.2.3 Contact Incidents

The MAIB define a contact incident as when “a vessel hits an object that is immobile and is not subject to the collision regulations e.g., buoy, post, dock (too hard), etc. Also, another vessel if it is tied up alongside, or floating logs, containers, etc.

A total of 262 contact incidents were reported to MAIB in UK waters (excluding ports, etc.) between 1994 and 2014 involving 294 vessels. (A small number of contact incidents involved a moving vessel contacting a stationary vessel).

The locations of contact incidents reported in the vicinity of the UK are presented in Figure 28.3.

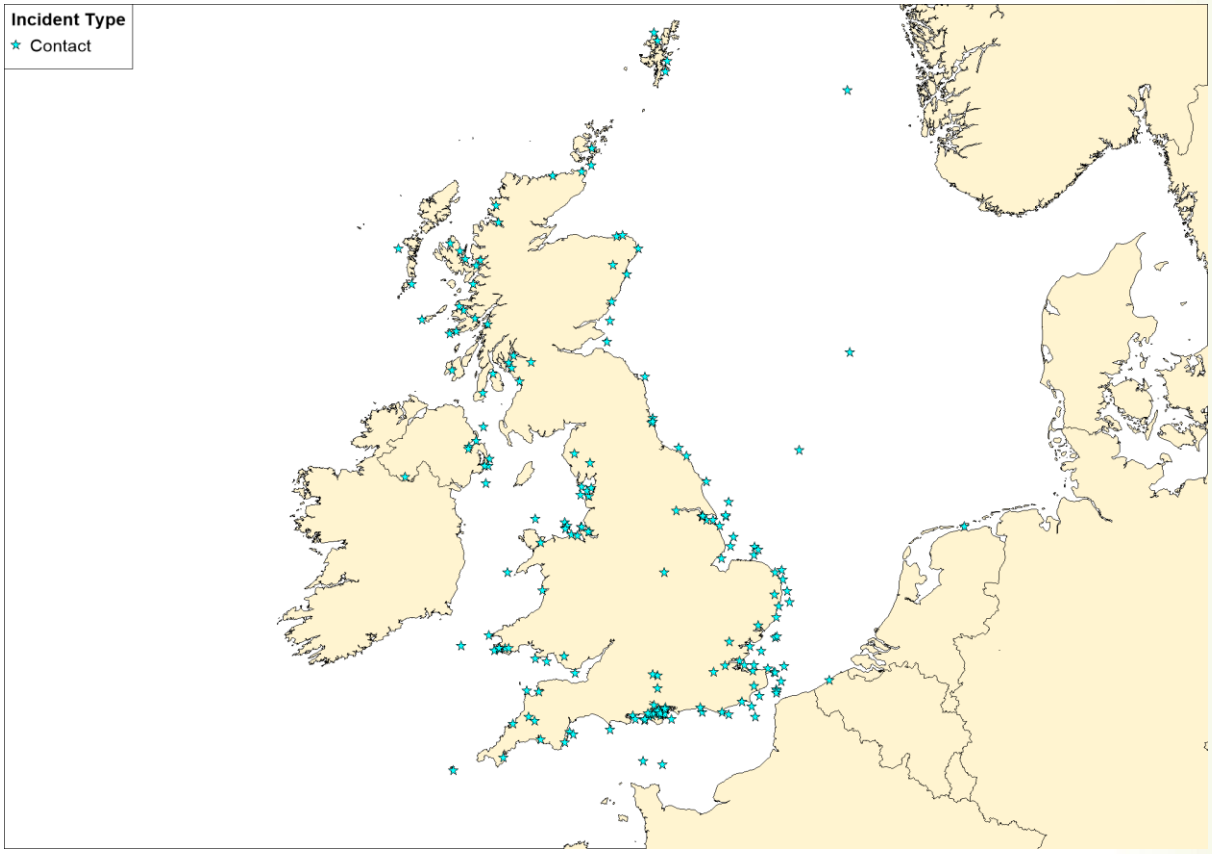
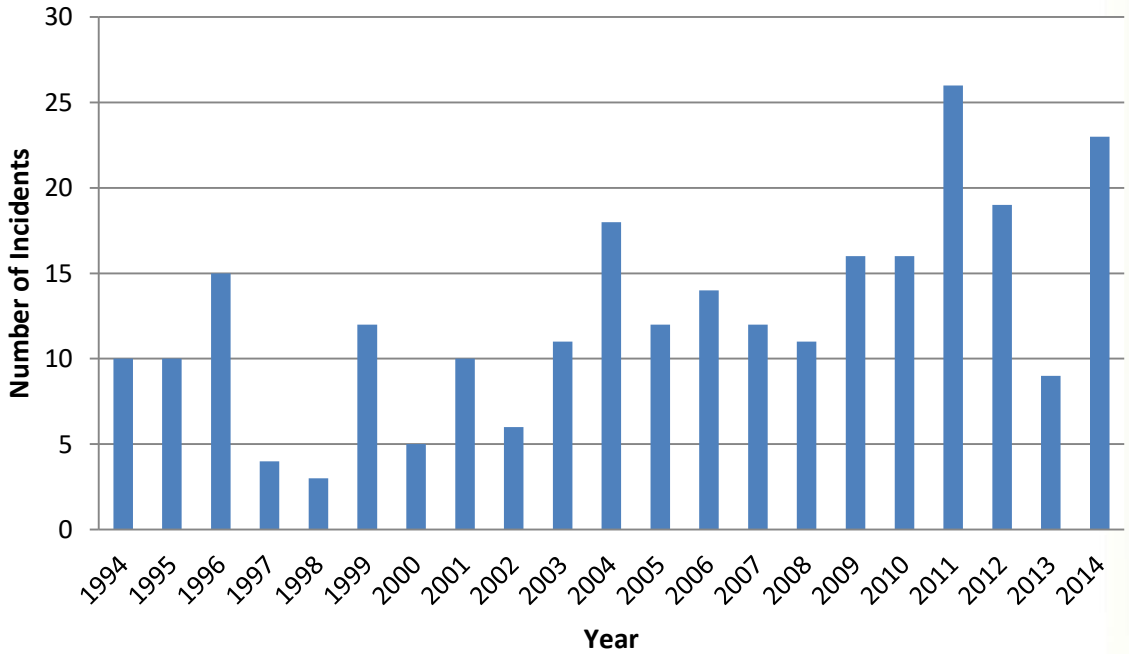


Figure 28.3 Contact Incident Locations within UK waters (MAIB 1994-2014)

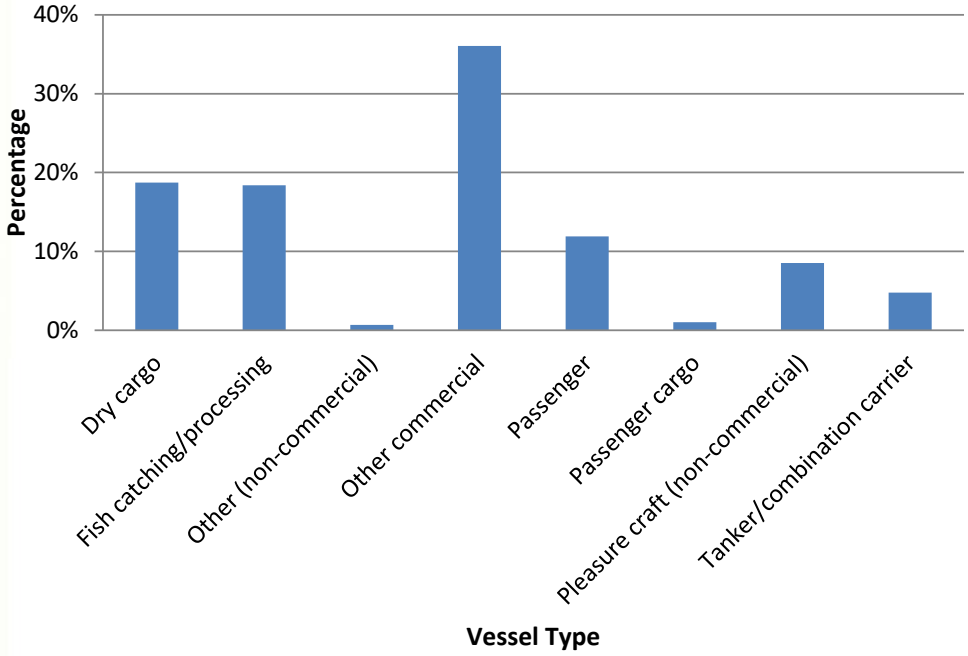
The distribution of contact incidents by year is presented in **Graph 28-9**.



Graph 28-9 Contact Incidents per Year within UK Waters (MAIB 1994-2014)

The average number of contact incidents per year was 13. As with collision incidents there has been an increasing trend over the 21 year period, which may be due to improved reporting of less serious incidents in more recent years.

The distribution of vessel types involved in contacts is presented in Graph 28-10.



Graph 28-10 Contact Incidents per Year within UK Waters (MAIB 1994-2014)

The most common vessel types involved in contact incidents were other commercial vessels (36%), dry cargo vessels (18%) and fishing vessels (18%).

There were no fatalities reported in any of the MAIB contact incidents within UK waters between 1994 and 2014 when excluding incidents occurring in ports and harbours.

28.3 Fatality Risk

28.3.1 Introduction

This section uses the MAIB incident data along with information on average manning levels per vessel type to estimate the probability of fatality in a marine incident associated with the Development.

The Development is assessed to have the potential to affect the following incidents:

- Vessel to vessel collision;
- Powered vessel to structure allision;
- Drifting vessel to structure allision; and
- Fishing vessel to structure allision.

Of these incidents, only vessel to vessel collisions match the MAIB definition of collisions and hence the fatality analysis presented in Section 28.2.2 is considered to be directly applicable to these types of incidents.

The other scenarios of powered vessel to structure allision, drifting vessel to structure allision and fishing vessel to structure allision are technically contacts since they involve a vessel striking an immobile object in the form of a wind turbine or substation. From Section 28.2.3 it can be seen that none of the 262 contact incidents reported by MAIB between 1994 and 2014 resulted in fatalities.

However, as the mechanics involved in a vessel contacting a wind turbine may differ in severity from hitting, for example, a buoy, quayside or moored vessel, the MAIB collision fatality risk rate has also been conservatively applied for these incidents.

28.3.2 Fatality Probability

Four of the 447 collision incidents reported by the MAIB in UK waters between 1994 and 2014 resulted in one or more fatalities. This gives a 0.89% probability that a collision incident will lead to a fatal accident.

To assess the fatality risk for personnel onboard a vessel, either crew, passenger or other, the number of persons involved in the incidents needs to be estimated. From analysis of the MAIB incident data, the average commercial passenger vessel had approximately 193 people on board (POB) (total of crew and passengers). For commercial cargo / freight vessels there was an average of approximately 14 POB. For fishing vessels the average POB was approximately 3.3 and for pleasure craft the average POB was approximately 6.4.

It is recognised that these numbers can be substantially higher or lower on an individual vessel basis depending upon size, subtype, etc., but applying reasonable averages is considered sufficient for the purposes of this analysis.

Using the average number of persons carried along with the vessel type information involved in collision incidents reported by the MAIB (see Graph 28-10), it is estimated that there were 12,966 personnel/passengers onboard the vessels involved in the collision incidents. Therefore, based on four fatalities, the overall fatality probability in a collision for any individual onboard is approximately 3.1×10^{-4} per collision.

It is considered inappropriate to apply this rate uniformly, as the statistics indicate that the fatality probability associated with smaller craft is higher. Therefore the fatality probability has been subdivided into three categories of vessel as presented in Table 28.3.

Table 28.3: Fatality Probability per Collision per Vessel Category (1994-2014)

Vessel Category	Sub Categories	Fatalities	People Involved	Fatality Probability
Commercial	Dry cargo, passenger, tanker, etc.	1	9,718	1.0×10^{-4}
Fishing	Trawler, potter, dredger, etc.	1	708	1.4×10^{-3}
Pleasure Craft	Yacht, small commercial motor vessel, etc	2	2,540	7.9×10^{-4}

It can be seen that the risk is approximately one order of magnitude higher for people onboard small craft compared to larger commercial vessels.

28.3.3 Fatality Risk due to the Development

The base case and future case annual collision frequency levels pre and post wind farm are summarised in Table 28.4.

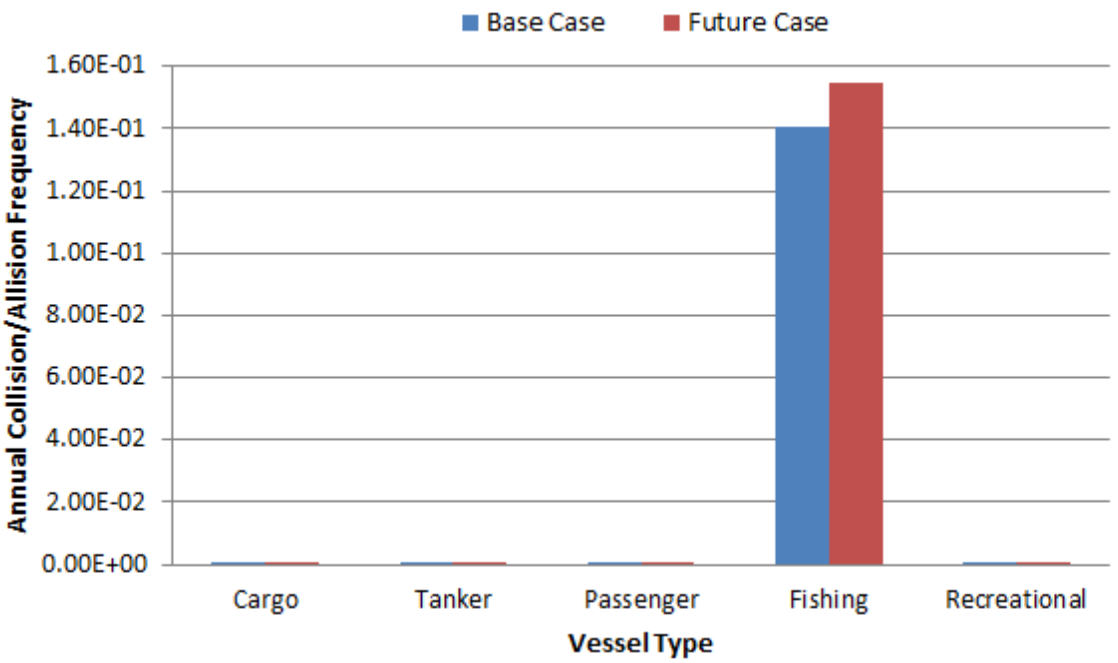
Table 28.4: Summary of Annual Collision Frequency Results				
Scenario	**Base Case**		**Future Case**	
	Pre Wind Farm	**Post Wind Farm**	**Pre Wind Farm**	**Post Wind Farm**
Vessel to Vessel	3.50×10^{-5}	6.03×10^{-5}	4.19×10^{-5}	7.23×10^{-5}
Allision – Powered	n/a	5.21×10^{-5}	n/a	5.73×10^{-5}
Allision - Drifting	n/a	6.81×10^{-6}	n/a	7.39×10^{-6}
Allision - Fishing	n/a	1.40×10^{-1}	n/a	1.54×10^{-1}
Total	**3.50×10^{-5}**	**1.40×10^{-1}**	**4.19×10^{-5}**	**1.54×10^{-1}**

Table 28.5 presents the anticipated number of POB of the vessel types operating in the vicinity of the Moray West Site. It is noted that as the average POB of a passenger vessel can significantly fluctuate depending on the vessel, passenger and crew capacities of the individual passenger vessels identified within the marine traffic surveys have been researched, with the results used to produce the average POB presented in the table. The majority of passenger vessels operating within the Moray Firth were large cruise ships, and this is reflected in the estimated passenger vessel POB.

Table 28.5: Vessel Types, Incidents and Average Number of POB		
Vessel Type	**Collision/Allision Incidents**	**Average Number of POB[15]**
Cargo/freight	Vessel to vessel collision Powered vessel to structure allision Drifting vessel to structure allision	15
Tanker	Vessel to vessel collision Powered vessel to structure allision Drifting vessel to structure allision	20
Passenger	Vessel to vessel collision Powered vessel to structure allision Drifting vessel to structure allision	1,900
Fishing vessel	Vessel to vessel collision Fishing vessel to structure allision	3
Recreational vessel	Vessel to vessel collision	4

From the detailed results of the collision and allision frequency modelling, the distribution of the predicted change (due to the Development) in annual collision and allision frequency by vessel type is presented in Graph 28-11.

[15] Note that these POB values should not be confused with the average POB values calculated using the MAIB data (as presented in Section 28.3.2).

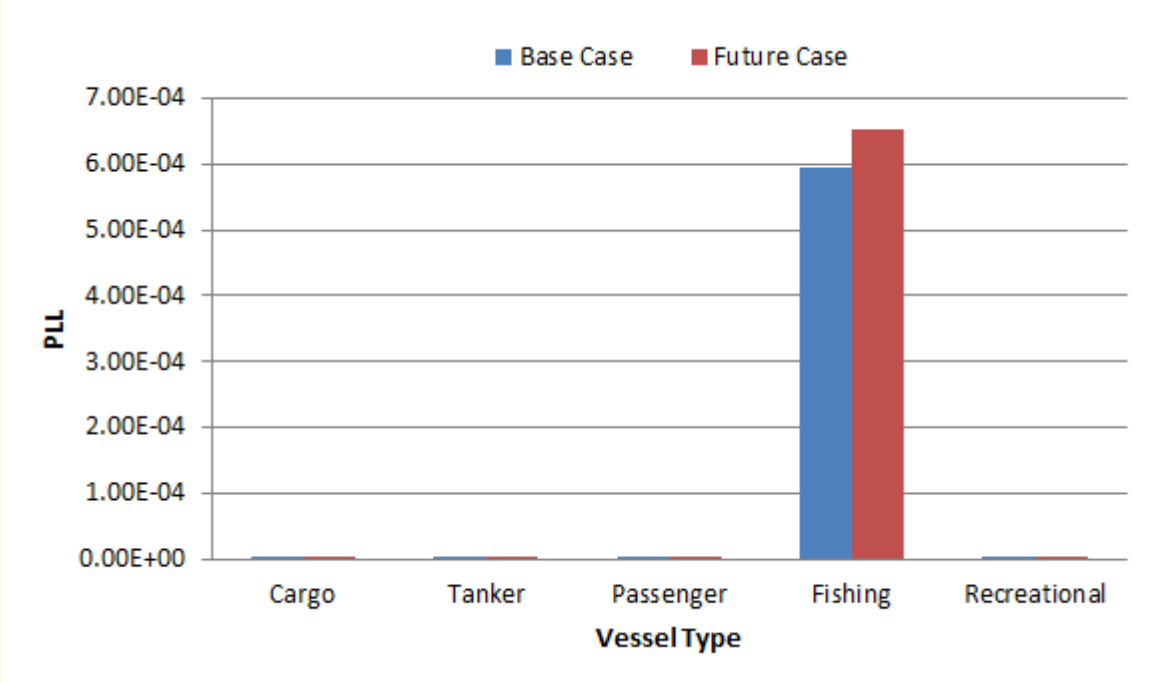


Graph 28-11 Change in Annual Collision and Allision Frequency by Vessel Type

It can be seen that the significant majority of the allision/collision risk is to fishing vessels. As is further discussed in Appendix 12.1: NRA, this was due to the assumption that levels of fishing traffic within the Moray West Site will remain consistent post wind farm (or increase in the future case scenario), which leads to a high estimated fishing vessel to structure allision frequency. This is considered a conservative approach. Given that there will be no restrictions on fishing in or transit through the Moray West Site during the operational phase (and hence the decision to fish or transit within the wind farm structures will be at the digression of the vessel's master), the conservative approach was considered appropriate.

Combining the annual collision and allision frequency (Table 28.4), the estimated POB per vessel type (Table 28.5), and the estimated fatality probability for each vessel category (Table 28.3), the annual increase in PLL due to the impact of the Development for the base case is estimated at 5.96×10^{-4}, which corresponds to one fatality per 1,700 years. At future case traffic levels, the corresponding annual increase is 6.55×10^{-4}, equating to one fatality per 1,500 years (an increase of approximately 10% from the base case).

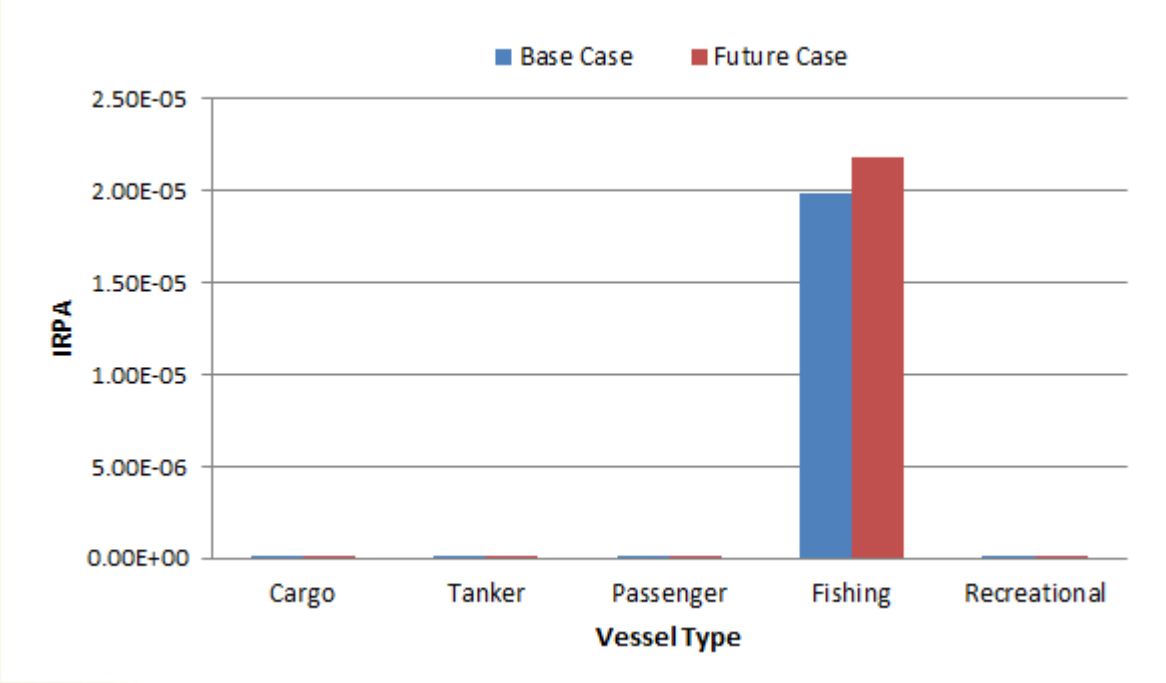
The estimated incremental increases in PLL due to the Development, distributed by vessel type for the base and future cases, are presented in Graph 28-12.



Graph 28-12 Estimated Change in Annual PLL by Vessel Type

The majority of change in PLL was associated with fishing vessels, which again is due to the assumption that there will not be a reduction in fishing within the Moray West Site during its operational life (whereas regular routed traffic is expect to deviate to avoid the structures).

Converting the PLL to individual risk per annum (IRPA) based on the average number of people exposed by vessel type, the results are presented in Graph 28-13 (this calculation assumes that the risk is shared between 10 vessels of each type, which is considered to be conservative based on the number of different vessels operating in the vicinity of the Moray West Site).



Graph 28-13 Estimated change in Individual Risk by Vessel Type

28.3.4 Significance of Increase in Fatality Risk

The overall increase in PLL estimated due to the Development is 5.69 x 10^{-4}, corresponding to one fatality per 1,700 years. MAIB statistics indicate an average of 20 fatalities per year in UK territorial waters, and the additional increase associated with the Development is therefore considered only a minor change.

In terms of individual risk to people, the incremental increase for commercial vessels (approximately 1.15 x 10^{-9} for the base case) is negligible compared to the background risk level for the UK sea transport industry of 2.9 x 10^{-4} per year.

For fishing vessels, the change in individual risk is higher than for commercial vessels (approximately 1.98 x 10^{-5} for the base case, compared to 1.15 x 10^{-9} for commercial vessels). However it is low when compared to the background level of risk for the UK fishing industry of 1.2 x 10^{-3} per year.

28.4 Pollution Risk

28.4.1 Historical Analysis

The pollution consequences of a collision in terms of oil spill depend upon the following:

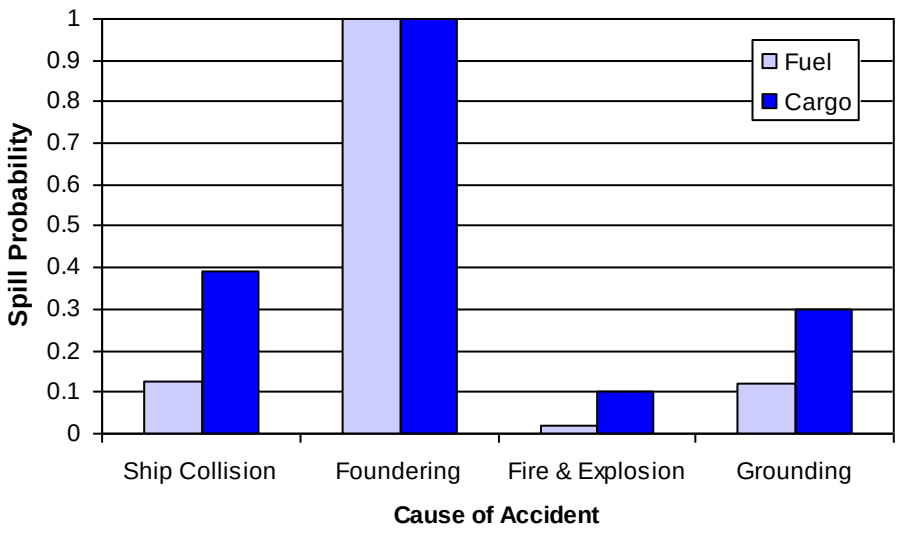
- Spill probability (i.e., the likelihood of outflow following an accident); and
- Spill size (amount of oil).

Two types of oil spill are considered in this assessment:

- Fuel oil spills from bunkers (all vessel types); and
- Cargo oil spills (laden tankers).

The research undertaken as part of the Department for Transport's (DfT) Marine Environmental High Risk Areas (MEHRAs) project (DfT, 2001) has been used as it was comprehensive and based on worldwide marine spill data analysis.

From this research, the overall probability of a spill per accident was calculated based on historical accident data for each accident type as presented in Graph 28-14.



Graph 28-14 Probability of an Oil Spill Resulting from an Accident

Therefore it was estimated that 13% of vessel collisions result in a fuel oil spill, and 39% of collisions involving a laden tanker lead to cargo oil spill.

In the event of a bunker spill, the potential outflow of oil depends upon the bunker capacity of the vessel. Historical bunker spills from vessels have generally been limited to a size below 50% of the bunker capacity, and in most incidents much lower. For the types and sizes of vessels exposed to the Development, an average spill size of 100 tonnes of fuel oil is considered to be a conservative assumption.

For cargo spills from laden tankers, the spill size can vary significantly. The International Tanker Owners Pollution Federation (ITOPF) report the following spill size distribution for tanker collisions between 1974 and 2004:

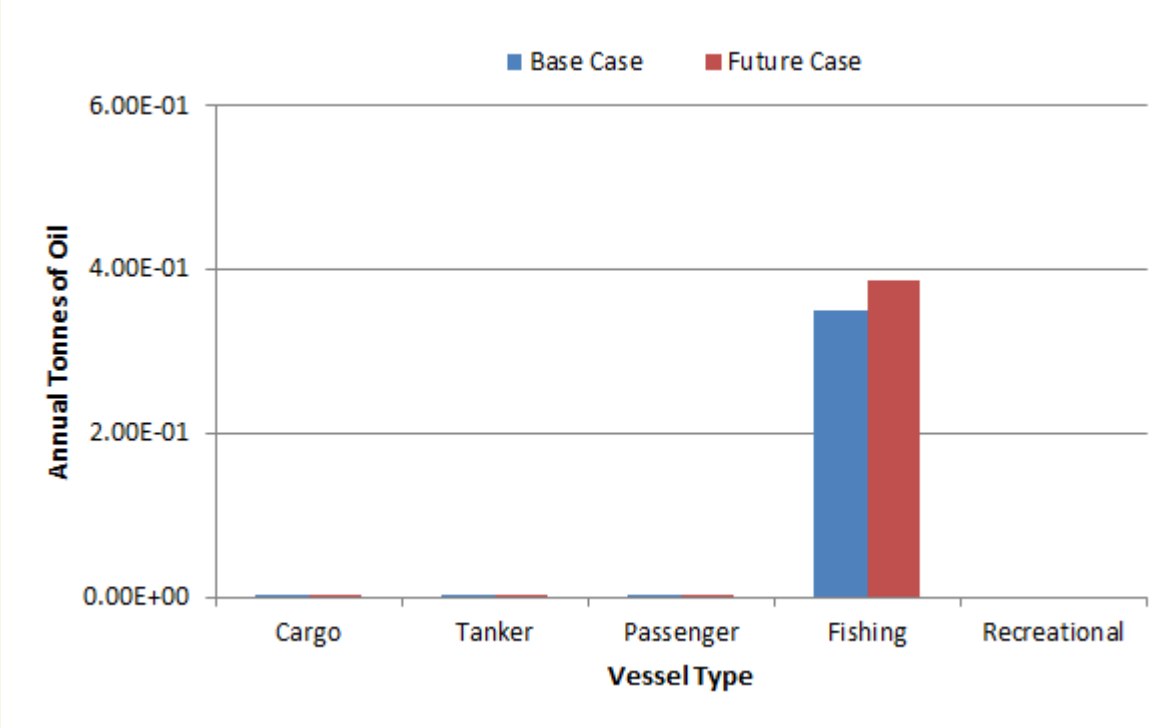
- 31% of oil spills below seven tonnes;
- 52% of spills between seven and 700 tonnes; and
- 17% of spills greater than 700 tonnes.

For fishing vessel collisions, comprehensive statistical data is not available. Consequently, it is conservatively assumed that 50% of all collisions involving fishing vessels will lead to oil spill with the quantity spilled being on average five tonnes. Similarly for recreational vessels, due to a lack of data 50% of collisions are assumed to lead to a spill with an average size of one tonne.

28.4.2 Pollution Risk due to the Development

Applying the above probabilities to the annual collision and allision frequency by vessel type presented in Graph 28-15 and the average spill size per vessel, the amount of oil spilled per year due to the Development is estimated to be 0.35 tonnes for the base case, and 0.39 tonnes for the future case.

The estimated increase in tonnes of oil spilled distributed by vessel type for the base and future cases are presented in Graph 28-15.



Graph 28-15 Estimated Change in Pollution by Vessel Type

As expected based on the input allision/collision frequencies, the majority of the anticipated oil spill was associated with fishing vessels.

28.4.3 Significance of Increase in Pollution Risk

To assess the significance of the increased pollution risk from marine vessels caused by the Development, historical oil spill data for the UK has been used as a benchmark.

From the MEHRAs research (DfT, 2001), the annual average tonnes of oil spilled in the waters around the British Isles due to marine accidents in the 10 year period from 1989 to 1998 was 16,111. This is based on a total of 146 reported oil pollution incidents of greater than one tonne (smaller spills are excluded as are incidents which occurred within port and harbour areas or as a result of operational errors or equipment failure). Commercial vessel spills accounted for approximately 99% of the total while fishing vessel incidents accounted for less than 1%.

The estimated increase in oil spill due to the Development equates to 0.002% of the historical average pollution quantities from marine accidents in UK waters (for both the base and future cases).

28.4.4 Conclusions

This annex has assessed the fatality and pollution risk associated with the Development. The quantitative risk assessment indicates that the collision and allision risk associated with fishing vessels is highest.

Overall, the impact of the Development on people and the environment is relatively low compared to the existing background risk levels in UK waters. However, it should be noted that this is the localised impact of a single project and there will be additional maritime risks associated with other offshore wind farm developments in the Moray Firth and the UK as a whole.

Further discussion of mitigation measures and monitoring is provided in the NRA.

28.5 References

IMO (2001). Maritime Safety Committee, 74th Edition, Agenda Item 5 (MSC 74/5/X), Bulk Carrier Safety – FSA, 2001.

DfT (2001), Identification of Marine Environmental High Risk Areas (MEHRAs) in the UK, 2001.

29 Annex12.1D Regular Operators Consultation

29.1 Introduction

29.1.1 Background

This Annex summarises the consultation undertaken with Regular Operators as part of the overarching consultation process with shipping and navigation stakeholders, undertaken for the Moray West Offshore Wind Farm. The arising responses are included within Section 5.3 of the Navigation Risk Assessment (NRA) (Technical Appendix 12.1 to Chapter 12: Shipping and Navigation).

29.1.2 Methodology

The marine traffic survey data collected for the Project (as described in Section 12 of the NRA), was used to identify key marine Regular Operators, relative to the Moray West Site. A Regular Operator is defined as any commercial operator observed as owning, or being responsible for, vessels with multiple transits in the area. It is noted that fishing vessels and recreational vessels were not included in this analysis, with the focus instead on regular routed traffic that may be impacted by the Project.

The following Regular Operators were identified on this basis:

- Arklow Shipping;
- BP Shipping;
- Briggs Marine;
- Cruise & Maritime Voyages;
- Faversham Ships;
- Green Marine UK;
- Hagland Shipping;
- Hapag-Lloyd;
- Hebridean Island Cruises;
- James Fisher Everard;
- Norwegian Cruise Line;
- Peak Group;
- Princess Cruises;
- Scotline;
- Solstad Farstad;
- Subsea 7;
- Teekay Shipping Norway AS;
- Vadero Shipping;
- Viking Supply Ships;
- Vroon Offshore;
- Wijnne Barends;
- Windstar Cruises;

- AIDA Cruises;
- Fred Olsen Cruise Lines; and
- MSC Cruises

Each of the Regular Operators listed above were sent a letter via email containing information on the Project, and a request for a consultation response. The letter template used is provided in Image 29.1 below for reference.

Responses received are included in Section 5.3 of the NRA.

Image 29.1: Letter Template

MORAY WEST
OFFSHORE WINDFARM

{STAKEHOLDER ADDRESS}

Date: XXX

Stakeholder Consultation on Navigation Impacts for the Proposed Moray West Offshore Wind Farm

Dear Stakeholder {OR CONTACT NAME IF KNOWN},

Moray Offshore Windfarm (West) Limited (known as 'Moray West') is promoting the Moray West Offshore Wind Farm on behalf of Moray Offshore Renewable Power Limited (referred to as 'Moray Offshore'). The Moray West Offshore Wind Farm is located in the outer Moray Firth, approximately 22 km southeast of the Caithness coastline as shown in Figure 1. The Moray West Offshore Wind Farm will comprise an offshore array of up to 85 Wind Turbine Generators (WTGs) connected to one another by subsea inter-array cables, which will in turn connect the WTGs to the Offshore Transmission Infrastructure (OfTI). The OfTI will comprise up to two Offshore Substation Platforms (OSPs); interconnector cables linking the OSPs; and export cable circuits running from the OSPs to landfall at Sandend Bay.

Anatec has been contracted by Moray West to provide technical support on navigation during the consenting process. Therefore, we are writing to you on behalf of Moray West to provide an outline of their proposals for developing the project.

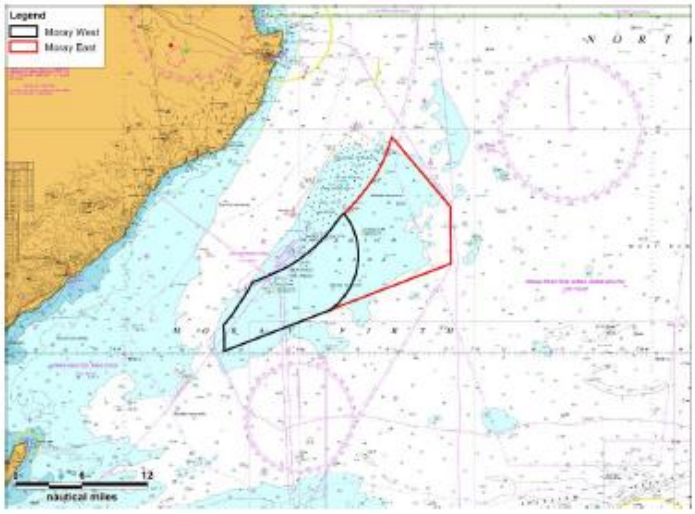


Figure 1 Moray Offshore Wind Farm Projects

The Environmental Impact Assessment (EIA) process requires Moray West to identify impacts that the development could potentially have on shipping and navigation, and to ensure that consultation is carried out in a comprehensive and consistent manner. In order to analyse shipping and navigation movements in the area, Automatic Identification System (AIS) and Radar data has been collected

www.moraywest.com

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Registered Office c/O 7side Secretarial Ltd
1st Floor 1418 City Road, Cardiff, United Kingdom CF24 3DL
Registered Company in England and Wales
Company Number 10515140

MORAY WEST
OFFSHORE WINDFARM

from a combination of vessel-based and shore-based surveys which will feed into the Navigational Risk Assessment (NRA).

Anatec has analysed the aforementioned AIS and Radar data and has observed that your organisation's vessels have regularly navigated in the sea area around the proposed Moray West development site. As a result, your company has been identified as a potential Marine Stakeholder for the Moray West project. We therefore invite your feedback on the development including any impact it may have on the navigation of vessels. To assist your review, Figure 2 shows plots of your vessels' movements recorded throughout the surveys during seasonal periods of 2016 and 2017 relative to the development. A buffer covering 10nm has been placed around the wind farm boundary for context.

{FIGURE SHOWING OPERATORS VESSELS RELATIVE TO MORAY WEST SITE}

Figure 2 Marine Traffic Survey Data for XXX (2016/17)

We would be grateful if you could review this letter and provide us with any comments or feedback that you may have by the 5th December 2017. This will allow us to assess your feedback as part of the NRA which is currently being undertaken. We would also be grateful if you could forward a copy of this information on to any vessel operators / owners you feel may be interested in commenting.

In particular, we are keen to receive comments on:

1. Whether the proposal to develop Moray West is likely to affect the routeing of any specific vessels;
2. Whether there are any particular parts of the development area which would pose greater safety or routeing concerns to your vessels; and
3. Whether you wish to be retained on our list of Marine Stakeholders and consulted throughout the NRA process.

Further project information is available at:

http://www.morayoffshore.com/moray-west/the-project/

However should you require any further information to support your review or additional information on the navigational consenting process in general, please do not hesitate to contact us.

We look forward to receiving your response.

Yours sincerely,

XXX

Risk Analyst

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OFFSHORE WINDFARM

Contact

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MORAY WEST
OFFSHORE WINDFARM

Initial Aviation Assessment

Moray Offshore Windfarm (West) Limited

Technical Appendix 13.1

moray offshore renewables ltd

Environmental Statement

Technical Appendix 5.3 A - Initial Aviation Assessment

edp renewables
powered by nature

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MORAY FIRTH OFFSHORE WIND FARM: INITIAL AVIATION ASSESSMENT REPORT

November 2010

Report No. 10/283/MOR/4

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DISCLAIMER

Acceptance of this document by the client is on the basis that Spaven Consulting is not responsible for the application or use made of the findings from the analysis. Such responsibility remains with the client.

1. Introduction

1.1 This document reviews the desk study of aviation issues conducted for Moray Offshore Renewables Ltd (MORL) in 2009, taking into account consultation responses received from aviation stakeholders.

1.2 This assessment addresses potential aviation issues in relation to both Phase 1 of the Moray Offshore development, also referred to as the Eastern Development Area, and Phase 2, also referred to as the Western Development Area. The boundaries of the Phase 1 and 2 areas and relevant aviation features in the Moray Firth area are shown in Figure 1.

2. Review of MORL desk study

2.1 A high level screening of potential aviation issues for the Moray Offshore wind farm was conducted by Pager Power in 2009.[1] This study identified the following potential aviation issues associated with the Moray Firth proposal:

- line of sight to NATS Allanshill radar
- line of sight to RAF Lossiemouth primary radar
- obstacle clearance for helicopter instrument approach procedures to the Beatrice platforms
- location of parts of the Western Development Area within the Kinloss/Lossiemouth Area of Intense Aerial Activity (AIAA).

2.2 Following submission of a consultation proforma to the Civil Aviation Authority (CAA) and the Ministry of Defence (MoD), responses were received from those bodies which identified the following additional issues:

- obstacle clearance issues for helicopters flying on Helicopter Main Route X-Ray
- proximity to Wick Airport
- obstacle clearance issues for military air activity in Danger Area D807.

2.3 Of the potential issues listed above, the Kinloss/Lossiemouth AIAA can now be discounted since, following a review by the CAA Directorate of Airspace Policy (DAP) in 2008-9, this AIAA was removed from 31 December 2009.

2.4 In addition to the above, three further issues have been raised since 2009: (a) the potential for line of sight to the Moray Offshore turbines from the air defence radar at RAF Buchan, (b) the potential for impacts on operations by search and rescue helicopters and (c) the impacts of meteorological masts on aviation in the vicinity.

[1] Pager Power, *6131A – RPS Moray Firth – High Level Screening Assessment*, February 2009.

2.5 The full range of potential aviation issues addressed in this report is therefore:

- line of sight to NATS Allanshill radar
- line of sight to RAF Lossiemouth primary radar
- obstacle clearance for helicopter instrument approach procedures to the Beatrice platforms
- obstacle clearance issues for helicopters flying on Helicopter Main Route X-Ray
- proximity to Wick Airport
- obstacle clearance issues for military air activity in Danger Area D807
- line of sight to RAF Buchan radar
- impacts on search and rescue helicopter operations
- impacts of meteorological masts.

3. NATS Allanshill radar

3.1 Primary surveillance radar can be affected by wind turbines in three ways:

- Air traffic control radar is designed to detect moving objects, while filtering out static objects such as buildings, radio masts and terrain. The moving blades of a wind turbine may be detected and displayed by the radar, and may appear to controllers as being similar to the radar returns from an aircraft. Controllers may then have to treat them as if they were unknown aircraft, with consequences for the provision of services to known aircraft in the vicinity.
- Primary surveillance radars used for air traffic control are designed to filter out static and slow-moving radar returns by use of 'clutter mapping' techniques. The radar returns from wind turbines can have the effect of raising the clutter mapping thresholds in the area of the wind farm, resulting in a reduced probability of detection of real aircraft targets overhead the wind farm.
- Blocking of the radar signal by the wind turbine towers and nacelles can reduce the radar's ability to detect aircraft at low altitude behind the wind farm.

3.2 NATS En Route Ltd operates a combined primary and secondary surveillance radar station at Allanshill, 6 km south west of Rosehearty in Aberdeenshire (see Figure 1). The Allanshill radar supplies data to controllers located at Aberdeen Airport who provide services to helicopters and fixed-wing aircraft within the Aberdeen Radar sector (see Figure 1). The Allanshill radar was installed in the 1980s to supplement the main NATS Aberdeen radar at Perwinnes Hill (located 4 km east of Aberdeen Airport), which has poor low level coverage over the Moray Firth due to intervening terrain. The original Watchman radar at the Allanshill site was replaced in 2009 by a Raytheon ASR-10SS solid-state primary surveillance radar co-located with a Mode S Secondary Surveillance Radar (SSR).

3.3 The NATS self-assessment radar coverage diagrams show that the whole of the Phase 1 area, and approximately two thirds of the Phase 2 area, will be within

5.3A4

radar line of sight of the Allanshill radar. Figure 2 shows the Allanshill radar coverage at 140 metres above sea level, annotated with the boundaries of the Moray Offshore Phase 1 and Phase 2 development areas. It can be expected that turbines in the Beatrice Offshore Wind Ltd (BOWL) development, which abuts the MORL Phase 1 and 2 northern boundaries, will also be visible to the Allanshill radar.

3.4 The Allanshill radar's coverage at 182 metres above sea level – the maximum blade tip height on current plans – would extend slightly further south west than shown in Figure 2. However the radar's coverage of the south western parts of MORL Phase 2 would remain significantly constrained by high terrain within 5 km of the radar. This is illustrated in Figures 3 and 4, which show the line of sight from the radar to the blade tip height of 182m turbines located at points 12 and 13 of the MORL Phase 2 boundary, in the vicinity of the Beatrice C platform. In both cases, the line of sight is blocked by the terrain close to the radar.

3.5 The display of wind turbine returns on radar is not necessarily unacceptable from an air traffic control (ATC) point of view. If the wind turbines are in an area which is not operationally significant to ATC, or appear on radar in a manner which can be accommodated within controller procedures and practices, the effects on radar may be deemed acceptable, perhaps with some alteration to ATC procedures. However in view of the scale of the MORL development and its proximity to air traffic routes in uncontrolled airspace, NATS is unlikely to accept the MORL proposal without some form of technical and/or procedural mitigation.

3.6 In the case of the Moray Offshore development, both the Phase 1 and Phase 2 areas lie underneath two routes on which NATS ATC personnel provide air traffic radar services:

- Helicopter Main Route (HMR) X-Ray, which is used by offshore helicopters routing between Aberdeen Airport and the Foinaven and Schiehallion floating production facilities, 130 km west of Shetland. The section of the route which overlies the Moray Offshore development is bi-directional and extends from 1500ft above sea level up to the base of W4D (see below).
- Advisory Route W4D, which follows the same route as HMR X-Ray between Aberdeen and Wick but extends from Flight Level 55 (approximately 5,500 feet) up to Flight Level 185 (approximately 18,500 feet). Advisory Routes provide a degree of protection to aircraft using them, but unlike fully controlled airspace, do not provide separation against all other aircraft. W4D is predominantly used by Eastern Airways scheduled passenger services between Wick and Aberdeen and by light aircraft on transatlantic ferry flights between Europe and North America via Wick.

3.7 The locations of W4D and HMR X-Ray relative to the Phase 1 and Phase 2 areas are shown in Figure 1. A schematic diagram showing the profile of the airspace boundaries in elevation is at Figure 5.

3.8 Air traffic radar services to helicopters flying on the portion of HMR X-Ray between Aberdeen and Wick are provided by Aberdeen Radar controllers located at Aberdeen Airport. Services to aircraft flying on W4D are provided by Scottish

Control, located at the Scottish Area Control Centre at Prestwick. Since both routes are outside controlled airspace, controllers may be required to provide horizontal separation of five nautical miles (nm) between the aircraft to which they are providing a service and any unidentified radar returns. A large portion of both the Phase 1 and Phase 2 areas are located within 5nm of the centreline of HMR X-Ray/W4D, therefore radar-visible turbines in this area are likely to have an operational impact on provision of these air traffic radar services.

3.9 Mitigation for the effects of the Moray Offshore wind farm on the Allanshill radar could range from operational measures (e.g. re-routing traffic, changes to the type of radar service provided, changes to the airspace classification) to radar technical measures (e.g. provision of cover from another radar which cannot see the turbines; development of radar processing to filter out the turbines; provision of services using secondary surveillance radar only; multilateration).

3.10 In the case of the Allanshill radar, any mitigation of Moray Offshore Phase 1 will have to take account of cumulative impacts with Moray Offshore Phase 2 and the Beatrice Offshore Wind development. Because of the cumulative scale of these developments, operational mitigation measures on their own are unlikely to be sufficient. However the scale of the developments also increases the economic viability of technical mitigation measures.

3.11 Two strategies for mitigation of the effects on the Allanshill radar are likely to have particular relevance:

- implementation of the Raytheon upgrade programme on the Allanshill radar
- blanking of the Allanshill primary radar in the area over the wind farms(s), provision of radar services using secondary surveillance radar (SSR) only, and imposition of a Transponder Mandatory Zone (TMZ) over the area[2].

3.12 The Raytheon upgrade programme is a project funded by the wind industry, DECC and the Crown Estate to investigate a number of processing enhancements to the Raytheon radars in service with NATS En Route, in order to improve their performance against wind turbines. The research and development phase is under way and is due to report in June 2011. It is currently running to schedule. Raytheon and the Royal Netherlands Air Force successfully completed trials of the enhancements to the ASR-10 radar (the type installed at Allanshill) in early July 2010. Similar trials on the ASR-23 radar at Lowther Hill are due to be conducted in February 2011. The ultimate aim of the Raytheon upgrade programme is to achieve radars which are unaffected by wind turbines while maintaining or enhancing their performance against aircraft. Deployment of the solution is expected to commence in 2013 if development work proceeds according to schedule and wind industry funding for implementation is agreed. The NERL plan is to implement the upgrade on all 23 radars in its network, commencing with those most affected by wind farm proposals. The position of Allanshill in the implementation programme would be a matter for negotiation.

3.13 The blanking/SSR only/TMZ approach may be regarded either as a stop-gap measure pending the successful completion of the Raytheon project; a fall-back in

[2] Multilateration – the tracking of aircraft using triangulation by multiple SSR transmitter/receivers – would also be likely to require a Transponder Mandatory Zone.

5.3A6

case Raytheon does not meet required specifications; or as a stand-alone long-term solution. It has a precedent in the arrangements for mitigation of the effects of the London Array and Thanet Offshore wind farms on the radar at Kent Airport (Manston). This approach has the benefit of not requiring any technical upgrades since the required SSR coverage is already in place at Allanshill. Blanking of the primary radar is relatively straightforward, and imposition of a TMZ in an offshore area is also relatively simple since there are likely to be few aviation stakeholders who would want to fly through this area in aircraft not equipped with transponders.

3.14 In the event that neither the Raytheon upgrade programme nor the combination of blanking, SSR only and TMZ are found to be viable mitigations, a 'gap-filler' approach may be appropriate. This would use the data from a radar which has coverage of the airspace above the turbines but does not have line of sight to the turbines themselves, due to intervening terrain. The data from this radar would replace the affected radar's coverage over the wind farm. The gap-filler radar could be an existing facility with the required level of coverage or, if no such radar exists, a new radar procured specifically to mitigate the wind farm effects, and located so as to avoid line of sight to the turbines but provide adequate low level coverage above the turbines.

4. RAF Lossiemouth primary radar

4.1 RAF Lossiemouth has a Watchman primary radar located in the centre of the airfield. The potential effects of the Moray Offshore wind farm on this radar are the same as those outlined in paragraph 3.1 above.

4.2 RAF Lossiemouth ATC use their primary radar to provide services to aircraft inbound to and outbound from RAF Lossiemouth and RAF Kinloss, to military aircraft operating over the Moray Firth, including the area of the wind farm, and to transiting civil and military aircraft operating within a 40nm radius of Lossiemouth, up to 9,500 feet, from Monday to Friday between 0900 and 1700hrs.

4.3 The line of sight from the Lossiemouth radar to the blade tips of 182 metre turbines at illustrative positions on the south west, west and northern boundaries of the Phase 1 area is shown in Figures 6, 7 and 8. From these it can be summarised that turbines in the south western parts of the area will be fully visible to the radar; turbines in the central and western parts of the area will be partially visible; and turbines in the eastern and northern parts of the area will not be visible to the Lossiemouth radar because they will be beyond the radar horizon.

4.4 From the above it can be concluded that 182m turbines in all but the northern extremities of the MORL Phase 2 area will also be within line of sight of the RAF Lossiemouth primary radar. It can be expected that turbines in the Beatrice Offshore Wind Ltd (BOWL) development, which abuts the MORL Phase 1 and 2 northern boundaries, will also be visible to the Lossiemouth radar.

4.5 The display of wind turbine returns on radar is not necessarily unacceptable from an air traffic control (ATC) point of view. If the wind turbines are in an area which is not operationally significant to ATC, or appear on radar in a manner which can be accommodated within controller procedures and practices, the effects on

radar may be deemed acceptable, perhaps with some alteration to ATC procedures. The MoD has accepted the impact of the two Beatrice Demonstrator turbines on the RAF Lossiemouth radar and in 2009 approved a major expansion of the existing Rothes wind farm, also fully visible to the RAF Lossiemouth radar. However in view of the scale of the MORL development and subsequent shifts in MoD policy, the MoD is unlikely to accept the MORL proposal without some form of technical and/or procedural mitigation.

4.6 Technical mitigation solutions for the Lossiemouth radar may be more complex than for the NATS Allanshill radar. The MoD's long-term programme for replacement of all Watchman air traffic control radars in UK military service is likely to include a requirement that any new equipment is not vulnerable to wind farm effects. However this programme has already been delayed and may slip further due to public expenditure cuts. It cannot be relied upon to deliver a mitigation solution in the required timescale for development and construction of MORL.

4.7 'Gap-filler' solutions would depend on another radar to provide coverage over the wind farm. This could be:

- an existing radar which cannot see the turbines, but can see a short distance above them; or
- an existing radar which has been upgraded to eliminate wind turbine returns (such as Allanshill after the Raytheon upgrade); or
- a new radar funded by the Moray Firth offshore wind developers, in a suitable location chosen to avoid line of sight to the turbines.

4.8 A solution based on blanking, provision of services using SSR only, and implementation of a TMZ over the MORL wind farm, as outlined in paragraph 3.13 above in relation to the Allanshill radar, could also be applied to the RAF Lossiemouth radar. This would negate any requirement for a source of gap-filler radar data. However it would require MoD acceptance of the provision of air traffic services using SSR only over a significant part of the RAF Lossiemouth area of responsibility.

4.9 The Defence Review on 19 October 2010 announced the cancellation of the Nimrod MRA.4 programme and the closure of RAF Kinloss. It also announced a reduction in the Tornado GR.4 fleet and that two other RAF bases would be closed. However it stated that no decision had been taken on which bases these would be. One proposal is to disband two of the Tornado squadrons at Lossiemouth and move the remainder to the other RAF Tornado base at Marham in Norfolk. This would result in the closure of RAF Lossiemouth. However another proposal under consideration is to retain Losssiemouth on a care and maintenance basis for use during exercises. The latter option would result in the MoD continuing to safeguard the airfield and its radar services and would therefore sustain their objection to the MORL development.

5.3A8

5. Helicopter instrument approach procedures to the Beatrice platforms

5.1 The CAA advises that an area of 6nm radius around helideck-equipped offshore installations should be clear of obstacles in order to facilitate helicopter instrument approach procedures to those platforms from any direction.[3]

5.2 The boundaries of the MORL Phase 1 area have been defined in order to remain beyond this 6nm radius zone around the Beatrice A, B and C platforms and the Jacky platform, which was installed 2.7nm NNE of the Beatrice B in early 2009.

5.3 If all Phase 1 turbines are kept beyond the 6nm radius from all offshore platforms in the area, impacts on helicopter instrument approach procedures may be avoided, although an analysis of the impact on the vertical profile of the procedure may be required. Consideration may also have to be given to the acceptability of helicopter overflight of the wind farm below specified altitudes, in order to address emergency landing considerations.

5.4 Development of the BOWL and MORL Phase 2 areas will require placing turbines inside the 6nm obstacle-free zones. The impacts of this on helicopter access to the platforms in instrument conditions will require analysis of the existing obstacle environment on and around the installation, and of meteorological data, in order to define prohibited approach sectors, devise amendments to existing approach procedures, determine the frequency with which instrument approaches may be precluded, and develop mitigation measures.

5.5 The current standard instrument approach procedure used by helicopters to access offshore platforms, the Airborne Radar Approach (ARA), will shortly be replaced by the Satellite-Based Augmentation System Offshore Approach Procedure (SOAP). This offers some benefits over the ARA in terms of ability to work around obstacles and is likely to form a key element of any mitigation strategy for the Phase 2 development.

6. Helicopter Main Route X-Ray

6.1 HMR X-Ray is used by helicopters transiting between Aberdeen and the Atlantic Rim offshore installations west of Shetland. The potential impact of the MOR project on helicopters using this route is two-fold: (1) impact on air traffic radar services to these aircraft using the Allanshill radar (see section 3 above); and (2) potential obstacle clearance issues when icing conditions force helicopters to fly visually below cloud at altitudes lower than the normal minimum of 2000ft.

6.2 In order to address the obstacle clearance issue, the CAA advises in CAP 764 that HMRs should be clear of obstacles for a distance of 2nm either of the HMR centreline. The implications of this for the MORL project will depend on the current operational parameters for use of HMR X-Ray, including restrictions on low-level icing routings due to significant overland portions of the route to the north west of Aberdeen Airport passing over or within 5nm of terrain and obstacles up to 1300ft in height.

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[3] CAP 764, Chapter 3, Section7.

6.3 Analysis of the impact on helicopter operations in icing conditions will require consultations with helicopter operators currently using this route.

6.4 Mitigations for this effect may include:

- tactical re-routing to be used when icing conditions prevail
- a re-design of HMR X-Ray so that it avoids the wind farm in all circumstances and permanently
- introduction of helicopters which are approved for flight in known icing conditions
- future changes to the location of the supply base for helicopter flights to the Atlantic Rim platforms.

7. Wick Airport

7.1 The Moray Offshore wind farm has the potential to conflict with instrument approach procedures to Wick Airport. To assess this, analysis has been conducted of the horizontal and vertical proximity of the closest turbines to these procedures.

7.2 The northern boundary of the Eastern (Phase 1) Development Area is located 25.8 km (13.9 nm) south east of Wick Airport. Instrument Flight Rules traffic inbound to Wick from the south east mainly flies along Advisory Route W4D. In the area within a 25 nautical mile (nm) radius of Wick Airport, the Minimum Sector Altitude (MSA) – the lowest altitude to which aircraft can safely descend while maintaining 1000ft vertical separation from all terrain and obstacles – is 1800ft above sea level. Descent below 1800ft is not authorised until the aircraft is established on the final approach track, which is more than 5nm from the northern boundary of the Eastern Development Area.[4] Therefore, any turbines in the Phase 1 area will be within the area where aircraft are currently permitted to descend to 1800 ft. On current plans the maximum tip height of any turbines will be 182 metres (597 ft). The current MSA of 1800 ft will therefore continue to give well in excess of the required minimum 1000ft vertical separation over the turbines. Consequently the Phase 1 development will have no impact on Wick Airport instrument flight procedures.

7.3 Consideration may also need to be given to the impact of the Moray Offshore development on handover arrangements between Wick ATC and en route ATC agencies in the area to the south east of Wick. Wick is not equipped with radar. Controllers may be handing aircraft over from Wick to radar controllers at Aberdeen Radar, Scottish Control or Lossiemouth Radar (and vice versa) in the vicinity of the Moray Offshore development. Impacts of the development on radar performance in this area may have implications for the handover process.

8. Danger Area D807

8.1 Danger Area D807 comprises a circle of 10nm radius, extending from the sea surface to 1500 feet above sea level. The south west corner of the Phase 1

[4] Civil Aviation Authority, UK AIP AD 2-EGPC-8-5, 1 July 2010.

area and approximately the south-eastern half of the Phase 2 area are within the boundaries of D807 (see Figure 1).

8.2 D807 is permanently notified, i.e. other airspace users are advised that this area is always active during its published activity hours, which are Monday to Friday, 0700hrs to 2359hrs local time (and other times as notified). However, in practice, other airspace users can contact RAF Lossiemouth air traffic control for information on whether the area is active or not and, if advised that the area is inactive, other aircraft may fly through it.

8.3 D807 is predominantly used for low level anti-submarine sonobuoy training by Nimrod aircraft from RAF Kinloss (currently inactive but re-equipping with the Nimrod MRA.4 from 2011). This activity may be conducted in any meteorological conditions including flight in cloud as low as 500 feet above sea level. Since this is below the proposed heights of the turbines, obstacle clearance from any turbines located inside D807 is an issue which must be addressed.

8.4 Promulgated activity in D807 includes live firing and bombing. However, unlike most weapons ranges, there are no byelaws which prohibit other aircraft from entering the area when it is active. This is believed to be due to the fact that D807 is wholly beyond UK territorial waters and therefore not within the jurisdiction of byelaws.

8.5 The nature and scale of the impact of the Moray Offshore wind farm on activities in D807 will depend on the extent to which the northern parts of the danger area are used by participating aircraft. In consultations with the MoD their initial response has been that no turbines are permissible within the lateral limits of D807. However further details of the nature, frequency and control of operations inside D807 will be required in order to assess the scope for discussion of mitigation measures.

8.6 Mitigation measures may include consideration of turbine locations and dimensions and amendment of the location, size and/or shape of D807 to accommodate wind farm developments.

8.7 The announcement of the withdrawal of all Nimrod aircraft and the closure of RAF Kinloss in the Defence Review of October 2010 is expected to mean the disestablishment of D807. This will require confirmation from MoD.

9. RAF Buchan radar

9.1 Potential impacts on the RAF Buchan air defence radar are similar to those outlined in paragraph 3.1. However the Type 92 radar which is currently in place at Buchan is known to have a good capability at filtering out wind turbine returns compared to other primary radars.

9.2 The line of sight from the RAF Buchan radar to the blade tips of 182 metre turbines at illustrative positions on the south eastern and eastern margins of the Phase 1 area is shown in Figures 9 and 10. From these it is clear that turbines in any part of the Moray Offshore development area will not be visible to the Buchan radar due to intervening terrain to the north of the radar site. Consequently no mitigation measures will be required for the Buchan radar.

9.3 The MoD has confirmed in a meeting on 20 July 2010 that it has no concerns about impacts on the RAF Buchan air defence radar.

10. Impacts on search and rescue helicopter operations

10.1 Search and rescue helicopter cover in the Moray Offshore Development Area is provided by two Sea King HAR.3 helicopters from D Flight No.202 Squadron based at RAF Lossiemouth. Plans for contractorisation of all search and rescue helicopter provision in the UK under a Private Finance Initiative contract were announced in February 2010 but put on hold by the incoming government in June 2010.

10.2 Search and rescue (SAR) helicopter operations within the Moray Offshore wind farm area could include:

- response to a vessel emergency within the wind farm
- response to an emergency involving wind farm personnel
- response to an aircraft ditching in the wind farm area
- emergency helicopter access to adjacent oil platforms.

10.3 Two studies relating to SAR helicopter operations within offshore wind farms have been carried out. The first assessed the performance of marine radar, radio communications and GPS in close proximity to wind turbines.[5] The second used an RAF Sea King helicopter to assess the effects of operating a SAR helicopter within an offshore wind farm.[6]

10.4 The first study found that the only significant cause for concern was the effect of wind farm structures on shipborne and shore-based radar systems. The second study concluded that, while a helicopter could be safely flown into a regularly-spaced wind farm in good visibility, there could be limitations on the use of helicopters in offshore wind farms due to:

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5 MCA and QinetiQ, *Results of the electromagnetic investigations and assessments of marine radar, communications and positioning systems undertaken at the North Hoyle wind farm by QinetiQ and the Maritime and Coastguard Agency*, November 2004.

6 Maritime and Coastguard Agency, *Offshore Wind Farm Helicopter Search and Rescue Trials Undertaken at the North Hoyle Wind Farm*, 2005.

- Significant radar side lobe returns from structures, limiting target detection when vessels were within 100 metres of turbines.
- The current inability of some wind farm operators to remotely lock turbine blades in rotation and in yaw.
- Limitations in approach distances from turbines in clear weather.
- Inability to effect surface rescues within wind farms in restricted visibility.
- Limitations of helicopters as radar search platforms if the wind farm was large and had irregularly spaced turbines.
- Limitations in the use of thermal imaging in conditions of mist or precipitation.
- Tracking, by vessel or shore-based marine radar, of helicopter movements within wind farms was generally poor.
- Increase of aircraft power requirements downwind of the wind farm.

10.5 While no concerns have been raised by the MoD about the impact of the Moray Offshore wind farm on SAR helicopter operations, consultations with maritime operators and the operators of the Beatrice and Jacky platforms will be required in order to address any issues relating to platform safety cases and rescue planning within the wind farm area.

11. Meteorological masts

11.1 Meteorological masts for the MORL development will constitute a potential hazard to low flying aircraft. Mitigation of this effect is normally achieved by passing full details of the location, height and construction of any obstacle to the Defence Geographic Centre prior to construction. DGC is responsible for maintaining the obstacles database from which civil and military aeronautical charts are compiled.

11.2 Lighting of offshore wind turbines is mandated by Article 220 of the Air Navigation Order. However this does not cover offshore obstacles which are not turbines and which are less than 150m in height. There is therefore no mandatory requirement for lighting on offshore met masts and no standards for the type and intensity of any lighting to be installed on them. Discussions are under way between the maritime and aviation industries and regulators on the preferred method of meeting lighting requirements for both industries.

12. Conclusions

12.1 The NATS Allanshill radar will be affected by the MORL Phase 1 and 2 developments. Mitigation will be required. Discussions with NATS will be required to determine the scope for different approaches to mitigation, including the Raytheon upgrade programme, a blanking/SSR only/TMZ solution, and gap-filler radar. Any mitigation for the Allanshill radar will require to address cumulative impacts of MORL Phase 1, MORL Phase 2 and BOWL.

12.2 Progression of a mitigation strategy based on the Raytheon upgrade programme will require ongoing consultation and liaison with RenewablesUK and the Fund Management Board in addition to NATS.

12.3 Progression of a mitigation strategy based on blanking/TMZ/SSR-only will require ongoing consultation and liaison with the CAA Directorate of Airspace Policy in addition to NATS and the MoD.

12.4 As a back-up to the principal mitigation options of blanking/TMZ and Raytheon upgrade, a feasibility study should be conducted of procurement and installation of a new radar to act as a gap-filler for both the NATS Allanshill and RAF Lossiemouth radars.

12.5 The RAF Lossiemouth radar will be affected by the MORL Phase 1 and 2 developments. Mitigation will be required. Discussions with MoD will be required to determine the scope for different approaches to mitigation, including a blanking/SSR only/TMZ solution, and gap-filler radar. Any mitigation for the Lossiemouth radar will require to address cumulative impacts of MORL Phase 1, MORL Phase 2 and BOWL.

12.6 The MORL Phase 1 area has been designed to remain outwith the CAA-recommended 6nm radius obstacle-free zone around the Beatrice and Jacky oil platforms. The Phase 1 development may therefore avoid impacts on helicopter instrument approach procedures to those platforms. However an analysis of the development's impact on the vertical profile of those procedures will be required.

12.7 The MORL Phase 2 and BOWL developments will require turbines to be placed within 6nm of the Beatrice and Jacky platforms. Detailed analysis of the scale and frequency of impact of this on helicopter instrument approach procedures, and potential mitigation measures, will be required. This work will require consultations with the relevant helicopter operators and the CAA.

12.8 The MORL Phase 1, Phase 2 and BOWL developments have the potential to create obstacle hazards to helicopters operating along HMR X-Ray, particularly in icing conditions. The development of mitigations for this effect will require consultations with the relevant helicopter operators, with NATS, the air traffic service provider on this route, and with the CAA.

12.9 Impacts on Wick Airport's instrument approach procedures are not predicted to occur. Confirmation of this may require submission of an assessment report to the airport's operator, Highlands & Islands Airports Ltd. The potential for effects on air traffic control handover arrangements between Wick and en route ATC agencies will require discussion with those agencies.

12.10 Turbines placed within danger area D807 will pose an obstacle hazard to aircraft operating inside that area. Development of mitigations for this impact will require further discussions with the relevant personnel within MoD.

12.11 There will be no impacts on the RAF Buchan air defence radar. No further action is required in relation to that facility.

12.12 No concerns have been raised by the MoD about the impact of the Moray Offshore wind farm on SAR helicopter operations. However consultations with maritime and offshore platform operators will be required in order to address any

issues relating to platform safety cases and rescue planning within the wind farm area.

12.13 Meteorological masts for the MORL development will pose a hazard to civil and military aircraft. This can be addressed in the normal way by promulgation of information through the Defence Geographical Centre. Lighting requirements for met masts are expected to emerge from aviation/marine industry discussions on this issue.

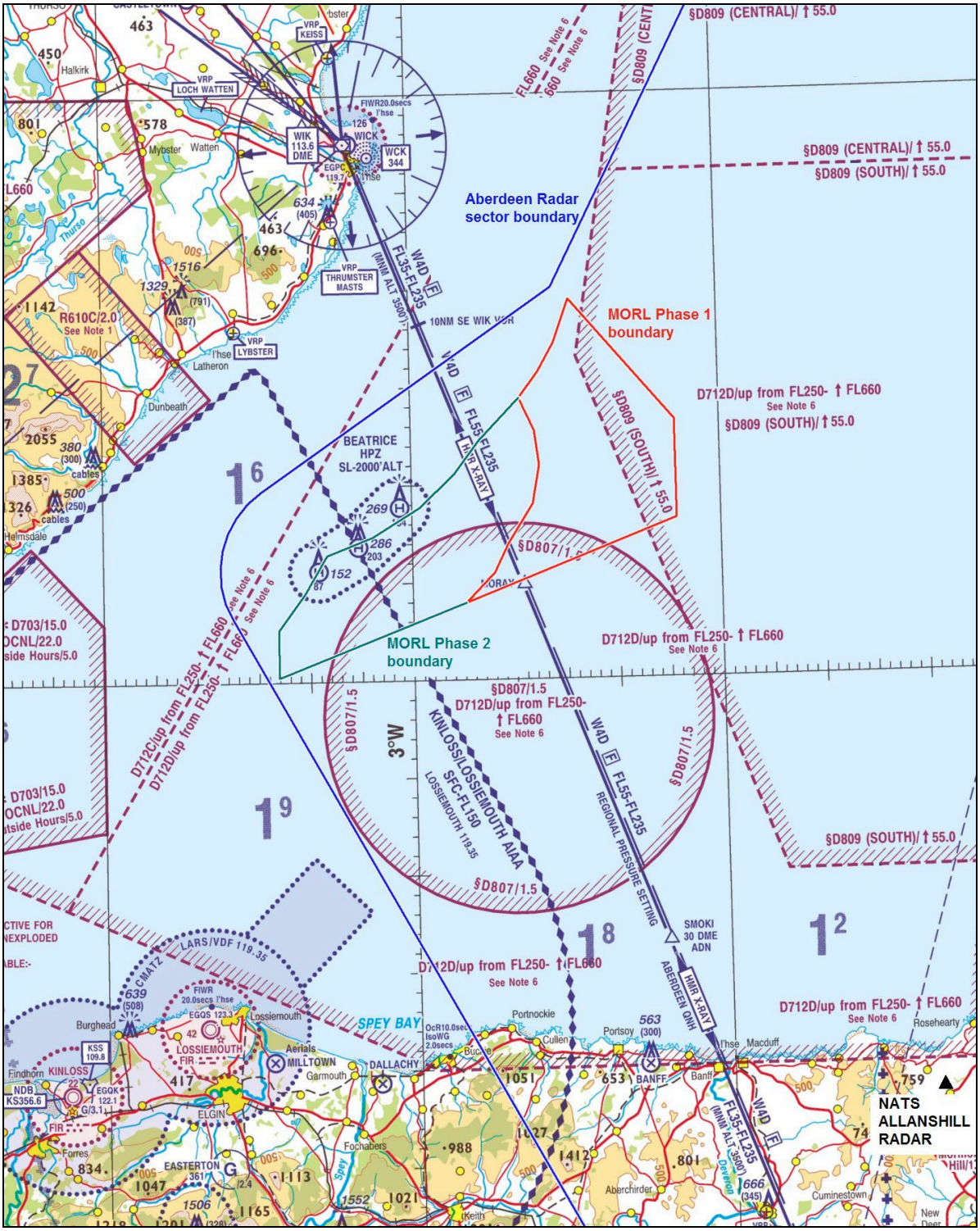

Figure 1: Aviation features in the Moray Firth area[7]

[7] NB the Kinloss/Lossiemouth AIAA has since been withdrawn.

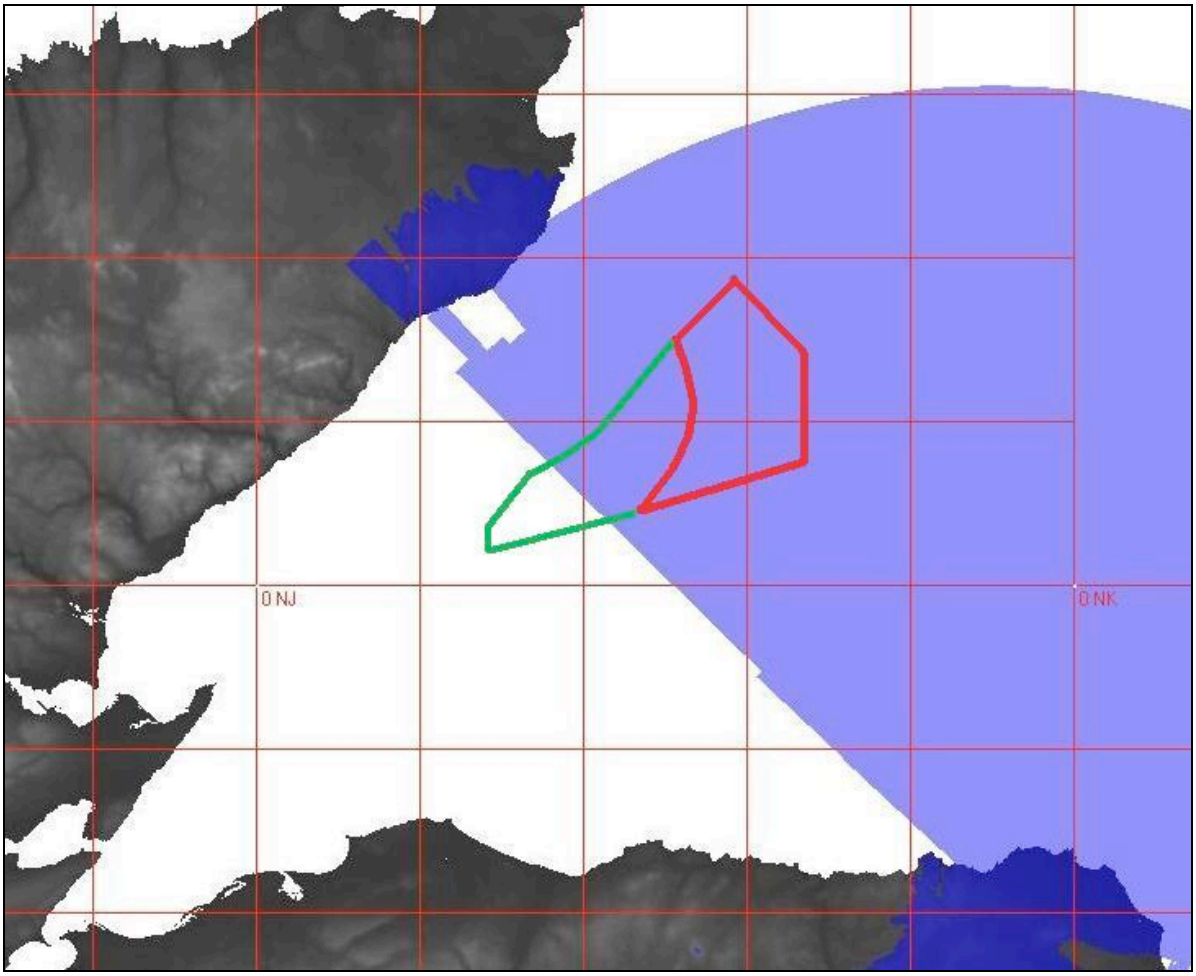

Figure 2: Allanshill radar coverage at 140m above sea level

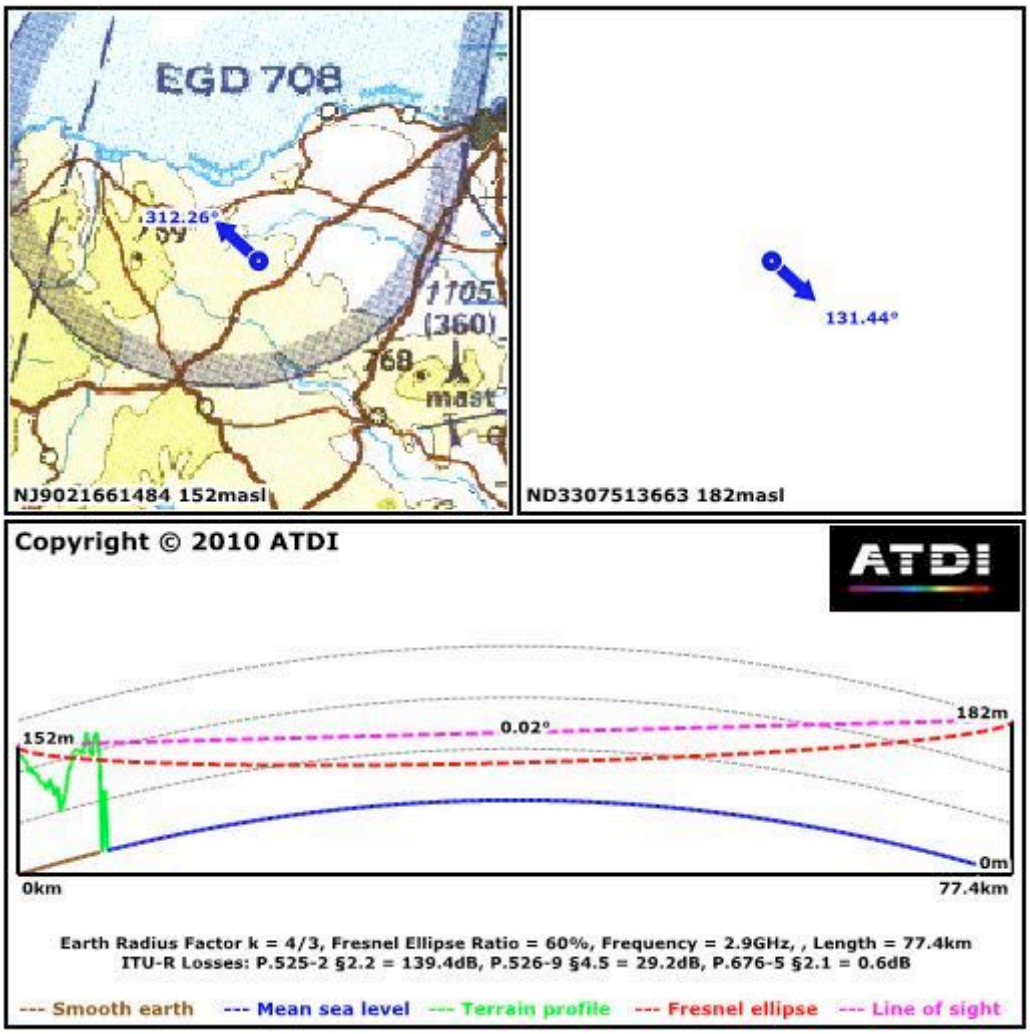

Figure 3: Radar line of sight from NATS Allanshill radar to 182m turbine blade tips at MORL Phase 2 boundary point 12[8]

[8] The upper, pink line shows the line of sight from the radar. Where this is infringed by the terrain (green line) or the sea (blue line), the radar will not have line of sight to objects at the illustrated location.

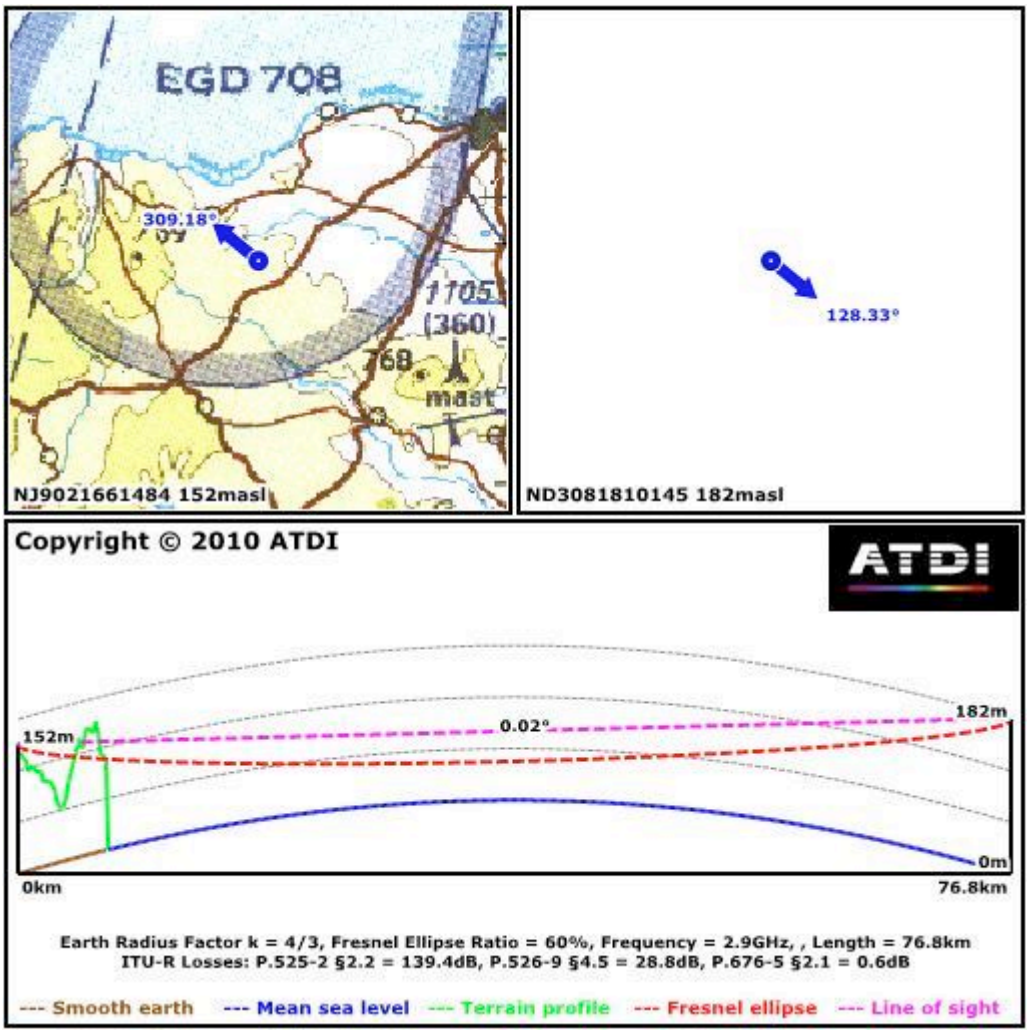

Figure 4: Radar line of sight from NATS Allanshill radar to 182m turbine blade tips at MORL Phase 2 boundary point 13

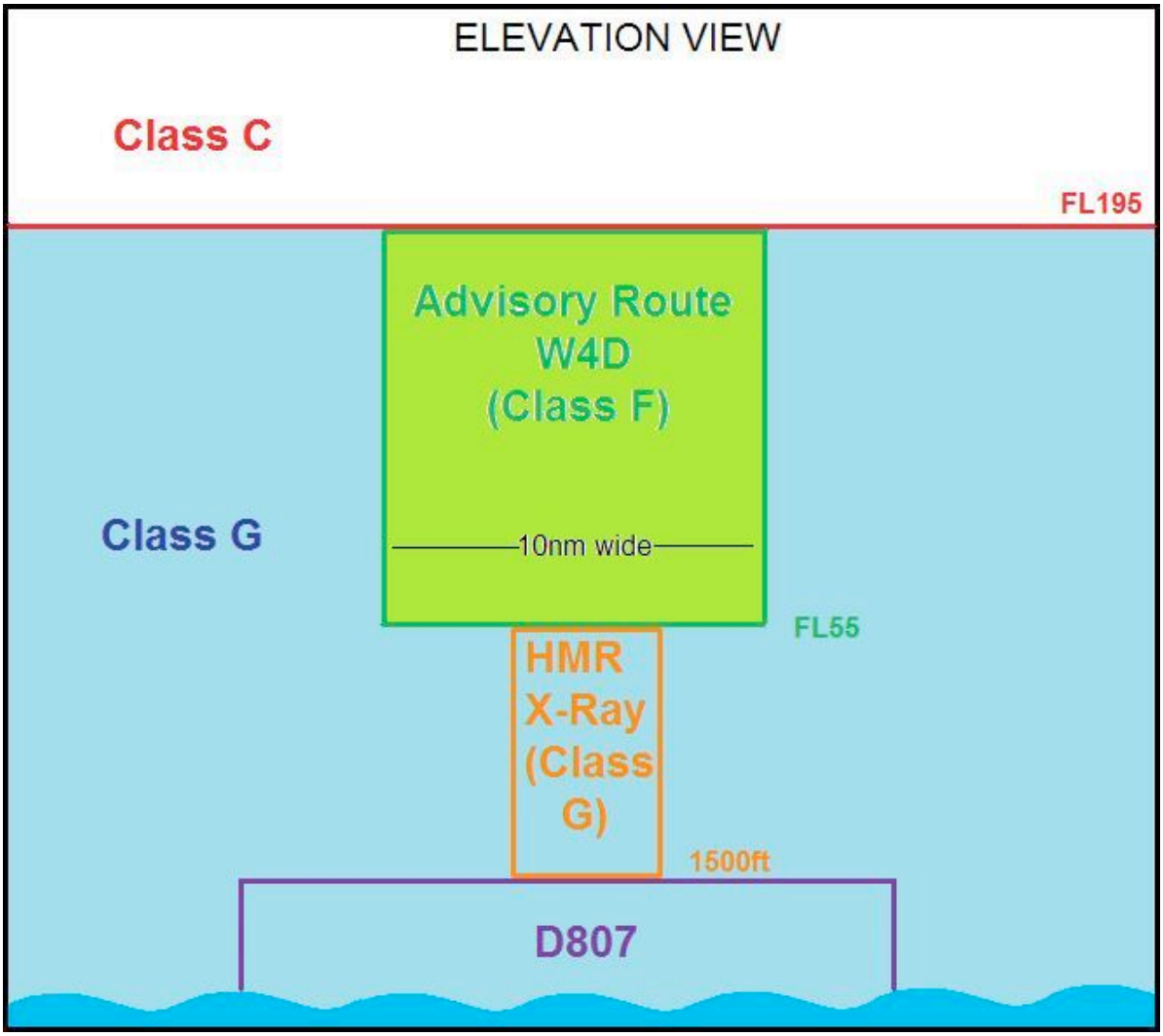

Figure 5: Elevation view of airspace features in the vicinity of MORL

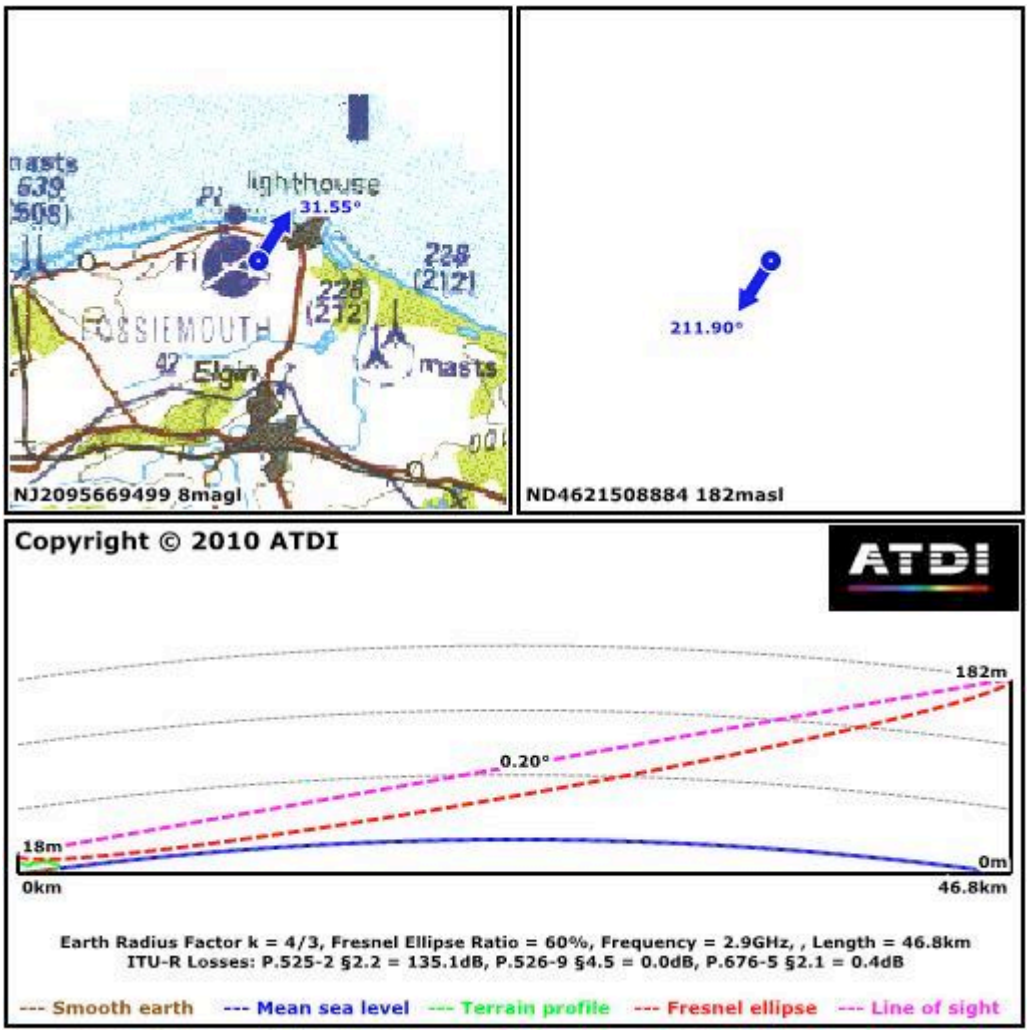

Figure 6: Line of sight from RAF Lossiemouth primary radar to 182m turbine in SW corner of Moray Offshore Phase 1 area

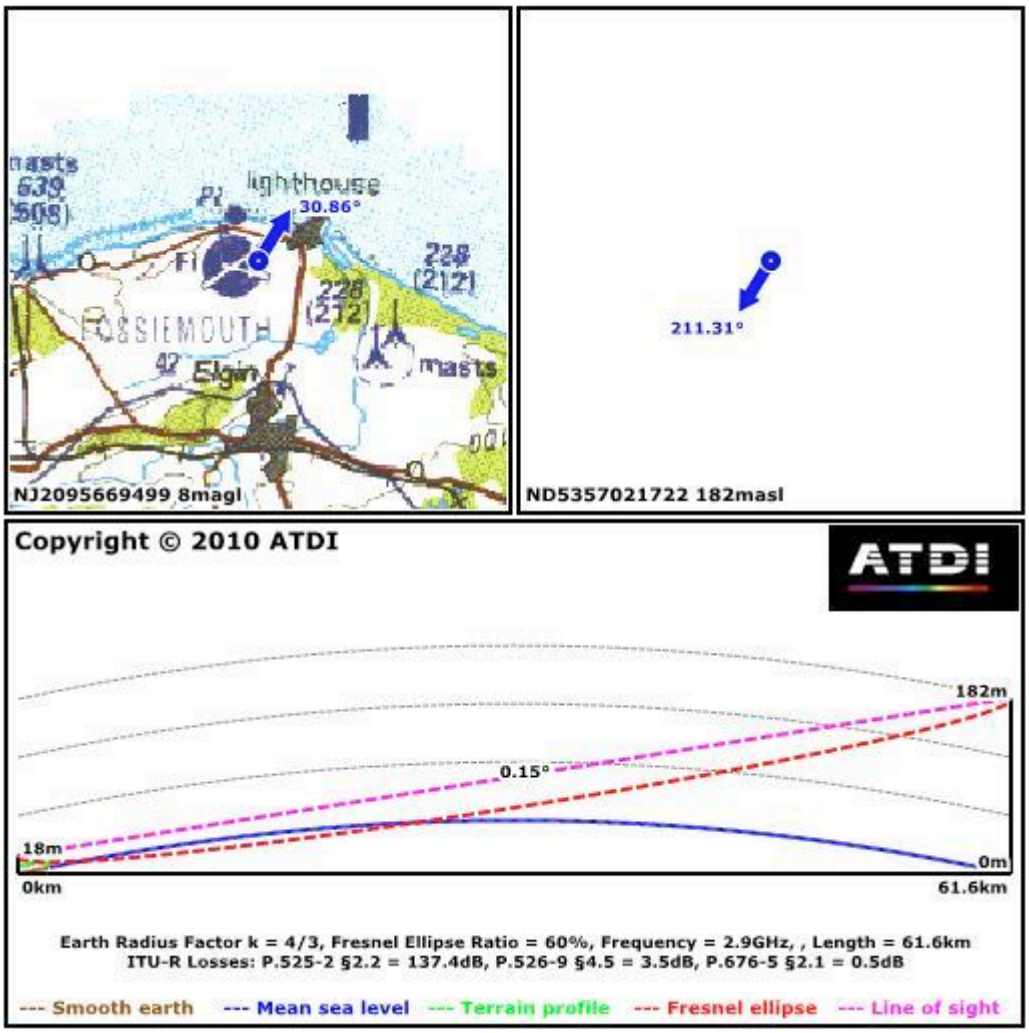

Figure 7: Line of sight from RAF Lossiemouth primary radar to 182m turbine on W boundary of Moray Offshore Phase 1 area

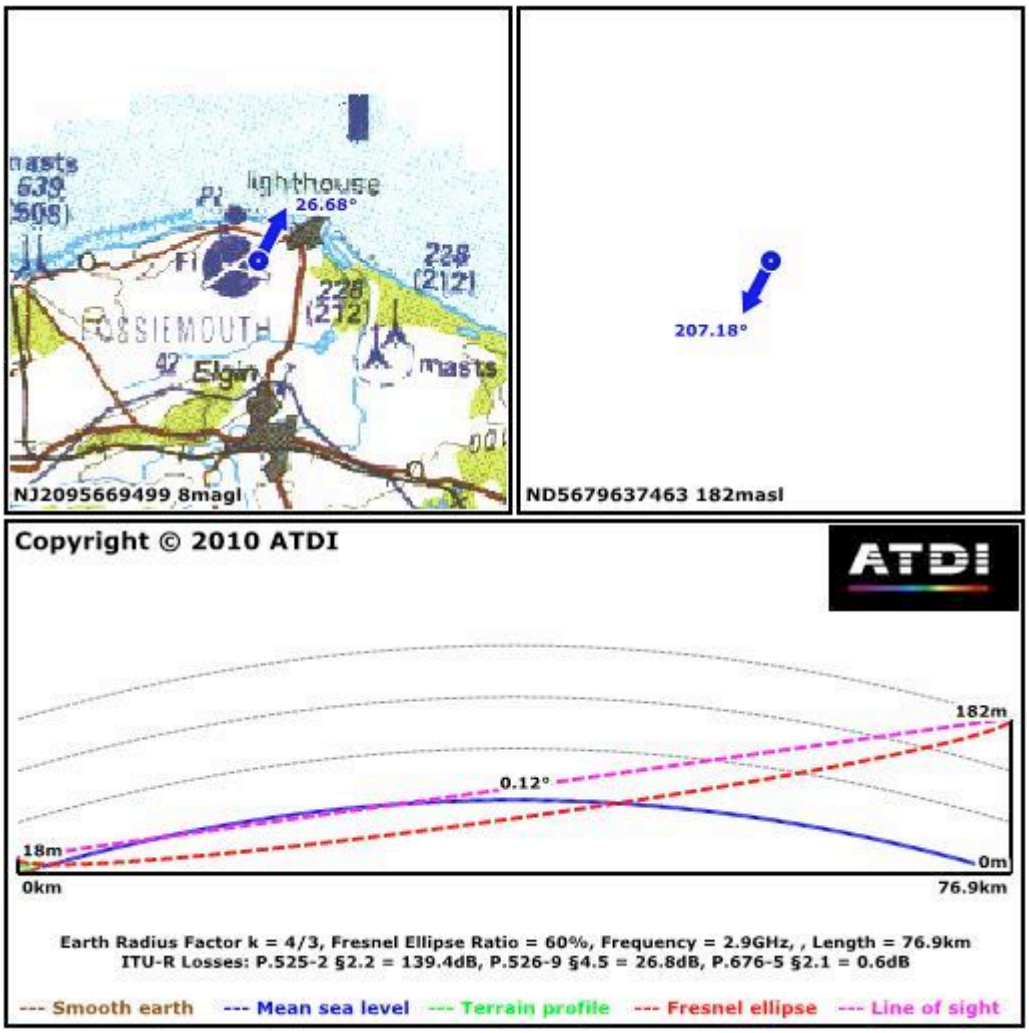

Figure 8: Line of sight from RAF Lossiemouth primary radar to 182m turbine in N corner of Moray Offshore Phase 1 area

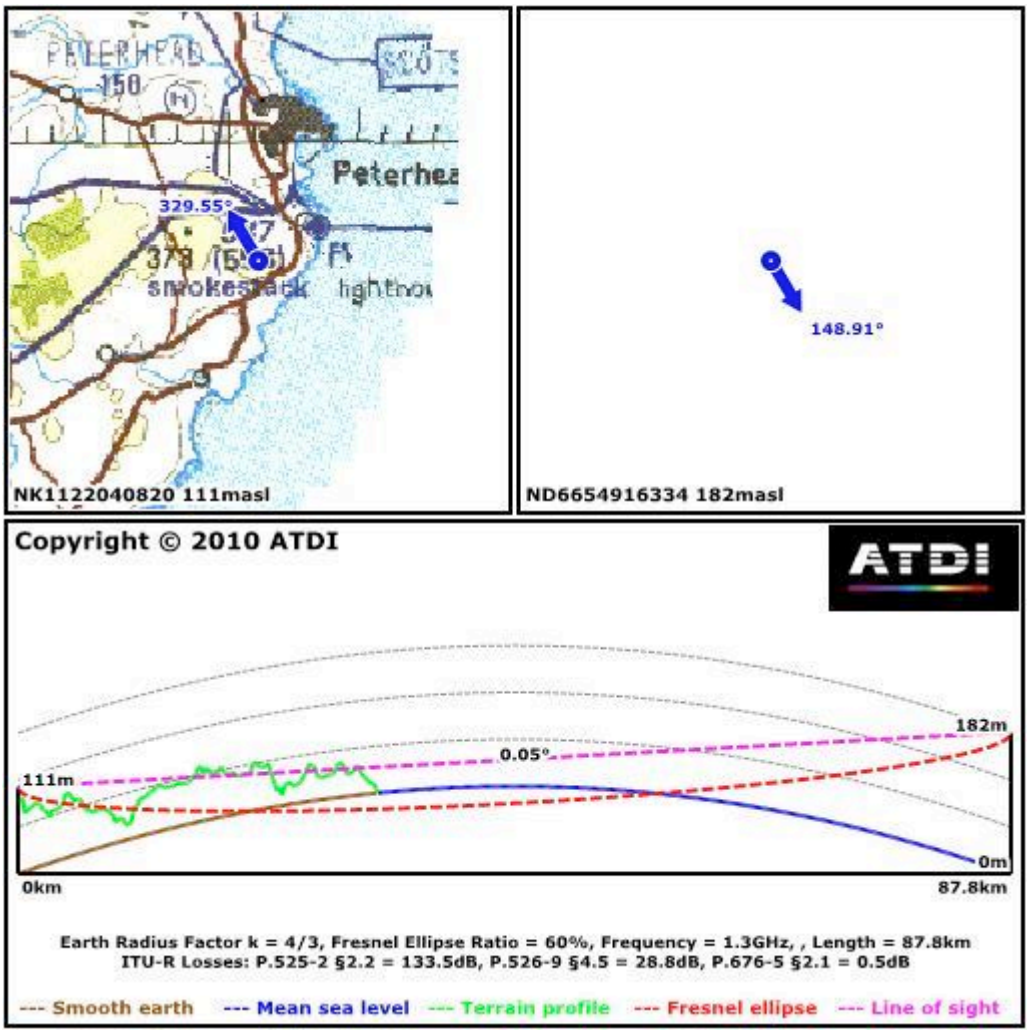

Figure 9: Line of sight from RAF Buchan primary radar to 182m turbine in SE corner of Moray Offshore Phase 1 area

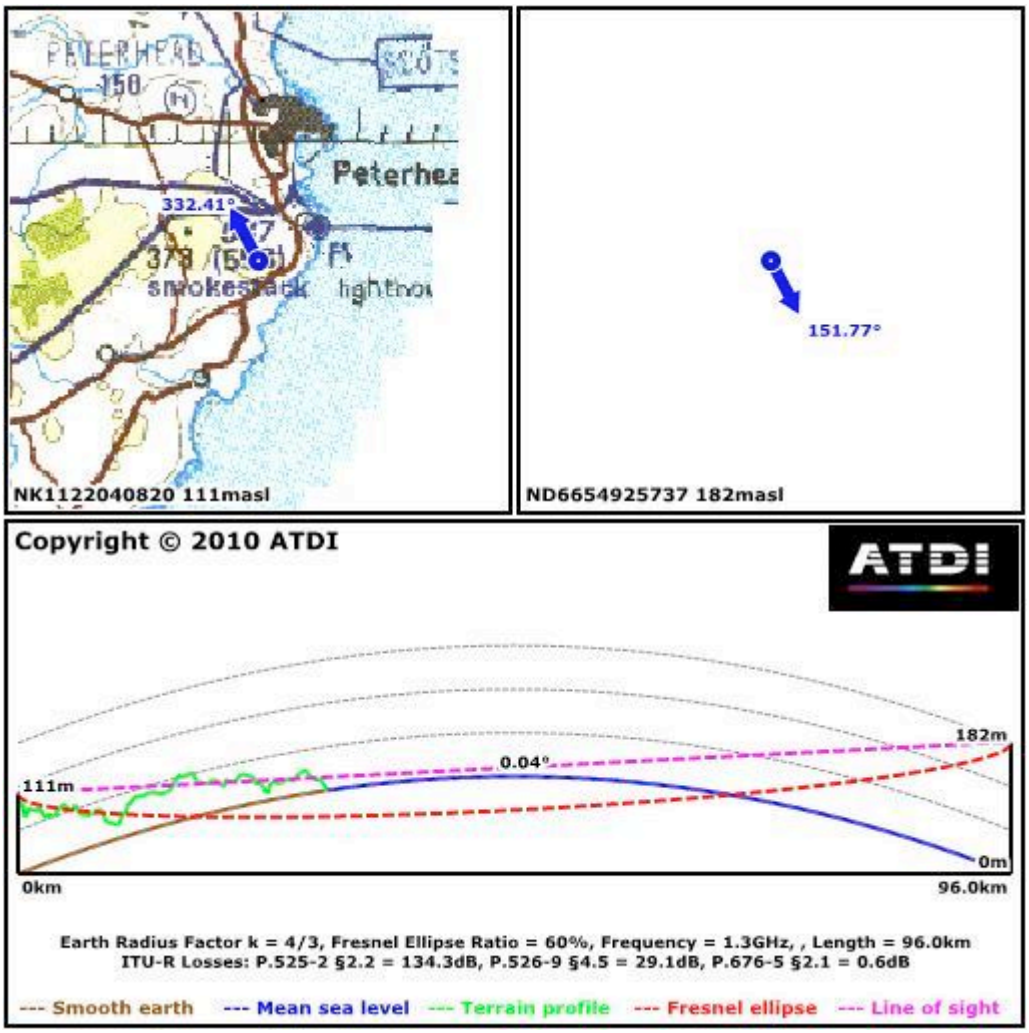

Figure 10: Line of sight from RAF Buchan primary radar to 182m turbine on eastern boundary of Moray Offshore Phase 1 area

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MORAY WEST
OFFSHORE WINDFARM

Helicopter Impact Assessment

Moray Offshore Windfarm (West) Limited

Technical Appendix 13.2

moray offshore renewables ltd

Environmental Statement

Technical Appendix 5.3 B - Helicopter Impact Assessment

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Beatrice and Moray Offshore Wind Farm Developments Helicopter Impact Assessment

APPENDIX 5.3 B

Document information

Document title	Beatrice and Moray Offshore Wind Farm Developments Helicopter Impact Assessment	
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Executive Summary

This document presents the results of an analysis of the combined impact of the Beatrice and Moray offshore wind farm developments upon commercial air transport helicopter operations to and from the Beatrice and Jacky fields in the Moray Firth.

The document considers the separate and cumulative impacts of the developments and compares then to the current situation. The cumulative impact analysis suggests that under a worst case scenario with no mitigations applied the following number of flights would be impacted each year:

	BOWL& MORL cumulative impact	
Destination	**Total flights prevented currently by existing obstructions**	**Additional flights prevented by BOWL & MORL**
Beatrice A	~5 flights p.a.	~3 flights p.a.
Beatrice B	~1 flight in 2 years	~3 flights p.a.
Beatrice C	~1 flight in 2 years	~1 flight in 3 years
Jacky	None	~1 flight p.a.
Total	**6 flights p.a.**	**7-8 flights p.a.**

A set of proposed mitigations are presented that are believed to be sufficient to mitigate the vast majority of impacted flights to each platform.

The individual impacts of each development are as follows:

	BOWL impact	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by BOWL**
Beatrice A	~5 flights p.a.	~1 flight in 5 years
Beatrice B	~1 flight in 2 years	~1 flight in 2 years
Beatrice C	~1 flight in 2 years	None
Jacky	None	~1 flight p.a.
Total	**6 flights p.a.**	**1-2 flights p.a.**

	MORL EDA impact	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by MORL EDA**
Beatrice A	~5 flights p.a.	~3 flights p.a.
Beatrice B	~1 flight in 2 years	~3 flights p.a.
Beatrice C	~1 flight in 2 years	None
Jacky	None	~1 flight p.a.
Total	**6 flights p.a.**	**7 flights p.a.**

	MORL EDA + WDA impact	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by MORL EDA + WDA**
Beatrice A	~5 flights p.a.	~3 flights p.a.
Beatrice B	~1 flight in 2 years	~3 flights p.a.
Beatrice C	~1 flight in 2 years	~1 flight in 3 years
Jacky	None	~1 flight p.a.
Total	**6 flights p.a.**	**7-8 flights p.a.**

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1 Introduction

1.1 General

1.1.1 This report presents a cumulative assessment of the potential impact of the Beatrice and Moray offshore wind farms on helicopter operations to and from oil platforms in the Beatrice and Jacky fields. The report has been commissioned by Beatrice Offshore Windfarm Ltd (BOWL) and Moray Offshore Renewables Ltd (MORL) and has been prepared by Helios and Spaven Consulting.

1.2 The BOWL and MORL developments

1.2.1 The Beatrice offshore wind farm site (BOWL site) is positioned in the Moray Firth on the north-west corner of the Smith Bank within Scottish territorial waters. The development site covers an approximate area of 131.5km² and is located, at its closest point, approximately 13.5km off the Caithness coast. The proposed wind farm would have an anticipated capacity of up to1,000MW generated from up to 277 turbines with a maximum tip height of 198m (650ft) above LAT. The consent application will be submitted in December 2011 with expected determination in late 2012. Construction is expected to commence late 2014 or early 2015 with final commissioning completed by 2018.

1.2.2 The proposed Moray offshore wind farms will consist of up to 339 wind turbines with an expected maximum tip height of up to 204m (669ft) above Lowest Astronomical Tide (LAT), located some 22km off the southern Caithness coast. The development will have a maximum capacity of 1,500MW.

1.2.3 The Moray offshore wind farms (MORL site) are planned to be built in two phases.

- The first phase will occupy the Eastern Development Area (EDA), covering 295km². This will contain up to a maximum of 339 turbines, with final commissioning anticipated by 2018 and construction commencing in 2015. The Eastern Development Area is further split into three sectors, designated Telford, Stevenson and MacColl. Consent applications will be made in mid-2012 with a consent determination anticipated early 2013

- The second phase will occupy the Western Development Area (WDA), covering 225km². The WDA is expected to contain up to 100 turbines with construction anticipated to commence in 2018 and final commissioning completed by 2020. Consent applications will be made in mid-2015 with a consent determination anticipated early 2016.

1.3 The Beatrice Oil Field

1.3.1 The Beatrice field consists of three platforms, two of which are unmanned. In addition the adjacent Jacky field also has an unmanned installation connected by pipeline to Beatrice with the potential for a jack-up platform to be located temporarily whilst work is undertaken on the well-head:

- Beatrice Alpha is a manned production platform. It typically accommodates 70-80 staff, although in recent years this has peaked at 100+. It has a helideck height of 201ft and is cleared for helicopters of a size up to the EC225. It is currently served by Bond Helicopters typically with two to three flights a week.

- Beatrice Bravo is an unmanned production platform. It has a helideck height of 184ft and can accommodate most aircraft types up to a weight limit of 9.3t.

Operations are limited to wind speeds below 15kts. It is currently served by Bond Helicopters when required with no scheduled flights.

- Beatrice Charlie is an unmanned water pumping platform. It has helideck height of 87ft and a smaller deck and can accommodate aircraft up to an AW139, although there are legacy rights for Bristows to use an AS332. Operations are restricted to daylight hours and when the wind is of less than 15kts. Beatrice C is no longer in active use as a pumping platform. All equipment is retained, but isolated with the exception of a generator to power navigation aids, a fire detection system and a telemetry link to Beatrice A.

- Jacky is an unmanned platform without a certified helideck although there is a deck with a height of approximately 115ft that could be accessed by winching. Jacky is typically visited monthly by boat from Beatrice Alpha and facilities on-board are such to accommodate a six person crew with the possibility of an overnight stay. It is anticipated that there may be a need for at least one well work-over during the life of Jacky. This would necessitate the temporary installation of a jack-up rig.

1.3.2 The Beatrice oil platforms, and Jacky, are located close to the northern boundary of the MORL WDA and to the south-west boundary of the BOWL site as shown in Figure 1-1 below.

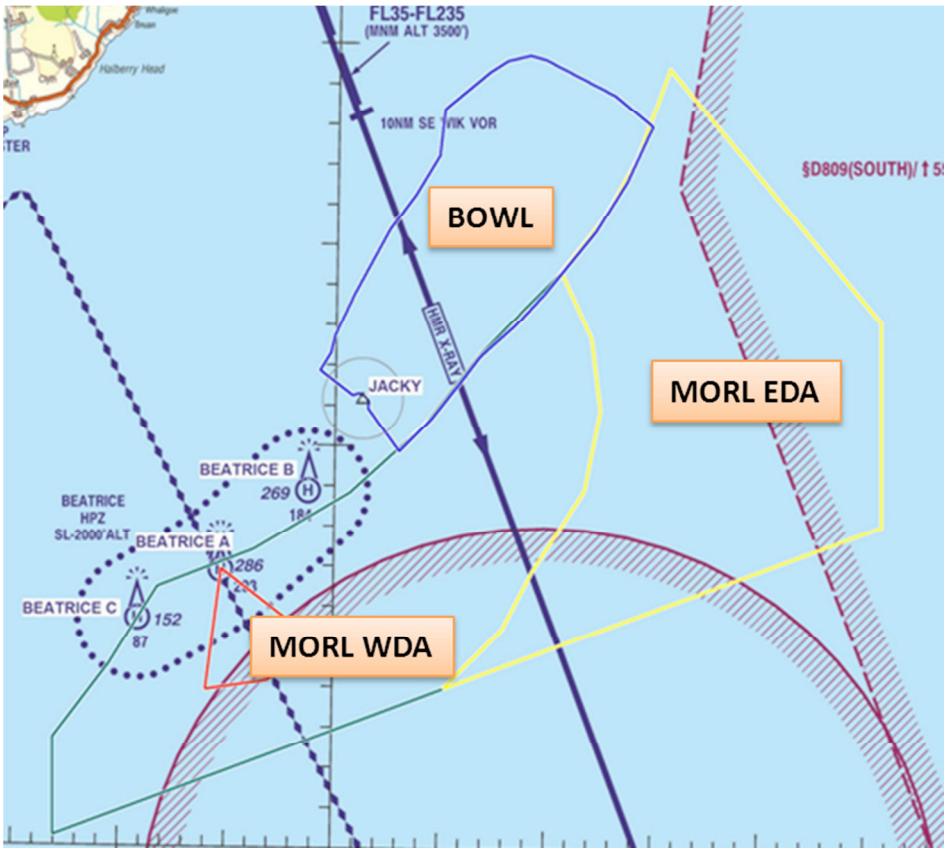

Figure 1-1: Overview of BOWL & MORL developments

1.4 Methodology

1.4.1 This report is concerned with the impact of the BOWL and MORL developments on helicopter access to the Beatrice and Jacky platforms. As such it is primarily concerned with the availability of instrument approach procedures – the GPS

assisted Airborne Radar Approach (ARA). A copy of the Bond Offshore Helicopters ARA procedure chart is attached at Annex C. In Instrument Meteorological Conditions (IMC) conditions, when the wind is blowing from certain directions, a standard ARA procedure will not be able to be flown due to the proximity of wind turbines to the approach track. To analyse the impact the following steps have been undertaken:

- The ARA approach headings restricted by the BOWL and MORL wind farms, the existing demonstrator turbines and the oil platforms themselves have been identified. This has involved the following assumptions:
  - No approaches will be made over the turbines, even during the initial part of the procedure that is flown at MSA.
  - No wind turbines or platforms are allowed within 1nm either side of the approach track.
- Wind, visibility and cloud base data from Wick and Lossiemouth airfields has been analysed so that the number of ARA approaches that would be flown within each restricted sector can be identified. This has included the following assumptions:
  - There is no change to the current visibility or cloud base requirements that define IMC operations in the field (<1,000ft cloud base or < 5km visibility).
  - There is no change to the GPS ARA minima (300ft cloud base and 1.5nm visibility).
- The current flight schedule to each platform has been combined with the results of the Met analysis to arrive at a number of flights per annum impacted by:
  - Existing obstacles (platforms and the Demonstrator Turbines)
  - The BOWL development alone
  - The MORL EDA and WDA
  - The BOWL, MORL EDA and WDA
- Subsequently, the possible mitigations to alleviate the impacts are considered.

1.4.2 This report documents the results of this analysis.

1.4.3 In addition to the impact of the BOWL and MORL developments on ARAs to the Beatrice field platforms, this report considers the potential impacts of the developments on obstacle clearance in the missed approach phase of ARAs, and for helicopter departures from the Beatrice field platforms.

1.5 Meteorological data analysis

1.5.1 In order to understand the impact of specific constraints on helicopter operations it is necessary to examine the likelihood of particular weather conditions in the Beatrice Field. Ideally full wind, cloud base and visibility data from in-field would be available to support such analysis. However, Met data from the Beatrice Alpha is only retained by the operator for one month, data from the operators was limited and only available for the time of scheduled flights and the UK Met Office only had sporadic marine weather observations to offer.

1.5.2 As a result of the lack of in-field data, data from the nearest airfield locations were used instead. Two years' worth of hourly METARS from Wick Airport and three years' worth of hourly METARS from RAF Lossiemouth that were available to the project teams were processed to provide statistics on wind direction, wind speed, cloud base and visibility. The data highlights that winds in the field are predominantly from the south-west with strong winds possible from any direction but significantly less likely from the north-east. Around 1% of the time there are no significant winds (<5 kts), see Figure 1-2 and Figure 1-3 below.

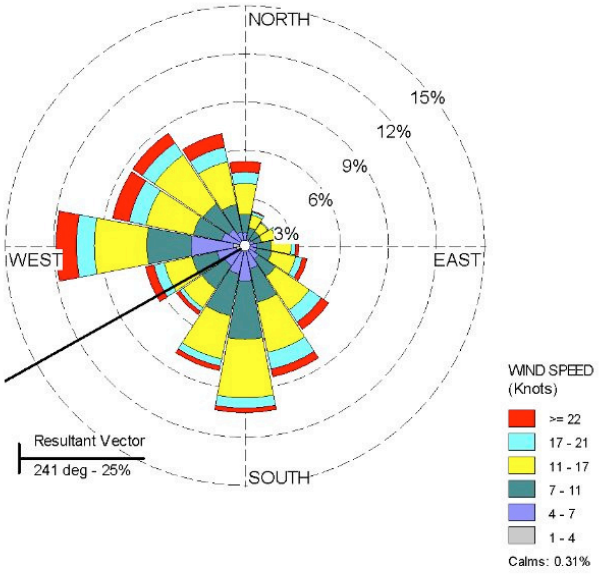

Figure 1-2: Wind rose for Wick Airport (2 years of data)

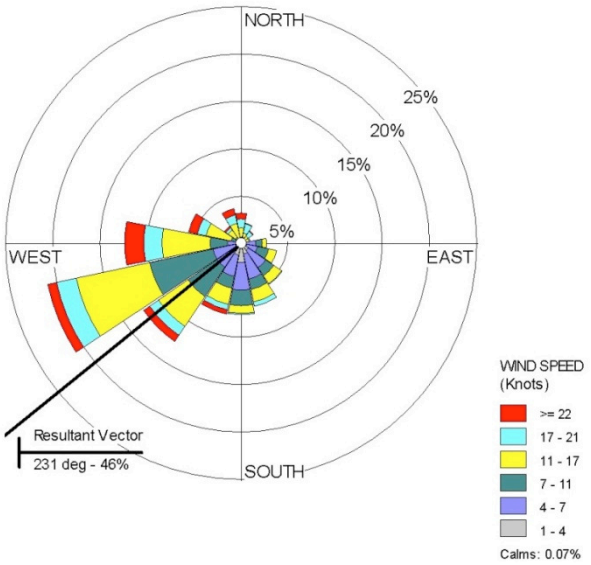

Figure 1-3: Wind rose for RAF Lossiemouth (3 years of data)

1.5.3 Both sets of cloud base and visibility data were also compared to ensure that they provided similar results giving confidence that they could be generalised to represent conditions at the platforms. On the basis of current ARA minima more

than 1% of flights would already be impacted by low cloud, poor visibility or a combination thereof. Figure 1-4 and Figure 1-5 below show the incidence of VMC conditions in the field and the data for Lossiemouth, whilst consistent with Wick does show a markedly higher incidence of good weather. Therefore, the more conservative data set from Wick (providing a higher impact) was used for the full impact analysis of the combined situation. The data is expected to be representative of the conditions in-field.

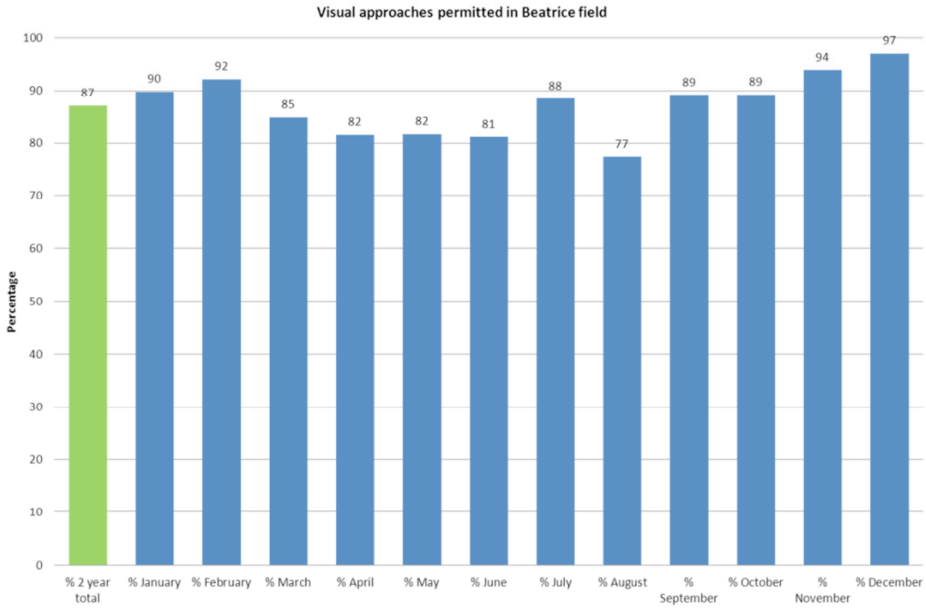

Figure 1-4: Estimated incidence of visual conditions in Beatrice field (Wick data)

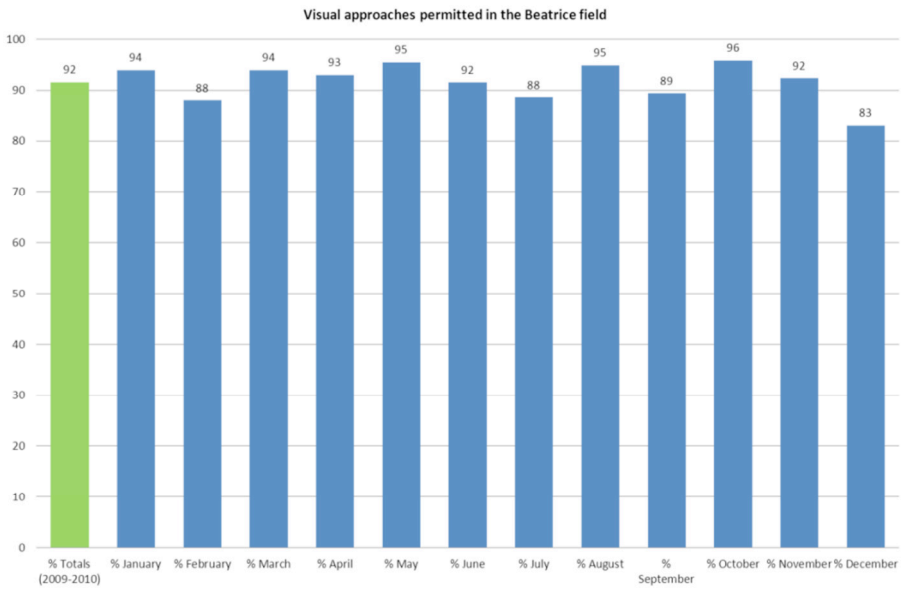

Figure 1-5: Estimated incidence of visual conditions in Beatrice field (Lossiemouth data)

1.5.4 With the current criteria that dictate whether instrument or visual approaches are required (>5km visibility and cloud base (coverage of 3 oktas or more) > 1,000ft) the weather data from Wick suggests that on average 87% of approaches

undertaken will be in visual conditions or conversely slightly more than 10% of approaches will require an ARA. The data from Lossiemouth suggests that on average 92% of approaches undertaken will be in visual conditions. Consequently something less than 10% of flights would require an ARA.

1.6 Structure of this report

1.6.1 This report is structured as follows:

- Section 2 presents an overview of the current situation in the Beatrice and Jacky fields, outlines current operating restrictions and demonstrates the impact of these restrictions on helicopter operations.
- Section 3 presents an overview of the situation when the BOWL development is constructed, outlines the expected operating restrictions and demonstrates the impact of these restrictions on helicopter operations.
- Section 4 presents an overview of the situation when the MORL EDA is constructed, outlines the expected operating restrictions and demonstrates the impact of these restrictions individually and cumulatively on helicopter operations.
- Section 5 presents an overview of the situation when the MORL WDA is constructed, outlines the expected operating restrictions and demonstrates the impact of these restrictions individually and cumulatively on helicopter operations.
- Section 6 presents an overview of the situation when the BOWL and MORL developments are constructed, outlines the expected operating restrictions and demonstrates the impact of these restrictions on helicopter operations.
- Section 7 discusses the proposed mitigations to alleviate the cumulative impact of the BOWL and MORL developments.

1.6.2 The report is also supported by specific annexes:

- Annex A provides a glossary of the terms, abbreviations and acronyms used within this report.
- Annex B provides a calculation of the distances involved in an ARA procedure in the future environment.
- Annex C provides an overview of the existing GPS ARA procedure.

2 Baseline situation

2.1 Overview

2.1.1 Helicopter operations in the Beatrice field are already limited due to the presence of the Demonstrator Turbines near to the Alpha platform and due to the alignment of the platforms themselves. This leads to:

- a range of approach headings where the crew would either undertake an ARA to an adjacent platform and fly a visual transit ("shuttle") to the destination or where they would have to undertake an out-of-wind ARA and circle to land;
- a 60 degree restricted sector out to 3nm from Beatrice Alpha, due to the Demonstrator Turbines, within which night and instrument flight is not permitted; and
- a higher decision height and visibility requirement for both ARA (300ft + 1.5nm) and circling approaches (500ft + 3nm).[1]

2.1.2 There is also a military danger area, D807, to the south of the platforms that when promulgated active (7am through 12 midnight Monday to Friday) and in actual use, prevents flight operations below 1,500ft. The danger area is understood to receive little current use and typically the helicopter operators will call RAF Lossiemouth departures for permission to operate through the danger area.

2.1.3 The result of these restrictions is that a number of approaches to the Beatrice field will already be precluded. This forms the baseline against which additional impacts due to BOWL and MORL will be assessed. In order to understand the impact on flights it is necessary to consider a particular flying schedule for each platform. The following has been assumed:

- Beatrice Alpha – 3 flights per week (all year) – 156 per annum
- Beatrice Bravo – 3 visits per month requiring 2 flights per visit – 72 per annum
- Beatrice Charlie – 3 visits every 3 months requiring 2 flights per visit – 16 per annum
- Jacky – 2 flights per week for an 8 week period – 16 per annum

2.1.4 The calculation of the sectors where ARAs are restricted by existing obstacles is based on the following assumptions:

- No ARAs are flown from any sector where there are turbines within 9nm of the destination platform. This is derived from calculations of the required descent profile (see Annex B), and is in line with new CAA guidance (CAP 764, July 2011).
- All obstacles in the Final Approach phase of the ARA must be avoided laterally by a minimum of 1nm.

2.1.5 In addition, obstacles must be avoided laterally by 1nm in the missed approach phase of an ARA, until the helicopter has climbed to the MSA. The standard missed approach in an ARA procedure involves a climbing turn from the missed

[1] The minima at platforms that are not constrained by other obstacles are 200ft and 0.75nm for a straight-in ARA in daylight and 300ft and 1nm for a circling ARA in daylight.

approach point. In the case of ARAs in the Beatrice field, where the missed approach point is at 1.5nm from the platform, it can be expected that the missed approach turn will be through up to 45° of heading change.

2.1.6 Existing obstructions and the future BOWL and MORL developments will place constraints on ARAs from certain directions because of this additional requirement for an obstacle-free corridor in which to conduct the missed approach. These constraints will typically take the form of the missed approach turn having to be flown in one direction only. Consideration of the impact on missed approaches must also consider the One Engine Inoperative (OEI - engine failure) situation. In such a situation the climb performance of the aircraft can be greatly degraded. The worst case needing protection is when the engine fails at the missed approach point with obstacles in the area ahead. In the case of the Beatrice field, an engine failure at the missed approach point would occur at 300ft or higher and with the aircraft already at or above a safe speed for OEI manoeuvring. The direction of the missed approach turn will have been agreed between the pilots prior to the approach so that it will be flown away from any obstacles. Under some circumstances crews will have to accept that missed approach turns can only be flown to one side of the approach track.

2.1.7 Obstacles will also affect helicopter departures from the Beatrice platforms. Departures may be conducted in weather conditions in which the helicopter enters IMC soon after take-off. In addition, the worst case of an engine failure immediately after take-off has to be considered. This requires that, following the initial descent to attain take-off safety speed, the aircraft climbs straight ahead with a headwind component, and any necessary turn away from obstacles is not initiated until the helicopter attains its best rate of climb speed (Vy) of 80 kts and has reached a height of 500ft. On the basis of calculations undertaken by Bond Helicopters (for a hot day with low pressure) this will require a 9.3km departure corridor from the helideck to be clear of obstacle (including a 1.5km safety buffer between the obstacle and the flight path).

2.1.8 The impacts on operations to each platform are documented below. It should be noted that at this point these impacts take no consideration of potential mitigations.

2.2 Beatrice Alpha

2.2.1 Approaches to the Beatrice Alpha are currently restricted from the south-west due to the Charlie platform, from the north-east due to the Bravo platform and due to the Demonstrator Turbines to the south and south east. When these restricted sectors prevent a direct into-wind approach, flight crew will have to choose to:

- Fly an ARA to Alpha with a cross wind component;
- Make a circling approach to Alpha[2] and accept the higher circling minima,
- Approach to another platform and shuttle to Alpha, accepting shuttling minima.

2.2.2 The current ARA restrictions for the Beatrice A are shown in Table 2-1 and Figure 2-1 below.

---

[2] A circling approach is defined as one which is carried out with a difference of more than 30° between the final approach track and the wind direction.

Destination platform	Restricted approach sector (°T)	Nature of restriction and possible mitigations	Minima
Beatrice A	035-083	Charlie platform within 1nm of approach path. Approach to Charlie and shuttle to Alpha, fly an out-of-wind ARA or fly a circling approach.	1.5NM. 300ft. (Day shuttling) 2.4NM. 500ft (Night shuttling) 3.0NM. 500ft (Circling) 1.5NM. 300ft (oow ARA)
	206-247	Bravo (and Jacky) platform in approach path. Approach to Jacky/Bravo and shuttle to Alpha, fly an out-of-wind ARA or fly a circling approach.	1.5NM. 300ft. (Day shuttling) 2.7NM. 500ft (Night shuttling) 3.0NM. 500ft (Circling) 1.5NM. 300ft (oow ARA)
	306-006	Existing no go sector due to Demonstrator Turbines.	1.5NM. 300ft. (Day shuttling) 2.4NM. 500ft (Night shuttling) 3.0NM. 500ft (Circling) 1.5NM. 300ft (oow ARA)

Table 2-1: Current restricted approach sectors for Beatrice Alpha

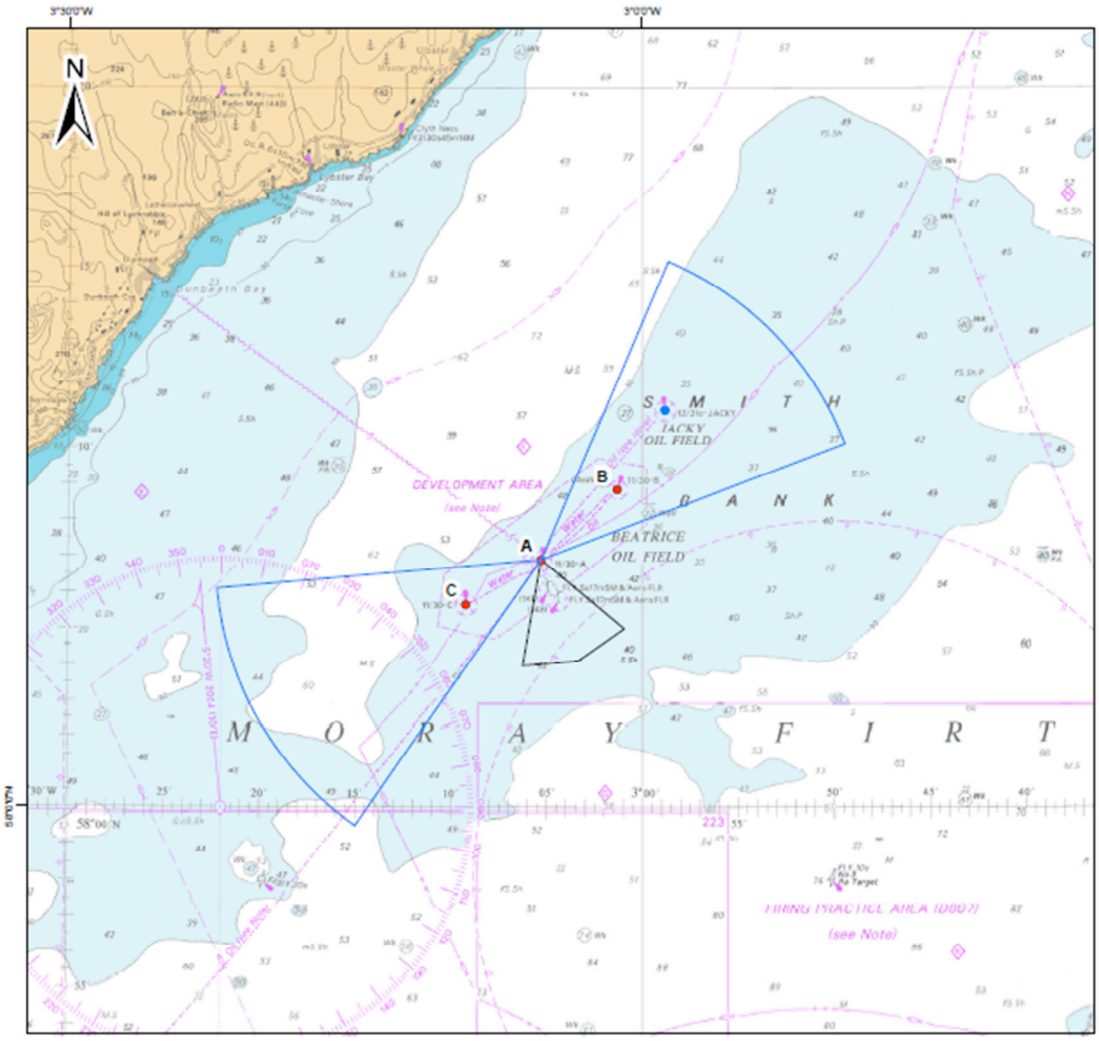

Figure 2-1: Current restricted approach sectors for Beatrice Alpha

2.2.3 Missed approaches from ARAs to the Beatrice Alpha are also currently constrained by existing obstacles, most notably the Demonstrator Turbines restricted zone. Table 2-2 summarises the current constraints on missed approaches at the Beatrice Alpha. It can be seen that these consist primarily of restricting the available missed approach directions to one.

ARA final approach track (°T)	007-034	035-083	084-090	091-121	122-133	134-190	191-205	206-247	248-305	306-006
Missed approach turn direction available	Left only (R prevented by Demo Tbns sector)	ARA not possible due Beatrice C within 1nm of FAT	Left only (R prevented by Demo Tbns sector)	Left only (R prevented by Demo Tbns sector)	Right (with turn required to avoid B) or Left	Left only (R prevented by Beatrice C)	Right only (L prevented by Demo Tbns sector)	ARA not possible due Beatrice B within 1nm of FAT	Right only (L prevented by Demo Tbns sector)	ARA not possible due Demo Turbines restricted zone
Constraints on straight climb-out after 45° initial turn	None		None (Jacky at 5nm+)	Beatrice B	To right: Beatrice B; None to left	None	None		None	

Table 2-2: Beatrice A ARA missed approach constraints (current)

2.2.4 Departures from the Beatrice Alpha, taking account of the OEI climb criteria set out in 2.1.7, are currently restricted to the west due to the Beatrice C, to the south and south east by the Demonstrator Turbines and to the north east by the Beatrice B. In addition, when danger area D807 is active, take-offs on south-easterly and easterly headings will not be possible since the boundary of the danger area is some 4km from the platform.

2.3 Beatrice Bravo

2.3.1 Approaches to the Beatrice Bravo are currently restricted from the south-west due to the Alpha platform, from the north-east due to the Jacky platform and due to the Demonstrator Turbines to the south west. When these restricted sectors prevent a direct into-wind approach, flight crew will have to choose to:

- Fly an ARA to Bravo with a cross wind component;
- Make a circling approach to Bravo and accept the higher circling minima,
- Approach to another platform and shuttle to Bravo, accepting shuttling minima.

2.3.2 The current ARA restrictions for the Beatrice B are shown in Table 2-3 and Figure 2-2 below.

Destination platform	Restricted approaches	Nature of restriction	Minima
Beatrice B	048-067 (023-067)	Alpha (and Charlie) platform within 1nm of the approach path. Approach to Alpha/Charlie and shuttle to Bravo, fly an out-of-wind ARA or fly a circling approach.	1.5NM. 300ft. (Day shuttling) 2.7NM. 500ft (Night shuttling) 3.0NM. 500ft (Circling) 1.5NM. 300ft (oow ARA)
	188-231	Jacky platform within 1nm of the approach path. Approach Jacky and shuttle to Bravo, fly an out-of-wind ARA or fly a circling approach.	1.5NM. 300ft. (Day shuttling) 2.5NM. 500ft (Night shuttling) 3.0NM. 500ft (Circling) 1.5NM. 300ft (oow ARA)
	355-047	Demonstrator Turbines no-go sector in the approach path.	1.5NM. 300ft. (Day shuttling) 2.5NM. 500ft (Night shuttling) 3.0NM. 500ft (Circling) 1.5NM. 300ft (oow ARA)

Table 2-3: Current restricted approach sectors for Beatrice Bravo

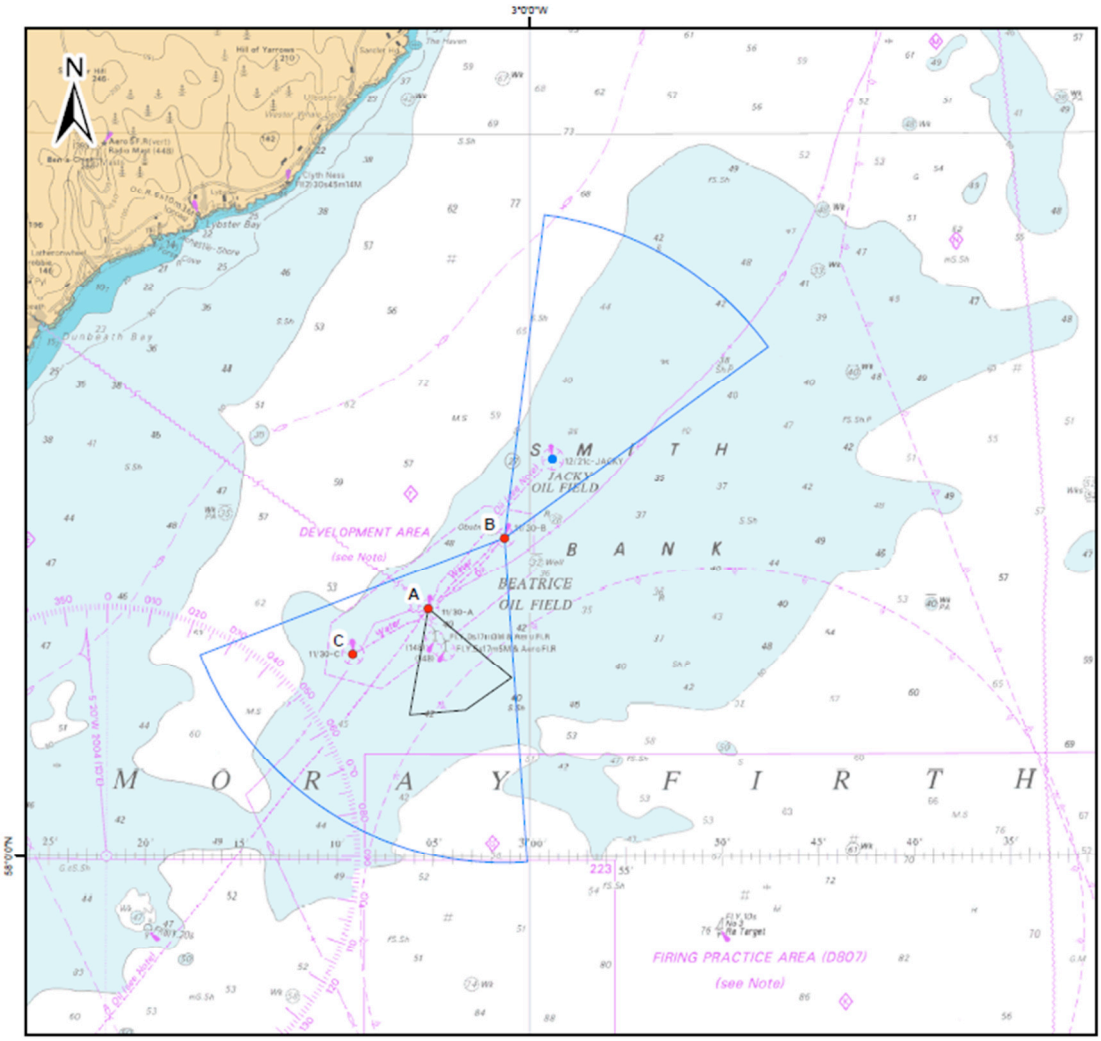

Figure 2-2: Current restricted approach sectors for Beatrice Bravo

2.3.3 Missed approaches from ARAs to the Beatrice Bravo are also currently constrained by existing obstacles, most notably ARAs on north-westerly headings, where a left turn is prevented by the Demonstrator Turbines restricted zone, and on southerly headings, where a right turn is constrained by the Beatrice A and the Demonstrator Turbines restricted zone.

2.3.4 Departures from the Beatrice Bravo, taking account of the OEI climb criteria set out in 2.1.7, are currently restricted in the sector from south-east to south-west due to D807, the Demonstrator Turbines and the Beatrice A, and to the north east by the Jacky.

2.4 Beatrice Charlie

2.4.1 Approaches to the Beatrice Charlie are currently restricted from the north-east due to the Alpha platform and from the east due to the Demonstrator Turbines. When these restricted sectors prevent a direct into-wind approach, flight crew will have to choose to:

- Fly an ARA to Charlie with a cross wind component;
- Make a circling approach to Charlie and accept the higher circling minima,

- Approach to another platform and shuttle to Charlie, accepting shuttling minima.

2.4.2 The current ARA restrictions at the Beatrice C are shown in Table 2-4 and Figure 2-3 below.

Destination platform	Restricted approaches	Nature of restriction	Minima
Beatrice C	239-315	Demonstrator Turbines no-go sector in the approach path.	1.5NM. 300ft. (Day shuttling) 2.7NM. 500ft (Night shuttling) 3.0NM. 500ft (Circling) 1.5NM. 300ft (oow ARA)
	214-238	Alpha (and Bravo/Jacky) platform within 1nm of the approach path. Approach to Alpha/Bravo/Jacky and shuttle to Charlie, fly an out-of-wind ARA or fly a circling approach.	1.5NM. 300ft. (Day shuttling) 2.7NM. 500ft (Night shuttling) 3.0NM. 500ft (Circling) 1.5NM. 300ft (oow ARA)

Table 2-4: Current restricted approach sectors for Beatrice Charlie

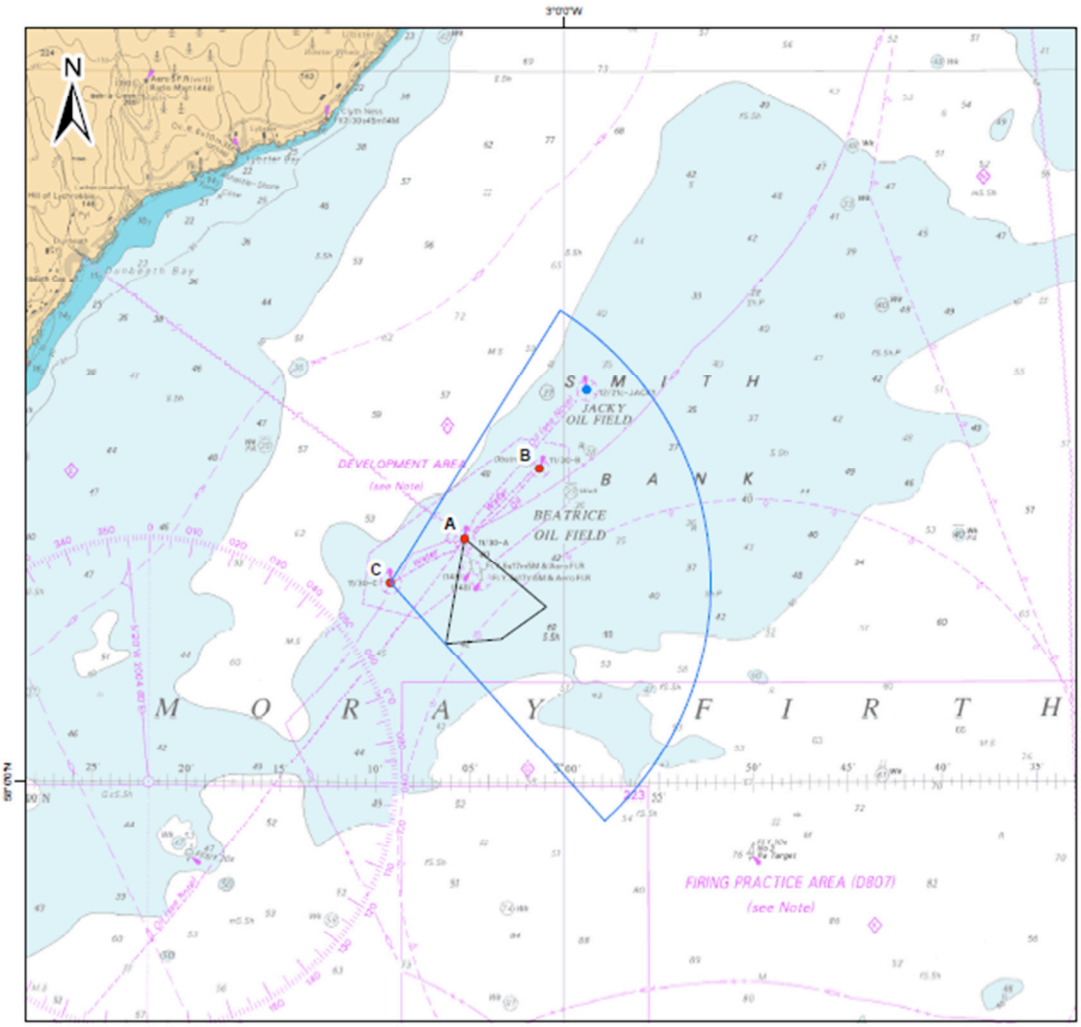

Figure 2-3: Current restricted approach sectors for Beatrice Charlie

2.4.3 Missed approaches from ARAs to the Beatrice Charlie are currently constrained by existing obstacles, most notably ARAs on headings between north and east, where a right turn is prevented by the Demonstrator Turbines restricted zone and the Beatrice A, and on headings between south and east, where a left turn is similarly constrained.

2.4.4 Departures from the Beatrice Charlie, taking account of the OEI climb criteria set out in 2.1.7, are currently restricted on all easterly departure headings by the Demonstrator Turbines and the Beatrice A, and to some extent on south-south easterly departure headings by D807 (when it is active).

2.5 Jacky

2.5.1 Approaches to a jack-up rig positioned at the Jacky platform are currently restricted from the south-west due to the Bravo platform. When this restricted sector prevents a direct into-wind approach, flight crew will have to choose to:

- Fly an ARA to Jacky with a cross wind component;
- Make a circling approach to Jacky and accept the higher circling minima,
- Approach to another platform and shuttle to Jacky, accepting shuttling minima.

2.5.2 The current ARA restrictions at the Jacky are shown in Table 2-5 and Figure 2-4 below.

Destination platform	Restricted approaches	Nature of restriction	Minima
Jacky	009-052	Bravo (and Alpha/Charlie) platform within 1nm of approach path. Approach to Bravo/Alpha/Charlie and shuttle to Jacky, fly an out-of-wind ARA or fly a circling approach.	1.5NM. 300ft. (Day shuttling) 2.7NM. 500ft (Night shuttling) 3.0NM. 500ft (Circling) 1.5NM. 300ft (oow ARA)

Table 2-5: Current restricted approach sectors for Jacky

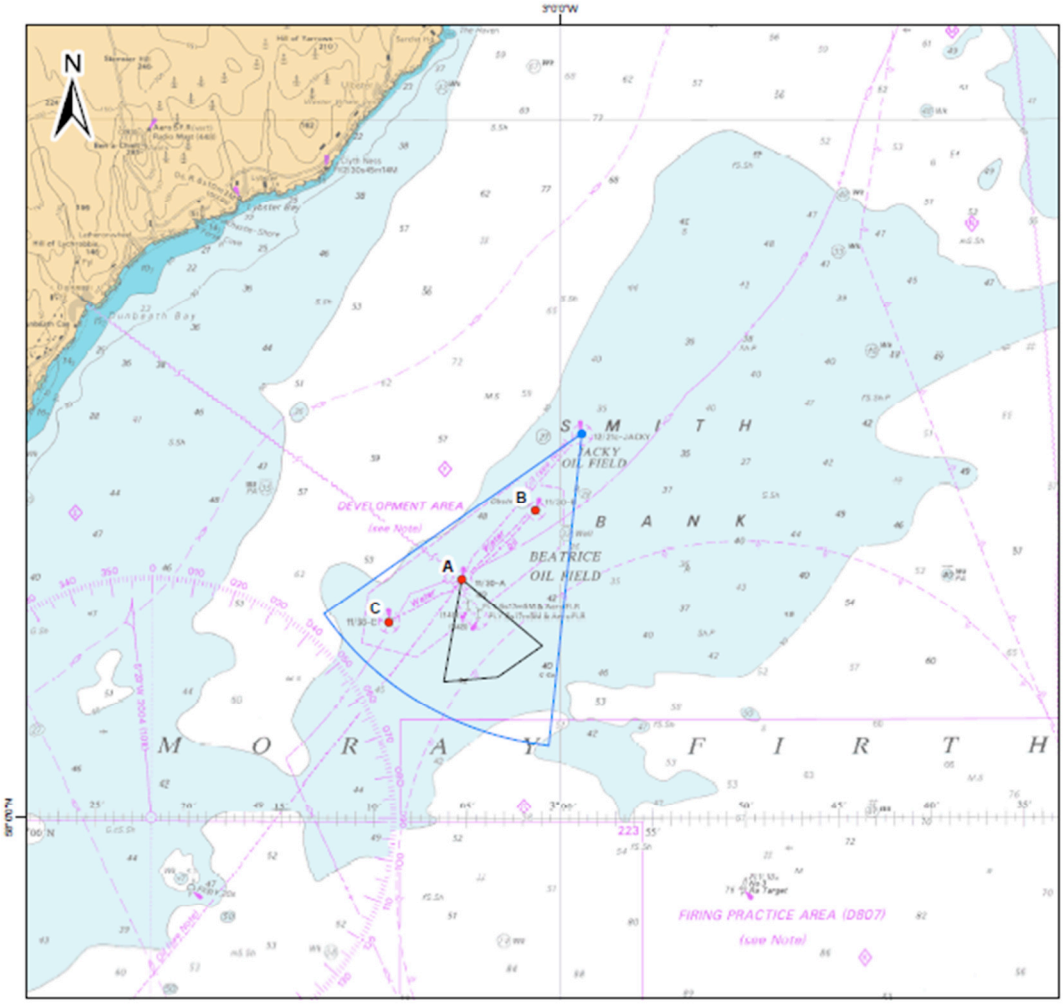

Figure 2-4: Current restricted approach sectors for Jacky

2.5.3 Missed approaches from ARAs to the Jacky are currently constrained by existing obstacles, most notably ARAs on westerly headings, where a left turn is prevented by the Beatrice B, and on southerly headings, where a right turn is similarly constrained.

2.5.4 Departures from the Jacky, taking account of the OEI climb criteria set out in 2.1.6, are currently restricted to the south west by the Beatrice B. There may also be some restrictions on southerly departure headings when D807 is active.

2.6 Impact on operations of the baseline

2.6.1 To assess the impact of current constraints upon the helicopter approaches to the Beatrice field it is necessary to bring together the restrictions outlined above, the weather conditions in-field and a representative flight schedule.

2.6.2 The meteorological data were analysed on the basis that:

- ARAs are required to be flown whenever the cloud ceiling is less than 1,000ft and/or the visibility is less than 5km;
- cloud ceiling is defined as any cloud amount of three oktas or more; cloud amounts of one or two oktas are considered to permit a visual approach; and

- any instance of a wind direction which would require an ARA in a restricted sector, but where the wind speed is less than five knots, is discounted, since in those low wind speeds the crew can fly an out-of-wind approach.

2.6.3 The current operators and owners of the Beatrice (and Jacky) platforms, Ithaca Energy and Wood Group have provided an indicative flight schedules to each of the platforms, see 2.1.3 above:

2.6.4 The impact on the basis of Wick weather data is therefore expected to be as outlined in Table 2-6 below.

	Baseline situation (Wick Data)		
Destination	**Flights prevented by other platforms**	**Flights prevented by Demonstrator Turbines**	**Total flights prevented by existing obstructions**
Beatrice A	0.6% (~1 flights p.a.)	2.6% (~4 flights p.a.)	3.2% (~5 flights p.a.)
Beatrice B	0.6% (~1 flight in 2 years)	0.2% (negligible)	0.7% (~1 flight in 2 years)
Beatrice C	0.2% (negligible)	2.9% (~1 flight in 2 years)	3.1% (~1 flight in 2 years)
Jacky	0.1% (negligible)	N/A	0.1% (negligible)

Table 2-6: Summary of baseline scenario impact (Wick data)

2.6.5 Where it is indicated that approaches would be prevented that does not in itself mean that a flight will not take place. In practice, given forecast weather conditions the helicopter operators may choose to postpone the flight to later in the day, or even reschedule for the following day. However, if these options were not available, the Wick meteorological data analysed for this report indicate that current obstacle constraints around the Beatrice field prevent approximately six flights to the Beatrice field per annum.

2.6.6 It should be emphasised that the figures quoted above assume that no mitigation measures are applied, e.g. no ARA is ever flown other than directly into wind.

2.6.7 It should also be emphasised that the analysis above assumes that all flights to all of the platforms are flown direct from Aberdeen. However in practice a high proportion of the flights to the B, C and Jacky platforms are local flights from the A platform, most if not all of which will be flown in visual conditions.

2.6.8 For comparison, the equivalent figures for flights prevented, using the Lossiemouth meteorological data, are shown in Table 2-7 below.

	Baseline situation (Lossiemouth Data)		
Destination	**Flights prevented by other platforms**	**Flights prevented by Demonstrator Turbines**	**Total flights prevented by existing obstructions**
Beatrice A	1.2% (~2 flights p.a.)	0.6% (~1 flight p.a.)	1.8% (~3 flights p.a.)
Beatrice B	0.4% (~1 flight in 3 years)	0.8% (~1 flight in 2 years)	1.3% (~1 flight p.a.)
Beatrice C	0.1% (negligible)	0.9% (~1 flight in 10 years)	1.0% (~1 flight in 5 years)
Jacky	0.8% (~1 flight in 10 years)	N/A	0.8% (~1 flight in 10 years)

Table 2-7: Summary of baseline scenario impact (Lossiemouth data)

2.6.9 The Lossiemouth meteorological data summarised above indicate that current obstacle constraints prevent approximately four flights to the Beatrice field per annum.

2.6.10 Conclusions drawn from the analysis in this report are based on the Wick meteorological data since these indicate generally worse weather conditions compared to Lossiemouth. The conclusions drawn from the Wick data are therefore expected to be conservative.

3 Impact of BOWL

3.1 MSA

3.1.1 Minimum safe altitude (MSA) is established at the height of the highest obstacle within 5nm plus 1,000ft. The current MSA in the vicinity of the Beatrice field is 1,300ft above sea level, determined by the height of the derrick on the Beatrice A, plus 1,000ft, rounded up to the next highest hundred feet. Proposed turbine heights in the BOWL development are approaching 200 metres (656ft). Therefore, due to the BOWL development the MSA is likely to increase to 1,700ft. The direct in-field consequence is the additional distance required in order for the aircraft to descend to the minimum decision height (MDH) when on an instrument approach.

3.1.2 In order for an ARA to be flown with the approach starting at the revised MSA and for none of the approach to be flown over the wind farm will require approximately 9nm of separation between turbines and helideck.

3.2 Beatrice Alpha

3.2.1 Beatrice Alpha will incur additional restrictions to approaches from the north-east due to the BOWL development.

Destination platform	Restricted approaches	Nature of restriction and potential mitigations
Beatrice A	035-083	Charlie platform within 1nm of the approach path. Approach to Charlie and shuttle to Alpha, fly an out-of-wind ARA or fly a circling approach.
	306-006	Existing no go sector due to Demonstrator Turbines.
	198-249 (195-205)	BOWL development in the approach path. Includes sector where shuttling to Bravo and/or Jacky would be required as these also restricted.

Table 3-1: Restricted approach sectors for Beatrice Alpha including BOWL

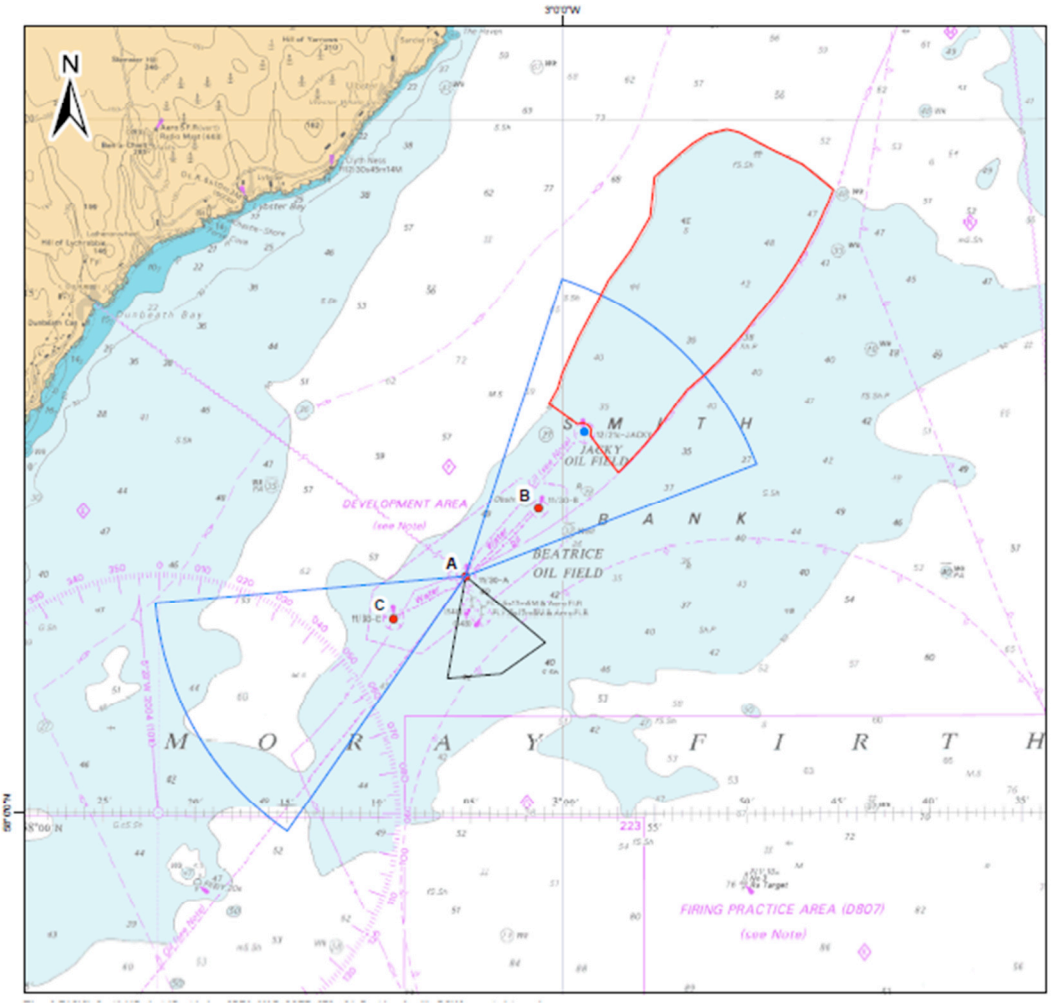

Figure 3-1: Restricted approach sectors for Beatrice Alpha including BOWL

3.3 Beatrice Bravo

3.3.1 Beatrice Bravo will incur additional restrictions to approaches from the north-east due to the BOWL development.

Destination platform	Restricted approaches	Nature of restriction and potential mitigations
Beatrice B	048-067 (023-067)	Alpha (and Charlie) platform within 1nm of the approach path. Approach to Alpha/Charlie and shuttle to Bravo, fly an out-of-wind ARA or fly a circling approach.
	355-047	Demonstrator Turbines no-go sector in the approach path.
	166-269	BOWL development in the approach path. Includes where shuttling from Jacky would be required as this also restricted.

Table 3-2: Restricted approach sectors for Beatrice Bravo including BOWL

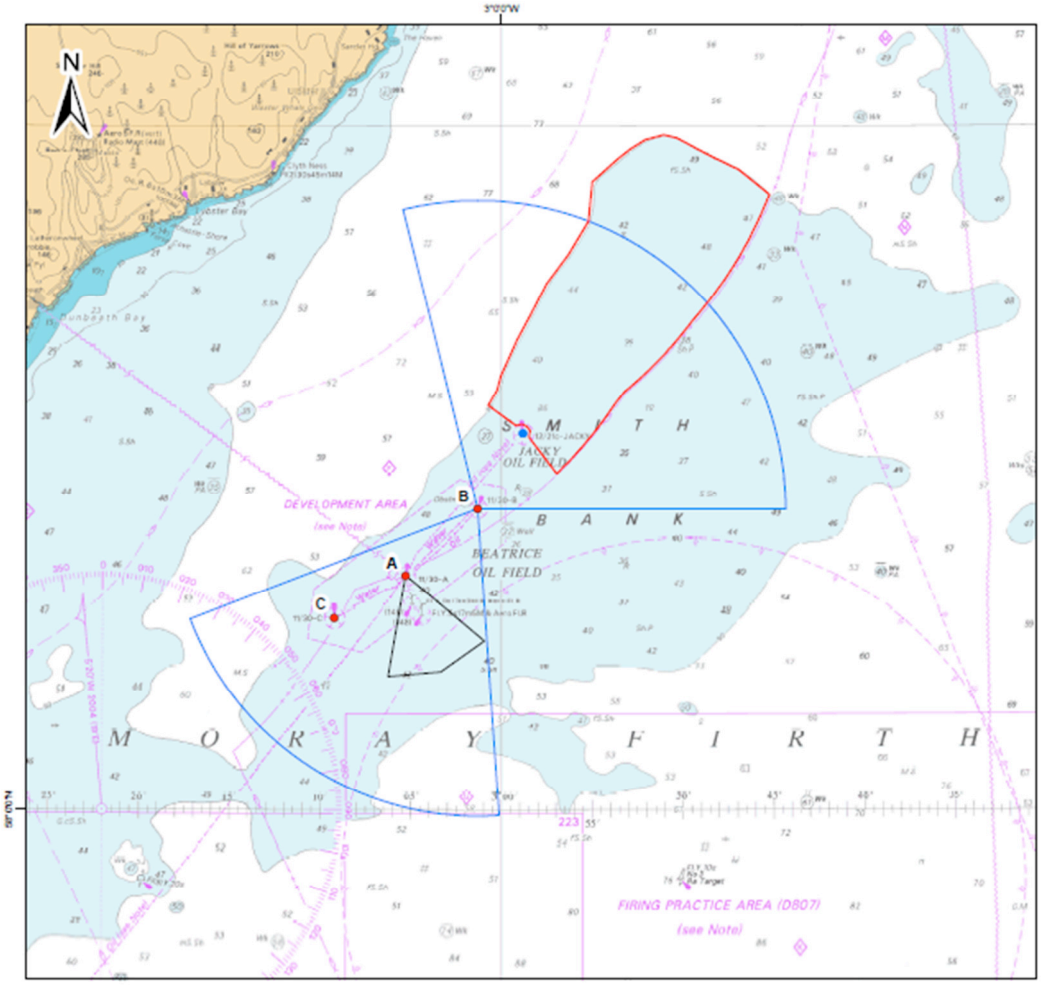

Figure 3-2: Restricted approach sectors to Beatrice Bravo including BOWL

3.4 Beatrice Charlie

3.4.1 Beatrice Charlie will incur some minor additional restrictions to approaches from the north-east due to the BOWL development.

Destination platform	Restricted approaches	Nature of restriction and potential mitigations
Beatrice C	239-315	Demonstrator Turbines no-go sector in the approach path.
	214-238	Alpha platform within 1nm of the approach path. Approach to Alpha and shuttle to Charlie, fly an out-of-wind ARA or fly a circling approach.
	208-213	BOWL development in the approach path

Table 3-3: Restricted approach sectors for Beatrice Charlie including BOWL

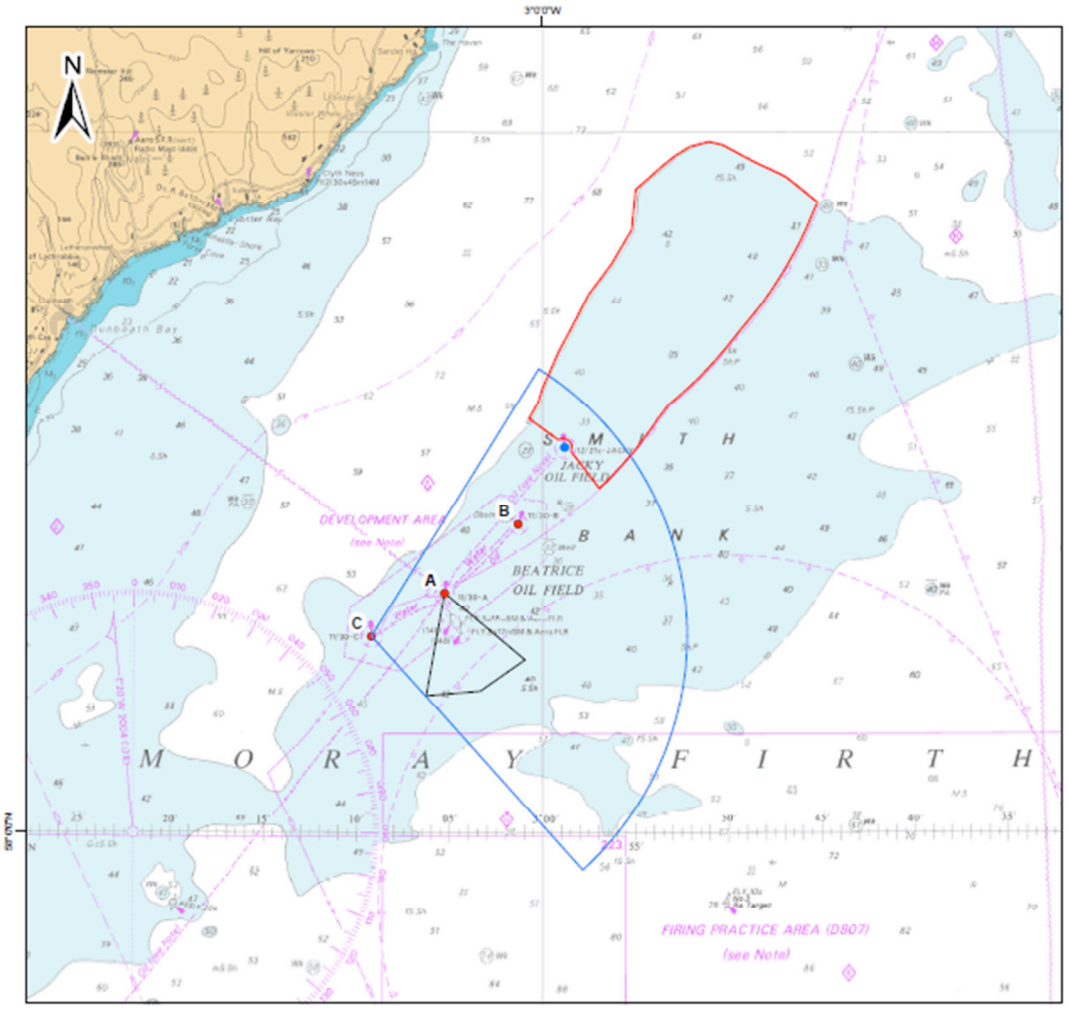

Figure 3-3: Restricted approach sectors to Beatrice Charlie including BOWL

3.5 Jacky

3.5.1 The proximity of the BOWL development to the Jacky effectively prevents all approach headings.

Destination platform	Restricted approaches	Nature of restriction
Jacky	All	BOWL development encompasses the platform

Table 3-4: Restricted approach sectors for Jacky including BOWL

3.6 Impact on operations of BOWL

3.6.1 To assess the impact of current constraints upon the operations in the Beatrice field it is necessary to bring together the existing and BOWL restrictions outlined above, the weather conditions in-field and a representative flight schedule as outlined above.

3.6.2 The impact is therefore expected to be as outlined in Table 3-5 below.

	BOWL situation	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by BOWL**
Beatrice A	3.2% (~5 flights p.a.)	0.1% (~1 flight in 5 years)
Beatrice B	0.7% (~1 flight in 2 years)	0.8% (~1 flight in 2 years)
Beatrice C	3.1% (~1 flight in 2 years)	0.1% (negligible)
Jacky	0.1% (negligible)	7.7% (~1 flight p.a.)

Table 3-5: Summary of BOWL impact (Wick data)

3.6.3 As before, where it is indicated that approaches would be restricted or prevented that does not in itself mean that a flight will be totally prevented. Similarly to the mitigation of delaying a flight the other identified mitigations have not been considered in the analysis above. On this basis, with no mitigations applied the impact would be such that around two additional flights per annum would be prevented. Operations to Bravo and to Jacky receive a greater impact as would be expected due to their proximity to the proposed development.

3.6.4 On the basis of Lossiemouth Met data the impact is therefore expected to be as outlined in Table 3-6 below.

	BOWL situation	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by BOWL**
Beatrice A	1.8% (~3 flights p.a.)	0.0% (negligible)
Beatrice B	1.3% (~1 flight p.a.)	0.4% (~1 flight in 3 years)
Beatrice C	1.0% (~1 flight in 5 years)	0.0% (negligible)
Jacky	0.8% (~1 flight in 10 years)	2.8% (~1 flight in 2 years)

Table 3-6: Summary of BOWL impact (Lossiemouth data)

3.6.5 The figures indicate that, with no mitigations applied, the net effect of the BOWL development would be to prevent approximately less than one flight to the Beatrice field per annum, over and above the existing constraints.

3.6.6 The impact of BOWL on missed approaches, other than those to Jacky, would be relatively small, consisting of some additional constraints on ARAs to the Beatrice B on northerly and easterly headings.

3.6.7 The impact of BOWL on departures would apply to take-offs from Jacky on headings from north west clockwise round to south east, and to north-easterly departures from the Bravo. Departures from the A and C would not be affected.

4 Impact of MORL Eastern Development Area (EDA)

4.1 MSA

4.1.1 The maximum proposed turbine heights in the MORL development are 204 metres above Lowest Astronomical Tide (LAT). This is equivalent to a maximum of 207 metres (679ft) above mean sea level. Therefore, due to the MORL development the MSA is likely to increase to 1,700ft. The direct in-field consequence is the additional distance required in order for the aircraft to descend to the minimum decision height (MDH) when on an instrument approach.

4.1.2 In order for an ARA to be flown with the approach starting at the revised MSA and for none of the approach to be flown over the wind farm will require approximately 9nm of separation between turbines and helideck.

4.1.3 In addition, the presence of turbines approaching 700ft above sea level in the MORL EDA may affect the altitudes at which helicopters are able to fly in VFR conditions while inbound to or outbound from the Beatrice field. Aircraft flying VFR must maintain a minimum of 500ft separation from any structures. For helicopters whose track takes them over the MORL EDA, this would impose a minimum en route VFR altitude of 1,200ft. In view of the geometry of the EDA area this is only likely to affect helicopters in transit direct from Aberdeen to the Jacky platform; direct tracks from Aberdeen to all the other platforms will pass to the west of the EDA.

4.2 Beatrice Alpha

4.2.1 Beatrice Alpha will incur additional restrictions to approaches from the east due to the MORL EDA development.

Destination platform	Restricted approaches	Nature of restriction and potential mitigations
Beatrice A	035-083	Charlie platform within 1nm of the approach path. Approach to Charlie and shuttle to Alpha, fly an out-of-wind ARA or fly a circling approach.
	206-247	Bravo platform within 1nm of the approach path. Approach to Jacky/Bravo/Charlie and shuttle to Alpha, fly an out-of-wind ARA or fly a circling approach.
	306-006	Existing no go sector due to Demonstrator Turbines.
	252-305	MORL EDA development in the approach path.

Table 4-1: Restricted approach sectors for Beatrice Alpha including MORL EDA

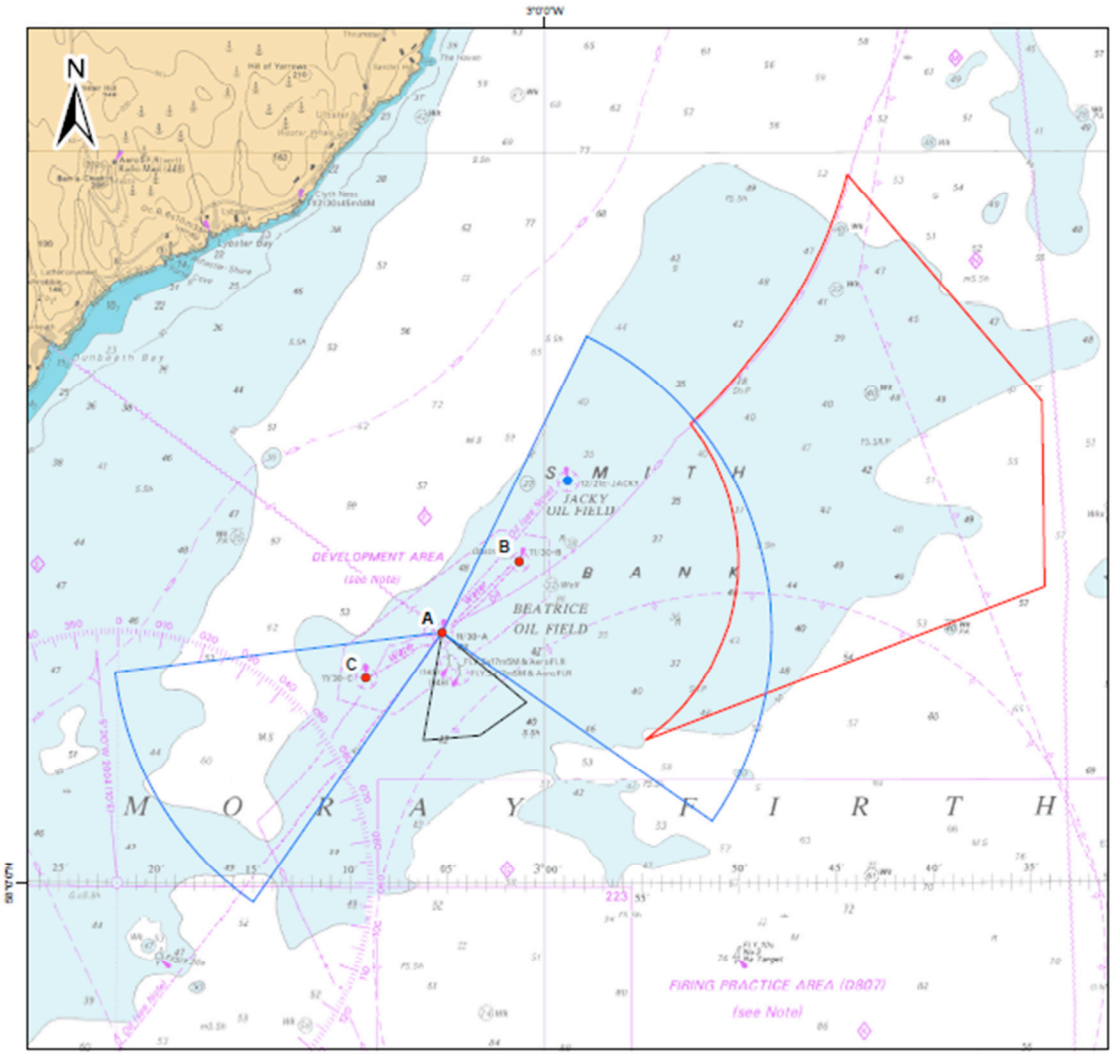

Figure 4-1: Restricted approach sectors for Beatrice Alpha including MORL EDA

4.3 Beatrice Bravo

4.3.1 Beatrice Bravo will incur additional restrictions to approaches from the east and south east due to the MORL EDA development.

Destination platform	Restricted approaches	Nature of restriction and potential mitigations
Beatrice B	048-067	Alpha platform within 1nm of the approach path. Approach to Alpha/Charlie and shuttle to Bravo, fly an out-of-wind ARA or fly a circling approach.
	355-047	Demonstrator Turbines no-go sector in the approach path.
	232-334	MORL EDA development in the approach path.

Table 4-2: Restricted approach sectors for Beatrice Bravo including MORL EDA

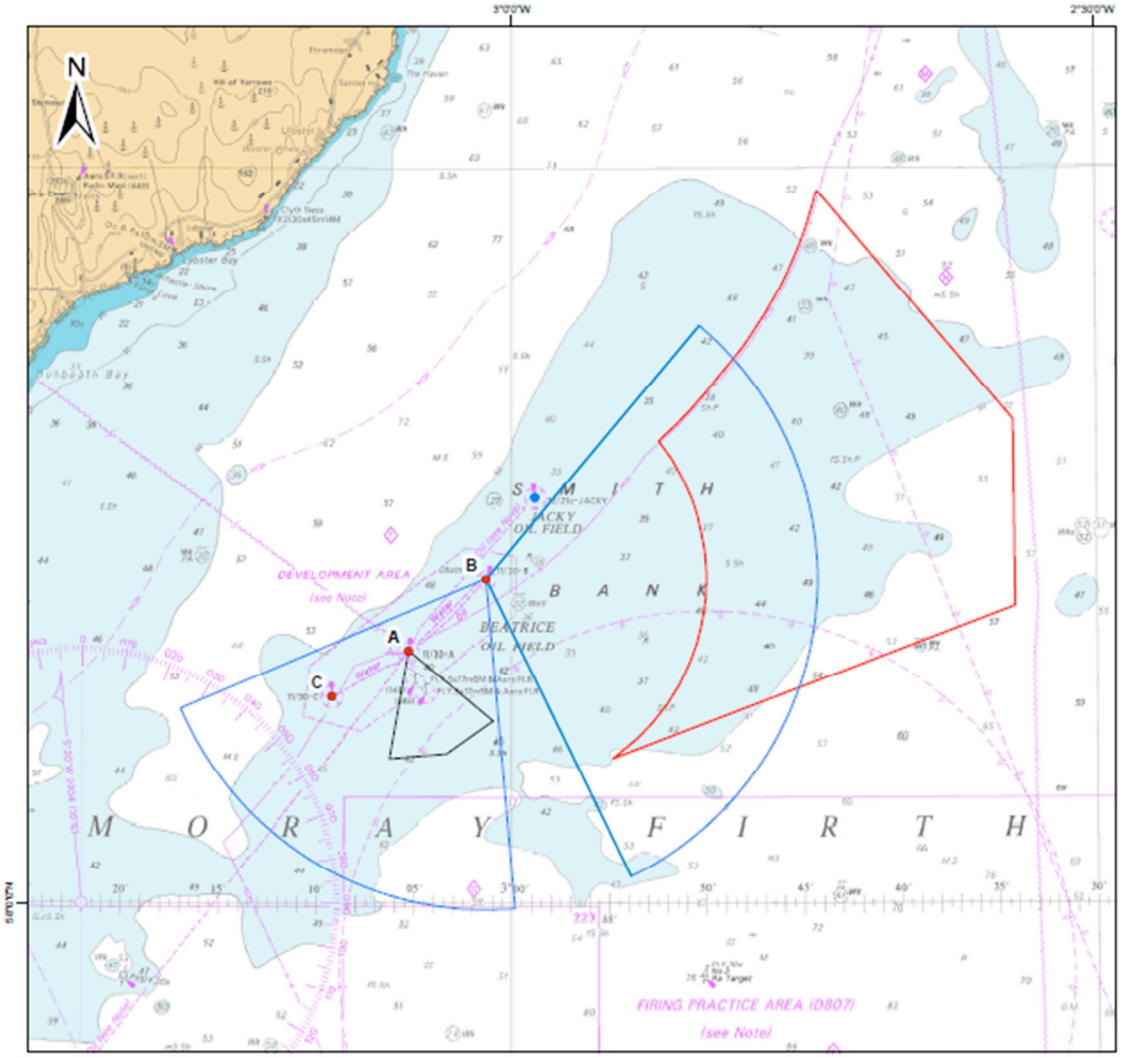

Figure 4-2: Restricted approach sectors to Beatrice Bravo including MORL EDA

4.4 Beatrice Charlie

4.4.1 Beatrice Charlie will not incur any additional restrictions to approaches due to the MORL EDA development. Approaches to the Charlie from that sector are already constrained by the Demonstrator Turbines restricted zone.

4.5 Jacky

4.5.1 Approaches to the Jacky from a sector from north-east round to south would be additionally restricted due to the MORL EDA development.

Destination platform	Restricted approaches	Nature of restriction
Jacky	009-052	Bravo platform within 1nm of the approach path. Approach to Bravo and shuttle to Alpha, fly an out-of-wind ARA or fly a circling approach.
	222-351	MORL EDA development in the approach path.

Table 4-3: Restricted approach sectors for Jacky including MORL EDA

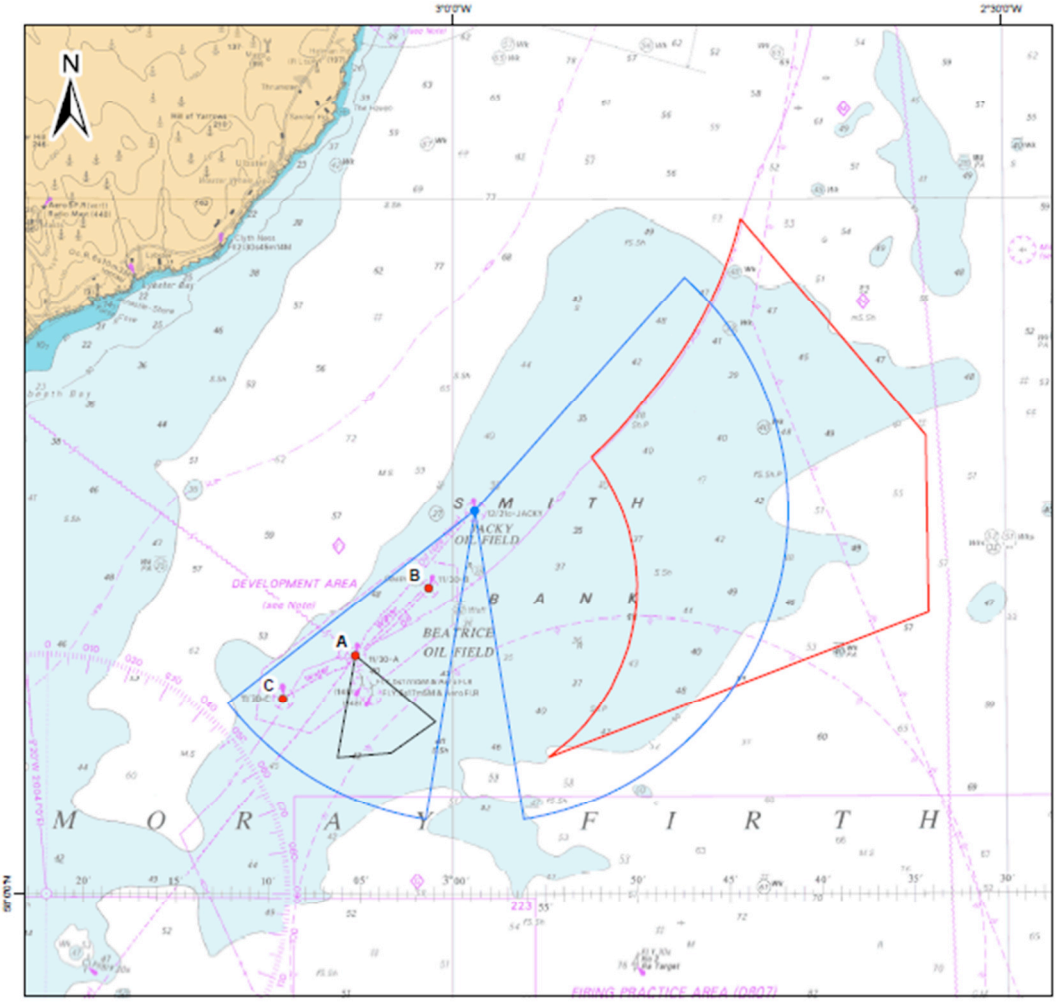

Figure 4-3: Restricted approach sectors for Jacky including MORL EDA

4.6 Impact on operations of MORL EDA

4.6.1 To assess the impact of current constraints upon the operations in the Beatrice field it is necessary to bring together the existing and MORL EDA restrictions outlined above, the weather conditions in-field and a representative flight schedule as outlined above.

4.6.2 The impact is therefore as shown in Table 4-4 below.

	MORL EDA situation (Wick data)	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by MORL EDA**
Beatrice A	3.2% (~5 flights p.a.)	1.9% (~3 flights p.a.)
Beatrice B	0.7% (~1 flight in 2 years)	4.3% (~3 flights p.a.)
Beatrice C	3.1% (~1 flight in 2 years)	0.0% (negligible)
Jacky	0.1% (negligible)	4.9% (~1 flight p.a.)

Table 4-4: Summary of MORL EDA impact (Wick data)

4.6.3 As before, where it is indicated that approaches would be restricted or prevented that does not in itself mean that a flight will be totally prevented. Similarly to the mitigation of delaying a flight, the other identified mitigations have not been considered in the analysis above. On this basis, with no mitigations applied the impact would be such that around seven additional flights per annum would be prevented. Operations to Bravo and to Jacky receive a greater impact as would be expected due to their proximity to the proposed development.

4.6.4 On the basis of Lossiemouth Met data the impact is therefore expected to be as outlined in Table 3-5 below.

	MORL EDA situation (Lossiemouth data)	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by MORL EDA**
Beatrice A	1.8% (~3 flights p.a.)	0.6% (~1 flight p.a.)
Beatrice B	1.3% (~1 flight p.a.)	1.1% (~1 flight p.a.)
Beatrice C	1.0% (~1 flight in 5 years)	N/A
Jacky	0.8% (~1 flight in 10 years)	1.4% (~1 flight in 5 years)

Table 4-5: Summary of MORL EDA impact (Lossiemouth data)

4.6.5 The figures indicate that, with no mitigations applied, the net effect of the MORL EDA would be to prevent approximately two more flights to the Beatrice field per annum, over and above the existing constraints.

4.6.6 MORL EDA would not impose any additional constraints on missed approaches since the EDA boundary is sufficiently far from all possible missed approach points. MORL EDA would have no impact on departures since all platforms are in excess of 9.3 km from the closest boundary of the EDA.

5 Impact of MORL Western Development Area (WDA)

5.1 Scope

5.1.1 The MORL WDA will only be developed in addition to the EDA. There are no circumstances in which the WDA would be developed as a stand-alone wind farm. Consequently this section addresses the impact of the WDA in combination with the EDA.

5.2 Sectors for visual manoeuvring

5.2.1 The northern boundary of the MORL WDA abuts the Beatrice Charlie platform, encompasses the Alpha platform and passes a short distance to the south of the Bravo platform. In order to permit operations to and from the helidecks of these platforms, it has been assumed in this report that no turbines are placed within a radius of 1.5nm (2.8km) of each of those three platforms.

5.3 MSA

5.3.1 The effect of the MORL WDA on the MSA for helicopters flying IFR in the area will be as set out in 4.1.1.

5.3.2 In order for an ARA to be flown with the approach starting at the revised MSA and for none of the approach to be flown over the wind farm will require approximately 9nm of separation between turbines and helideck (see Annex B).

5.3.3 For helicopters flying VFR or in VMC, the effect of the MORL WDA on minimum overflight altitudes will be as set out in 4.1.2. However this will apply to all flights between Aberdeen and any of the Beatrice field platforms since the WDA extends under all of those flight paths. Analysis of the Lossiemouth meteorological data suggests that the effect of this raising of the minimum en route VFR altitude from 1,000ft to 1,200ft would be that three or four additional flights a year from Aberdeen to the Beatrice field, which would otherwise have completed an en route descent into visual conditions and flown a visual approach to the destination platform, will be required to fly an ARA.[3]

5.4 Beatrice Alpha

5.4.1 Beatrice Alpha will incur additional restrictions to approaches from the east and south due to the MORL EDA + WDA developments.

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[3] The Lossiemouth data were used for this calculation since the en route descent to visual conditions would be conducted in an area within 40km of Lossiemouth but more than 50km from Wick. Lossiemouth data are therefore expected to be more representative of actual conditions in the en route descent area.

Destination platform	Restricted approaches	Nature of restriction and potential mitigations
Beatrice A	035-083	Charlie platform within 1nm of the approach path. Approach to Charlie and shuttle to Alpha, fly an out-of-wind ARA or fly a circling approach.
	206-247	Bravo platform within 1nm of the approach path. Approach to Jacky/Bravo/Charlie and shuttle to Alpha, fly an out-of-wind ARA or fly a circling approach.
	306-006	Existing no go sector due to Demonstrator Turbines.
	248-305	MORL WDA development in the approach path.
	007-034	MORL WDA development in the approach path.

Table 5-1: Restricted approach sectors for Beatrice Alpha including MORL EDA/WDA

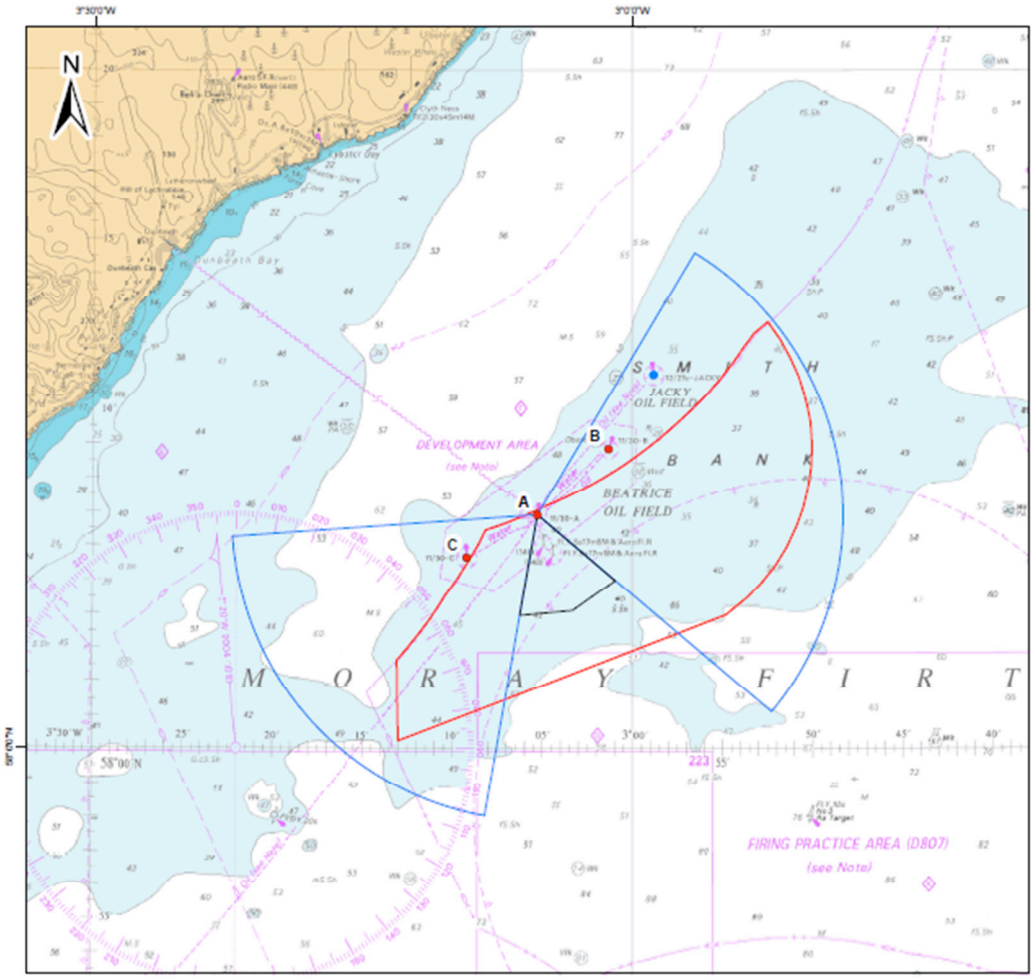

Figure 5-1: Restricted approach sectors for Beatrice Alpha including MORL EDA/WDA

5.5 Beatrice Bravo

5.5.1 Beatrice Bravo will incur additional restrictions to approaches from the east and south due to the MORL EDA + WDA developments.

Destination platform	Restricted approaches	Nature of restriction and potential mitigations
Beatrice B	048-067	Alpha platform within 1nm of the approach path. Approach to Alpha/Charlie and shuttle to Bravo, fly an out-of-wind ARA or fly a circling approach.
	355-047	Demonstrator Turbines no-go sector in the approach path.
	232-354	MORL WDA development in the approach path.

Table 5-2: Restricted approach sectors for Beatrice Bravo including MORL EDA/WDA

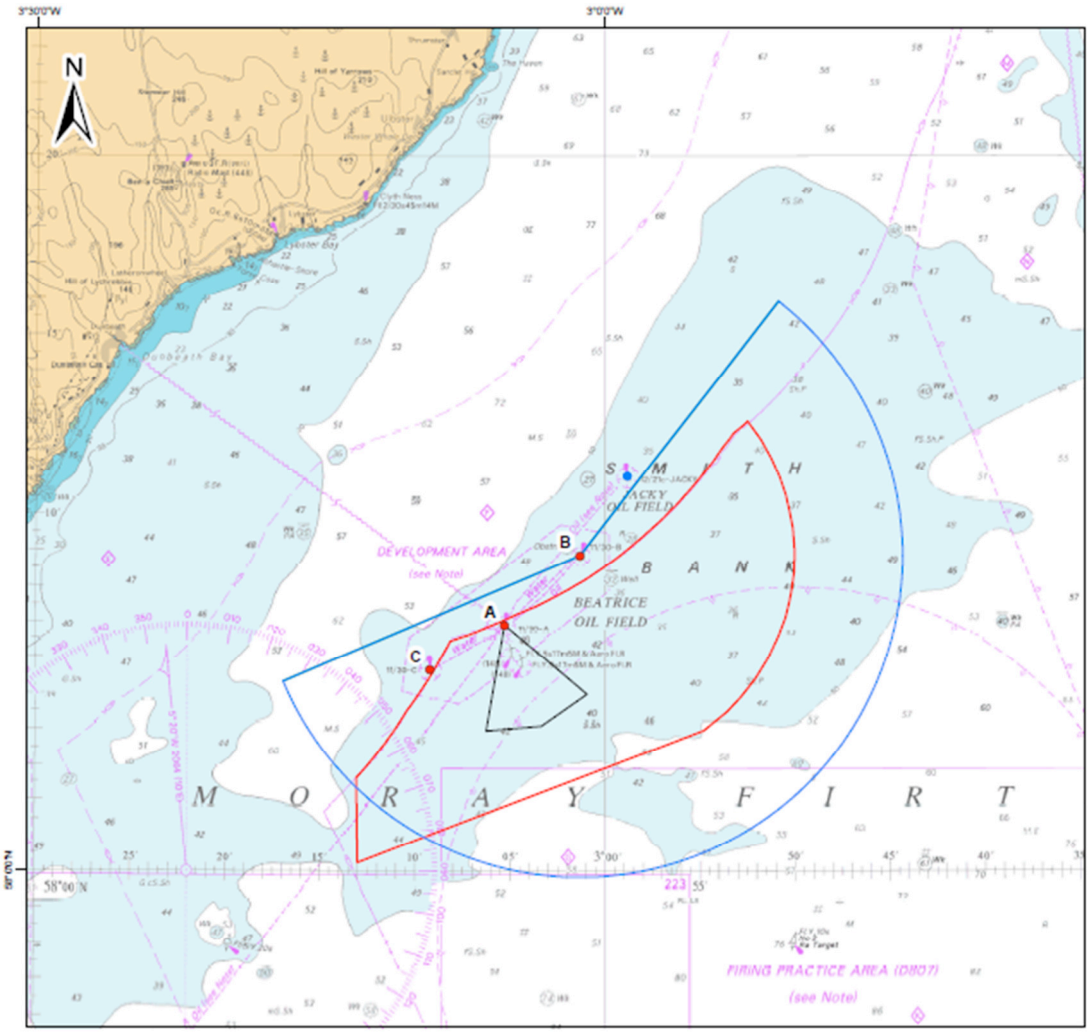

Figure 5-2: Restricted approach sectors to Beatrice Bravo including MORL EDA/ WDA

5.6 Beatrice Charlie

5.6.1 Beatrice Charlie will incur additional restrictions to approaches from the south and south-west due to the MORL EDA + WDA developments.

Destination platform	Restricted approaches	Nature of restriction and potential mitigations
Beatrice C	214-238	Alpha platform within 1nm of the approach path. Approach to Alpha and shuttle to Charlie, fly an out-of-wind ARA or fly a circling approach.
	239-315	Demonstrator Turbines no-go sector in the approach path.
	316-073	MORL WDA development in the approach path.

Table 5-3: Restricted sectors for Beatrice Charlie including MORL EDA/ WDA

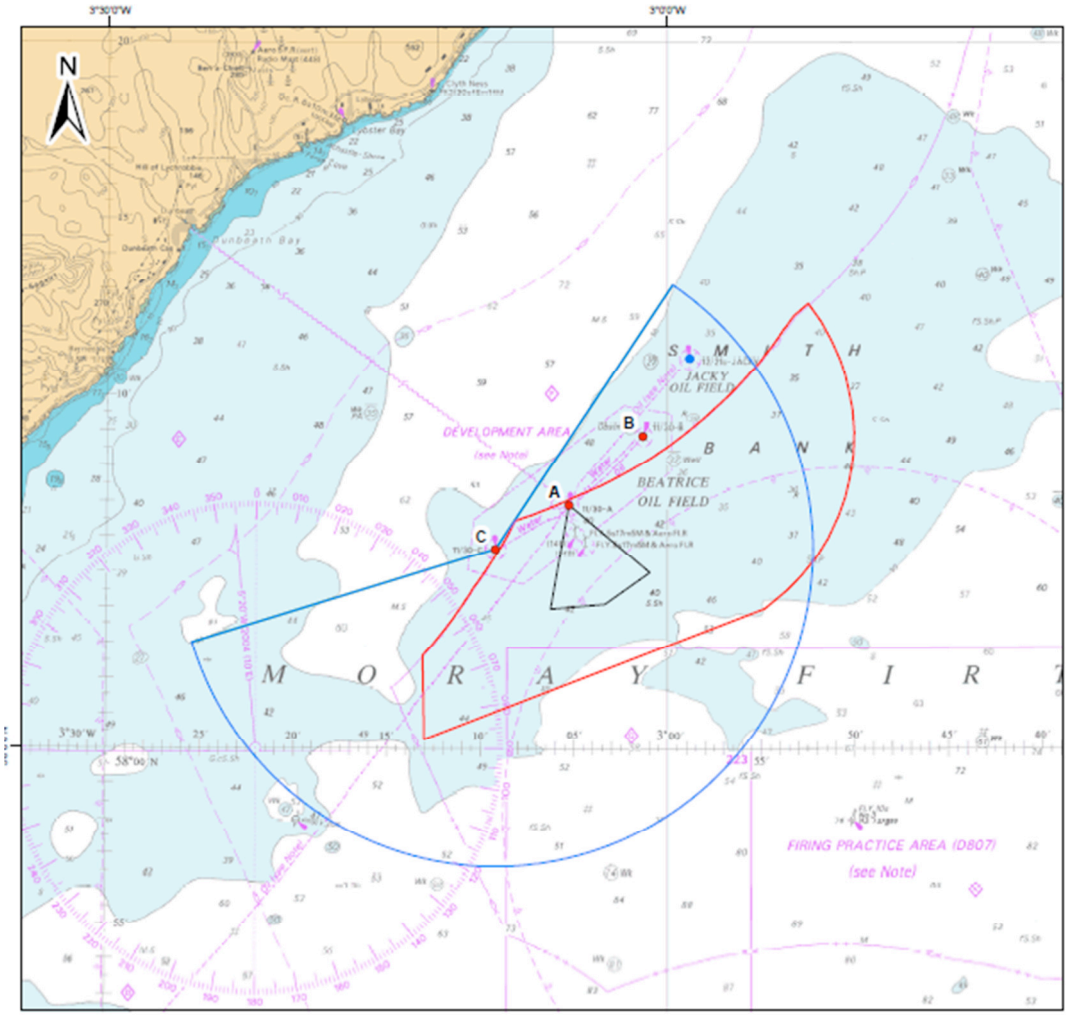

Figure 5-3: Restricted approach sectors to Beatrice Charlie including MORL EDA/ WDA

5.7 Jacky

5.7.1 Approaches to the Jacky from a sector from north-east round to south would be additionally restricted due to the MORL EDA + WDA developments.

Destination platform	Restricted approaches	Nature of restriction
Jacky	009-052	Bravo platform within 1nm of the approach path. Approach to Bravo and shuttle to Alpha, fly an out-of-wind ARA or fly a circling approach.
	222-226	MORL EDA development in the approach path
	227-008	MORL WDA development in the approach path.

Table 5-4: Restricted approach sectors for Jacky including MORL EDA/WDA

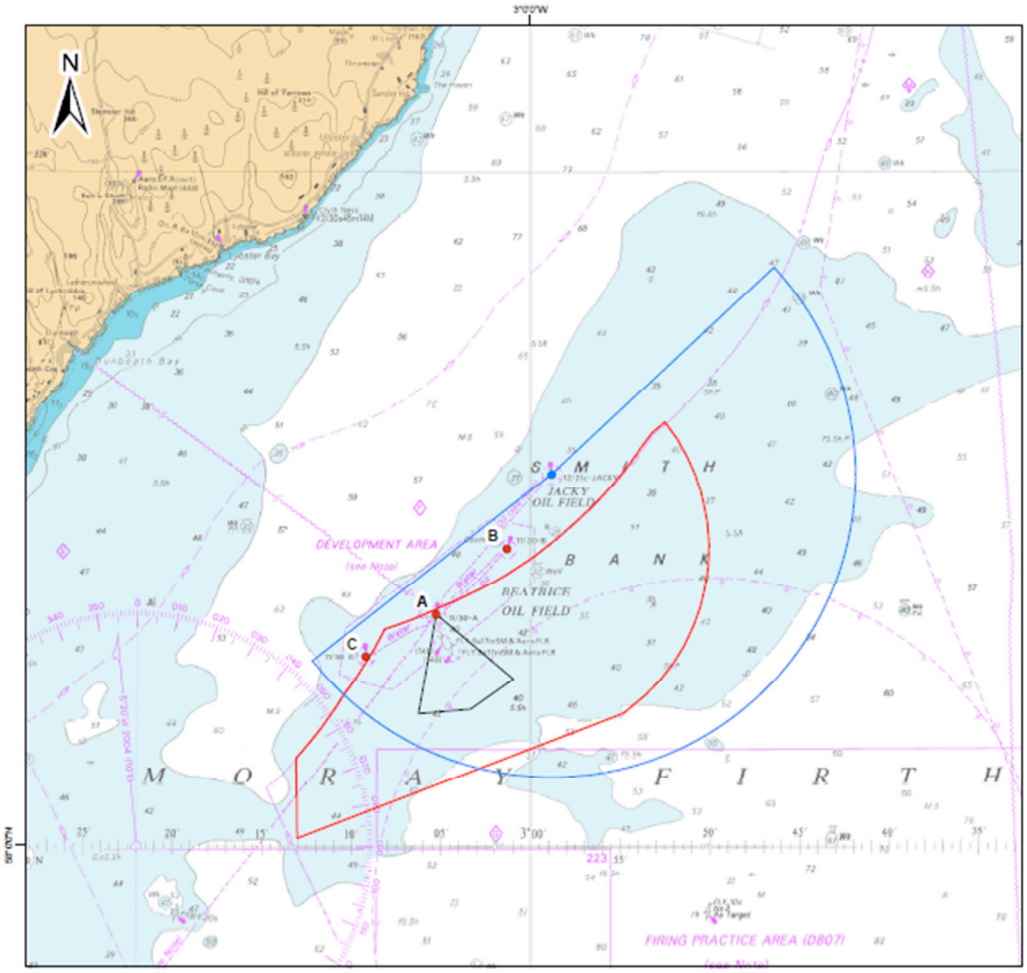

Figure 5-4: Restricted approach sectors for Jacky including MORL EDA/WDA

5.8 Impact on operations of MORL EDA + WDA

5.8.1 To assess the impact of current constraints upon the operations in the Beatrice field it is necessary to bring together the existing and MORL EDA + WDA restrictions outlined above, the weather conditions in-field and a representative flight schedule as outlined above.

5.8.2 The impact is therefore expected to be as outlined in Table 5-5 below.

	MORL EDA + WDA situation (Wick data)	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by MORL EDA + WDA**
Beatrice A	3.2% (~5 flights p.a.)	2.1% (~3 flights p.a.)
Beatrice B	0.7% (~1 flight in 2 years)	4.8% (~3 flights p.a.)
Beatrice C	3.1% (~1 flight in 2 years)	2.1% (~1 flight in 3 years)
Jacky	0.1% (negligible)	4.9% (~1 flight p.a.)

Table 5-5: Summary of MORL EDA + WDA impact (Wick data)

5.8.3 As before, where it is indicated that approaches would be restricted or prevented that does not in itself mean that a flight will be totally prevented. Similarly to the mitigation of delaying a flight, the other identified mitigations have not been considered in the analysis above. On this basis, with no mitigations applied the impact would be such that around seven-eight additional flights per annum would be prevented. Operations to Bravo and to Jacky receive a greater impact as would be expected due to their proximity to the proposed development.

5.8.4 On the basis of the Lossiemouth data the impact is therefore expected to be as outlined in Table 5-6 below.

	MORL EDA + WDA situation (Lossiemouth data)	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by MORL EDA + WDA**
Beatrice A	1.8% (~3 flights p.a.)	1.2% (~2 flight p.a.)
Beatrice B	1.3% (~1 flight p.a.)	1.3% (~1 flight p.a.)
Beatrice C	1.0% (~1 flight in 5 years)	1.8% (~1 flight in 3 years)
Jacky	0.8% (~1 flight in 10 years)	1.5% (~1 flight in 5 years)

Table 5-6: Summary of MORL EDA + WDA impact (Lossiemouth data)

5.8.5 The figures indicate that, with no mitigations applied, the net effect of the MORL EDA + WDA would be to prevent approximately three more flights to the Beatrice field per annum, over and above the existing constraints.

5.8.6 MORL WDA would impose some significant additional constraints on missed approaches since any missed approach requiring the helicopter to fly to the south of the platforms would be prevented. ARAs on southerly headings would be particularly affected. These may require the missed approach turn to be flown

through more than 45° in order to establish on an obstacle-free track, away from the wind farms. The impact of the WDA on missed approaches can be seen in Table 6-5, which summarises the cumulative impact of BOWL and MORL on missed approaches from ARAs to the Beatrice Alpha. Missed approaches to the Bravo are likely to be similarly affected. Impacts of MORL (without BOWL) on missed approaches to the Charlie and Jacky will be of a lesser scale.

5.8.7 MORL WDA will have a potentially significant impact on departures on southerly headings from all platforms. If, as assumed for this report, WDA turbines are placed up to 1.5nm (2.8km) from the A, B and C platforms, modification to departure procedures and/or aircraft weights may be required in certain wind conditions. These are discussed further in Section 7.

6 Cumulative impact of BOWL and MORL

6.1 Impact of BOWL + MORL EDA

6.1.1 MSA

6.1.1.1 Both the BOWL and the MORL EDA developments would cause the MSA to be increased to 1,700ft. The cumulative impact of BOWL and MORL EDA together would also be to increase the MSA to 1,700ft.

6.1.1.2 In order for an ARA to be flown with the approach starting at the revised MSA and for none of the approach to be flown over the wind farm will require approximately 9nm of separation between turbines and helideck.

6.1.1.3 The cumulative impact of BOWL and MORL EDA together on the minimum en route altitude for helicopters flying VFR will be the same as that for MORL EDA – an increase in overflight altitude to 1,200ft.

6.1.2 Beatrice Alpha

6.1.2.1 Beatrice Alpha will incur additional restrictions to approaches from the east due to the BOWL and MORL EDA developments.

Destination platform	Restricted approaches	Nature of restriction
Beatrice A	035-083	Charlie platform within 1nm of approach path. Approach to Charlie and shuttle to Alpha, fly an out-of-wind ARA or fly a circling approach.
	206-247	Bravo platform within 1nm of approach path
	306-006	Existing no go sector due to Demonstrator Turbines.
	195-205	BOWL development in the approach path.
	252-305	MORL EDA in the approach path.

Table 6-1: Restricted sectors for Beatrice A including BOWL and MORL EDA

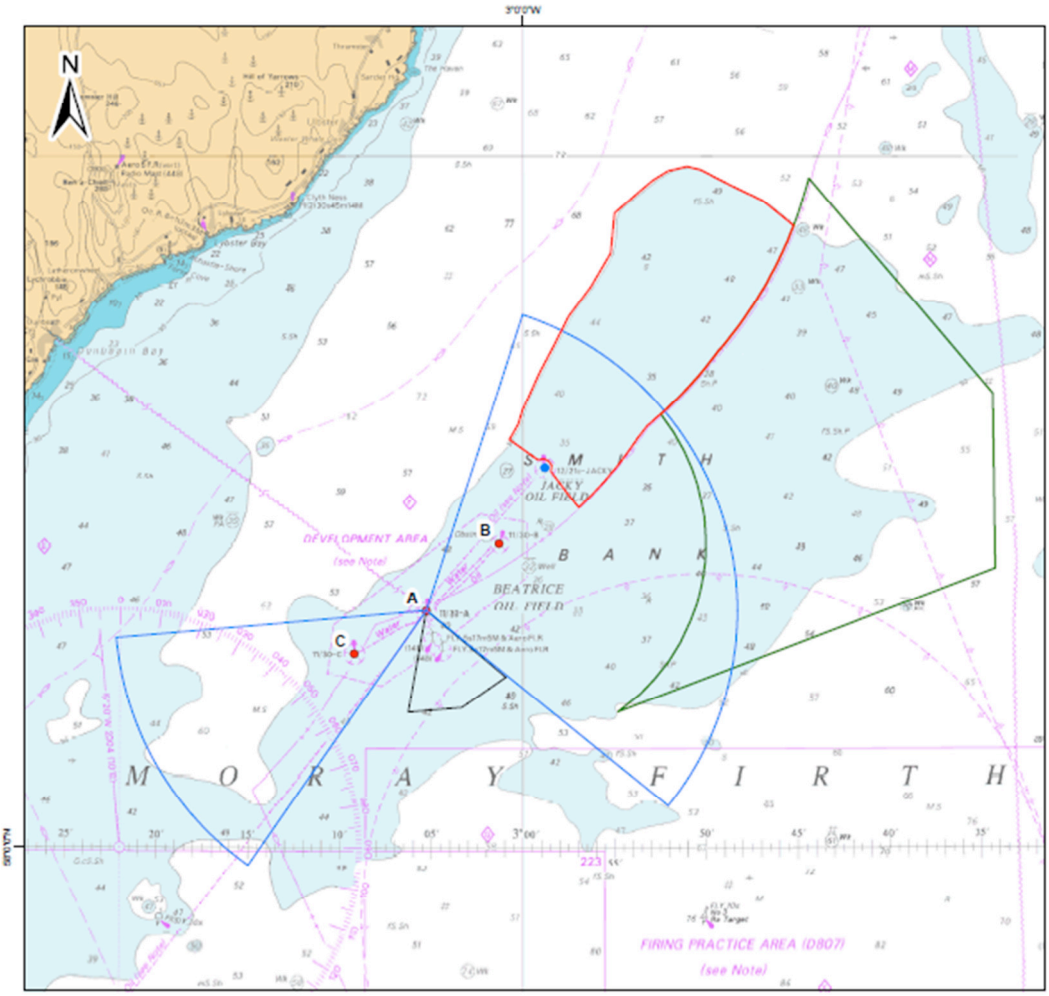

Figure 6-1: Restricted approach sectors for Beatrice A including BOWL & MORL EDA

6.1.3 Beatrice Bravo

6.1.3.1 Beatrice Bravo will incur additional restrictions to approaches from the east and south due to the BOWL and MORL EDA developments.

Destination platform	Restricted approaches	Nature of restriction
Beatrice B	048-067	Alpha platform within 1nm of the approach path. Approach to Alpha/Charlie and shuttle to Bravo, fly an out-of-wind ARA or fly a circling approach.
	355-047	Demonstrator Turbines no-go sector in the approach path.
	188-231	Jacky platform within 1nm of the approach path.
	166-187 232-269	BOWL development in the approach path.
	270-334	MORL EDA development in the approach path.

Table 6-2: Restricted approach sectors for Beatrice B including BOWL & MORL EDA

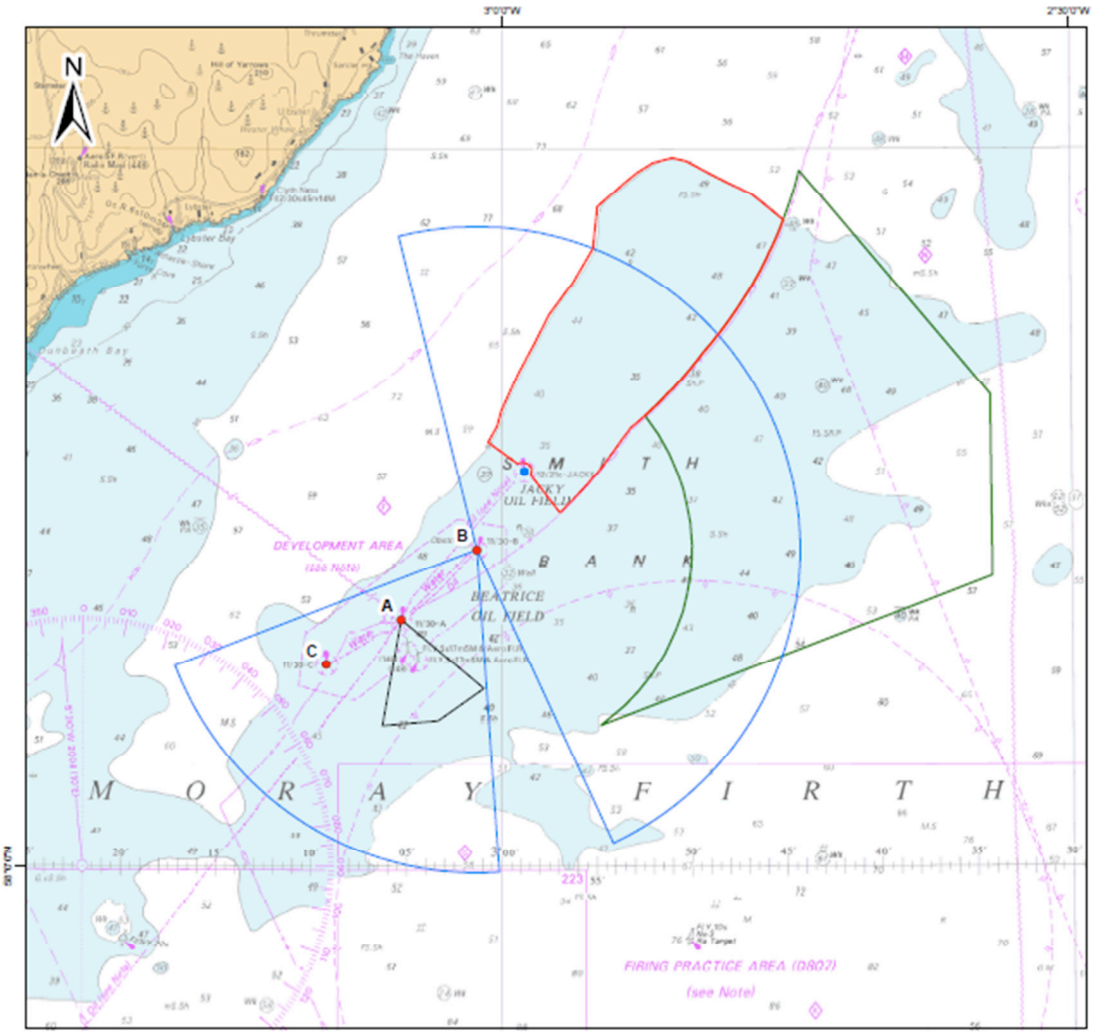

Figure 6-2: Restricted approach sectors for Beatrice B including BOWL & MORL EDA

6.1.4 Beatrice Charlie

6.1.4.1 There is no additional impact of the MORL EDA upon Charlie as the development is masked by the current no-fly zone for the Demonstrator Turbines. The cumulative impact of BOWL and MORL EDA on ARAs to the Beatrice Charlie is therefore the same as the impact on BOWL alone.

6.1.5 Jacky

6.1.5.1 There is no additional impact of the MORL EDA upon Jacky as the development is masked by the BOWL development boundaries. The cumulative impact of BOWL and MORL EDA on helicopter access to the Jacky is therefore the same as the impact of BOWL.

6.1.6 Impact on operations of BOWL& MORL EDA

6.1.6.1 To assess the cumulative impact of constraints upon the operations in the Beatrice field it is necessary to bring together the existing and BOWL & MORL EDA restrictions outlined above, the weather conditions in-field and a representative flight schedule as outlined above.

6.1.6.2 The impact is therefore expected to be as outlined in Table 6-3 below.

	BOWL& MORL EDA situation (Wick data)	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by BOWL & MORL EDA**
Beatrice A	3.2% (~5 flights p.a.)	2.0% (~3 flights p.a.)
Beatrice B	0.7% (~1 flight in 2 years)	4.6% (~3flights p.a.)
Beatrice C	3.1% (~1 flight in 2 years)	0.0% (negligible)
Jacky	0.1% (negligible)	7.7% (~1 flight p.a.)

Table 6-3: Summary of BOWL & MORL EDA impact (Wick data)

6.1.6.3 As before, where it is indicated that approaches would be restricted or prevented that does not in itself mean that a flight will be totally prevented. Similarly to the mitigation of delaying a flight, the other identified mitigations have not been considered in the analysis above. On this basis, with no mitigations applied the impact would be such that around seven to eight additional flights per annum would be prevented. Operations to Bravo and Jacky are impacted to a greater extent as would be expected due to their proximity to the proposed developments.

6.1.6.4 For comparison, using the Lossiemouth meteorological data, the cumulative impact of BOWL and MORL EDA is estimated to be as follows:

	BOWL& MORL EDA situation (Lossiemouth data)	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by BOWL & MORL EDA**
Beatrice A	1.8% (~3 flights p.a.)	0.6% (~1 flight p.a.)
Beatrice B	1.3% (~1 flight p.a.)	1.1% (~1 flight p.a.)
Beatrice C	1.0% (~1 flight in 5 years)	0.0% (negligible)
Jacky	0.8% (~1 flight in 10 years)	2.8% (~1 flight in 2 years)

Table 6-4: Summary of BOWL & MORL EDA impact (Lossiemouth data)

6.1.6.5 Leaving aside the impact on ARAs to the Jacky platform, the Lossiemouth data indicate that, with no mitigations applied, the cumulative impact of BOWL and MORL EDA would be such that approximately two to three additional flights per annum would be prevented, over and above the restrictions caused by existing obstructions.

6.1.6.6 The impact of BOWL with MORL EDA on missed approaches would be the same as the impact of BOWL as a stand-alone development. The constraints on missed approaches from ARAs to the Alpha are summarised in Table 6-5 below.

ARA final approach track (°T)	007-034	035-083	084-090	091-121	122-133	134-190	191-194	195-205	206-247	248-305	306-006
Missed approach turn direction available	Left only (R prevented by Demo Tbns sector)	ARA not possible due Beatrice C within 1nm of FAT	Left only (R prevented by Demo Tbns sector)	Left only (R prevented by Demo Tbns sector)	Left (with turn required to avoid B) or Right	Left only (R prevented by Beatrice C)	Right only (L prevented by Demo Tbns sector)	ARA not possible due BOWL within 1nm of FAT	ARA not possible due Beatrice B within 1nm of FAT	Right only (L prevented by Demo Tbns sector)	ARA not possible due Demo Turbines restricted zone
Constraints on straight climb-out after 45° initial turn	None		None (Jacky and BOWL at 5nm+)	Beatrice B	To left: Beatrice B; None to right	None	None			None	

Note: constraints additional to those currently in place are highlighted in yellow

Table 6-5: Beatrice A ARA missed approach constraints (future BOWL + MORL EDA)

6.1.6.7 The impact of BOWL with MORL EDA on departures would be the same as the impact of BOWL as a stand-alone development.

6.2 Impact of BOWL + MORL EDA + WDA

6.2.1 MSA

6.2.1.1 The BOWL, MORL EDA and MORL WDA developments would each cause the MSA to be increased to 1,700ft. Therefore, the cumulative impact of BOWL, MORL EDA and WDA together would also be to increase the MSA to 1,700ft.

6.2.1.2 The cumulative impact of BOWL, MORL EDA and WDA together on the minimum en route altitude for helicopters flying VFR will be the same as that for MORL WDA – an increase in overflight altitude to 1,200ft.

6.2.2 Beatrice Alpha

6.2.2.1 Beatrice Alpha will incur additional restrictions to approaches due to the BOWL and MORL developments.

Destination platform	Restricted approaches	Nature of restriction
Beatrice A	035-083	Charlie platform within 1nm of approach path. Approach to Charlie and shuttle to Alpha, fly an out-of-wind ARA or fly a circling approach.
	206-247	Bravo platform within 1nm of approach path
	306-006	Existing no go sector due to Demonstrator Turbines.
	195-205	BOWL development in the approach path.
	248-305	MORL EDA + WDA in the approach path.
	007-034	MORL WDA in the approach path.

Table 6-6: Restricted sectors for Beatrice A including BOWL and MORL EDA/WDA

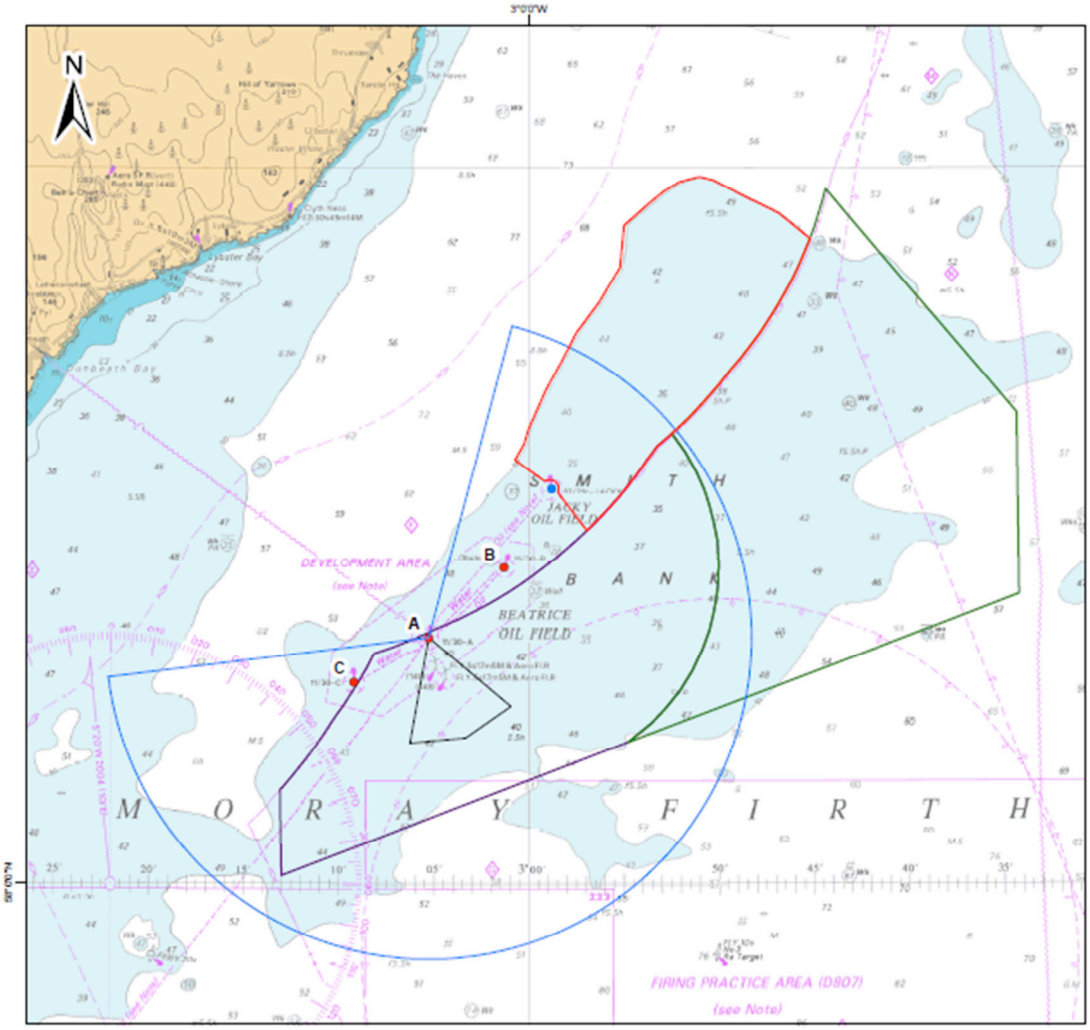

Figure 6-3: Restricted sectors for Beatrice A due to BOWL & MORL EDA/WDA

6.2.3 Beatrice Bravo

6.2.3.1 Beatrice Bravo will incur additional restrictions to approaches due to the BOWL and MORL EDA + WDA developments.

Destination platform	Restricted approaches	Nature of restriction
Beatrice B	048-067 (023-067)	Alpha platform within 1nm of the approach path. Approach to Alpha/Charlie and shuttle to Bravo, fly an out-of-wind ARA or fly a circling approach.
	355-047	Demonstrator Turbines no-go sector in the approach path.
	188-231	Jacky platform within 1nm of the approach path.
	166-187 232-269	BOWL development in the approach path.
	270-354	MORL EDA + WDA development in the approach path.

Table 6-7: Restricted sectors for Beatrice B including BOWL & MORL EDA+WDA

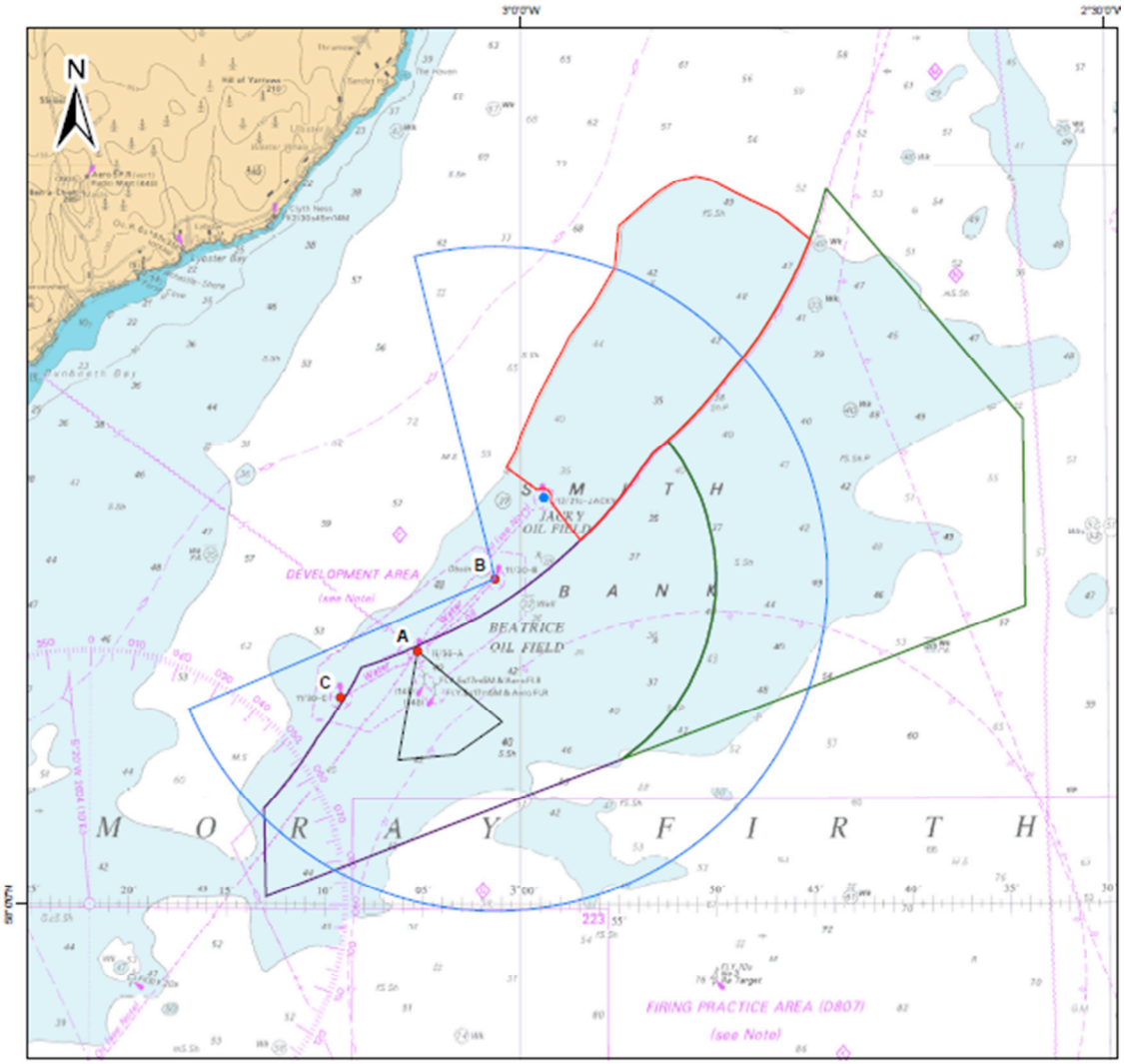

Figure 6-4: Restricted sectors for Beatrice B including BOWL & MORL EDA+WDA

6.2.4 Beatrice Charlie

6.2.4.1 Beatrice Charlie will incur additional restrictions to approaches due to the BOWL and MORL EDA/WDA developments.

Destination platform	Restricted approaches	Nature of restriction
Beatrice C	214-238	Alpha platform within 1nm of the approach path. Approach to Alpha and shuttle to Charlie, fly an out-of-wind ARA or fly a circling approach.
	239-315	Demonstrator Turbines no-go sector in the approach path.
	208-213	BOWL development in the approach path.
	316-073	MORL WDA in the approach path.

Table 6-8: Restricted sectors for Beatrice C including BOWL, MORL EDA/WDA

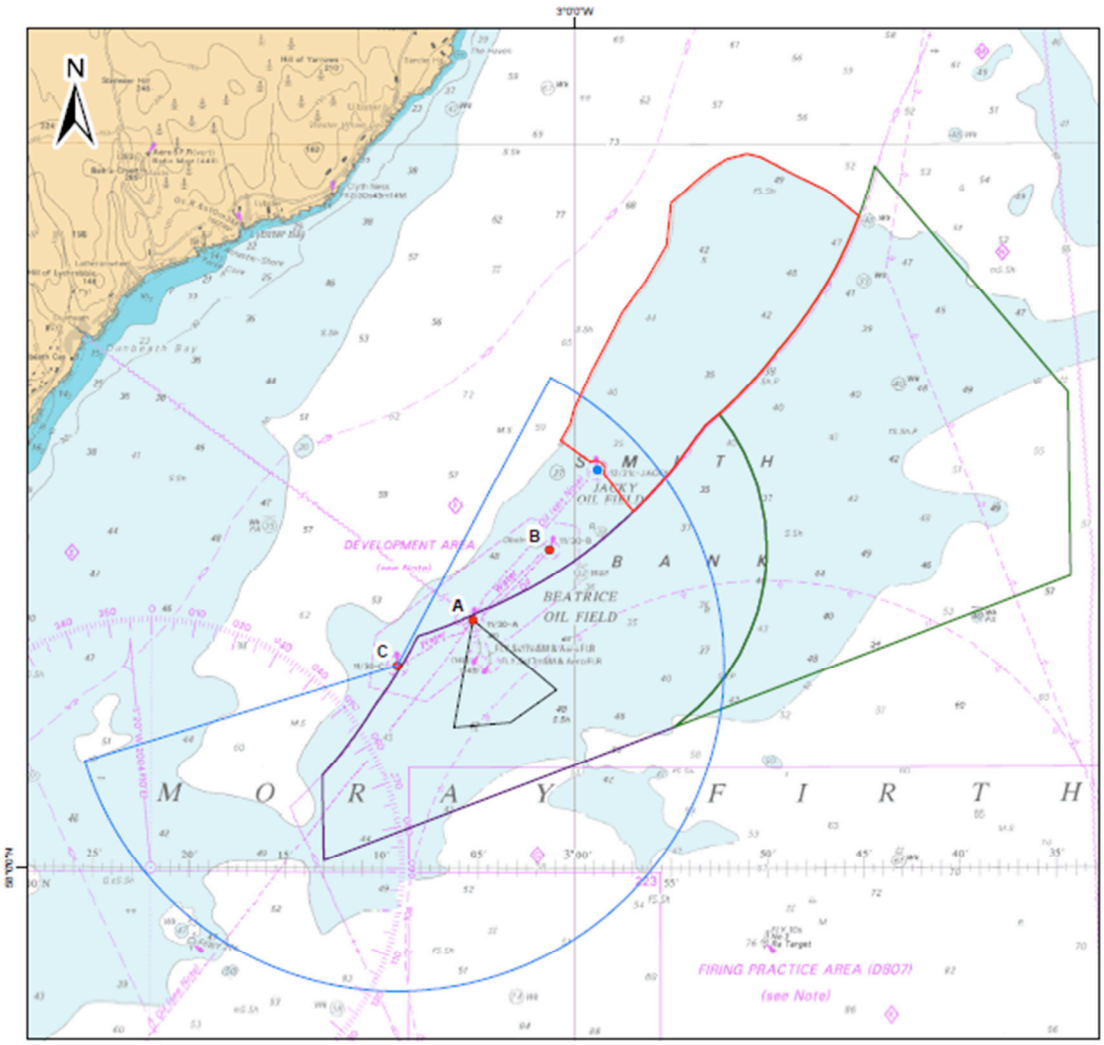

Figure 6-5: Restricted sectors for Beatrice C including BOWL & MORL EDA/WDA

6.2.5 Jacky

6.2.5.1 The cumulative impact of the BOWL, MORL EDA and WDA developments upon Jacky is no greater than the impact of BOWL alone.

6.2.6 Impact on operations of BOWL& MORL EDA/WDA

6.2.6.1 To assess the cumulative impact of constraints upon the operations in the Beatrice field it is necessary to bring together the existing and BOWL & MORL EDA/WDA restrictions outlined above, the weather conditions in-field and a representative flight schedule as outlined above.

6.2.6.2 The impact is therefore expected to be as outlined in Table 6-9 below.

	BOWL& MORL EDA/WDA situation (Wick data)	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by BOWL & MORL EDA/WDA**
Beatrice A	3.2% (~5 flights p.a.)	2.2% (~3-4 flights p.a.)
Beatrice B	0.7% (~1 flight in 2 years)	5.1% (~3-4 flights p.a.)
Beatrice C	3.1% (~1 flight in 2 years)	2.2% (~1 flight in 2 years)
Jacky	0.1% (negligible)	7.7% (~1 flight p.a.)

Table 6-9: Summary of BOWL & MORL EDA/WDA impact (Wick data)

6.2.6.3 As before, where it is indicated that approaches would be restricted or prevented that does not in itself mean that a flight will be totally prevented. Similarly to the mitigation of delaying a flight, the other identified mitigations have not been considered in the analysis above. On this basis, with no mitigations applied the impact would be such that around nine to ten additional flights per annum would be prevented.

6.2.6.4 For comparison, using the Lossiemouth meteorological data, the cumulative impact of BOWL and MORL EDA + WDA is estimated to be as follows:

	BOWL& MORL EDA + WDA situation (Lossiemouth data)	
Destination	**Total flights prevented by existing obstructions**	**Additional flights prevented by BOWL & MORL EDA + WDA**
Beatrice A	1.8% (~3 flights p.a.)	1.2% (~2 flights p.a.)
Beatrice B	1.3% (~1 flight p.a.)	1.3% (~1 flight p.a.)
Beatrice C	1.0% (~1 flight in 5 years)	1.8% (~1 flight in 3 years)
Jacky	0.8% (~1 flight in 10 years)	2.8% (~1 flight in 2 years)

Table 6-10: Summary of BOWL & MORL EDA + WDA impact (Lossiemouth data)

6.2.6.5 Leaving aside the impact on ARAs to the Jacky platform, the Lossiemouth data indicate that, with no mitigations applied, the cumulative impact of BOWL and MORL EDA and WDA would be such that approximately three to four additional flights per annum would be prevented, over and above the restrictions caused by existing obstructions.

6.2.6.6 The impact of BOWL plus MORL on missed approaches will be significant, driven primarily by the presence of the WDA to the south of the platforms. The constraints on missed approaches from ARAs to the Alpha are summarised in Table 6-11below.

ARA final approach track (°T)	007-034	035-083	084-090	091-121	122-144	145-150 (approx)	151-190	191-194	195-205	206-247	248-305	306-006
Missed approach turn direction available	ARA not possible due MORL WDA occupying FAT sector	ARA not possible due Beatrice C within 1nm of FAT	Left only (R prevented by Demo Tbns sector)	Left only (R prevented by Demo Tbns sector)	Left only (with turn required to avoid B)	Left or right (with turns required to avoid B or C)	Right only (L prevented by MORL WDA)	Right only (L prevented by MORL WDA + Demo Tbns sector)	ARA not possible due BOWL within 1nm of FAT	ARA not possible due Beatrice B within 1nm of FAT	ARA not possible due MORL WDA occupying FAT sector	ARA not possible due Demo Turbines restricted zone
Constraints on straight climb-out after 45° initial turn			None (Jacky and BOWL at 5nm+)	Beatrice B	Beatrice B	Beatrice B to left Beatrice C to right	Beatrice C	None				

Table 6-11: Beatrice A ARA missed approach constraints (future BOWL, MORL EDA/WDA)

6.2.6.7 The impact of BOWL plus MORL on departures would be significant, again driven primarily by the presence of the WDA to the south of the platforms.

7 Mitigations

7.1 Overview

7.1.1 There are a range of operational measures available to helicopter flight crews in order to overcome the restrictions imposed by the wind farms. Specific examples for each platform are outlined below.

7.2 Beatrice Alpha

7.2.1 Instrument approaches

7.2.1.1 The impact of the BOWL and MORL developments is to restrict approaches to Alpha from a 105 degree wide range located to the east of the platform. The MORL WDA adds a further 27 degree wide restriction to the south-east of the platform. On top of this a further 60 degree restriction from the existing demonstrator turbines and other restrictions from the other platforms. This leaves approaches from a 112 degree sector from the west of Alpha through to the north.

7.2.1.2 The mitigations to Alpha would consist of a range of measures already practised in the offshore environment:

- ARA slightly out of wind – the ARA procedure offers the flexibility to accept a slightly out of wind approach track of up to 30 degrees, cross wind permitting. At 30 degrees out of wind the aircraft will experience 50% of the wind as a cross wind component. With the aircraft being able to accept 20-25 kts of cross wind such approaches would be possible in wind speeds of 40-50 kts. The Wick meteorological data show a maximum recorded wind speed of 60kts knots. The Lossiemouth meteorological data show a maximum recorded wind speed of 37 knots. This suggests that ARAs flown up to 30° out of wind would mostly be within the aircraft's crosswind limits. It should be noted that previous safety assessments had suggested that for GPS ARA procedures the maximum out of wind heading should be limited to 20 degrees due to the errors inherent in GPS and weather radar. This recommendation, along with other factors will also come into consideration, but this would in theory allow ARA approaches to Alpha from the north-east down one side of the BOWL/MORL development in a wide range of south-westerly wind conditions.

- Circling approach – an ARA undertaken more than 30° out of wind is known as a circling approach. Such an approach provides complete flexibility in approach track. However, in order to position the aircraft into wind to land safely at the end of the approach, to reduce speed and achieve the correct configuration, additional time is required. This additional time results in the need for a higher cloud base and increased visibility conditions than for a standard ARA.

- Shuttling – typically, prior to the BOWL & MORL development, it would be practical to shuttle to Alpha from Bravo when the wind is from the south-west, and from Charlie when it is from the north-east. Shuttling from Charlie will still be a practical proposition. However, shuttling from Bravo is unlikely to be practical.

7.2.1.3 The additional complication for the instrument approach is the need to be able to undertake a missed approach with an engine inoperative. In such a situation the climb performance of the aircraft can be greatly degraded. The worst case needing protection is when the engine fails at the missed approach point when the aircraft is heading towards the BOWL/MORL development. In the case of the Alpha

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platform an engine failure at the missed approach point would occur at 300ft and with the aircraft already at or above a safe speed for engine inoperative manoeuvring. It is expected that the direction of the missed approach will be agreed prior to the approach so that it will be flown away from the wind farms. Under some circumstances crews will have to accept that missed approaches can only be flown to one side of the approach track.

7.2.2 Visual approaches

7.2.2.1 Visual approaches will have greater flexibility in the selection of approach tracks to avoid the turbines, as is currently the situation. Furthermore, obstacle clearance requirements are reduced due to the ability of the crew to visually avoid obstacles. The mitigations foreseen above for instrument approaches are expected to provide adequate mitigation for visual approaches made in-field.

7.2.3 Departures

7.2.3.1 Engine inoperative departures from Alpha in IMC need to be safely protected. However, they ideally require that aircraft initially climb with a headwind component and subsequently initiate any necessary turn away from the wind farm when at 500ft and 80kts. On the basis of calculations undertaken by Bond Helicopters (for a hot day with low pressure) this will require 9.3km from the helideck to be clear of turbines (including a 1.5km safety buffer). The separation between the Alpha helideck and the BOWL development is 9.8km and between the Alpha and the MORL EDA is 11km. However, the separation to the MORL WDA is likely to be a minimum of 1.5nm (2.8km) therefore there may need to be additional restrictions imposed upon the wind conditions within which IMC departures can take place.

7.2.3.2 It has been indicated that when the weather conditions are such that a departure towards the wind farms would be preferable there is insufficient separation between the Alpha platform and the MORL WDA turbines for the aircraft to reach safe, engine inoperative manoeuvring speed. The options to address this issue are:

- Accept a smaller head-wind component by adopting a heading with some head-wind, but largely clear of the wind farm;
- Accept that in certain strong winds from the north-east through to south, departures from the platform will be limited. For example, a 25kt restriction on departures could apply, as was the recent situation when the Bravo helideck had a broken perimeter net;
- Restrict the weight of the aircraft to allow a climb performance that will enable manoeuvring much closer to the helideck – however it has been suggested that the weight restrictions needed to achieve the performance needed on a single engine would impose significant restrictions on operations; or
- Accept that manoeuvring may be necessary below 500ft once the aircraft has established a positive rate of climb.

7.3 Beatrice Bravo

7.3.1 Instrument approaches

7.3.1.1 The impact of the BOWL development is to restrict approaches to Bravo from a 99 degree wide range located to the north-east of the platform.

7.3.1.2 The mitigations to access Bravo would consist of a range of measures already practiced in the offshore environment, and as outlined above:

- ARA slightly out of wind – Clearly, other factors will also come into consideration, but this technique would in theory narrow the range of 'lost sectors' for ARA approaches to Bravo from 99 degrees to perhaps 40 – 50 degrees.
- Circling approach – Circling approaches are likely to feature heavily at the Bravo platform if direct approaches are required.
- Shuttling – typically, prior to the BOWL & MORL developments, it would be practical to shuttle to Bravo from Alpha when the wind is from the south-west, and from Jacky when it is from the north-east. Shuttling from Alpha will still be a practical proposition, but the operators have expressed a desire not to shuttle between multiple platforms (e.g. Charlie – Alpha – Bravo) in order to reach their destination. Shuttling from Jacky will no longer be an option.

7.3.1.3 Combined together these procedures should allow crew to partially mitigate the impact of the BOWL/MORL developments for access to the Bravo platform.

7.3.1.4 The additional complication for the instrument approach is the need to be able to undertake a missed approach with an engine inoperative. In such a situation the climb performance of the aircraft can be greatly degraded. The worst case needing protection is when the engine fails at the missed approach point when the aircraft is heading towards the BOWL/MORL development. In the case of the Bravo platform an engine failure at the missed approach point would occur at 300ft and with the aircraft above a safe speed for engine inoperative manoeuvring. It is expected that the direction of the missed approach will be agreed prior to the approach so that it will be flown away from the wind farms. Under some circumstances crews will have to accept that missed approaches can only be flown to one side of the approach track. This is already the case at the Bravo platform due to the restrictions imposed by the Jacky and Alpha platforms and the Demonstrator Turbines restricted zone. The construction of the BOWL, MORL EDA and particularly MORL WDA wind farms is likely to require some missed approaches from ARAs to the Bravo to continue the missed approach turn until the helicopter can be established on a track clear of obstacles.

7.3.2 Visual approaches

7.3.2.1 Visual approaches will have greater flexibility in the selection of approach tracks to avoid the turbines as is currently the situation. Furthermore, obstacle clearance requirements are reduced due to the ability of the crew to visually avoid obstacles. The mitigations foreseen above for instrument approaches are expected to provide adequate mitigation for visual approaches made in-field.

7.3.3 Departures

7.3.3.1 Engine inoperative departures from the Bravo helideck in IMC conditions need to be safely protected. However, they ideally require that aircraft initially climb with a headwind component and subsequently initiate any necessary turn away from the wind farm when at 500ft and 80kts. On the basis of calculations undertaken by Bond Helicopters (for a hot day with low pressure) this will require 9.3km from the helideck to be clear of turbines (including a 1.5km safety buffer). The separation between the Bravo helideck and the BOWL development is 4.6km. The separation to the MORL WDA is likely to be a minimum of 1.5nm (2.8km).

7.3.3.2 With stronger winds from the north-east it has been suggested that in the event of an engine failure after moving off the helideck the crew may fly the aircraft to the left or right of the platform before turning into wind. If this is reasonable in IMC then it is possible that the aircraft could be on a heading more or less directly into the wind farm. Fortunately, strong winds from the north-east do not appear to be frequent so that the BOWL development is not likely to be too problematic for departures.

7.3.3.3 It has been indicated that when the weather conditions are such that a departure towards the wind farms would be preferable there is insufficient separation between the Bravo platform and the BOWL/MORL WDA turbines for the aircraft to reach safe, engine inoperative manoeuvring speed. The options to address this issue are:

- Accept a smaller head-wind component by adopting a heading with some head-wind, but largely clear of the wind farm;
- Accept that in certain strong winds from the north-east through to south, departures from the platform will be limited. For example, a 25kt restriction on departures could apply, as was the recent situation when the Bravo helideck had a broken perimeter net. Fortunately analysis of Met data shows that strong winds from the north-east are rare;
- Restrict the weight of the aircraft to allow a climb performance that will enable manoeuvring much closer to the helideck – however it has been suggested that the weight restrictions needed to achieve the performance needed on a single engine would impose significant restrictions on operations; or
- Accept that manoeuvring may be necessary below 500ft once the aircraft has established a positive rate of climb. If it is realistic to manoeuvre the engine inoperative aircraft to avoid the immediate risk posed by the Bravo platform just to orient into wind then a manoeuvre to avoid the wind turbine may be equally justifiable.

7.4 Beatrice Charlie

7.4.1 Instrument approaches

7.4.1.1 Beatrice Charlie is minimally impacted by the BOWL development due predominantly to the current restricted sector imposed by the demonstrator turbines. However, the MORL WDA is close to the south of the platform leaving access limited to a 137 degree sector from the west to north-east.

7.4.1.2 The mitigations to access Charlie would consist of a range of measures already practiced in the offshore environment, and as outlined above:

- <u>ARA slightly out of wind</u> – Clearly, other factors will also come into consideration, but this technique would in theory narrow the range of 'lost sectors' for ARA approaches to Charlie. For example, accepting up to 20 degrees out of wind on an ARA would provide an additional 40 degrees of approach headings.
- <u>Circling approach</u> – Circling approaches are likely to feature at the Charlie platform if direct approaches are required.
- <u>Shuttling</u> – typically, prior to the BOWL & MORL developments, it would be practical to shuttle to Bravo from Alpha when the wind is from the south-west, and from Jacky when it is from the north-east. Shuttling from Alpha via Charlie

will still be a practical proposition, but the operators have expressed a desire not to shuttle between multiple platforms (e.g. Charlie – Alpha – Bravo) in order to reach their destination. Shuttling from Jacky will no longer be an option.

7.4.1.3 Combined together these procedures should allow crew to partially mitigate the impact of the BOWL/MORL development for access to the Charlie platform.

7.4.1.4 The additional complication for the instrument approach is the need to be able to undertake a missed approach with an engine inoperative. In such a situation the climb performance of the aircraft can be greatly degraded. The worst case needing protection is when the engine fails at the missed approach point when the aircraft is heading towards the BOWL/MORL development. In the case of the Charlie platform an engine failure at the missed approach point would occur at 300ft and with the aircraft above a safe speed for engine inoperative manoeuvring. It is expected that the direction of the missed approach will be agreed prior to the approach so that it will be flown away from the wind farms. Under some circumstances crews will have to accept that missed approaches can only be flown to one side of the approach track, as is already the case due to existing obstacles.

7.4.2 Visual approaches

7.4.2.1 Visual approaches will have greater flexibility in the selection of approach tracks to avoid the turbines as is currently the situation. Furthermore, obstacle clearance requirements are reduced due to the ability of the crew to visually avoid obstacles. The mitigations foreseen above for instrument approaches are expected to provide adequate mitigation for visual approaches made in-field.

7.4.3 Departures

7.4.3.1 Engine inoperative departures from Charlie in IMC need to be safely protected. However, they ideally require that aircraft initially climb with a headwind component and subsequently initiate any necessary turn away from the wind farm when at 500ft and 80kts. On the basis of calculations undertaken by Bond Helicopters (for a hot day with low pressure) this will require 9.3km from the helideck to be clear of turbines (including a 1.5km safety buffer). The separation to the BOWL development is 7.7nm (14.2km) and to the MORL EDA is 6nm (11.1km). The separation to the MORL WDA is likely to be a minimum of 1.5nm (2.8km) therefore there may need to be additional restrictions imposed upon the wind conditions within which IMC departures can take place.

7.4.3.2 It has been indicated that when the weather conditions are such that a departure towards the wind farms would be preferable there is insufficient separation between the Charlie platform and the MORL WDA turbines for the aircraft to reach safe, engine inoperative manoeuvring speed. The options to address this issue are:

- Accept a smaller head-wind component by adopting a heading with some head-wind, but largely clear of the wind farm;
- Accept that in certain strong winds from the north-east through to south, departures from the platform will be limited. For example, a 25kt restriction on departures could apply, as was the recent situation when the Bravo helideck had a broken perimeter net;
- Restrict the weight of the aircraft to allow a climb performance that will enable manoeuvring much closer to the helideck – however it has been suggested

that the weight restrictions needed to achieve the performance needed on a single engine would impose significant restrictions on operations; or

- Accept that manoeuvring may be necessary below 500ft once the aircraft has established a positive rate of climb.

7.5 Jacky

7.5.1 Instrument approaches

7.5.1.1 The impact of the BOWL/MORL development is to restrict instrument approaches to Jacky from all approach headings due to the proximity of turbines. The mitigation is to operate to the platform in visual conditions where the aircraft will be able to undertake all manoeuvres, including the early stages of a missed approach, with good sight of the wind farm. The minima may not need to be as stringent as full VMC such that shuttling from Bravo could still be undertaken under certain weather conditions.

7.5.2 Visual approaches

7.5.2.1 To allow safe visual manoeuvring a combination of mitigations is suggested. Firstly, the OFZ for the helideck of any jack-up rig positioned at Jacky should be oriented to the south-west. This is in any event aligned with regulatory best practice for prevailing winds, but also ensures the best accessibility to the helideck.

7.5.2.2 Secondly it is likely to be necessary to keep a radius clear of turbines around the location of a jack-up at Jacky. This is primarily to permit visual circling to land when the wind is from the south-west, where there is the requirement for the pilot handling the landing to always have the platform in sight on the final stage of the approach. It has been suggested that 1.5km clearance from the turbines is required at all times. A rate one turn at 100kts airspeed has a radius less than 1km, so 2.5km will be adequate clearance, particularly if the turn can be tighter in visual conditions.

7.5.3 Departures

7.5.3.1 Due to the proximity of the turbines it is likely that departures are going to be restricted to those weather conditions in which departures into wind can be made away from the BOWL development. There will be insufficient space to allow engine inoperative departures from the helideck in the situation where the wind is blowing from the north-east. Fortunately, analysis of the Met data shows that strong winds from the north-east are rare and departures predominantly into the prevailing wind (ideally to the due west) will be common.

A Glossary, abbreviations and acronyms

AIP	Aeronautical Information Publication
amsl	Above mean sea level
ARA	Airborne Radar Approach
BOWL	Beatrice Offshore Wind farm Limited
CAA	Civil Aviation Authority
FAF	Final Approach Fix. The point at which descent is commenced at the start of the final approach, defined by a radio navigation facility or a specified distance and bearing from such a facility.
FAP	Final Approach Point. The point at which descent is commenced at the start of the final approach.
FAT	Final Approach Track (a compass bearing in degrees)
GPS	Global Positioning System
Heading	The direction in which the aircraft is pointing (a compass bearing in degrees) [see also 'Track']
ICAO	International Civil Aviation Organization – a UN agency which sets the main international standards and recommended practices for aviation.
IEM	Interpretive and Explanatory Material (guidance material in JAR-OPS documents)
IFR	Instrument Flight Rules. The rules governing flight conducted on instruments. They consist of rules on minimum height above terrain, altimeter setting, cruising levels for traffic flying in different directions, the filing of flight plans and air traffic control clearance.
Initial Approach phase	The part of an instrument approach procedure from the Initial Approach fix (usually a radio beacon) to the point at which the aircraft is lined up with the final approach track.
IMC	Instrument Meteorological Conditions. Weather conditions which would preclude flight by the Visual Flight Rules, i.e. conditions where the aircraft is in or close to cloud or flying in visibility less than a specified minimum.
JAA	Joint Aviation Authorities
JAR-OPS	Joint Aviation Requirements for Operations
MAP	Missed Approach Procedure. The actions for the crew of an aircraft to take when an instrument approach procedure is not successful e.g. the crew are unable to see the runway, approach lights or helideck.
MAPt	Missed Approach Point. The location in an instrument approach procedure where, if the crew have not achieved visual contact with the runway, approach lights or helideck, they must initiate a missed approach.
MDA	Minimum Descent Altitude (as measured by a barometric altimeter, referenced to sea level)
MDH	Minimum Descent Height (as measured by a radio altimeter)
MDR	Minimum Decision Range. The distance from the platform at which the helicopter crew must be able to see the platform in order to complete an approach to land, and at which, if they cannot see the platform, they must execute a Missed Approach.

MOC	Minimum Obstacle Clearance (the minimum vertical separation applied between obstacles and an aircraft flying an approach or departure)
MORL	Moray Offshore Renewables Ltd
MSA	Minimum Safe Altitude (under the IFR, the height above sea level of the highest object within 5nm, plus 1000ft, rounded up to the next hundred feet)
NDB	Non-Directional Beacon
nm	Nautical mile. One nautical mile = 6076 feet or 1852 metres.
NUI	Normally unmanned installation
OEI	One Engine Inoperative. The condition when a multi-engined aircraft has had a failure of one engine.
Offset Initiation Point	The point in the later stages of an airborne radar approach at which the helicopter is turned on to a track offset from the Final Approach Track.
okta	A measure of cloud amount. One okta of cloud is one eighth of the sky covered by cloud.
Rate 1	A turn involving a change of heading of 3º per second - the standard rate of turn used during instrument flying.
Track	The path described by an aircraft across the ground. This will differ from the aircraft's heading (q.v.) when a crosswind is present.
VFR	Visual Flight Rules. The rules governing flight conducted visually i.e. with the crew maintaining separation from obstacles and other aircraft visually. They consist principally of rules on minimum visibility and separation from cloud.
WCA	Wind correction angle. The difference between an aircraft's heading and its track, caused by a wind direction which is not aligned with the aircraft's track.

B Derivation of minimum range of turbines from platforms

B.1 It has been assumed for this report that no Airborne Radar Approaches can be flown to any of the Beatrice/Jacky platforms from any sector where there are turbines within a range of 9nm from the platform. This is based in part on the new guidance contained in the Fourth Edition of the CAA's guidance document CAP 764, published in July 2011, but is also derived from calculation of the distance required for a helicopter to descend from the new higher Minimum Safe Altitude dictated by the BOWL and MORL turbines, using the standard descent rates used in the GPS-assisted ARA procedure. This Annex provides an explanation of those calculations.

B.2 In the standard GPS-assisted ARA procedure (see Annex C for the Bond Offshore Helicopters procedure chart), it is assumed that the Initial Approach phase of the procedure is flown at 1,500ft; that descent is initiated when lined up with the Final Approach Track at 7nm from the platform; and that the Minimum Descent Height of 200ft is reached at a range of 2nm from the platform. The rate of the descent is 50ft in the first and last half miles, otherwise 150ft per half mile. This provides for a smoother descent profile and lower cockpit workload. In light of recent incidents the operators are keen to fly stabilised approaches at descent rates that minimise workload. Hence we have not considered any higher descent rates within this report.

B.3 In the BOWL/MORL case, the Initial Approach phase will be flown at 1,700ft. Additionally, ARAs in the Beatrice field differ from the standard in that the MDH (for day VFR) is 300ft. Thus the helicopter must descend 1400ft compared to 1,300ft in the standard procedure.

B.4 Working backwards from 300ft at 2nm, and using a similar descent profile to the standard procedure,[4] the heights at half mile intervals would be as shown below:

---

4 As shown, the start of the descent is rather more gradual than in the standard procedure since the required amount of descent in this case is not divisible into whole 150ft segments.

Range from platform (nm)	Height above sea level (ft)
7.5	1700
7	1650
6.5	1550
6	1400
5.5	1250
5	1100
4.5	950
4	800
3.5	650
3	500
2.5	350
2	300

B.5 The table shows that the helicopter would roll out of the base turn to line up with the FAT at a range of 7.5nm. Working back again from this point, the helicopter will have flown a Rate 1 turn commencing at 7.5nm from the platform. Using a conservative estimate of an 120 knot airspeed for the base turn phase of the approach, the turn will have a radius of 0.64nm.[5] Thus it can be assumed that the helicopter's flight track will take it to a maximum range of 8.14nm from the platform. A turbine free range of 9nm radius from the platform will therefore ensure that helicopters will not overfly turbines at any stage in the ARA given that there will be some margin between the closest turbine and the commencement of the descent.

B.6 It may be possible to reduce the size of the ARA restricted sectors, and therefore reduce the number of flights that would be impacted by BOWL/MORL, by designing the ARA procedure according to standard ICAO procedure criteria in which the Intermediate phase of the approach (lined up with the FAT, flying level, before commencing descent at the Final Approach Point) is flown with a minimum 500ft vertical separation from the turbines, rather than the 1,000ft assumed in this report. This would mean that, at the point where the helicopter descends below 1,200ft (maximum turbine tip height plus 500ft), 1nm horizontal separation must exist from all turbines. From the table above, this would permit ARAs to be flown from sectors where there were turbines located as close as 6.5nm from the platform. On those assumptions, the helicopter would overfly the last turbine at a height of 1,550ft, i.e. with a vertical clearance of some 850ft over the turbine blade tips.

5 The actual ground track of the helicopter in the base turn will be determined by the wind vector in combination with the airspeed.

C Bond Offshore Helicopters GPS-Assisted ARA procedure

GPS - Assisted AIRBORNE RADAR APPROACH

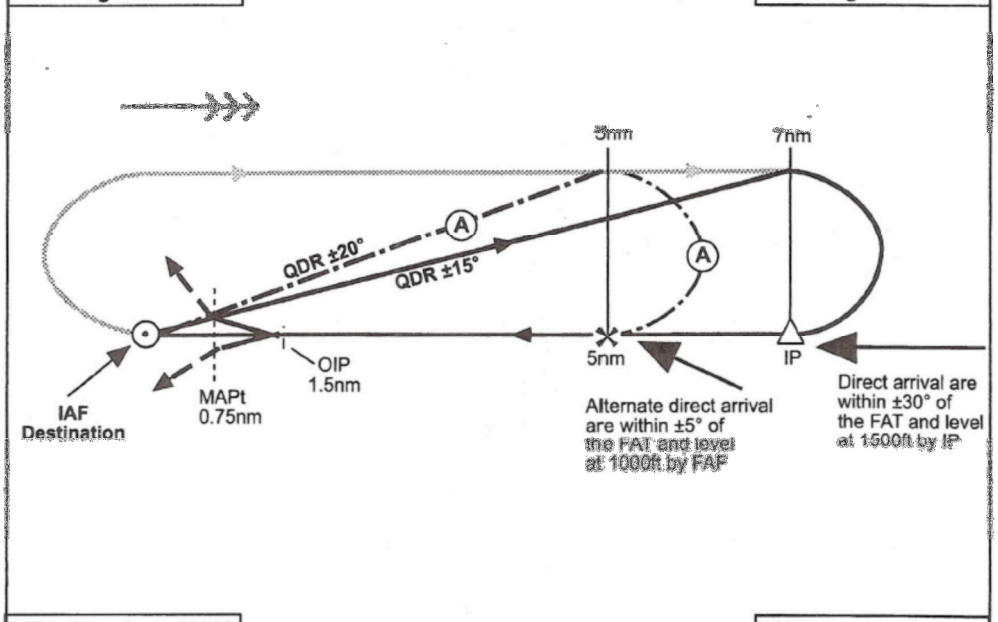
(Bond Offshore Helicopter Ltd.)

L1

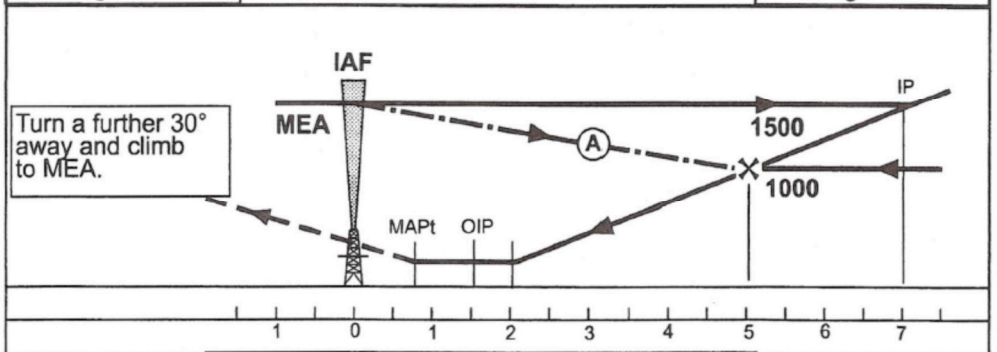
05 MAR 10

NORMAL MINIMA			MAPt 0.75nm	CIRCLING MINIMA (if FAT not into wind ±30°)				
MDH (Radalt)		MDA (Baralt)		MDH (Radalt)		MDA (Bar)	MAPt	
Day 200ft (1)	Night 300ft (1)	Day or Night 500ft		Day 300ft (2)	Night 500ft (3)	Day or Night 500ft (3)	Day 1nm	Night 1.5nm
(1) Or deck height plus 50ft if higher			Max GS on FAT 90kt	(2) Or deck height plus 100ft if higher (3) Or deck height plus 200ft if higher				

MEA: **Rig elev +1000ft** MEA: **Rig elev +1000ft**



MEA: **Rig elev +1000ft** MEA: **Rig elev +1000ft**



G/S (kts)	Time to turn 5nm	Time to turn 7nm
150	2:00	2:48
130	2:18	3:14
120	2:30	3:30
110	2:44	3:49
100	3:00	4:12
90	3:20	4:40
80	3:45	5:15
70	4:17	6:00

1. Below 1000ft fly on Radalt.
2. Below MEA all radar contacts are to be avoided by at least 1nm.
3. Minimum range for the MAPt is 0.75nm.
4. At 1.5nm (OIP) turn away 10°. At 1nm confirm track offset is approx 15°, adjust heading if necessary.
5. If not visual at MAPt (0.75nm) turn a further 30° and climb to MEA.
6. No descent below MDH/A until on correct visual approach profile.
7. If available, NDB may be used to confirm ident / QDR.

Range	Radalt Day	Radalt Night	Baralt
7	1500	1500	1500
6.5	1450	1450	1450
6	1300	1300	1300
5.5	1150	1150	1150
5	1000	1000	1000
4.5	850	850	850
4	700	700	700
3.5	550	550	550
3	400	400	500
2.5	250	300	500
2	200	300	500

Rev: Procedure

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MORAY WEST
OFFSHORE WINDFARM

Radar Propagation Demonstrating

Moray Offshore Windfarm (West) Limited

Technical Appendix 13.3

moray offshore renewables ltd

Environmental Statement

Technical Appendix 5.3 C - Radar Propogation Modelling

edp renewables
powered by nature

REPSOL

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Osprey Consulting Services Ltd

MORL Three Development Sites: Radar Line of Sight Assessment

Methodology

This letter describes the methodology and results of the radar line of sight assessment carried out by Osprey.

Osprey used the ATDI ICS Basic Version 10 tool to model the terrain elevation profile between the given radar and each wind turbine point. Otherwise known as a point-to-point line of sight analysis the result is a graphical representation of the intervening terrain and the direct signal line of sight (taking into account earth curvature and radar signal properties).

Caveat: This is a limited and theoretical desk based study; in reality there are unpredictable levels of signal diffraction and attenuation within a given radar environment that can influence the probability of a turbine being detected. Our analysis is designed to give an indication of the likelihood of the turbine being detected such that the ***operational*** *significance of the wind farm relative to nearby aviation assets can be assessed.*

The qualitative definitions used in our assessment are defined in Table 1 below.

Result	Definition
Yes	the turbine is highly likely to be detected by the radar: direct line of sight exists between the radar and the turbine
Likely	the turbine is likely to be detected by the radar at least intermittently
Unlikely	the turbine is unlikely to be detected by the radar but cannot rule out occasional detection
No	the turbine is unlikely to be detected by the radar as significant intervening terrain exists

Table 1 Qualitative Definitions of line of sight results

The figures in this assessment show the line of sight terrain elevation profile between the PSR (left of the diagram) and the blade tips of a 204m turbine at the given coordinates. The grey area represents the intervening terrain. The direct line of sight is represented by the red straight line and the orange ellipse around the signal is known as the 1st Fresnel zone. The Fresnel zone is an area around the direct line of sight where the signal remains strong; Osprey looks at the degree to which the direct line of sight and the Fresnel ellipse are blocked by the terrain in order to make a qualitative assessment of the likelihood that turbines will be detected.

Figure 1 below gives the locations of the points assessed for theoretical radar detectability with regard to the identified aviation stakeholder radar systems. The complete sets of Line of Sight profiles are contained in Annex A at the end of this report.

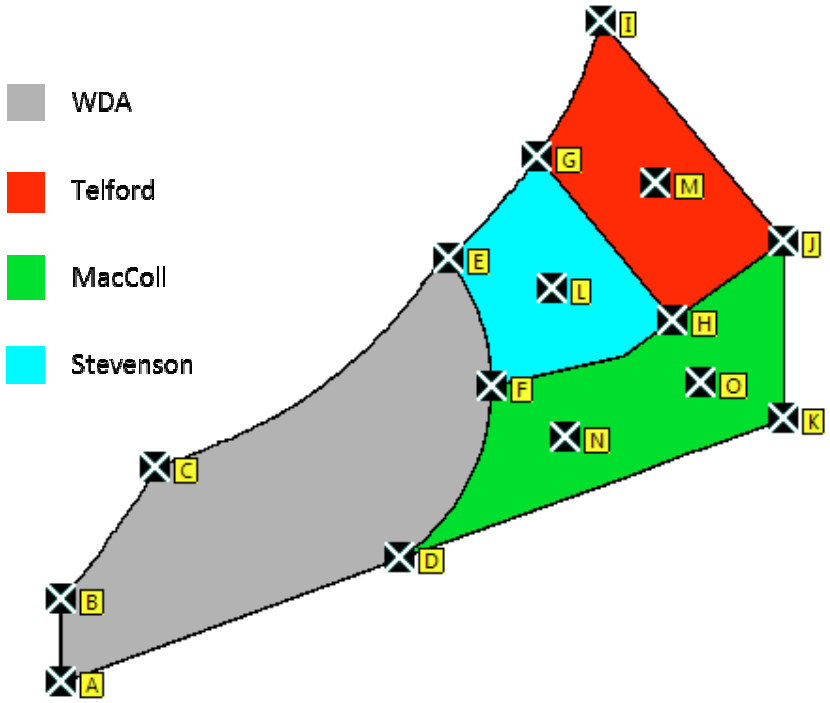


Figure 1 Turbine Theoretical Detectability - Assessed Points

For reference, points A-C are not considered as constituent points of the three proposed wind farm sites as they lie within the Western Development Area, and are not included in further analysis.

Table 2 below indicates whether the radars will theoretically detect the individual turbines at a maximum blade tip height of 204m. The results for Buchan ADR are presented illustratively overleaf in Figure 2.

Turbine Location	NERL Allanshill PSR	ASACS Buchan ADR	RAF Lossiemouth PSR
D	Yes	No	Yes
E	Yes	No	Yes
F	Yes	No	Yes
G	Yes	Unlikely	Yes
H	Yes	Likely	Yes
I	Yes	Unlikely	Likely
J	Yes	Likely	Yes
K	Yes	Likely	Yes
L	Yes	No	Yes
M	Yes	Likely	Yes
N	Yes	No	Yes
O	Yes	Likely	Yes

Table 2 Theoretically Detectability - maximum blade tip height of 204m

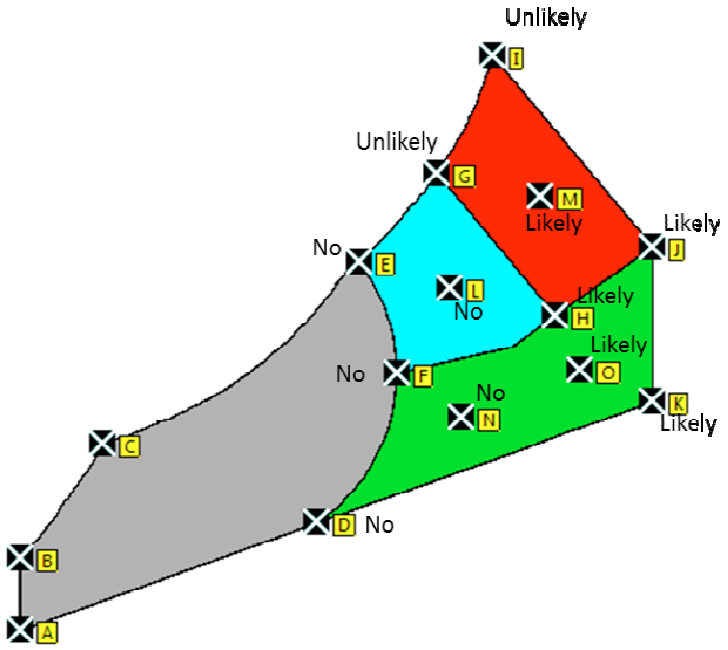


Figure 2 Buchan ADR Turbine Theoretical Detectability - Assessed Points with Results

Breakdown by Aviation Stakeholder

NERL Allanshill PSR

An assessment was completed to ascertain the likelihood of the MORL development having the potential to be detected by the NERL Allanshill PSR.

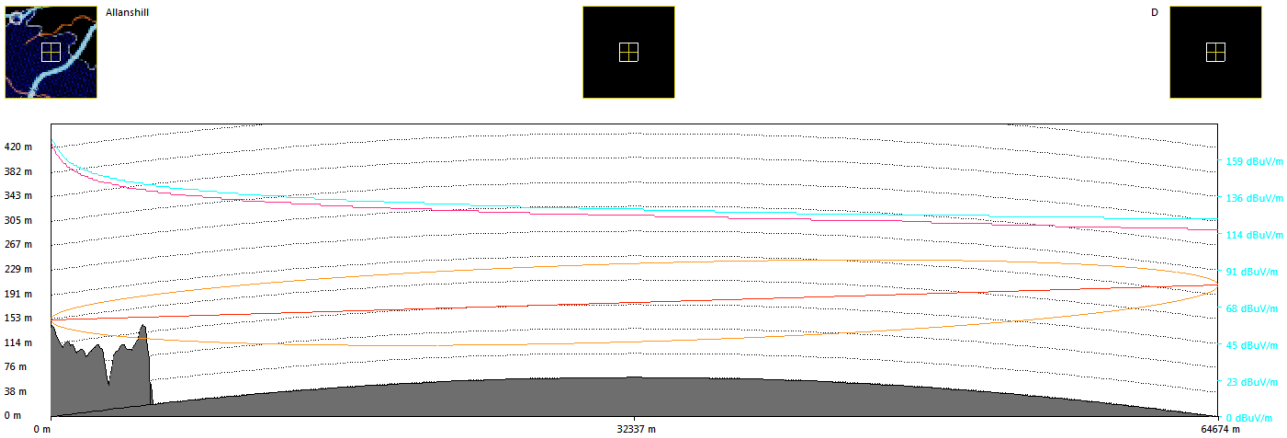


Figure 3 Terrain elevation profile Allanshill PSR to MORL Point D

Figure 3 shows that the direct line of sight, the red line, is unobstructed. The turbine will, in theory, be detected by the Allanshill PSR. The result is indicative of the results of line of sight assessments for Points D-O.

ASACS Buchan ADR

An assessment was also completed to ascertain the likelihood of the MORL development having the potential to be detected by the ASACS Buchan ADR.

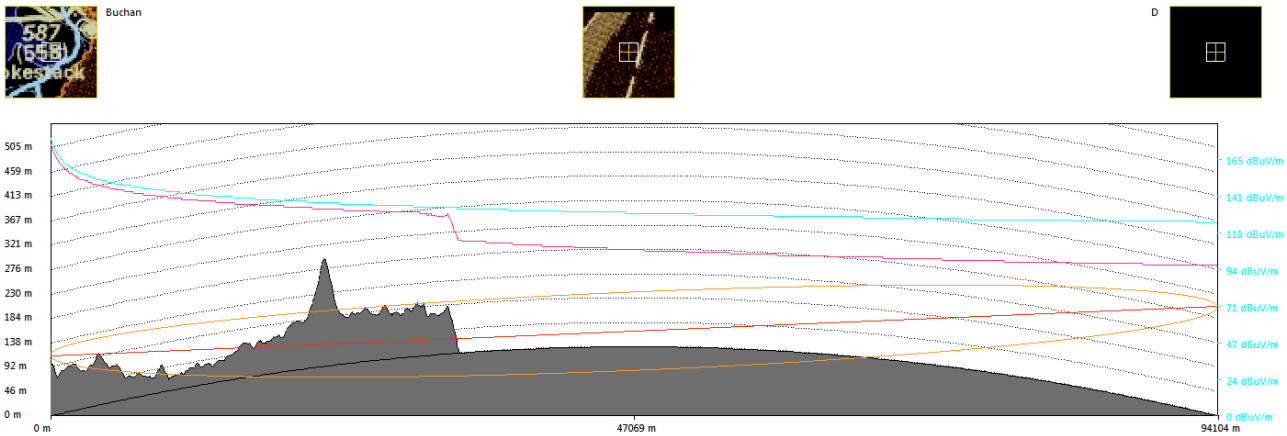


Figure 4 Terrain elevation profile Buchan ADR to MORL Point D

Figure 4 shows that the direct line of sight, the red line, is obstructed. The turbine will, therefore, not be detected by the Buchan ADR. The result is indicative of the results of line of sight assessments for Points D-F and Points L and N. Points H, J, K, M and O are theoretically likely to be detected by the radar at least intermittently. Points G and I are unlikely to be theoretically detected by the radar, but cannot rule out occasional detection.

RAF Lossiemouth

A similar assessment was completed with regard to the potential for the development to be detected by the Lossiemouth PSR.

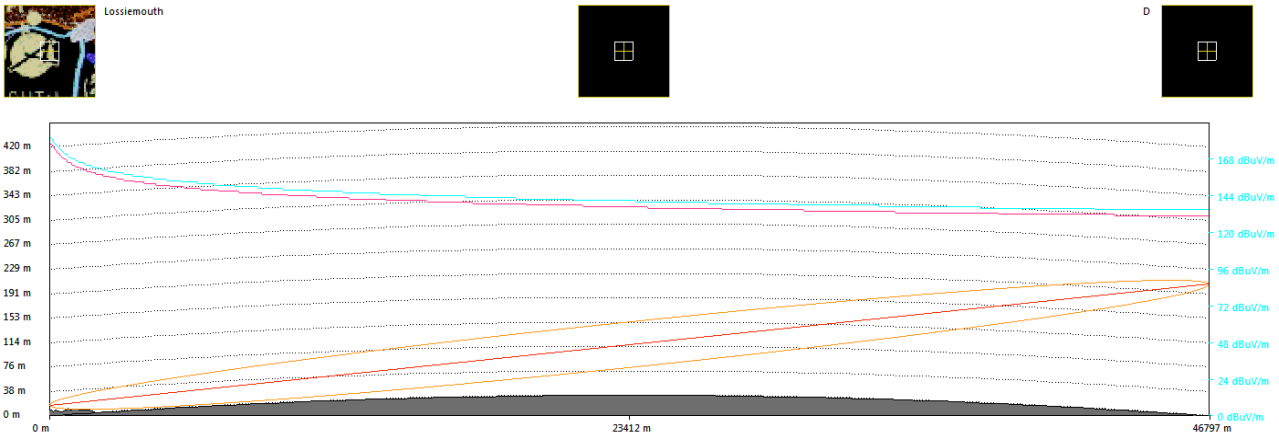
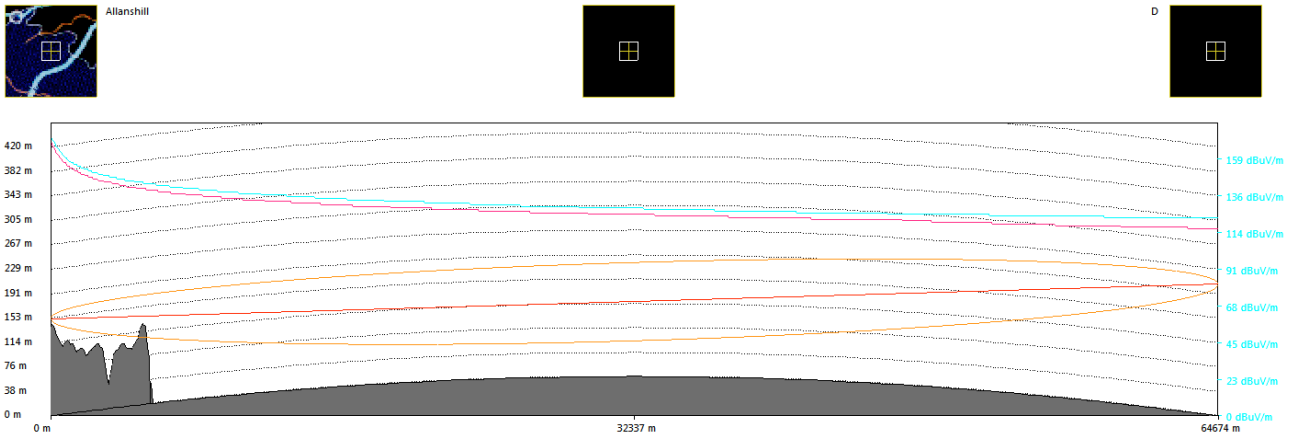


Figure 5 Terrain elevation profile Lossiemouth PSR to MORL Point D

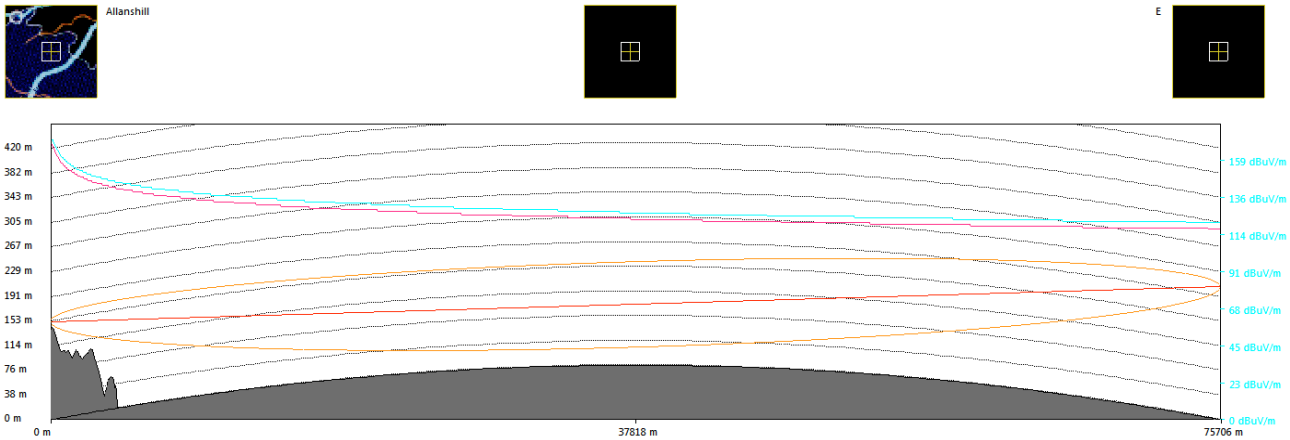
Figure 5 shows that the direct line of sight, the red line, is unobstructed. The turbine will therefore be theoretically detected by the Lossiemouth PSR. The result is indicative of the results of line of sight assessments for Points D-H and Points J-O. Point I is theoretically likely to be detected by the radar at least intermittently.

Annex A – Turbine Location Point - Theoretical Detectability to Radar

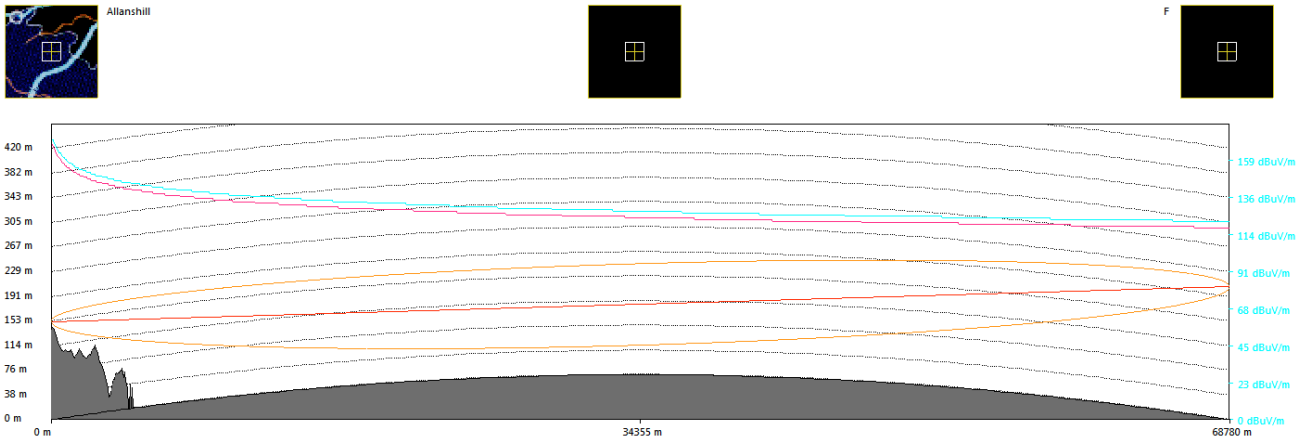
NERL Allanshill PSR



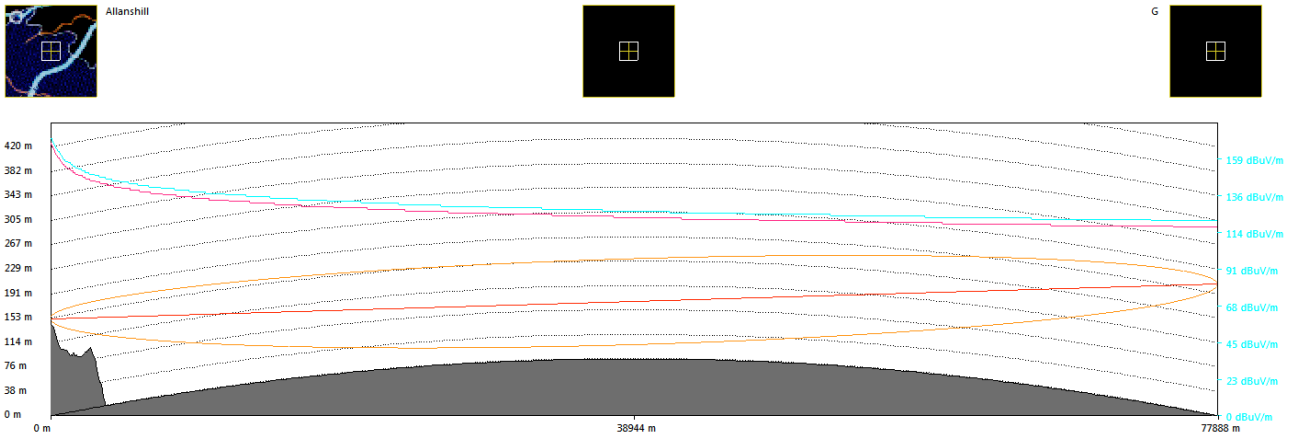
Terrain elevation profile Allanshill PSR to MORL Point D



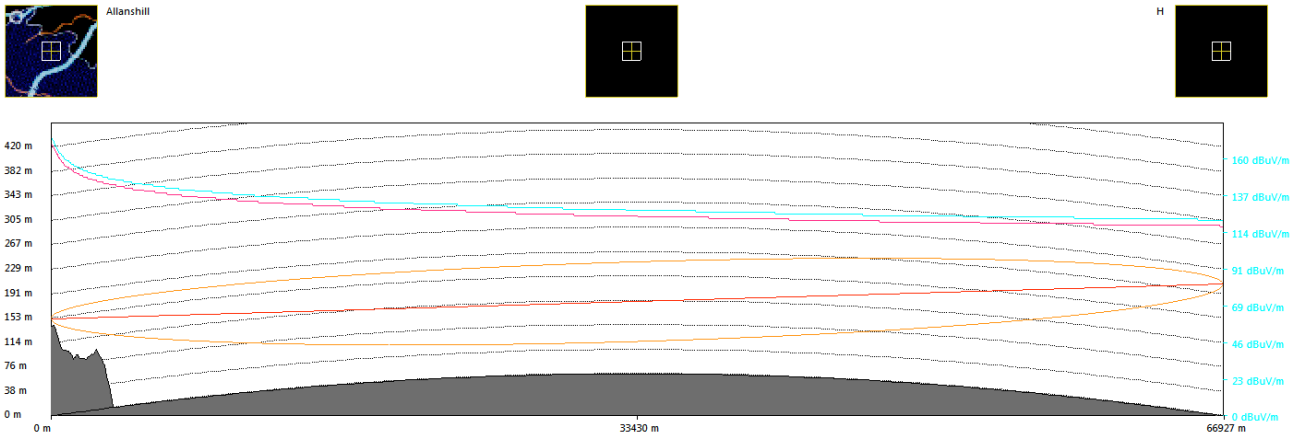
Terrain elevation profile Allanshill PSR to MORL Point E



Terrain elevation profile Allanshill PSR to MORL Point F



Terrain elevation profile Allanshill PSR to MORL Point G



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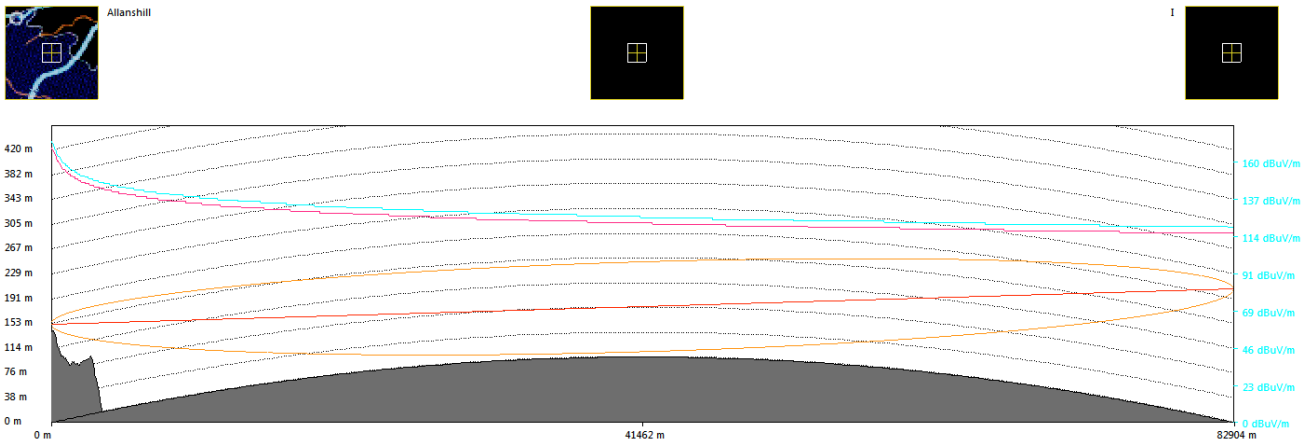

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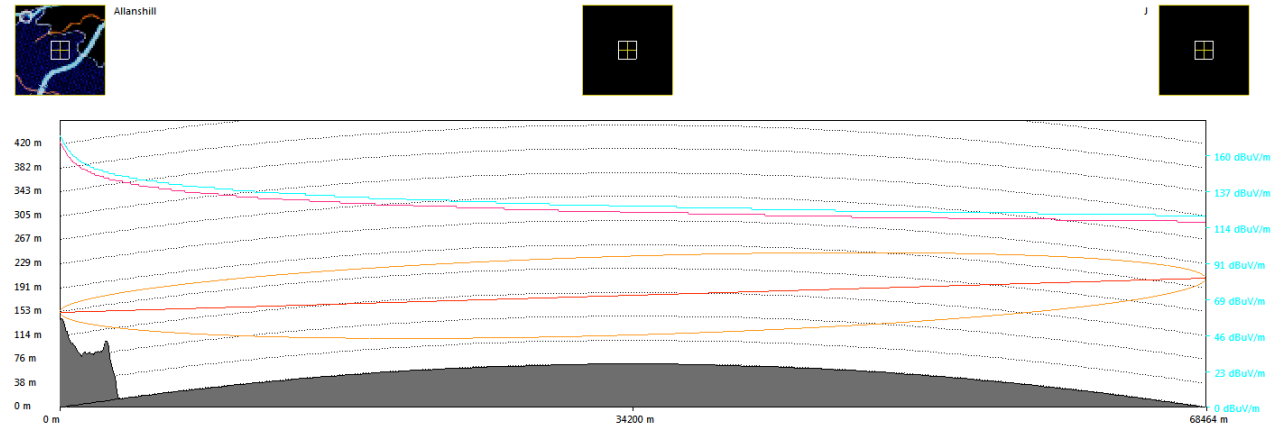

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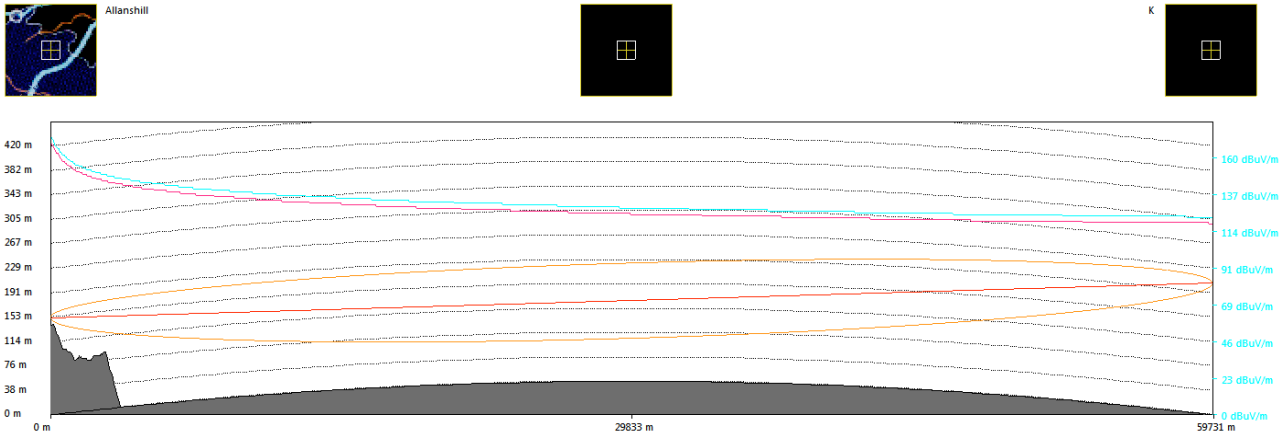

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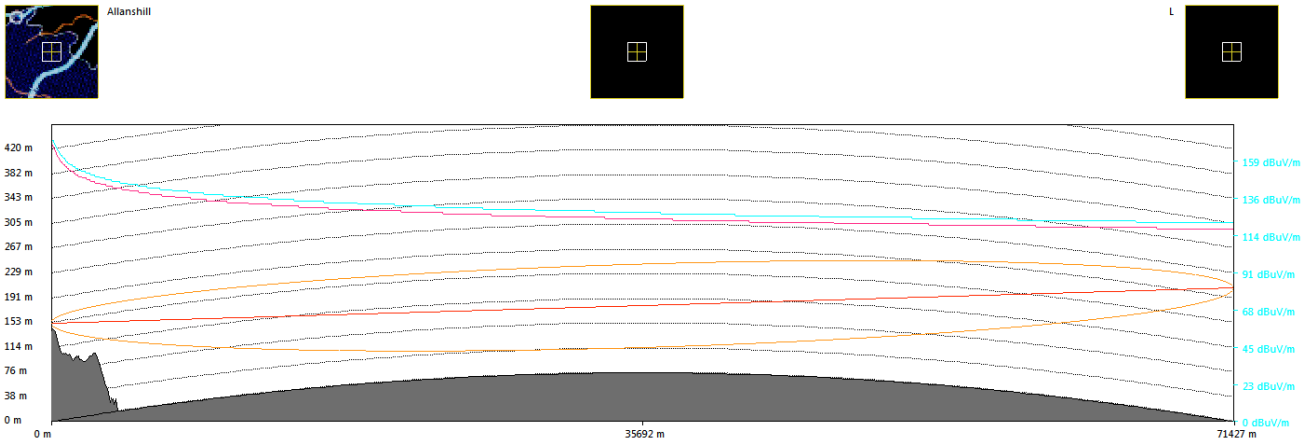

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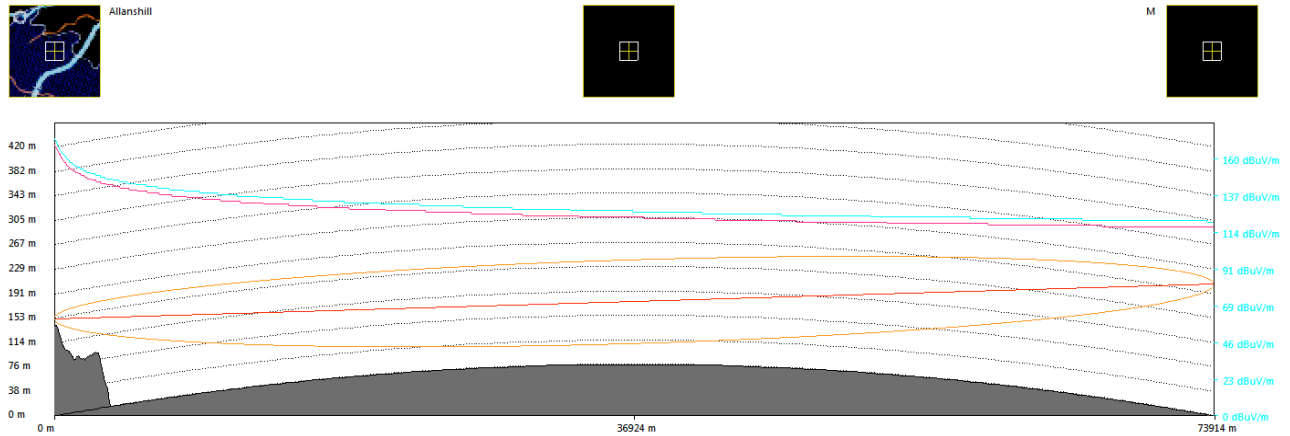
APPENDIX 5.3 C



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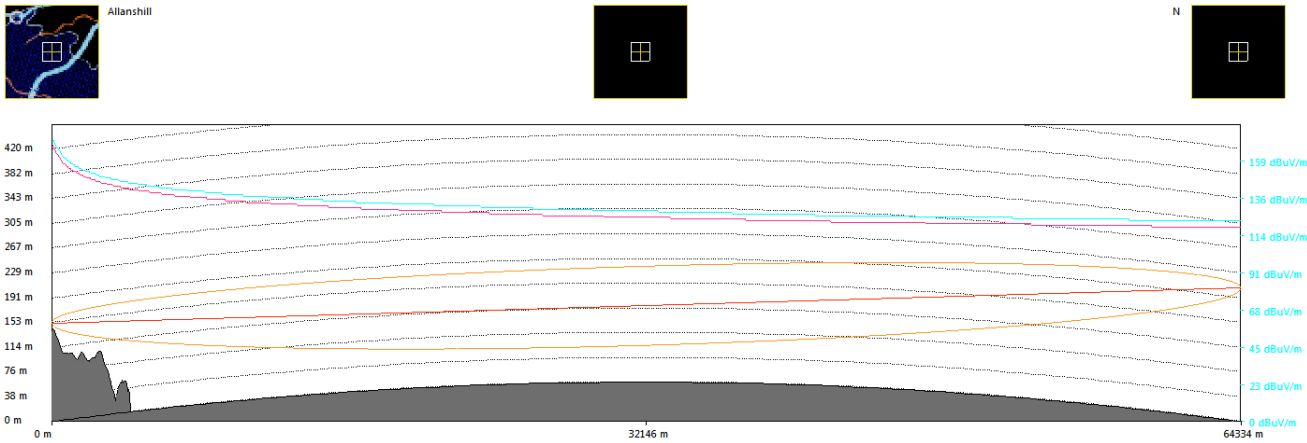

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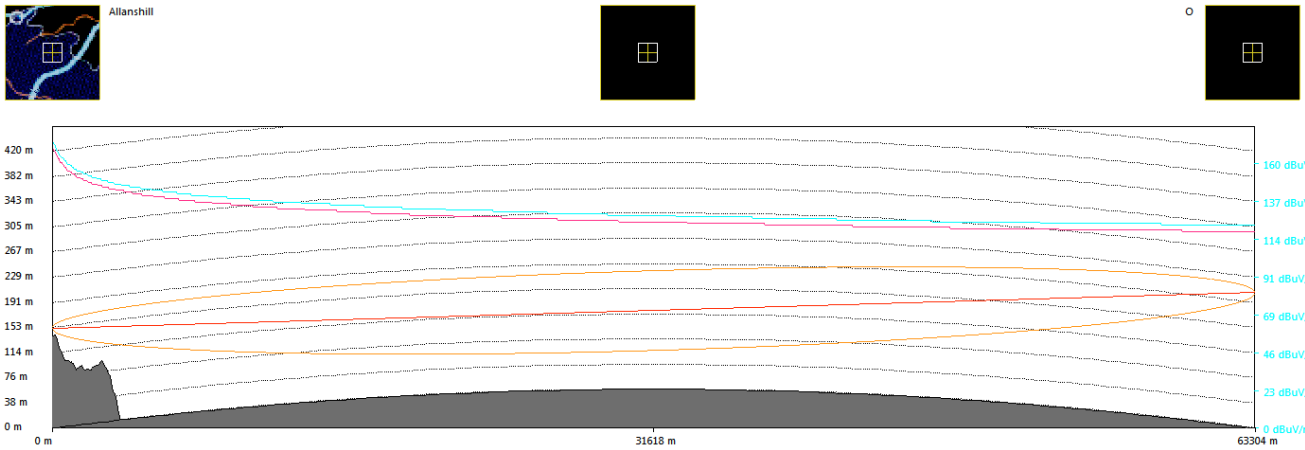

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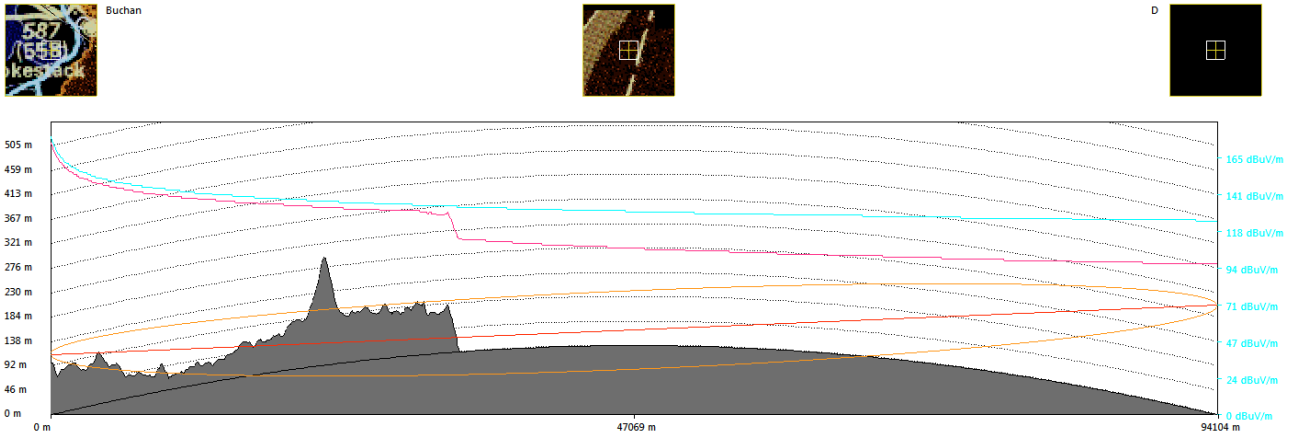

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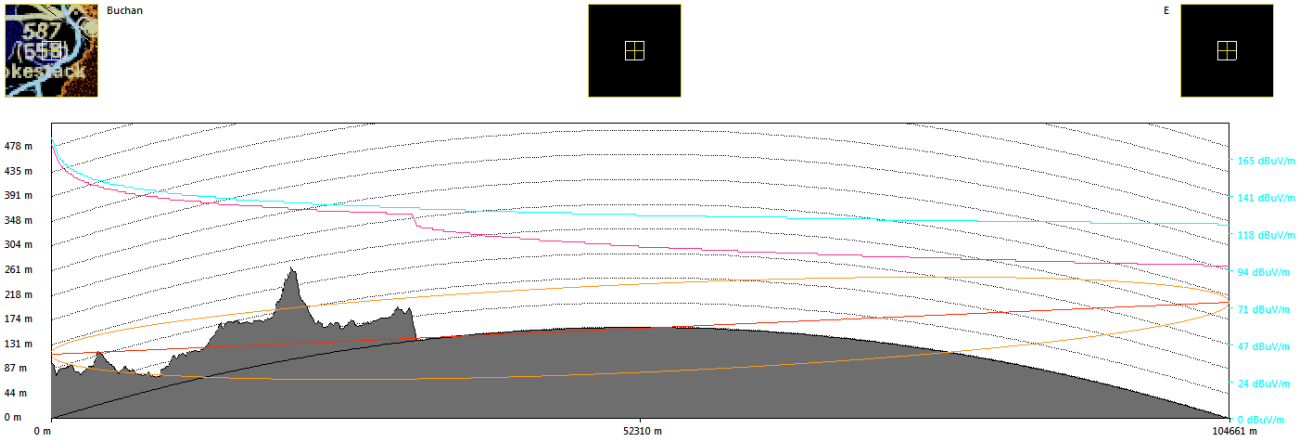

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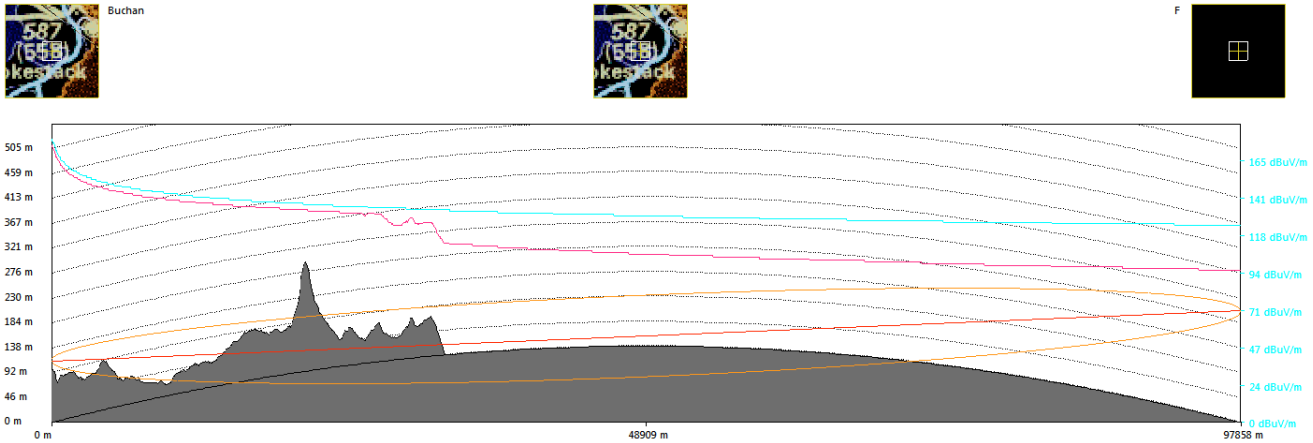

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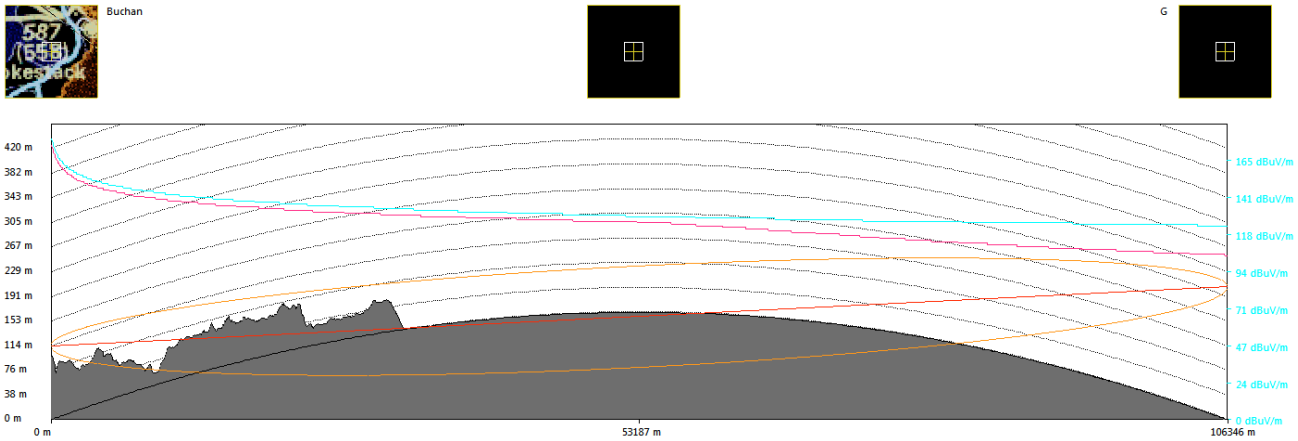

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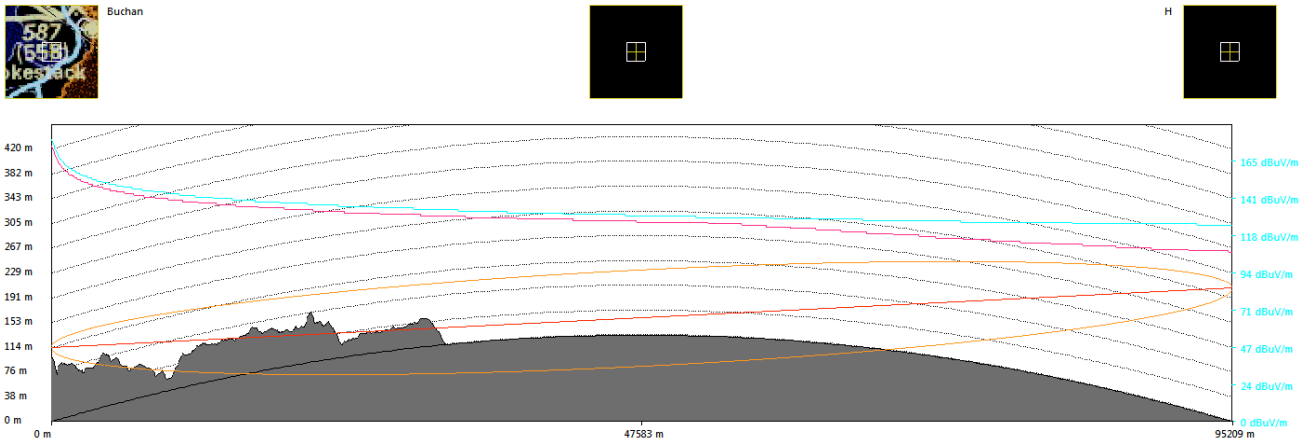

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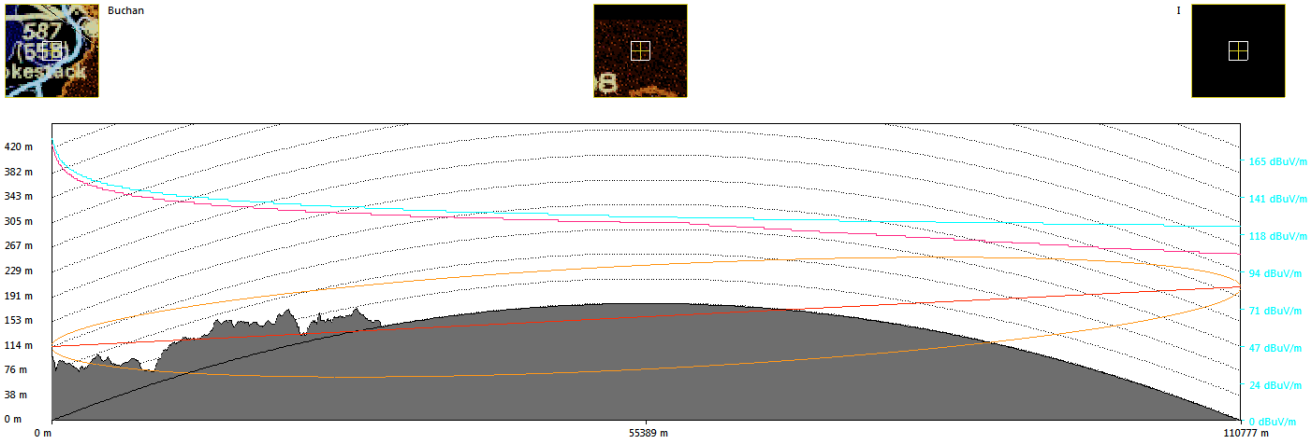

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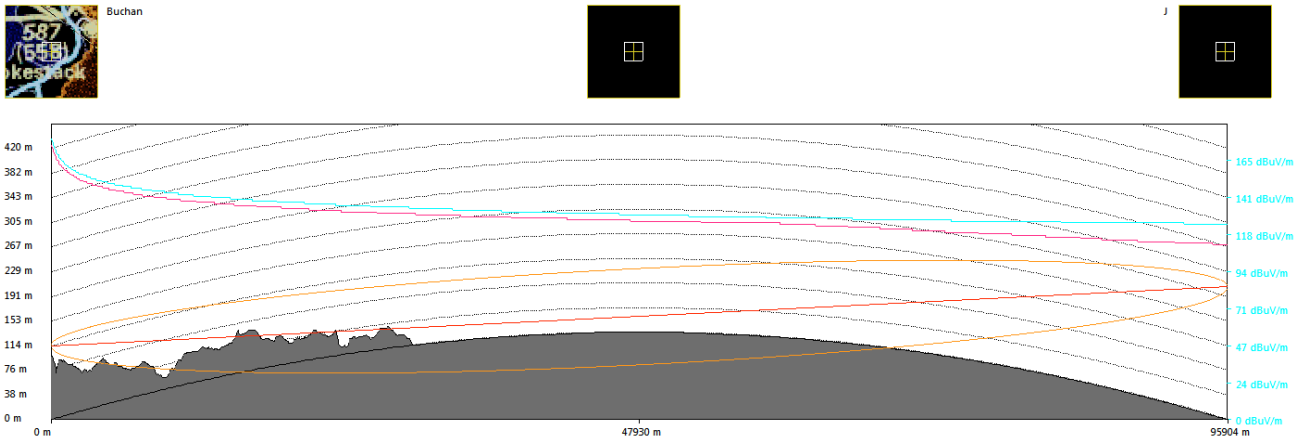

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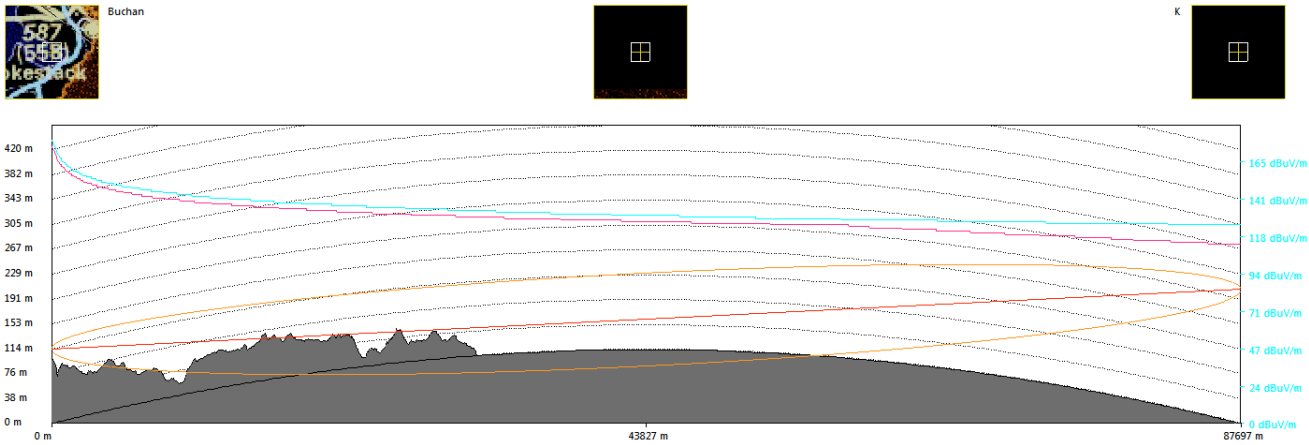

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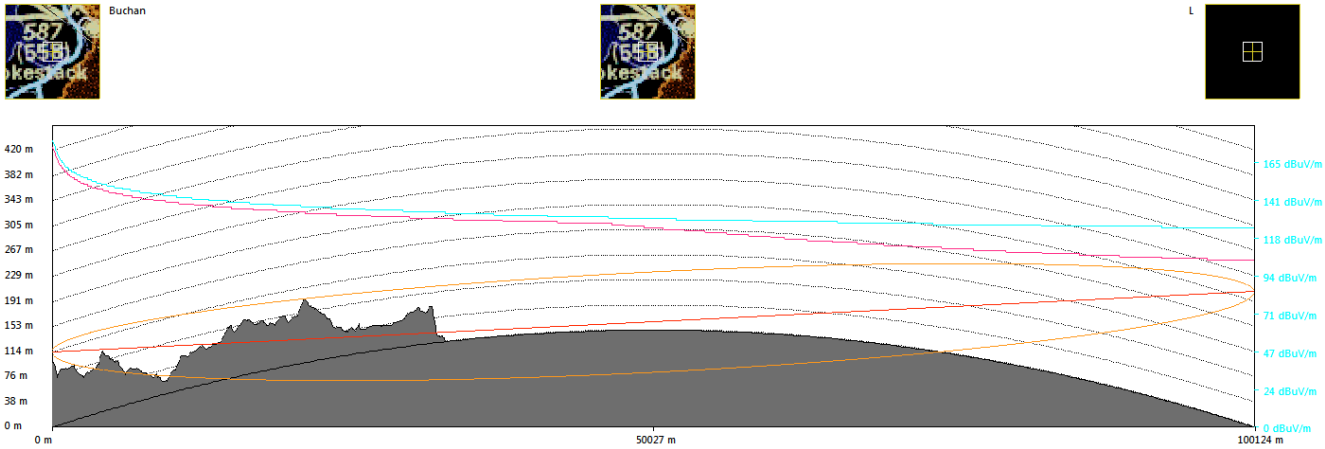

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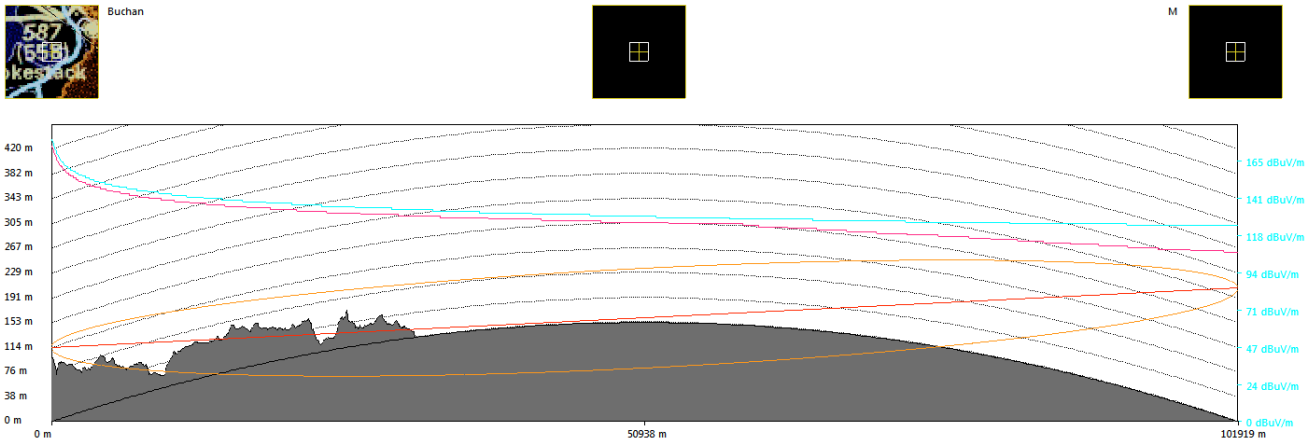

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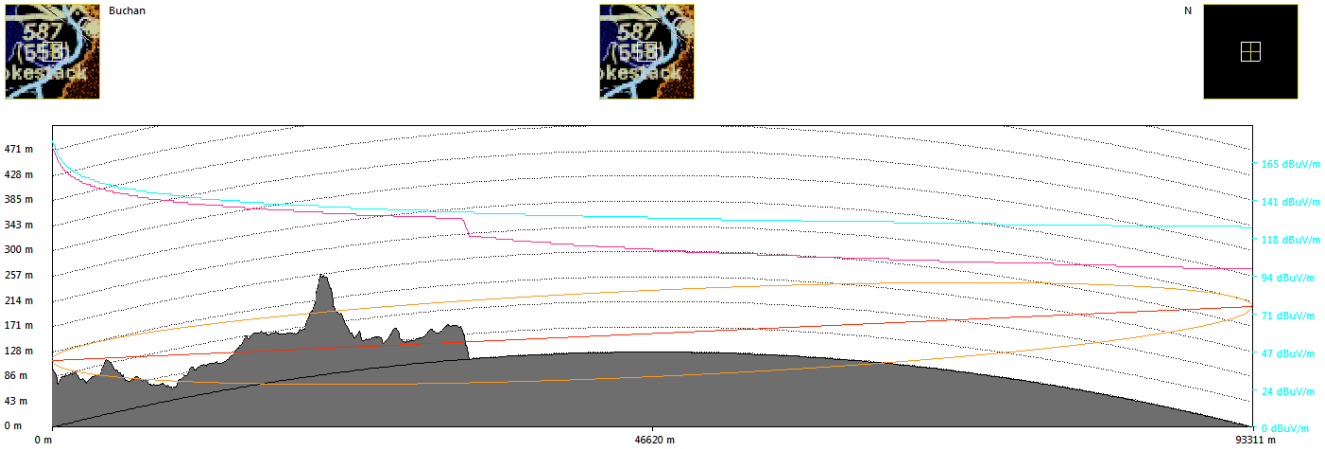

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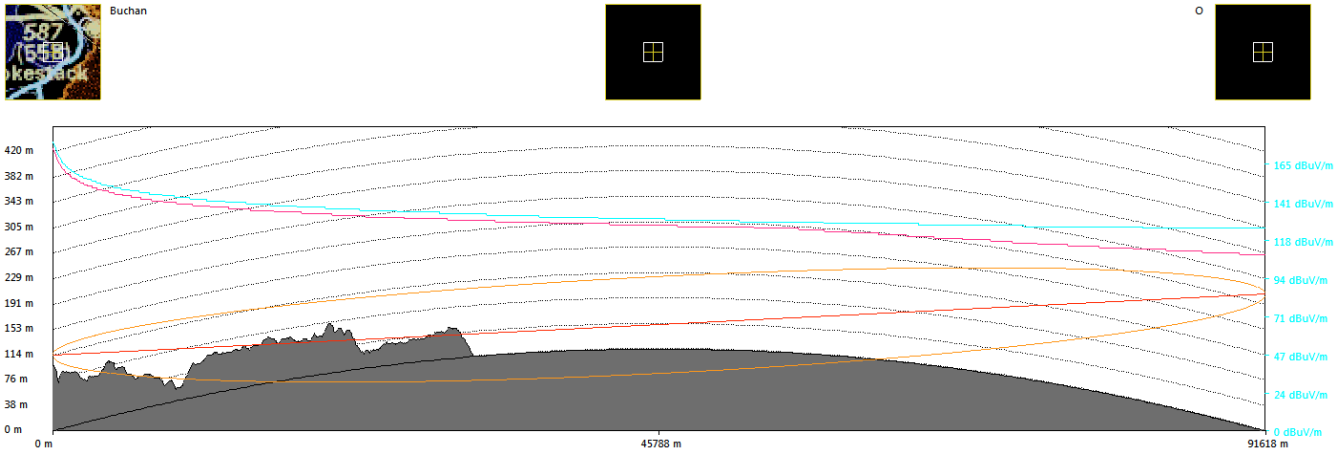

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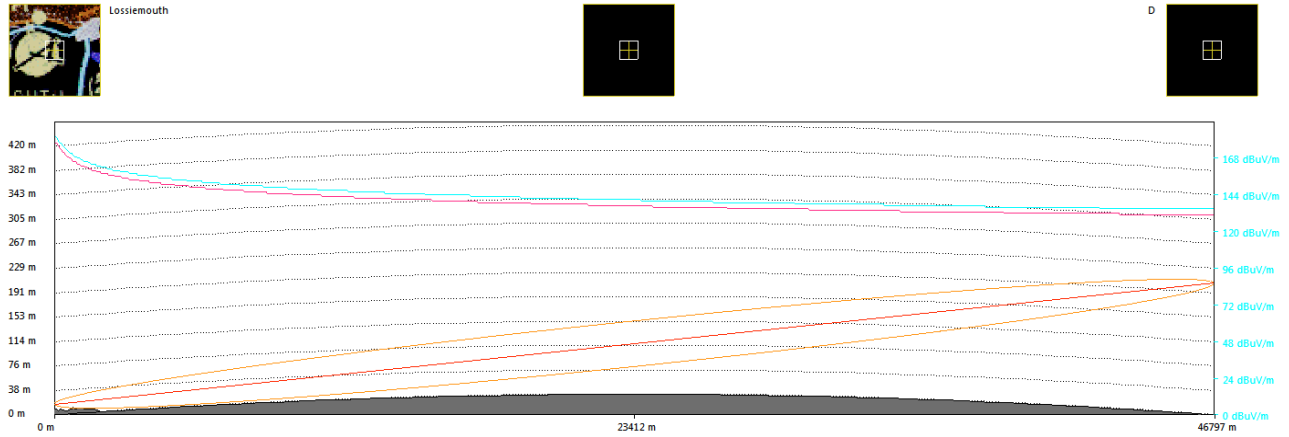
RAF Lossiemouth PSR



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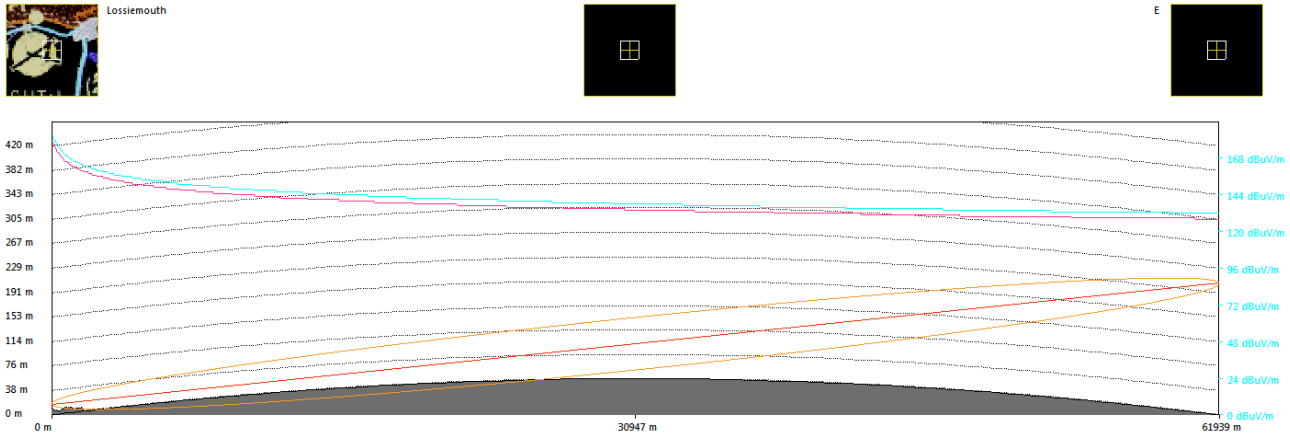

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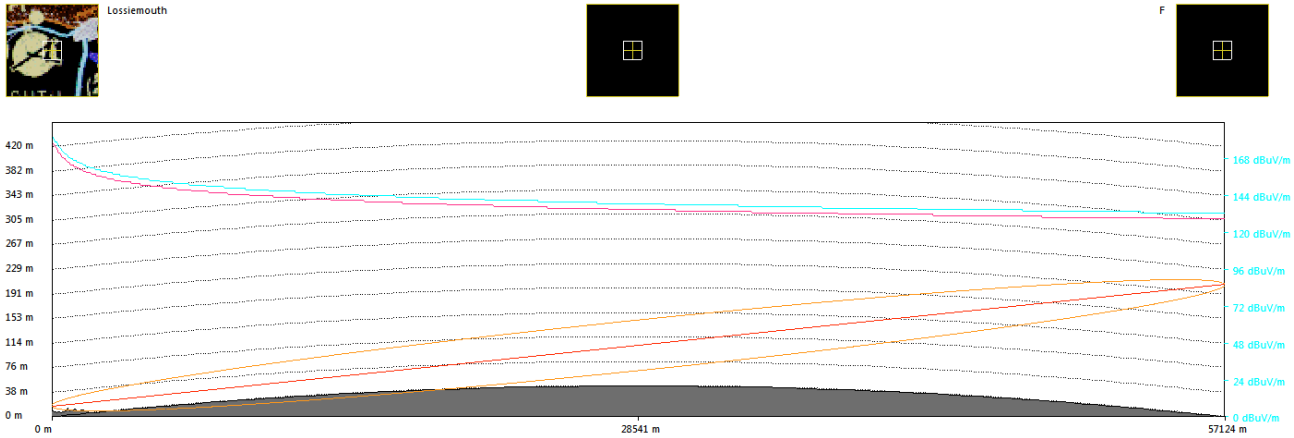

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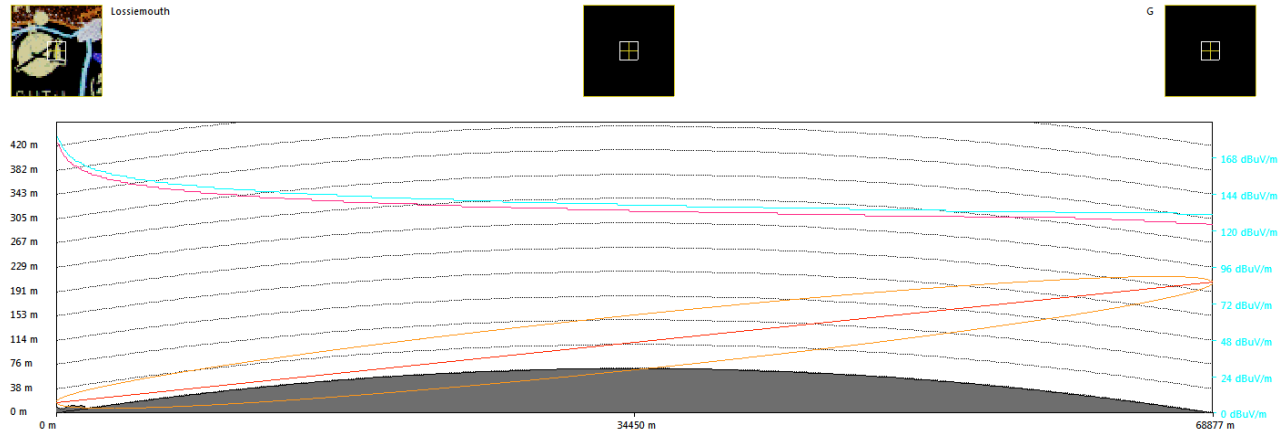

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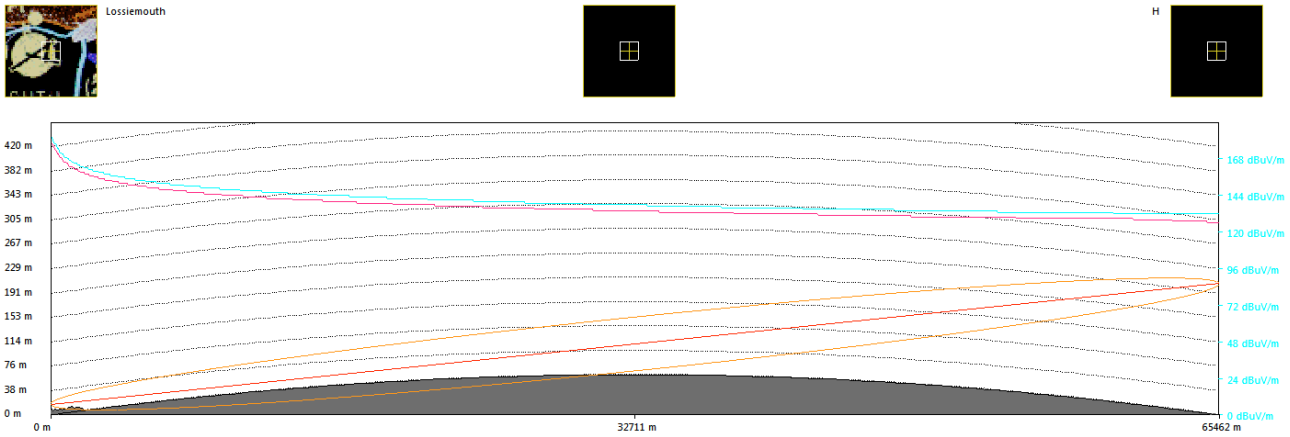

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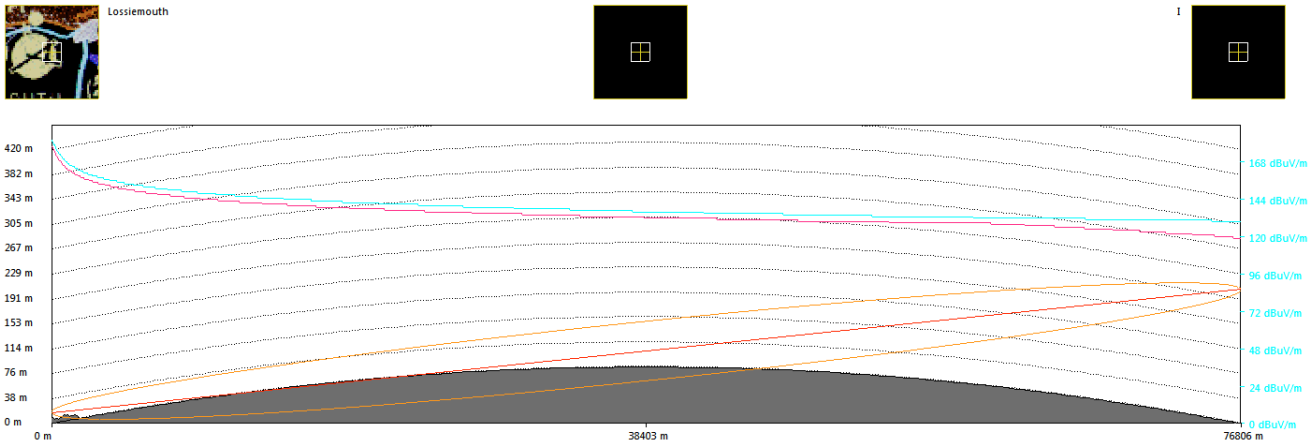

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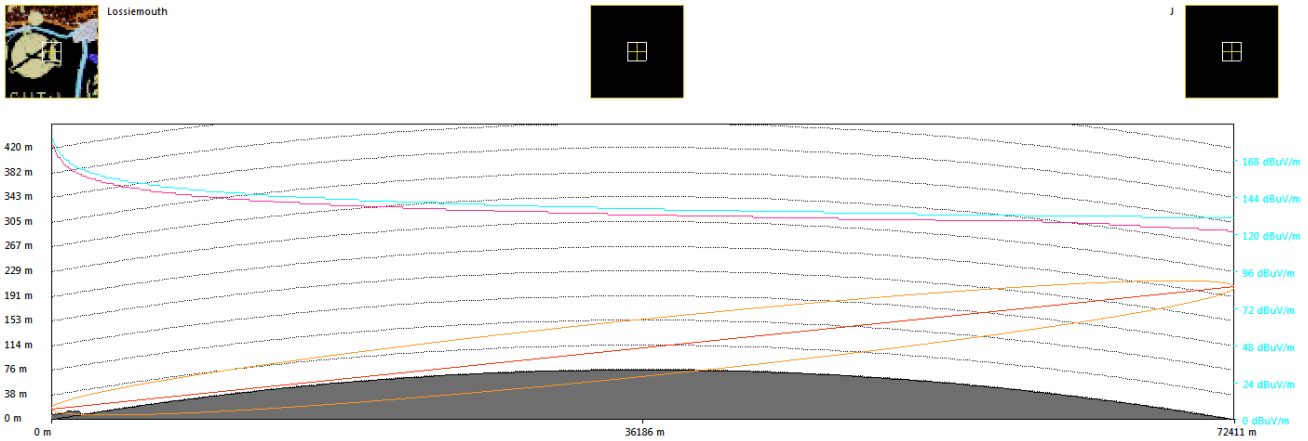

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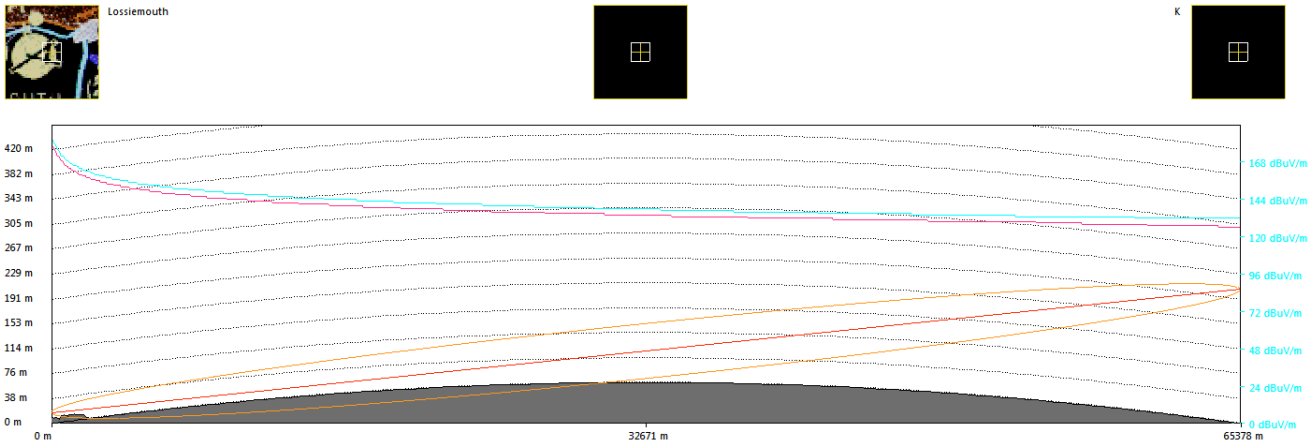

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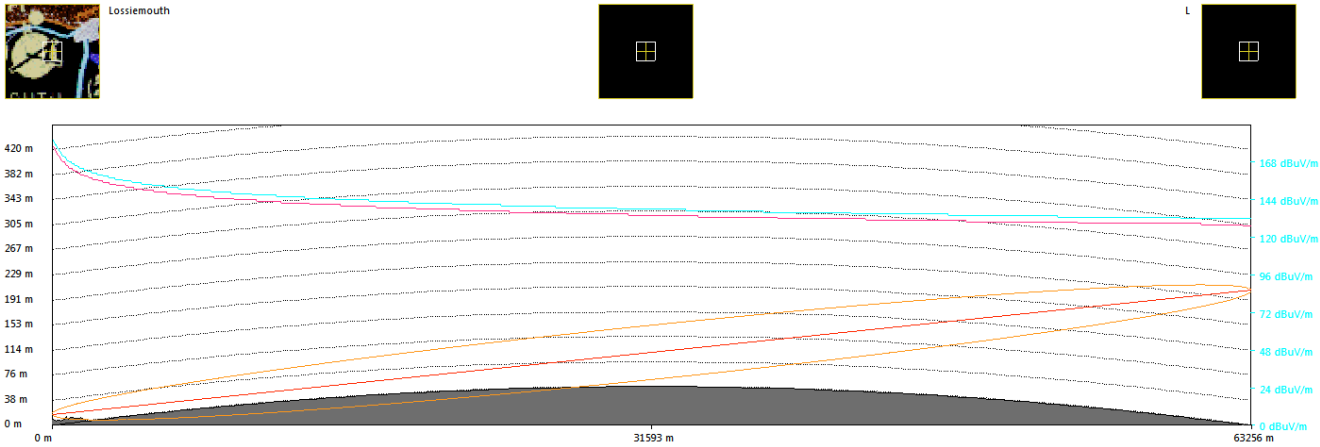

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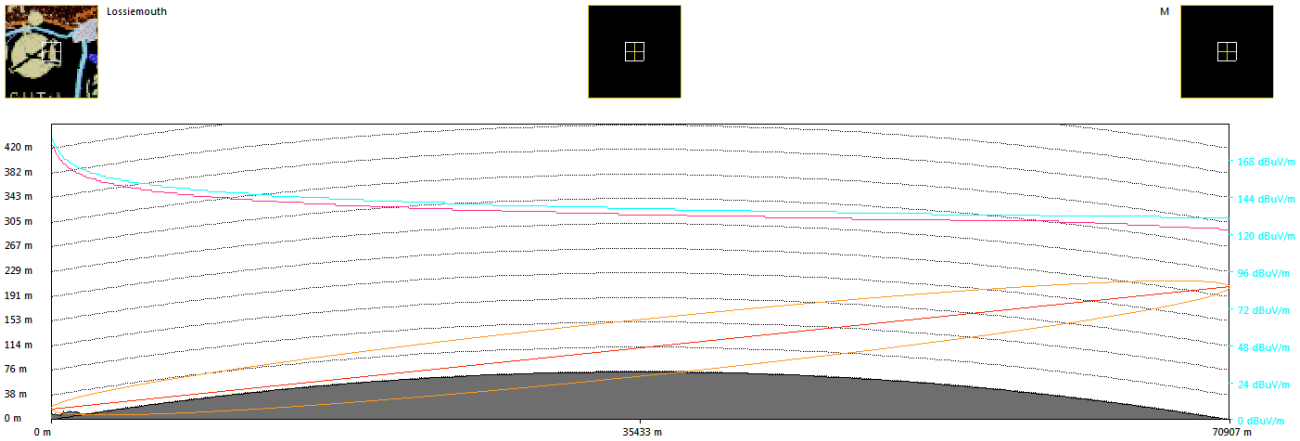
APPENDIX 5.3 C



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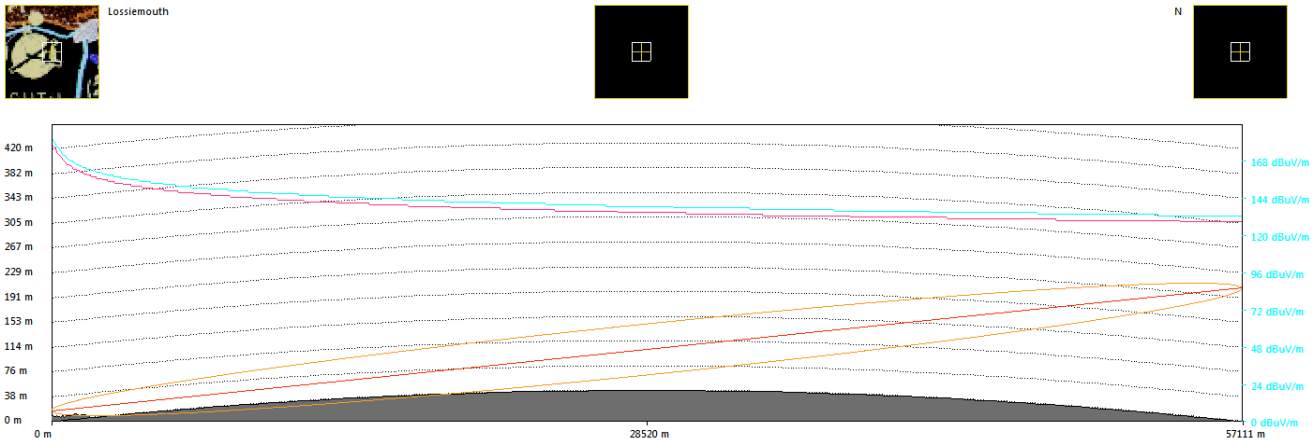

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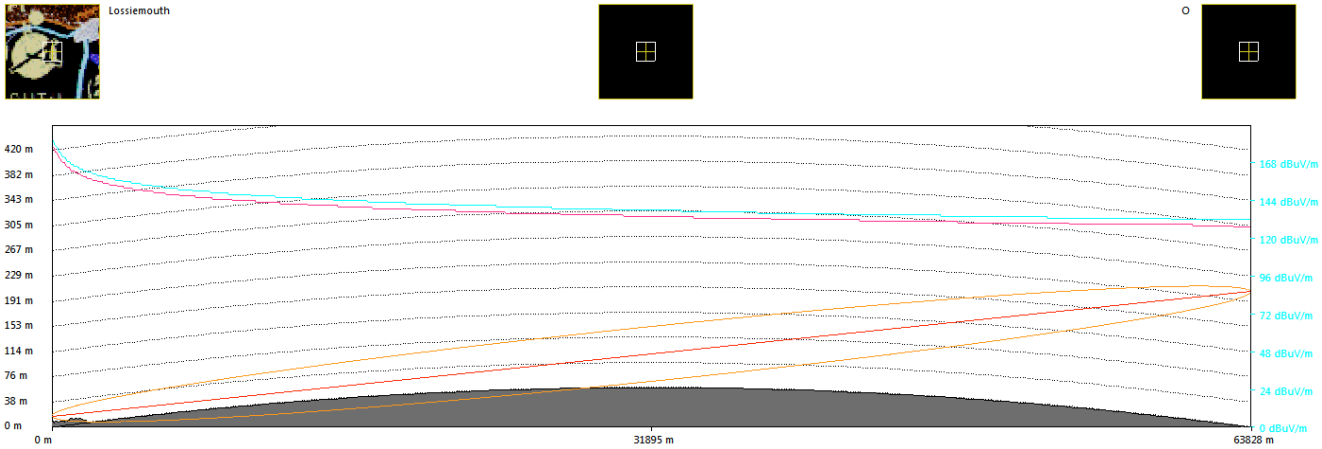

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MORAY WEST
OFFSHORE WINDFARM

SLVIA Methodology

Moray Offshore Windfarm (West) Limited

Technical Appendix 14.1

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Acronyms	
Acronym	**Expanded Term**
AOD	Above Ordnance Datum
BOWL	Beatrice Offshore Windfarm Limited
GLVIA	Guidelines for Visual Impact Assessment
NSA	National Scenic Area
SLVIA	Seascape Landscape and Visual Assessment
SNH	Scottish Natural Heritage
OS	Ordnance Survey
THC	The Highland Council
ZTV	Zone of Theoretical Visibility

1 Introduction

This Technical Appendix describes in detail the methodology that has been used to carry out the Seascape, Landscape and Visual Impact Assessment (SLVIA) for the Moray West Offshore Wind Farm and Offshore Transmission Infrastructure (OfTI), the 'Development'. The SLVIA identifies and assesses the effects that the Development will have on the seascape, landscape and visual resource of the 50 km radius study area as set out in Chapter 14 of Volume 1 of the Environmental Impact Assessment Report (EIA Report).

2 Categories of Effects

For the purpose of assessment, the potential effects on the seascape/landscape and visual resource are grouped into three categories. The physical effect on landscape elements is not considered in this SLVIA since the Development is entirely offshore, including the area up to Mean High Water Springs. There would be no apparent physical changes to the shore. The SLVIA does not include detailed assessment of the effects on Wild Land Areas or National Scenic Areas and therefore no detailed methodology for the assessment of Wild Land Areas or National Scenic Areas is included.

Effects on seascape/ landscape character: landscape character is the distinct and recognisable pattern of elements that occurs consistently in a particular type of landscape, and the way that this pattern is perceived. Effects on landscape character arise either through the introduction of new elements that physically alter this pattern of elements, or through visibility of the Development, which may alter the way in which the pattern of elements is perceived. This category of effects is made up of landscape character receptors, which fall into two groups: landscape character types and landscape-related designated areas.

Effects on views: the assessment of effects on views is an assessment of how the introduction of the Development will affect views throughout the study area. The assessment of effects on views is carried out in two parts:

- An assessment of the effects that the Development will have on a series of viewpoints around the study area; and
- An assessment of the effects that the Development will have on views from principal visual receptors, which are relevant settlements, routes and tourism features found throughout the study area.

Cumulative effects arise where the study areas for two or more wind farms (or in some cases other relevant development) overlap so that both of the wind farms are experienced at a proximity where they may have a greater incremental effect, or where wind farms may combine to have a sequential effect. In accordance with guidance (SNH, 2012), the SLVIA assesses the effect arising from the addition of the Development to the cumulative situation, and not the overall effect of multiple wind farms.

3 Assessment of Effects

The objective of the assessment of the Development is to predict the likely significant effects on the landscape and visual resource. In accordance with The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017, seascape, landscape and visual effects are assessed to be either significant or not significant. The SLVIA does not define intermediate levels of significance as the EIA Regulations do not provide for these.

The broad principles used in the assessment of the significance of effects on the four relevant categories listed above are the same and are described below. The detailed methodology for the assessment of significance does, however, vary for each category, and the specific criteria used are described in Sections 3.1 to 3.4 of this Appendix.

OPEN's SLVIA methodology accords with the guidance set out in the GLVIA3. Where it diverges from specific aspects of the guidance, in a small number of areas, reasoned professional justification for this is provided as follows.

GLVIA 3 sets out an approach to the assessment of magnitude of change in which three separate considerations are combined within the magnitude of change rating. These are the size or scale of the effect, its geographical extent and its duration and reversibility.

OPEN considers that the process of combining all three considerations in one rating can distort the aim of identifying significant effects of wind farm development. For example, an increased magnitude of change, based on size or scale, may be reduced to a lower rating if it occurred in a localised area and for a short duration. This might mean that a potentially significant effect will be overlooked if effects are diluted down due to their geographical extents and/or duration or reversibility.

OPEN has chosen to keep these three considerations separate, by basing the magnitude of change on size or scale to determine where significant and not significant impacts occur, and then describing the geographical extents of these impacts and their duration and reversibility separately.

The significance of effect is assessed through a combination of two considerations; the sensitivity of the seascape/landscape receptor or view (baseline) and the magnitude of change that will result from the addition of the Development.

The way that these two criteria are combined to result in a significant or not significant effect is shown in Table 3.1.

Sensitivity is an expression of the ability of the baseline seascape/ landscape receptor or view to accommodate the Development. Sensitivity is determined through a combination of the value of the receptor and its susceptibility to the Development.

Magnitude of change is an expression of the extent of the effect on landscape receptors and views that will result from the introduction of the Development. The magnitude of change is assessed in terms of a number of variables, including the size and scale of the impact. An assessment is also made of the geographical extent of the area over which this change would occur.

The variables that interact to determine the levels of the sensitivity and magnitude differ depending on the receptors being assessed. These variables are set out in sections 3.2-3.4 below.

3.1 Assessing Significance of Effects

The significance of effects is assessed through a combination of the sensitivity of the seascape/landscape receptor or view and the magnitude of change that will result from the addition of the Development. While this methodology is not reliant on the use of a matrix to arrive at the conclusion of a significant or not significant effect, a matrix is included in Table 3.1 below to illustrate how combinations of sensitivity and magnitude of change ratings can give rise to significant effects. The matrix also gives an understanding of the threshold at which significant effects may arise.

Table 3.1: Approach for Determination of Significance						
		Sensitivity				
		High	**High-Medium**	**Medium**	**Medium-Low**	**Low**
Magnitude of Change	**High**	Significant	Significant	Significant	Significant or Not significant	Significant or Not significant
	High-Medium	Significant	Significant	Significant or Not significant	Significant or Not significant	Not significant
	Medium	Significant	Significant or Not significant	Significant or Not significant	Not significant	Not significant
	Medium-Low	Significant or Not significant	Significant or Not significant	Not significant	Not significant	Not significant
	Low	Not significant	Not significant	Not significant	Not significant	Not significant
	Negligible/ None	Not significant	Not significant	Not significant	Not significant	Not significant

Combinations of higher magnitude and sensitivity are generally assessed as significant effects in terms of the requirements of the EIA Regulations. Combinations of lower levels of magnitude and sensitivity are generally assessed as not significant.

It should be noted however that intermediate combinations may be significant, or not significant, depending on the specific factors and effect that is assessed in respect of a particular landscape or visual receptor. In accordance with the GLVIA3 (paragraph 6.43), experienced professional judgement is applied to the assessment of all effects and reasoned argument is presented in respect of the findings in each case.

A significant effect occurs where the Development will provide a defining influence on a landscape element, seascape/landscape character receptor or view. A not significant effect occurs where the effect of the Development is not defining, and the baseline characteristics of the landscape element, seascape/landscape character receptor, view or visual receptor continue to provide the definitive influence. In this instance, a not significant effect would indicate that the Development may have an influence but this influence will not be defining.

Following this process it is assessed whether such an impact is positive, negative or neutral; whether it is permanent or reversible; long, medium or short term; and over what geographical extent this may occur.

3.2 Assessment of Effects on Seascape/ Landscape Character

The seascape/ landscape baseline provides an understanding of the seascape/ landscape in the area that may be affected – its constituent elements, its character, distinctiveness, condition and value, and the way this varies spatially. The seascape/ landscape baseline describes aspects of the landscape that may be significantly affected. Establishing the seascape/ landscape baseline will, when reviewed alongside the description of the Development, form the basis for the identification and description of the seascape/ landscape effects of the Development. The baseline description of the seascape/ landscape that may be affected is primarily determined by the physical footprint of the Development and its Zone of Theoretical Visibility (ZTV).

An overview of the seascape/ landscape baseline is described in the SLVIA and a preliminary assessment identifies seascape and landscape receptors that may experience significant effects, which require to be assessed in full. A detailed description of the baseline is provided for each seascape/ landscape receptor that may experience significant effects. Those receptors which are identified as not having the potential to undergo significant effects and significant cumulative effects, are not included in the subsequent detailed assessment, but are considered in the preliminary assessment.

The baseline study of each seascape/ landscape character receptor collates and presents information relevant to the assessment drawn from a combination of desk study and field-work. The baseline study utilises descriptions of seascape/ landscape character receptors from the Moray East Environmental Statement (ES) (2012), the relevant published seascape or landscape character assessment, citations in respect of landscape designations and descriptions in relation to Wild Land Areas. Field work has also been undertaken to verify the documented seascape/ landscape character area descriptions and boundaries. The key characteristics and value of each relevant seascape/ landscape receptor are set out, covering key features and patterns of the landform, land-cover and land-use which make the seascape/ landscape of these areas distinctive.

The seascape/ landscape baseline also describes current pressures that may cause change in the landscape in the future, in particular drawing on information for wind energy developments that are not yet present in the seascape/ landscape, but are at other stages in the consenting process. Operational and under construction wind energy developments, are regarded as part of the baseline seascape /landscape character of the area. Any changes resulting from the Development are assessed within this context in the assessment of seascape/ landscape and visual effects.

Effects on seascape/ landscape character arise through the introduction of new elements that physically alter this pattern of elements, the removal of characterising elements, or through visibility of the Development, which may alter the way in which the pattern of elements is perceived. This category of effects is considered in relation to four types of seascape/ landscape character receptor; Regional Coastal Character Areas, landscape character types/ units, designated areas and Wild Land Areas.

The objective of the assessment of effects on seascape/ landscape character is to determine which receptors will be affected by the Development, and whether these effects will be significant or not significant. The assessment of effects on seascape/ landscape character involves an evaluation of sensitivity and magnitude of change, and the resultant assessment of significance.

3.2.1 Sensitivity of Seascape/ Landscape Character Receptors

The sensitivity of a landscape character receptor is an expression of its ability to accommodate the Development as part of its own character or as part of the visual setting or context to the character receptor. This is dependent on the value of the landscape receptor and its susceptibility to change.

3.2.1.1 Value of Landscape Character Receptors

The value of a seascape/ landscape character receptor is a reflection of the value which society attaches to that seascape/ landscape. The assessment of the seascape/ landscape value is classified as high, medium-high, medium, medium-low or low and the basis for this assessment is made clear using evidence and professional judgement, based on the following range of factors:

- **Seascape/ landscape designations:** a receptor that lies within a recognised landscape-related planning designation will generally have an increased value, depending on the proportion of the receptor that is covered and the level of importance of the designation (international, national, regional or local). It is important to note that the absence of designations does not preclude local resource value, as an undesignated landscape character receptor may be important as a resource in the local or immediate environment, particularly when experienced in comparison with other nearby landscapes;

- **Seascape/ landscape quality:** the quality of a seascape/ landscape character receptor is a reflection of its attributes, such as scenic quality, sense of place, rarity and representativeness and the extent to which these attributes have remained intact. A seascape/ landscape with consistent, intact and well-defined, distinctive attributes is generally considered to be of higher quality and, in turn, higher value, than a seascape/ landscape where the introduction of inappropriate elements has detracted from its inherent attributes; and
- **Seascape/ landscape experience:** the experience of the landscape character receptor can add to its value and relates to a number of factors including the perceptual responses it evokes, the cultural associations that may exist in literature or history, or the iconic status of the landscape in its own right, the recreational value of the landscape for outdoor pursuits, and the contribution of other values relating to the nature conservation or archaeology of the area.

3.2.1.2 Susceptibility to Change of Seascape/ Landscape Character Receptors

The susceptibility of a seascape/ landscape character receptor to change is a reflection of its ability to accommodate the changes that will occur as a result of the addition of the Development. The assessment of the susceptibility of the seascape/ landscape receptor to change is classified as high, medium-high, medium, medium-low or low and the basis for this assessment is made clear using evidence and professional judgement, based on the following criteria:

- **The specific nature of the Development**: the susceptibility of seascape landscape receptors is specific to the change arising from the particular development that is proposed, including its individual components and features, and its size, scale, location, context and characteristics;
- **Seascape/ landscape character:** the key characteristics of the existing seascape/ landscape character of the receptor are considered in the evaluation of susceptibility as they determine the degree to which the receptor may accommodate the influence of the Development. For example, a seascape/ landscape that is of a particularly wild and remote character may have a high susceptibility to the influence of the Development due to the contrast that it would have with the landscape, whereas a developed landscape where built elements and structures are already part of the landscape character may have a lower susceptibility. However, there are instances when the quality of a landscape may have been degraded to an extent whereby it is considered to be in a fragile state and therefore a degraded seascape/ landscape may have a higher susceptibility to the Development; and
- **Seascape/ landscape association:** the extent to which the Development will influence the character of the seascape/ landscape receptors across the study area also relates to the associations that exist between the seascape/ landscape within which the Development is located and the seascape/ landscape receptor from which the Development is being experienced. This association will be most important where the seascapes/ landscapes are directly related; for example, if the Development is located in an upland landscape that has a strong enclosing influence on an adjacent valley landscape. Elsewhere, the association may be less important; for example, where the Development lies inland of a coastal landscape that has its main focus outwards over the sea.

3.2.1.3 Levels of Sensitivity

The sensitivity of each receptor is a product of the specific combination of value and susceptibility to the Development as evaluated by professional judgement. The sensitivity of the landscape receptor is evaluated as high, medium or low. Interim levels of sensitivity – high-medium and medium-low - may also be applied where appropriate.

3.2.2 Magnitude of Change on Landscape Character Receptors

The magnitude of change that the Development will have on seascape/ landscape receptors is assessed in terms of the size or scale of the change. An assessment is also made of the geographical extent of the area over which this will occur and the duration and reversibility of such changes. Duration and reversibility are not incorporated into the overall magnitude of change and are stated separately.

The basis for this assessment is made clear using evidence and professional judgement, based on the following criteria. The key elements of the Development that will influence the level of change on seascape/ landscape character are views of movement, form, material, colour and scale of the turbines, although other infrastructure is also considered.

3.2.2.1 Size or Scale of Change

This criterion relates to the size or scale of change to the landscape that will arise as a result of the addition of the Development, based on the following factors:

- The degree to which the pattern of elements that makes up the seascape/ landscape character will be altered by the Development, through removal or addition of elements in the seascape, in this instance. The magnitude of change will generally be higher if key features that make up the seascape/ landscape character are extensively removed or altered, and if many new components are added to the seascape/ landscape;
- The extent to which the Development will change - physically or perceptually - the characteristics that may be important in the creation of the distinctive character of the seascape/ landscape. This may include the scale of the landform, its relative simplicity or irregularity, the nature of the seascape/ landscape context, the grain or orientation of the seascape/ landscape, the degree to which the receptor is influenced by external features and the juxtaposition of the Development with these key characteristics;
- The degree to which seascape/ landscape character receptors will be changed by the addition of the Development to baseline wind energy developments that are already present in the seascape/ landscape. If the Development is located in a seascape/ landscape receptor that is already affected by other wind energy development, this may reduce the magnitude of change if there is a high level of integration and the developments form a unified and cohesive feature in the seascape/ landscape. The converse could also be applicable;
- The seascape/ landscape context in which the Development and other wind energy development are located. If the Development is located in a similar seascape/ landscape context, the magnitude of change is likely to be lower as they relate consistently to key seascape/ landscape characteristics. If developments are located in different seascape/ landscape settings, this can lead to a perception that wind energy development is unplanned and uncoordinated, affecting a wide range of seascape/ landscape characters and blurring the distinction between them;
- The scale of the seascape/ landscape, landform and patterns of the landscape. A large-scale seascape/ landscape can provide a more appropriate receiving environment than a more intimate, small-scale setting where development may result in uncomfortable scale comparisons and increase the magnitude of change;
- The distance between the seascape/ landscape character receptor and the Development. Generally, the greater the distance, the lower the scale of change as the Development will constitute a less apparent influence on the seascape/ landscape character; and
- The extent of the Development that will be seen from the seascape/ landscape receptor. Visibility of the Development may range from one turbine blade tip to all of the turbines, and generally the greater the extent of the Development that can be seen, the greater the change.

3.2.2.2 Geographical Extent

The geographic extent over which the seascape/ landscape effects will be experienced is also assessed, which is distinct from the size or scale of effect. This evaluation is not combined in the assessment of the level of magnitude, but instead expresses the extent of the receptor that will experience a particular magnitude of change and can therefore affect the geographical extents of the effects.

The extent of the effects will vary depending on the specific nature of the Development and is principally assessed through analysis of the extent to which the characteristics of seascape/ landscape character will change through visibility of the Development.

3.2.2.3 Duration and Reversibility

The duration and reversibility of landscape effects are based on the period over which the Development is likely to exist and the extent to which the Development will be removed and its effects reversed at the end of that period. Duration and reversibility are not incorporated into the overall magnitude of change, and are stated separately in relation to the assessed effects.

3.2.2.4 Levels of Magnitude of Change

An assessment of the magnitude of change resulting from the Development on the seascape/ landscape receptor is made by assessing the size or scale of change. The geographical extent over which this change takes place is also assessed. The basis for the assessment of magnitude for each receptor is made clear using evidence and professional judgement. The magnitude of change is assessed as high, medium, low, negligible or none according to the following definitions:

- **High,** where the Development would result in a major alteration to the baseline character of the seascape/ landscape, providing a prevailing influence and/or introducing elements that are substantially uncharacteristic in the receiving seascape/ landscape;
- **Medium,** where the Development will result in a moderate alteration to the baseline character of the seascape/ landscape, providing a readily apparent influence and/or introducing elements that may be prominent but are not uncharacteristic in the receiving seascape/ landscape;
- **Low,** where the Development will result in a minor alteration to the baseline character of the seascape/ landscape, providing a slightly apparent influence and/or introducing elements that are characteristic in the receiving seascape/ landscape;
- **Negligible,** where the alteration to seascape/ landscape character is barely discernible; and
- **None,** the Development will result in no change to the baseline characteristics of the seascape/ landscape.

There may also be intermediate levels of magnitude of change – high-medium and medium-low - where the change falls between two of the definitions.

3.2.3 Significance of Effects on Seascape/ Landscape Character Receptors

The significance of the effect on each seascape/ landscape character receptor is dependent on the factors that are considered in the sensitivity of the receptor and the magnitude of change upon it. These factors are combined using professional judgement to arrive at an overall assessment as to whether the Development will have a significant or not significant effect on the receptor. The matrix shown in Table 3.1 above is also used to inform the threshold of significance when combining sensitivity and magnitude of change.

A significant effect will occur where the combination of the variables results in the Development having a defining effect on the receptor. A not significant effect will occur where the effect of the Development is not definitive and the seascape/ landscape character of the receptor continues to be characterised principally by its baseline characteristics.

3.3 Assessment of Effects on Views

The visual baseline establishes the area in which the Development may be visible, the different groups of people who may experience views of the Development, the viewpoints where they will be affected and the nature of the views at those points. The visual baseline describes aspects of the visual environment that may be significantly affected. The baseline description of the groups of people concentrated within areas (referred to as principal visual receptors) and viewpoints that may be affected is primarily determined by the ZTV of the Development.

An overview of the visual baseline is described and a preliminary assessment identifies visual receptors that may experience significant effects, which require to be assessed in full. A full description of the baseline is provided for each visual receptor that may experience significant effects, allowing the full baseline to be described for visual receptors that may be significantly affected. Those receptors which are identified as not having the potential to undergo significant effects are not included in the subsequent detailed assessment, but are considered in a preliminary assessment, where effects are scoped out.

The assessment of effects on views evaluates how the introduction of the Development will affect views and visual amenity. The assessment of visual effects is carried out in two parts:

- An assessment of the effects that the Development will have on a series of viewpoints around the study area; and
- An assessment of the effects that the Development will have on people's views where people tend to be concentrated in relevant settlements, routes and tourism features found throughout the study area.

The objective of the assessment of effects on views and visual receptors is to determine what the likely effects of the Development will be on views and visual amenity of people across the study area, and whether these effects will be significant or not significant. The assessment of effects on views involves an evaluation of sensitivity and magnitude of change, and the resultant assessment of significance.

3.3.1 Sensitivity of Visual Receptors

The sensitivity of views and visual receptors is determined by a combination of the value of the view and the susceptibility of the viewer or visual receptor to the Development.

3.3.1.1 Value of Views

The value of a view is a reflection of the recognition and the importance attached formally through identification as a viewpoint on mapping, by signposting or through planning designation; or informally through the value which society attaches to the view. The value of a view is classified as high, medium or low, based on the following factors:

- **Formal recognition:** the value of views can be formally recognised through their identification on maps as formal viewpoints, are signposted and provide facilities to facilitate the enjoyment of the view such as parking, seating and interpretation boards. Specific views may be afforded protection in local planning policy, where they are recognised as valued views. Specific views can also be cited as being of importance in relation to landscape or heritage planning designations; for example the value of a view may be increased if it presents an important vista from a designed landscape or lies within or overlooks a designated area such as a National Scenic Area (NSA), which implies a greater value to the visible landscape;
- **Informal recognition**: views that are well-known at a local level or have particular scenic qualities can have an increased value, even if there is no formal recognition or designation. Views or viewpoints are sometimes informally recognised through references in art or literature and this can also add to their value; and

- **Scenic quality:** the value of the view is a reflection of the scenic qualities gained in the view. This relates to the content and composition of the landscape, whereby certain patterns and features can increase the scenic quality while others may reduce the scenic quality.

3.3.1.2 Susceptibility to Change

Susceptibility relates to the nature of the viewer and how susceptible they are to the potential effects of the Development. This is determined by the nature of the viewer, which is the occupation or activity in which the viewer is engaged at the viewpoint, and is classified as high, medium or low. The most common groups of viewers considered in the visual assessment include residents, road-users, workers and walkers.

- **Nature of the viewer:** The nature of the viewer is described by the occupation or activity which they are engaged in at the viewpoint or series of viewpoints. The most common groups of viewers considered in the visual assessment include residents, motorists, people taking part in recreational activity or working. Viewers whose attention is focused on the landscape, or with static long-term views, are likely to have a higher sensitivity. Viewers travelling in cars or on trains will tend to have a lower sensitivity as their view is transient and moving. The least sensitive viewers are usually people at their place of work as they are generally less sensitive to changes in views.
- **Experience of the viewer:** The experience of the visual receptor relates to the extent to which the viewer's attention or interest may be focused on the view and the visual amenity they experience at a particular location. The susceptibility of the viewer to change arising from the Development may be influenced by the viewer's attention or interest in the view, which may be focused in a particular direction, from a static or transitory position, over a long or short duration, and with high or low clarity. For example, if the principal outlook from a settlement is aligned directly towards the Development, the experience of the visual receptor will be altered more notably than if the experience relates to a glimpsed view seen at an oblique angle from a car travelling at high speed. The visual amenity experienced by the viewer varies depending on the presence and relationship of visible elements, features or patterns experienced in the view and the degree to which the landscape in the view may accommodate the influence of the Development.

3.3.1.3 *Levels of Sensitivity*

The sensitivity of each receptor/view is a product of the specific combination of value and susceptibility to the Development as evaluated by professional judgement. The sensitivity of the view or visual receptor is evaluated as high, medium or low by combining the value and susceptibility to change. Interim levels of sensitivity – high-medium and medium-low - may also be applied where appropriate for the combination of value and susceptibility.

3.3.2 Magnitude of Change on Views

The magnitude of change on views is an expression of the scale of the change that will result from the Development, and is dependent on a number of variables regarding the size or scale of the change. The key elements of the Development that will influence the level of change on views are the movement, form, material, colour and scale of the turbines, although infrastructure is also considered. A separate assessment is also made of the geographical extent of the area over which this will occur and the duration and reversibility of such changes.

3.3.2.1 Size or Scale

This criterion relates to the size or scale of change to the view that will arise as a result of the Development, based on the following factors:

- The distance between the visual receptor/viewpoint and the Development. Generally, the greater the distance, the lower the magnitude of change, as the Development will constitute a smaller scale component of the view.
- The amount and size of the Development that will be seen. Visibility may range from one blade tip to all of the turbines. Generally, the larger the Development appears in the view, and the more of the Development that can be seen, the higher the magnitude of change.
- The scale of the change in the view, with respect to the loss or addition of features in the view and changes in its composition. The Development will often appear as an extension to the Beatrice Offshore Wind Farm (BOWL) and its scale of change is assessed in the context of the existing views of BOWL.
- The field of view available and the proportion of the view that is affected by the Development. Generally, the more of a view that is affected, the higher the magnitude of change will be. If the Development extends across the whole of the open part of the outlook, the magnitude of change will generally be higher as the full view will be affected. Conversely, if the Development covers just a part of an open, expansive and wide view, the magnitude of change is likely to be reduced as the Development will not affect the whole open part of the outlook.
- The scale and character of the context within which the Development will be seen and the degree of contrast or integration of any new features with existing landscape elements, in terms of scale, form, mass, line, height, colour, luminance and motion. Contrasts and changes may arise particularly as a result of the rotation movement of the wind turbine blades, as a characteristic that gives rise to effects.
- The consistency of image of the Development in relation to other developments. The magnitude of change of the Development is likely to be lower if its wind turbine height, arrangement and layout design are broadly similar to other offshore wind farm developments in the views, as they are more likely to appear as relatively simple and logical components of the seascape.
- The uniformity of appearance of the Development in different views. If the Development appears relatively uniform and consistent in appearance from different viewpoints and viewing angles, in a similar setting and familiar form, this tends to reduce the magnitude of change. If, on the other hand, it appears inconsistent in image, scale and appearance, or from a variety of different angles, and is seen in a different form and setting, the magnitude of change is likely to be higher as it will be a variable and less familiar component of views.
- The extent of the wind energy developed skyline. If the Development will add notably to the wind energy developed skyline in a view, extending the lateral spread of development or increasing the perceived connection between other wind farms, the magnitude of change will tend to be higher;
- The number and scale of developments seen simultaneously or sequentially. Generally, the greater the number of clearly separate developments that are visible, the higher the magnitude of change will be, whereas an extension to an existing wind farm would tend to result in a lower magnitude of change than a separate, new wind farm; and
- The scale and form comparison between developments. If the Development is of a similar scale and form to other visible developments, particularly those seen in closest proximity to it, the magnitude of change will generally be lower as it will have more integration with the other sites and will be less apparent as an addition.

3.3.2.2 Geographical Extent

The geographic extent over which the visual effects will be experienced is also assessed, which is distinct from the size or scale of effect. The extent of the effects will vary depending on the specific nature of the Development and is principally assessed through analysis of the extent of visibility of the Development from visual receptors, to assess the geographical extent of the receptor that will be affected, based on the following criteria:

- The extent of the visual receptor (a road, footpath or settlement for example) that will experience changes through visibility of the Development; and
- The extent to which the change affects views, whether this is unique to the viewpoint or if similar changes occur over wide areas represented by the viewpoint.

3.3.2.3 Duration and Reversibility

The duration and reversibility of effects on views are based on the period over which the Development is likely to exist and the extent to which it will be removed and its effects reversed at the end of that period. Duration and reversibility are not incorporated into the overall magnitude of change, and are stated separately.

3.3.2.4 Levels of Magnitude of Change

An assessment of the magnitude of change resulting from the Development on each visual receptor and viewpoint is made by assessing the size or scale of change. The geographical extent over which this change takes place is also assessed and, where relevant, the duration and reversibility of the effect. The basis of the assessment is made clear using evidence and professional judgement. The magnitude of change is assessed as high, medium, low, negligible or none according to the following definitions:

- High, where the Development will result in a major alteration to the baseline view, providing a prevailing influence and/or introducing elements that are substantially uncharacteristic in the view;
- Medium, where the Development will result in a moderate alteration to the baseline view, providing a readily apparent influence and/or introducing elements that may be prominent but are not uncharacteristic in the view;
- Low, where the Development will result in a minor alteration to the baseline view, providing a slightly apparent influence and/or introducing elements that are characteristic in the view;
- Negligible, where the alteration to the view is barely discernible; and
- None, where the Development will result in no change to the existing view or its baseline characteristics.

There may also be intermediate levels of magnitude of change – high-medium, medium-low and low-negligible - where the change falls between two of the definitions.

3.3.3 Significance of Effects on Views

The significance of the effect on each view or visual receptor is dependent on the factors that are considered in the sensitivity of the view or receptor and the magnitude of change upon it. These factors are combined using professional judgement to arrive at an overall assessment as to whether the Development will have a significant or not significant effect on the view or visual receptor. The matrix shown in Table 3.1 above is also used to inform the threshold of significance when combining sensitivity and magnitude of change.

A significant effect will occur where the combination of the variables results in the Development having a defining effect on the view or visual receptor. A not significant effect will occur where the effect of the Development is not definitive and the view continues to be characterised principally by its baseline

characteristics. In this instance, a not significant effect would indicate that the Development may have an influence on the view, but this influence will not be a defining one.

The assessment of visual effects assumes clear weather and optimum viewing conditions. This means that effects that are assessed to be significant may be not significant under different, less clear conditions. Viewing conditions and visibility tend to vary considerably and therefore the likelihood of effects resulting from the Development will vary greatly dependent according to a number of factors.

3.4 Assessment of Cumulative Effects

Cumulative effects are the incremental effects that arise through the interaction of two or more developments within the landscape and visual baseline context. Cumulative effects arise where the study areas for two or more wind energy developments (or other relevant development) overlap so that both are experienced at a proximity where they may have a greater incremental effect, or where wind energy developments may combine to have a sequential effect irrespective of any overlap in study areas. The cumulative effect assessed is that which will arise from the addition of the Development to the predicted cumulative situation, and not the overall effect of multiple wind farms.

3.4.1 Types of Cumulative Effect

Cumulative effects on seascape/ landscape character arise when the influence of two or more wind farms becomes a characteristic of a seascape/ landscape receptor. This can occur to varying extents, as described in Section 3.4.3 of this Appendix.

Cumulative effects on views consist of combined visibility and sequential effects. Combined visibility occurs where the observer is able to see two or more developments from one viewpoint. Combined visibility may either be 'in combination', where several wind farms are within the observer's main angle of view at the same time, or 'in succession', where the observer has to turn to see the various wind farms. Sequential effects occur when the observer has to move to another viewpoint to see different developments, and may arise assessed on roads, cycle paths, railway lines and footpaths. Such effects may be frequently sequential or occasionally sequential depending on the time lapses between instances of visibility.

The significance of cumulative effects is determined through a combination of the sensitivity of the seascape/ landscape receptor or visual receptor/view and the cumulative magnitude of change arising from the addition of the Development. The sensitivity of landscape receptors and visual receptors/views is taken from the main assessment, while the cumulative magnitude of change is evaluated according to additional criteria, described below.

3.4.2 Cumulative Magnitude of Change

The cumulative magnitude of change is an expression of the degree to which seascape/ landscape character receptors and visual receptors/views will be changed by the addition of the Development to wind farm developments that are already operational/under construction, consented or at application stage. The cumulative magnitude of change is assessed based on a number of criteria, as follows:

- The location of the Development in relation to other wind farm developments. If the Development is seen in a part of the view or setting to a seascape/ landscape receptor that is not affected by other wind farm development, this will generally increase the cumulative magnitude of change as it will extend wind farm influence into an area that is currently unaffected. Conversely, if the Development is seen in the context of other sites, the cumulative magnitude of change may be lower as wind farm influence is not being extended to otherwise undeveloped parts of the outlook or setting. This is particularly true where the scale and layout of the Development is similar to that of the other sites as where there is a high level of integration and cohesion with an existing wind farm site the various developments may appear as a single site;

- The extent of the developed skyline. If the Development will add notably to the developed skyline in a view, the cumulative magnitude of change will tend to be higher as skyline development can have a particular influence on both views and landscape receptors;
- The number and scale of wind farm developments seen simultaneously or sequentially. Generally, the greater the number of clearly separate developments that are visible, the higher the cumulative magnitude of change will be. The addition of the Development to a view or landscape where a number of smaller developments are apparent will usually have a higher cumulative magnitude of change than one or two large developments as this can lead to the impression of a less co-ordinated or strategic approach;
- The scale comparison between wind farm developments. If the Development is of a similar scale to other visible wind farms, particularly those seen in closest proximity to it, the cumulative magnitude of change will generally be lower as it will have more integration with the other sites and will be less apparent as an addition to the cumulative situation;
- The consistency of image of the Development in relation to other wind farm developments. The cumulative magnitude of change of the Development is likely to be lower if its turbine height, arrangement and layout design are broadly similar to other wind farms in the landscape, as they are more likely to appear as relatively simple and logical components of the landscape;
- The context in which the wind farm developments are seen. If developments are seen in a similar landscape context, the cumulative magnitude of change is likely to be lower due to visual integration and cohesion between the sites. If developments are seen in a variety of different landscape settings, this can lead to a perception that wind farm development is unplanned and un-coordinated, affecting a wide range of landscape characters and blurring the distinction between them; and
- The magnitude of change of the Development as assessed in the main assessment. The lower this is assessed to be, the lower the cumulative magnitude of change is likely to be. Where the Development itself is assessed to have a negligible magnitude of change on a view or receptor there will not be a cumulative effect as the contribution of the Development will equate to the 'no change' situation.

Definitions of cumulative magnitude of change are applied in order that the process of assessment is made clear. These are:

- High, the addition of the Development to other wind energy developments in the seascape/ landscape or view will result in a major change to the cumulative wind farm situation;
- Medium, the addition of the Development to other wind energy developments in the seascape/ landscape or view will result in a moderate change to the cumulative wind farm situation;
- Low, the addition of the Development to other wind energy developments in the seascape/ landscape or view will result in a minor change to the cumulative situation;
- Negligible, where the alteration to the cumulative situation is barely discernible; and
- None, where there would be 'no change'.

There may also be intermediate levels of cumulative magnitude of change – high-medium, medium-low and low-negligible - where the change falls between two of the definitions.

3.4.3 Significance of Cumulative Effects

Significant cumulative landscape and visual effects arise where wind farms become a principal characteristic of the seascape/ landscape or view as a result of the addition of the Development to other existing or proposed wind farms, which results in wind turbines becoming so prolific that they become a prevailing landscape and visual characteristic. The creation of a wind farm landscape may evolve as follows:

- A small-scale, single wind farm will often be perceived as a new or 'one-off' feature or landmark within the seascape/ landscape. Except at a local site level, it will not usually change the overall existing seascape/ landscape character, or become a new characteristic element of a wider seascape/ landscape;
- With the addition of further wind farm development, wind farms can become a characteristic element of the seascape/ landscape, as the wind farms appear as repeated seascape/ landscape elements. Providing there is sufficient separation, physically, visually and perceptually, between each development, coalescence is avoided and the wind farms are likely to appear as a series of wind farms within the seascape/ landscape, without becoming the dominant or defining characteristic of the seascape/ landscape; and
- The next stage is to consider larger commercial wind farms or an increase in the number of wind farms that appear to physically, visually and perceptually coalesce. This may lead to a 'wind farm seascape/ landscape' where multiple wind farms are the prevailing or defining characteristic of the seascape/ landscape. A wind farm characterised seascape/ landscape may already exist as part of the baseline seascape/ landscape or visual context.

In this context, the addition of the Development may lead to the final step of the key characteristics of a seascape/ landscape or view becoming defined by the presence of wind farms, so that other patterns and components are no longer definitive and in some cases, to transform it into a different landscape type. In this case, the cumulative effect would be assessed as significant. In some cases, significant cumulative effects may arise where the Development lies in close proximity to other developments, but with notable differences between them in terms of scale and setting, thus increasing the cumulative magnitude of change. However, provided that the Development is designed to achieve a high level of visual integration with adjacent or nearby wind farms, these effects may not be assessed as significant.

Significant cumulative effects may also result from the creation of a situation where wind farms have some geographical separation but remain highly inter-visible, potentially resulting in a proliferation of wind farm development on the skyline, the creation of multiple discrete wind farm landscapes or where there are distinct inconsistencies in image/differences in appearance between wind farms.

In the SLVIA the main assessment undertaken in section 14.7 covers the effect of the addition of the Development to the predicted baseline context that contains operational and under construction wind farms (including BOWL) and its interaction with them. The cumulative section (14.8) of the SLVIA chapter assesses the addition of the Development to a context that contains operational/ under construction, consented (including Moray East Offshore Wind Farm) and application stage wind energy developments considered under two predicted scenarios.

3.5 The Nature of Effects

The ‘nature of effects’ relates to whether the effects of the Development are beneficial or adverse. Guidance provided in GLVIA3 states that “thought must be given to whether the likely significant landscape and visual effects are judged to be positive (beneficial) or negative (adverse) in their consequences for landscape or for views and visual amenity” but does not provide an indication as to how that may be established in practice. The nature of effect is therefore one that requires interpretation and reasoned professional opinion.

In relation to many forms of development, the ES will identify positive and negative effects under the term 'nature of effect'. The landscape and visual effects of wind farms are difficult to categorise as either positive or negative as, unlike other disciplines, there are no definitive criteria by which these effects can be measured as being categorically positive or negative. For example, in disciplines such as noise or ecology it is possible to identify the nature of the effect of a wind farm by objectively quantifying its effect and assessing the nature of that effect in prescriptive terms. However, this is not the case with landscape and visual effects, where the approach combines quantitative and qualitative assessment.

In this assessment, positive, neutral and negative effects are defined as follows:

- Positive effects contribute to the seascape/ landscape and visual resource through the enhancement of desirable characteristics or the introduction of new, beneficial attributes. The removal of undesirable existing elements or characteristics can also be beneficial, as can their replacement with more appropriate components;
- Neutral effects occur where the Development neither contributes to nor detracts from the seascape/ landscape and visual resource and is accommodated with neither beneficial nor adverse effects, or where the effects are so limited that the change is hardly noticeable. A change to the seascape/ landscape and visual resource is not considered to be adverse simply because it constitutes an alteration to the existing situation; and
- Negative effects are those that detract from or weaken the seascape/ landscape and visual resource through the introduction of elements that contrast, in a detrimental way, with the existing characteristics of the landscape and visual resource, or through the removal of elements that are key in its characterisation.

A precautionary approach has been adopted which assumes that significant landscape and visual effects will be weighed on the negative side of the planning balance, although beneficial or neutral effects may arise in certain situations. Unless it is stated otherwise, the effects on the landscape and visual amenity of the Development are therefore considered to be adverse.

3.6 Duration and Reversibility of Effects

GLVIA3 advises that duration and reversibility should be a consideration in the assessment of magnitude of change. The majority of the changes to views that occur in relation to wind farm development are reversible, however, following the construction stage they are also generally long-term (up to 50 year operational period). OPEN's methodology does not include duration and reversibility as part of magnitude of change, as there is the potential that the reversibility aspect could alter or reduce potentially significant effects even though they are long-term. The duration and reversibility of the effects is instead determined separately and recorded alongside significance rather than being a factor of it.

The effects of the Development are of variable duration, and are assessed as short-term, medium-term or long-term, and permanent or reversible. It is anticipated that the operational life of the Development will be 50 years. The wind turbines and OSPs will be apparent during this time, and these effects are considered to be long-term.

Other infrastructure and operations such as the construction processes and plant (including tall cranes and jack-up barges for wind turbine erection) will be apparent only during the construction period of the Development and are considered to be short-term effects.

The reversibility of effects is variable. The most apparent effects on the landscape and visual resource, which arise from the presence of the wind turbines, are reversible as they will be removed on decommissioning. The effects of the tall cranes, vessels and heavy machinery used during the construction and decommissioning periods are also temporary and reversible.

In order to avoid repetition, the duration and reversibility of effects are not reiterated throughout the assessment.

4 Technical productions and their limitations

4.1 Zone of Theoretical Visibility (ZTV)

The ZTVs have been generated using GIS software (ESRI ArcGIS Version 10.5) to demonstrate the number of wind turbines that may theoretically be seen from any point in the study area. The hub height ZTV shows the number of wind turbine hubs of the Development theoretically visible in the study area. When used in conjunction with the blade tip ZTV, the hub height ZTV provides an indication of the degree to which the wind turbines may be visible.

There are limitations in this theoretical production, and these should be considered in the interpretation and use of the ZTV:

- The ZTV illustrates the 'bare ground' situation, and does not take into account the screening effects of vegetation, buildings, or other local features that may prevent or reduce visibility;
- The ZTVs are based on theoretical visibility from 2 m above ground level;
- All ZTVs are based on Ordnance Survey (OS) Terrain 5 Digital Terrain Model (DTM). Due to the extensive size of the resulting dataset, and to ensure correlation with wireline outputs, the data has been interpolated to a 10m grid resolution;
- The Blade Tip ZTV does not indicate the decrease in visibility that occurs with increased distance from the Development. The nature of what is visible from 3 km away will differ markedly from what is visible from 10 km away, although both are indicated on the Blade Tip ZTV as having the same level of visibility; and
- There is a wide range of variation within the visibility shown on the ZTV, for example, an area shown on the blade tip ZTV as having visibility of 62 turbines may gain views of the smallest extremity of blade tips, or of 62 full turbines. This can make a considerable difference in the effects of the Development on that area. The hub height ZTV should be used in conjunction with the blade tip ZTV to provide an indication of the degree to which the wind turbines are visible.

These limitations mean that while the ZTVs are used as a starting point in the assessment, providing an indication of where the Development will theoretically be visible, the information drawn from the ZTV is checked with wirelines and in the field, to ensure that the assessment conclusions represent the visibility of the Development reasonably accurately.

The SLVIA includes a Horizontal Angle ZTV. This has been generated using Arcmap 10.5 and the same data as the other ZTVs. The Horizontal Angle ZTV shows the horizontal field of view (in degrees) that may be affected by views of the Development. As with the Blade Tip ZTV analysis, the Horizontal Angle ZTV is a helpful starting point for assessment.

4.2 Visualisations

The viewpoint assessment is illustrated by a range of visualisations, including photographs and photomontages, which accord with SNH's Visual Representation of Wind Farms Version 2.2 (SNH, 2017) and in some cases THC Visualisation Standards (THC, 2016). Visualisations of wind farms have a number of limitations when using them to form a judgement on a wind farm proposal. These include:

- A visualisation can never show exactly what the wind farm will look like in reality due to factors such as: different lighting, weather and seasonal conditions, which vary through time and the resolution of the image;
- The images provided give a reasonable impression of the scale of the wind turbines/OSPs and the distance to them, but can never be 100% accurate;

- A static image cannot convey wind turbine movement, or lighting from the sun on the wind turbines blades as they move;
- The viewpoints illustrated are representative of views in the area, but cannot represent visibility at all locations;
- To form the best impression of the effects of the wind farm proposal these images are best viewed at the viewpoint location shown; and
- The visualisations must be printed at the right size to be viewed properly (A1 width or as otherwise specified) and viewed at a comfortable viewing distance.

The photographs used to produce the photomontages have been taken using Canon EOS 5D and 6D Digital SLR cameras, with a fixed lens and a full-frame (35 mm negative size) sensor. The photographs are taken on a tripod with a pano-head at a height of approximately 1.5 m above ground.

To create the baseline panorama, the frames are individually cylindrically projected and then digitally joined to create a fully cylindrically projected panorama using PTGui software. This process avoids the wide-angle effect that would result should these frames be arranged in a perspective projection, whereby the image is not faceted to allow for the cylindrical nature of the full 360-degree view but appears essentially as a flat plane.

Tonal alterations are made using Adobe software to create an even range of tones across the photographs once joined.

Sections of these panoramas are then cropped and planar projected using PTGui software. These are used in the creation of the 53.5 degree field of view (or in some cases 63.5 degree field of view) photomontages.

Wireline representations that illustrate the wind turbines set within a computer-generated image of the landform are used in the assessment to predict theoretical appearance of the wind turbines. These are produced with Resoft WindFarm software and are based on a terrain model with a 10m data grid (OS terrain 5, interpolated to 10m due to the very large data set required for the 50 km radius study area). There are limitations in the accuracy of DTM data so that landform may not be picked up precisely and may result in wind turbines being more or less visible than is shown, however, the use of OS terrain 5 minimises these limitations. Where descriptions within the assessment identify the numbers of wind turbines visible this refers to the illustrations generated and therefore the reality may differ to a degree from these impressions.

Photomontages have been produced for a number of agreed viewpoints, again using Resoft WindFarm software, to provide a more realistic image of the appearance of the Development. Photomontages show the OSPs and the wind turbines. The yellow navigational paint is included in the turbine model portrayed, however the foundation type is not accurately modelled in the photomontages as this level of detail would not have a defining influence on the level of effect assessed in the SLVIA.

The baseline photographs and cumulative wireline visualisations shown for each viewpoint cover a 90-degree field of view (or in some cases, up to 360-degree), which accords with SNH guidance. These are cylindrically projected images and should be viewed flat at a comfortable arm's length. BOWL has been added to the baseline view photography for those viewpoints where the software dictated it would be theoretically visible.

The 53.5 degree field of view wirelines and photomontages are prepared using a planar projected image and should also be viewed flat at a comfortable arm's length. These images are each printed on paper 841 x 297 mm (half A1), which provides for a relatively large scale image. In some instances the Development does not fit within a 53.5 degree field of view and a 63.5 degree field of view has been prepared on a longer sheet, but with the same height and principal viewing distance as the 53.5 degree field of view wirelines.

In the wirelines, the turbines are shown with the central wind turbines facing the viewer directly, with the full rotor diameter visible at its tallest extent. In the photomontages, the wind turbine rotors are shown

with a random appearance with the central wind turbines facing the viewer directly. This is with the exception of the night time visualisations which portray the turbines so that they are facing away from the viewpoint so that the aviation lights are not screened from view by passing turbine blades.

Single frame images have been prepared for some viewpoints at the request of THC. These show a photograph and wireline or a photomontage. The photographs and photomontages are produced at a standard size from a single 50mm fixed lens photographic image (39.6 degree field of view) recalibrated to show a 75mm focal length (27 degree field of view) image. The wirelines have been generated to match this size.

For a number of viewpoints THC has requested planar panoramas for use in its single frame panoramic viewer. These have a vertical field of view of a focal length of 75 mm (18 degrees field of view), based on a recalibration of the 50mm single frame. Such viewpoints have a a colour photomontage which includes BOWL, which shows the addition of the Development turbines to the baseline view and a cumulative monochrome panorama, which illustrates the relationship between BOWL, Moray East (consented SLVIA worst-case scenario Layout 4c) and the Development.

The photographs and other graphic material such as wirelines and photomontages used in this assessment are for illustrative purposes only and, whilst useful tools in the assessment, are not considered to be completely representative of what will be apparent to the human eye. The assessments are carried out from observations in the field and therefore may include elements that are not visible in the photographs.

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MORAY WEST
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Baseline Landscape Character

Moray Offshore Windfarm (West) Limited

Technical Appendix 14.2

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Acronyms	
Acronym	**Expanded Term**
HES	Historic Environments Scotland
GDL	Garden and Designed Landscape
LCT	Landscape Character Type
RCCA	Regional Coastal Character Area
SLA	Sensitive Landscape Area

1 Introduction

This Technical Appendix describes the baseline characteristics that have been used to inform the assessments of the effects on the Landscape Character Types (LCTs), Regional Coastal Character Types (RCCAs) and Landscape Planning Designations in Sections 14.7 and 14.8 of Chapter 14: Seascape, Landscape and Visual Assessment of the Moray West Offshore Wind Farm EIA Report.

2 Landscape Character Types

Table 2.1 sets out the baseline characteristics of the LCTs that are assessed in detail in Table 14.7.6: Effect on Character of LCTs.

Table 2.1: Baseline Character of LCTs

LCT	Baseline Character
Sweeping Moorland - 25	The closest areas of this LCT lie inland of the Small Farms and Crofts LCT between Borgue and Lybster. Buolfruich and Gordonbush onshore wind farms are partly located within this LCT. Landscape type influenced by the sea /coast: • Some influence by the sea where south east and east facing slopes allow visibility over the Small Farms and Crofts LCT and its rolling landform. Sea and coast do not provide the defining characteristics of this landscape type, which is defined by: • Wide open space results in a high degree of exposure, affording extensive visibility. • Simple visual composition, its main elements being the sky, a horizontal or gently sloping, uninterrupted skyline, and vegetation. • Fairly flat, or gently sloping or undulating landform. • Largely uninhabited, resulting in a perceived sense of remoteness. This, in addition to the visual simplicity, tends to direct attention towards the foreground details and other experiential characteristics. • Most existing settlements occur on the outer edges, particularly where abutting the sea or a strath. Ruined buildings and boundaries evidence past depopulation. • Lochs and mature, meandering rivers as well as juvenile streams. • Ribbons of broadleaf woodland and coniferous plantations. • Pockets of improved grazing and evidence of peat hagging. • Service elements, such as roads and powerlines, pass through some parts of this landscape, tending to be highly visible on account of the open surroundings.
Small Farms and Crofts - 23 Viewpoints 5: Sarclet, 6: Minor Road South of Osclay,	This LCT covers a relatively extensive, continuous strip of settled, sloping land located along the coast between Berriedale and Sarclet Head. The width of the strip varies between a narrow edge between the sea and Sweeping Moorland and large areas extending inland where the landform and quality has allowed for a crofting and settled landscape to establish. Such areas generally extend along the catchments of water courses and/or roads. BOWL is visible across a large part of the views from this coast to the south east. The Beatrice Demonstrator Turbines and the associated oil platforms are visible as point features further to the south. Buolfruich onshore wind farm is partly located within this LCT. Burn of Whilk wind farm is visible at relatively close range.

Table 2.1: Baseline Character of LCTs	
LCT	**Baseline Character**
7: Lybster, 8: Latheron, 9 a and b: Dunbeath, 11: Berriedale	Landscape type influenced by the sea /coast: • Nature of the sea and the coastline strongly influences the areas that lie adjacent to the coast. • The land division tends to relate directly to the coastal edge. • Influenced by the sea, clarity of coastal light, the activity and sound of the waves, strong wind and sea birds. Sea and coast do not provide the defining characteristics of this landscape type, which is defined by: • Dominated by the occupation and activity of people, who are responsible for a complex variety of different land use characteristics. • Range from clearly ordered crofts, to open and fairly rich, small farms and areas of marginal moorland and ruined properties. • Comprises a number of common elements despite the variation in their arrangement: houses, outbuildings, fields depicted by fences / walls. • Extent of visibility often limited because of screening effect of surface features and sloping landform. • Complex visual composition of different spaces, edges, points and lines.
Moorland Slopes and Hills - 18	These are extensive areas of moorland slopes and hills with the largest areas located on either side of Strath Ullie and extending far inland. There are also other smaller hill areas interspersed within the Sweeping Moorland to the north. Areas of the LCT extend close to the coast allowing only narrow strips of High Cliffs and Sheltered Bays against the shore or sloping steeply to define the inner edges of the Coastal Shelf LCTs. Their sea facing slopes tend to be influenced by infrastructure and some limited settlement whilst the interior areas are less developed and have wide, relatively uniform characteristics. Kilbruar wind farm is located within this LCT and Gordonbush onshore wind farm is partly located within this LCT. These are sited well back from the coast in the upland areas of this LCT. Landscape type influenced by the sea / coast: • The coastline is generally not visible because of the convex slopes and drops in the landform. • Variable landform allows distant views of the sea and its bays further along the coast. Sea and coast do not provide the defining characteristics of this landscape type, which is defined by: • Sloping open moorland that usually undulates or gradually rises to form broad hills.

Table 2.1: Baseline Character of LCTs	
LCT	**Baseline Character**
	• Variable slope of landform creates some pockets of enclosure but broadly this landscape remains overwhelmingly open. • Interlocking arrangement of moorland landform with tops of the hills tending to be spaced far apart and of a similar height. • Generally difficult to discern relative elevation as no one point tends to be more visually dominant than the other, creating numerous minor foci.
Coastal Shelf - 6 Viewpoint 12: Navidale	This LCT is located between the Moorland Slopes and Hills LCT and the coast. It consists of a long strip of land running between Kintradwell and Portgower and two further areas at Navidale and Ousdale. Parts of the LCT are steeply sloping with other areas more settled and providing gentler slopes that facilitate routes along the coast. There are expansive views across the open sea with BOWL visible to the east north east at a range of 33.8 km and the Beatrice Demonstrator Turbines and the associated oil platforms visible as point elements at 29 km distant. Sea and / or coast provide the defining characteristics: • Elevated platform, created by a coastal plain of sedimentary rocks, with linear space semi-enclosed by inland hills thus directing views out to sea. • Beach cliffs or dunes along some stretches of the coast tend to limit direct visibility and experience of the coastline from inland areas. • Strongly influenced by the character of open skies and the distinctive coastal light. Sea and coast do not provide the defining characteristics of this landscape type, which is defined by: • Pattern of land use largely relates to the linear space. • Transport corridor / small settlements and often farmed.
Coastal High Cliffs and Sheltered Bays - 11	There are two narrow sections of this LCT running along the coast between Berriedale and Navidale. Located between the Moorland Hills and Slopes and the coast. BOWL is visible across the open sea views to the east round to the east north east at a range of 29 km and the Beatrice Demonstrator Turbines and the associated oil platforms visible as point elements at 26 km distant. Sea and / or coast provide the defining characteristics: • Long, narrow, exposed stretches of very high cliffs interrupted by bays at glen intersections. • Stacks, caves, pebbles and collapsed cliffs. • Cliffs within this landscape create a strong and limiting linear edge where experience is dominated by the presence of the land / sea edge. • Views directed along coast and out to sea focusing on islands, rigs and boats. • Backed by moorland or small farms / crofts. Road aligned parallel to coast.

Table 2.1: Baseline Character of LCTs	
LCT	**Baseline Character**
	• Access and views to coast restricted due to cliffs. • Distinctive coastal light, immense openness, soaring and nesting sea birds, and movement and sound of breaking waves. • Remote and exposed with some wildness attributes associated with sense of isolation, risk associated with accessing cliffs and elemental coastal processes.
Long Beaches Dunes and Links	This LCT is located along the coast in an almost continuous strip around the headland at Brora. North east of Kintradwell and south of Lothbeg. Sea and / or coast provide the defining characteristics: • Soft, linear edge to sea. • Wide open space, exposure and extensive visibility. • Simple visual composition. • Dynamic landscape, both physically and experientially. • Recreation / golf links / caravan parks along coastal hinterland. • Generally backed by farmland or settlements. • Composition and relative prevalence of elements is strongly affected by the northern coastal light. • Linear transport routes and settlement influential.

3 Regional Coastal Character Areas

Table 3.1 sets out the baseline characteristics of the RCCAs that are assessed in detail in Table 14.7.7: Effect on Character of Regional Coastal Character Areas.

Table 3.1: Baseline Character of Regional Coastal Character Areas

Regional Coastal Character Area	Baseline Character
Sarclet Head - G Viewpoint 4: Sarclet and Viewpoint 5: Whaligoe Steps	Forms the coastal edge to a variety of settled/farmed LCTS, namely Small Farms and Crofts, Mixed Agriculture and Settlement and Open Intensive Farmland. Maritime influences: • Broad convex headland with south east orientation towards the sea. • Dynamic coastal influences and processes under continual force from the sea. • Small harbours once gave a safe haven for fishing boats. • Low level of shipping parallel to coast and some recreational sailing. Shipping is a common feature seen further out to sea on the horizon. • Strong maritime connection with settlements and agricultural land use patterns. • Beatrice platform and wind turbines visible out to sea. • BOWL influence through visibility of offshore wind farm to the south east as part of wide sea views at a range of approximately 14.7 km. Character of coastal edge: • Rocky coastline with open sea views, vertical cliffs and small enclosed bays / harbours. • Stacks, caves and cliffs, with strong contrast between verticality of cliffs and wide horizon of sea. • Some recreational / visitor opportunity in places, such as Sarclet Haven and Whaligoe Steps. • Exposed coastline with open views and strong historical associations of castles and cliff top forts and cultural interest of fishing villages. Character of immediate hinterland: • Scattered small farms and crofts adjacent to the coast, occasionally concentrated to form crofting settlements such as Ulbster and Thrumster. • Rough open grassland with gorse scrub in places and small lochs. • A99 runs parallel to coastline. • Settlements and built features appear at even intervals and provide a visual rhythm of foci along coast.

Table 3.1: Baseline Character of Regional Coastal Character Areas	
Regional Coastal Character Area	**Baseline Character**
	• Some onshore wind farm visibility inland between Wick and Thrumster. Wildness / isolated coast: • Although it is exposed, built features including main road and settlements limit sense of wildness experienced. • Coastal edge is mainly inaccessible due to vertical cliff faces. • Some illumination at night with BOWL, Beatrice Oil Platforms and Beatrice Demonstrator Turbines visible alongside lighthouses and distant views of lights on the Moray Coast.
Lybster Bay - H Viewpoint 7: Lybster	Forms the coastal edge to an area of the Small Farms and Crofts LCT. Maritime influences: • Broad, shallowly concave bay with a mainly south east orientation. • Dynamic coastal influences and processes under continual force from the sea. • Small harbour in Lybster Bay with fishing vessels. Low level of shipping parallel to coast and some recreational sailing. • Shipping is a common feature seen further out to sea on the horizon. • Sea more distant from elevation and less immediate due to undulating coastal edge. • Beatrice platform and wind turbines visible out to sea to the south east. • BOWL influence through visibility of offshore wind farm to the east as part of wide sea views at a range of approximately 16.7 km. Character of coastal edge: • Rocky, undulating coastline with indentations stacks and small enclosed bays. • Lybster Bay formed from confluence of Reisgill Burn and the North Sea. Character of immediate hinterland: • Scattered small farms and crofts with open fields. • Rough open grassland with gorse and scrub in places. • A99 running parallel to coastline. • Some onshore wind farm visibility inland between Clyth and Forse and from the A99.

Table 3.1: Baseline Character of Regional Coastal Character Areas	
Regional Coastal Character Area	**Baseline Character**
	Wildness / isolated coast: • Although it is exposed, built features including main road, communications / power lines and dwellings limit the sense of wildness likely to be experienced. • Some areas inaccessible due to vertical cliff faces.
Dunbeath Bay - I Viewpoints 8: Latheron, 9a and b: Dunbeath and 11: Berrydale.	Forms the coastal edge to an area of the Small Farms and Crofts LCT. Maritime influences: • Broad, shallowly concave bay with a mainly south east orientation. • Smaller, local bays at Latheronwheel and Dunbeath. • Harbours in the bays with fishing and maritime vessels. Low level of shipping parallel to coast and some recreational sailing. Shipping is a common feature seen further out to sea on the horizon. • Views across the bays towards headlands and out to sea to the distant horizon. • Beatrice platform and wind turbines visible out to sea. • BOWL influence through visibility of offshore wind farm to the east as part of wide sea views at a range of approximately 21 km. Character of coastal edge: • Rocky, undulating coastline with elevated views along the coast and across the open expanse of sea. • Sea views framed in places by undulations in the landform and in bay areas. • Coastline includes large number of indentations, stacks and cliffs. • Latheronwheel and Dunbeath Bays formed from the confluence of Latheronwheel Burn and Dunbeath Water • Exposed coastline with open views and strong historical associations of castles, cliff top forts and cultural interest. Character of immediate hinterland: • Topography rising to form hills adjacent to the vertical cliffs and coastline. • Scattered small farms and crofts with open fields. • Rough open grassland with gorse and scrub in adjacent to cliffs and on hill tops. • Areas of native woodland along steep river valleys and in gardens – most notably at Dunbeath Castle. • A99/A9 running parallel to coastline.

Table 3.1: Baseline Character of Regional Coastal Character Areas	
Regional Coastal Character Area	**Baseline Character**
	• Some onshore wind farm visibility inland west of Dunbeath. Wildness / isolated coast • Although it is exposed, built features including main road, communications / power lines and dwellings limit the sense of wildness likely to be experienced. • Some areas inaccessible due to vertical cliff faces.
Helmsdale to Berriedale Coastal Shelf - J Viewpoint 12: Navidale	Forms the coastal edge to a variety of LCTSs. The most prolific are the High Cliffs and Sheltered Bays and Coastal Shelf LCTs with areas of Small Farms and Crofts LCT and Harbour LCT in the vicinity of Helmsdale. Maritime influences: • Linear coastal shelf with mainly south east orientation. • Bay with harbour at Helmsdale with fishing and maritime vessels. Low level of shipping parallel to coast and some recreational sailing. Shipping is a common feature seen further out to sea on the horizon. • Rugged coastal terrain with high cliffs. • Beatrice platform and wind turbines visible out to sea. • BOWL influence through visibility of offshore wind farm to the north east as part of wide sea views at a range of approximately 29 km. Character of coastal edge: • Predominantly rocky but 'straight' coastline, backed by a narrow corridor of level land tightly constricted by inland hills and the open sea. • Undulating landscape with a series of small coastal hill formations and glens. • Long stretches of high cliff which are regularly interrupted by the location of a bay, typically corresponding to the intersection of a glen. • Coastal shelves creating semi-enclosed elevated spaces with views out to the sea and a screen of inland hills. Character of immediate hinterland: • Mixed woodland along glen at Berridale. • Areas of heather moorland interspersed with coniferous woodland plantations.

Table 3.1: Baseline Character of Regional Coastal Character Areas	
Regional Coastal Character Area	**Baseline Character**
	• Large agricultural fields at Ousdale. • Generally sparsely settled with small harbour settlements situated on inlets; and with historic churches, harbours and houses within these settlements forming foci. • Communications / power lines evident along coast. • Exposed coastline with open views and strong historical associations of castles, cliff top forts and cultural interest. Wildness / isolated coast: • Inaccessible areas due to vertical cliff faces. • Rugged coastal terrain with dynamic coastal influences and processes. • Although it is exposed, built features including main road, communications / power lines and dwellings limit the sense of wildness likely to be experienced.
Brora to Helmsdale Deposition Coast - K Viewpoint 13: Brora	Forms the coastal edge to sections of the Coastal Shelf and Long Beaches, Dunes and Links LCTs Maritime influences: • Sense of light influenced by interplay of light and the sea. • Mainly south east orientation. • Low level of shipping parallel to coast and some recreational sailing. Shipping is a common feature seen further out to sea on the horizon. • Sense of space from views out to the sea and across the low lying coastline. • Beatrice platform and wind turbines just visible out to sea. • BOWL limited influence through visibility of offshore wind farm to the north east as part of wide sea views at a range of approximately 41.5 km. Character of coastal edge: • Low lying coastal edge. • Coastal shelves creating semi-enclosed elevated spaces with views out to the sea and a screen of inland hills. • Sandy beaches from Brora to Lothbeg Point and Sron Rubha na Gaoithe. • Exposed underlying rock with shingle and pebbbles from Sron Rubha na Gaoithe to Portgower and Helmsdale. Character of immediate hinterland: • Railway line runs adjacent to the coast line with the A9 running parallel and further inland.

Table 3.1: Baseline Character of Regional Coastal Character Areas	
Regional Coastal Character Area	**Baseline Character**
	• Occasional mature deciduous trees beside A9 and along access tracks in small settlements. • Riparian woodland adjacent to burns. • Semi-improved grassland with agricultural fields. • Rough grassland with gorse and scrub on hills. • Small settlement at coastal edge at Portgower. • Communications / power lines evident along coast. Wildness / isolated coast: Although it is exposed, built features including rail line, main road, communications / power lines and dwellings limit the sense of wildness likely to be experienced.

4 Landscape Planning Designations

Table 4.1 sets out the baseline characteristics of the LCTs that are assessed in detail in Table 14.7.8: Effect on Character of Landscape Planning Designations.

Table 4.1: Baseline Character of Landscape Planning Designations

Landscape Planning Designation	Baseline Character
Dunbeath Castle GDL 23.9 km Nearest viewpoint Viewpoint 9a (Dunbeath nr. Heritage Centre) – Figure 14.7.17	This relatively small, 17th/18th century formal landscape and imposing castle is dramatically located on a cliff top area that projects out into the sea. Its relationship to the sea and its exposed cliff edge location is an inherently important aspect of its setting, which has been manipulated so that this is highly evident through its approach and aligned garden views. The contrast of the simple, sea backdrop with the more complex, pale facades and rooflines of the Castle and the smaller scale enclosure of the walled gardens adds to this importance. The GDL covers a narrow (200 m wide) area aligned north west to south east and extending to approximately 1 km in length between the coast and the A9. The four storey castle building is oriented in a south easterly direction with key views over the North Sea and along the Caithness coast. The majority of the designed landscape lies to the north west of the castle, however it also takes in a short section of cliff edged coastline with some open, grass pastures behind. The designed landscape is laid out within an earlier pattern of flat, regular, fields. These fields with their associated walls, hedgerows and shelter belts comprise the immediate setting of the Dunbeath GDL and form an important landscape context. The design of the landscape is heavily based upon geometric connections between the rectangular formal gardens, the castle, associated architecture (doocot) and the backdrop of the open seascape. Two square enclosures were laid out on either side of the main approach to the north of the Castle, on the site of the existing Walled Gardens. One of the walled gardens has a similar axis to the main drive with an arched doorway in the wall offering framed views towards the Castle and the sea beyond. The approach drive from the north west forms the central axis of the design and lies in a deep cutting in places. It is lined by an avenue, tree belts and the garden walls, which channel views to focus on the Castle, which is symmetrically framed by a backdrop of open sea. The site has a strong history dating to prehistoric times with the first Castle dating back to the Medieval period. Today the castle is privately owned and not generally open to the public although access to the gardens can be arranged and has been encouraged on garden open days in the past. Associated estate buildings are let as holiday rentals and the Castle and grounds can be rented for weddings. Although not open to the public the castle can be glimpsed from the A9 through breaks in roadside plantations and from parts of Dunbeath where it contributes to the character of the coastal landscape. Roadside planting of conifers along the A9 is gradually limiting views. The open space and dominance of the sky on this coastal area means that the Castle is highlighted in the landscape, which is particularly emphasised by the clarity of the northern, coastal light. In addition, the improved grass parks appear as bright pockets of grassland, further emphasising the designed landscape character. BOWL will be apparent in the open sea skyline to the east and north east, across a field of view of approximately 26 degrees at a distance of 25.7 km. It will be readily visible in very good visibility, obliquely, from the north east facing aspect of the Castle.

Table 4.1: Baseline Character of Landscape Planning Designations	
Landscape Planning Designation	**Baseline Character**
	The Beatrice Demonstrator Turbines and the associated oil platforms are currently visible directly south west from the Castle, however, as point features they do not have wide spread effect across the views in this direction.
Dunrobin Castle GDL 40.2 km Nearest viewpoint Viewpoint 13: Brora – Picnic Area off Salt Street Figure 14.7.22	This is a relatively large GDL, which provides the setting for one of the oldest inhabited castles in Scotland. The turreted Castle and gardens are open to the public from April to October. The Castle itself is set on a rocky terrace above the shore overlooking the extensive formal garden and with fine views out across the Moray Firth to the north Morayshire coast. The aspect of the Castle that faces out to sea is facetted with grand terraces affording expansive views over the coast and historic, formal gardens. The formal gardens are aligned on a north west to south east axis with walks and staircases generally aligned in this direction. The designed landscape is enclosed by the extensive area of Dunrobin Wood which clothes the slopes and hills to the west and north of the policies. The inner core of the designed landscape today is bounded by the A9 and the railway to the north and by the Moray Firth to the south The main access to the castle is via a north-south avenue lined with 200 year old oak and beech trees, which completely enclose any views outwards. There are extensive views out across the Moray Firth to the north Morayshire coast and these views are important to the setting of the designed landscape. Views into the policies are limited by the avenues and shelterbelt which line the A9, but the baronial turrets of the Castle can be glimpsed amid its wooded setting from the main road and railway line. Woodland on the lower slopes of the GDL to the east and west of the Castle and formal gardens restricts views along the coast from there. The wider approach is along the A9 which has frequent open views over the Moray Firth (including glimpses of the top of the castle turrets) when approaching from the east. Approaching from the west, views are restricted by the presence of a thicker band of woodland which encloses the castle. The wider policy woodlands contain a comprehensive path network, some leading to scheduled monuments and listed buildings (Garden pavilion. Tower lodge, Ice house…). Cairn Laith Broch is a scheduled monument, iron age settlement within the designed landscape boundary with open views across the Moray Firth.
Flow Country and Berriedale Coast SLA	The SLA area extends from the coastal shelf and cliffs near Berriedale in the south, including Badbea, to Loch More in the north. It includes the wide expanse of interior peatland known as The Flow Country and extends westwards to include Knockfin Heights and the highly distinctive range of hills in the south that includes the peaks of Morven, Maiden Pap and Scaraben. **Overview – extracted from citation THC (2011)** 'This extensive area comprises a contrasting range of landscapes, from interior peatland to isolated mountains and a raised coastal shelf. It includes a large portion of the distinctive Flow Country of Caithness.

Table 4.1: Baseline Character of Landscape Planning Designations	
Landscape Planning Designation	**Baseline Character**
	The area is dominated by the overriding simplicity and horizontal emphasis to the landscape and the feeling of remoteness and wildness which is experienced directly from within its interior, and indirectly when looking in from the roads and tracks around its edge. The south western edge of the Flow country peatland is marked by a highly distinctive range of lone mountain peaks and moorland peaks that form a distinctive skyline which is visible from much of Caithness. These hills are largely bounded by the glens of the Berriedale and Langwell rivers and offer a series of fine vantage points from which to enjoy panoramic views over much of the Flow Country and out to the North Sea. The Berriedale and Langwell glens are steeply incised in their middle and lower reaches, and where they approach the sea they converge and cleave through the coastal cliffs. These glens offer welcome shelter and enclosure as well as a sense of human scale within the wider open space. The woodlands of Langwell and Berriedale together form the largest tract of semi-natural broadleaved woodland in Caithness.' **Key Landscape and Visual Characteristics – extracted from citation THC (2011)** • 'A striking combination of mountains rising abruptly from surrounding extensive areas of peatland that is vast in scale, with a long low horizon and broadly very simple in character, although containing numerous lochs, lochans and pools. The peatland areas are very difficult to access or cross due to the lack of tracks and roads and because of the drainage conditions. As a consequence, these areas tend to possess a strong sense of wildness. • The isolated mountains are typified by exposed rock, rocky outcrops and scree, and montane vegetation. They form distinctive and offer extensive views over the Flow Country and out to sea. • The moorland foothills which flank the lone mountains typically comprise undulating and sloping broad convex hills, plateaux, rocky outcrops and crags, dense heather and grassland mosaics. The landform sweeps gently north from impressive elevations across vast open moorland to the flat peatland. • Views of peatland are typically very simple in composition at a broad scale. However at a more detailed level, lochs, pools and patches of surface water, networks of watercourses and tussocky wetland grass and heather provide variation of detail including sounds, colours and textures. • The peatland expanse is incised in places by deeply carved, meandering wooded glens. Parallel tracks and footpaths, penetrate some interior parts of these glens also occupied by isolated lodges and bothies utilising the shelter and protection offered by these glen slopes. • These built structures empathises and contrast the vast scale of the surrounding peatlands. • Settlement only occurs at the south eastern part of this area, restricted to the sheltered glens and coastal areas. This leaves the area largely undeveloped and consequently possessing strong qualities of wildness.' **Special Qualities – relevant aspects extracted from citation THC (2011)** Distinctive Mountain and Moorland Skyline

Table 4.1: Baseline Character of Landscape Planning Designations	
Landscape Planning Designation	**Baseline Character**
	• Morven forms a prominent conical landmark feature landmark which is visible from both the north coast and the Morayshire coast. It stands in strong contrast to its long-backed neighbor Scaraben but is echoed on a smaller scale by the rocky profile of the nearby Maiden Pap. The latter is an especially striking landscape feature and backdrop when viewed from the Braemore area. Exposed Peaks, Vast Openness and Intimate Glens • The mountain summits offer rare opportunity to view a panorama of wide ranging characteristics extending over the Flow Country peatlands, out to sea and as far south as the Cairngorms in clear conditions. The Historic Landscape **Sensitivity to change – relevant aspects extracted from citation THC (2011)** • Development could compromise views of the exposed and striking skyline profile of the lone mountains and peatlands. • The introduction of large scale structures could be prominent in views and would affect the perception of the scale of the mountains and the extent of the peatlands. This could occur cumulatively as well as individually. • Development could compromise the qualities of wildness which are particularly sensitive to landscape change. **Existing wind farm influence** There is existing onshore wind farm influence on the designated area through visibility of Buolfruich wind farm between the SLA and the coast at Latheronwheel. Also to the north east there are close range views of Causeymire, Achlachan and Bad a'Cheo wind farms. The upland and east and south east facing slopes would also be influenced by views of BOWL some 27.2 km to the south-east out in the sea. At Viewpoint 11: Berriedale (Figure 14.7.20) BOWL is seen to extend across approximately 24 degrees of the sea skyline to the east. Visibility of the Beatrice Demonstrator Turbines and the associated oil platforms is also possible at a range of approximately 24.7 km. There is a large separation by open sea between the Development and the SLA and it is seen as a separate entity far out to sea.
Loch Fleet, Loch Brora and Glen Loth SLA Nearest Representative Viewpoints –	Lying along the east coast of Sutherland, this area stretches from the southern slopes of Strath Ullie in the north to Loch Fleet in the south, including areas of coastal shelf and interior moorland and hills. **Overview – extracted from citation THC (2011)** 'This is an area of rolling moorland hills, punctuated by a series of southeast orientated glens, straths and lochs, and edged to a narrow strip of farmed coastal shelf running along the shoreline. The character of this area is distinguished by its composition of contrasting landscape features – the contrasting landform, landcover and landscape pattern that empathise the distinction of each other.' **Key Landscape and Visual Characteristics – extracted from citation THC (2011)**

Table 4.1: Baseline Character of Landscape Planning Designations	
Landscape Planning Designation	**Baseline Character**
Viewpoint 12: Navidale, Viewpoint 13a – Brora and Viewpoint 13b-Dornoch	• 'A relatively simple uniform, rolling plateau of interior broad, interwoven rounded hills, clothed by an open mosaic of heather and grass moorland. As this composition is fairly simple, and extends throughout the area, there is a strong consistency of this backdrop to the coast. • The hill area is breached by major straths and glens which have differing local character derived from the varying combination of native woodland, forest plantation, moorland and water bodies. They provide sheltered access routes through the hills and provide physical and visual connections between the interior and the coastal shelf and North Sea. • To the east lies a narrow but relatively fertile coastal shelf contains the main road and rail routes in this area, and small farms and settlements at fairly regular intervals. A distinctive field pattern of pasture runs parallel to the coast, marked in places by windswept trees and stone walls. • The linear coastal shelf, is defined on its interior side by the edge formed by the adjacent hill slopes, the elevation which provide expansive views both along the coastal edge and outwards across the open sea. Interior views are limited by the convex nature of the hill slopes. • Loch Fleet is the most northerly inlet on the east coast. Where an inlet occurs, defined by its distinctive opposing spits of land, a sheltered, enclosed tidal basin is fringed with shingle shores and pine woods. At low tide, exposed mudflats create a distinctive feature whose character is enlivened by large flocks of wading birds. • Views are obtained from some areas of wind turbines and overhead electricity lines whose large scale and man-made character can seem to diminish the scale of the interior hills and their wildness qualities. • Along the coast and around the inlet, there are a number of historic built features that form prominent focal features and landmarks.' **Special Qualities – relevant aspects extracted from citation THC (2011)** 'Historic features • The Mound is a very prominent and clearly man-made causeway over which the main A9 coastal road passes. Engineered by T Telford in 1814 -16 it spans the mouth of Loch Fleet with a bridge at its northern end and offers spectacular coastal views. An Integrated Combination of Landforms • The combination and juxtaposition of the rolling moorland hills, linear glens, the coastal shelf and tidal basin creates a diverse yet connected landscape composition which is experienced in sequence when travelling along the A9 and from the railway. • Many small, often linear, settlements lie to the north west of the A9, strung along the footslopes of the interior hills, and these enjoy panoramic views out to sea. In contrast the larger settlements just outside the SLA boundary but visible from within it. • There is a strong contrasts between the expansive open forms of the moorland hills, the narrow, enclosed and intimate forms of the glens and straths, the linear coastal fringe with its extensive sea views and the intimate wooded enclosure of the Loch Fleet tidal basin. • The locally dominant ridgeline of Ben Bhraggie overlooking Loch Fleet and lower lying coastland is overlooked by the monument to the Duke of Sutherland which acts as a focal feature within the southern part of the SLA.

Table 4.1: Baseline Character of Landscape Planning Designations	
Landscape Planning Designation	**Baseline Character**
	Accessible yet Secluded Glens and Lochs • The interior is largely screened by the edge of the hill landform but occasional views are obtained where glens intersect with the coastal shelf. Readily accessible, these sheltered glens offer a sense of seclusion, tranquillity and intimacy from the busier coastal fringe.' **Sensitivity to change – relevant aspects extracted from citation THC (2011)** • 'Additional large scale features could, in combination with the existing wind turbines and overhead electricity line to the west of the SLA, could diminish the perceived scale of the hills and their qualities of wildness and tranquillity. • Large-scale offshore development could introduce focal features that could impinge on panoramic sea views.' **Existing wind farm influence** There is existing onshore wind farm influence on the designated area through the influence of the Kilbraur and Gordonbush wind farms on/near to the north western boundary of the SLA. The upland and east and south east facing slopes would also be influenced by views of BOWL some 42 km to the east north east out in the sea. At Viewpoint 12: Navidale BOWL is seen to extend across approximately 17 degrees of the sea skyline to the east north east. Visibility of the Beatrice Demonstrator Turbines and the associated oil platforms is also possible at a range of approximately 32.8 km.

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Offshore Wind Farm Visibility

Moray Offshore Windfarm (West) Limited

Technical Appendix 14.3

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1 Introduction

There are a number of factors that influence the degree to which the Development would be visible and how this is defined and assessed. These are set out in the following sections.

2 Visibility Range

The Met Office sets out definitions for the different ranges of visibility on its website at https://www.metoffice.gov.uk/guide/weather/symbols#visibility ranging from 'very poor' to 'excellent' as follows:

- Very poor visibility - range is less than 1 km;
- Poor visibility - range is 1 to 4 km;
- Moderate visibility - range is 4 to 10 km;
- Good visibility - range is 10 to 20 km;
- Very good visibility - range is 20 - 40 km; and
- Excellent visibility - range is over 40 km.

This suggests that the Development would require 'very good' or 'excellent' visibility conditions for it to be visible from Highland or from Moray and excellent visibility conditions to be visible from Aberdeenshire.

The assessments made in the SLVIA are based on optimum viewing conditions with clear visibility of the turbines and as such assess the 'worst case' or maximum visual effect in optimum or 'excellent' visibility conditions.

It is reasonable to conclude that the prevailing visibility and weather conditions combine to reduce the duration and potential for significant effects to periods when clear views of the Development are available. In views from the land visibility would often be limited to the nearer rows of turbines, and the full depth of the Development would often not be seen or would be less visible.

Whilst this 'visibility' analysis is a useful indicator other factors such as contrast (largely influenced by lighting by the sun) scale, orientation and movement of the structures also need to be considered when determining the likely impact of optimum visibility at a certain range.

3 Offshore Wind Turbine Visibility

There has been some informative research undertaken relatively recently by a group based in the USA. This is entitled Offshore Wind Turbine Visibility and Visual Impact Threshold Distances (2012) and is based on fieldwork and reporting of observations carried out in the U.K. in relation to a number of offshore wind farms located in the Irish Sea and the English Channel.

The study observed that *'Past assessments of offshore wind turbine visibility were based on smaller turbines and facilities in use at the time and underestimate the visibility for current projects, which use more and larger turbines.*'

The objectives identified for the study '*included identifying the maximum distances the facilities could be seen in both daytime and night-time views and assessing the effect of distance on visual contrasts associated with the facilities.*'

It should be noted that the study does not attempt to assess whether such potential visibility would be significant or not but instead provides a useful aid to ascertaining the likely potential for visibility and the magnitude of change at various distances.

As referred to in the study there is a trend towards the Development of larger turbines and groups of turbines, which has continued since 2012. The study was based on offshore wind farms of 25-140 turbines

of heights ranging between 107m and 153m tall. Development some of the findings are helpful, particularly in relation to turbine lighting.

The effect of turbine distance to ratings of visibility (measured between 1 and 6 within the study) provides a useful gauge to potential visibility of large scale offshore wind farms. Although it is noted that 'Caution is warranted because of the relatively small number of observations' it found that in relation to moderately sized offshore wind facilities analysis of the visibility rating data indicated the following:

'*a gradual drop-off in ratings with distance; the change is non-linear, perhaps because of variability in lighting, contrast of the wind turbines with the background, facility size and layout, blade orientation and rotation rate, and various other factors the affect visibility of real landscape/seascape settings.*'

It should be noted that the reference to lighting above is to light from the sun rather than from artificial sources.

Reference is made to a graph within the study, which shows the '*relationship between distance and the visibility rating for all daytime assessments, regardless of weather and atmospheric conditions.*' The graph shows that at distances of between 22 and 30 km the rating of visibility (of moderately large offshore wind farms) was found to be between levels two and four (mainly between levels two and three) which are defined and described as follows:

- *'Visibility level 2. Visible when scanning in the general direction of the study subject: otherwise likely to be missed by casual observers.*
    - *Description: an object/phenomenon that is very small and/or faint, but when the observer is scanning the horizon or looking more closely at an area, can be detected without extended viewing. It could sometimes be noted by casual observers; however, most people would not notice it without some active viewing.*
- *Visibility level 3. Visible after a brief glance in the general direction of the study subject and unlikely to be missed by casual observers.*
    - *Description: An object/phenomenon that can be easily detected after a brief look and would be visible to most casual observers, but without sufficient size or contrast to compete with major landscape/seascape elements.*
- *Visibility level 4. Plainly visible, so could not be missed by casual observers, but does not strongly attract visual attention or dominate the view because of its apparent size, for views in the general direction of the study subject.*
    - *Description: An object/phenomenon that is obvious and with sufficient size or contrast to compete with other landscape/seascape elements, but with insufficient visual contrast to strongly attract visual attention and insufficient size to occupy most of an observer's visual field.'*

The graph also shows that at distances of 30-40 km, the rating of visibility (of moderately large offshore wind farms) was found to be between levels one and three which are defined and described as follows:

- *'Visibility level 1. Visible only after extended, close viewing; otherwise invisible.*
    - *Description: An object/phenomenon that is near the extreme limit of visibility. It could not be seen by a person who was unaware of it in advance and looking for it. Even under those circumstances, the object can be seen only after looking at it closely for an extended period.*
- *Visibility level 2. Visible when scanning in the general direction of the study subject: otherwise likely to be missed by casual observers.*
    - *Description: an object/phenomenon that is very small and/or faint, but when the observer is scanning the horizon or looking more closely at an area, can be detected without extended viewing. It could sometimes be noted by casual observers; however, most people would not notice it without some active viewing.*

- *Visibility level 3. Visible after a brief glance in the general direction of the study subject and unlikely to be missed by casual observers.*
    - *Description: An object/phenomenon that can be easily detected after a brief look and would be visible to most casual observers, but without sufficient size or contrast to compete with major landscape/seascape elements.'*

The graph also shows that at distances of 40km and greater, the rating of visibility (of moderately large offshore wind farms) was found to be reduced to between levels one and two.

Whilst these observations included more than twice as many, substantially smaller turbines compared to the Development the Greater Gabbard offshore wind farm, which consists of 140 turbines of 131.5m to tip was included and observed at ranges of up to 41km.

A maximum distance of offshore wind farm visibility was recorded for Gunfleet Sands (at a range of 44km). It consists of 48No 128.5m to tip turbines. The study describes this incidence of visibility as 'barely visible'. It is also noted that:

'when atmospheric conditions and lighting angles resulted in higher contrasts between the turbines and the sky backdrops, the facilities were judged likely to be seen easily by casual observers as a far away as 29 km for a relatively large wind facility (100 turbines). Smaller wind facilities (25-48 turbines) were generally judged to be easily visible at distances of 22-25 km.'

The difference between these wind farms and the Development is the size of the turbines themselves and the degree to which this makes them more visible over distance. The horizontal extent of turbine visibility tends to be a major factor in determining magnitude of change and relative to the scale of the horizontal effect the larger vertical extent of the turbines visible is a relatively minor factor. Much of the effect is defined by whether the turbines are there (and visible) or not and how much of the view they affect. Turbines of larger sizes are also less densely spaced than smaller turbines, which will reduce their density and visual confusion across the extent of the view affected.

A factor of the larger turbine size is, however, the greater 'widths' of the components and the movement of the larger, rotating blades. The study found that 'Turbine blade movement was visible at distances as great as 42km and was routinely observed at distances of 34km or less' and 'blade motion was visible at distances beyond 30km regardless of sun angle, lighting conditions, or contrast levels.'

Helpful reference is made within the study to Bishop and Miller (2007) who found that in all atmospheric and lighting conditions, impact declined with distance and increased with rising levels of contrast. This is relevant to the visibility of the Development in that the prevailing wind will most often mean that the rotating blades will most often be seen turned towards the south-west, i.e. partially oblique to the closest parts of the Highland, Moray and Aberdeenshire coasts.

Due to the angle of the sun and its movement between the east, south and west throughout the day, along with the relationship of the coast to the turbines, the turbines would be mostly be 'lit' by the sun in the afternoon, which in turn may increase their likely contrast when the sun is very bright (which has been found through observation does not generally coincide with the best long range visibility over the sea). The pale coloured turbines would be mostly backclothed by the pale colour of the distant sky at the horizon and therefore the contrast is not generally high.

In relation to the visibility of offshore turbines at night the researchers observed red, flashing, medium intensity lights mounted on the nacelles of moderately sized offshore wind facilities at night. It found the aviation obstruction lighting to be visible at just under 40km. This would imply that visibility of the lights at just over 40km would be limited. At a distance of 21 km both red aviation obstruction lighting and amber marine navigation lighting were visible at one facility, as seen from an elevated viewpoint.

The Beatrice Offshore Demonstrator Turbines were observed by OPEN at night in very good visibility conditions at a range of 26 km from Dunbeath. Whilst the flashing, red aviation lights were visible intermittently the low intensity navigation lights were not visible. The Moray Council planning officer advised that he had not seen the Beatrice Offshore Demonstrator Turbines from the Moray Coast. This is

likely to be due to their range of over 43 km and their location in views below or just above the skyline, due to the curvature of the earth.

Relatively early work carried out on behalf of SNH (University of Newcastle (2002). Visual Assessment of Windfarms Best Practice. Scottish Natural Heritage Commissioned Report F01AA303A) includes helpful information on the visibility and perception of wind turbines which considers the theoretical and actual visibility of objects located at a distance from observers.

Whilst it is noted that a 100m structure could theoretically be seen from near to sea level at a distance of 46km (i.e. it would not be fully screened beyond the horizon formed due to the earth's curvature) it is also advised that:

'*actual human perception is affected by the acuity of the human eye. In good visibility (visibility is meteorologically defined as the greatest distance at which an object in daylight can be seen and recognised), a pole of 100 mm diameter will become difficult to see at 1 km and a pole of 200 mm diameter will be difficult to see at 2 km. In addition, mist, haze or other atmospheric conditions may significantly affect visibility (Hill et al, 2001). Assuming this relationship is linear, and assuming absolute clarity of view, this suggests that the outer limit of human visibility in clear conditions of a pole (e.g. a notionally cylindrical wind turbine tower) 5000 mm (5 m) in diameter (a representative figure for a 60+ m high tower) will be of the order of 50 km; and the absolute limit of visibility imposed by the limit of the horizon viewed across a flat plane is similar at approximately 46 km.*'

This finding corresponds with OPEN's observations of onshore wind farms in the field where occasionally, in clear conditions, it is possible to observe wind turbines at distances in excess of 50 km. Turbines of larger size, such as those at Whitelee (107-140 m to tip) are occasionally visible in excellent weather conditions at even greater distances (e.g. from the Merrick to the south-south-east at a distance of approximately 57 km and from the west on the Isle of Arran at similar distances).

The cylindrical towers of the worst case scenario Development turbines would have a larger maximum diameter of 9 m. Assuming the same linear relationship of visual acuity suggested above this would suggest that in the clearest of conditions it would be difficult to see a 9 m wide structure at a range of 90 km. However, whilst this may theoretically be the case from elevated locations it would not be possible to see the Development at this range, from heights of less than 40m AOD, due to the screening effect of the earth's curvature.

The Best Practice Guidance (University of Newcastle (2002)) provides further detail on how human perception is also a factor in how a wind farm will be seen. Importantly it states at 3.4.5 that:

'People perceive size, shape, depth and distance by using many cues, so that context is critically important. When people see partial or incomplete objects, they may mentally "fill in" the missing information, so that partial views of turbines may have less effect than imagined. Although people may be able to physically "see" an object, inattentional "blindness" caused by sensory overload, or a lack of contrast or conspicuousness, can mean they fail to "perceive" the object. In a contrary way, large size, movement, brightness and contrast, as well as new, unusual or unexpected features, can draw attention to an object. In all these effects, issues such as experience, familiarity and memory may have an important role to play. Therefore, perception depends on experience, the visual field, attention, background, contrast and expectation, and may be enhanced or suppressed.'

Two further factors of depth perception and size constancy are also discussed as being fundamental to perception and the following conclusions drawn:

'*that the magnitude or size of windfarm elements, and the distance between them and the viewer, are basic physical measures that affect visibility, but the real issue is human perception of visual effects, and that is not simply a function of size or distance.*'

Other factors of relevance to the understanding of the seascape, landscape and visual effect of the Development are listed in section 5 of the study and are summarised as follows:

- **Lighting** – It was observed that direct light shining on the turbines has the effect of increasing the prominence of the structures and this effect operated over a wide middle distance range.

Viewpoints to the south of a windfarm (in the arc from east through south to west) were said to experience this effect whereas back-lit effects occurred at viewpoints to the north (in the arc from east through north to west). It was also noted that:

'*The seasonal effects of light (linked with weather and cloud cover) should be considered in relation to human receptors. For residents, year-round conditions are relevant. For tourists and other recreationists, winter conditions will affect fewest people and summer conditions will affect most.'*

- **Movement and Orientation** – It was found that the movement of the blades, in all cases where this was visible, increased the visual effect of the turbines because it tended to draw the eye. Movement was more perceptible when backdropped against dark vegetation compared to grey sky. In addition, due to the fact that the prevailing wind in the UK is generally from the south-west, viewpoints in the quadrants from south through south-west to west, and from north through north-east to east, experience the longest periods of exposure to visible movement. It was also judged that rotors seen in the plane oriented at 180 degrees to the viewpoint appear relatively nearer.
- **Distance, Colour and Contrast** - At short distances the study found that colour is clearly seen and colour and light do not have a dramatic modifying effect on visibility, except in extreme overcast conditions or at dawn or dusk. As distance increases, the eye cannot distinguish colour and all structures are seen as grey. Light coloured (lit) turbines appeared closer than grey (unlit) turbines at similar distances. '*Seen against a blue or pale sky, but not sunlit, grey turbines appear dark. As the sky darkens, because of cloud cover or time of day or season, the contrast between sky and turbines decreases and at long distances (e.g. over approximately 10 km) the turbines may become indistinct because of this. Turbines can appear white against a dark sky if they are lit by sun through patches of cloud.'*
- **Landscape character and receptors -** The character of the landscape and especially elements within it was found to affect perceptions of magnitude. In landscapes that were free of man-made elements the turbines were sometimes much more conspicuous in the middle and long-distance ranges and this affected the author's judgements of their magnitude.

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Assessment and Cumulative Wirelines Illustrating Moray East Current Base Case Layout

Moray Offshore Windfarm (West) Limited

Technical Appendix 14.4

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Acronyms	
Acronym	**Expanded Term**
BOWL	Beatrice Offshore Windfarm Limited
CBCL	Current Base Case Layout
CFD	Contract for Difference
DSLP	design specification and layout plan
EIA	Environmental Impact Assessment
OSP	Offshore Substation Platform
SLVIA	seascape, landscape and visual impact assessment
WCS	worst case scenario

1 Introduction

During the time the Environmental Impact Assessment (EIA) Report for the Development has been being prepared, the adjacent Moray East Offshore Wind Farm has been progressing following Moray East attaining a Contract for Difference (CfD).

Site investigations along with further survey work and technical inputs have allowed Moray East to progress with defining the turbine and Offshore Substation Platform (OSP) layout. The final layout will be defined once the design specification and layout plan (DSLP) process is concluded later in 2018.

Chapter 14: SLVIA of the Offshore EIA Report and supporting figures includes a cumulative assessment for the Development in the context of the Moray East worst case scenario (WCS) for seascape, landscape and visual impact assessment (SLVIA). The Moray East WCS comprises layout 4c as no alternative information was previously available to Moray West to inform this assessment.

In order to allow the Moray West EIA Report to include an assessment of the cumulative effect of the Development in the context of a more likely Moray East Offshore Wind Farm scenario, Moray East has recently issued the Moray East Current Base Case Layout (CBCL) to Moray West.

This technical appendix had been prepared to illustrate the Moray West worst case scenario (WCS) model 4f in the context of the consented Moray East Current Base Case Layout (CBCL) as well as Beatrice Offshore Windfarm Limited (BOWL).

This Technical Appendix is accompanied by Figures 14.4.1 to 14.4.27 which are a layout plan and 90 degree field of view cumulative wirelines from each viewpoint.

2 Changes to the Impact on Viewpoints of Moray West when Added to the Moray East CBCL and BOWL

The accompanying assessment contained in Table 2.1 compares these cumulative wirelines with those contained in Figures 14.7.9 to 14.7.34 in the EIA Report and describes the difference this makes to the effect of Moray West as assessed in Table 14.7.1: Effect on Representative Viewpoints, Chapter 14: SLVIA.

Table 2.1: Changes to the Impact on Viewpoints of Moray West When Added to the Moray East CBCL and BOWL

No	Location	Change in view
1	Duncansby Head	Reduced density of Moray East CBCL seen in combination with BOWL. Moray West is seen to have a higher degree of consistency with the views of the other offshore wind farms in this context.
2	Keiss (A99)	Negligible change due to limited visibility of Moray West.
3	Wick (path south of South View)	Reduced density of Moray East CBCL seen in combination with BOWL. Moray West is seen to have a higher degree of consistency with the views of the other offshore wind farms in this context.
4	Sarclet (Sarclet Haven Info Board)	Reduced density of Moray East CBCL seen in combination with BOWL. Moray West is seen to have a higher degree of consistency with the views of the other offshore wind farms in this context.
5	Whaligoe Steps	Reduced density of Moray East CBCL seen in combination with BOWL. Moray West is seen to have a higher degree of consistency with the views of the other offshore wind farms in this context.
6	Minor Road (south east of Osclay)	No material change due to limited visibility of Moray East CBCL.

Table 2.1: Changes to the Impact on Viewpoints of Moray West When Added to the Moray East CBCL and BOWL

No	Location	Change in view
7	Lybster (end of Main Street)	Reduced density of Moray East CBCL seen in combination with BOWL. Moray West is seen to have a higher degree of consistency with the views of the other offshore wind farms in this context. Some reduction in turbine density where Moray West overlaps with Moray East CBCL and BOWL.
8	Latheron (A9)	Reduced density of Moray East CBCL seen in combination with BOWL. Moray West is seen to have a higher degree of consistency with the views of the other offshore wind farms in this context. Some reduction in turbine density where Moray West overlaps with Moray East CBCL and BOWL.
9a	Dunbeath (nr Heritage Centre)	Reduced density of Moray East CBCL seen in combination with BOWL. Moray West is seen to have a higher degree of consistency with the views of the other offshore wind farms in this context. Some reduction in turbine density where Moray West overlaps with Moray East CBCL and BOWL.
9b	Dunbeath (by harbour)	No material change due to limited visibility of Moray East CBCL.
10	Morven	Reduced density of Moray East CBCL seen in combination with BOWL. Moray West is seen to have a higher degree of consistency with the views of the other offshore wind farms in this context.
11	Berriedale (A9)	Reduced density of Moray East CBCL seen in combination with BOWL. Moray West is seen to have a higher degree of consistency with the views of the other offshore wind farms in this context. Some reduction in turbine density where Moray West overlaps with Moray East CBCL and BOWL.
12	Navidale	Reduced density of Moray East CBCL seen in combination with BOWL. Moray West is seen to have a higher degree of consistency with the views of the other offshore wind farms in this context. Some reduction in turbine density where Moray West overlaps with Moray East CBCL.
13a	Brora (picnic area off Salt Street)	No material change due to limited visibility of Moray East CBCL and BOWL.
13b	Dornoch (beach parking)	No material change due to limited visibility of Moray East CBCL and BOWL.
14	Tarbat Ness Lighthouse	No material change due to limited visibility of Moray East CBCL and BOWL.
15	Burghead Visitor Centre	No material change due to limited visibility of Moray East CBCL and BOWL.
16	Lossiemouth Harbour	No material change due to limited visibility of Moray East CBCL and BOWL.
17	Buckie (Cliff Terrace)	Reduced density and stacking of turbines of Moray East CBCL is likely to make it slightly less apparent at 44.38km distant.

Table 2.1: Changes to the Impact on Viewpoints of Moray West When Added to the Moray East CBCL and BOWL

No	Location	Change in view
		When Moray West is added to this the total horizontal extent of wind farms visible in this view may appear slightly less
18	Bin Hill	Reduced density of Moray East CBCL seen in combination with BOWL (however likely to be rarely apparent due to distance). Moray West may be seen to have a higher degree of consistency with the views of the other offshore wind farms in this context.
19	Portnockie (Bow Fiddle Rock Info Point)	Reduced density of Moray East CBCL. Moray West is seen to have a higher degree of consistency with the views of the other offshore wind farms in this context.
20	Cullen (viaduct)	Reduced density of Moray East CBCL. Moray West is seen to have a higher degree of consistency with the views of the other offshore wind farms in this context.
21	Findlater Castle	Moray East CBCL presents turbines stacked in rows at a distance of over 43km. These appear less random and dense with closest turbines most usually visible. Spacing of Moray West turbines appears to have a slightly higher degree of consistency with parts of the Moray East layout that may be most consistently visible. Other parts are less consistent.
22	Sandend	No material change due to limited visibility of Moray East CBCL and BOWL.
23	Portsoy	No material change due to limited visibility of Moray East CBCL and BOWL.
24	Ferry Route (Kirkwall to Aberdeen) – wireline only	No material change.

3 Summary of Comparison

The comparison of the cumulative wirelines illustrating Moray West WCS in the context of Moray East CBCL and BOWL with the cumulative wirelines illustrating Moray West WCS in the context of Moray East WCS (Layout 4c) and BOWL indicates that there would be some slight improvement in the relationship of the Moray West WCS when it is added to the BOWL and Moray East CBCL context.

This primarily arises due to the Moray East CBCL having fewer turbines set in a less dense layout than was the case with the Moray East WCS (Layout 4c). The Moray West layout has its turbines at a lower density than Moray East. Therefore, when Moray West is added to the context of the Moray East CBCL the consistency of the image presented is improved to a degree. In addition, in some views the overall density of the turbines where the wind farms overlap is also reduced, and this is a slight improvement.

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Socio-Economics Assessment Methodology

Moray Offshore Windfarm (West) Limited

Technical Appendix 15.1

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Acronyms	
Acronym	**Expanded Term**
EIA	Environmental Impact Assessment
FTE	Full Time Equivalent
GVA	Gross Value Added
HIE	Highlands and Islands Enterprise
O&M	Operation and Maintenance
SIC	Standard Industrial Classification
UK	United Kingdom

1 Socio-Economic Assessment Method

1.1 Introduction

This Technical Report provides information on the approach to assessing potential effects on socio-economic receptors, focusing on:

- Impact scenarios, including the rational and evidence underpinning sourcing assumptions;
- The method of calculating economic impacts; and
- The scale of economic impacts as measured by employment and GVA.

The impacts are assessed at two spatial levels:

- Local Study Area, comprising the local authorities of Aberdeen City, Aberdeenshire, Highlands, and Moray; and
- Scotland.

The Development has the potential to affect socio-economic receptors in each of the three phases of the project lifecycle:

- Construction (including project development);
- Operations and maintenance; and
- Decommissioning.

1.2 Impact Scenarios and Sourcing Assumptions

The capital, operational and decommissioning expenditure associated with the Development is the main driver of socio-economic impact. The cost estimates have been provided by Moray West and form the main basis for input into the economic impact model.

Two impact scenarios have been provided by Moray West which reflect the potential range of supply chain spend in Scotland and the Local Impact Area during the three phases of the Development. As there are many uncertainties associated with the expenditure which may occur in each of the areas, the scenarios are designed to illustrate the most likely range of expenditure and hence impacts which may arise. The scenarios are based on Moray West's view of the supply chain capability in Scotland and the Local Impact Area, and therefore the types of products and services which could be procured from these. A number of factors may affect the ability of the supply chain to respond to opportunities arising from the development:

- Ability of companies in the impact areas to compete for contracts;
- The capacity within businesses and the labour market to deliver the goods and services required; and
- As the Development is not expected to commence construction until 2022, the uncertainties associated with the forward look and what the supply chain may look like in five years.

To reflect these uncertainties, the scenarios are illustrative of a Low and a High view of sourcing. The Low scenario provides a conservative estimate of potential spend in each impact area, and the High scenario provides a more optimistic (but plausible) estimate.

The assumptions about the proportions of Development expenditure benefiting each spatial area have been calculated taking into account Moray West's assessments of the capabilities, facilities, experience, skills, capacity and competitiveness of the supply chain. This includes manufacturers, transportation

companies, professional and technical service providers and other members of the potential supply chain that are located in each of the two geographies that are considered in the assessment. Moray West's view was also informed by working with Scottish Enterprise, Highlands and Islands Enterprise (HIE), Marine Scotland, local authorities and local ports to strengthen the evidence base behind the sourcing assumptions in the local impact area and Scotland.

The decision on port selection will be an important driver of socio-economic impact particularly in the Local Study Area. The baseline section has identified several ports which have the capabilities to supply the development (especially during the O&M phase, but also for aspects of construction). The scenarios take into account these capabilities as well as the businesses located in the area from other parts of the supply chain.

1.2.1 Low Impact Scenario

The following sourcing patterns have been assumed under the low scenario for the offshore wind farm and the offshore transmission infrastructure (OfTI) during development, construction, and operation and maintenance phases. The main drivers are:

- Some local companies in the study area are used at the development stage, particularly for engineering services. The majority of services during development stage are procured from Scotland. Overall, it is assumed 38% is spent in the local study area and 67% in Scotland during the development phase;
- Limited use of local ports for construction in this scenario, with some limited use of local vessels for shipping and installation of wind turbines, substructures and cables. This is consistent with the assumptions for Scotland as the ports are likely to be within the local study area. Overall, it is assumed 4% is spent in the local study area and 14% in Scotland during the construction phase; and
- During operation and maintenance, it is assumed a local port is used, reflected in all vessels and helicopters services being sourced from within the local study area. As a result, it is also assumed half of the labour requirements for administration and engineering are also sourced locally. Overall, it is assumed 25% of expenditure is spent in the local study area and 26% in Scotland during the operation and maintenance phase. There is little difference between the sourcing across the two study areas due to few additional good and services being sourced from the wider Scottish area.

Table 1.1: Low Impact Scenario Sourcing

Phase	Category	Local Area	Scotland
Development costs	Engineering	50%	70%
	Management	10%	70%
	Environmental consultancy	30%	60%
	Transmission Infrastructure Development costs	50%	70%
Wind Farm: Turbines	Supply (Towers, Blades, Nacelles)	0%	10%
	Shipping & Logistics	20%	20%
	Installation	5%	5%
Wind Farm: Substructures	Design	5%	10%
	Project Management	5%	5%
	Supply	5%	15%

Table 1.1: Low Impact Scenario Sourcing			
Phase	**Category**	**Local Area**	**Scotland**
	Shipping & Logistics	30%	30%
	Installation	5%	20%
Wind Farm: Inter-Array Cables	Supply	0%	0%
	Shipping & Logistics	30%	30%
	Installation	5%	5%
Wind Farm: Principal Contractor	General Project Management/ Coordination	10%	50%
Offshore Transmission Infrastructure	OSPs	10%	20%
	Offshore Export Cable	5%	5%
Operation and Maintenance	Onshore Facilities	0%	0%
	Insurance	0%	0%
	Maintenance Personnel	5%	15%
	Marine Vessels / Helicopters	100%	100%
	Equipment/Consumables	10%	10%
	Spare parts	0%	0%
	Mgt/Administration	50%	50%
	Engineering Services	50%	50%
	TNUoS (grid) charges (25 yrs)	0%	0%

1.2.2 High Impact Scenario

The following sourcing pattern has been assumed under the high scenario for offshore wind farm and the OfTI during development, construction, and operation and maintenance phases. The main drivers are:

- The assumptions at the development phase remain the same, as the evidence base is more certain for the ability of local and Scottish companies to provide these services. Therefore, the overall shares of procured value remains the same at 38% for the local study area and 67% for Scotland during the development phase;
- The high scenario assumes a more extensive use of local ports for construction as well as the supply of some of the wind turbine components – this is likely to be steel products or towers procured from Scotland. It is assumed a Scottish principal contractor is appointed, securing more of the value during construction. Overall, it is assumed 21% is spent in the local study area and 49% in Scotland during the construction phase; and
- During operation and maintenance, it assumed that as well as using a local port, the majority of the labour requirements are met by workers from within the local study area. The exception is spare parts for the turbine as there is a lack of capability in Scotland, and insurance which is likely to be procured from elsewhere in the UK. Overall, it is assumed 40% is spent in the local study area and 41% in Scotland during the operation and maintenance phase.

Table 1.2: High Impact Scenario Sourcing			
Phase	**Category**	**Local Area**	**Scotland**
Development costs	Engineering	50%	70%
	Management	10%	70%
	Environmental consultancy	30%	60%
	TI Development costs	50%	70%
Wind Farm: Turbines	Supply (Towers, Blades, Nacelles)	5%	25%
	Shipping & Logistics	50%	50%
	Installation	10%	10%
Wind Farm: Substructures	Design	20%	100%
	Project Management	40%	50%
	Supply	20%	80%
	Shipping & Logistics	50%	70%
	Installation	50%	75%
Wind Farm: Inter-Array Cables	Supply	10%	15%
	Shipping & Logistics	50%	70%
	Installation	25%	50%
Wind Farm: Principal Contractor	General Project Management/ Coordination	40%	100%
Offshore Transmission Infrastructure	OSPs	5%	25%
	Offshore Export Cable	50%	50%
Operation and Maintenance	Onshore Facilities	80%	80%
	Insurance	0%	0%
	Maintenance Personnel	80%	80%
	Marine Vessels / Helicopters	100%	100%
	Equipment/Consumables	50%	50%
	Spare parts	10%	30%
	Mgt/Administration	100%	100%
	Engineering Services	100%	100%
	TNUoS (grid) charges (25 yrs)	0%	0%

1.3 Impact Assessment Method

The financial data on Development expenditure have been provided by Moray West. The figures take into account the cost reduction which is likely to take place by the time the Development will commence construction. The figures are commercially sensitive and confidential, therefore cannot be stated in this report.

The potential socio-economic effects are estimated using the Development expenditure figures and the sourcing scenarios in the two study areas. Each type of expenditure category has been matched to Regeneris Consulting's Input-Output Model product categories based on Standard Industrial Classification[1] (SIC). This enables the estimation of impact patterns (and associated employment and Gross Value Added (GVA)) that reflect the specific value creation and supply chains for relevant sectors.

1.3.1 Direct Impact Calculation

The estimates for first round expenditure in each area and by spend category form the basis for direct employment and GVA calculations. The expenditure in each of the study areas is converted to employment and GVA using employment coefficients (i.e. employment per £1 m of spend in the sector) and GVA coefficients (i.e. percentage of output in the product category that is GVA).

Table 1.3: Direct Impact and Employment Coefficients by SIC code

Phase	Category	SIC	Employment Coefficient	GVA Coefficient
Development costs	Engineering	71	10.6	48%
	Management	70	14.8	49%
	Environmental consultancy	74	9.4	50%
	TI Development costs	74	9.4	50%
Wind Farm: Turbines	Supply (Towers, Blades, Nacelles)	28	4.8	35%
	Shipping & Logistics	50	1.0	41%
	Installation	43	9.0	41%
Wind Farm: Substructures	Design	71	10.6	48%
	Project Management	70	14.8	49%
	Supply	25.1-3 & 25.5-9	7.1	43%
	Shipping & Logistics	50	1.0	41%
	Installation	43	9.0	41%
Wind Farm: Inter-Array Cables	Supply	27	5.6	36%
	Shipping & Logistics	50	1.0	41%
	Installation	43	9.0	41%
Wind Farm: Principal Contractor	General Project Management/ Coordination	70	14.8	49%
Offshore Transmission Infrastructure	OSPs	27	5.6	36%
	Offshore Export Cable	27	5.6	36%
	Onshore Facilities	50	1.0	41%

[1] Standard Industrial Classification (SIC) is used in classifying business establishments and other statistical units by the type of economic activity in which they are engaged (Source: ONS).

Table 1.3: Direct Impact and Employment Coefficients by SIC code				
Phase	**Category**	**SIC**	**Employment Coefficient**	**GVA Coefficient**
Operation and Maintenance	Insurance	65.1-2 & 65.3	2.0	38%
	Maintenance Personnel	35.1	1.2	25%
	Marine Vessels / Helicopters	50	1.0	41%
	Equipment/Consumables	28	4.8	35%
	Spare parts	28	4.8	35%
	Mgt/Administration	35.1	1.2	25%
	Engineering Services	71	10.6	48%
	TNUoS (grid) charges (25 yrs)	35.1	1.2	25%

1.3.2 Indirect Impact Calculation

Indirect impacts relate to the economic activity supported in the chain of suppliers of goods and services to the direct activities. The Regeneris Consulting's Scottish Input Output tables are used to estimate the scale and sectoral distribution of subsequent rounds of output in the lower tiers of the development's supply chain. The calculation of indirect impacts is carried out firstly for the Scotland impact area. The steps taken in the model are as follows:

- Aggregate the sum of direct output by product code (using the assigned codes shown in Table 1.3.1);
- Use indirect multipliers to model how direct expenditure on goods and services will be distributed amongst supply chain sectors (i.e. the total value and sectoral distribution of subsequent rounds of output); and
- Convert the subsequent rounds of supply chain output to employment and GVA respective multipliers for each product code in which subsequent rounds of expenditure are expected.

To estimate the impact for the local study area, the indirect multipliers need to be adjusted to reflect the smaller economic scale at a local level (and therefore impact) compared to Scotland. This is done based on the share of FTE employment in the local study area relative to Scotland. The indirect impacts are then adjusted accordingly.

1.4 Definition of Impact Magnitude

There are four important points to note in relation to the criteria used to determine the magnitude of socio-economic impacts:

- In line with the requirements of the EIA methodology, the change in baseline conditions which would occur as a result of socio-economic impacts is the basis of the assessment. For some receptors multiple measures could be used as part of the baseline. Indeed, for the employment and GVA receptors, different baseline measures are needed for direct and indirect economic impacts; static employment and GVA indicators as well as average change;
- The level at which quantitative criteria are set reflects the nature of the measures. For some receptors, the appropriate measure is very tightly defined (e.g. employment in a single sector)

whilst for other receptors the baseline indicators used are broader (e.g. employment across the full economy). To reflect this, different criteria are used to define the magnitude of impact for each receptor;

- The impact magnitude is considered in the context of historic growth to establish how much the impact of the Development would contribute to the annual changes in employment and GVA. The magnitude of impact in the context of average historic growth is judged qualitatively; and
- Therefore, it is not always possible to undertake the assessment of magnitude in a wholly quantitative way. An element of professional judgement is required to bring together quantitative and qualitative elements of the assessment. To reflect this, the criteria for assessment of magnitude set out in the EIA Report are provided in qualitative terms.

In addition to the qualitative magnitude criteria set out in the main chapter, the following quantitative criteria have been used.

1.4.1 Employment in the Construction and O&M Supply Chain

The magnitude of impact for direct employment is assessed in the relevant supply chain sectors. Definitions for these chapters are provided in the main chapter. The magnitude of impact of indirect employment is assessed in the context of employment in the whole economy, as indirect impact is dispersed across more industries. The magnitude is assessed for direct and indirect employment separately, and then combined.

Table 1.4: Criteria for Assessment of Magnitude: Employment Impacts

Phase	Baseline measure	No change	Negligible	Low	Medium	High
Construction	Direct = relevant sectors Indirect = whole economy	0%	Up to 0.5%	0.5 - 1%	1 - 2%	2% +
O&M	Direct = electricity generation sector	0%	Up to 0.5%	0.5 - 1%	1 - 2%	2% +

1.4.2 GVA in the Construction and O&M Supply Chain

Similarly to employment effects, GVA effects are assessed for magnitude in the context of GVA in the local study area and Scotland. The effects are assessed in the context of the whole economy – this is because GVA data is not available for the defined supply chain sectors. To reflect the broader baseline measure, lower thresholds have been used to measure change against.

Table 1.5: Criteria for Assessment of Magnitude: GVA Impacts

Phase	Baseline measure	No change	Negligible	Low	Medium	High
Construction	Whole economy GVA (Local Study Area and Scotland)	0%	Up to 0.1%	0.1 - 0.5%	0.5 - 1%	1% +
O&M		0%	Up to 0.1%	0.1 - 0.5%	0.5 - 1%	1% +

1.5 Results of Assessment

The assessment magnitude for employment and GVA receptors during construction, and operation and maintenance phases are presented in this section.

Table 1.6 presents a summary of the construction employment impacts.

Table 1.6: Magnitude of Construction Employment Impact

Indicator	Impact type	Local Study Area		Scotland	
		Low	High	Low	High
Person years	Direct	570	2230	1880	5400
	Indirect	80	290	1360	3860
	Direct + indirect	650	2520	3250	9250
Annual FTEs (during a 3-year construction period)	Direct	190	740	630	1800
	Indirect	30	100	450	1290
	Direct + indirect	220	840	1080	3080
Baseline employment	Direct	63400		272900	
	Indirect	354750		2067250	
Baseline employment growth rate (average annual between 2009-2015)	Direct	2%		2%	
	Indirect	0.8%		0.8%	
Employment uplift	Direct	0.3%	1.2%	0.2%	0.7%
	Indirect	0.0%	0.0%	0.0%	0.1%
	Direct + indirect	0.1%	0.2%	0.1%	0.1%

Table 1.7 presents a summary of the construction GVA impacts.

Table 1.7: Magnitude of Construction GVA Impact

Indicator	Impact type	Local Study Area		Scotland	
		Low	High	Low	High
Cumulative GVA (£millions)	Direct	30	140	90	320
	Indirect	0	20	70	230
	Direct + indirect	**30**	**150**	**160**	**550**
Annual GVA (£millions) during a 3-year construction period	Direct	10	50	30	110
	Indirect	0	10	20	80
	Direct + indirect	**10**	**50**	**50**	**180**

Table 1.7: Magnitude of Construction GVA Impact					
Indicator	**Impact type**	**Local Study Area**		**Scotland**	
		Low	**High**	**Low**	**High**
Baseline GVA (£m)		£25,324		£127,260	
GVA uplift		<0.1%	0.2%	<0.01%	0.14%

Table 1.8 presents a summary of the employment impacts during operation.

Table 1.8: Magnitude of Operational Employment Impact					
Indicator	**Impact type**	**Local Study Area**		**Scotland**	
		Low	**High**	**Low**	**High**
Person years	Direct	450	890	460	1000
	Indirect	340	500	2030	3070
	Direct + indirect	**790**	**1390**	**2490**	**4070**
Annual FTEs (during a 25-year operational period)	Direct	20	40	20	40
	Indirect	10	20	80	120
	Direct + indirect	**30**	**60**	**100**	**160**
Baseline employment	Direct	1500		11400	
	Indirect	354750		2067250	
Baseline employment growth rate (average annual between 2009-2015)	Direct	4%		2%	
	Indirect	0.8%		0.8%	
Employment uplift	Direct	1.3%	2.7%	0.2%	0.4%
	Indirect	0.0%	0.0%	0.0%	0.0%
	Direct + indirect	0.0%	0.0%	0.0%	0.0%

Table 1.9 presents a summary of the GVA impacts during operation.

Table 1.9: Magnitude of Operational GVA Impact					
Indicator	**Impact type**	**Local Study Area**		**Scotland**	
		Low	**High**	**Low**	**High**
Cumulative GVA (£millions)	Direct	30	220	90	320
	Indirect	0	50	70	230

Table 1.9: Magnitude of Operational GVA Impact					
Indicator	**Impact type**	**Local Study Area**		**Scotland**	
		Low	**High**	**Low**	**High**
	Direct + indirect	30	270	160	550
Annual GVA (£millions) (during a 25-year operational period)	Direct	10	10	30	110
	Indirect	0	0	20	80
	Direct + indirect	10	10	50	180
Baseline GVA (£m)		£25,324		£127,260	
GVA uplift		<0.1%	<0.1%%	0.04%	0.14%

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Marine Archaeology Baseline

Moray Offshore Windfarm (West) Limited

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Acronyms	
Acronym	**Expanded Term**
AD	Anno Domini
ADS	Archaeology Data Service
AEZ	Archaeological Exclusion Zone
ASA	Archaeological Study Area
ASLF	Aggregates Sustainability Levy Fund
BC	Before Christ
BGS	British Geological Society
BP	Before Present
CIfA	Chartered Institute for Archaeologists
DECC	Department for Energy and Climate Change
DEFRA	Department for the Environment, Farming and Rural Affairs
EIA	Environmental Impact Assessment
ETRS	European Terrestrial Reference System
HER	Historic Environment Record
HES	Historic Environment Scotland
HMPA	Historic Marine Protected Area
GIS	Geographical Information System
MLWS	Mean Low Water Springs
MORL	Moray Offshore Wind Limited
MPS	Marine Planning Statement
MS-LOT	Marine Scotland Licensing Operations Team
NPF	National Planning Framework
NMRS	National Monument Records of Scotland
OfTI	Offshore Transmission Infrastructure
OnTW	Onshore Transmission Works
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
RCAHMS	Royal Commission for Ancient and Historic Monuments of Scotland
SPP	Scottish Planning Policy
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UTM	Universal Transverse Mercator
WSI	Written Scheme of Investigation
WWI	World War One
WWII	World War Two
ZTV	Zone of Theoretical Visibility

Executive Summary

Wessex Archaeology was commissioned by GoBe Consultants Ltd on behalf of Moray Offshore Wind Farm (West) Limited (Moray West) to provide Lead Environmental Impact Assessment (EIA) Consultancy services in relation to the marine archaeological environment for the proposed Moray West Offshore Wind Farm.

The proposed Moray West Offshore Wind Farm and associated Offshore Transmission Infrastructure (OfTI) (hereafter 'the Development') is located in the north-eastern approaches of the Moray Firth, approximately 22.5 km from the Caithness coastline, covering an area of approximately 225 km². Under the role of marine archaeological consultant, Wessex Archaeology has prepared this Technical Report as part of the Environmental Impact Assessment (EIA) of the Development.

This document comprises the Technical Report outlining the marine archaeological baseline data (Sections 4, 5 and 6), and initial environmental impact assessment information on potential impacts, receptor value and sensitivity in support of the Offshore EIA Report (Sections 6 and 7). This information has informed the marine archaeology impact assessment, and incorporated into the subsequent EIA.

The aims of this document are to assess the known and potential marine archaeological resource within the Archaeological Study Area, comprising data sources from within a 2-km buffer around the Development, up to the Mean High Water Spring (MHWS), and to assess the likely impacts of the development proposals on this resource. The effect of the Development on the marine archaeological environment resource will be a material consideration in the determination of the planning application.

This assessment has established that there are the following marine archaeological environmental assets within the Archaeological Study Area:

- Potential for prehistoric archaeological material, particularly in areas with palaeo-channels;
- 39 documented shipwrecks, aircraft crash sites and obstructions within the Archaeological Study Area; comprising six shipwrecks, one possible aircraft, and 32 obstructions. There is also potential for additional currently unknown sites to exist; and
- Further potential is suggested by a further 166 recorded losses, including 34 aircraft which were lost while in military service, and therefore are automatically protected under the Protection of Military Remains Act 1986.

The need for, scale, scope and nature of any further assessment and/or archaeological works should be agreed through consultation with the statutory authorities.

1 Introduction

1.1 Background

Wessex Archaeology was commissioned by GoBe Consultants Ltd on behalf of Moray Offshore Windfarm (West) Limited, to prepare a marine archaeological Technical Report including a high level Environmental Assessment relating to the archaeological baseline and potential for the two elements of the Moray West Offshore Wind Farm and associated Offshore Transmission Infrastructure (OfTI) (hereafter referred to as the 'Development'). This assessment will in turn inform the Environment Impact Assessment (EIA).

The Moray West Site is located approximately 22.5 km south-east of the Caithness coastline, towards the north-eastern approaches of the Moray Firth.

1.2 Development Proposal

The proposed Development will consist of up to 85 wind turbine generators (WTGs), two Offshore Substation Platforms (OSPs), inter-array, OSP interconnector and offshore export cables. The offshore export cables will make landfall on the Aberdeenshire Coast (on the south coast of the Moray Firth) at a location between Findlater Castle and Redhythe Point near Portsoy. The proposed Offshore Export Cable Corridor will be approximately 65 km long.

1.3 Scope of Document

1.3.1 Aims

The purpose of this assessment is to determine, as far as is possible from existing information and bespoke survey data, the nature, extent and significance of the known and potential marine archaeological resource within the boundary of the proposed Development.

This report comprises a marine archaeological baseline study of the Development area, based on an archaeological assessment of geophysical data, gathered as part of the offshore site. A review of records held by national and local inventories and secondary sources relating to the marine and intertidal historic environment of the region will also be assessed for the Development area.

This archaeological baseline is developed into an initial assessment of the value and sensitivity of any identified marine or intertidal archaeological assets within the Development area, along with an assessment of their setting to support the Offshore EIA Report.

1.3.2 Objectives

The objectives of the assessment are as follows:

- To provide details of relevant legislation, national and local planning policy, and best practice guidance;
- To assess the 2010 geophysical survey datasets undertaken by Osiris in order to identify any material of possible archaeological and cultural heritage significance present within the Development;
- To compare the geophysical interpretation with desk-based assessments, historical data, known archaeological sites and previous investigations in the vicinity of the project area to outline the known and potential marine archaeological resource;
- To assess the significance of the known and potential marine archaeological resource through weighted consideration of their valued components; and

- To recommend mitigation measures for any potential archaeological or cultural heritage assets newly identified within the project area, including the addition of new Archaeological Exclusion Zones where necessary within the Development area.

1.4 Copyright

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2 Legislation, Guidance and Policy

2.1 Introduction

The Wind Farm Site lies outside the 12 nautical miles (nm) limit of Scottish Territorial Waters, however, the offshore transmission infrastructure component of the Development lies within Scottish Territorial Waters (12 nm). With respect to marine archaeology and cultural heritage the archaeological curator responsible for the offshore archaeological resource, from Mean High Water Springs (MHWS) to the 12 nm limit falls under Historic Environment Scotland (HES). HES also act as specialist advisors to Marine Scotland, on cultural heritage matters beyond 12 nm.

The following section provides a summary of the national, regional and local planning and legislative framework that governs the treatment of the marine historic environment in the planning process. More comprehensive details are provided in Annex 16.1A.

2.2 International Conventions

The United Nations Educational, Scientific and Cultural Organisation (UNESCO) Convention on the Protection of the Underwater Cultural Heritage was concluded in 2001, and is a comprehensive attempt to codify the law internationally, with regards to underwater cultural heritage. The UK abstained in the vote on the final draft of the Convention, however it has stated that it has adopted the Annex of the Convention, which governs the conduct of archaeological investigations, as best practice for archaeology. Although the UK is not currently a signatory, the Convention entered into force on 2 January 2009, having been accepted or ratified by over 50 member states[1].

2.3 Marine Legislation

The following legislation applies to marine heritage within Marine Scotland's licensing area:

- Marine (Scotland) Act 2010;
- Historic Environment Scotland Act (2014);
- Protection of Military Remains Act 1986;
- Merchant Shipping Act 1995; and
- The Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997.

The Marine (Scotland) Act 2010 is the primary legislation relevant to marine development plans to 12 nm limit within Scottish territorial waters. Under this legislation, marine plans must be consistent with the UK Marine Policy Statement (MPS; Department for Environment, Food and Rural Affairs (DEFRA), 2011) and fully reflect the requirements of the MPS at a local level. Marine plans must also be in accordance with other national policy, including the Scottish Planning Policy/National Planning Framework 3 (2014).

Under Scotland's Marine Plan 2016, the inshore waters (up to 12 nm) have been divided into 11 plan areas for which marine plans are to be produced. The Moray West project is within the Moray Firth Region.

2.4 Relevant Policy

The following policy applies to this archaeology and cultural heritage assessment:

- Scotland's National Marine Plan 2015 – this plan sets out a single framework for sustainable development within Scotland's marine area. Historic Environment Scotland (HES) states

[1] Convention on the Protection of the Underwater Cultural Heritage. Paris, 2 November 2001: http://www.unesco.org/eri/la/convention.asp?KO=13520&language=E&order=alpha (last accessed 08/11/2017.

"development and use of the marine environment should protect and, where appropriate, enhance heritage assets in a manner proportionate to their significance" (GEN 6); and

- Additionally, Scottish Historic Environment Policy 2016 (Historic Environment Scotland, 2016a) sets out Scottish Ministers' policies, providing direction for HES and a policy framework that informs the work of a wide range of public sector organisations.

The Scottish Planning Policy (SPP) was published by the Department of Built Environment in June 2014, sitting alongside the National Planning Framework (NPF), which provides a statutory framework for Scotland's long-term spatial development.

Section 135 of the SPP entitled 'Valuing the Historic Environment' sets out the principal national guidance on the importance, management and safeguarding of heritage assets within the planning process. The planning system should:

- promote the care and protection of the designated and non-designated historic environment (including individual assets, related settings and the wider cultural landscape) and its contribution to sense of place, cultural identity, social well-being, economic growth, civil participation and lifelong learning; and
- enable positive change in the historic environment which is informed by a clear understanding of the importance of the heritage assets affected and ensure their future use. Change should be sensitively managed to avoid or minimise adverse impacts on the fabric and setting of the asset, and ensure that its special characteristics are protected, conserved or enhanced.

2.5 Marine Guidance

This assessment was carried out in a manner consistent with available guidance as described below in chronological order of issue:

- Military Aircraft Crash Sites: Guidance on their significance and future management (English Heritage (now Historic England), 2002);
- Our Seas - A shared resource: High level marine objectives (DEFRA, 2009);
- Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector (COWRIE, 2011);
- COWRIE Historic Environment Guidance for the Offshore Renewable Energy Sector (Wessex Archaeology, 2007);
- Joint Nautical Archaeology Policy Committee (JNAPC) Code for Practice for Seabed Development (2006);
- Ships and Boats: Prehistory to Present: Designation Selection Guide (English Heritage (now Historic England), 2012);
- Marine Geophysics Data Acquisition, Processing and Interpretation Guidance Notes (Bates, R. Dix, J. K., Plets, R., 2013); and
- Chartered Institute for Archaeologists Standard and guidance for historic environment desk-based assessment (2014, updated in 2017).

3 Methodology

3.1 Introduction

The methodology employed during this assessment reflects the requirements of an EIA as set out in European Council Directive 2014/52/EU, which came into effect from 16 May 2017, and follows best practice professional guidance outlined by the Chartered Institute for Archaeologists' Standard and Guidance for Historic Environment Desk-Based Assessment (CIfA, 2014, updated in 2017).

3.2 Study Area

The area assessed in this report is defined by the development extents of the Offshore Wind Farm Site and the Offshore Transmission Infrastructure, hereafter referred to as the Development Archaeological Study Area (ASA) (Figure 3.1). This includes the following areas:

- Moray West Site ASA (including a two-km buffer); and
- Offshore Transmission Infrastructure (OfTI) ASA (including a two-km buffer except where this would overlap with the Moray West Site ASA and also excluding all areas above Mean High Water Springs (MHWS)).

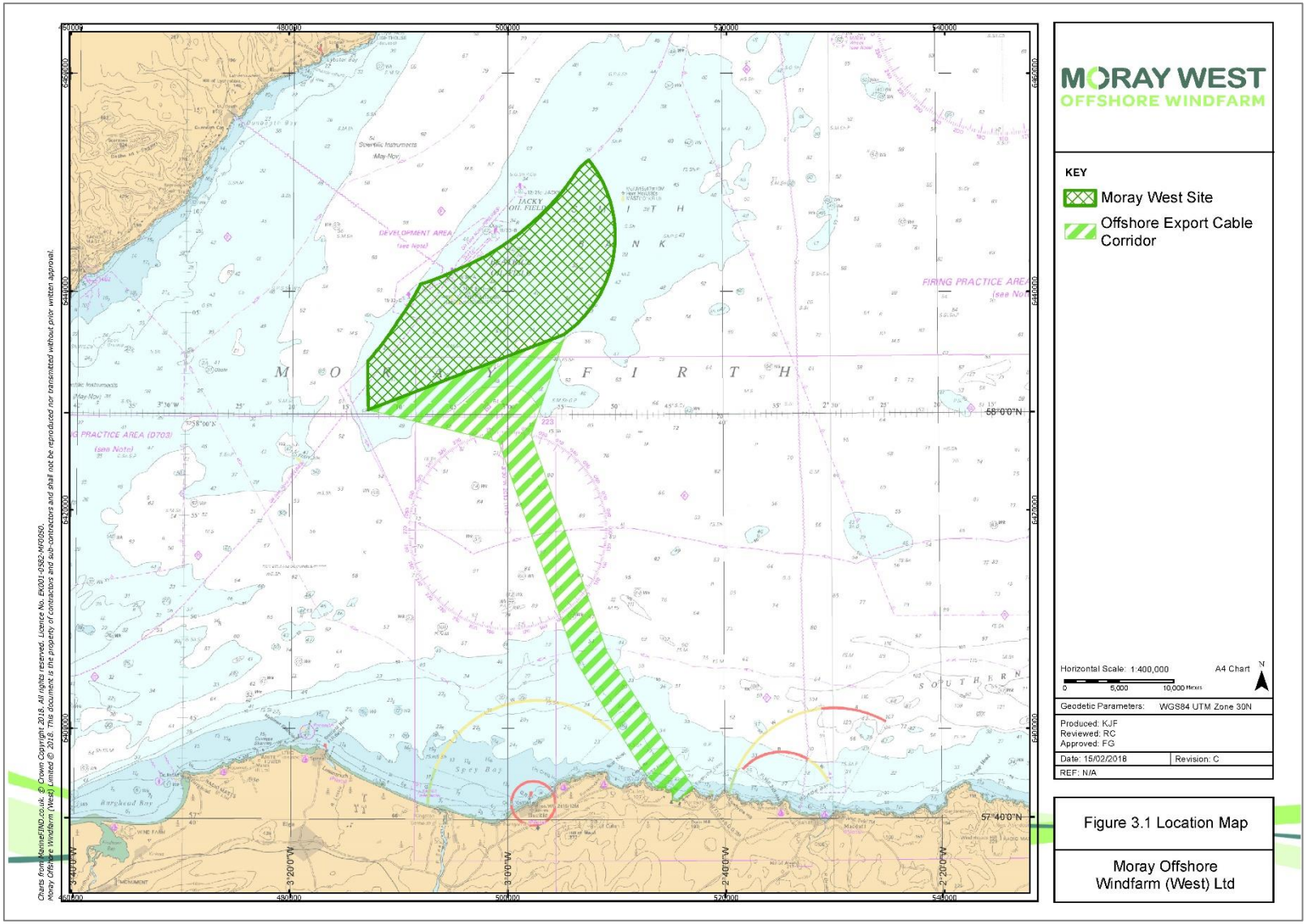

Figure 3.1: Location Map

3.2.1 Marine Data Search Area

A search area encompassing all of the Development elements, including a 2 km buffer around the Archaeological Study Area, was used for obtaining records from relevant archive databases. The wider search area allows for a greater understanding of the wider archaeological baseline environment, with the dual purpose of enabling any archaeological trends within the region to be recognised and to allow any heritage assets identified to be represented in a broader archaeological context.

All data for heritage assets located within this search area are stored on the Wessex Archaeology archive network and can be made available on request.

3.3 Marine Archaeological Desk-Based Assessment

The key marine archaeology assets relevant to marine archaeological baseline as assessed in this report are:

- Seabed prehistory (for example, palaeochannels and other features that contain palaeoenvironmental sediment sequences, and early prehistoric sites and derived artefacts e.g. lithic, bone and wooden tools, ecofacts and other archaeological materials);
- Seabed features, including maritime sites (such as shipwrecks and associated elements including cargo, obstructions and fishermens' fasteners); and; aviation sites (aircraft crash sites and associated debris); and
- Intertidal heritage assets.

3.3.1 Data Sources

A number of sources of information were consulted in order to compile this Technical Report. Data generated from marine geophysical surveys were also a main component of the data and are discussed further in Section 3.4.

The following data sources were consulted in order to compile the desk-based element of the assessment:

- The United Kingdom Hydrographic Office (UKHO) data for charted wrecks and obstructions;
- The National Record of the Historic Environment (CANMORE) maintained by Historic Environment Scotland (HES), comprising data of designated heritage assets including sites protected under the Protection of Military Remains Act 1986 and the Marine (Scotland) Act 2010 (i.e. HMPAs);
- Relevant mapping including Admiralty Charts, historic maps and Ordnance Survey; and
- Relevant documentary sources and grey literature held by Wessex Archaeology, and those available through the Archaeological Data Service (ADS) and other websites (presented in the 'References').

3.3.2 Data Handling

This report is supported by a Geographic Information System (GIS) using ArcGIS 10.5, incorporating the positional information of the various data sources listed above, allowing the data to be spatially analysed. The data were subsequently compiled into gazetteers of the prehistoric, maritime and aviation within the ASA; these were used to inform the assessment of geophysical data.

Within this assessment, the gazetteer for the marine datasets are compiled and presented in Universal Transverse Mercator (UTM) Zone 30 North projected from a European Terrestrial Reference System (ETRS) 1989 datum.

Information relating to the marine heritage that did not include location or positional information were also used to inform the marine archaeological baseline assessment where relevant.

3.3.3 Chronology

Archaeological material is generally studied within a framework of 'periods' or 'ages' that reflect the activities and cultural changes taking place over time. All dates are referred to as BC (before Christ), BP (before present) or AD (anno domini) within the text. By convention, BC refers to calibrated radiocarbon chronology that can be considered equivalent to calendar years. BP dates are used for periods of time older than c.10,000 years ago.

A list of the main archaeological periods in Scotland referred to in the text, along with their broadly defined dates, are presented in Annex 16.1B.

3.3.4 Seabed Prehistory

The baseline summary for Seabed Prehistory was based on a review of geological mapping of seabed sediments, solid geology and bathymetry from published BGS sources. This has been enhanced by the geoarchaeological review for geophysical datasets gathered for the project to produce a stratigraphic framework for understanding the archaeological potential of the Quaternary geology within the area investigated. Where appropriate, this was backed up by information gathered from the boreholes which were taken from the adjacent lease area (MORL, 2012).

This assessment was further supported by the examination of models of past sea level change, geomorphological features and baseline sources regarding potential for encountering submerged prehistoric landscapes. This palaeogeographic review, alongside the known archaeological record, formed the basis upon which the potential for submerged prehistory could be developed and discussed in support of the subsequent EIA Report Chapter.

3.3.5 Maritime and Aviation Archaeology

The sources of data for maritime and aviation history and archaeology listed in Section 3.3.3 above have been collated and summarised in order to develop a baseline of marine cultural heritage for the ASA, and the potential for encountering unknown shipwreck and aircraft crash sites (Section 5). Sources of data relevant to maritime and aviation archaeology are the UKHO and CANMORE datasets.

The data obtained were reviewed and those located within the ASA were extracted and compiled to form a gazetteer as part of the known maritime and aviation baseline. These records were combined with the geophysical dataset and each given a unique identifier beginning with 7200 and continuing sequentially (Annex 16.1C), and were added to the project GIS.

For the purposes of this assessment, records with duplicate positions between datasets were amalgamated and their co-ordinates are taken from the UKHO dataset as the raw data therein is based on hydrographic survey data presented in the WGS84 datum. These co-ordinates were converted from WGS84 into UTM30N eastings and northings based on the ETRS89 datum (as described in Section 3.2.6) using the Quest Geodetic Calculator version. Furthermore, the HES datasets are primary terrestrial datasets expressed in British National Grid, and are considered to be less accurate offshore.

The research for maritime and aviation history was then combined with the archaeological assessment of geophysical survey data.

Data relating to Recorded Losses were also extracted from HES data sources. Recorded Losses are records for ships or aircraft that are known to have wrecked or crashed offshore, but for which the exact locations are not known. Recorded Losses are often grouped by area into Maritime Named Locations. For example, a Recorded Loss within this dataset may be based on the loss of a vessel ‘wrecked at Portsoy’ or associated

with a known navigational hazard such as a sand bank or rocks (which may give rise to a falsely precise geographic coordinate for the record). The positional data of these records is unreliable and serves only to provide an indication of the types of vessels that passed through the area and the wrecking incidents that are known to have occurred in the general region. Whilst the remains of these vessels and aircraft are expected to exist somewhere on the seafloor, their location is unknown. As such, they signify the potential maritime and aviation resource.

Details regarding Recorded Losses, whose Named Location happens to be located within the ASA, are presented in a gazetteer format (Annex 16.1D). These records have retained their original identification assigned by HES for ease of cross-referencing. Where records are duplicated between datasets all corresponding identification numbers have been included, but are referred to in the text by the HES Monument ID if one exists. The gazetteer does not include positional data due to the inaccuracies therein.

The baseline assessment of maritime and aviation archaeology was further supplemented by a review of relevant primary and secondary source material in order to provide an indication on the nature of maritime and aviation activity across the region. As well as summarising the known archaeological resource, the baseline assessment underlines the potential for encountering unknown shipwreck and aircraft crash sites within the ASA (English Heritage (now Historic England), 2002; Wessex Archaeology, 2008).

3.3.6 Intertidal Archaeology

The assessment of the offshore element of the project will extend up to the MHWS, intertidal assets will be incorporated from HES datasets, which are provided in two spatial formats, points and polygons. All points and polygons that intersect the ASA have been included within the assessment; however, it should be noted that co-ordinates given for the polygon records is the centre-point generated using ArcGIS 10.2, which may lie outside the ASA.

3.4 Geophysical Methodology

This geophysical assessment focusses solely on the Moray West Site and consists of an assessment of sidescan sonar, magnetometer, sub-bottom profiler and multibeam bathymetry data acquired by Osiris Projects in 2010.

Wessex Archaeology has previously carried out an archaeological assessment of geophysical survey data in 2014, acquired over the proposed Offshore Transmission Infrastructure (OfTI) of the Telford, Stevenson and MacColl Offshore Wind Farms, now known as Moray East (Wessex Archaeology 2014). The results from this assessment are not presented within the current report.

3.4.1 Data Sources

A number of data sources were used as part of this assessment.

- The geophysical survey data comprised sidescan sonar, magnetometer, sub-bottom profiler and multibeam bathymetry data acquired between July and September 2010 (Osiris Projects 2011);
- Geophysical survey reports complied by Osiris Projects;
- Wreck and obstruction data within the ASA were obtained from the United Kingdom Hydrographic Office (UKHO). Any records located within the ASA were integrated with the geophysical results as outlined in Section 3.2.15; and
- Grey literature reports relating to Moray West:

- Moray Offshore Wind Farm: Transmission Works EIA: Baseline Review of Onshore and Offshore Archaeology (Wessex Archaeology 2014); and
- Moray Offshore Renewables Ltd. Environmental Statement Technical Annex 5.5A - Archaeology Technical Report (Headland Archaeology 2012).

Any sites found to be outside the Survey Areas, are deemed beyond the scope of the current assessment and are not included in this report.

3.4.2 Geophysical Data – Technical Specifications

The geophysical data over Moray West were acquired by Osiris Projects between 3 September and 25 September 2010 on board the survey vessel SV Chartwell. The analogue sub-bottom profiler (SBP) data survey was undertaken between 3 September and 25 September 2010 and the sidescan sonar, magnetometer and multibeam bathymetry survey was undertaken between 2 September and 25 September 2010.

The survey grid for the sensors consisted of 23 main lines orientated 045°/225° at 600 m line spacing and 30 cross lines orientated 135°/315° at 1000 m line spacing (Osiris Projects 2011). There is a 6 km gap in the cross lines to south-west of the centre of Moray West. The run line lengths were variable to fit inside the survey area boundary (Figure 3.2).

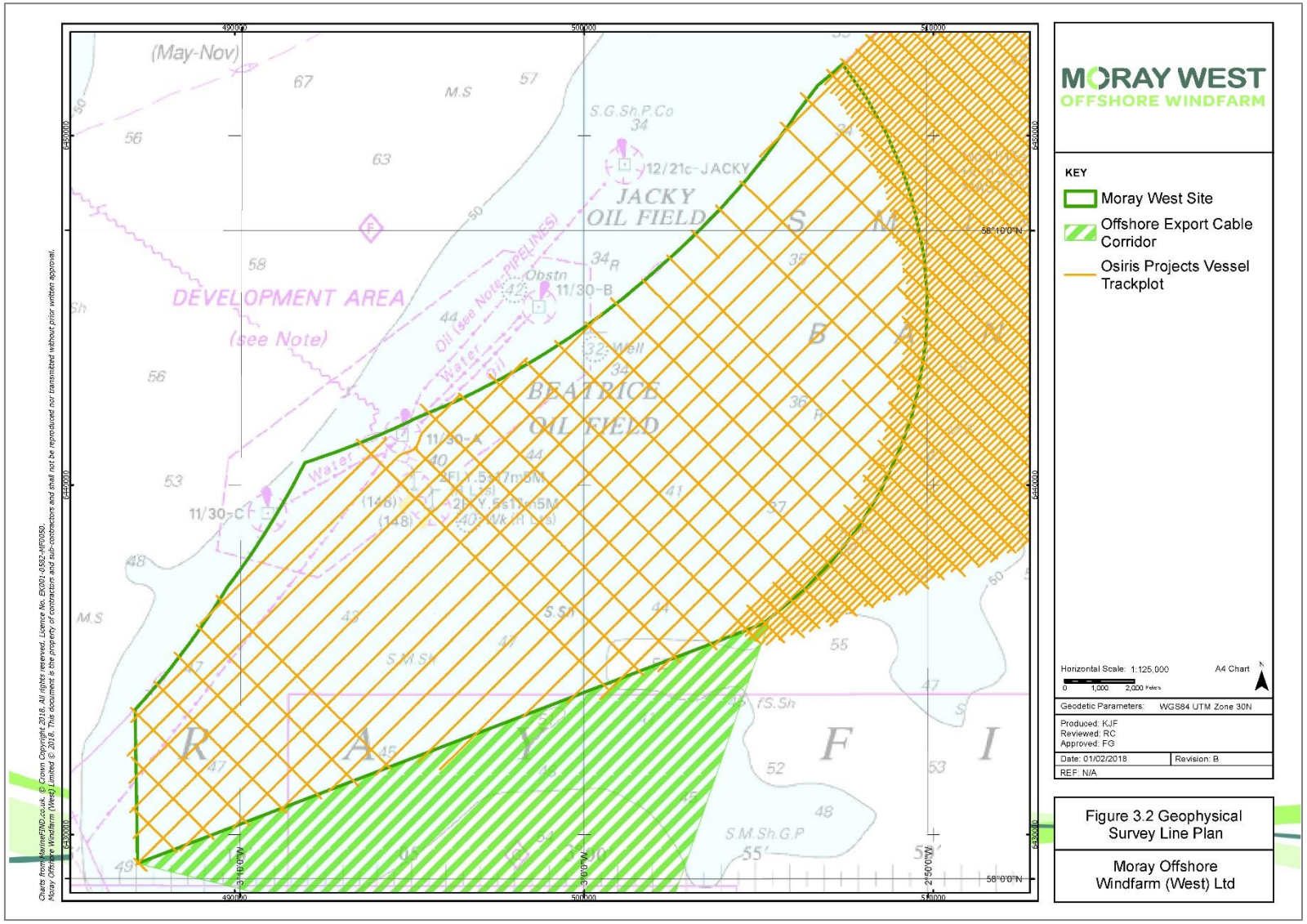

Figure 3.2: Geophysical survey line plan

The sidescan sonar deployed for the survey was a Klein 3000 digital dual frequency (100 kHz and 455 kHz) system. The system was operated in dual frequency mode at a maximum range of 200 m throughout the survey area. The data were digitally recorded and provided to Wessex Archaeology as both low and high frequency cod files.

The magnetometer deployed for the survey was a Geometrics G882 caesium vapour towfish capable of resolving anomalies to 5 nT. The data were provided to Wessex Archaeology as .txt files.

A Reson Seabat 7101 high resolution multi-beam echo sounder system was used to acquire the bathymetry data within Moray West. A Knudsen 320 M dual frequency hydrographic echo sounder was used to provide a quality check on the absolute values obtained from the multibeam system. The data were provided to Wessex Archaeology as a 1 m gridded pts file referenced to Ordnance Datum (Newlyn) (OD(N)).

The sub-bottom profiler data were acquired using a Geo-Spark 200 sparker system with a towed 8 element hydrophone receiver. The data were digitally recorded and provided to Wessex Archaeology as sgy files.

The geophysical survey coverage within Moray West is 20 %, as such anomalies located outside of the data extents will not have been identified (Figure 3.2).

3.4.3 Geophysical Data – Data Quality

The geophysical data sets used for this report were individually assessed for quality and their suitability for archaeological purposes, and rated using the following criteria (Table 3.1).

Table 3.1: Criteria for Assessing Data Quality Rating

Data Quality	Description
Good	Data which are clear and unaffected by weather conditions or sea state. The dataset is suitable for the interpretation of standing and partially buried metal wrecks and their character and associated debris field. These data also provide the highest chance of identifying wooden wrecks and debris.
Average	Data which are affected by weather conditions and sea state to a slight or moderate degree. The dataset is suitable for the identification and partial interpretation of standing and partially buried metal wrecks, and the larger elements of their debris fields. Wooden wrecks may be visible in the data, but their identification as such is likely to be difficult.
Variable	This category contains datasets with the quality of individual lines ranging from good to average to below average. The dataset is suitable for the identification of standing and some partially buried metal wrecks. Detailed interpretation of the wrecks and debris field is likely to be problematic. Wooden wrecks are unlikely to be identified.

The sidescan sonar data has been rated as ‘Average’ using the above criteria table. A number of lines displayed signs of noise in the data, such as cable snatching and water column noise from poor weather conditions. The data was acquired with a wide range setting of 200 m. However, data coverage was only achieved to approximately 125 m on each channel in the high frequency files. This range setting made the identification of small objects difficult, however, overall the data quality was found to be suitable for the identification of larger objects.

The magnetometer data have been rated as ‘Average’ using the above criterial table. Some of the files contained spiking, although these were removed during processing, and the files also displayed a degree of geological background noise across Moray West. As such, smaller anomalies may be masked by this background variation. Due to the wide line spacing of the magnetometer data, it is possible that unidentified ferrous material may be present between the survey lines.

The multibeam bathymetry data were rated as good using the above criteria. The data quality and resolution of 1 m was found to be of a good standard and suitable for archaeological assessment of objects and debris over 1 m in size.

The quality of the sub-bottom profiler data has been rated as 'Good' using the above criteria. Good penetration was achieved, with reflectors clearly visible and little background noise identified.

3.4.4 Geophysical Data – Processing

The high frequency and some low frequency cod sidescan sonar data files were processed using Coda Survey Engine Sidescan+ software. The lower frequency files provided a wider data range than the higher frequency files. This allowed the data to be replayed with various gain settings in order to optimise the quality of the images. The data were interpreted for any objects of possible anthropogenic origin. This involves creating a database of anomalies within Coda by tagging individual features of possible archaeological potential, recording their positions and dimensions, and acquiring an image of each anomaly for future reference.

A mosaic of the sidescan sonar data is produced during this process to assess the quality of the sonar towfish positioning. This process allows the position of anomalies to be checked between different survey lines and for the positioning to be further refined if necessary.

The form, size and/or extent of an anomaly is a guide to its potential to be an anthropogenic feature and therefore of archaeological interest. A single small but prominent anomaly may be part of a much more extensive feature that is largely buried. Similarly, a scatter of minor anomalies may define the edges of a buried but intact feature, or it may be all that remains as a result of past impacts from, for example, dredging or fishing.

The multibeam echosounder data were analysed to identify any unusual seabed structures that could be shipwrecks or other anthropogenic debris. The data were gridded at 1 m and analysed using QPS Fledermaus software, which enables a 3-D visualisation of the acquired data and geo-picking of seabed anomalies.

The magnetometer data were processed using Geometrics MagPick software in order to identify any discreet magnetic contacts which could represent buried metallic debris or structures such as wrecks.

The software enables both the visualisation of individual lines of data and gridding of data to produce a magnetic anomaly map. The data were first smoothed to try and eliminate any spiking. A trend was then fitted to the resulting data, and the trend values subtracted from the smoothed values. This was carried out in an attempt to remove natural variations in the data (such as diurnal variation in magnetic field strength and changes in geology). The processed data were then gridded to produce a map of magnetic anomalies, and individual anomalies tagged and images taken in a similar process to that undertaken for the sidescan sonar data.

The sub-bottom profiler data were studied in order to detect any in-filled palaeochannels, ravinement surfaces and peat/fine-grained sediment horizons that may have archaeological potential.

The sub-bottom profiler .sgy data were converted to .COD format, before being processed by Wessex Archaeology using Coda Seismic+ software. This software allows the data to be visualised with user selected filters and gain settings in order to optimise the appearance of the data for interpretation. The software then allows an interpretation to be applied to the data by identifying and selecting a sedimentary boundary that might be of archaeological interest.

The data were interpreted with two-way travel time (TWTT) along the z-axis. In order to convert from TWTT to depth, the velocity of the seismic waves was estimated to be 1,600ms-1. This is a standard estimate for shallow, unconsolidated sediments.

Any small reflectors which appear to be buried material such as a wreck site covered by sediment are recorded, the position and dimensions of any such objects noted in a gazetteer, and an image of each anomaly acquired. It should be noted that anomalies of this type are rare, as the sensors must pass directly over such an object in order to produce an anomaly.

3.4.5 Geophysical Data – Anomaly Grouping Discrimination

The previous section describes the initial interpretation of all available geophysical datasets which were conducted independently of one another. This inevitably leads to the possibility of any one object being the cause of numerous anomalies in different datasets and apparently overstating the number of archaeological features in Moray West.

To address this fact the anomalies were grouped together; allowing one ID number to be assigned to a single object for which there may be, for example, a UKHO record and multiple sidescan sonar anomalies.

Once all the geophysical anomalies and desk-based information have been grouped, a discrimination flag is added to the record in order to discriminate against those which are not thought to be of an archaeological concern. For anomalies located on the seabed, these flags are ascribed as follows:

Table 3.2: Criteria Discriminating Relevance of Seabed Features to Proposed Scheme		
Non-archaeological	U1	Not of anthropogenic origin
	U2	Known non-archaeological feature
	U3	Position of a recorded loss at which no physical wreck remains have ever been identified
Archaeological	A1	Anthropogenic origin of archaeological interest
	A2	Uncertain origin of possible archaeological interest
	A3	Historic record of possible archaeological interest with no corresponding geophysical anomaly

Similarly, the discrimination flags applied to shallow geological features of possible archaeological potential are ascribed as follows (Table 3.3):

Table 3.3: Criteria Discriminating Relevance of Palaeogeographic Features to Proposed Scheme		
Non-archaeological	U2	Feature of non-archaeological interest
Archaeological	P1	Feature of probable archaeological interest, either because of its palaeogeography or likelihood for producing palaeoenvironmental material
	P2	Feature of possible archaeological interest

The grouping and discrimination of information at this stage is based on all available information and is not definitive. It allows for all features of potential archaeological interest to be highlighted, while retaining all the information produced during the course of the geophysical interpretation and desk-based assessment for further evaluation should more information become available.

3.4.6 Co-ordinate System

The survey data was acquired using WGS84 UTM30 N.

3.5 Assumptions and Limitations

Data used to compile this report consists of primary geophysical survey data and secondary information derived from a variety of sources, only some of which have been directly examined for the purposes of this assessment. The assumption is made that the secondary data, as well as that derived from other secondary sources, is reasonably accurate.

The records held by the UKHO, CANMORE and the other sources used in this assessment are not a record of all surviving cultural heritage assets, rather a record of the discovery of a wide range of archaeological and historical components of the marine historic environment. The information held within these datasets is not complete and does not preclude the subsequent discovery of further elements of the historic environment that are, at present, unknown. In particular, this relates to buried archaeological features.

3.6 Determining Sensitivity and Value

In order to assess the potential impacts of a development upon the marine environment, EIAs typically adopt the conceptual approach known as the 'source-pathway-receptor' model. This approach is based on the identification of the source (i.e. the origin of a potential impact), the pathway (i.e. the means by which the effect of the activity could impact a receptor) and the receptor that may be impacted (e.g. known/potential heritage assets). For the significance of any given impact to be fully understood, the sensitivity of any receptors that may be impacted need to be considered. This section outlines how the sensitivity of marine heritage assets is ascertained.

The capability of a receptor to accommodate change and its ability to recover if affected is a function of its sensitivity. Receptor sensitivity is typically assessed via the following factors:

- Adaptability - the degree to which a receptor can avoid or adapt to an effect;
- Tolerance - the ability of a receptor to accommodate temporary or permanent change without significant adverse impact;
- Recoverability - the temporal scale over and extent to which a receptor will recover following an effect; and
- Value - a measure of the receptor's importance, rarity and worth.

Archaeological and cultural heritage receptors cannot typically adapt, tolerate or recover from physical impacts resulting in material damage or loss caused by development. Consequently, the sensitivity of each asset is predominantly quantified only by its value.

3.6.1 Assessment Criteria – Value of an Asset

Based on Historic England's *Conservation Principles, Policies and Guidance for the Sustainable Management of the Historic Environment* (English Heritage, 2008: 21), the significance of a historic asset 'embraces all the diverse cultural and natural heritage values that people associate with it, or which prompt them to respond to it'.

Within this document, significance is weighed by consideration of the potential for the asset to demonstrate the following value criteria:

- Evidential value - deriving from the potential of a place to yield evidence about past human activity;
- Historical value - deriving from the ways in which past people, events and aspects of life can be connected through a place to the present. It tends to be illustrative or associative;
- Aesthetic value - deriving from the ways in which people draw sensory and intellectual stimulation from a place; and

- Communal value - deriving from the meanings of a place for the people who relate to it, or for whom it figures in their collective experience or memory. Communal values are closely bound up with historical (particularly associative) and aesthetic values, but tend to have additional and specific aspects.

With regards to assessing the value of shipwrecks, the following criteria listed in English Heritage's *Ships and Boats: Prehistory to Present - Designation Selection Guide* (English Heritage (now Historic England), 2012) can be used to assess an asset in terms of its value:

- Period;
- Rarity;
- Documentation;
- Group value;
- Survival/condition; and
- Potential.

These aspects help to characterise each asset whilst also comparing them to other similar assets. The criteria also enable the potential to contribute to knowledge, understanding and outreach to be assessed.

The value of known archaeological and cultural heritage assets were assessed on a five-point scale using professional judgement informed by criteria provided in Table 3.4 below.

Table 3.4: Criteria to Assess the Archaeological Value of Marine Assets

Value	Definition
Very High	Best known or only example and / or significant potential to contribute to knowledge and understanding and / or outreach. Receptors with a demonstrable international dimension to their importance are likely to fall within this category. Wrecked ships and aircraft that are protected under the Historic Environment Scotland Act 2014, Protection of Military Remains Act 1986 or Merchant Shipping Act 1995, with an international dimension to their importance, plus as-yet undesignated sites that are demonstrably of equivalent archaeological value. Known submerged prehistoric sites and landscapes with the confirmed presence of largely in situ artefactual material.
High	Above average example and / or high potential to contribute to knowledge and understanding and / or outreach. Receptors with a demonstrable national dimension to their importance are likely to fall within this category. All other wrecked ships and aircraft with statutory protection under the Historic Environment Scotland Act 2014, Protection of Military Remains Act 1986 or Merchant Shipping Act 1995, plus as-yet undesignated sites that are demonstrably of equivalent archaeological value. Palaeogeographic features with demonstrable potential to include artefactual and / or palaeoenvironmental material, possibly as part of a prehistoric site or landscape.
Medium	Average example and / or moderate potential to contribute to knowledge and understanding and / or outreach. Includes wrecks of ships and aircraft that do not have statutory protection or equivalent significance, but have moderate potential based on a formal assessment of their importance in terms of build, use, loss, survival and investigation. Prehistoric deposits with moderate potential to contribute to an understanding of the palaeoenvironment.

Table 3.4: Criteria to Assess the Archaeological Value of Marine Assets	
Value	**Definition**
Low	Below average example and / or low potential to contribute to knowledge and understanding and / or outreach. Includes wrecks of ships and aircraft that do not have statutory protection or equivalent significance, but have low potential based on a formal assessment of their importance in terms of build, use, loss, survival and investigation. Prehistoric deposits with low potential to contribute to an understanding of the palaeoenvironment.
Negligible	Poor example and / or little or no potential to contribute to knowledge and understanding and / or outreach. Assets with little or no surviving archaeological interest.

Furthermore, on the Importance of Shipwrecks (Wessex Archaeology, 2006) suggests importance can be assessed through the following criteria: build, use, loss, survival and investigation.

To further supplement this approach, the ALSF-funded Marine Class Description and principles of selection for aggregate producing areas project (ALSF 5383), undertaken by Wessex Archaeology (2008a), proposed a composite timeline that considers wrecks in five distinct date ranges. The timeline takes into account the broad chronology of shipbuilding, thus drawing out generalisations regarding the age and special value of sites. The timeline is summarised as follows:

- Pre- 1508 AD: this covers the period from the earliest Prehistoric evidence for human maritime activity to the end of the medieval period, c. 1508. Little is known of watercraft or vessels from this period and archaeological evidence of them is so rare that all examples of craft are likely to be of special value;
- 1509 to 1815: this encompasses the Tudor and Stuart periods, the English Civil War, the Anglo-Dutch Wars and later the American Independence and French Revolutionary Wars. Wrecks and vessel remains from this date are also quite rare, and can be expected to be of special value;
- 1816 to 1913: this period witnessed great changes in the way in which vessels were built and used, corresponding with the introduction of metal to shipbuilding, and steam to propulsion technology. Examples of watercraft from this period are more numerous and as such, it is those that specifically contribute to an understanding of these changes that should be regarded as having special value;
- 1914 to 1945: this period encompasses the First World War (WWI), the Interwar years and the Second World War (WWII). This date range contains Britain's highest volume of recorded boat and ships losses. Those which might be regarded as having special interest are likely to relate to technological changes and to local and global activities during this period; and
- Post 1945: the final period extends from 1946 through the post-war years to the present day. Vessels from this date range would have to present a strong case if they are to be considered of special interest.

The perceived value of each marine archaeological asset is generally assessed and assigned on a site-by-site basis, depending on the criteria listed in Table 4. The UK Marine Policy Statement (Department for Environment, Food and Rural Affairs, 2011: 90) describes a heritage asset as holding a degree of significance. Significance relates to the heritage interest of an asset that may be archaeological, architectural, artistic or historic.

4 Archaeological Assessment of Seabed Prehistory

4.1 Geological Baseline

From a geological perspective, the ASA is situated within the inner Moray Firth region, approximately 29 km south-east of Dunbeath and 44 km north-east of Lossiemouth. The ASA encompasses part of the Beatrice oil field (Figure 3.1).

The basement geology of the ASA is described as Cretaceous sandstone and mudstone rock of the Cromer Knoll group (BGS online). This is directly overlain by a sequence of undifferentiated Quaternary deposits identified as soft muds to the south-west and a diamict (an unsorted glacial deposit) to the north-east of the ASA (Andrews *et al*. 1990; BGS online).

This bedrock is unconformably overlain by Quaternary (Pleistocene and Holocene) deposits. The Quaternary history of the UK has been a time of dramatic climate fluctuations due to glacial and interglacial cycles; rapid changes to relative sea levels caused by ice sheet presence and absence, and the associated periods of severe erosion and high levels of sediment accumulation that took place during the ice sheet formation and subsequent melting (Andrews *et al*. 1990).

The ASA and the surrounding landscape would have been subjected to these glacial and interglacial cycles and at various times the area would have been covered by ice sheets, inundated by water from melting ice sheets and associated rising sea levels, and at certain points would have been dry land and therefore, may have been suitable for human settlement.

4.2 Palaeogeographic Assessment

The following section details the results of the palaeogeographic assessment of the geophysical data in conjunction with the known geology of the area (Andrews *et al*. 1990; BGS 1984a). No geotechnical work was undertaken as part of this assessment, but boreholes from the adjacent area (MORL 2012) have been used as background information where appropriate. This broad stratigraphy is summarised below, with detailed descriptions of individual palaeogeographic features presented after by ASA. There are no designated prehistoric archaeological sites located in the ASA.

Seven Quaternary stratigraphic units ranging from the mid-Devensian to the Holocene have been proposed by BGS within the inner Moray Firth, based on shallow BGS boreholes, which bear very little correlation to Quaternary sediments identified in the outer Moray Firth (Andrews *et al*. 1990) and are described in Table 4.1 as follows.

Table 4.1: Generalised Stratigraphy of the ASA				
Unit	**Formation Unit**	**Description[1]**	**Environment**	**Archaeological Potential**
Seabed sediments	Holocene Marine	Silty, gravelly sand with occasional shell and organics	Outer estuarine/Marine	Considered of low potential in itself, but possibly contains re-worked artefacts and can cover wreck sites and other cultural heritage.
7	Holocene Estuarine	Well laminated soft silty clays and fine sands with some peaty clays	Possible estuarine, alluvial or terrestrial	High archaeological and palaeoenvironmental potential. Could contain *in-situ* and/or reworked artefacts and environmental material
6	Devensian	Muds and sandy muds	Periglacial, possible glaciolacustrine	Very low potential due to proximity to ice sheet
5	Devensian	Muddy sands and sandy clays with sands and gravels – Ablation till	Sub glacial/Glacial	Very low potential due to period of ice coverage
4	Devensian	Laminated gravelly, silty clays	Glaciomarine	Very low potential due to period of submersion and close proximity to ice sheet
3	Devensian	Laminated silty clays - Possible reworked Unit 1	Glaciomarine	Very low potential due to period of submersion and close proximity to ice sheet
2	Devensian	Sands	Sub glacial/Glacial	Very low potential due to period of ice coverage
1	Devensian	Gravelly Clay - Till	Sub glacial/Glacial	Very low potential due to period of ice coverage
Bedrock	Cretaceous Bedrock	Mudstone and Sandstone		None – too old to be of archaeological potential
(1) Description based on secondary sources (Andrews *et al*. 1990; BGS 1984a; BGS 1984b; BGS [online]) and project borehole data (MORL 2012; Wessex Archaeology 2014)				

Unit 1 is located north-east of a line from MacDuff to Dunbeath (Andrews *et al.* 1990); defined as a diamict and interpreted as a grey pebbly till (Andrews *et al*. 1990), which was described as compact pebbly sandy clays to muddy sands in the previously assessed boreholes (Wessex Archaeology 2014). Localised deposits of olive grey sands have been identified associated with Unit 1, which have been interpreted as a separate unit (Unit 2).

These units, as till and associated sands, would have been laid down underneath an ice sheet, and therefore the ASA would not have been an environment suitable for human occupation during this time. As such, Unit 1 and Unit 2 are not considered to be of archaeological potential.

Overlying this till are glaciomarine sequences comprising laminated, grey, silty clays, interpreted as Units 3 and 4. Unit 3 consists of grey pebble-free muds and rhythmites, likely derived from the melting and reworking of Unit 1 tills. Unit 4 is composed of gravelly muds, possibly from ablation or ice melt tills (Andrews *et al*. 1990).

As glaciomarine deposits, these sediments would have been lain down in full marine conditions adjacent to an ice sheet, and therefore in an environment unsuitable for human occupation. As such, Unit 3 and Unit 4 are not considered to be of archaeological potential.

A second diamict above these glaciomarine deposits, interpreted as ablation till (Unit 5), occurs to the south-west of Unit 1, described as brown to grey brown muddy sands and sandy clays with varying proportions of sands and gravels (Wessex Archaeology 2014).

Unit 6, found to be red, pink and brown muds, is described as the lateral equivalent of the Unit 5 till (Andrews *et al*. 1990), becoming sandy to the north-west and outcrop across the Moray Firth area.

These sediments indicate a terrestrial landscape and would usually be considered suitable for human occupation but, due to the likely environment at the time of deposition (cold and harsh conditions), it is unlikely that humans could have occupied the land in the ASA at this time. As such, Unit 5 and Unit 6 are considered to be of low archaeology potential. However, as the units (especially Unit 6) appear to outcrop across the seabed of the Moray Firth, it is possible that these may have formed land surfaces at one time upon which human occupation may have been possible and artefacts may have been deposited (i.e. during the Holocene).

The primary Holocene deposit across the site is Unit 7, and is described as being a pale olive-grey to olive green, clayey calcareous soft muds including fine grained sands, silts and some peaty clays. This has been and interpreted as Holocene in age, with thicknesses of up to 47 m in the inner Moray Firth area (Andrews *et al*. 1990).

This Unit, defined as Holocene in age, has been identified as potentially being deposited during a time when the ASA was exposed as a terrestrial environment after the last glacial period, post ice retreat but prior to the Holocene marine transgression. The layers of peats and silts suggest the presence of organic material within these sediments which would support the evidence of a land surface, and therefore suitable for human occupation and settlement. The potential for archaeological material to be found within this Unit is relatively high.

Evidence of Mesolithic shell middens has previously been uncovered in the inner Moray Firth (in the Inverness Area), while further upriver in the Beauly Firth, the remains of a number of late Bronze Age and Iron Age marine crannogs have been found (Hale and Cressey 2003 in DECC 2004).

While known submerged prehistoric sites from the last 5-10 000 years from Orkney, Shetland, Viking Bank, the Yorkshire coast and Denmark have shown that these types of site have survived the marine transgression, the strong currents and exposure to North Atlantic storms further off shore, in addition to the thin sediment cover and large areas of exposed bedrock in the outer Moray Firth and surrounding area, would make the survival of prehistoric deposits *in situ* here very unlikely (Flemming 2004 in DECC 2004).

As the ASA is located within the inner Moray Firth, any prehistoric remains deposited here would have had more protection and therefore may have been more likely to survive *in situ*, as the identification of Unit 7 as a possible Holocene deposit would suggest.

The uppermost sediments consist of more recent tidal and shallow marine sands and gravels, with fine to coarse grained gravelly sand (BGS 1984a). Areas of till outcrop or till thinly masked with sediment are considered more common towards the outer Moray Firth, which may be present in the north and east of ASA (BGS 1984b).

4.3 Archaeological Potential – Seabed Prehistory

Although there are no known prehistoric sites within the ASA, the potential for archaeological material of a prehistoric date to exist within the area cannot be discounted. Archaeological investigations of the North Sea basin have revealed that considerable areas of what is now seabed were once dry land during the Middle and Late Pleistocene and the Holocene (Bicket and Tizzard, 2015; Dix and Sturt, 2011; Gaffney *et al*., 2007; Gupta *et al*., 2004; Momber, 2000; Momber *et al*., 2012). These palaeolandscapes provided habitable environments for hominins (human ancestors).

The full sequence of units identified in Table 16-5 of the geological baseline (Section 4.2) may not be present in all points within the ASA and not all of these units were observed in the assessed sub-bottom profiler data due to the shallow penetration of the seabed.

No individual paleogeographic features (e.g. individual buried palaeochannels) of archaeological interest were identified within the sub-bottom data assessed by Wessex Archaeology. As such the ASA is generally discussed.

The geophysical data penetrates approximately 60 m below the seabed across the extents of the ASA, and as such it is inferred that the basal units (bedrock and Units 1, 2 3 and 4) have not been observed.

The lower units visible within the geophysical data vary between a layer of strong on lapping or prograding reflectors, and a more chaotic unit with no observable structure. Some deep channels of uniform sediments appear in this layer, but all are topped with strong hyperbolic reflectors which appear to indicate the presence of rocks or irregular material (Figure 4.2). It is not possible to fully determine the nature of these layers from geophysical data alone but these layers have been tentatively interpreted as the different till deposits of Units 5 and 6 (Table 16-5; as described by BGS), which is further supported by the results of the borehole logs from the adjacent area (MORL 2012).

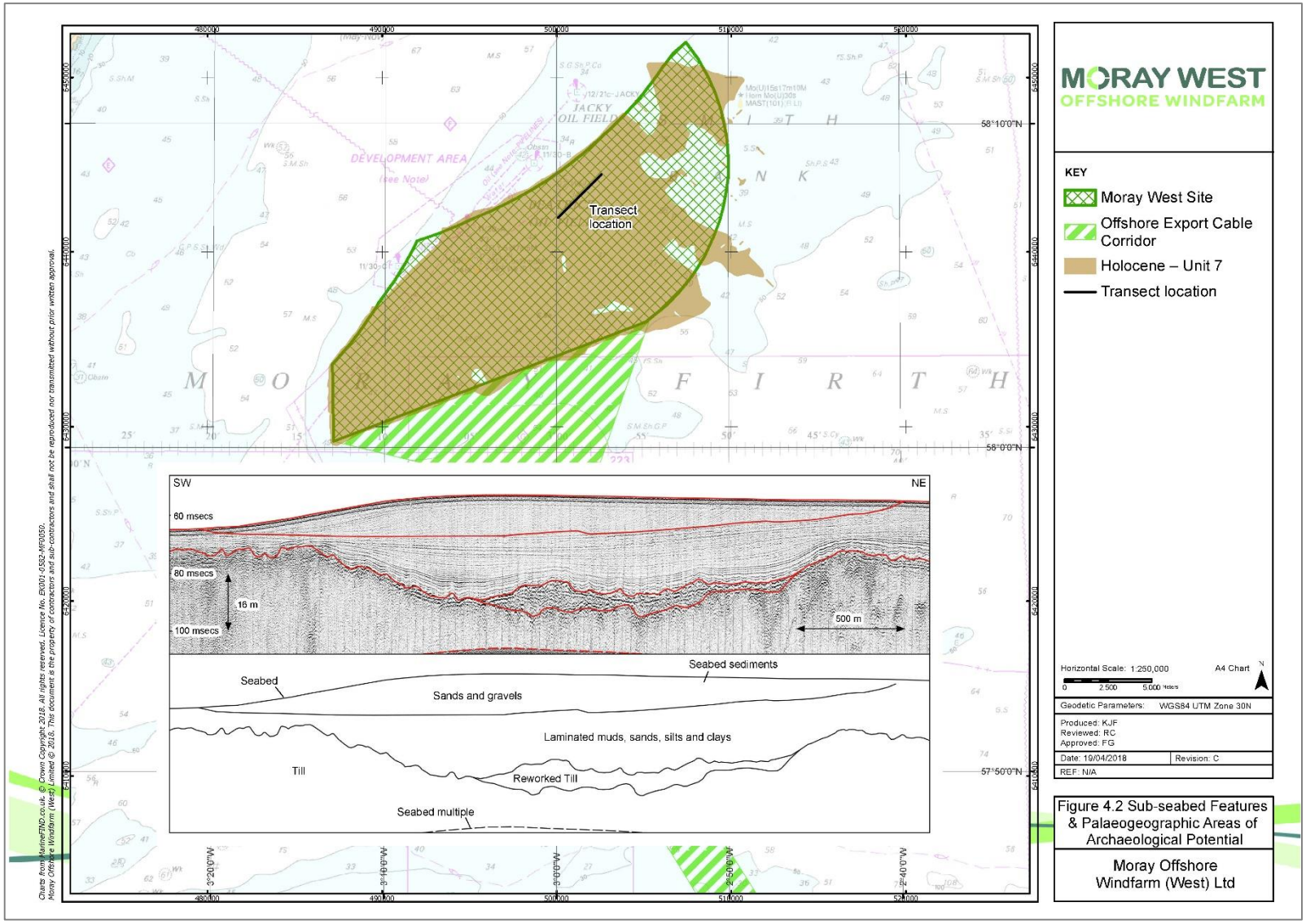

Figure 4.1: Sub-seabed features & palaeogeographic areas of archaeological potential

These Units would have been laid down at a time when this area and the surrounding landscape would have been under ice sheets and therefore, as all current research suggests, human settlement in the UK, if it reached this far up north, would have likely been abandoned at this time. Therefore, these layers are of low archaeological interest.

Across a large expanse of the ASA these till layers are overlain by a deposit of uniform laminated sediments which are interpreted to be the Holocene muds, sands, silts and clays of the BGS Unit 7 (Figure 4.2), as described in the borehole logs assessed for the adjacent area (MORL 2012). This layer ranges from 0.5 m to approximately 40 m below the seabed. Some stronger reflective layers of sediments are visible within this unit, which may indicate the presence of more organic or peaty material. A sporadic coverage of gas chimneys is also visible within this layer, which further implies the presence of organic material within or at the base of this layer.

This unit has the potential to contain material of palaeoenvironmental interest which may aid in dating the deposits, and determining whether they were deposited on dry land (high archaeological potential), under decaying ice sheets, or under full marine conditions (low archaeological potential). The presence of organic material suggests that at least part of this Unit was dry land at one time, and that the Unit 7 potentially represents an estuarine or alluvial deposit. From this it can be inferred that the ASA, situated in proximity to vegetation in addition to fresh water and the sea, would have been a favourable location for human occupation.

The presence of Bronze Age and Iron Age marine crannogs in the Beauly firth, in addition to Mesolithic shell middens (DECC 2004) around Inverness prove that early human occupation did take place in this region, although all the evidence has been identified in the nearshore. As stated in the DECC (2004) report, the likelihood of Holocene deposits surviving the climatic conditions is lessened the further offshore they were deposited, and so the presence of such an expanse of Holocene deposits this far East may be quite rare (although the ASA only covers a small section of the Moray Firth). Therefore, these Holocene deposits of Unit 7 are considered to be of archaeological potential.

Modern marine sediments overlay the uppermost units, the tills of Units 5 and 6 or the sands, silts and clays of Unit 7. In some places the strong layer of hyperbole, interpreted as the most recent layer of till, is directly overlain by a shallow deposit of seabed sediments or forms an outcrop on the seabed. The modern marine sediments are not considered to be of archaeological potential in themselves, but they have the potential to cover archaeological sites (e.g. wrecks) in areas where they attain sufficient thickness.

Towards the north-east of the ASA a possible sand wave was identified, aligned NNW to SSE and overlying Unit 7 as slightly prograded or on-lapping layers of chaotic sediments of approximately 12 m in thickness (Figure 4.2). This sand wave has the potential to conceal archaeological sites and add further protection to deeper sediments.

5 Archaeological Assessment of Maritime and Aviation Sites

5.1 Introduction

The following assessment of the maritime resource is based on records of known shipwrecks, aircraft crash sites and obstructions combined with recent archaeological assessments of geophysical data.

5.2 Geophysical Seabed Features Assessment

5.2.1 Introduction

An archaeological assessment of 2010 geophysical survey dataset was undertaken by Wessex Archaeology. Within the ASA, a total of 39 geophysical anomalies were identified within the geophysical data after the grouping and discrimination phase. A full gazetteer of anomalies is presented in Annex 16.1C

These anomalies are discussed below, with respect to the Moray West Site ASA and OfTI ASA.

5.2.2 Moray West Site ASA

The results of this assessment are collated in gazetteer format detailed in Annex 16.1C and illustrated in Figures 5.1 – 5.3.

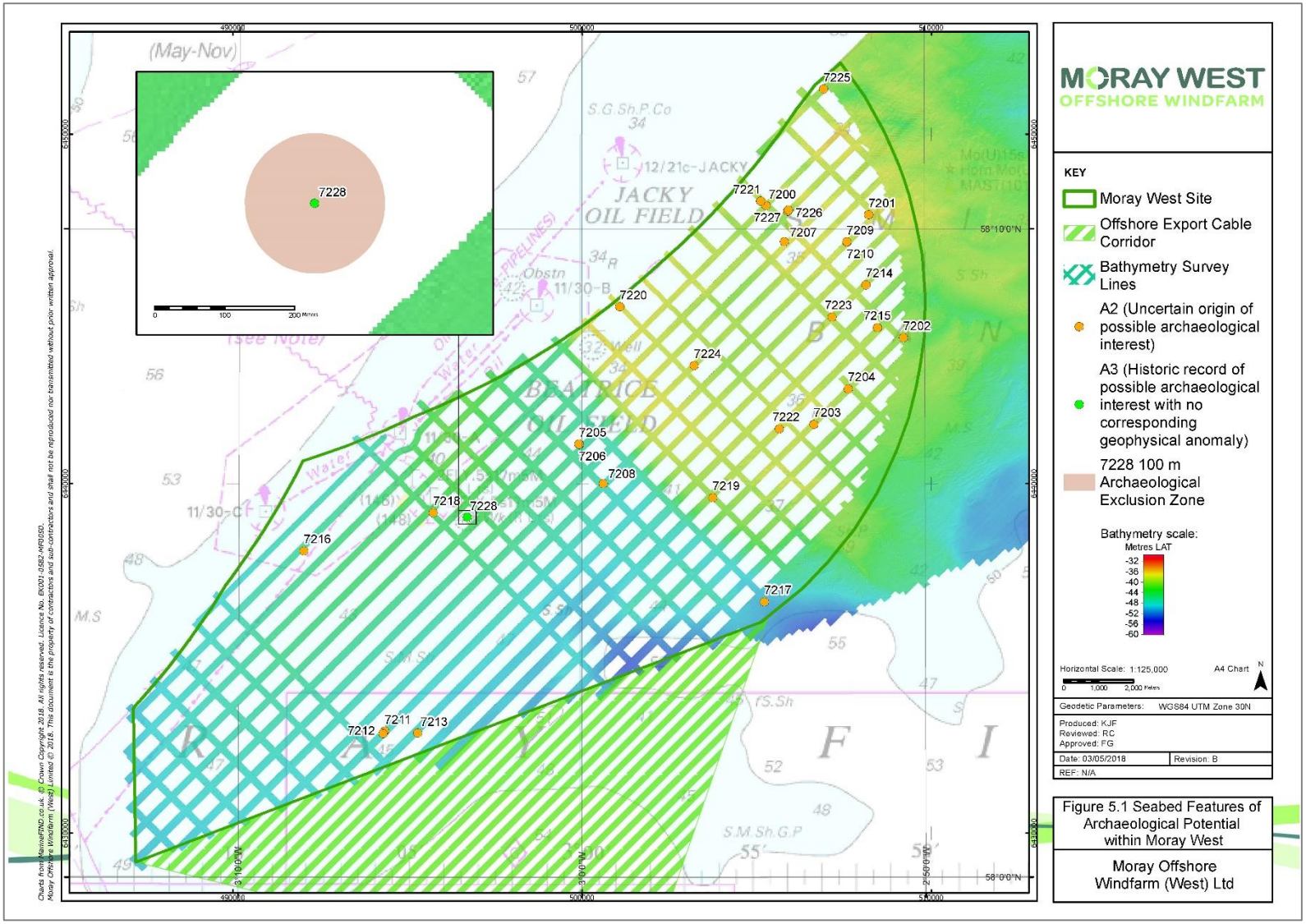

Figure 5.1: Seabed features of archaeological potential within Moray West Site

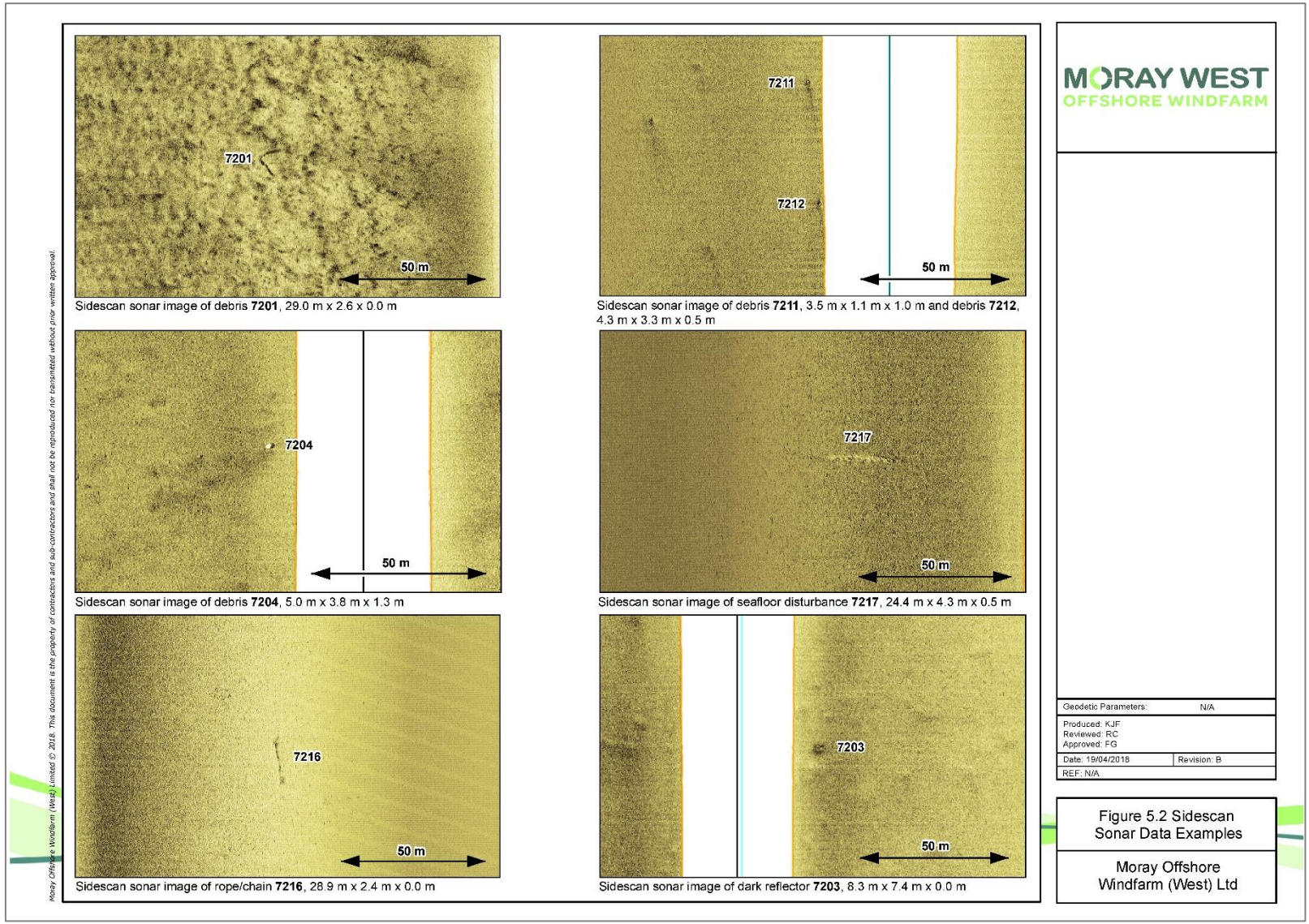

Figure 5.2: Sidescan sonar data examples

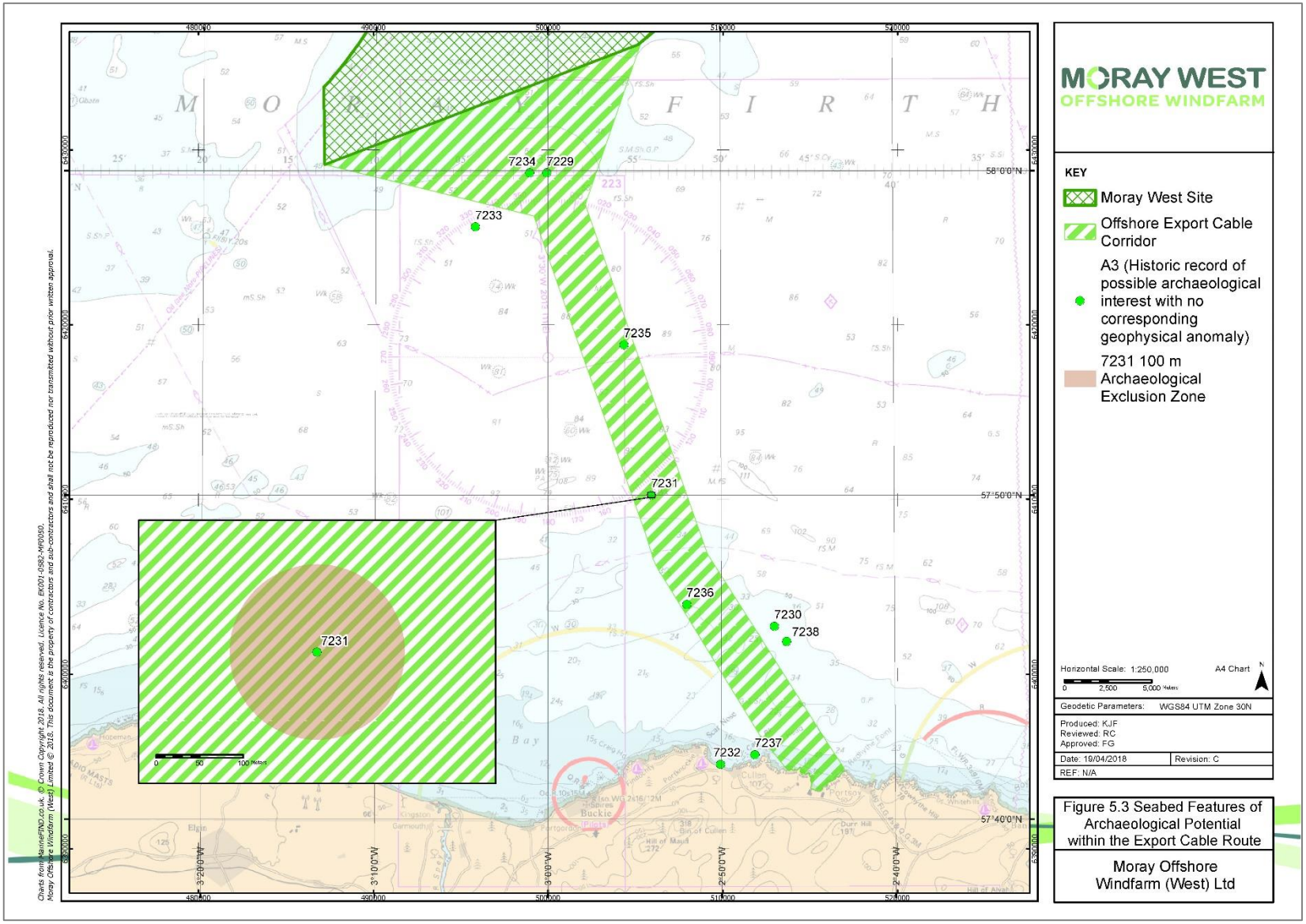

Figure 5.3: Seabed features of archaeological potential within the Offshore Transmission Infrastructure

Twenty-nine anomalies have been identified as being of possible archaeological potential within the Moray West and are discriminated as shown in Table 5.1.

One recorded wreck is present (**7228**), this has been classified as A3, a historic record of possible archaeological interest. The wrecks position was not covered by the geophysical survey data (Figure 5.1).

Table 5.1: Anomalies of Archaeological Potential Within the ASA

Archaeological discrimination	Quantity	Interpretation
A1	0	Anthropogenic origin of archaeological interest
A2	28	Uncertain origin of possible archaeological interest
A3	1	Historic record of possible archaeological interest with no corresponding geophysical anomaly
Total	29	

Furthermore, these anomalies can be classified by probable type, which can further aid in assigning archaeological potential and importance (Table 5.2).

Table 5.2: Types of Anomalies Identified

Anomaly Classification	Number of Anomalies
Debris	9
Seafloor disturbance	1
Rope/chain	1
Dark reflector	9
Magnetic	8
Recorded Wreck	1
Total	**29**

Recorded wreck **7228** has been identified in the UKHO database as the *Sunbeam* (Possibly). This is a wooden sailing vessel with original dimensions of 30.4 m x 7.0 m x 3.4 m built in 1878 by Massey, Portreath, Cornwall. The vessel was captured by enemy submarine and sunk by gunfire in 1915. When it sunk it was owned by William B. Firth of Finstown, Orkney. The wreck was last identified by geophysical survey for the UKHO in 2008 and recorded as being highly degraded. It was identified in sidescan sonar data with dimensions of 25.0 m 20.0 m x 2.7 m and a slight magnetic anomaly. This wreck location was not covered by the 2010 geophysical survey data and as such its position cannot be confirmed in this report. However, it can be assumed that it still exists at the recorded location.

Nine items of debris have been identified across Moray West, none of which have magnetic anomalies associated. The largest piece of debris identified is **7201** with dimensions of 29.0 m x 2.6 m with no measurable height off the seabed. The debris is a long and thick right angled dark reflector that is situated on a rough and uneven area of the seabed. The debris has an anthropogenic appearance in contrast to the rest of the seabed (Figure 5.2).

The smallest piece of debris identified within Moray West is **7211**. This anomaly has dimensions of 3.5 m x 1.1 m x 1.0 m and is visible in the sidescan sonar data as a medium sized dark reflector with a small but bright shadow. The object has an internal shadow or a possible internal depression with scouring identified orientated south-west and measuring 25 m (Figure 5.2). Situated 87 m to the south-west of this is debris **7212**. This is a rounded anomaly with dimensions of 4.3 m x 3.3 m x 0.5 m. The dark reflector has no shadow visible and appears to have a central depression.

Debris **7204** has been identified in both the sidescan sonar and bathymetry data. This is a distinct, curvilinear shaped dark reflector with a very bright rounded shadow and dimensions of 5.0 m x 3.8 m x 1.3 m (Figure 5.2). In the bathymetry data, this anomaly is visible as a medium sized mound with a slightly pointed tip, situated in a depression measuring 11.0 m x 10.0 m.

Debris anomalies **7226** and **7227** are situated 38 m away from one another and have very similar characteristics. The former is a slightly oval shaped dark reflector with a bright, tapered shadow. The anomaly has dimensions of 7.0 m x 6.0 m x 0.8 m and is very distinct in the sidescan sonar data. In the bathymetry data, this is visible as a large pointed mound. Debris **7227** is situated 38 m north-east of **7226**, this anomaly has dimensions of 6.3 m x 4.0 m x 0.5 m. It is visible in the sidescan sonar data as a slightly square shaped dark reflector with a bright, but small shadow. In the bathymetry data, this is discernible as a medium sized, distinct oval mound situated on a sandy area of the seabed.

One seafloor disturbance has been identified across Moray West (**7217**). This is an area of disturbed seabed that may be covering objects of archaeological potential. The feature is visible in the sidescan sonar data as a long, linear shaped group of small and indistinct dark reflectors with height, covered by sands. The feature has dimensions of 24.4 m x 4.3 m x 0.5 m and is situated on an otherwise sandy and even area of the seabed (Figure 5.2). This seafloor disturbance has no magnetic anomaly associated and any possible buried debris at this location is likely to be non-ferrous.

One possible rope or chain feature has been identified within Moray West (**7216**). This has dimensions of 28.9 m x 2.4 m with no measurable height off the seabed. The feature is a thick and very distinct linear dark reflector that may be partially buried across its extent. The ends of the feature appear slightly wider than the main body, this is situated on a sandy and even area of the seabed and appears to be anthropogenic in origin (Figure 5.2).

Nine dark reflector anomalies have been identified across Moray West. The largest of these is **7203**, with dimensions of 8.3 m x 7.4 m and no measurable height off the seabed. This anomaly is visible in the sidescan sonar data as a large and rounded dark reflector on an otherwise featureless area of seabed. The dark reflector is quite indistinct and may be partially buried (Figure 5.2).

The smallest dark reflector identified within Moray West is **7214** which has dimensions of 2.2 m x 1.0 m x 1.1 m. This is visible in the sidescan sonar data as a small, rounded dark reflector with a very bright shadow. The anomaly is isolated and very distinct on a sandy and even area of the seabed. Dark reflector **7200** has been identified in both the sidescan sonar and bathymetry data. This is a medium sized, distinct dark reflector with a bright shadow, located on a gravelly area of the seabed. In the bathymetry data, this anomaly is discernible as an isolated mound with dimensions of 5.0 m x 4.4 m x 1.0 m.

Eight magnetic anomalies with no associated sidescan sonar feature have been identified across Moray West. These have all been given an archaeological potential rating of A2 (see Annex 16.1C). Seven small magnetic anomalies ranging in size from 5 nT to 31 nT and one large magnetic anomaly measuring 230 nT (**7218**) have been identified across the Moray West. All of the magnetic anomalies classified as A2 have the possibility to be objects with ferrous content that are of archaeological potential, but don't have a surface expression.

5.2.3 Offshore Transmission Infrastructure ASA

A search of records in the UKHO datasets was undertaken by Wessex Archaeology. Within the OfTI, a total of ten sites were identified (**7229-7238**) (Annex 16.1C). These consist of six wrecks and five obstructions and are discusses below (Figure 5.3).

The *U77* (**7229**) was a WWI German UE-class minelaying submarine. The submarine had a length of 56.7 m, with a beam of 5.8 m and 830 displacement tonnage. It was sunk by gunfire on 7th July 1916 by an unnamed British ship, after leaving Heligoland on the 5th July 1916 to lay mines off Kinnaird Head. In 1988 no wreck was located within one mile to the north of the original position.

Record **7230** refers to a British steamship, probably the *Moray Firth*. The steamship sank on the 28th of March 1943 following a collision. It was built at Firth Shipping Co. Ltd. with a gross tonnage of 314, measuring 48.81 m x 8.07 m x 2. 97 m. In 1987 a search for this record was undertaken, but no wreck was found.

The *Mayflower* (**7231**) was a wooden motor fishing vessel, measuring 18.3 m in length. The vessel sunk on the 1st of February 1973 following a collision with MFV Devotion II. The wreck is non-dangerous and situated at a general depth of 81 m. It was last located in 1986.

Similarly, the Artemis (**7232**) was a motor fishing vessel that sunk on 2nd September 1974 whilst on passage for the Isle of Man. It grounded in dense fog and reported as having been pounded. Recorded by UKHO consisting of a wreck with potion of hull or superstructure of a motor fishing vessel. It sunk on 2nd of September 1974 whilst on passage for the Isle of Man. It grounded in dense fog and reported as having been pounded. In 1940, it sustained damage to the keel and stern as it listed to starboard. In 1987 no wreck was found at original position.

Record **7234** is a possible aircraft wreck of an A/C Day Jet. The aircraft was ditched, however, the year it wrecked is unknown. The wreck was not located during 1987 and 1988 searches.

The remaining 5 obstructions (**7233, 7235, 7236, 7237 & 7238**) relate to features that were surveyed by the UKHO in the 1980s, assigned as possibly wreckage, with one (**7237**) classed as 'dead'. This record refers to an old steamship located 1 mile north east of Cullen.

5.3 Maritime and Aviation Archaeological Potential

5.3.1 Introduction

There is potential for discoveries of maritime craft from the Mesolithic to the modern period. Post-medieval and modern wrecks, as they were generally made of more substantial material, are more likely to have been discovered through surveys undertaken by UKHO and others, and thus recorded in the archaeological record. However, there is still potential for discovery of previously unrecorded wreck sites, particularly of wooden wrecks, broken up wrecks or partially buried wrecks that are more difficult to detect through geophysical survey.

There is also potential for 20th century aircraft, particularly in relation to Second Wold War. Aircraft crash sites are also difficult to identify through archaeological assessments of geophysical survey, although past experience indicates material from the site, such as engines or other material may be recorded as small obstructions or anomalies.

5.3.2 Recorded Losses

As discussed in Section 3.3.5, Recorded Losses are records for ships or aircraft that are known to have wrecked or crashed offshore, but for which the exact locations are not known. Recorded Losses are often grouped together by their general area of loss into Maritime Named Locations (displayed spatially as

polygons or centre points of polygons). Although many records are given co-ordinates (displayed spatially as points), these are unsubstantiated.

Recorded Losses can be considered as an indication of the potential for archaeological maritime remains to exist within the ASA and the type and number of wrecks that could be present.

A search of records in CANMORE datasets revealed 167 sites, excluding double entries from the UKHO dataset; consisting of 11 records already discussed above (**7228-7238**). Of the 167 sites, 155 can be described as wreck sites; 34 of which consist of aircraft sites; 10 are possible wreck sites; and the remaining one is an obstruction. The majority are located within the OfTI; only four are located within the Moray West Site.

Table 5.3 shows the distribution of these documented losses according to the date of loss for those records whose positions fall within the ASA. Details regarding these losses are presented in Annex 16.1D and Annex 16.1E.

Table 5.3: Recorded Losses Based on HES Data

Period	Number of records of ships	Number of records of aircraft
Post-medieval	23	-
19th century	76	-
Modern	28	34
Unknown	5	-
Total	**132**	**34**

Recorded Losses are predominantly reported to have stranded in coastal areas along the Banffshire coast, around Cullen Bay, Sandend Bay and Portsoy. Other areas mentioned include Buckie, Portessie, Portknockie, and Banff, roughly covering 32 km of coastline. The majority of losses were wrecked at or near Portsoy, with Cullen Bay representing the second highest density of wreck events. Both locations are Maritime Named Locations. A total of 18 vessels are recorded within the Cullen Named Location, whilst 23 vessels are recorded within the Portsoy Named Location.

In general, Recorded Losses paint a vibrant picture of the types of voyages being undertaken around the Banffshire coast. The losses across the area generally represent 19th and 20th century vessels, including those involved in international trade. The sailing ships of the 19th century predominantly feature crafts, luggers, schooners, and sloops, with a handful of steam trawlers and fishing vessels.

The aircraft losses are particularly important, as any aircraft that was lost while in military service is automatically protected under the Protection of Military Remains Act 1986, and therefore, if remains from any of these aircraft are discovered, they would be protected.

The 34 aircraft recorded losses include 13 British A/C type aircraft; ten British Fairey bomber type aircraft; three British Blackburn attack type aircraft; two British Hawker Osprey reconnaissance type aircraft; one Short Sunderland Flying Boat; four different British aircraft (Parnall Panther, Armstrong Whitworth Whitley, Vickers Wellington IC, Avro Ansan I) and one unknown type.

Although not all the recorded losses retain details on how they crashed and when, all aircraft were lost while in military service. Details are retained for the following two aircraft: the Vickers Wellington IC crashed into the sea in 1941; and the Short Sunderland Flying Boat was lost in 1943.

5.3.3 Navigational Hazards

Many vessels were lost without a record being made, and sometimes even the records that were created have since been lost (Cant, 2013). Examining the recorded losses discussed above, provides an indication to the potential for further discoveries.

Although the assessment of navigational hazards undertaken by Bournemouth University (Merrit *et al*., 2007) does not cover Scottish waters, from the number of recorded losses, discussed above, the ASA can be identified as an area of high navigational hazard.

Apart from the recorded losses, sand banks and other bathymetric features, and during storm events, especially in shallow waters (less than 30 m), wave-induced currents significantly increase the amount of sediment that is transported towards the inner Moray Firth. Both severe weather conditions and deposition of sediments within the ASA can present a navigational hazard.

5.3.4 Overview of Potential

The assessment of potential for the discovery of wrecks and wreck-derived material within the ASA draws on the results of the geophysical survey and desk-based research combined with further research of the wider area. The key areas of potential are summarised in Table 5.4 below.

Table 5.4: Summary of Key Areas of Maritime Potential

Period	Summary
Pre-1508 AD	Low potential for material associated with prehistoric maritime activities. Prehistoric maritime activities include coastal travel, fishing and the exploitation of other marine and coastal resources. Vessels of this period include rafts, hide covered watercraft and log boats.
	Low potential for material associated with later prehistoric maritime activities, including seaworthy watercraft suitable for overseas voyages to facilitate trade and the exploitation of deep water resources. Such remains are likely to comprise larger boat types, including those representing new technologies such as the Bronze Age sewn plank boats which are associated with a growing scale of seafaring activities.
	Low potential for material of Romano-British date, associated with the expansion and diversification of trade with the Continent. Watercraft of this period, where present, may be representative of a distinct shipbuilding tradition known as 'Romano-Celtic' shipbuilding, often considered to represent a fusion of Roman and northern European methods.
	Low potential for material associated with coastal and seafaring activity in the 'Dark Ages', associated with the renewed expansion of trade routes and Germanic and Norse invasion and migration. Vessels of this period may be representative of new shipbuilding traditions such as the technique.
	Low potential for material associated with medieval maritime activity, including that associated with increasing trade between the UK and Europe, the development of established ports around the southern North Sea and the expansion of fishing fleets and the herring industry. Vessels of this period are representative of a shipbuilding industry which encompassed a wide range of vessel types (comprising both larger ships and vernacular boats). Such wrecks may also be representative of new technologies (e.g. the use of flush-laid strakes in construction), developments in propulsion, the development of reliable navigation techniques and the use of ordnance.
1509 to 1815	Medium potential for post-medieval shipwrecks representative of continuing technological advances in the construction, fitting and arming of ships, and in navigation, sailing and steering techniques. Vessels of this period continued to variously represent both the clinker techniques and construction utilising the flush-laid strakes technique.

Table 5.4: Summary of Key Areas of Maritime Potential	
Period	**Summary**
	Medium potential for post-medieval shipwrecks associated with the expansion of transoceanic communications and the opening up of the New World.
	Medium potential for post-medieval shipwrecks associated with the establishment of the Royal Navy during the Tudor period and the increasing scale of battles at sea.
	Medium potential for post-medieval shipwrecks associated with continuing local trade and marine exploitation including the transport of goods associated with the agricultural revolution.
1816 to 1913	Higher potential for the discovery of shipwrecks associated with the introduction of iron and later steel in shipbuilding techniques. Such vessels may also be representative of other fundamental changes associated with the industrial revolution, particularly with regards to propulsion and the emergence of steam propulsion and the increasing use of paddle and screw propelled vessels.
	Higher potential for the discovery of shipwrecks demonstrating a diverse array of vernacular boat types evolved for use in specific environments.
	Higher potential for wrecks associated with large scale worldwide trade, the fishing industry or coastal maritime activity including marine exploitation.
1914 to 1945	Higher potential for the discovery of shipwrecks associated with the two world wars including both naval vessels and merchant ships. Wrecks of this period may also be associated with the increased shipping responding to the demand to fulfil military requirements. A large number of vessels dating to this period were lost as a result of enemy action.
Post- 1946	Potential for wrecks associated with a wide range of maritime activities, including military, commerce, fishing and leisure. Although ships and boats of this period are more numerous, loses decline due to increased safety coupled with the absence of any major hostilities. Vessels dating to this period are predominantly lost as a result of any number of isolated or interrelated factors including human error, adverse weather conditions, collision with other vessels or navigational hazards or mechanical faults.

5.3.5 Potential for Preservation

The potential for preservation is influenced by the composition of the seabed, and areas of deep mud afford far greater protection for organic materials than bedrock (Gregory, 2006; Merritt *et al*., 2007). Therefore, the BGS Units 5, 6 and 7 (Section 4.3), consisting of Holocene muds, sands, silts and clays, along with modern marine sediments provide an opportunity for high levels of preservation. Areas of sand, with sufficient thickness, also provide some degree of protection, with potential to cover archaeological sites.

6 Value and Sensitivity

6.1 Introduction

The value of the archaeological resource has been assessed based on the criteria identified in Section 3.7. The nature of the archaeological resource is such that there is a high level of uncertainty concerning the distribution of potential, unknown archaeological remains on the seabed. It is often the case that data concerning the nature and extent of sites is out of date, extremely limited or entirely lacking. In line with the Precautionary Principle (Wessex Archaeology, 2007), unknown potential cultural heritage assets are considered to be of **high** sensitivity and **high** value.

The Marine Policy Statement (Department for Environment, Food and Rural Affairs, 2011) states 'the more significant the [designated] asset, the greater should be the presumption in favour of its conservation' (Section 2.6.6.8 and 2.6.6.5). However, 'many heritage assets are not currently designated as scheduled monuments or protected wreck sites but are demonstrably of equivalent significance. The absence of designation for such assets does not necessarily indicate lower significance and the marine plan authority should consider them subject to the same policy principles as designated heritage assets' (East Inshore and East Offshore Marine Plans, 2014: no.148 p.52).

6.2 Seabed prehistory

6.2.1 Value

There are no known seabed prehistory sites within the ASA. However, the palaeogeographic assessment of the geophysical data has demonstrated the potential for the presence of as yet undiscovered *in situ* prehistoric sites and finds. The values assigned to these potential heritage assets are outlined in Table 6.1.

Table 6.1: Value of Seabed Prehistory Heritage Assets

Asset Type	Definition	Value
Potential *in situ* prehistoric sites	Primary context features and associated artefacts and their physical setting (if found).	High
	Known submerged prehistoric sites and landscape features with the demonstrable potential to include artefactual material.	High
Potential submerged landscape features	Other known submerged palaeolandscape features and deposits likely to date to periods of prehistoric archaeological interest with the potential to contain *in situ* material.	High
Potential derived prehistoric finds	Isolated discoveries of prehistoric archaeological material discovered within secondary contexts.	Medium
Potential palaeoenvironmental evidence	Isolated examples of palaeoenvironmental material	Low
	Palaeoenvironmental material associated with specific palaeolandscape features or archaeological material	High

On the basis of age and the rarity of Palaeolithic and Mesolithic finds underwater, if any sites or material was discovered, it would likely be of **high**, probably national archaeological importance. A guidance note published by English Heritage (now Historic England) *Identifying and Protecting Palaeolithic Remains: archaeological guidance for planning authorities and developers* (1998) indicated that sites containing Palaeolithic features are so rare in Britain that they should be regarded as of national importance and wherever possible should remain undisturbed.

In the event that prehistoric archaeological material discovered offshore is found *in situ* it should be considered of particularly high archaeological importance. As such, the features and deposits that have the potential to contain within them *in situ* material should be considered as **high** value assets.

Prehistoric archaeological material discovered within secondary contexts also has the potential to provide valuable information on patterns of human land use and demography in a field of study that is still little understood and rapidly evolving (Hosfield *et al*. 2007). They are, however, by their very nature derived and, as such, isolated prehistoric finds should be regarded as **medium** value assets.

Palaeoenvironmental evidence in the context of an *in situ* prehistoric site (if found) will be of **high** value. More widely, palaeolandsurfaces and palaeolandscape features will be considered of **high** value for the purpose of this assessment owing to the Quaternary scientific potential of such sedimentary sequences, to contextualise the wider early prehistoric palaeogeography and the potential of palaeolandscape features to preserve in situ artefacts and sites (Bicket and Tizzard 2014). Palaeoenvironmental evidence from isolated contexts will be regarded as **low** value.

6.3 Seabed features: maritime

6.3.1 Value

The perceived value assigned to an individual wreck site is, to a large degree, site specific. A vessel may be considered of special interest on the basis of any number of interrelating integral and relative factors, as discussed in Section 3.7. Those regarded as being of special interest may further be designated under the Marine (Scotland) Act 2010 or the Protection of Military Remains Act 1986. Only features located within the ASA are discussed in this section.

There are no wrecks with statutory designations located within the ASA.

There are 39 known and charted sites or obstructions, and the potential for further wrecks or maritime-related debris to exist within the ASA. The values assigned to these heritage assets are outlined in Table 6.2.

Table 6.2: Value of Maritime Heritage Assets

Asset Type	Definition		Value
Known assets	Wrecks (A1); identified in geophysical survey		High
	Named wrecks (A3); not identified in geophysical survey	*U77* (**7229**); *Moray Firth* (Probably) (**7230**); *Mayflower* (**7231**); *Artemis* (**7232**); *Sunbeam* (possibly) (**7228**)	High
	Un-named wrecks (A3); not identified in geophysical survey	**7234; 7237**	High
	Obstructions (A3); not identified in geophysical survey	**7233; 7235; 7236; 7238**	Medium

Table 6.2: Value of Maritime Heritage Assets		
Asset Type	**Definition**	**Value**
Additional anomalies	Anomalies identified by geophysical assessment that could be of anthropogenic origin totalling 28 (A2), within Moray West	High
Potential wrecks	Wrecks within the ASA that are yet to be discovered.	High
Potential derived maritime finds	Isolated artefacts lost from a boat or ship or moved from a wreck site.	Medium

Two of the documented wrecks comprise of WWI losses by gunfire (**WA7228**; **WA7229**), one being a British loss the other a German submarine loss. Two comprise vessels that sank as a result of collision dating to the 1940s and 70s respectively (**WA7230**; **WA7231**), whilst one grounded due to dense fog in the 1970s (**WA7232**). Although none can be physically located on the seabed, these examples are considered to be of **high** archaeological value due to the importance of their military involvement during the wars.

For all unknown wrecks, there is insufficient data to assess the value of each individual wreck. As such, all wreck sites must be considered to have archaeological value, to a greater or lesser degree and, in accordance with the precautionary approach, must be considered as **high** value assets. Similarly, as the value of potential wrecks cannot be evaluated until they are discovered, potential wrecks of all periods should be expected to be of **high** value.

As there is insufficient information to assess the value of each individual unidentified anomaly identified in the geophysical assessment (A2), all of these additional anomalies must be considered to have **high** archaeological value until more information becomes available.

Derived artefacts are likely to be of limited archaeological value as individual discoveries. However, the occurrence of a number of seemingly isolated objects within a particular area has the potential to indicate shipping routes or maritime battlegrounds, or possibly even indicate the presence of a hitherto unknown wreck site. Isolated maritime finds are, therefore, regarded as being of **medium** archaeological value.

6.4 Seabed Features: Aviation

6.4.1 Value

There is a total of 34 known aircraft crash sites in the ASA, with the possibility that the any of the 28 (A2) geophysical anomalies of uncertain origin of possible archaeological interest located within the ASA could relate to aircraft material. Therefore, there is the potential for aircraft or aircraft-related debris to exist on the seafloor of the ASA and it is still possible to comment on the value of such discoveries.

The values assigned to these heritage assets are outlined in Table 6.3 and refer to aviation remains located across the entire ASA.

Table 6.3: Value of Aviation Heritage Assets		
Asset Type	**Definition**	**Value**
Known assets (A3)	Named aircrafts; not identified in geophysical survey (Total 33)	High
	Unknown aircrafts; not identified in geophysical survey (**NMRS_321470**)	High
Additional anomalies	Anomalies identified by geophysical assessment that could be of anthropogenic origin totalling 28 (A2).	High
Potential aircraft	Aircraft within the ASA that are yet to be discovered.	High
Potential derived aviation finds	Isolated artefacts lost from an aircraft or moved from a crash site.	Medium

Aircraft lost at sea prior to 1939 would be considered of value due to their relative rarity, and the lightweight construction of earlier airframes means that they are less likely to survive in the marine environment unless buried within seabed sediments.

Aircraft lost as a result of military action during WWII would have value associated with that international event, however, the level of conservation of material on the seabed, the rarity of the aircraft type, the potential for the discovery of human remains associated with the aircraft, and a number of other factors, for example those outlined in the BULSI guidance (Build, Use, Loss, Survival and Investigation; Wessex Archaeology 2011a-e), would need to be considered to confirm its value.

Any aircraft lost after WWII will likely have been reported and recorded, and are more likely to represent types that are still known today. Therefore, a special case would likely need to be made for any recent material.

Aircraft are considered to have significance for remembrance and commemoration, but also have an implicit heritage value as historic artefacts, providing information on the aircraft itself and also the circumstances of its use and loss (Historic England 2002: 2). On this basis, all potential aircraft sites are considered to be of **high** value.

It is also conceivable that any of the unidentified geophysical anomalies could be identified as aircraft crash sites, and subsequently are presently considered of **high** archaeological value.

Isolated aircraft finds are considered as being of **medium** archaeological value as they may provide insight into patterns of historical aviation across the ASA or indicate the presence of uncharted aircraft crash sites.

6.5 Intertidal Heritage Assets

6.5.1 Value

The intertidal zone runs along the edge of Sandend Bay, on the Banffshire coast. The inter-tidal zone was likely to have been exploited for subsistence, as well as potentially containing the remains of vessels, boats and other watercraft.

A number of recorded losses have been given positions that place them in or on the edge of the intertidal zone (Annex 16.1D).

There is potential for wreck material from any of the recorded losses to be in the intertidal zone of the proposed landfalls. There is also potential for wreck material from other unknown losses to be present.

6.6 Environmental Assessment and Recommendations

6.6.1 High-level Environmental Assessment

This section presents a high-level review of the identified assets and their sensitivity, used to determine the significance of the effects of the preparation, installation, operation, maintenance and decommissioning elements of the Development. There is no guidance that specifically refers to laying inter-array cables, however, as cable laying is a routine element of offshore wind farm construction, the impact assessment refers to guidance developed for the Offshore Renewable Energy sector (COWRIE 2007, 2008, 2011). The assessment has also been based on professional archaeological judgement and best practice that has been applied to other consented cable routes.

Offshore developments can affect heritage assets in two ways:

- from the direct effect of the physical siting of the project; and
- from indirect changes to the physical marine environment.

Impacts to heritage assets and their historic environment occur as a result of changes to their physical environment in terms of loss and/or degradation, which can subsequently reduce the significance of a heritage asset and its wider historic environment. The management and mitigation of such change is based on the principle that archaeological assets are finite, non-renewable and cannot adapt, tolerate or recover from direct impacts.

Heritage assets may be buried within seabed sediments or may rest upon the seafloor, either with or without height. As such, direct impacts to such assets can occur during any development or related activity that makes contact with the seafloor or cuts through seabed deposits. Heritage assets with height, such as wrecks, may also be impacted by development or activities that occur within the water column.

The implementation of the marine element of the project is anticipated to entail the following sources of ground disturbance:

- Seabed preparation prior to substructure installation and cable laying;
- Survey and clearance of unexploded ordnance (UXO);
- Installation of turbine substructures (options include jacket, gravity base, suction caisson and monopile foundations);
- Placing of scour protection around turbine locations;
- Installation of OSPs;
- Laying of inter-array, inter-connector and export cables (methods include ploughing, jet trenching, dredging, mass flow excavation and / or mechanical trenching);
- Backfilling of cable trenches and protection/stabilisation of surface laid marine cables (options include rock placement, concrete/frond mattresses, or uraduct);
- Scour associated with the disturbances listed above; and
- Seabed contact by legs of jack-up vessels and/or anchors on vessels associated with the installation, maintenance and decommissioning phases of the Development.

The activities listed above may result in impacts that have potential direct and/or indirect effects on marine archaeological heritage assets. The activities and anticipated effects are summarised in Table 6.4.

Table 6.4: Impact Types and Potential Effects on Marine Archaeological Heritage Assets		
Activity	**Anticipated Effects on Archaeological Asset**	**Impact Type**
Seabed preparation	Direct damage/destruction to assets lying on the seafloor and buried within the shallower seabed sediments.	Direct
UXO survey and clearance	Direct damage to assets located within close proximity to UXO	Direct
Installation of turbine foundations and placing of scour protection	Direct damage/destruction to assets lying on the seafloor and buried within the shallower seabed sediments.	Direct
Installation of ancillary infrastructure	Direct damage/destruction to assets lying on the seafloor and buried within the shallower seabed sediments.	Direct
Cable burial whereby seabed is truncated	Direct damage/destruction to assets, and / or their physical setting, lying on the seafloor and buried within the seabed sediments.	Direct
Cable laying on the seabed	Direct damage/destruction to assets lying on the seafloor.	Direct
Installation of cable protection (where burial is not possible)	Direct damage/destruction to assets, and / or their physical setting, lying on the seafloor and buried within the seabed sediments.	Direct
	Potential scour and plume effects resulting in increased protection to, or deterioration of, assets in the vicinity.	Indirect
Seabed contact by legs of jack-up vessels and/or anchors on vessels during installation, scheduled and unplanned maintenance works and decommissioning works.	Localised damage/destruction to assets, and/or their physical setting, lying on the seafloor and buried within the seabed sediments.	Direct
Deployment of large vessels during construction and decommissioning phases	Potential displacement of sediment either affording increased protection to, or deterioration of, assets in the vicinity.	Indirect
Changes to the hydrodynamic and sedimentary regimes due to spoil removal and distribution caused by installation of foundations and trenching operations.	Increased protection to, or deterioration of, assets resulting in a beneficial or adverse effect on assets in the vicinity.	Indirect
Changes to hydrodynamic and sedimentary regimes resulting from the removal of turbines and cables and associated scour	Increased protection to, or deterioration of, assets resulting in a beneficial or adverse effect on marine archaeological assets in the vicinity.	Indirect

Table 6.4: Impact Types and Potential Effects on Marine Archaeological Heritage Assets		
Activity	**Anticipated Effects on Archaeological Asset**	**Impact Type**
protection as part of decommissioning works.		

6.7 Recommendations

There is the potential for the Development to impact as yet unknown heritage assets, including sites relating to seabed prehistory, wreck sites and aircraft remains situated within the ASA.

Mitigation is necessary to reduce, remove or offset the impacts on heritage assets and falls under three main categories: avoidance; reduction of impact; and remedying and offsetting. Prior to the construction of the Development, any further planned archaeological work should be detailed within a Written Scheme of Investigation (WSI). Any changes to the Development design may require additional assessment of geophysical data in the future.

6.7.1 Avoidance

Avoidance is considered to represent the primary option with regards to mitigating impacts upon the marine archaeological resource. This is typically achieved through the implementation of Archaeological Exclusion Zones (AEZs), around known sites prohibiting any development activities to take place within its remit, or through the micro-siting of the project design to avoid vulnerable heritage assets.

In order to implement an avoidance mitigation strategy archaeological review of geophysical data covering 100% of the seabed is required, and best-practice.

A total of 39 anomalies of potential archaeological interest have been identified within the ASA.

Twenty-eight anomalies have been interpreted as A2s – uncertain origin of possible archaeological interest. Although no AEZs are recommended at this time, an avoidance strategy with respect to these anomalies is advised where possible. Further work may be necessary to ascertain the precise nature and archaeological potential of individual features should avoidance prove unfeasible. A protocol for reporting of archaeological discoveries may be implemented in the event of any material of archaeological potential being encountered during cable emplacement. Other similar protocols are already successfully undertaken for the offshore renewables and marine aggregates industries.

Eleven (**WA 7228-7238**) locations have been classed as A3s - historic records of possible archaeological interest with no corresponding geophysical anomaly (as a result of the grid-pattern coverage of the available geophysical survey data, it is likely of these records may be resolved further through review of 100% seabed coverage). Record **7228** is located within Moray West, consisting of a recorded wreck, *(possibly) Sunbeam*. Although the 2010 geophysical survey did not locate its position, it can be assumed to still be exist at the recorded location and therefore, a precautionary AEZ of 100m radius is recommended around the location.

Record **7231** is located within the OfTI and was last located by HMS in 1987, classified as recorded MFV *Mayflower.* As the record is a known and located wreck an AEZ of 100m radius is recommended around the boundary of the field.

For the remaining nine anomalies, no AEZ is recommended as these records either have unreliable position or not identified within recent surveys.

6.7.2 Reduction

Reduction of impact can be achieved by means of receiving prompt archaeological advice in the event of a discovery and by recording and conserving any objects that have been disturbed. In a marine environment, this is often achieved by means of implementing a protocol for reporting finds of archaeological interest. It is recommended that if any objects of possible archaeological interest are recovered during any groundwork operations, that they should be reported using the established Protocol for Archaeological Discoveries: Offshore Renewables Projects (The Crown Estate, 2014). This will establish whether the recovered objects are of archaeological interest and recommend appropriate mitigation measures where necessary.

It is also recommended that when further geophysical survey or geotechnical sampling be undertaken in the area archaeological input into the survey locations, data obtained, and sampling strategy should be considered.

6.7.3 Remedying and Offsetting

Remedying and offsetting could include re-stabilising sites after they have been disturbed or archaeologically recording sites that cannot be preserved.

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8 Annexes

8.1 Annex 16.1A: Legislative, Policy and Guidance

Legislation/Policy	Summary
Global Policy and Legislation	
The World Heritage Convention 1972	The Convention provides for the identification, protection, conservation and presentation of cultural and natural sites of 'outstanding universal value' for inscription on the World Heritage List. The Convention sets out the duties of States Parties in identifying potential sites and their role in protecting and preserving them. By signing the Convention, each country pledges to conserve not only the World Heritage sites situated on its territory, but also to protect its national heritage. The 1972 UNESCO World Heritage Convention was ratified by the UK in 1984 and the UK currently has 29 World Heritage Sites.
The United Nations Convention on the Law of the Sea 1982	UNCLOS 1982 was ratified by the UK in 1997. Article 149 applies only to those archaeological and historical objects that lie outside national jurisdiction and stipulates that 'all objects of an archaeological and historical nature found in the Area shall be preserved or disposed of for the benefit of mankind as a whole, particular regard being paid to the preferential rights of the State or country of origin, or the State of cultural origin, or the State of historical and archaeological origin'. Article 303 stipulates that 'states have the duty to protect objects of an archaeological and historical nature found at sea and shall co-operate for this purpose'. Article 303 also provides for coastal states to exert a degree of control over the archaeological heritage to 24 nm, though the UK has not introduced any measures to implement this right.
International Council of Monuments and Sites Charter on the Protection and Management of Underwater Cultural Heritage 1996 (the Sofia Charter)	The Charter upon which the Annex of the UNESCO Convention is largely based includes a series of statements regarding best practice, intending 'to ensure that all investigations are explicit in their aims, methodology and anticipated results so that the intention of each project is transparent to all'. The UK is a member of the International Council of Monuments and Sites.
UNESCO Convention on the Protection of the Underwater Cultural Heritage (2001)	The UNESCO Convention was concluded in 2001, and is a comprehensive attempt to codify the law internationally with regards to underwater archaeological heritage. The UK abstained in the vote on the final draft of the Convention, however, it has stated that it has adopted the Annex of the Convention, which governs the conduct of archaeological investigations, as best practice for archaeology. Although the UK is not a signatory, the convention entered into force on 2nd January 2009 having been signed or ratified by 20 member states.

Legislation/Policy	Summary
European Policy and Legislation	
The European Convention on the Protection of the Archaeological Heritage (Revised) 1992 (The Valletta Convention)	The Articles of the Valletta Convention tackle various aspects. Article 1 deals with the inventorying and protection of sites and areas; Article 2 deals with the mandatory reporting of chance finds and providing for 'archaeological reserves' on land or underwater; Article 3 promotes high standards for all archaeological work undertaken by suitably qualified people; Article 4 requires the conservation of excavated sites and the safe-keeping of finds; and Article 5 is concerned with consultation that should take place between planning authorities and developers to avoid damage to archaeological remains. The Valletta Convention was ratified by the UK Government in 2000 and came into force in 2001. The convention binds the UK to implement protective measures for the archaeological heritage within the jurisdiction of each party, including sea areas. Insofar as the UK exerts jurisdiction over the Continental Shelf, then it would appear that the provisions of the Valletta Convention apply to that jurisdiction.
The European Landscape Convention 2000	The European Landscape Convention became binding on the UK from 1 March 2007. Its principal clauses require the Government to protect and manage landscapes and to integrate landscape into regional and town planning policies including its cultural, environmental, agricultural, social and economic policies. The Convention applies to the entire territory of the UK and includes land, inland water and marine areas. It is not regarded as applying to sea areas regulated by the UK that lie beyond territorial waters.
European Directives for Environmental Impact Assessments (2014/52/EU)	The EIA Directive entered into force on 15 May 2014 to simplify the rules for assessing the potential effects of projects on the environment. The newly amended directive replaces former directives (85/337/EEC; 97/11/EC; 2003/35/EC; 2009/31/EC; 2011/92/EU) and Member States must apply these from 16 May 2017 at the latest.

Legislation/Policy	Summary
Scottish & UK Legislation and Policy	
Protection of Military Remains Act 1986	Under the Protection of Military Remains Act 1986, all aircraft that have crashed whilst in military service are automatically protected. Maritime vessels (e.g. ships and boats) lost during military service are not automatically protected, although the Ministry of Defence (MoD) has powers to protect any vessel that was in military service when lost. The MoD can designate wrecks whose position is known as 'controlled sites' and can designate named vessels whose location is unknown 'protected places'. It is not necessary to demonstrate the presence of human remains for wrecks to be designated as either 'controlled sites' or 'protected places'.
Merchant Shipping Act 1995	This Act sets out the procedures for determining the ownership of underwater finds classified as 'wreck'; defined as any flotsam, jetsam, derelict and lagan found in or on the shores of the sea or any tidal water. It includes ship, aircraft, hovercraft, parts of these, their cargo or equipment. If any such finds are brought ashore, the salvor is required to give notice to the Receiver of Wreck that he/she has found or taken possession of them and, as directed by the Receiver, either hold them pending the Receiver's order or deliver them to the Receiver. The Act is administered by the Maritime and Coastguard Agency. Beyond the 12 nm limit, the Merchant Shipping Act 1995 covers wreck found or taken into possession outside UK waters, and stipulates that if brought into UK waters, finds must be reported to the Receiver of Wreck. The provisions of the Protection of Military Remains Act 1986 regarding Controlled Sites are applicable in international waters, though they are only enforceable with respect to British-controlled ships, British citizens and British companies.
Ancient Monuments and Archaeological Areas Act 1979 (as amended)	This provides legal protection for heritage assets of national importance, AMAA 1979 primarily deals with terrestrial sites but there is provision to designate sites in territorial waters as Scheduled Monuments.
Marine (Scotland) Act 2010	This provides for the establishment of national and regional marine plans (see Scotland's Marine Plan below) and for offshore sites of national importance to be designated as Historic Marine Protected Areas.
Historic Environment Scotland Act 2014	Sets out guidance for the implementation of SPP 2014 in relation to the Historic Environment.
Historic Environment Scotland Policy Statement (HESPS) 2016	This sets out Scottish Ministers' policies, providing direction for HES and a policy framework that informs the work of a wide range of public sector organisations.
Scottish Planning Policy 2014	Outlines planning policy in relation to heritage assets, their setting and their protection.

Legislation/Policy	Summary
Scotland's Marine Plan 2016	This includes statements on mitigation of offshore development on cultural heritage as well as an "Interaction Matrix" (Section 10.5 and 10.6) which describes the degree of interaction between developments and receptors. Historic assets are considered to have a high degree of interaction with dredging, shipping and renewables construction among others.
UK Marine Policy Statement 2011	The Marine Policy Statement was jointly published by all UK Administrations in March 2011 as part of a new system of marine planning being introduced across UK seas.

Guidance	Summary
Standard and guidance for historic environment desk-based assessment (Chartered Institute for Archaeologists 2014)	This guidance seeks to define good practice for the execution and reporting of desk-based assessment, in line with the by-laws of the Chartered Institute for Archaeologists. The standard and guidance was formally adopted as approved practice at the Annual General Meeting of the Institute held on 14 October 1994. This revision recognises the new Chartered status of the Institute.
Code of Practice for Seabed Developers, Joint Nautical Archaeology Policy Committee (Joint Nautical Archaeology Policy Committee 2006)	This voluntary Code provides a framework for seabed developers similar to the principles found in current policy and practice on land. The aim of the Code is to ensure a best practice model for seabed development. The Code offers guidance to developers on issues such as risk management and legislative implications.
COWRIE Historic Environment Guidance for the Offshore Renewable Energy Sector (2007);	Guidance on mitigation and protection for the historic environment in relation to Offshore Renewable Development.
COWRIE Guidance for Assessment of Cumulative Impacts on the Historic Environment from Offshore Renewable Energy (2008);	Guidance on mitigation and cumulative impacts on the historic environment in relation to Offshore Renewable Development.

Guidance	Summary
Historic Environment Scotland (2016) Managing Change in the Historic Environment –Setting;	Statement on managing setting in relation to development and the historic environment.

8.2 Annex 16.1B: Terminology

The terminology used in this assessment follows definitions contained within the UK's National Planning Policy Framework (Department for Communities and Local Government, 2012: 50-57):

Glossary of Terms	
Term	**Definition**
Archaeological interest	There will be archaeological interest in a heritage asset if it holds, or potentially may hold, evidence of past human activity worthy of expert investigation at some point. Heritage assets with archaeological interest are the primary source of evidence about the substance and evolution of places, and of the people and cultures that made them.
Conservation (for heritage policy)	The process of maintaining and managing change to a heritage asset in a way that sustains and, where appropriate, enhances its significance.
Designated heritage asset	A World Heritage Site, Scheduled Monument, Listed Building, Protected Wreck Site, Registered Park and Garden, Registered Battlefield or Conservation Area designated under the relevant legislation.
Development Plan	This includes adopted Local Plans, neighbourhood plans and the London Plan, and is defined in section 38 of the Planning and Compulsory Purchase Act 2004.
Environmental Impact Assessment	A procedure to be followed for certain types of projects to ensure that decisions are made in full knowledge of any likely significant effects on the environment.

Glossary of Terms	
Term	**Definition**
Heritage asset	A building, monument, site, place, area or landscape identified as having a degree of significance meriting consideration in planning decisions, because of its heritage interest. Heritage asset includes designated heritage assets and assets identified by the local planning authority (including local listing).
Heritage coast	Areas of undeveloped coastline which are managed to conserve their natural beauty and, where appropriate, to improve accessibility for visitors.
Historic environment	All aspects of the environment resulting from the interaction between people and places through time, including all surviving physical remains of past human activity, whether visible, buried or submerged, and landscaped and planted or managed flora.
Historic environment record	Information services that seek to provide access to comprehensive and dynamic resources relating to the historic environment of a defined geographic area for public benefit and use.
Setting of a heritage asset	The surroundings in which a heritage asset is experienced. Its extent is not fixed and may change as the asset and its surroundings evolve. Elements of a setting may make a positive or negative contribution to the significance of an asset, may affect the ability to appreciate that significance or may be neutral.
Significance (for heritage policy)	The value of a heritage asset to this and future generations because of its heritage interest. That interest may be archaeological, architectural, artistic or historic. Significance derives not only from a heritage asset's physical presence, but also from its setting.

8.3 Annex 16.1C: Chronology

Where referred to in the text, the main archaeological periods in Scotland are broadly defined by the following date ranges[2]:

Chronology		
Period		**Date Range**
Early Prehistory	Late Upper Palaeolithic	c. 14,700 - 11,600 BP
	Mesolithic	8500 - 4100 BC
Later Prehistory	Neolithic	4100 - 2500 BC
	Chalcolithic & Bronze Age	2500 – 800 BC
	Iron Age	800 BC – AD 400
Roman		AD 77 - 211
Medieval		400 - 1500
Post-medieval		1500 - 1800
19th century		1800 - 1899
Modern		1900 – present day

[2] Based on http://www.scottishheritagehub.com/node/1203 (accessed 12/12/2017).

8.4 Annex 16.1C: Seabed Anomalies of Archaeological Potential

Archaeological Potential										
WA ID	**Classification**	**Easting**	**Northing**	**Archaeological Discrimination**	**Length (m)**	**Width (m)**	**Height (m)**	**Magnetic Amplitude (nT)**	**Description**	**External References**
7200	Dark reflector	505258	6447954	A2	5	4.4	1	-	A medium sized distinct dark reflector with a bright shadow located on a gravelly area of the seabed. This anomaly is visible in the bathymetry data as a medium sized distinctive mound located on an otherwise featureless area of the seabed. This could be natural or a piece of debris	
7201	Debris	508203	6447687	A2	29	2.6	0	-	A right angled linear dark reflector with no shadow. This large debris feature that appears to be anthropogenic in origin and is located on a rough and uneven area of the seabed	
7202	Debris	509191	6444173	A2	5	5	0.4	-	A possible piece of debris, a medium sized broken up or possibly partially buried dark reflector with height. One part of the anomaly appears to be 'v' shaped	
7203	Dark reflector	506639	6441688	A2	8.3	7.4	0	-	A large and rounded dark reflector, the anomaly is very indistinct in the data. This may be natural or a piece of debris	

Archaeological Potential										
WA ID	**Classification**	**Easting**	**Northing**	**Archaeological Discrimination**	**Length (m)**	**Width (m)**	**Height (m)**	**Magnetic Amplitude (nT)**	**Description**	**External References**
7204	Debris	507617	6442709	A2	5	3.8	1.3	-	A distinct curvilinear shaped dark reflector with a very bright and rounded shadow. This anomaly is visible in the bathymetry data as a medium sized mound with a slightly pointed tip and situated in a depression. Possibly a medium sized piece of debris	
7205	Dark reflector	499910	6441120	A2	5.7	0.8	0	-	A medium sized, slightly curvilinear dark reflector with no shadow but in a slight depression. This could be natural or a piece of debris	
7206	Dark reflector	499907	6441129	A2	4.8	1.3	0.5	-	An irregularly shaped dark reflector with an indistinct shadow, possibly situated in a slight depression. This could be natural or a piece of debris	
7207	Dark reflector	505792	6446915	A2	6.5	3.1	0.6	-	A thick and curvilinear shaped dark reflector with a dull shadow. This is a medium sized and distinct feature, isolated on a sandy area of the seabed. This could be natural or a piece of debris	

Archaeological Potential										
WA ID	**Classification**	**Easting**	**Northing**	**Archaeological Discrimination**	**Length (m)**	**Width (m)**	**Height (m)**	**Magnetic Amplitude (nT)**	**Description**	**External References**
7208	Debris	500596	6439995	A2	7.8	5.5	1	-	A distinct half-moon shaped dark reflector with a bright and tapered shadow, this is an isolated feature. The debris is visible in the bathymetry data as a medium sized oval mound, possibly situated in a slight depression	
7209	Dark reflector	507578	6446910	A2	2.9	0.9	0.6	-	A medium sized distinct dark reflector with a bright shadow, looks anomalous to the surrounding seabed	
7210	Dark reflector	507580	6446918	A2	4.3	0.9	0.6	-	A medium sized dark reflector with a bright shadow that may have some sediment build up around it	
7211	Debris	494350	6432910	A2	3.5	1.1	1	-	A medium sized dark reflector with a small but bright shadow, the anomaly possibly has an internal depression. There is scouring orientated south-west and measuring 25 m associated, possibly debris	
7212	Debris	494294	6432843	A2	4.3	3.3	0.5	-	A medium sized dark reflector with a small internal shadow or depression. A rounded anomaly, distinct possible piece of debris	

Archaeological Potential										
WA ID	**Classification**	**Easting**	**Northing**	**Archaeological Discrimination**	**Length (m)**	**Width (m)**	**Height (m)**	**Magnetic Amplitude (nT)**	**Description**	**External References**
7213	Debris	495284	6432861	A2	6.8	5	1.2	-	A medium sized, rounded dark reflector with a bright and tapered shadow. This is visible in the bathymetry data as a medium sized pointed mound on an otherwise featureless area of the seabed. Possible piece of debris	
7214	Dark reflector	508122	6445682	A2	2.2	1	1.1	-	A small and rounded dark reflector with a very bright shadow, could be natural or a piece of debris	
7215	Dark reflector	508456	6444467	A2	4.1	3	0.5	-	A slightly linear and thick dark reflector with a large shadow. This anomaly is located on the edge of a sandwave and is an isolated and distinct feature which could be natural or a piece of debris	
7216	Rope/chain	492029	6438073	A2	28.9	2.4	0	-	A long and thick linear dark reflector with no shadow. This anomaly appears to be anthropogenic in origin and is possibly a rope or chain	
7217	Seafloor disturbance	505218	6436609	A2	24.4	4.3	0.5	-	A large area of possible disturbed seabed comprising a group of small indistinct dark reflectors with height. The anomaly is a long thick linear shape and is located on an otherwise sandy and even area of the seabed	

Archaeological Potential										
WA ID	**Classification**	**Easting**	**Northing**	**Archaeological Discrimination**	**Length (m)**	**Width (m)**	**Height (m)**	**Magnetic Amplitude (nT)**	**Description**	**External References**
7218	Magnetic	495733	6439162	A2	-	-	-	230	Large negative monopole identified on more than one survey line. Indicative of possible buried ferrous debris	
7219	Magnetic	503730	6439599	A2	-	-	-	9	Small asymmetric dipole. Indicative of possible buried ferrous debris	
7220	Magnetic	501075	6445052	A2	-	-	-	5	Small dipole. Indicative of possible buried ferrous debris	
7221	Magnetic	505110	6448078	A2	-	-	-	31	Small asymmetric dipole. Indicative of possible buried ferrous debris	
7222	Magnetic	505642	6441562	A2	-	-	-	5	Small dipole. Indicative of possible buried ferrous debris	
7223	Magnetic	507148	6444756	A2	-	-	-	24	Small asymmetric dipole. Indicative of possible buried ferrous debris	
7224	Magnetic	503206	6443376	A2	-	-	-	7	Small asymmetric dipole. Indicative of possible buried ferrous debris	
7225	Magnetic	506914	6451286	A2	-	-	-	12	Small asymmetric dipole. Indicative of possible buried ferrous debris	

Archaeological Potential										
WA ID	**Classification**	**Easting**	**Northing**	**Archaeological Discrimination**	**Length (m)**	**Width (m)**	**Height (m)**	**Magnetic Amplitude (nT)**	**Description**	**External References**
7226	Debris	505881	6447799	A2	7	6	0.8	-	A slightly oval shaped dark reflector with a bright and tapered shadow. This is a very distinct anomaly and possible piece of debris. In the bathymetry data this is visible as a large pointed mound located 38 m to the south-west of a similar feature 7227	
7227	Debris	505907	6447827	A2	6.3	4	0.5	-	A medium sized slightly square shaped dark reflector with a bright but small shadow. This is a distinct possible piece of debris situated on a sandy area of the seabed. In the bathymetry data this is visible as a medium sized, oval shaped mound located 38 m north-west of 7226	

Archaeological Potential										
WA ID	**Classification**	**Easting**	**Northing**	**Archaeological Discrimination**	**Length (m)**	**Width (m)**	**Height (m)**	**Magnetic Amplitude (nT)**	**Description**	**External References**
7228	Recorded Wreck	496704	6439032	A3	-	-	-	-	UKHO record of the *Sunbeam* (Possibly), a wooden sailing vessel with original dimensions of 30.4 m x 7 m x 3.4 m built in 1878 by Massey, Portreath, Cornwall. The vessel was captured by submarine and sunk by gunfire in 1915. The wreck is recorded as being highly degraded, it was identified in sidescan sonar data in 2008 with dimensions of 25 m 20 m x 2.7 m and also in magnetometer data. This location is not covered by the 2010 geophysical survey data.	897 (UKHO); 321471 (CANMORE)

Archaeological Potential										
WA ID	**Classification**	**Easting**	**Northing**	**Archaeological Discrimination**	**Length (m)**	**Width (m)**	**Height (m)**	**Magnetic Amplitude (nT)**	**Description**	**External References**
7229	Recorded Submarine	499908.59	6428674.2	A3	-	-	-	-	Recorded by UKHO as a wreck of a German WWI UE-class minelaying submarine, identified as *U77*. It sank by gunfire from an unamed British ship on 7th July 1916 after having left Heligoland on 5th July 1916 to lay mines off Kinnaird Head, but did not return or send any reports. In 1988 no wreck was located within 1 mile to the north of the original position. It is believed that the wreck was first located in 1990; 'The wreck lies with a bow up attitude, her stern section of her deck gun completely buried in deep mud...The port side of the wreck is intact, but the plating on the starboard side has fallen away, the conning tower unrecognisable, although to periscoped project upwards from amongst the debris. Her forward hatch is closed.' (Larn & Larn 1998).	894 (UKHO); 321469 (CANMORE)

Archaeological Potential										
WA ID	**Classification**	**Easting**	**Northing**	**Archaeological Discrimination**	**Length (m)**	**Width (m)**	**Height (m)**	**Magnetic Amplitude (nT)**	**Description**	**External References**
7230	Recorded Craft (Possible) Steamship	512946.14	6402719.7	A3	-	-	-	-	Recorded by UKHO in 1986 as a possible wreckage at Portsoy, *Moray Firth* (probably). The wreck is considered to be non-dangerous consisting of a British steam ship which sank on 28th of March 1943 following a collision. It was built at Firth Shipping Co. Ltd.	2157 (UKHO); 101718 (CANMORE)
7231	Recorded Motor Fishing Vessel	505895.45	6410247.8	A3	-	-	-	-	Recorded by UKHO as a the wreck of a wooden hulled fishing vessel, identified as *Mayflower*, which sank on the 1st of February 1973 following a collision with MFV Devotion II. The wreck is considered to be non-dangerous and situated at a general depth of 81 m. It was last located in 1986.	2159 (UKHO); 321882 (CANMORE)
7232	Recorded Motor Fishing Vessel	509842.6	6394826.4	A3	-	-	-	-	Recorded by UKHO consisting of a wreck with potion of hull or superstructure of a motor fishing vessel, identified as *Artemis*. It sunk on 2nd of September 1974 whilst on passage for the Isle of Man. It grounded in dense fog and reported as having been pounded. In 1940 it sustaining damage to keel and stern as it listed to starboard. In 1987 no wreck was found at original position.	2151 (UKHO); 321881 (CANMORE)

Archaeological Potential										
WA ID	**Classification**	**Easting**	**Northing**	**Archaeological Discrimination**	**Length (m)**	**Width (m)**	**Height (m)**	**Magnetic Amplitude (nT)**	**Description**	**External References**
7233	Recorded Obstruction	495817.21	6425583.5	A3	-	-	-	-	Recorded by UKHO in 1987 in the Moray Firth, possibly consisting of fishing gear and situated at a general depth of 54 m.	2118 (UKHO); 101774 (CANMORE)
7234	Recorded Aircraft (Possible)	498922.55	6428674.6	A3	-	-	-	-	Recorded by UKHO in 1965 as a non-dangerous wreck. Thought to be the wreck of a ditched Day Jet aircraft. In 1987 wreck was not located and the following year no wreck was found within 1 mile to the north of the original position.	895 (UKHO); 321470 (CANMORE)
7235	Recorded Obstruction	504335.3	6418842.2	A3	-	-	-	-	Recorded by UKHO in 1986 as a possible wreckage situated at a general depth of 90 m in the Moray Firth. Considered to be non-dangerous.	2195 (UKHO); 101806 (CANMORE)
7236	Recorded Obstruction	507919.38	6403975.5	A3	-	-	-	-	Recorded by UKHO in 1986 as a possible wreckage in the North Sea. Considered to be a dangerous wreck situated at a general depth of 30 m.	2204 (UKHO); 101717 (CANMORE)
7237	Recorded Obstruction (Steamship)	511827.38	6395388.7	A3	-	-	-	-	Recorded by UKHO in 1981 as the wreck of an old steamship located about 1 mile north-east of Cullen. Two large boilers were found in a depth of 26 m. Classed as dead.	2172 (UKHO); 101789 (CANMORE)

Archaeological Potential										
WA ID	**Classification**	**Easting**	**Northing**	**Archaeological Discrimination**	**Length (m)**	**Width (m)**	**Height (m)**	**Magnetic Amplitude (nT)**	**Description**	**External References**
7238	Recorded Obstruction	513641.92	6401856.9	A3	-	-	-	-	Recorded by UKHO in 1986 as a possible wreckage at Moray Firth. Searched for in 1987 but not found.	2205 (UKHO); 101815 (CANMORE)

8.5 Annex 16.1D: Recorded Losses – Shipwrecks

Recorded Losses - Shipwrecks					
ID	**Name**	**Type**	**Period**	**Year Lost**	**Description**
NMRS_327066	Unknown	Craft (Possible)	Post-medieval	1648	-
NMRS_310937	*Thomas and Anne*	Craft	Post-medieval	1724	Wrecked near Portsoy.
NMRS_326862	*Isobel*	Craft	Post-medieval	1728	-
NMRS_310248	*St Nicholas*	Craft	Post-medieval	1728	Registration: Swedish. Stranded at Portnockie.
NMRS_327789	Unknown	Fishing Vessel	Post-medieval	1734	-
NMRS_310648	Unknown	Craft	Post-medieval	1739	Wrecked at the entrace to Portsoy Harbour.
NMRS_310236	Unkown	Craft	Post-medieval	1739	Registration: Danish. Wrecked on Cullen Sands, 2 miles north west of Portsoy.
NMRS_329225	Unknown	Craft (Possible)	Post-medieval	1739	Registration: Danish. Wrecked on Cullen Sands, 2 miles north west of Portsoy.

Recorded Losses - Shipwrecks					
ID	**Name**	**Type**	**Period**	**Year Lost**	**Description**
NMRS_310235	Unkown	Sloop	Post-medieval	1739	Wrecked on Cullen Sands.
NMRS_329226	Unknown	Sloop	Post-medieval	1740	Wrecked on Cullen Sands.
NMRS_310918	Unknown	Craft	Post-medieval	1755	Registration: Elgin. Built 1827. Wrecked outside Portsoy Harbour.
NMRS_328944	Unknown	Craft (Possible)	Post-medieval	1755	Wrecked outside Portsoy Harbour.
NMRS_310919	*Vernon*	Craft	Post-medieval	1760	Wrecked near Portsoy.
NMRS_310961	*William and Peggy*	Craft	Post-medieval	1764	Stranded near Portsoy.
NMRS_310930	*Friendship*	Craft	Post-medieval	1765	Stranded at Sandend.
NMRS_310960	*Brothers and Sisters*	Craft	Post-medieval	1768	Stranded at Portsoy.
NMRS_329560	Unknown	Fishing Vessel	Post-medieval	1768	-
NMRS_310920	*Experiment*	Craft	Post-medieval	1780	Hit rocks at Portsoy and sank.
NMRS_328480	Unknown	Sloop	Post-medieval	1785	-
NMRS_328481	Unknown	Sloop	Post-medieval	1785	-
NMRS_326202	Unknown	BUSS	Post-medieval	1789	-
NMRS_310234	*Earl of Findlater and Seafield*	Craft	Post-medieval	1790	Hit a rock off Cullen and sank.
NMRS_310605	*Elizabeth*	Craft	Post-medieval	Unknown	-
NMRS_329101	Unknown	Brig	19th Century	1817	-
NMRS_208731	*Agenoria*	Schooner	19th Century	1818	Built in 1814, registed in Portsoy.
NMRS_310250	Unknown	Craft	19th Century	1819	Stranded at Portnockie.
NMRS_327079	Unknown	Craft (Possible)	19th Century	1819	-
NMRS_310251	Unknown	Craft	19th Century	1821	Wrecked at Portnockie.

Recorded Losses - Shipwrecks					
ID	**Name**	**Type**	**Period**	**Year Lost**	**Description**
NMRS_327873	Unknown	Fishing Vessel	19th Century	1821	-
NMRS_208755	*Elizabeth's Success*	Schooner	19th Century	1825	Registration: Stromness.
NMRS_208804	*Jean*	Brig	19th Century	1826	Stern of the vessel came on shore at Cullen. Thought to have been wrecked 0.25 miles west of the Marchioness of Huntly, opposite Whitehills, although unconfirmed.
NMRS_310578	Unknown	Craft	19th Century	1829	Wrecked at Portnockie.
NMRS_327083	Unknown	Craft (Possible)	19th Century	1829	-
NMRS_272542	*Thistle*	Schooner	19th Century	1831	Registration: Arbroath. Built 1824. Wrecked at Portnockie Head.
NMRS_272801	*Thomas and Eleanor*	Craft	19th Century	1832	Possibly recovered.
NMRS_310972	*Fancy*	Schooner	19th Century	1833	Registration: Spey[mouth]. Built 1833. Wrecked at the back of the New Pier, Portsoy.
NMRS_328410	Unknown	Fishing Vessel	19th Century	1835	Swamped off Sandend.
NMRS_328412	Unknown	Fishing Vessel	19th Century	1835	Lost in Cullen Bay.
NMRS_310927	*Helen*	Schooner	19th Century	1835	Stranded at Sandend.
NMRS_208912	*Isabella*	Sloop	19th Century	1835	Vessel stranded 2 miles west of Portsoy.
NMRS_272760	*Duchess of Gordon*	Craft	19th Century	1836	Sustained damage in Finfochty Harbour.
NMRS_328407	Unknown	Fishing Vessel	19th Century	1836	-
NMRS_274517	*Mary*	Brig	19th Century	1837	Built in 1814, registered at Peterhead. Location of wrecksite unconfirmed.
NMRS_208932	*Alexander*	Sloop	19th Century	1837	Built in 1827, registered in Inversess. Location of wrecksite unconfirmed.

Recorded Losses - Shipwrecks					
ID	**Name**	**Type**	**Period**	**Year Lost**	**Description**
NMRS_259717	*James and William*	Smack	19th Century	1839	Registration: Elgin. Built 1827. Driven on shore near Portsoy harbour during a gale.
NMRS_310817	*Margaret*	Craft (Possible)	19th Century	1843	Location of wrecksite unconfirmed.
NMRS_282884	*Barbara*	Schooner	19th Century	1852	Registration: Banff. Built 1844. Sank during a heavy gale in the outer harbour of Portsoy.
NMRS_248224	*Lyra*	Schooner	19th Century	1852	Registration: Liverpool. Built 1832. Wrecked 0.5 miles east of Banff.
NMRS_249858	*Elizabeth*	Sloop	19th Century	1854	Registration: Spey. Built 1847. Stranded and broken up in Cullen Bay.
NMRS_297178	*Onward*	Craft	19th Century	1861	Wrecked on the rocks between Port Gordon and Banff during a hurricane.
NMRS_286745	*Frolic*	Sloop	19th Century	1863	Struck on the point of the pier whilst entering the latter harbour at Portsoy.
NMRS_310926	Unknown	Craft	19th Century	1864	Stranded at Sandend.
NMRS_327089	Unknown	Craft (Possible)	19th Century	1864	Prussian
NMRS_209303	*Walter Frederick*	Sloop	19th Century	1865	Registration: Glasgow. Built 1833. Wrecked in Cullen Bay.
NMRS_285469	*Equity*	Craft	19th Century	1866	Wrecked at the back of Portsoy pier.
NMRS_273982	*Scotia*	Schooner	19th Century	1866	Registration: Banff. Built 1854. Driven on shore and wrecked at Portsoy Harbour.
NMRS_327288	*Heckler*	Sloop	19th Century	1866	-
NMRS_297756	*Heckler*	Smack	19th Century	1866	Possibly recovered.
NMRS_285477	*Ann Gibson*	Schooner	19th Century	1867	Registration: Berwick. Built 1839. Went ashore in Sandend Bay, 8 miles to the west of Kepock Ferry during a violent gale.

Recorded Losses - Shipwrecks					
ID	**Name**	**Type**	**Period**	**Year Lost**	**Description**
NMRS_310547	*Belhaven*	Schooner	19th Century	1871	Registration: Banff. Built 1862. Wrecked on Downy Rock (Donnie Point).
NMRS_262645	*Paul*	Schooner	19th Century	1873	Possibly recovered.
NMRS_209468	*Moray*	Steamship	19th Century	1873	Steel steamship, built in 1889, registered at Inverness. Vessel foundered, supposedly off Portsoy, maybe Garron Head, 12 dead.
NMRS_265165	Unknown	Craft	19th Century	1874	-
NMRS_256692	*Town of Liverpool*	Sloop	19th Century	1875	Stranded at Strathline.
NMRS_256571	*Freedom*	Smack	19th Century	1875	Registration: Banff. Built 1868. Wrecked at Cullen.
NMRS_209344	*Maria*	Galliot	19th Century	1877	Built in 1857, registered in Germany. Wrecked upon entering the harbour.
NMRS_328386	*Concordant (BF 879)*	Lugger	19th Century	1881	-
NMRS_209376	*Mediateur*	Schooner	19th Century	1883	Built in 1867, registered in Inverness. The vessel struck the rocks at Scarnose and was wrecked, with all its cargo lost, some ropes and sails saved. Location of wrecksite unconfirmed.
NMRS_209389	*Amiability*	Lugger	19th Century	1885	Registration: Portessie. Stranded at the entrance to Cullen Harbour.
NMRS_209408	*Meliora*	Smack	19th Century	1887	Registration: Stornoway. Built 1866. Stranded near Cullen.
NMRS_209416	*Whim*	Ketch	19th Century	1888	Registration: Sunderland. Built 1845. Stranded at Cullen.
NMRS_252183	*Fair Chance*	Lugger	19th Century	1890	Regiastration: Buckie. Built 1874. Was in a collision and sank approximaely 5 miles east north east of Buckie.

Recorded Losses - Shipwrecks					
ID	**Name**	**Type**	**Period**	**Year Lost**	**Description**
NMRS_310967	*Sweet Home*	Lugger	19th Century	1892	Burnt while lying at Portsoy Harbour.
NMRS_251780	*Wargrien*	Schooner	19th Century	1892	Registration: Danish. Built 1852. Wrecked in Cullen Harbour.
NMRS_209479	*Lillie*	Lugger	19th Century	1893	Built in 1893, registered at Sandend. Driven from moorings and stranded at Sandend.
NMRS_209475	*Active*	Lugger	19th Century	1893	Registration: Portnockie. Built 1888. Driven from moorings and stranded at Portnockie.
NMRS_251591	*Maggies*	Lugger	19th Century	1893	Registration: Sandend. Built 1889. Driven from moorings and stranded at Sandend.
NMRS_209495	*Daisy*	Lugger	19th Century	1894	Registration: Sandend. Built 1890. Vessel foundered at Portsoy
NMRS_251335	*Bee*	Lugger	19th Century	1894	Registration: Portsoy. Built 1872. Stranded at Portsoy.
NMRS_251344	*Jolly Boys*	Lugger	19th Century	1894	Registration: Portsoy. Built 1887. Stranded at Portsoy.
NMRS_209485	*Jane Shearer*	Schooner	19th Century	1894	Registration: Banff. Built 1865. Stranded near the entrance to Cullen Harbour.
NMRS_209499	*James Clay*	Ketch	19th Century	1895	Registration: Scarborough. Built 1865. Stranded near the entrance to Portnockie Harbour.
NMRS_209503	*Polly*	Lugger	19th Century	1895	Registration: Portnockie.
NMRS_209504	*Gem*	Schooner	19th Century	1895	Registration: Inverness. Built 1860. Stranded near Cullen.
NMRS_209527	*Margaret*	Lugger	19th Century	1897	Registration: Janstown. Built 1883.
NMRS_209542	*Ellen*	Lugger	19th Century	1897	Built 1820. Was in a collision and sank while moored at Findochty.
NMRS_209536	*Thames*	Schooner	19th Century	1897	Registration: Ipswich. Built 1829. Stranded near Logie Head, Banff.

Recorded Losses - Shipwrecks					
ID	**Name**	**Type**	**Period**	**Year Lost**	**Description**
NMRS_310602	*Stephens*	Craft	19th Century	Unknown	-
NMRS_310604	Unknown	Craft	19th Century	Unknown	-
NMRS_208777	*Janet*	Craft	19th Century	Unknown	-
NMRS_208849	*Margaret*	Craft	19th Century	Unknown	-
NMRS_308938	*Meanwell*	Craft	19th Century	Unknown	-
NMRS_308974	Unknown	Craft	19th Century	Unknown	-
NMRS_310603	*Concordant*	Lugger	19th Century	Unknown	-
NMRS_209444	*Dianas*	Lugger	19th Century	Unknown	It remains unclear whether the vessel stranded within the Old Harbour or the New Harbour at Portsoy.
NMRS_248110	*Ocean Queen*	Schooner	19th Century	Unknown	-
NMRS_298308	*St Kilda*	Sloop	19th Century	Unknown	-
NMRS_308910	*Royal Burgh*	Smack	19th Century	Unknown	-
NMRS_308940	Unknown	Yawl	19th Century	Unknown	-
NMRS_209580	*Isa Ann Sutherland*	Lugger	Modern	1901	Classified as wooden zulu. Registration: Portnockie. Built 1885. Standed near Portnockie.
NMRS_209589	*Tempus Fugit*	Ketch	Modern	1903	Registration: Banff. Built 1877. Stranded near the entrance to Portnockie Harbour.
NMRS_209601	*Venus Star*	Lugger	Modern	1903	Built 1883. Foundered after being driven to sea from Portnockie.
NMRS_209598	*Maria*	Schooner	Modern	1903	Registration: German. Built 1877. Stranded on the east side of Sandend Bay, Banff.

Recorded Losses - Shipwrecks					
ID	**Name**	**Type**	**Period**	**Year Lost**	**Description**
NMRS_209609	*James and Annie*	Lugger	Modern	1905	Registration: Findochty. Built 1881. Was in a collision and sank 2 miles north east of Findochty.
NMRS_209610	*Ephratah*	Lugger	Modern	1905	Built 1901. Stranded near the entrance to Portnockie Harbour.
NMRS_207477	*Mie*	Steam Trawler	Modern	1909	Built in 1897, registered in Belgium.
NMRS_310550	Unknown	Craft(s)	Modern	1926	5 fishing boats were wrecked at Portnockie. Three were on shore.
NMRS_328348	Unknown	Craft (Possible)	Modern	1937	-
NMRS_310233	*Janet Watson*	Lugger	Modern	1937	Registration: Findochty. Built 1899. Crushed and wrecked in Cullen Harbour.
NMRS_310573	*Utility*	Motor Fishing Vessel	Modern	1938	Caught fire in Portnockie Harbour.
NMRS_310579	*Sickle*	Craft	Modern	1941	Capsized at the entrance to Portnockie Harbour, presumed to have been removed.
NMRS_309555	*Sheldon*	Steam Trawler	Modern	1942	Registration: Grimsby. Built 1912. Standed on the landward side of Craigenroan Rock.
NMRS_209759	*Moray Firth*	Steamship	Modern	1943	Registration: Newcastle. Built 1927. Was in a collision and sank.
NMRS_194110	*Artemis*	Trawler	Modern	1974	Motor trawler which wrecked on the rocks to the east of Cullen.
NMRS_308957	*Cedron*	Auxiliary Lugger	Modern	Unknown	-
NMRS_308973	*Racer*	Auxiliary Lugger	Modern	Unknown	-
NMRS_310934	*Sovereign*	Auxiliary Lugger	Modern	Unknown	Registration: Whitehills. Lost at sea, gear found at Sandend.
NMRS_308969	*Better Hope*	Craft	Modern	Unknown	-
NMRS_309269	*Misty Isle*	Craft	Modern	Unknown	-

Recorded Losses - Shipwrecks					
ID	**Name**	**Type**	**Period**	**Year Lost**	**Description**
NMRS_310853	*Paragon*	Ketch	Modern	Unknown	Wooden sloop built in 1863, resistered in Banff. Location of wrecksite unconfirmed.
NMRS_310590	*Margaret*	Lugger	Modern	Unknown	-
NMRS_310881	*Fidelity*	Motor Fishing Vessel	Modern	Unknown	-
NMRS_222141	*Sunbeam*	Schooner	Modern	Unknown	-
NMRS_308972	*May Queen*	Steam Drifter	Modern	Unknown	-
NMRS_209709	*Norseman*	Steam Trawler	Modern	Unknown	-
NMRS_222098	*Marguerite*	Steam Trawler	Modern	Unknown	-
NMRS_310591	*Borderglen*	Steamship	Modern	Unknown	-
NMRS_325326	*A/C*	Craft (Possible)	Unknown	Unknown	-
NMRS_325327	*A/C*	Craft (Possible)	Unknown	Unknown	-
NMRS_328607	*Montgomery*	Privateer	Unknown	Unknown	-
NMRS_202206	Unknown	Craft	Unknown	Unknown	-
NMRS_325148	Unknown	Obstruction	Unknown	Unknown	-

8.6 Annex 16.1E: Recorded Losses – Aircraft

Recorded Losses - Aircraft						
ID	**Name**	**Location**	**Type**	**Period**	**Year Lost**	**Description**
NMRS_308861	Fairey Barracuda II	North Sea	Aircraft	20th Century	-	
NMRS_308864	Fairey Barracuda II	North Sea	Aircraft	20th Century	-	
NMRS_308872	Fairey Barracuda II	Moray Firth	Aircraft	20th Century	-	
NMRS_308874	Fairey Barracuda II	North Sea	Aircraft	20th Century	-	
NMRS_308876	Fairey Barracuda II	Moray Firth	Aircraft	20th Century	-	
NMRS_308877	Fairey Barracuda II	Moray Firth	Aircraft	20th Century	-	
NMRS_308878	Fairey Barracuda II	Moray Firth	Aircraft	20th Century	-	
NMRS_308896	Fairey Swordfish II	Moray Firth	Aircraft	20th Century	-	
NMRS_308902	Fairey Barracuda II	Moray Firth	Aircraft	20th Century	-	
NMRS_308903	Fairey Swordfish II	Moray Firth	Aircraft	20th Century	-	
NMRS_308906	Hawker Osprey I	Moray Firth	Aircraft	20th Century	-	
NMRS_308909	Hawker Osprey IV	Moray Firth	Aircraft	20th Century	-	
NMRS_308941	Blackburn Ripon	Moray Firth	Aircraft	20th Century	-	
NMRS_308942	Blackburn Dart	Moray Firth	Aircraft	20th Century	-	
NMRS_308943	Blackburn Dart	Moray Firth	Aircraft	20th Century	-	
NMRS_308958	Parnall Panther	Moray Firth	Aircraft	20th Century	-	
NMRS_308975	Armstrong Whitworth Whitley V	Moray Firth	Aircraft	20th Century	-	
NMRS_309819	Vickers Wellington IC	Moray Firth	Aircraft	20th Century	1941	20 OUT (RAF) crashed into the sea 4 miles north north east of Buckie

Recorded Losses - Aircraft						
ID	**Name**	**Location**	**Type**	**Period**	**Year Lost**	**Description**
NMRS_310613	Short Sunderland Flying Boat	North Sea	Aircraft	20th Century	1943	Lost between Banf and Kinloss. 6 bodies recovered.
NMRS_310822	Avro Ansan I	Cullen Bay, Moray Firth	Aircraft	20th Century	-	
NMRS_321470	Unknown	-	Aircraft (Possible)	20th century	-	
NMRS_325962	A/C Buccaneer	-	Aircraft	20th Century	-	
NMRS_325963	A/C Hunter	-	Aircraft	20th Century	-	
NMRS_325964	A/C Buccaneer	-	Aircraft	20th Century	-	
NMRS_325969	A/C Buccaneer	-	Aircraft	20th Century	-	
NMRS_325970	A/C Sea Vixen	-	Aircraft	20th Century	-	
NMRS_328356	A/C Hawker	-	Aircraft	20th Century	-	
NMRS_329733	A/C Boulton Paul	-	Aircraft	20th Century	-	
NMRS_329748	A/C Boulton Paul	-	Aircraft	20th Century	-	
NMRS_329762	A/C Bristol	-	Aircraft	20th Century	-	
NMRS_329831	A/C Hawker	-	Aircraft	20th Century	-	
NMRS_330048	A/C Westland	-	Aircraft	20th Century	-	
NMRS_330049	A/C Fairey	-	Aircraft	20th Century	-	
NMRS_330050	A/C Fairey	-	Aircraft	20th Century	-	

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MORAY WEST
OFFSHORE WINDFARM

Moray Firth High Level Screening Assessment

Moray Offshore Windfarm (West) Limited

Technical Appendix 17.1

6131A – RPS Moray Firth – High Level Screening Assessment

Pager Power has been engaged to assess the technical impacts caused by any wind farm(s) located within the Moray Firth Round 3 Offshore zone and to comment on the level of effort and funding that might be required to solve any problems.

Given the large size of the Moray Firth Zone, technical issues are likely to vary across the site. In order to account for this the zone has been assessed separately as eastern and western areas. Appendix 1 illustrates this split.

This document includes a prescreen report identifying issues and a summary page indicating potential solutions for each area.

The severity of the issues identified has been graded in the following way:

0	No solution on the horizon
1	Poor, Difficult to solve
2	Fair, Possible to solve with time and money
3	No issues or easy to solve

	Name	**Date**	**Contact**
Author	Adam Knights	13th Feb 2009	adam@pagerpower.co.uk
Reviewer	Kai Frolic	13th Feb 2009	kai@pagerpower.co.uk

Site Summary Table

	Civil Aviation Radar Sites	Military Aviation Radar Sites	Meteorological Radar	Non-Radar Aviation Issues	Low Fly Areas, Military Training Areas & Ranges	TV and Radio Interference	Microwave Links
Western Area	**2**	**1**	**3**	**1**	**3**	**3**	**3**
Eastern Area	**2**	**2/3**	**3**	**3**	**3**	**3**	**3**

Note that this is a high level analysis, and other factors not considered during the assessment may provide adequate mitigation for issues identified during this assessment. Therefore, it is not recommended that otherwise good sites should be dismissed due to major issues identified in this report without further investigation.

Western Area

Co-ordinates used were taken from the Crown Estate website for the Moray Firth Zone.

The Western Area assessed has the following BNG boundary coordinates:

Easting	Northing
328206	902271
328206	906750
332917	913346
347378	923498
347378	909295

Civil Aviation Radar Sites 2

The National Air Traffic Services (NATS) Primary Surveillance Radar (PSR) at Allanshill has line-of-sight to some parts of the Western Area.

It is likely that turbines located within the south western part of this area would not be visible to the Allanshill PSR. Charts included.

Military Aviation Radar Sites 1

RAF Lossiemouth PSR (MoD) has line-of-sight to the entirety of this area. Chart included.

Meteorological Radar 3

No issues.

Non-Radar Aviation Issues 1

Two offshore heliports lie on the northern boundary of the Western Area. One further offshore heliport, also to the north, lies within the 6 nautical mile safeguarding distance for offshore heliports. Such a safeguarding distance significantly constrains the Western Area.

Low Fly Areas, Military Training Areas & Ranges 3

Parts of the Western Area lie under the Kinloss/Lossiemouth Area of Intense Aerial Activity (AIAA). This is not expected to be a significant issue but should be noted.

TV and Radio Interference 3

No issues.

Microwave Links 3

An initial scan of our database suggests that some microwave links may pass through the northern edge of the Western Area, possibly associated with the heliports mentioned above. Microwave links regularly come into commission and are decommissioned and therefore full Ofcom consultation is recommended when specific sites are awarded. Chart attached.

Given the proximity of these links to the already safeguarded heliports the risk of these links is considered small, as it is unlikely a developer would gain planning permission to build close enough to the heliports to interfere with such links.

Eastern Area

The Eastern Area assessed has the following BNG boundary coordinates:

Easting	Northing
347378	923498
347378	909295
366549	916319
366549	925722
356797	937448

Civil Aviation Radar Sites 2

The National Air Traffic Services (NATS) Primary Surveillance Radar (PSR) at Allanshill has line-of-sight to the Eastern Area. Chart included.

Military Aviation Radar Sites 2/3

RAF Lossiemouth PSR (MoD) has line-of-sight to the western most part of this area. The majority of the area will not be within the line-of-sight of this radar. Charts included.

Meteorological Radar 3

No issues.

Non-Radar Aviation Issues 3

No issues.

Low Fly Areas, Military Training Areas & Ranges 3

No issues.

TV and Radio Interference 3

No issues.

Microwave Links 3

No issues.

Conclusions

A high level screening assessment has been produced.

This has identified the most significant installations that may be affected by the proposed development.

These are:

- RAF Lossiemouth PSR (MoD)
- Allanshill PSR (NATS)

The estimated line of sight visibility between each installation and the proposed wind farm location has been considered.

Objection is likely from the MoD for those turbines within the line-of-sight of the primary radar installation at RAF Lossiemouth.

Objection is likely from NATS for those turbines within the line-of-sight of the primary radar installation at Allanshill.

Three offshore heliports are likely to constrain the western half of the Moray Firth Zone.

Mitigations, such as data fusion involving new or existing radar, are likely to be viable for large offshore developments. Once specific sites within the Moray Firth zone are awarded, a detailed study of the mitigations available to that site could be conducted.

Should a developer win a bid to develop within the Moray Firth Zone, Pager Power recommends that further work is undertaken to produce radar area coverage charts for the entire zone for each radar outlined above. Such charts may allow developers to identify specific areas free of radar issues should such areas exist.

Due to the large size of the Moray Firth zone radar issues vary considerably across the zone.

Appendix 1 – Chart Showing the 2 Assessed Areas

Division Illustration

Moray Firth

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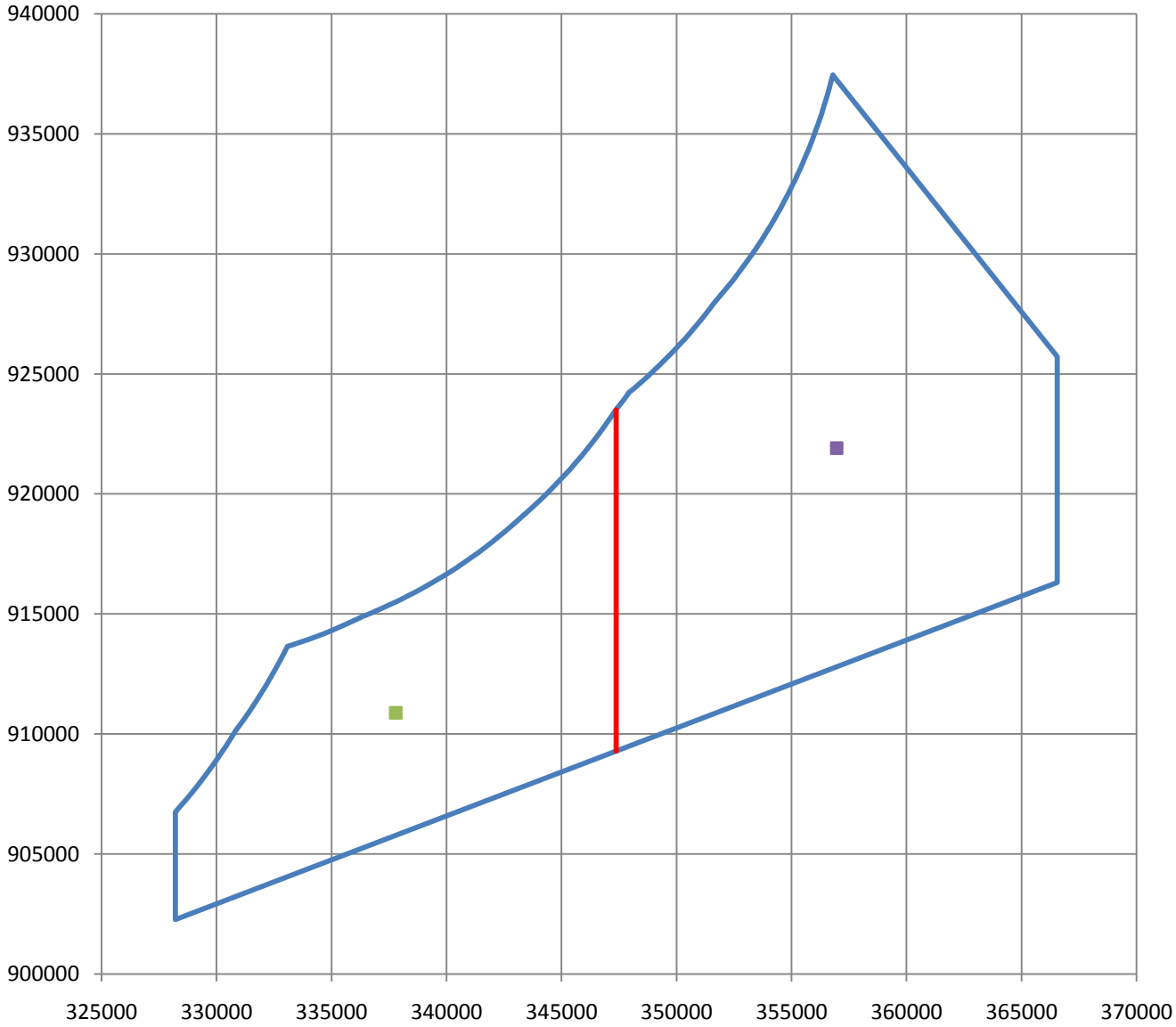

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Appendix 2 – Pre-Screen Chart

Wind Site Pre-screening Report [WindPrescreen02]

Customer Name	Date
RPS	13/02/2009

Our Ref.
6131A

PAGERPOWER aviation studies

Site Information

Site Name	Bottom Left (BNG)		Top Right (BNG)		Site Center (BNG)		Site Radius
	Eastings	Northings	Eastings	Northings	Eastings	Northings	(km)
Moray Firth	328000	902000	366800	937700	347400	919850	26.4

Installations and Facilities Detected by Pre-screen

Name	Estimated Radar Visibility	Approximate Range (km)	Likelihood Of Objection	Assessor's Notes
Lossiemouth PSR	Varies	57	Likely	Military Airfield ATC
Allanshill PSR (NATS)	Varies	72	Likely	NERL PSR
Beatrice Alpha	N/A	13	Likely	Offshore Heliport
Beatrice Bravo	N/A	8	Likely	Offshore Heliport
Beatrice Charlie	N/A	17	Likely	Offshore Heliport

Microwave Link Issues

	Ending Inside	Crossing	Near to	No Issue
Number of links	3	0	0	0

Tool Last Updated 11/04/08

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Assessed By	Adam Knights	Date	13/02/2009

This report identifies the most significant aviation and radar issues associated with a wind site. There may be other issues. It also gives an indication of the level of microwave link constraints.This report is intended to assist a developer decide whether an Initial Site Assessment report is required. Such a report examines aviation issues in greater depth than this prescreening report. An Initial Site Assessment report also covers Communications issues such as Microwave links and TV. Estimated Radar Visibility gives an indication of the maximum turbine tip height that should not affect a radar. Categories are: *less than 60m* , *60m to 90m* , *90m to 120m* , *120m to 150m* , and *greater than 150m* . Pager Power Limited is not liable for inaccuracies in this report.

Appendix 3 –Line-of-Sight Charts for Western Area

Radar Impact Assessment
Moray Firth
RPS
by Pager Power Limited

Turbine Reference	**West - Bottom Left**
Hub Height /m	**80**
Rotor Diameter /m	**90**
Turbine Height /m	**125**
Turbine Grid Reference	**E328206 N902271**
Turbine Land Height /m	**0.0**
Blocking Point Grid Reference	**E385868 N864345**
Blocking Point Adjusted Land Height /m	**180.9**
Distance from Turbine to Radar /km	**74.2**
Distance from Turbine to Blocking Point /km	**69.0**
Visible Turbine Height /m	**-464.9**

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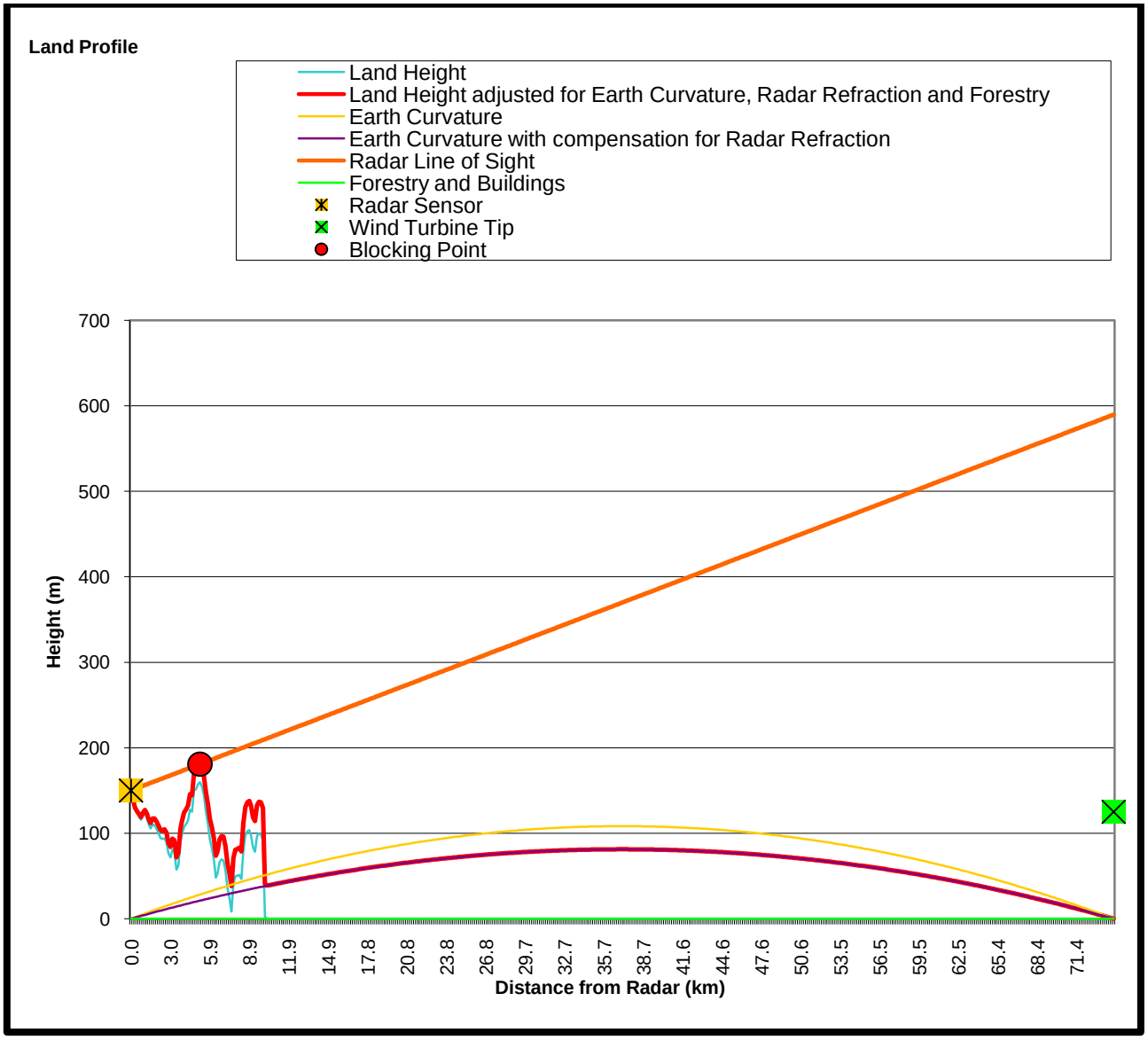

Radar Impact Assessment
Moray Firth
RPS
by Pager Power Limited

Turbine Reference	**West - Top Left**
Hub Height /m	**80**
Rotor Diameter /m	**90**
Turbine Height /m	**125**
Turbine Grid Reference	**E328206 N906750**
Turbine Land Height /m	**0.0**
Blocking Point Grid Reference	**E385495 N864931**
Blocking Point Adjusted Land Height /m	**176.7**
Distance from Turbine to Radar /km	**76.8**
Distance from Turbine to Blocking Point /km	**70.9**
Visible Turbine Height /m	**-375.8**

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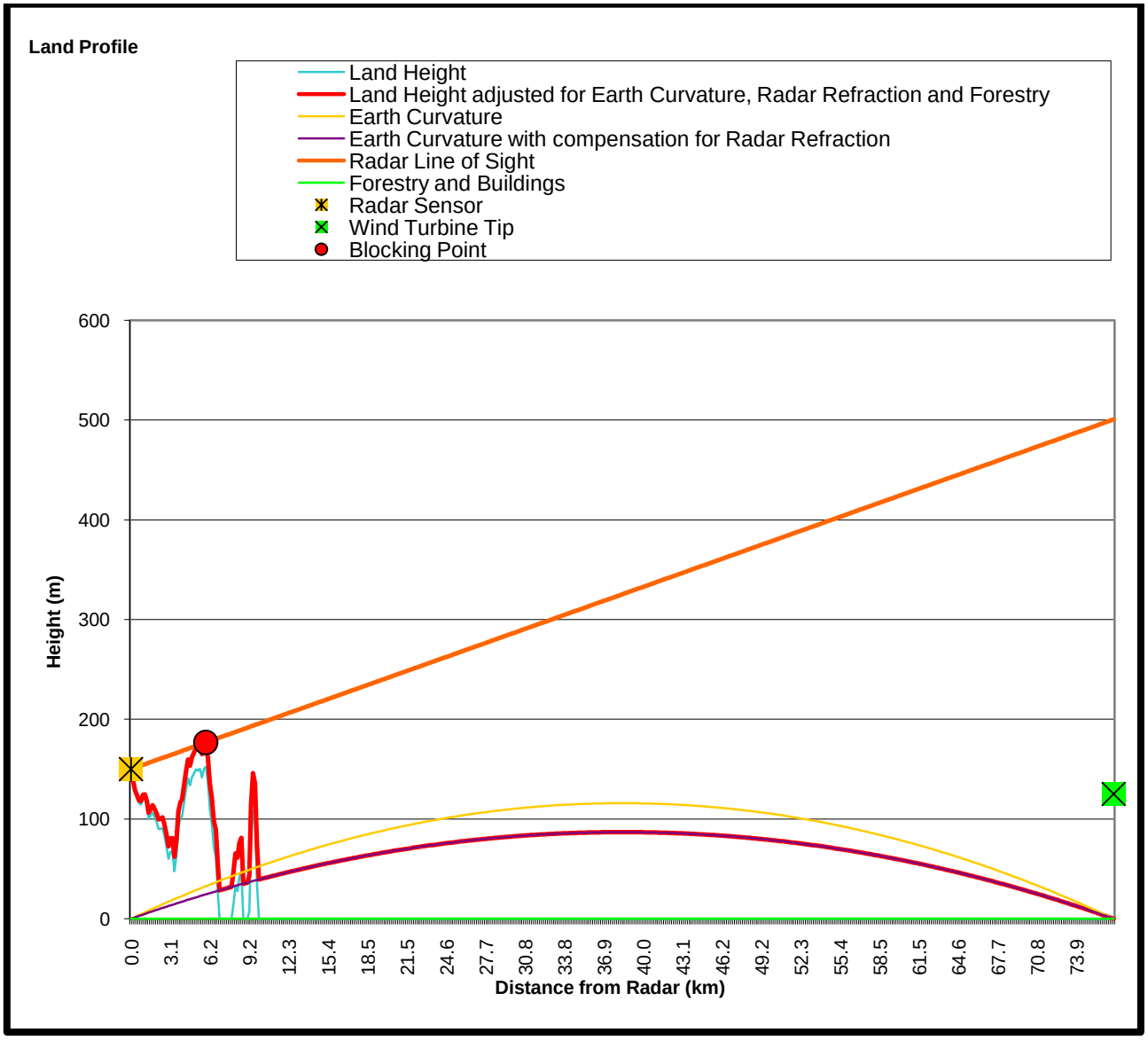

Radar Impact Assessment
Moray Firth
RPS
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Turbine Reference	**West - Bottom Right**
Hub Height /m	**80**
Rotor Diameter /m	**90**
Turbine Height /m	**125**
Turbine Grid Reference	**E347378 N909295**
Turbine Land Height /m	**0.0**
Blocking Point Grid Reference	**E386869 N865221**
Blocking Point Adjusted Land Height /m	**141.5**
Distance from Turbine to Radar /km	**64.2**
Distance from Turbine to Blocking Point /km	**59.2**
Visible Turbine Height /m	**84.2**

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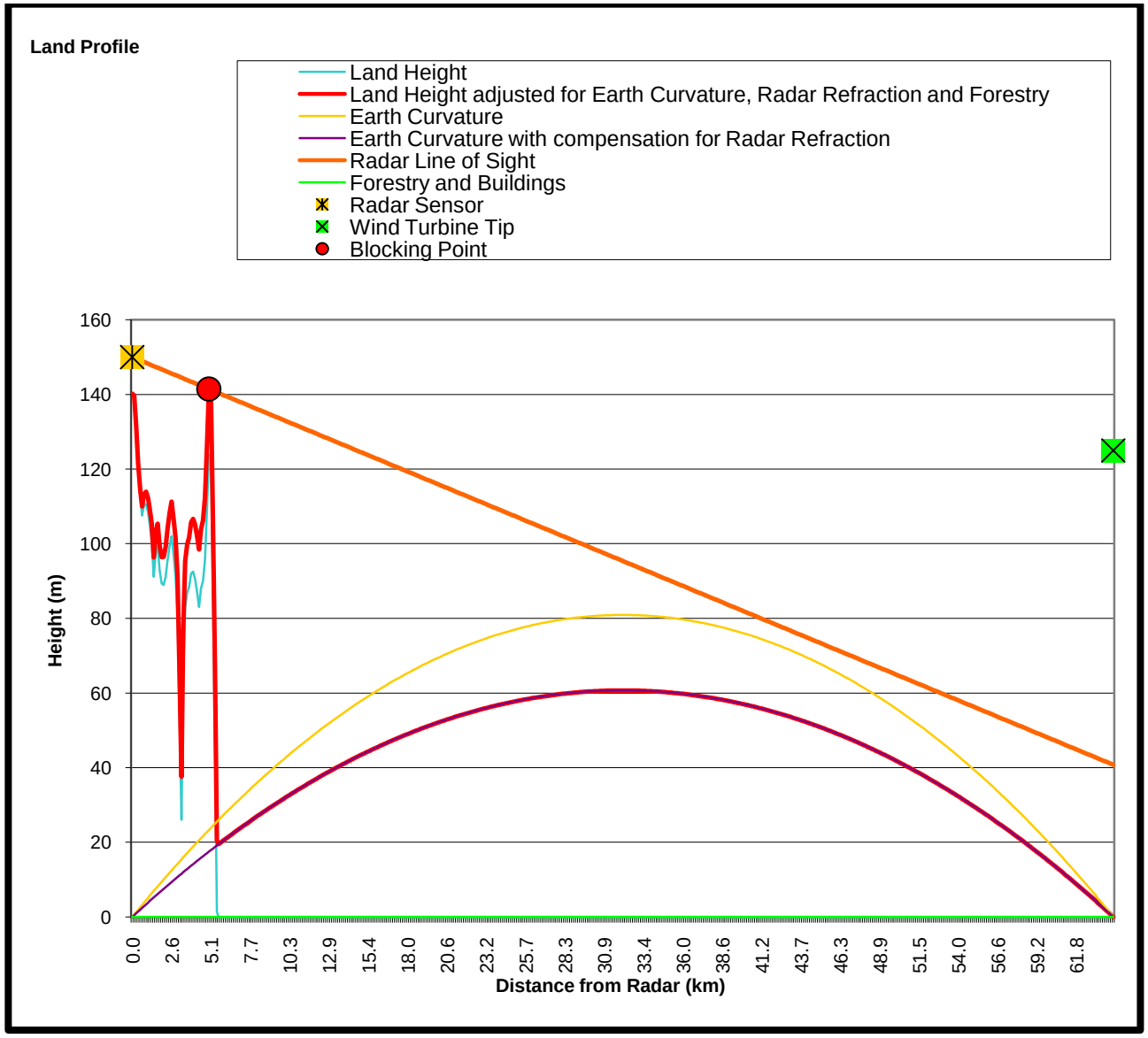

Radar Impact Assessment
Moray Firth
RPS
by Pager Power Limited

Turbine Reference	**West - Centre**
Hub Height /m	**80**
Rotor Diameter /m	**90**
Turbine Height /m	**125**
Turbine Grid Reference	**E337792 N910885**
Turbine Land Height /m	**0.0**
Blocking Point Grid Reference	**E386015 N865444**
Blocking Point Adjusted Land Height /m	**151.7**
Distance from Turbine to Radar /km	**72.0**
Distance from Turbine to Blocking Point /km	**66.3**
Visible Turbine Height /m	**-46.1**

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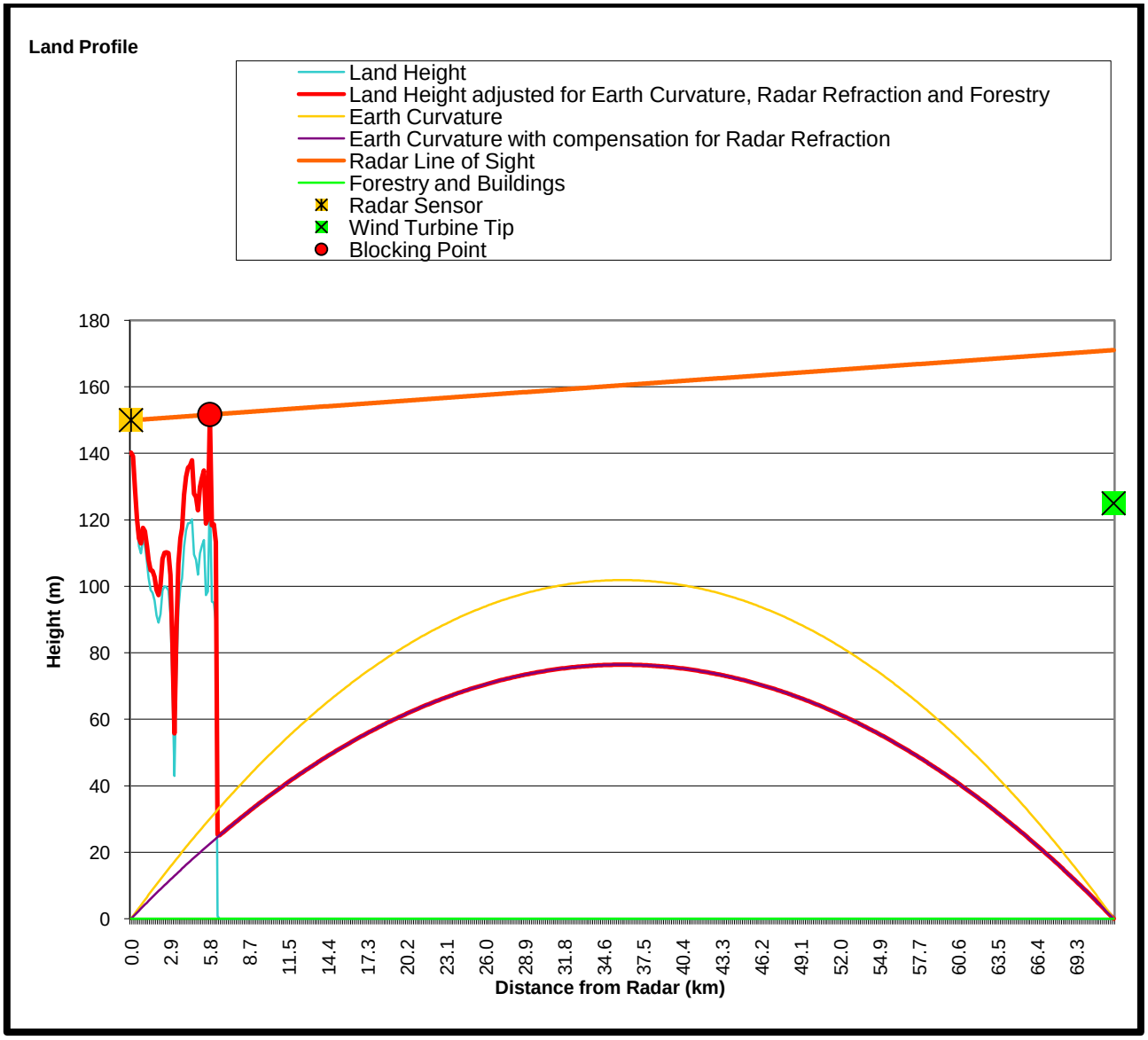

Radar Impact Assessment
Moray Firth
RPS
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Turbine Reference	**West - Centre**
Hub Height /m	**80**
Rotor Diameter /m	**90**
Turbine Height /m	**125**
Turbine Grid Reference	**E337792 N910885**
Turbine Land Height /m	**0.0**
Blocking Point Grid Reference	**E326894 N884096**
Blocking Point Adjusted Land Height /m	**26.9**
Distance from Turbine to Radar /km	**44.7**
Distance from Turbine to Blocking Point /km	**28.9**
Visible Turbine Height /m	**75.8**

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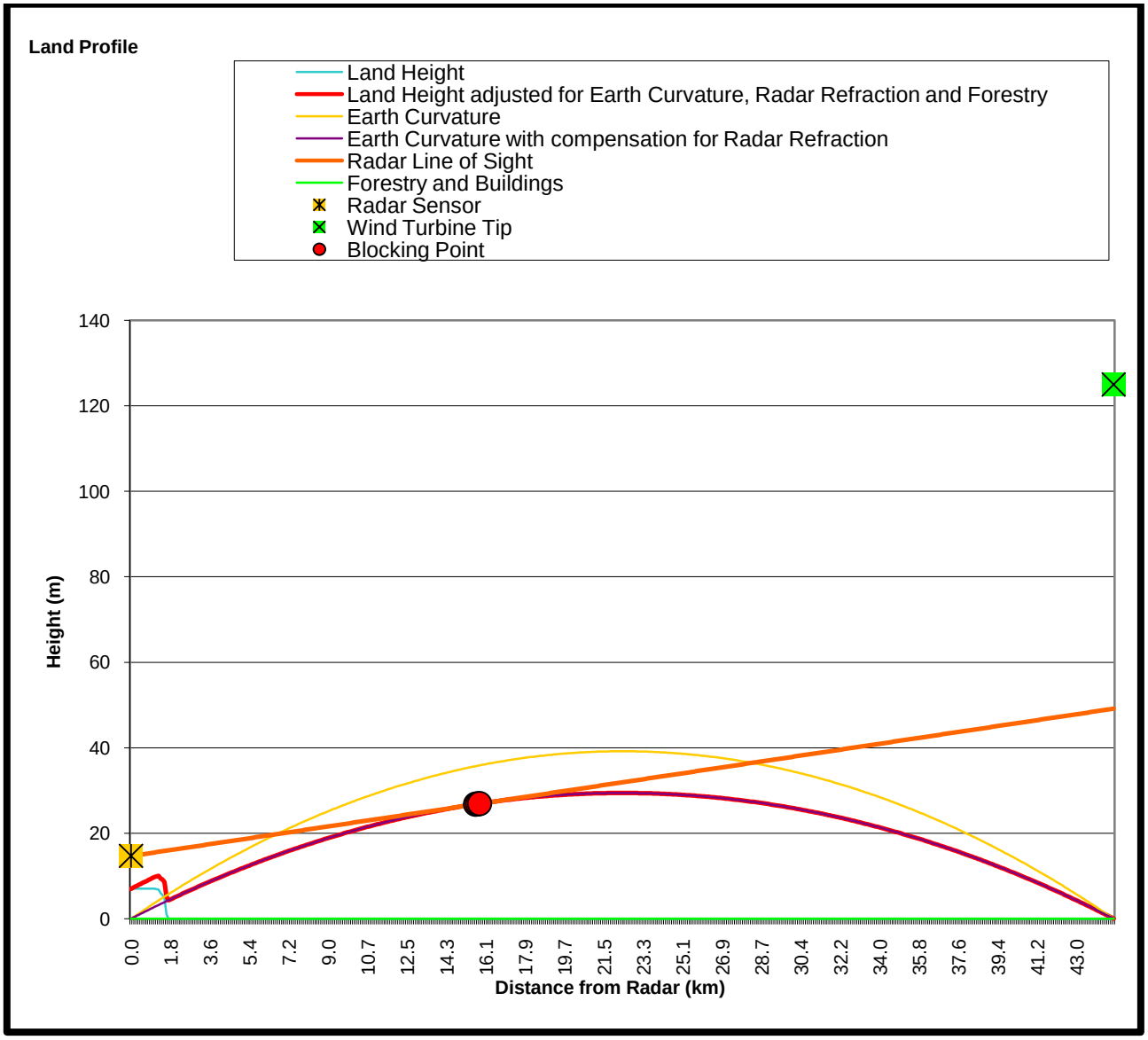

Appendix 4 – Line-of-Sight Charts for Eastern Area

Radar Impact Assessment
Moray Firth
RPS
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Turbine Reference	**East - Centre**
Hub Height /m	**80**
Rotor Diameter /m	**90**
Turbine Height /m	**125**
Turbine Grid Reference	**E356964 N921909**
Turbine Land Height /m	**0.0**
Blocking Point Grid Reference	**E365894 N905683**
Blocking Point Adjusted Land Height /m	**55.1**
Distance from Turbine to Radar /km	**69.0**
Distance from Turbine to Blocking Point /km	**18.5**
Visible Turbine Height /m	**104.8**

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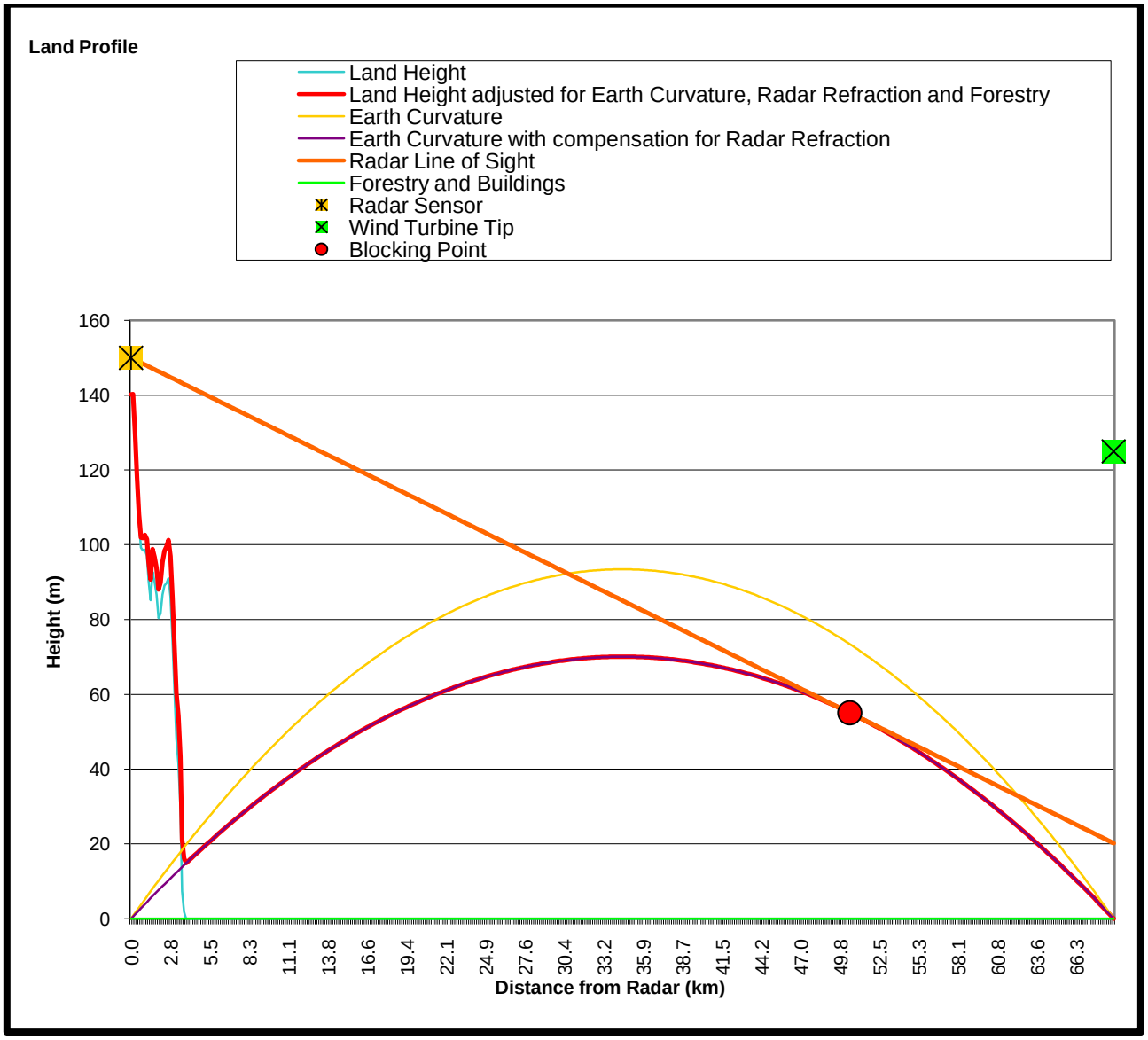

Radar Impact Assessment
Moray Firth
RPS
by Pager Power Limited

Turbine Reference	**East - Bottom Left**
Hub Height /m	**80**
Rotor Diameter /m	**90**
Turbine Height /m	**125**
Turbine Grid Reference	**E347378 N909295**
Turbine Land Height /m	**0.0**
Blocking Point Grid Reference	**E329693 N882658**
Blocking Point Adjusted Land Height /m	**29.8**
Distance from Turbine to Radar /km	**47.8**
Distance from Turbine to Blocking Point /km	**32.0**
Visible Turbine Height /m	**64.8**

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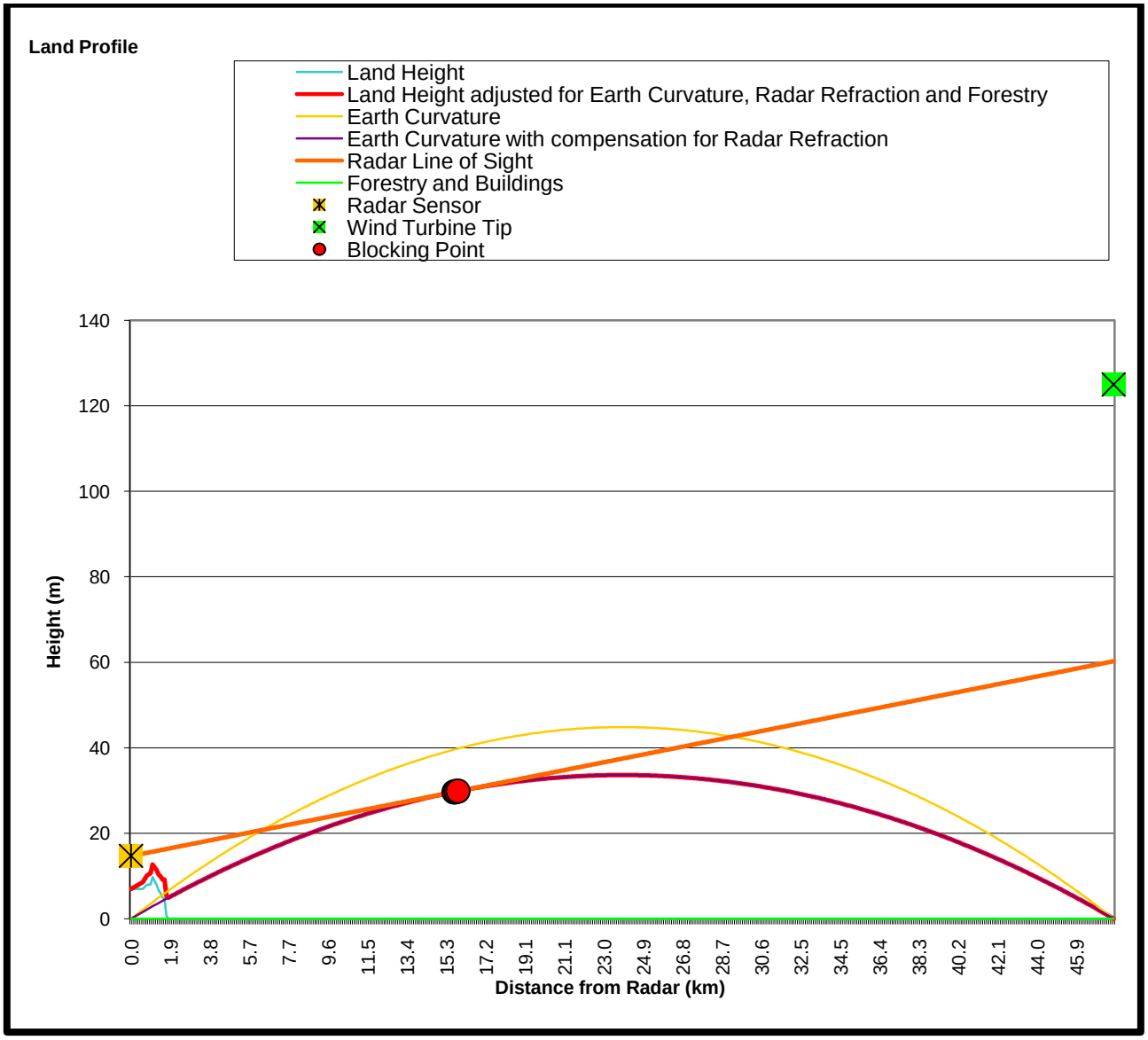

Radar Impact Assessment
Moray Firth
RPS
by Pager Power Limited

Turbine Reference	**East - Top Left**
Hub Height /m	**80**
Rotor Diameter /m	**90**
Turbine Height /m	**125**
Turbine Grid Reference	**E347378 N923498**
Turbine Land Height /m	**0.0**
Blocking Point Grid Reference	**E327892 N883675**
Blocking Point Adjusted Land Height /m	**41.2**
Distance from Turbine to Radar /km	**60.1**
Distance from Turbine to Blocking Point /km	**44.3**
Visible Turbine Height /m	**9.3**

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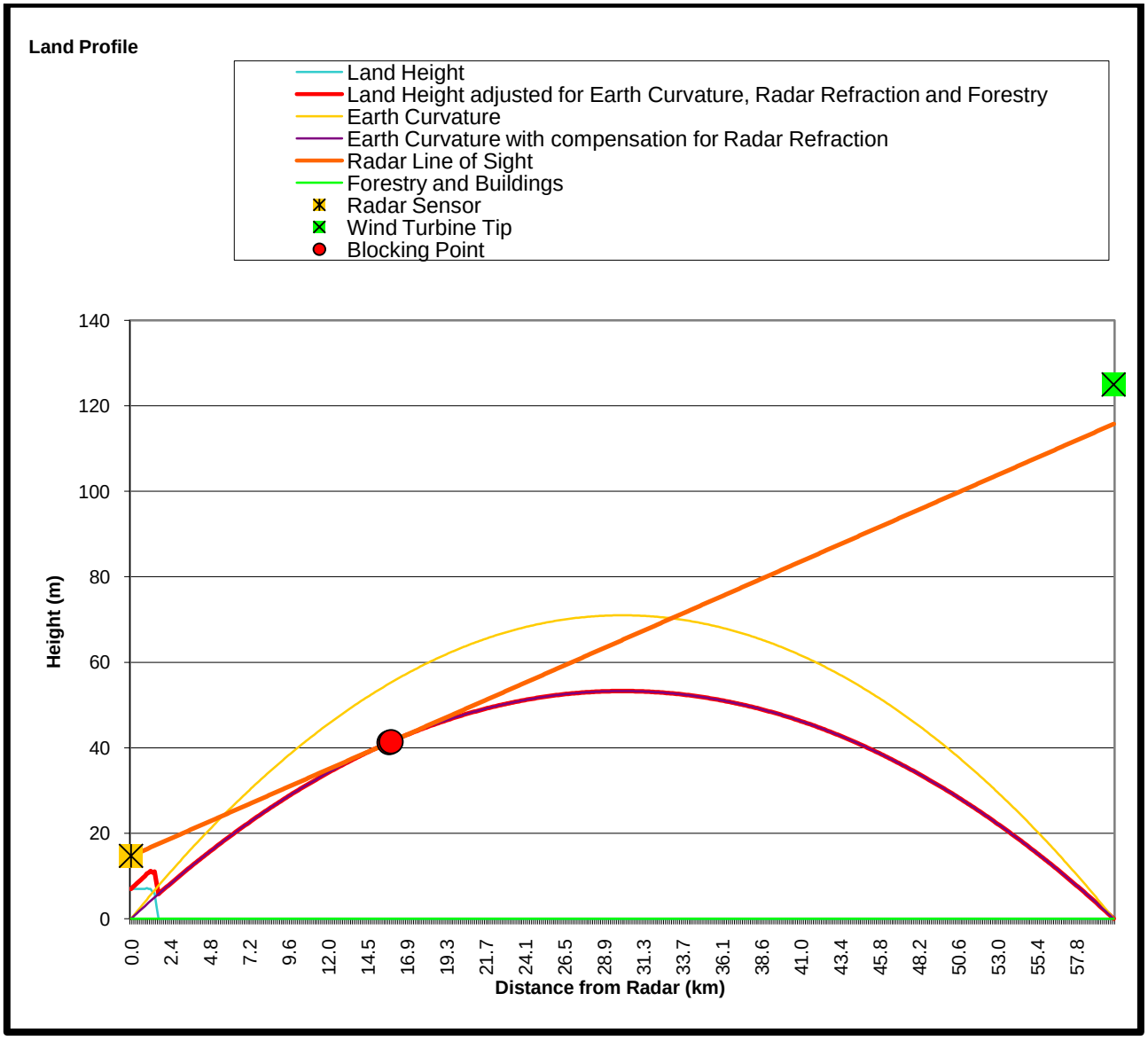

Radar Impact Assessment
Moray Firth
RPS
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Turbine Reference	**East - Bottom Right**
Hub Height /m	**80**
Rotor Diameter /m	**90**
Turbine Height /m	**125**
Turbine Grid Reference	**E366549 N916319**
Turbine Land Height /m	**0.0**
Blocking Point Grid Reference	**E332012 N880852**
Blocking Point Adjusted Land Height /m	**46.2**
Distance from Turbine to Radar /km	**65.4**
Distance from Turbine to Blocking Point /km	**49.5**
Visible Turbine Height /m	**-19.7**

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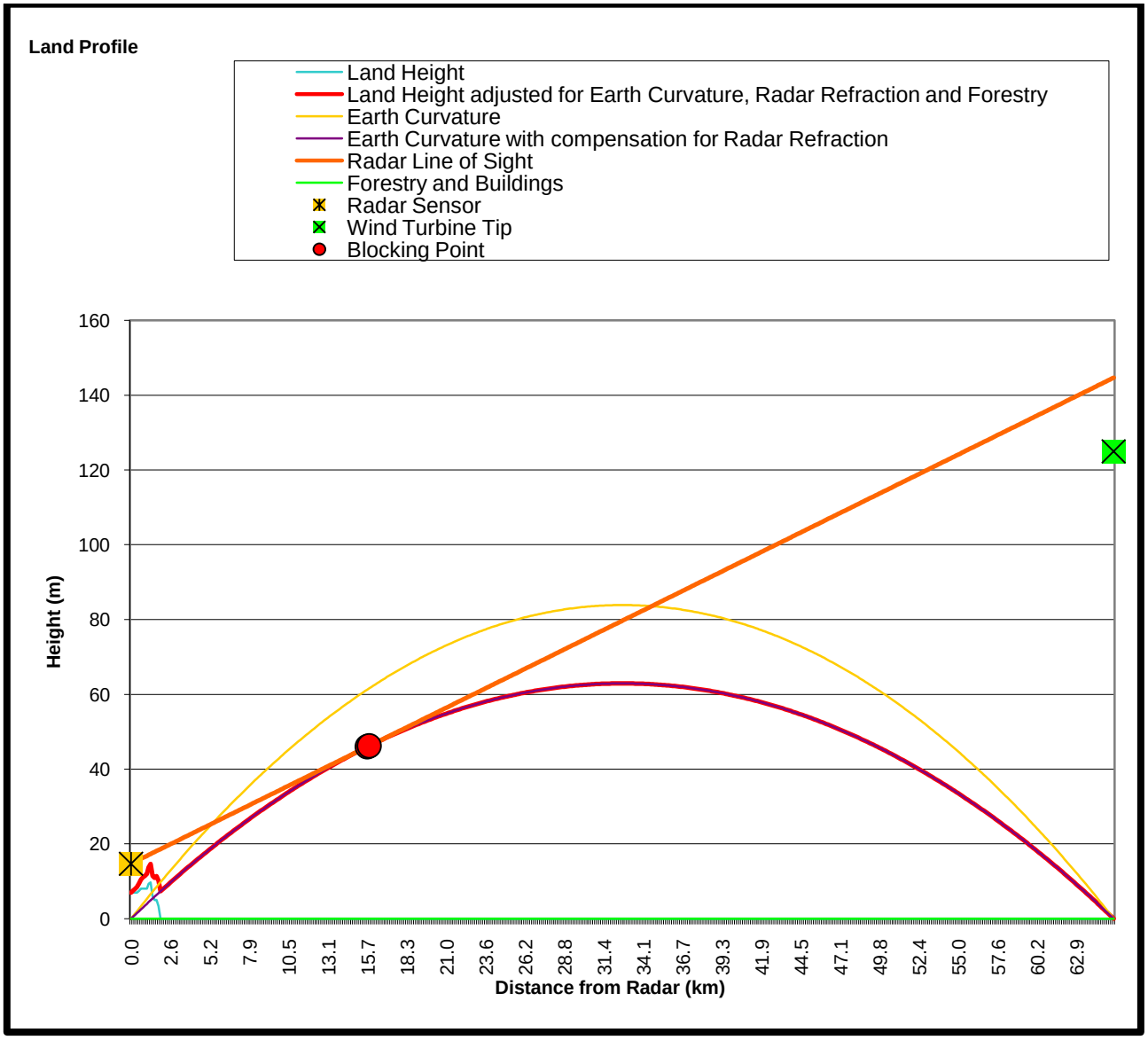

Radar Impact Assessment
Moray Firth
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Turbine Reference	**East - Centre**
Hub Height /m	**80**
Rotor Diameter /m	**90**
Turbine Height /m	**125**
Turbine Grid Reference	**E356964 N921909**
Turbine Land Height /m	**0.0**
Blocking Point Grid Reference	**E329904 N882523**
Blocking Point Adjusted Land Height /m	**44.5**
Distance from Turbine to Radar /km	**63.6**
Distance from Turbine to Blocking Point /km	**47.8**
Visible Turbine Height /m	**-9.6**

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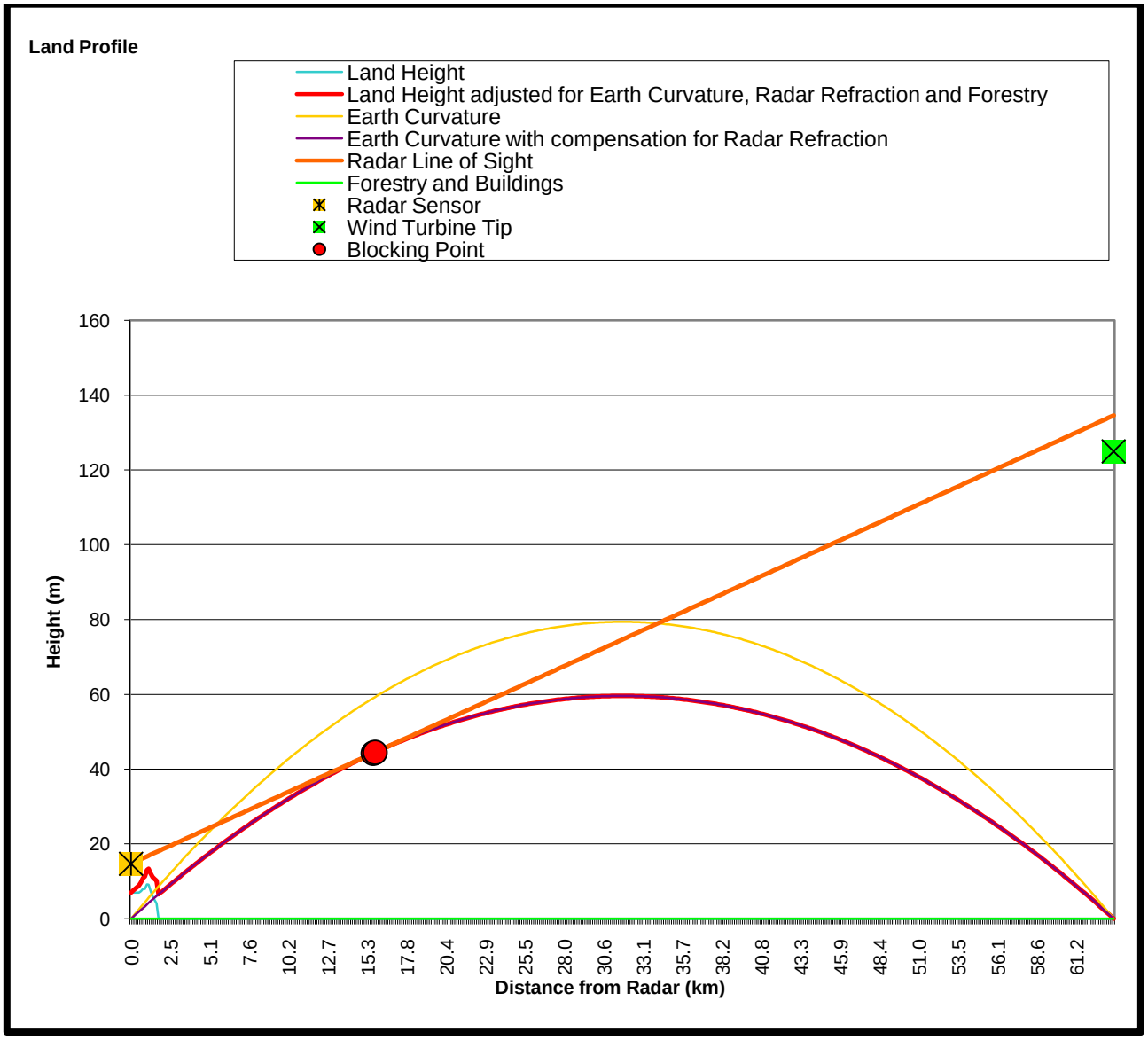

Radar Impact Assessment
Moray Firth
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Turbine Reference	**East - Top Middle**
Hub Height /m	**80**
Rotor Diameter /m	**90**
Turbine Height /m	**125**
Turbine Grid Reference	**E356797 N937448**
Turbine Land Height /m	**0.0**
Blocking Point Grid Reference	**E328354 N883525**
Blocking Point Adjusted Land Height /m	**57.0**
Distance from Turbine to Radar /km	**76.8**
Distance from Turbine to Blocking Point /km	**61.0**
Visible Turbine Height /m	**-94.4**

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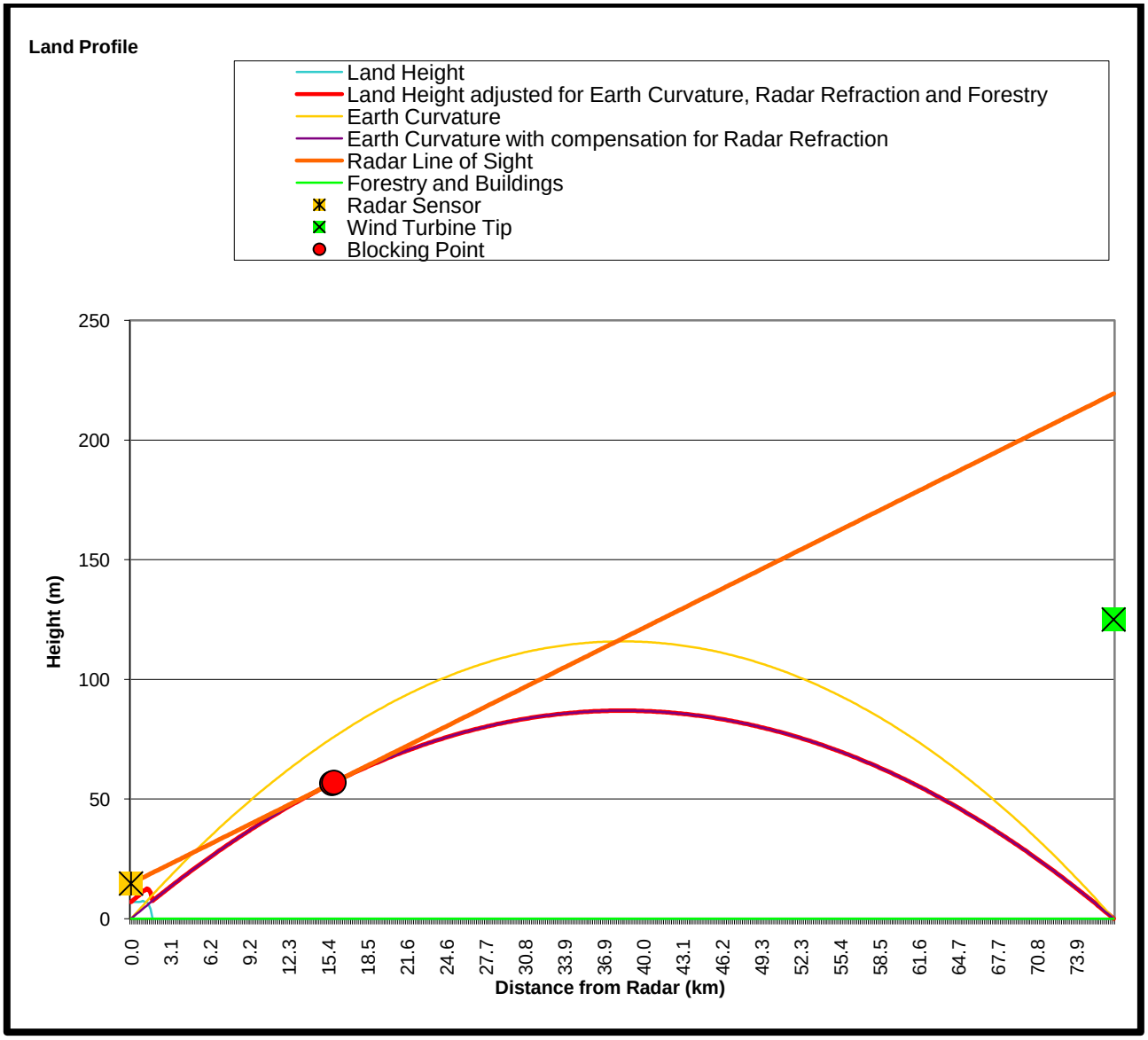
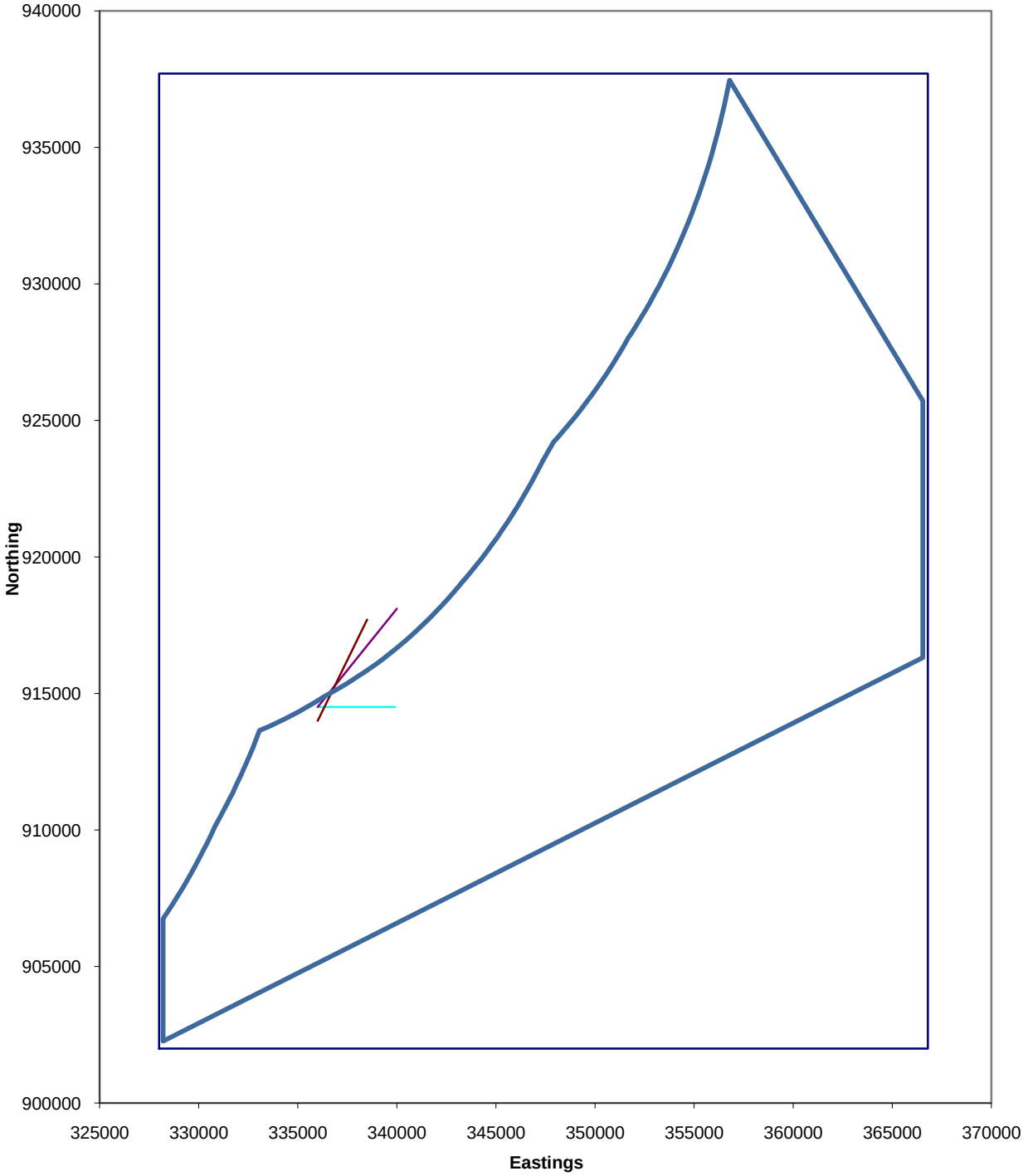


Appendix 5 – Microwave Link Chart

Microwave Communications Links - Moray Firth



MORAY WEST
OFFSHORE WINDFARM

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MORAY WEST
OFFSHORE WINDFARM

UXO Risk Assessment

Moray Offshore Windfarm (West) Limited

Technical Appendix 17.2

moray offshore renewables ltd

Environmental Statement

Technical Appendix 5.8 A - UXO Threat and Risk Assessment

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Final Version 2.0

Prepared by:	Gary Hubbard	22nd February 2011
Reviewed by:	Lee Gooderham	4th March 2011
Released by:	Simon Cooke	4th March 2011

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Appendix 09 Ordnance Characteristics

Appendix 10 Project Risk Assessment Tables

Appendix 11 Project UXO Probability Map

Acronyms and Abbreviations

ALARP	As Low As Reasonably Practicable
CIRIA	Construction Industry Research and Information Association
BD	Bomb Disposal
BDO	Bomb Disposal Officer
BMAPA	British Marine and Aggregate Producers Association
dGPS	Differential Global Positioning Systems
EO	Explosive Ordnance
EOD	Explosive Ordnance Disposal
ERW	Explosive Remnants of War
GIS	Geographical Information System
HE	High Explosive
HMX	High Molecular (mass) RDX
HSE	Health and Safety Executive
IB	Incendiary Bomb
JSEODOC	Joint Service Explosive Ordnance Disposal Operations Centre
KHz	Kilohertz
Kg	Kilogram
Km	Kilometre
lb	Pound (weight)
LSA	Land Service Ammunition
M	Metres
MCM	Mine Countermeasures
MDA	Mine Danger Area
MCA	Maritime and Coastguard Agency
MoD	Ministry of Defence
MORL	Moray Offshore Renewables Ltd
mm	Millimetres
NaREC	New and Renewable Energy Centre
NEQ	Net Explosive Quantity
NGR	National Grid Reference

Nm	Nautical Mile
RDX	Research Department (composition) ‘X’
ROV	Remotely Operated Vehicle
RN	Royal Navy
QA/QC	Quality Assurance/Quality Control
SAA	Small Arms Ammunition
SI	Site Investigation
SOP	Standard Operating Procedure
SSS	Side Scan Sonar
SQRA	Semi Quantitative Risk Assessment
TNT	Trinitrotoluene
UK	United Kingdom
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
WWI	World War One
WWII	World War Two

Executive Summary

Purpose

Items of Unexploded Ordnance (UXO) are regularly encountered along the northern coast and rarely become inert or lose their high explosive effectiveness with age. There is therefore, a risk that UXO could be encountered at the Moray Firth Offshore Wind Farm.

Cathie Associates Limited (Cathie Associates), on behalf of Moray Offshore Renewables Ltd (MORL), has commissioned 6 Alpha Associates Limited to conduct a detailed UXO desk based study for this wind farm development.

Aim and Objectives

The aim of this document is to address the initial stages of the UXO risk management process by providing a holistic overview of the UXO threats and risks for both the marine and land components of the entire operation. In commissioning 6 Alpha as the project's UXO consultant, MORL intends to:

- Discharge its duty of care to those involved in the development of the project site;
- Ensure that it takes appropriate "best practice" measures to manage all of the risks posed by the UXO threat;
- Protect the development itself from the risks of UXO blight and in doing so protect its investors, investment and reputation;
- Identify UXO risk areas (subject to available information), in order to avoid or manage UXO risks;
- Procure the most time efficient and cost effective means of managing and mitigating the UXO risk.

Therefore, the report will cross reference and account for relevant statutory instruments *vis-à-vis* UXO risk (with which clients will have to comply), including Heath and Safety at Work legislation as well as the Corporate Manslaughter and Corporate Homicide Act of 2007 and common law liabilities. Additionally, and in particular, the report will explain how and why the Construction Design and Management (CDM) Regulations 2007 apply as does CIRIA's *UXO – A Guide for the Construction Industry*, (the latter providing the first UK "good practice guide", helping developers and the construction industry to deal with UXO).

The report will describe the potential for UXO encounter, the risks that may be posed as a result, as well as how those risks can be reduced to As Low As Reasonably Practicable (ALARP), at best value. In this way we anticipate that MORL will be able to both satisfy and discharge their liabilities concerning corporate governance and UXO risk management through the provision of appropriate levels of project safety.

Land UXO Threat and Risk (Annex A to the main report)

During WWII the study site was mostly devoid of residential or commercial properties and accordingly there were no primary bombing targets. Accordingly there was a very low level of Luftwaffe bombing during WWII. There are only three notable dates where bombing incidence occurred.

Under the threat of German invasion in the summer of 1940, the creation of a defensive 'coastal crust' represented one of the largest construction projects of the war in Britain. Hundreds of miles of beaches were closed to the public and fortified with barbed wire, minefields and gun emplacements. There was one such minefield located to the north of the study site. The northern extent of the minefield was the mouth of the River Wanabech, while the southern boundary is not specified.

When dealing with beach minefields there are a number of inherent concerns by the success of WWII clearance operations. Firstly, the very high rates of clearance during the war may have caused some mines to be missed and secondly, there is commonly a recorded discrepancy in the numbers of mines that were laid to those that were cleared. In many areas along the north east coast these factors have resulted in mines being discovered post WWII.

Across the site the UXO risk profile varies. Moderate Risk has been assigned to the areas of the beach where the minefield was installed. The remaining areas of the site have been assessed as Low Risk.

Marine UXO Threat and Risk

In terms of UXO threat, this report will demonstrate that the UXO threat is primarily the result of munitions and weaponry employed during WWI and WWII; this includes, in priority order: sea-dumped explosives/munitions, shipwrecks and sea mines. The report will summarise this threat and will present a Semi Quantitative Risk Assessment (SQRA) concerning UXO and the effects that they may have upon personnel and the construction work that they are expected to undertake.

Conclusions

The report concludes that whilst there is a risk posed by UXO to the project, the risk level does vary with both the proposed activity and its location within the development zone. Such risks are not uncommon and have been encountered on a high proportion of wind farm developments in the North Sea.

The UXO risks can be managed throughout the construction phase in general (and the foundastion, inter-array and export cable installation phases in particular). By employing the proven risk management techniques, which have been described general (and in section 12.3.2 in particular), those risks can be managed and reduced to ALARP, at best value.

The potential presence of UXO and the associated hazard it might pose should not be considered a barrier to wind farm development.

Land Risk Mitigation Recommendations

6 Alpha have recommended that the following actions are required to address the UXO risk on land:

All Works across the Entire Site

1. Documentary procedures to be taken in the event of a suspicious find;

2. Brief all personnel involved with the intrusive works on the potential risk of an associated UXO discovery.

Eastern Area

1. Non-intrusive magnetometer survey of areas ahead of subsurface construction activities, the whole area does not need to be searched.

2. Avoid or investigate any geophysical anomalies that model as potential items of UXO.

3. If required 6 Alpha can support the project with UXO survey procurement and operational QA/QC. On receipt of satisfactory method statements, technical specifications and results from the survey contractor, 6 Alpha can sign off the works to state that the risk has been reduced to ALARP

Marine Risk Mitigation Recommendations

6 Alpha have therefore recommended that the following actions are required to address the UXO risk. This table should be read in conjunction with the "probability of UXO encounter map" at *Appendix 11*.

UXO Probability Encounter Rating	Grading	Action Required ahead of Intrusive Works	Associated Additional Costs Low High
1-2	**Remote - Possible**	Areas defined as "background residual risk". Use, wherever possible, existing geophysical datasets for UXO risk reduction. Define smallest UXO threat items, interpret the datasets for contacts similar to UXO and avoid during future works. **6 Alpha Deliverable** - Client's must accept that this is not a 100% survey coverage for UXO, although if conducted by 6 Alpha the risk will be reduced to ALARP.	
3-4	**Likely - Highly Likely**	Areas which display a specific significant threat, there are three options for dealing with the risk in these areas: • **Option 1** - Conduct a UXO Specific Geophysical Survey and avoid targets. This survey should be designed to match the defined UXO threat and provide 100% coverage of specific threat area; • **Option 2** – Relocate works to areas with a grading of 1 or 2; • **Option 3** – If target avoidance not possible conduct either diver investigation or ROV inspection, which may discount the item or lead to UXO disposal. **6 Alpha Deliverable** - Once the UXO risk reduction actions have been successfully implemented and subject to our own QA/QC measures, 6 Alpha will sign-off the UXO risk as ALARP.	
5	**Almost Certain**	6 Alpha would strongly suggest avoiding these areas, and relocation work. As the costs associated reducing the risk to ALARP are likely to be considerable.	

1 Introduction

1.1 Overview

Cathie Associates Limited (Cathie Associates), on behalf of Moray Offshore Renewables Ltd (MORL), has commissioned 6 Alpha Associates Limited (6 Alpha) to conduct a detailed Unexploded Ordnance (UXO) desk based study for the Round 3 – Zone 1, Moray Firth Offshore Wind Farm (the project's location is depicted at *Appendix 01*).

Items of UXO are regularly encountered along the northeast coast, as has been confirmed by a variety of Royal Navy clearance tasks and associated media reports. UXO rarely becomes inert or loses its effectiveness with age. Over time, trigger mechanisms (such as fuzes and gaines) can become more sensitive and therefore more prone to detonation. This applies equally to items that have been submersed in water and/or lodged within the seabed. It is possible that the generation of significant kinetic energy over a short duration, which might be created by marine engineering (such as site investigation boreholes, foundation installation or cable trenching), could cause an inadvertent detonation of sensitive UXO.

In order to enable early site investigation works to be undertaken, 6 Alpha have already delivered two abbreviated UXO Risk Assessment reviews (which were dated on 2nd and 13th November 2010), ahead of this formal threat and risk assessment. The purpose of this document is to address Stage 2 of the overarching UXO Marine Risk Management process by providing a holistic overview of the UXO threats and risks for the entire marine component of the operation. This includes employing background research and factual data, which has been provided *inter alia* by (client engaged) third parties, and upon which we have relied.

1.2 Background

In commissioning 6 Alpha as the project's UXO consultant, MORL intends to:

- Discharge its duty of care to those involved in the development of the project site;
- Ensure that it takes appropriate "best practice" measures to manage all of the risks posed by the UXO threat;
- Protect the development itself from the risks of UXO blight and in doing so, protect its investors, investment and reputation;
- Identify UXO risk areas (subject to available information), in order to avoid or manage UXO risks;

- Procure the most time efficient and cost effective means of managing and mitigating the UXO risk.

2 Report Methodology

2.1 Structure

This study consists of a desk-based collation and review of readily available documentation and records relating to the possibility of encountering UXO and/or dangerous Explosive Ordnance (EO) related paraphernalia, within the study area. This study methodology is based on best practice for UXO risk assessment.

Certain information obtained by 6 Alpha may be either classified or restricted material, or may otherwise be considered confidential to 6 Alpha. Therefore summaries of such information have been provided. Please note that our appraisal partly relies on the accuracy of the information contained in these and other third party documents and that 6 Alpha will, in no circumstances, be held responsible for the accuracy of such third party information or data supplied.

In agreement with Cathie Associates, the following facets will be covered within this report:

- The entire scope of the proposed wind farm project has been considered;
- All sources of potential UXO threat will be considered including those within and outside of the concession boundary, because UXO outside of the boundary can migrate (though the action of tides and currents) into it;
- The history of the region has been considered, incorporating data from the abbreviated UXO Risk Assessment reviews;
- Relevant modern military records have been researched and presented;
- Wartime activities have been researched and presented;
- The holistic UXO threat has been considered, including the types that could be encountered, the probabilities of encountering them as well as exposing their potential mechanisms and risks of detonation;
- An outline assessment of how UXO interacts with the natural environment and conditions has been made;
- The risks regarding UXO have been assessed;
- A semi-quantitative risk assessment (SQRA) has been undertaken employing 6 Alpha's "Azimuth ©" proprietary risk model;
- The consequences of an inadvertent High Explosive (HE) detonation has been considered;

- Conclusions have been drawn;
- Recommendations, and an overview risk mitigation strategy has been presented.

The detailed UXO risk assessment for the landfall element of the export cable has not been commissioned however 6 Alpha can provide that in the form of a separate off-the-shelf study (see www.6alpha.com/bombsearch).

2.2 Sources of Information

The sources of information consulted for this report include:

- Royal Navy (Northern Diving Unit), Scotland;
- The National Archives, Kew;
- Naval Historical Centre, Portsmouth;
- UK Hydrographic Office, Taunton;
- 6 Alpha's "Agility Database ©" which contains historic maps, aerial photographs and records;
- Development boundary supplied by Cathie Associates.

2.3 Standards, Guidance and Best Practice

In producing this document 6 Alpha has consulted the most relevant published guidance and best practice. It should be noted that some of these sources may *prima facie*, not appear to be distinctively relevant to this project/study but, in the absence of specific guidance concerning the management of UXO for the offshore renewable industry, the following sources of guidance are considered most applicable:

- Construction Industry Research & Information Association (CIRIA) – UXO A Guide for the Construction Industry (reference number C681);
- Maritime and Coastguard Agency (MCA);
- British Marine Aggregate Producers Association (BMAPA);
- Health & Safety Executive (HSE).

2.4 Joint Service Explosive Ordnance Disposal Operations Centre, UK

According to Joint Service Explosive Ordnance Disposal Operations Centre (JSEODOC – collocated with one of the British Army's Bomb Disposal Regiments at Didcot, Oxfordshire), UXO discovered during wind farm related operations have presented a problem in the recent past. However, and as yet, there is no clear guidance as to what actions should be taken to

mitigate the risk nor in what circumstances the Ministry of Defence (MoD) might respond. JSEODOC have in the past, directed 6 Alpha to the BMAPA guidance employed for mitigating UXO risk during dredging operations, although this only partly addresses the UXO risk in a wind farm situation.

In summary the pertinent points gathered from the JSEODOC are:

- There is no legal obligation on the Royal Navy (RN) to respond to UXO incidents outside the UK's 12 nautical mile (Nm) limit;
- Each reported UXO find would be risk assessed on a case by case basis;
- The RN response will depend upon the perceived risk and their commitments to other operations;
- If commercial operations are active in an area where there is a "reasonably foreseeable" risk from UXO, then commercial Explosive Ordnance Disposal (EOD) consultancy and/or contracting support should be arranged. However, in terms of offshore cable laying and foundation installation especially, there is no clear indication as to which areas might have a "reasonably foreseeable" UXO risk. (For dredging operations, by comparison, UXO is (generally), evenly distributed over the seabed and thus the associated risk is often cleared and delivered as part of the operating license.

3 UXO Risk and Legal Position

3.1 Introduction

6 Alpha believe our clients need to have a coherent view of what the law is likely to require concerning potential UXO risk, not only to discharge both statutory and tortuous legal duties, but also to protect those that might exposed to UXO risks in the marine environment.

The consideration of the legal position *vis-à-vis* UXO risk on this project is substantively based upon the principles and guidelines employed to assist the UK's Health and Safety Executive (HSE) in its judgment that duty-holders have to reduce risks to As Low As Reasonably Practicable (ALARP).

6 Alpha's interpretation of the HSE guidelines concerning UXO has not been subject to formal legal scrutiny or any form of legal test, nor has been endorsed (formally or informally) by the HSE. Nonetheless we believe that it is accurate and founded upon significant empirical legal research and UXO project management experience.

Ultimately however, it is for the courts to decide whether or not duty-holders have complied with the law, both national, European Union and/or international. The following legal interpretation, the subsequent UXO risk assessment and associated risk mitigation measures upon which they are founded, aim to discharge legal duties in relation to the ALARP principal in general and its applicability to UXO risk in particular.

3.2 Appropriate Legislation, UXO Guidelines and ALARP Application

In the construction/civil engineering arena (in the UK), relevant statutory instruments (with which clients will have to comply) are in general, likely to encompass Heath and Safety at Work legislation (namely the 1974 Act and 1999 Regulations), as well as the Corporate Manslaughter and Corporate Homicide Act of 2007.

Clients also face a common law liability (for negligence and a potential breach of duty) if reasonable steps are not taken to identify and appropriately ameliorate risk posed by UXO.

Additionally, and in particular, the Construction Design and Management (CDM) Regulations 2007 apply as does CIRIA's *UXO – A Guide for the Construction Industry*, the latter providing the first UK "good practice guide", helping developers and the construction industry to deal with UXO. Whilst CIRIA's guide is concerned with UXO risk on land, the same generic principles apply to construction activities in the marine environment, where 6 Alpha's programme and project managers also have extensive experience.

In terms of dealing with UXO hazards and risks, we believe that by applying broad HSE's guidelines in term of risk assessment, risk treatment and risk management together with our own UXO expertise, enables our clients to comply with UK statutory and common law. In addition, if and when this is employed as a legal and technical benchmark (including outside UK territorial waters or overseas), it is also likely to meet with any other reasonable legislation, guidance and standards that might be encountered.

3.3 Determining that UXO Risk has been reduced to ALARP

Determining that UXO risks have been reduced to ALARP involves an assessment of the **UXO risk** to be avoided, of the **sacrifice** (in money, time and effort) involved in taking control measures to avoid or mitigate that risk, and a **comparison** of the two. A diagrammatic representation for meeting with ALARP is presented at Figure 3.3.

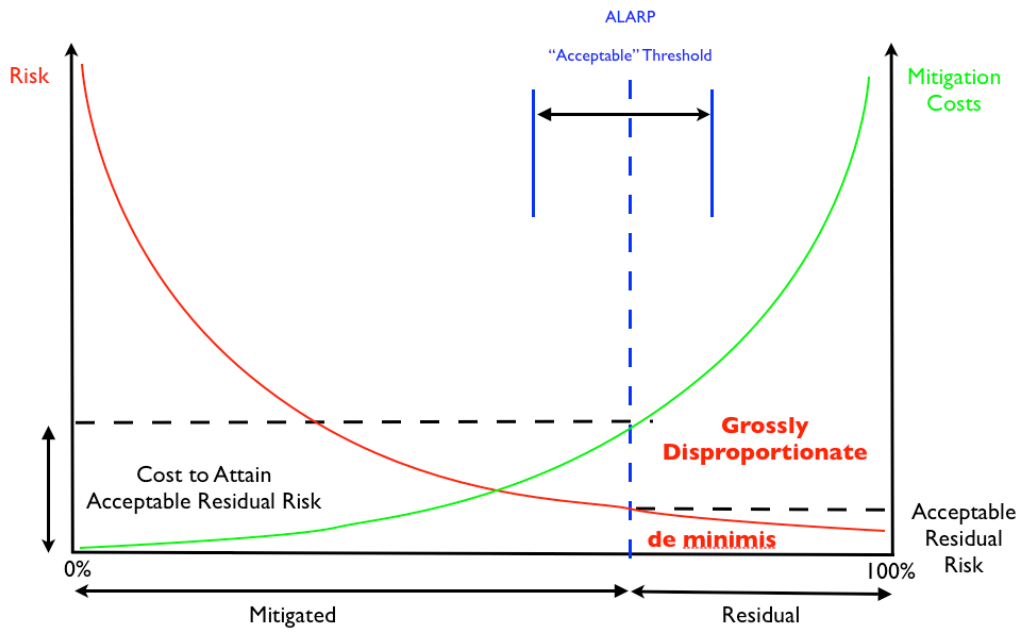


Figure 3.3 – Meeting with the ALARP

This process can involve varying degrees of rigor that will depend on the nature of the UXO hazard, the extent of the risk and the control measures to be adopted. The more systematic the approach, the more rigorous and more transparent it is to any regulator and other interested parties. The greater the initial levels of risk under consideration, the greater the degree of rigor that might be required of the arguments purporting to show that those risks have been reduced to ALARP.

In terms of UXO risk, it is clear that it may present a significant hazard (as death or deaths may be caused), and that the UXO threat should be described and the UXO risk determined

in an open, systematic, rigorous, consistent and transparent way. Similarly, risk control measures should therefore be adopted to demonstrate that the risk has been reduced to ALARP, which can, in accordance with the law (be assessed by addressing the UXO risk and sacrifice, and comparing the two).

3.4 UXO Risk Tolerance

6 Alpha have made certain assumptions about MORL and their individual and collective tolerance for the acceptance of UXO risk. Our assumptions include that there are three interrelated elements to be considered:

- **Corporate Governance** – is the system by which companies are managed and controlled. It is assumed that MORL adhere to the highest international standards of corporate governance. Discharge of corporate responsibility is expected to be on risk-based criteria and it is expected that MORL will have in place a framework for managing risk for good governance. It is anticipated that safety and risk management are integrated in the business culture.
- **Risk Management** – MORL will expect the highest standard of risk and safety management to be applied to this project. MORL will have a risk management system in place for responding to business, programme and project risks. Any risks posed by UXO will have to be assessed based upon probability and consequence criteria. High rated UXO risks will have to be avoided or otherwise mitigated not only in accordance with the law but also with best proactive risk management guidelines. MORL will not only rely upon 6 Alpha's professionalism and independence to identify UXO risks but also to design appropriate UXO risk management solutions in accordance with the law in general and the ALARP principle in particular; and to warrant that the UXO risk mitigation contractors responsible for the subsequent execution of those works, perform to appropriate quality and best practice standards.
- **Safety** – we assume that safety will be the highest priority for MORL on this project. Personnel safety will assume the highest priority; the protection and preservation of equipment, property and the environment, whilst highly important, will remain subservient to personnel safety.

4 Moray Firth Offshore Wind Farm

4.1 Background

MORL have been awarded the exclusive rights to develop offshore wind farm sites within the Crown Estate's Round 3 Offshore Wind zone for Moray Firth, (and see Appendix 1), which aims to deliver 1.4 – 1.5GW (target capacity), of offshore wind power.

4.2 Site Definition

The zone is located on the Smith Bank in the Moray Firth, off the northeast coast of Scotland and covers an area of 520 Km^2. It is located approximately 25 km southeast of the Caithness coast and has water depths ranging form 30-60 m.

4.3 Site Considerations

The client has divided the site into two development zones: east and west, (and see Appendix 2).

5 Proposed Intrusive Works

5.1 Marine Site Investigation

As part of the initial concession survey, as is good practice in all offshore renewable projects, geophysical and/or geotechnical work has been undertaken at this development.

5.1.1 Geophysical Survey

In terms of geophysical survey, the methodology generally employs remote and direct sensing (eg swathe bathymetry, sub-bottom profiling (aka “pinger”), and Side Scan Sonar (SSS)), all of which use the reflection or refraction of energy sources to generate data that can be interpreted to provide a “picture” of the seabed. Whilst it might be theoretically possible that some of these energy sources could initiate very sensitive marine explosive ordnance, it is considered practically impossible to do so. Furthermore, there is no evidence of historic UXO in the marine environment (or elsewhere), being initiated by conventional methods of marine geophysical survey.

5.1.2 Geotechnical Survey

Marine geotechnical survey methods (eg Bore-Holing (BH) and Cone Penetrometry (CPT) techniques), employ kinetic energy to invasively penetrate the sea-bed. Such techniques are capable of initiating UXO, especially if it comes in to direct contact wit the leading edge of the equipment.

Similarly, some platforms employed (eg jack-up barges) may deploy legs which also deliver significant kinetic energy and which themselves might also initiate UXO.

5.2 Marine Cable Installation

It is expected that an export cable will connect the wind turbine array to the Scottish mainland; in addition there will be a number if inter array cables between the turbines. Given empirical evidence it is conceivable that potential interaction with UXO may occur during the following installation operations:

5.2.1 Pre-Lay Grapnel Run (PLGR)

PLGRs are used to prove that the route is clear of disused cables or scrap. It will involve towing a heavy grapnel iron(s) along the route and may encounter UXO that is either shallow buried or on the seabed surface. In such circumstances, and depending upon the types of UXO that might be encountered and their position on (or in) the sea bed, the PLGR might be

considered as a method of partially ameliorating UXO risk, in advance of subsequent intrusive engineering works (especially cable trenching and foundation installation).

5.2.2 Cable Trenching

Cable trenching is often employed to lay, and to concurrently bury the export cable. Although cable plough will often be preceded by a PLGR, the cable installation operation can be conducted by a variety of installation methodologies, which will be influenced primarily by water depths and seabed conditions. Cable ploughs can generate significant forces, which are considered sufficient to initiate sensitive items of UXO that they encounter directly.

5.2.3 Cable Jetting

Cable jetting is often employed to install inter-array cables, especially where there is a mobile seabed or relatively soft sediment, which would not require a plough to bury the cables. Water jetting is considered a more benign and less aggressive installation methodology (as compared with cable ploughing), and therefore be less likely to inadvertently initiate UXO.

5.2.4 Deployment of Barge Anchors

In areas where the water depth is less than 10m a cable plough may be deployed from a moored cable-laying vessel. Anchors are required to stabilise the vessel and to give it sufficient counter-force to plough in the cable. The anchor spread will facilities this and the anchors will generally be positioned using a tugboat.

5.3 Wind Turbine Installation

5.3.1 Foundations

Although the wind turbine foundation design has not been confirmed at this early stage of the project, they are expected to be either monopiles, suction bucket, gravity base structure, pin piles or similar. Whatever type is selected, a specialist vessel employing significant kinetic energy is usually employed to install them.

Whatever foundation techniques are employed the key factor, concerning UXO risk, is the resultant kinetic energy employed which, regardless of technique, might be sufficient to initiate any UXO in the immediate vicinity.

Once the foundation design has been scoped, perhaps at the conceptual engineering phase 6 Alpha will be in a better informed position to advise about the nature of the potential risks risk that might be encountered and how they might be ameliorated.

5.3.2 Scour Protection Systems

It is expected that the wind turbine foundations will require some form of anti-scour protection system in the form of either static or dynamic rock armour. Rock is usually emplaced after turbine installation works and inter array cabling work is complete. The type and extent of anti-scour protection depends upon the soil and sea conditions and type of foundations employed; other types may be employed that will involve interaction and intrusion into the seabed. Subject to the type and installation method employed and the associated kinetic energy is generated, it might also be considered sufficient to initiate UXO.

6 Sources of UXO Contamination - Marine

6.1 General

6 Alpha have undertaken detailed archive research to support this project, and after analysing the datasets it is envisaged that there are six principle potential sources of UXO contamination that may influence the project, which are presented at Table 6.1.

Study Area	Area Bombed	Axis Minefields	Allied Sea Minefields	Military Training Ranges	Munitions Related Shipwrecks	Munitions Disposal
All Zones	**Yes**; allied aircraft attacked at least one U Boat in the region – but outside of the project boundary - sinking it with depth charges on 26th June 1944. It is known that axis aircraft bombed allied shipping in this region in 1939 and 1940.	**Yes**; mine laying in the region in WWI. HMS Lynx was sunk by an Axis mine in 1915. Axis mine-laying in WWII not recorded; sporadic mine laying by U-Boat and air likely.	**Yes**; 463 mines were laid in WWI (1916) within 20Nm of the site to counter U-Boats. Approx, 5,600 mines were laid in WWII (1940-42) within 30Nm-46Nm of the site to counter U-Boats (and general invasion).	**Yes**; WWII RN, Army and RAF training ranges (torpedoes, AAA and bombing respectively). Current; Army and RAF training ranges (incl. SAA firing; UXO Dmls (latter land); gunnery; missiles; torpedoes; air to air firing.	**Yes**; there are 7 ship wrecks in the region. 6 of them were sunk by either mines, torpedoes; gunfire or bombing. 4 of them are within the site boundary. Once wreck (HMS Lynx) contains some UXO & it is located on the periphery of area.	**Yes**; sea mines were cleared post WWII. It is suspected that some sea mines may remain in place in the general region because clearance techniques were ineffective and uncertain. Mines may have migrated to site.

Table 6.1 – UXO threats to the Study Areas (within 500m of the Site)

The details of all summarised UXO threats are described in detail subsequently.

6.2 British Military Activities (20th Century to Current)

6.2.1 WWII Armament and Training Areas

The range areas employed in WWII have been geo-referenced from historical data sets; they are presented at *Appendix 03* and summarised in table 6.2.1.

Range Number	Name	Facility	Distance (to the Main Array Site)
N233	Fearn (Sandwick Bay)	Royal Navy - Anti Aircraft Artillery (AAA) - Light	27 Nm (50Km)
N220	Moray Firth North	Royal Navy - Torpedo Running From Aircraft	Encroaches
N229	Moray Firth South	Royal Navy - Torpedo Running From Aircraft	2Nm/4Km
A318	Strathlene Links	Army - (AAA) - Heavy and Light	9Nm/17Km
127A	Spey Bay	RAF - Live Bombing	2Nm/9Km

Table 6.2.1 – WWII Armament Training Areas in Proximity of the Project
(Distances are Approximate and measure to the nearest edge of the concession boundary).

Because of its encroachment into the south-west corner of the main array site, Range N220 is considered potentially significant, because of the threat posed by air delivered torpedoes. Similarly, ranges N229 and 127A are in relatively close proximity (approximately 2Nm/4Km and 5Nm/9Km respectively) and it is considered possible that high NEQ items of UXO may have migrated to site (especially iron bombs from 127A, which is the closest to the periphery of the site). Clearly, the direction of the export cable route may also have a significant bearing upon sorts of UXO threats that might be posed, especially if the route passes through a former armament range.

Generally, the other armament training areas (N233 and A318) are considered less significant sources of threat to the main array site because:

- Most live or practice items are considered too far away (between 17 – 50Km) to have drifted to site in significant numbers;
- Those that might drift are considered to be in sufficiently small numbers to present a low level of threat.
- The ordnance is generally sufficiently small (in terms of NEQ) to present a low level of threat;
- A proportion of UXO that might be generated may be of training (rather than live) natures, thus some may be relatively benign.

6.2.2 Current Armament and Training Areas

The current armament and training areas have been geo-referenced from current data sets; they are presented at *Appendix 04* and summarised in table 6.2.2.

Range Number	Name	Facility	Distance (to the Main Array Site)
X5072	Binhill	Army – Firing	19Nm (35Km)
X5819	Old Wick	Army – Firing	12Nm/22Km
D702	Fort George	Army – Firing & UXO Demolition	40Nm/74Km
DS809(S)	Moray Firth - South	RAF: High and Low Angle Gunnery (ground to ground): Air to Air firing; Air General; Air to Surface Firing; HM Ships: non-firing exercises, practice and trials; Pilotless Target Aircraft; Torpedo Firing.	9Nm/17Km
DS809(C)	Moray Firth - Central	RAF: High and Low Angle Gunnery (ground to ground); Air to Air firing; Air General; Air to Surface Firing; HM Ships: non-firing exercises, practice and trials; Pilotless Target Aircraft; Torpedo Firing.	Encroaches
D712C	Northern MDA	Air Combat Training; High Energy Manouvers.	2.2Nm approx.
D703	Tain	RAF; Practice Bombing (up to 1,000lb); Strafe up to 30mm; Rocket Projectiles; (On Land: Small Arms; General Purpose Machine Gun (GPMG - Sustained Fire); EOD Demolitions).	9Nm/17Km
D807	Moray Firth	RAF: Bombing; Firing; Radar Training Buoy.	Encroaches

Table 6.2.2 – WWII Armament Training Areas in Proximity of the Project
(Distances are Approximate and measure to the nearest edge of the concession boundary).

Because of their significant encroachment into the central region the site D807 and D809S are considered potentially significant, not only because of their encroachment but also because of the threat posed by the employment RAF weapons generally (including gunnery and torpedo firing).

Whilst ranges D809S and D807 have been employed for similar purposes (the former range especially), they are considered sufficiently far enough away to pose a reduced degree of UXO threat (and *de facto* risk).

Clearly, the direction of the export cable route may also have a significant bearing upon types of UXO threats that might be posed by the other ranges in this category, especially as the cable reaches landfall.

6.2.3 Munition / Explosives Disposal

Although both chemical and conventional munitions were extensively dumped at sea off the UK coast following WWI and WWII, our research has not discovered any specific evidence for munitions dumping either within or close to the concession boundary.

Whilst the locations of some of these areas are well known (as are the type and numbers of munitions deposited), in other areas there are problems concerning accuracy of types and numbers dumped. This inaccuracy has been incurred because of a combination of factors including; inadequate record keeping, the dumping of items outside designated official dumping areas; and, to an extent, the movement of munitions post dumping as the result of tidal flow.

6.3 Allied Sea Minefields

A naval mine is a self-contained explosive device placed in the water to destroy ships and/or submarines. They are fused so that they are detonated by the close proximity (or in some cases contact with) a ship. Naval mines can be employed offensively, to hamper enemy shipping and e.g. lock it into it's harbour; or defensively, e.g. to protect Allied shipping and create "safe" movement zones. A figure, showing a range of WWI and WWII "marine UXO threats", including deep sea mines off the Scottish Coast is presented and geo-referenced from historical data sets at Appendix 05 (6 Alpha UK Map).

6.3.1 WWI Minefields

In 1915 the east coast of Scotland was subject to U-Boat attack; natural headlands were a favoured U-Boat hunting ground because such features not only enabled easier navigation but also provided plentiful opportunities to attack unescorted allied shipping. As a result barrier minefields were laid to defend against such attacks.

Records of mine laying from WWI are relatively poor (as compared with the quality and accuracy of those from WWII), but according to official Royal Naval records, in excess of 69,000 British mines were deployed a defensive barrier, in deep water (i.e. between 45ft (13m) and 240ft (73m)), off the Scottish coast (but at distances in excess 35Nm from the project boundary).

Closer to shore (as depicted and geo-referenced from historical data sets at Appendix 06), up to 463 sea mines were laid in June 1916 in three minefields, which were located off Lybster, Tarbtness and Lossiemouth. The WWI minefields are located approximately 10Nm to 20Nm to the west of the concession boundary.

6.3.2 WWII Minefields

As a result of Axis sea mining activity, proposals were made in November 1939 to mine the North Sea. These proposals considered the likely effect on fishing as well as the requirement to provide mine-cleared sea-channels for British, Dutch and Belgian shipping. The WWII minefields are located approximately 30Nm to 46Nm the east of the concession boundary (as depicted and geo-referenced from historical data sets at Appendix 07). In comparison with WWI records the details of mine lays in WWII are more comprehensive, and the details of each mine lay is summarised in *Table 6.3.2*.

Mine Lay Number (Date Month/Year)	Number of Mines (Approx Length)	Mine / Sinker	Depth Below Chart Datum (feet/meters)
PA1A (Jan 1940)	240 (6Nm)	H2/ VIII	78-79 feet (24m)
PA2B (Mar 1940)	330 (8.5Nm)	H2/ VIII	90 feet (27m)
PA3C (Mar 1940)	150 (3.8Nm)	H2/ VIII	90 feet (27m)
PA4D (Mar 1940)	180 (17Nm)	H2/ VIII	86 feet (26m)
SN12 (Aug 1940)	2092 (52Nm)	MXIV/XV & XX/XVII	10-12 feet (4m)
SN15A (Jan 1942)	1778 (45Nm)	XX/XVII	7-11 feet (3m)
SN15B (Jan 1942)	842 (20Nm)	XX/XVII	10 feet (3m)

Table 6.3.2 – WWII Mine Lays in the Moray Firth

6.3.3 Mine Clearance

Historical Admiralty mapping confirms that minefields that had been situated off the north-eastern British coast were cleared post-WWII, and there was a significant sea-mine clearance operation undertaken by both Allied and German Navies, who attempted to clear their respective minefields. Whether all those mines that were recorded as being laid, were *de facto* recovered during clearance, could not be confirmed (it should be noted that 100% clearance of minefields, even with today's technology, is not always achievable).

The clearance operation was undertaken by one of two methods:

- Using two minesweepers, a sweep-wire (with a serrated edge and an "otter" or "kite" to keep the sweep wire at the required depth), was laid into the water and both ends were attached to a winch at the stern of each ship. The sweep-wire was towed by both vessels over a mined area and, when connected to the "mooring stay" of a moored mine, the ships momentum would then force the stay to the serrated edge of the sweep wire, which cut it. The mine would then (usually), float to the surface for disposal;
- An alternative method was to use one ship only with the sweep wire attached to an oropesa float (to keep the sweep wire away from the ships), and the wire would then cut the mooring stay of the mine (as described above). The untethered mine would then (usually) float to the surface for disposal.

6.3.4 Mine Clearance Analysis

Mine disposal was often by rifle fire however, on occasions, the rifle bullet only penetrated the outer casing of the mine, which allowed water to ingress and it would then sink and come to rest on the sea bed; an explosive hazard thus remained. Some historical sources suggest that up to 70% of sea mines were not recovered after WWII; based upon that (worst case) statistic, approximately 340 WWI mines and up to 3,900 WWII mines might not have been cleared.

Whilst wartime sea mines undoubtedly pose a potential residual hazard, it is not possible to say how many - if any - might be located with the concession boundary. Certainly, not all of the mines were laid close to the concession boundary (especially the longer minefield lays i.e. SN15A and SN12, which also contained the highest number of mines). Discounting, for purposes of simple analysis, SN15A and SN12 (which were the furthest away and therefore would have the longest distance to migrate west), then up to 1200 WWII mines, plus 340 WWI mines, - total 1540 mines - may have remained in the region (i.e. up to 30Nm away) post WII clearance.

6.4 Aerial Bombing Campaign

6.4.1 Overview

Limited bombing occurred during WWI, as the main German threat in the marine environment were U-Boats. With the development of aircraft and air delivered weaponry, aerial bombardment became an important phase prior to any possible invasion during WWII. During the early stages of the war, Britain was continuously bombed between 1940 and 1943. Strategic targets along the coastlines of Britain included ports, docks, shipping lanes and power stations.

6.4.2 Shipping Lanes, Sea Convoy Routes and Ports

The east coast ports were important commercially and, as WWII progressed, they achieved strategic importance for the transport of coal, as well as for fishing (which was considered key to helping feed the UK's wartime population). A military lesson learned during WWI was implemented, namely the gathering of merchant ships into convoys for protection. Notwithstanding the Royal Navy's attempts to protect convoys, they were regularly attacked from the air. The Luftwaffe also dropped thousands of HE bombs on these convoys and regularly targeted other vessels as the opportunity arose. Details concerning this site are described more specifically at 6.5 below.

6.4.3 Tip and Run

Given that the RAF occupied a number of airfields in the area during WWII, it is likely that they were attacked and/or that air-to-air battles also occurred over the region. Some of those battles may have which resulted in allied and enemy aircraft jettisoning all or part of their payloads i.e. *inter alia* medium and large capacity, UXBs (a tactic known as "Tip and Run"), either in an attempt to escape their pursuers, or to quickly offload weapons from damaged aircraft, before returning to base. Although records of these events are poor, the threat of encountering jettisoned munitions in the sea must be considered an unquantifiable risk, when assessing the background UXO threat for all areas in the North Sea in general and for the Moray Firth in particular.

6.4.4 Defensive Anti Aircraft Artillery (AAA)

There were two types of AAA battery deployed during WWII; heavy and light. These weapons were deployed on the ranges along the east coast.

Heavy batteries were static and usually sited in the same position for the duration of the war. They deployed either 4.5 or 3.7 inch guns in groups of 2, 4, 6 or 8 guns per battery. Typically heavy battery was divided between two sites each with four guns and up to several miles apart. The 4.5 inch gun could fire a HE shell (weighing approximately 25kg and fitted with either a barometric or time fuze) 8 miles in 50 seconds. The 3.7 inch gun had a similar ceiling height but smaller calibre shell, again with barometric or time fuzes.

The light batteries were deployed with the 40mm Bofors gun. This weapon could fire up to 120 x 40mm HE shells per minute to approximately 6,000ft; the shells were designed to explode on impact with enemy aircraft. These batteries were not static and could be moved easily to new positions by truck when required.

The Royal Navy and Army both had WWII AAA ranges in the region (at Sandwick bay and Strathlene Links respectively), the details of which have been presented separately at paragraph 6.2.2. Given the proximity of RAF and other military bases in the region during WWII, AAA fire will have been directed at Axis aircraft as they approach over land and sea. If AAA shells failed to explode or strike an aircraft they would eventually fall back to land or sea, settling on the seabed in the latter case, presenting a potential UXO hazard

Naval and merchant vessels are also commonly equipped with various types of deck guns to protect themselves against enemy air attack. If projectiles or AAA fire missed the target, then they could fall into the sea (or over land), and may still present a potential UXO hazard.

Records of land and sea based AAA training and defensive activities of this activity are scant and therefore AAA UXO should be considered as a part of the residual "background" UXO risk.

6.5 Shipwrecks / Downed Aircraft

Shipwrecks in the zone indicate/confirm that the following military activity has taken place within the project boundary:

- Aerial bombing;
- Both Allied and Axis sea mine laying;
- Naval combat utilising torpedoes;
- Additionally, the specific deployment of Allied depth charges been recorded outside the project boundary).

Both merchant and naval vessels that were sunk in WWII may have contained munitions. Empirical evidence has shown that munitions did spill from the ships as they sank and subsequently broke-up. Similarly, aircraft that were shot down or otherwise had to ditch into the sea, may have also contained munitions. In general, the risk of munitions contamination is somewhat reduced in the vicinity of wrecks (as compared with munitions dump-sites), because the munitions within the body of wrecks generally remain enclosed and immobile. However, it may be possible that some might have been thrown clear of the vessel as it sank or they could become exposed and migrated as the wrecks gradually broke up.

There are number of wrecks that may potentially impact upon the project; there is specific evidence that 7 ships were sunk by variously, gunfire, bombing, torpedo and sea mines, near the site boundary (3 wrecks are within the boundary and two are on its periphery); their locations have been and geo-referenced from historical data sets and are presented at *Appendix 8*) and they are summarised in table 6.5:

Wreck Name	Date Sunk	Vessel Type	Weapons Employed (to sink vessel)	UXO Threat?
Sunbeam	1915	Sailing/ Transport	U-Boat attack; captured at first instance and sunk by deck gun subsequently	Not Known
SS Minsk	1940	Supply Ship Steamer Transport	U-Boat attack employing torpedo and deck gun	Not Known
HMS Lynx	1915	Her Majesty's Ship Steamer Destroyer	Axis sea mine – broke vessel in two before or during sinking. (Any munitions therefore might have spilled from wreck).	3 No 4 inch guns; AA Gun; 2 No Torpedo Tubes (Number of associated munitions on board - not known)
Active	1939	Fishing Vessel Trawler	Air launched torpedo attack	Not Known
Llanishen	1940	Steamer Cargo	Bombed– thus air delivered iron bomb – likely to have been 250Kg	Not Known
Carisbrook	1915	Steamer Cargo	U-Boat attack; captured at first instance and sunk by deck gun subsequently	Not Known
Not Known	Not Known	Steamer (Possibly Cargo)	Not Known	Not Known

Table 6.5 – WWI and WWII Wrecks in the Moray Firth

Regardless of the type of weapons system employed to attack the ships it is unlikely that any vessel was sunk in the first exchange of fire and it is entirely feasible that a number of exchanges of fire would have preceded a successful attack. As a result many of the weapons systems employed are likely to have missed the target at first instance. As a result there may also be UXO in the regions of the wrecks.

Standard project procedures are to avoid shipwrecks for both technical and legal reasons, however given the nature of how some of these vessels were sunk, the potential UXO "avoidance zone" should be set at 500m radius (see recommendations section for further comment on this issue, together with an option for potentially reducing this distance).

7 Explosive Threat Items

7.1 General

Having established potential contamination sources, the following generic ordnance groups are considered likely to present a threat to the proposed development. Clearly, some varieties of UXO are likely to be more common within the project area than others. The table at *Appendix 9* provides a schedule of dimensions and explosive quantities for the main threat items.

7.2 Weapon Fill Materials

7.2.1 High Explosives (HE)

A HE compound detonates at rates ranging from 1,000m to 9,000m per second, and may be subdivided into two explosives classes, differentiated by their respective sensitivity:

- **Primary Explosives** – are extremely sensitive to mechanical shock, friction and heat to which they will respond by burning rapidly or detonating. Examples include mercury fulminate and lead azide. This characteristic makes them unsuitable to use as base (i.e. main-fill) explosives in military ordnance. Sensitivity is an important consideration in selecting an explosive for a particular purpose, e.g. the explosive in an armour-piercing projectile must be relatively insensitive, or the shock of impact would cause it to detonate before it penetrated the target.
- **Secondary Explosives** – are relatively insensitive to shock, friction and heat. They may burn when exposed to heat in small-unconfined quantities, although the risk of detonation is always present (especially when they are confined and/or are burnt in bulk). Dynamite, TNT, RDX and HMX are classed as secondary high explosives, which are commonly used as, base explosives in military ordnance. PETN is the benchmark compound; those explosives that are more sensitive than PETN are classed as primary explosives.

7.2.2 Low Explosives

A low explosive is usually a mixture of a combustible substance and an oxidant that decomposes rapidly (in a process akin to very rapid burning and known as deflagration).

Under normal conditions, low explosives undergo deflagration at rates that vary from a few centimetres per second to approximately 400m per second. Low explosives are normally

employed as propellants, included in this group are e.g. gun-powders, pyrotechnics and illumination devices such as marine markers or flares.

7.2.3 Propellants

In ballistics and pyrotechnics, a propellant is a generic name for those chemicals used for propelling projectiles (e.g. artillery shells or mortars) from a weapon system.

Propellants are always chemically different from high explosives (as compared with those used in munitions for “target effect” for example), as they are not designed to release their energy as quickly and as a result do not produce a blasting/shattering effect (such an effect would damage or destroy the weapon platform e.g. gun/howitzer or mortar).

However, some explosive substances can be used both as propellants and as “burster charges”, (e.g. gunpowder), and some of the ingredients of a propellant may be similar to those employed to make explosives. If bulk propellants are confined and burn very rapidly the result can be similar to that witnessed by a (small) high explosive charge. Propellants therefore, remain highly dangerous and can come in various forms e.g. powder or thin sticks and can be contained in pre-formed containers or bags.

A very typical propellant burns very rapidly but controllably and non-explosively, to produce thrust (generated by rapidly expensing gas, generating pressure), and thus accelerating a projectile/rocket from a weapons platform. In this sense, common or well-known propellants include:

- Gun propellants, such as:
    - Gunpowder (black powder);
    - Nitrocellulose-based powders;
    - Cordite;
    - Ballistite;
    - Smokeless powders.
- Compounds, which may be mixed with a solid oxidiser (such as ammonium perchlorate or ammonium nitrate), or a rubber (such as HTPB or PBAN), or a powdered metal (commonly aluminium).

7.3 Artillery Projectiles

Artillery projectiles may be classified and grouped as follows:

- **HE –** High Explosives (HE) are designed to cause damage by combination of high explosive blast and fragmentation;
- **Fragmentation** – designed to be used primarily against personnel;
- **AP and SAP** Armour Piercing (AP) and Semi-Amour Piercing (SAP) shells are always base fuzed and are generally designed for the attack of lightly armoured vehicles, concrete emplacements dug outs etc. they are not intended for heavily armoured targets.
- **Smoke** – Used for the production of smoke screens; various fillings are used, the most common being white phosphorous;
- **Illuminating** – designed to illuminate an area or specific target at night; a burning flare is suspended from a small parachute to provide an intense white light;
- **Practice** – commonly a solid shot fitted with a so-called "spotting charge" which gives an indication of where it lands.

7.4 Torpedoes

Torpedoes were utilised by a range of vessels including submarines and the surface fleet. Unlike sea mines (which are a "mass-weapon" system deployed in order to strike an opportunity target), torpedoes were usually specifically targeted (i.e. fired and/or guided to a known target) rather than deployed in mass.

The guidance systems used in torpedoes are often sophisticated and include homing systems reliant upon *inter alia* acoustic signature. Any power supply in WWII torpedoes is considered expended, and it is therefore highly unlikely that any residual current in fact exists, or that a tiny amount which may still exist, could not still be sufficient to enable the torpedo to function as originally intended.

Whilst it is possible that unexploded torpedoes might be encountered, it is anticipated that their potential discovery is likely to be less frequent than other naval weapons e.g. sea mines.

7.5 Sea Mines

7.5.1 General

Sea mines (which were employed by both sides engaged in WWI and WWII), were designed either to be buoyant or to sink; the former variety tended to be moored but if they were not initiated (or cleared at the end of the war), then they often sank and drifted on the seabed with tides/weather.

Some British mines could be programmed to self neutralise, often by sinking themselves and allowing the ingress of salt water to render the firing circuit inoperable. Although self-neutralising sea mines could not function today as originally designed, the detonators and HE charges remain intact; they are dangerous. Official records also state that not all of the mines had the "sterilisation plugs" fitted to enable self-neutralisation.

Additionally, the detonators in mines are, by design, made from a sensitive explosive compound (often picric-acid based), which remains susceptible to shock to this day, although exposure to saltwater does not generally increase this sensitivity. All WWII vintage sea mines are filled with HE (usually ammonium nitrate and TNT compositions e.g. ammonal or minol), which often remains in sufficiently good condition to detonate, to this day; thus they are dangerous.

7.5.2 Fuzing

Sea mines can be armed with complex fuzing and initiation mechanisms, which fall into 3 main categories:

- **Hydrostatic Fuzing** – A valve that detects the difference in water pressure (i.e. generated by a passing vessel). Some sophisticated German WWII mines had this type of fuzing and were used in the North Sea;
- **Magnetic Fuzing** – A fuze that detects a displacement of the ambient magnetic field, normally by the introduction of a ferrous metal object (such as a passing vessel);
- **Sonar Fuzing** – Based upon a similar principle as radar (i.e. "Doppler Shift'), whereby any "positive shift" (i.e. closing), underwater sonar signal to the sea mine, is interpreted as a potential target vessel and therefore the arming sequence is initiated.

The older generation of moored sea mines were, more commonly, designed to function upon contact with a ship or vessel. The externally mounted chemical horns (or spikes), consisted of a lead outer sheath, which contained two, separated, chemical ampoules. Upon contact, the external horn would crumple, thereby crushing the ampoules and allowing the chemicals to mix. The resultant mixture would immediately produce either an electrical charge or

combustion, forming the basis for an explosive chain-reaction and the detonation of its bulk high explosive.

7.5.3 German Influence Mines

After completing their initial mine campaigns, the German military sought to exploit the potential value of so called “influence mines”, which could be laid by aircraft. The mine was fabricated from aluminum and was cylindrical in shape with a rounded nose. Originally designed as a magnetically triggered sea mine, the two (German) designations were Luftmine A (LMA) and Luftmine B (LMB), which were 500 kg and 1,000 kg masses and 1.7m and 2.6m long, respectively. They were in fact modified land mines, which could be easily modified for deployment by surface craft. Although LM series mines had a range of different initiation devices, the basic design appears to have changed little throughout WWII.

When used as parachute mines they were armed by a clockwork fuze mechanism (although such mechanisms are considered highly unlikely to be working order today, the HE in the adjacent fuzes remain sensitive and potentially, highly dangerous).

They were very widely used by the Germans during WWII with devastating results. The firing system was most commonly initiated by magnetic influence, but acoustic types were also used, sometimes in combination with magnetic influence (i.e. both influences were required to initiate the mine). Later in WWII, water-pressure sensing initiation systems were also developed.

The primarily disadvantage of employing air delivered varieties of influence mines against shipping, was their low rate of descent which was deliberately retarded by parachute; (otherwise they may have broken up upon (un-retarded) impact with the water). It was therefore very difficult to emplace them with any accuracy, eg into shipping lanes. To enhance delivery accuracy, the mines had to be dropped from a relatively low altitude, which made the deploying aircraft more vulnerable to anti-aircraft fire. These problems were probably the main reason for the Luftwaffe’s development of the BM mine series, the first variant of which was dropped in the same manner as a conventional HE bomb ie in free-fall without any retarding features.

7.6 Depth Charges

The depth charge was designed to counter the threat posed by submarines/U-Boats. The generic design resembles a drum containing HE with a hydrostatic fuze, which initiated the main charge at a preset depth (as a result of water pressure). They were fired from the stern or sides of ships (or a combination of both). As the war progressed, the Royal Navy introduced the so-called “Hedgehog” and “Squid” systems, which enabled their depth charge

to be fired forward from the bow the ship (which were also known as forward throwing charges).

Depth charges varied in size (from 55Kg to 300Kg) and consequently the mass of HE of explosive changed to suit the type of target being attacked. Towards the end of WWII the RN were using a "Mark X" depth charge, which contained 1000kg of explosives; they were fired from tubes mounted on the decks of war-ships.

7.7 German Air-Delivered Weapons

7.7.1 Iron Bombs

Generally, most iron (i.e. air –delivered) bombs are of similar generic construction, consisting of a steel container, a fuze or fuses either located in the nose/tail of the bomb or located laterally (though sometimes in combined locations), and a stabilizing device (i.e. the bomb "tail" to aid accurate aerodynamic flight from the aircraft to the target). The steel container (i.e. the bomb body) contains either the HE content (or other contents e.g. sub-munitions).

Iron bombs are designed in broadly similar shapes (with some variations to ogive shape/angle), but in a much wider variety of masses, depending on the intention of the bombing mission and the targets. Iron bombs are generally categorised as follows;

- **General Purpose** – Designed, as the name suggests, to attack a variety of targets and they normally contain an explosive content of approximately 50% of the overall mass of the bomb.
- **Armour Piercing** – Designed to create a mechanically driven entry point in the target prior to detonation, in order to maximise the consequent blast and fragmentation effect. Bunker busting systems, anti-shipping, anti-armoured fighting vehicle and counter-tunnel systems are good examples of the tactical deployment of armour piercing bombs. In general, only 30% of the overall mass contains HE with the remaining 70% made up of steel (in order to maximise penetration and any subsequent fragmentation effect). Armour piercing bombs are always fitted with tail-fuzes.
- **Anti-Submarine** – As the name suggests, primarily designed to attack known underwater targets. These types of bombs are always equipped with a tail fitted hydrostatic fuse and 85 – 90% of the overall mass consists of HE.
- **Incendiary** – These are normally constructed of a thin metal casing containing a thermite (manganese/aluminium) compound. Generally, once the compound is

exposed to oxygen, an instantaneous combustion takes place with the heat generated reaching in excess of 800°C. These bombs were often targeted against high concentrations of industry, general urban development and shipping.

- **Fragmentation** – Fragmentation bombs are normally deployed to maximise the secondary effects of an explosion. The bomb is generally constructed from thick (sometimes segmented), steel, designed to for maximum fragmentation effect. Fragmentation bombs are generally deployed against "soft" unprotected targets.

The larger size high-explosive varieties, were used against shipping i.e. 1,000kg mass and greater, (compared with the smaller bombs (e.g. 50 kg and 250 kg variants), which were often used during "carpet-bombing" campaigns on land).

8 UXO Seabed Penetration, Burial and Migration

8.1 General

When assessing the potential for ordnance to penetrate either the ground or the sea-bed, it is essential to rely on just an empirical, or statistical or arithmetical formula. Experience has shown that a realistic penetration depth is best estimated by considering a blend of the above approaches supplemented by accounts of Explosive Ordnance Disposal Tasks (and thus empirical evidence), wherever possible in the same geographical region and using the same environmental conditions as are expected for the theoretical case.

8.2 Seabed Migration

Munitions can migrate across the seafloor, the main factors concerning the degree of movement concern *inter alia*; the strength and direction of hydrodynamic currents; the overall shape of the weapon (influencing the degree to which UXO are free to move without obstruction); weapon protrusions such as fins and lugs (the latter being employed for suspension from the aircraft in flight); and the UXO position on the seabed (e.g. in either sediment, gradient or a seabed recess), which could significantly impede movement.

After prolonged exposure to saline water and the action of sea, some munitions can break-up or be otherwise rendered ineffective as high explosive devices; others are still discovered (today), in excellent condition. Additionally, munitions tend to gather in seabed depressions (they roll in, but tidal action often has insufficient momentum to roll them out again). In some areas of the North Sea high concentrations of UXO may gather in such natural seabed “sinks”.

8.3 Seabed Burial

Empirical evidence has shown that it is possible for UXO that initially lie on the seabed, to become subsequently buried within the “offshore” environment. This occurs especially where substantial tidal and environmental factors impact seabed conditions e.g. when there are high sedimentation rates, and thus UXO movement (into a seabed depression), and subsequent concealment. Storms and/or exceptional tidal flows could significantly alter the topography of the seabed, and although items of UXO are usually very dense, if they are not moved (as they might during strong tidal flows), they may be concealed easily with the sequential passing of tides and associated sediment movement/deposition.

When establishing the options for UXO risk mitigation it is important to ascertain the level of potential sediment cover in areas of proposed works, and seabed mobility. On this project

areas in the near shore zone (where the export cable is expected to run) are likely to have only limited amounts of sediment cover, with the rockhead being exposed in some areas. Within the array zone seabed mobility is not known although sand wave peaks appear to be small. However it appears that there may be up to 1m of relatively soft sediment over the majority of the array zone.

Clearly, in such circumstances, smaller munitions are more likely to be completely buried (such as AAA or projectiles rather than the larger items of UXO (such as sea mines and iron bombs).

8.4 Seabed Penetration

The presence of a body of water will have a considerable effect on the conventional and expected penetration depth (into the seabed) for air dropped bombs. Bombs behave uniquely as they enter a body of water and their velocity is reduced significantly before the bomb comes into contact and attempts to penetrate the seabed. As a guideline and subject to specific UXO and geotechnical factors, the maximum penetration of a 500kg bomb is unlikely to exceed 1m below seabed level, when at least 10m of water is present (at the time the munition was delivered).

9 UXO Detonations

9.1 Initiation Scenarios

In 'normal' conditions at sea, UXO does not usually spontaneously explode. Ordinarily, high explosive requires the input of a significant amount of energy (usually kinetic energy) to create the conditions for detonation to occur. Although the British Geological Society seismological records suggest that there were 47 spontaneous detonations of dumped munitions in the Beauforts Dyke dumping grounds, between 1992 and 2004, it is possible that these were the result of munitions deteriorating in the salt-water environment (which is in itself unlikely) and/or becoming more sensitive to shock with age (which is more likely).

Notwithstanding this, in the event of UXO discovery within the construction environment, there are a number of potential initiation mechanisms; they are:

- **Direct Impact**; onto the main body of the munition e.g. from the PLGR, jack up barge leg or cable plough;
- **Friction Impact**; initiating the (more sensitive) fuze explosive caused by a number of construction related activities (for example impact from an excavator bucket, piling, or trenching equipment);
- **Over Pressure**; caused by piling that may initiate a hydrostatic fuzed munition (where present and in proximity).

During the 1980's British Royal Navy clearance divers were informed, by technical experts from North Atlantic Treaty Organisation (NATO), that WWII-era munitions, which relied on a capacitor in the firing system, would not retain enough electrical charge to function as designed. Therefore very old items, which rely on magnetic or acoustic fuzing to initiate them, are not considered a threat, although direct impact to these items may generate enough kinetic energy to cause a detonation.

9.2 Detonation Variables

The consequences of munitions detonation have been the subject of a number of studies. It is generally accepted that these consequences depend upon:

- The size of the item and its Net Explosive Quantity (NEQ).
- The proximity of the item to vulnerable equipment (and/or other structures).
- The type of explosive and/or fill (e.g. high explosive, incendiary, or specialist).
- Location of the item which may be:

- Floating on the body of water (buoyant mines only);
- On the seabed;
- On the surface;
- Partially buried;
- Totally buried.

- The construction and structural strength of any vessel, equipments or structures near the site of an explosion.

9.3 Underwater High Explosive Detonations

9.3.1 Underwater Detonation Hazards

When an item of UXO detonations underwater there are four main hazards:

- Fragmentation;
- Blast;
- A pulsing and rising gas bubble;
- A shockwave.

9.3.2 Direct Effects of Ordnance Detonation

If a significantly large high explosive item of UXO detonates underwater (e.g. after close contact with pile, jack up barge leg or trenching equipment), then the effect is very similar to that experienced at the surface. A high order detonation causing blast and fragmentation would certainly destroy mechanical equipment or significantly damage (shatter or buckle) part of a cable plough, for example.

9.3.3 Effect of Explosive Shockwave and Gas Bubble on Supporting Vessels

If a mine or a bomb detonated underwater at some distance from the underside of a floating vessel, fragmentation is not a primary consequence. On detonation of a high explosive charge the explosive gasses rapidly form a rising spherical bubble. The momentum imparted to the water in the early stages enables the water to expand until the pressure in the bubble is far less than the hydrostatic pressure of the surrounding water. A violent contraction therefore takes place, followed by a second expansion (almost as rapid as the first), which may be followed by further expansions and contractions.

Each expansion causes a pressure wave that is propagated outwards throughout the water in all directions. As water is highly incompressible the maximum pressure in the initial

shockwave is very much higher than would occur in either the ground or in air (but the peak pressure is of much shorter duration). Although these shockwaves become gradually weaker as the bubble rises, the origin of those shockwaves (i.e. centre point of the rising bubble) is often closing with the intended target (i.e. the underside of a floating ship), and therefore it still has sufficient energy to cause considerable shock wave damage at significant distance from the point of initiation. It is possible that the energy could be sufficient to damage and sink a vessel.

10 UXO Risk Assessment Factors

10.1 Source – Pathway – Receptor

The threat in this instance must be considered in light of the proposed operations, the intrusive related activities, as well as the impact on key receptors such as personnel, key installations, high-value equipment and the environment.

10.1.1 Source

6 Alpha has considered that the threat is primarily the result of munitions and weaponry used during WWI and WWII, generated through sea and air battles as well as defensive mine laying, resulting in a a variety of potential natures of UXO and/or spilled munitions. A secondary source is post WWII range activities, although a modern day rages tend to employ drill munitions which conation little or no HE (they tend to contain more benign spotting charges which indicate the point of impact).

10.1.2 Pathway

The pathway is described as the route by which the hazard reaches the site personnel. Given the nature of the site, the pathways could be generated during:

- Geotechnical investigation;
- PLGR;
- Marine cable trenching (jetting or ploughing);
- Laying barge anchors;
- Foundation Installation.

10.1.3 Receptors

Sensitive receptors on this site would include:

- Site Investigation Crews.
- Construction Workers/Engineers.
- High-value Equipment.
- Ships/vessels
- Third party shipping/vessels in the immediate vicinity – Note extended safety distances for detonations underwater apply (for reasons we have articulated above).

- Infrastructure and people located along the coastline (close enough to be harmed UXO if was inadvertently detonated). This only expected when approaching shore eg in beaching an export cable.

11 Semi-Quantitative Risk Assessment

11.1 Overview

In undertaking a series of Semi-Quantitative Risk Assessments (SQRA) across the project, we have employed the technical data associated with the items presented within this report and the proposed operation. The following sections outlines transparently the methodology and calculations used in conducting the SQRA for the project. Risk assessment tables are presented separately at *Appendix 10 abc*.

11.2 Risk Rating

For the purposes of this report, Risk (R) is a function of **Probability** of occurrence (P) and **Consequence** of occurrence (C), where R = P x C. In each case, the Probability and Consequence of the identified threats has been assessed on a scale of 1 to 5. (Where 1 = Very Low, & 5 = Very High) based on expert judgement. These ratings are multiplied together to create Risk scores with a maximum of twenty-five. This allows relative weighting and comparison of risk across the project. Colour coding is provided for ease of use, grouping figures in Green as Low Risk, in Yellow as Medium Risk and Red as High Risk.

Probability					
Very High	**5**	5	10	15	20	25
	4	4	8	12	16	20
Medium	**3**	3	6	9	12	15
	2	2	4	6	8	10
Very Low	**1**	1	2	3	4	5
		1	**2**	**3**	**4**	**5**
		Very Low		Medium		Very High
				Consequence		

Table 11.2 – Risk Matrix

11.3 Risk Rating Criteria

It is important that the numerical values assigned to the potential probability and impact of a risk match the risk tolerance of the Client. Table 11.3 outlines the risk rating rationale that has been applied in this analysis:

Risk Rating (P x C)	Grading	Risk Appetite (Tolerance)	Action Required
1-5	**Low**	Tolerable or Partly Tolerable	Little/No specific Risk Mitigation Required. Situation should be monitored. Reactive UXO risk mitigation required during operations, but overall, residual risks are carried.
6 - 12	**Medium**	Intolerable	Advance Mitigation Measures should be considered. Situation should be monitored. Risks to be mitigated subject to the mitigation being reasonable, practical and affordable. Note: High Consequence or High Probability that score as Medium Risk events should be afforded the same status as Highly Intolerable but assessed on a case-by-case basis.
15 - 25	**High**	Highly Intolerable	Risk Mitigation Measures should / will be implemented. All risks to be mitigated.

Table 11.3 – Risk Tolerability Table

The risk levels are used to determine the level of mitigation (see *Appendix 10*) required to reduce the risk to conform with the ALARP principle. In producing the risk mitigation strategy the risk levels are benchmarked against the various degrees of tolerability (shown in Table 11.3 above), in order to determine what degree of risk is considered acceptable.

11.4 Definition of Consequence and Probability

As is accepted practice in formalised Risk Management, the Risk Rating scales are dimensionless, allowing the user to apply these methods to any desired terminology in order to fit their discrete needs.

11.4.1 Consequence

If the key consequence is financial, then 5 on this scale should equate to the amount of money that will either, stop the contract, close the operation, exceed agreed budget or any other defined critical financial figure. The scale then sub-divides that amount into 5 equal portions down to zero financial impact.

If the key impact figure is the loss of a vessel, then 5 on the scale is equal to total loss of the vessel as an operational asset, and the sliding scale represents vessel operational efficiency

loss i.e. 1 = loss of 0% to 20% operational efficiency, while 5 = loss of 81% to 100% operational efficiency.

If the critical impact figure is loss of 50% of operational efficiency, then the scale represents loss of between 0% and 50% in 5 equal steps. This can be applied to any number of scenarios.

The critical consequence associated with UXO however is that associated injury or death. Both are considered unacceptable and therefore such circumstances should be avoided or the risk appropriately managed or otherwise mitigated to ameliorate such a consequence.

11.4.2 Consequences Specific to the Moray Firth Offshore Wind Farm

The detonation consequence assessment assigns a site-specific consequence level to any potential UXO that may be encountered at the site. This is achieved by combining the UXO impact distance from sensitive receptors, the Net Explosive Quantity (NEQ) of the item and, where applicable, the average water depth range (assumed here to be in the region of 45-60m). A rating system for assigning impact levels has been derived based on the expected effects of a detonation event on each of the receptors identified in the project consequence matrix is presented at Table 11.4.2. The expected impacts are ranked from 1 (no significant effect) to 5 (major widespread effects / catastrophic).

Impact Level	NEQ	Expected Consequences			
		Human Health	Plant and Equipment	Vessels	Environment
1	*Low Explosive <10kg & High Explosives <5kg*	Injury requiring medical treatment	No noticeable effect	No noticeable effect	Minor disturbance
2	*High Explosive 5-15kg*	Lost time injury < 3 days	Slight superficial damage	Slight superficial damage	Significant disturbance
3	*High Explosive 15-50kg*	Serious debilitating injury	Minor component replacement repair	Repairs - non-structural	Moderate damage to habitats.
4	*High Explosive 50-250kg*	Localised fatalities	Significant component replacement repair	Repairs – structural	Moderate damage to habitats. Some long term effects.
5	*High Explosive >250kg*	Multiple fatalities over extended area	Unit destruction	Localised structural failure and collapse	Localised destruction of habitats. Moderate long-term effects.

Table 11.4.2 – Consequence Matrix

11.4.3 Probability

The Probability scale is simply the assessed likelihood of an event-taking place. If units are required, then the scale frequently used on Project Risk Registers may be utilised.

11.4.4 Specific to the development of the Moray Firth Offshore Wind Farm

Based on 6 Alpha's significant experience of assessing the probability of UXO contamination, it is not always possible to present an accurate statistical (or purely quantitative) measure, simply because the base data is largely qualitative i.e. it is drawn form a variety of different historical and environmental sources.

However, 6 Alpha's semi-quantitative approach blends together professionally informed judgements made upon empirical, qualitative evidence and introduces a transparent statistical approach which has be successfully employed on a variety of land and marine sites where the environmental context remains relatively constant and the quantity and type of munitions employed, together with expected failure rates, is recorded.

For this purposes of this study the probability levels presented in the matrix at *Table 11.4.4*, (which is specifically tied to the probability of encounter chart presented separately at Appendix 11), which have been employed together to chart and to code the overarching probability ratings for this specific project:

Probability Level	Probability of Encountering UXO	Example seen at Moray Firth
1	Remote	Not seen on this project
2	Possible	Residual background risk based on WWI and WWII activities
3	Likely	Convoy routes which experienced enemy bombing
4	High Likely	Historically Live Bombing Range
5	Almost Certain	Shipwrecks contain munitions

Table 11.4.4 – Probability Matrix

6 Alpha have collated, reviewed and analysed the historical data presented in our desk study and conducted a separate assessment based on the levels in *Table 11.4.4* to produce a chart that demonstrates "probability of UXO encounter" (*Appendix 11*). The chart is an important tool not only in informing the subsequent and associated risk management process but also in helping to reduce risks to As Low as Reasonably Practicable (ALARP), because it visually displays areas as false colours, showing which might require UXO risk mitigation as well as others which might be avoided.

However, there are some limitations associated with practical employment of this chart. Primarily, it should not be used as a "risk chart" as it does not incorporate the construction activities that might be associated with a UXO "encounter". Moreover, it does not consider the complete threat (i.e. net explosive quantity (NEQ) and fuzing) posed by any particular item. Therefore, this chart cannot address the causing and initiation, nor the likely consequences; therefore it only informs one part of the risk process (i.e. part of the probability element); it does not address potential types of encounter nor the potential consequences.

The UXO threat locations and safety buffering have been produced by digitising *inter alia* historical Naval records and/or plotting coordinates provided by third parties. It is possible these activities may have generated a number of inherent inaccuracies. Primarily because much of this data was gathered in a wide variety of circumstances, by different agencies, to different standards, over a long time-frame, some of that data may not be accurate or as

detailed as 6 Alpha would like. Nonetheless, this data is the best that can be obtained and although 6 Alpha have relied upon it, we are not responsible for any inaccuracies that it might contain.

Notwithstanding this, 6 Alpha have taken all reasonable care to ensure that all base data employed is as accurate as possible and any potential inaccuracies have been taken into consideration in the final “probability” buffering. Moreover, UXO buffer areas also take into consideration potential for drift/movement since the time of UXO placement.

12 Recommended Risk Mitigation

12.1 Overview

In view of the UXO risk in this region and the proposed engineering works, 6 Alpha has designed the following mitigation strategy to reduce the risk to a level that conforms with the legal ALARP principle. This strategy has been developed in order to fully address the UXO risk across the entire development site (exempt export cabling which has not been specifically considered at this stage), whilst working within critical operational and time limitations.

6 Alpha believes that avoidance of potential risk items is the key to successful UXO risk management in this environment. By adhering to robust procedures and operational guidelines the impact to the ongoing development can be significantly reduced. We recommend that due to the nature of the sinking of some of these vessels, a baseline avoidance zone of 500m radius should be set around shipwrecks, for both technical and legal reasons.

However, the risk from UXO could never be considered '"zero" in the offshore environment, as there is always the potential for UXO migration through natural sedimentation and transportation. Therefore 6 Alpha recommend that the time between any proactive mitigation works and the proposed construction works is minimised (within reasonable operational constraints).

12.2 Quality Assurance / Quality Control

Given the scope of the overall strategy and the need to undertake real-time decisions during various phases of the project, 6 Alpha recommend that a QA/QC UXO Specialist is deployed to oversee key elements of the UXO risk mitigation work. 6 Alpha's view is that given the significant cost and potential implications on site associated with undertaking UXO risk mitigation measures, the presence of a QA/QC representative is essential in order to ensure quick informative decisions are made concerning the UXO Risk Management tactics (and potential strategy impact), and then report those findings directly to the client, wider project team and relevant authorities, in order to ensure that the highest quality of work is always being delivered at best client value.

12.3 Marine Operations – UXO Probabaility and Risk Mitigastion

12.3.1 UXO Risk - Overview

At first sight, the general level of UXO contamination and potential for its encounter during wind farm construction activities at this site may appear daunting. However, whilst UXO undoubtedly poses a risk across the development, it is not uncommon and it has been encountered on a high proportion of wind farm developments in the North Sea.

Therefore, the presence of UXO should not present a barrier to development although there is requirement to better quantify the risk by reviewing the possible types (including size and mass and density) of UXO contamination and reviewing the available information from previous geophysical, geotechnical and/or clearance surveys to determine the remaining/residual risk. In high risk areas no intrusive works should be undertaken without the location being properly cleared, however, it is usual practice to investigate possible ground investigation and/or structural locations before undertaking work. It is important to ensure this sort of investigation is correctly specified in order to ensure that when the survey instruments are deployed they can identify the anticipated munitions that are expected to be in the threat spectrum. If this investigation identifies munitions then the holistic risk mitigation options can be taken, including:

- Technically assess the nature of the UXO together with the nature of the proposed operations (eg an encounter of most natures of small arms ammunition are unliley to pose a risk to foundation installation or cable jetting/ploughing;
- Wherever possible rerouting should be employed to avoid survey anomalies that might be associated with dangerous items of UXO;
- Relocate to works to areas which appear less risky;
- If rerouting or relocation is neither practical nor possible, then conduct either diver investigation or ROV inspection, which might either discount the item or lead to UXO disposal.

Drawing upon 6 Alpha's considerable experience in this sector, the risks can be managed throughout the construction phase in general (and the foundation, inter-array and export cable installation phases in particular). By employing the proven risk management techniques we have described in general (and in section 12.3.2 in particular), those risks can be managed and reduced to ALARP, at best value.

The potential presence of UXO and the associated hazard it might pose should not be considered a barrier to wind farm development.

12.3.2 UXO Probability Grading - Overview

Red Zones (Rated 5); prior to undertaking any site investigation or positioning of the turbine locations and cable routes, the "*Almost Certain"* threat area as displayed at *Appendix 11* coloured red (and rated 5), should be avoided.

6 Alpha draw specific attention to the "munitions" related shipwreck (HMS Lynx - shown as a "red" spot) is outside of the concession area, it is on its periphery and should be avoided.

Orange Zones (Rated 4); prior to undertaking any site investigation or positioning of the turbine locations and cable routes, the "*Highly Likely "* threat area as displayed at *Appendix 11* coloured orange (and rated 4) should be subject to the following risk mitigation options, in priority order:

- Option 1 - Conduct a UXO Specific Geophysical Survey and avoid targets. This survey should be designed to match the defined UXO threat and provide 100% coverage of specific threat area;
- Option 2 – Relocate works to areas with a grading 2 or 3;
- Option 3 – If target avoidance not possible conduct either diver investigation or ROV inspection, which may discount the item or lead to UXO disposal.

6 Alpha draw specific attention to the semi-circular "orange" zone in the southeastern section of the site. The threat is driven by the presence of historically live bombing ranges i.e. current military range D807 (and see Appendix 04) and WWII Armament Range 127A (and see Appendix 03).

Yellow Zones (Rated 3); prior to undertaking any site investigation or positioning of the turbine locations and cable routes, the "*Likely "* threat area as displayed at *Appendix 11* coloured yellow (and rated 3) should be subject to the following risk mitigation options, in priority order:

- Option 1 - Conduct a UXO Specific Geophysical Survey and avoid targets. This survey should be designed to match the defined UXO threat and provide 100% coverage of specific threat area;
- Option 2 – Relocate works to areas with a grading of 2;
- Option 3 – If target avoidance not possible conduct either diver investigation or ROV inspection, which may discount the item or lead to UXO disposal.

6 Alpha draw specific attention to two "yellow" zones; the first is located to the east the threat is driven by the presence current range activities at "D809 South"; the second is to the west and the threat is driven by a former WWII armament range N228.

Green Zones (Rated 2); prior to undertaking any site investigation or positioning of the turbine locations and cable routes, the "*Possible"* threat area as displayed at *Appendix 11* coloured green (and rated 2), should be subject to the following risk mitigation option: wherever possible, existing geophysical datasets for UXO risk reduction. Define smallest UXO threat items, interpret the datasets for contacts similar to UXO and avoid during future works.

6 Alpha draw specific attention to one central "green" zone; it is considered to have background residual UXO threat of encounter driven the general wartime and subsequent military training activities in the region.

12.3.3 UXO Risk Mitigation Options - Summary

6 Alpha have recommended that the following actions are required to address the UXO risk. This table should be read in conjunction with the "probability of UXO encounter map" at *Appendix 11*.

UXO Probability Encounter Rating	Grading	Action Required ahead of Intrusive Works	Associated Additional Costs Low High
1-2	**Remote - Possible**	Areas defined as "background residual risk". Use, wherever possible, existing geophysical datasets for UXO risk reduction. Define smallest UXO threat items, interpret the datasets for contacts similar to UXO and avoid during future works. **6 Alpha Deliverable** - Client's must accept that this is not a 100% survey coverage for UXO, although if conducted by 6 Alpha the risk will be reduced to ALARP.	
3-4	**Likely - Highly Likely**	Areas which display a specific significant threat, there are three options for dealing with the risk in these areas: • **Option 1** - Conduct a UXO Specific Geophysical Survey and avoid targets. This survey should be designed to match the defined UXO threat and provide 100% coverage of specific threat area; • **Option 2** – Relocate works to areas with a grading of 1 or 2; • **Option 3** – If target avoidance not possible conduct either diver investigation or ROV inspection, which may discount the item or lead to UXO disposal. **6 Alpha Deliverable** - Once the UXO risk reduction actions have been successfully implemented and subject to our own QA/QC measures, 6 Alpha will sign-off the UXO risk as ALARP.	
5	**Almost Certain**	6 Alpha would strongly suggest avoiding these areas, and relocation work. As the costs associated reducing the risk to ALARP are likely to be considerable.	

Table 12.3.2 – Recommended UXO Risk Mitigation

13 Conclusions

13.1 Key Findings

In terms of UXO threat, this report has demonstrate that the UXO threat is primarily the result of munitions and weaponry employed during WWI and WWII; this includes in priority order sea-dumped explosives/munitions, shipwrecks and sea mines.

Military artillery ranges are recorded within the general region however given the nature of these operations and the type of munitions used 6 Alpha does not consider that this source will pose a significant threat to the project. This has been reflected in the SQRA tables presented at *Appendix 11*. It is conceivable that live HE items would have been fired out to sea (from land based weapons platforms) and a proportion of UXO could still be present in the area today. However, 6 Alpha's view is that there is only a remote chance that a grappling iron or cable plough would both strike and then initiate a projectile. Moreover, even if the unlikely but worst case scenario did occur (i.e. the item was struck on the fuze causing its initiation), the Net Explosive Quantity (NEQ) within these relatively small projectiles is highly unlikely to have any direct effect on the vessel itself or crew, especially as the grappling irons or plough would be towed at a significant distance from the vessel in sufficiently deep water to contain any HE blast or associated fragmentation.

The maximum penetration of a 500kg bomb along this route is not likely to exceed 1.0m below seabed level. It is conceivable that, if present, any bombs, mines, torpedoes and parachute mines would be on or just below the seabed.

Due to the relatively slow tidal movement within the North Sea, tides are likely to have a minimal short-term effect on seabed munitions movement. In the coastal areas, however, there may be sufficient tidal flow to move threat items either into, or out of, the proposed project area. Therefore it would be prudent to assume that items are still in the process of migration, although the magnitude is likely to negligible. Importantly, targets identified (potentially as UXO) may have moved since the time of the geophysical survey, in addition to new items being introduced via migration along the route of the cables.

Where detonation occurs underwater, potential damage may result from direct fragmentation as well as the pulsing gas bubble and its resultant shock wave. The main consequence depending upon water depth is likely to include injury to personnel and damage to installation vessels, and associated support vessels and equipment. Given typical water depths seen in the area, assumed to be between <10 to >55m, a reasonable and practical working

assumption is that any UXO which has a charge weight of 40kg or greater, is capable of causing significant damage.

As many of the sea mines and bombs that may be encountered have a NEQ of around 100kg or greater, the effect of them detonating (even on the seabed), is likely to be catastrophic, and remain extremely serious in the deeper waters.

Appendices

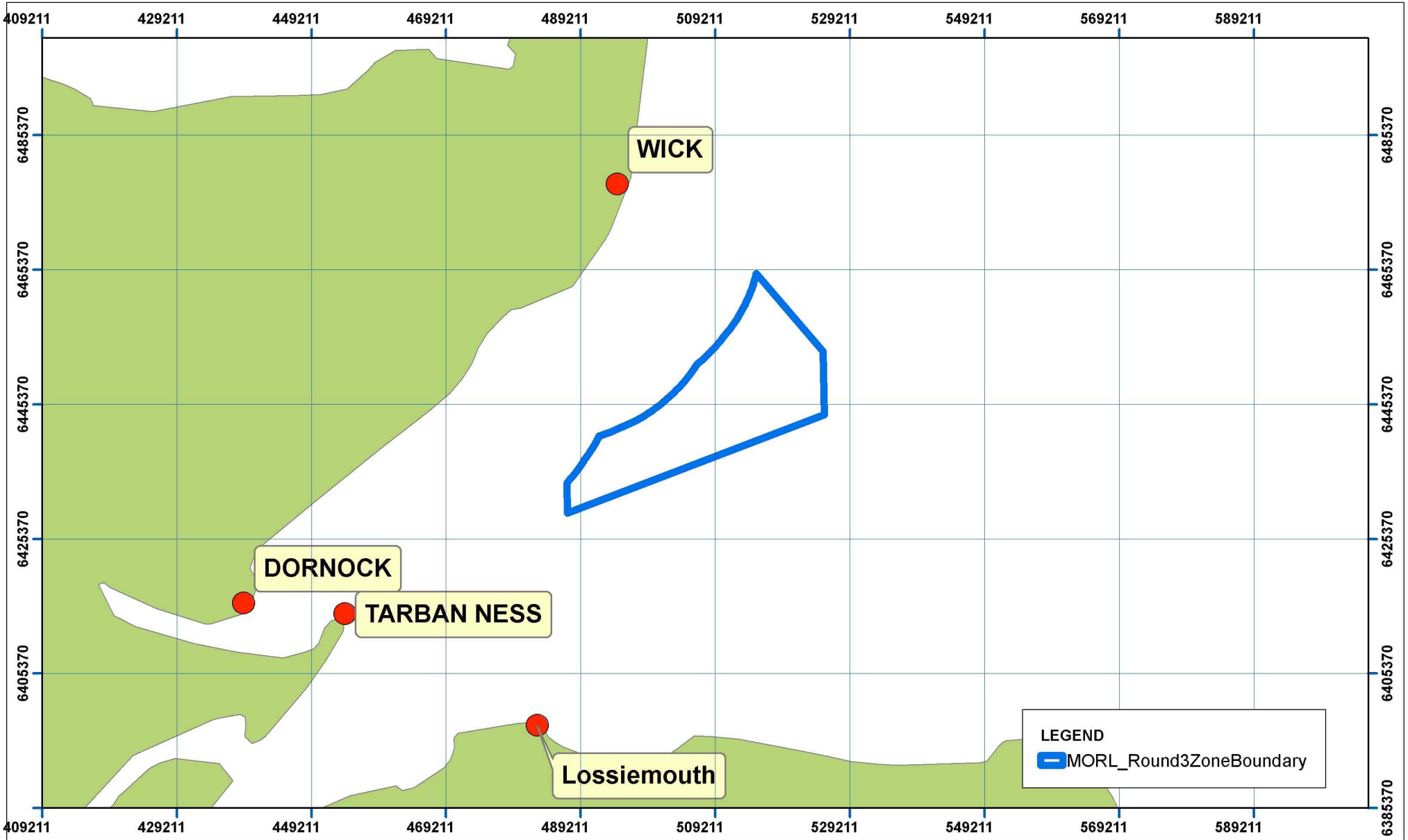
Appendix 01

Moray Firth Offshore Wind Farm – Project Location

5.8A62

Offshore Wind Farm - Moray Firth
Project Location

Appendix 01



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Drawn By: Gary Hubbard
Checked by: Lee Gooderham
Date: 9th November 2010

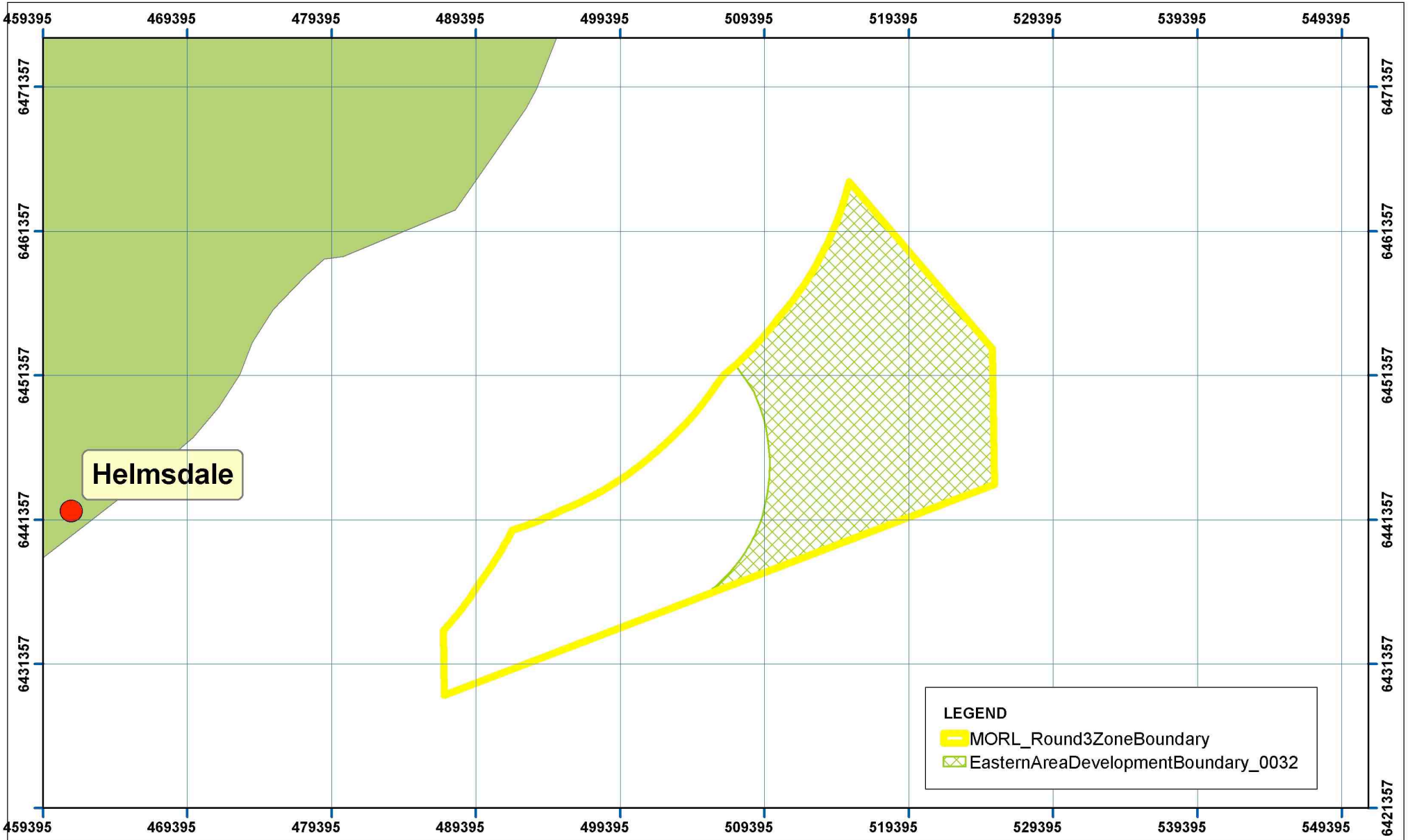
Appendix 02

Project Study Areas

5.8A64

Offshore Wind Farm - Moray Firth
Eastern Development Area - Round 3 Zone

Appendix 02



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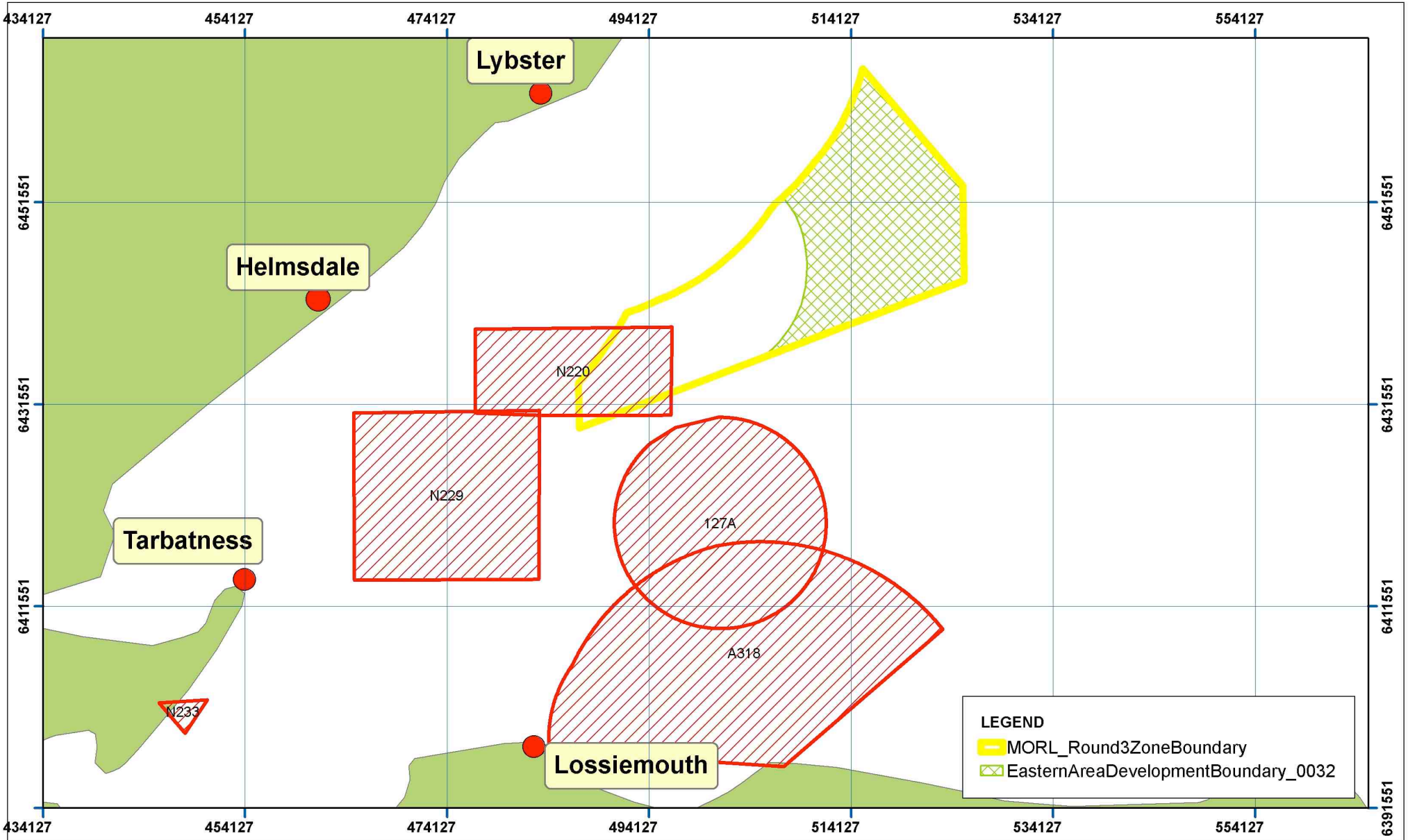
Appendix 03

WWII Armament Areas

5.8A66

Offshore Wind Farm - Moray Firth
WWII Armament Ranges

Appendix 03



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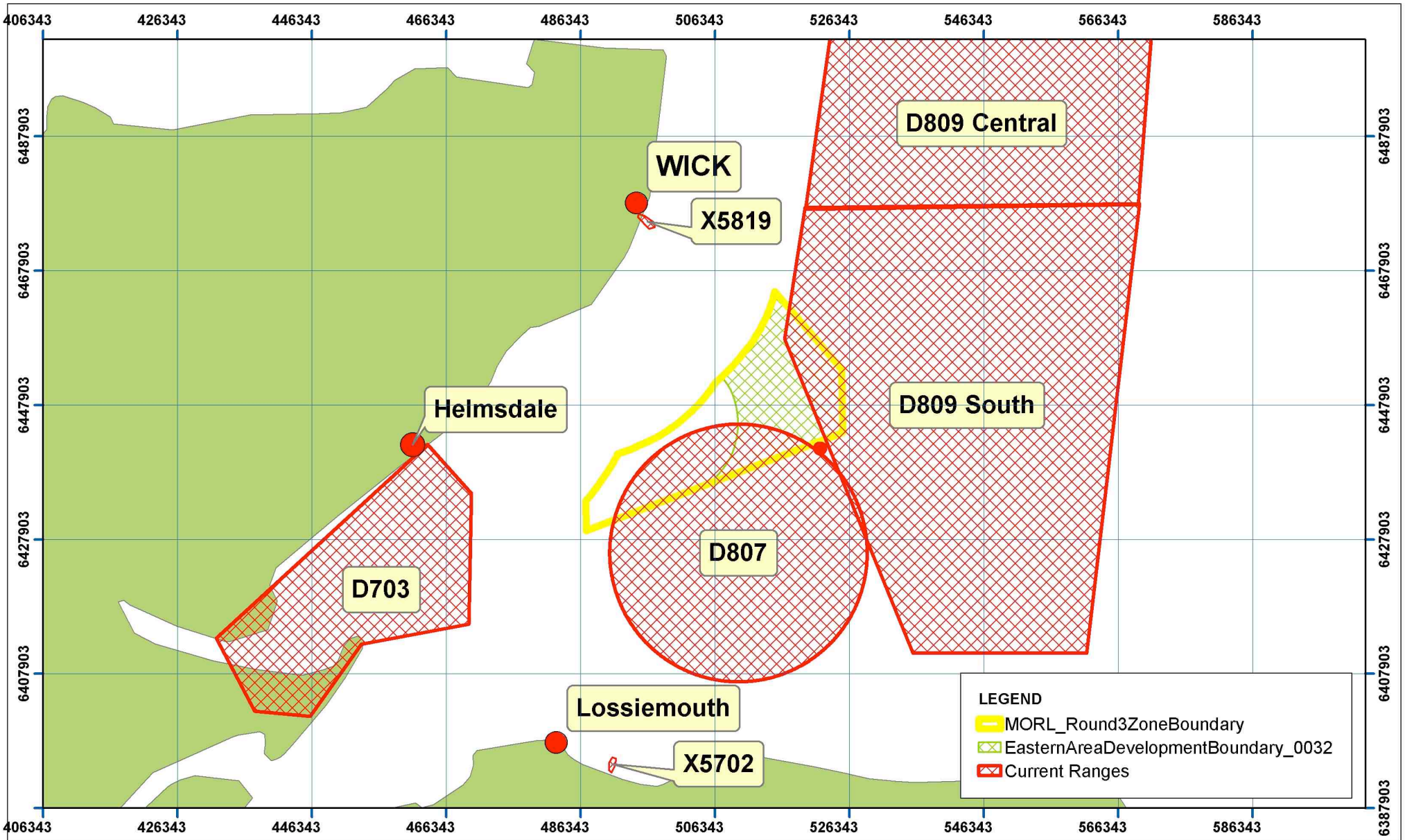
Appendix 04

Current Armament & Training Areas

5.8A68

Offshore Wind Farm - Moray Firth
Current Military Activity

Appendix 04



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Appendix 05

Marine UXO Threats

Unexploded Ordnance (UXO) in the Marine Environment

Cable Plough

Picture courtesy of Global Marine Systems Ltd

Turbine Installation

Legend

German Bomb	
Torpedo	
German Air Delivered Mines	
British Sea Mine	
General Munitions	
Artillery Projectiles	

Round 3 Wind Farms

Dumped Munitions

Artillery Ranges

Minefields

User Notes

1. This map should not be used as a substitute for UXO risk assessment. Should a perceived risk be identified then professional advice should be sought.
2. Map is for illustration purposes only and should not be used for navigation or scaling purposes.
3. Data has been extracted from third party historical sources and 6 Alpha will not be held responsible for the accuracy.
4. Only key UXO threat sources have been shown, further locations may be present but not shown due to scale and clarity of imagery.
5. Some UXO threat areas may be the sum total of numerous threat boundaries.

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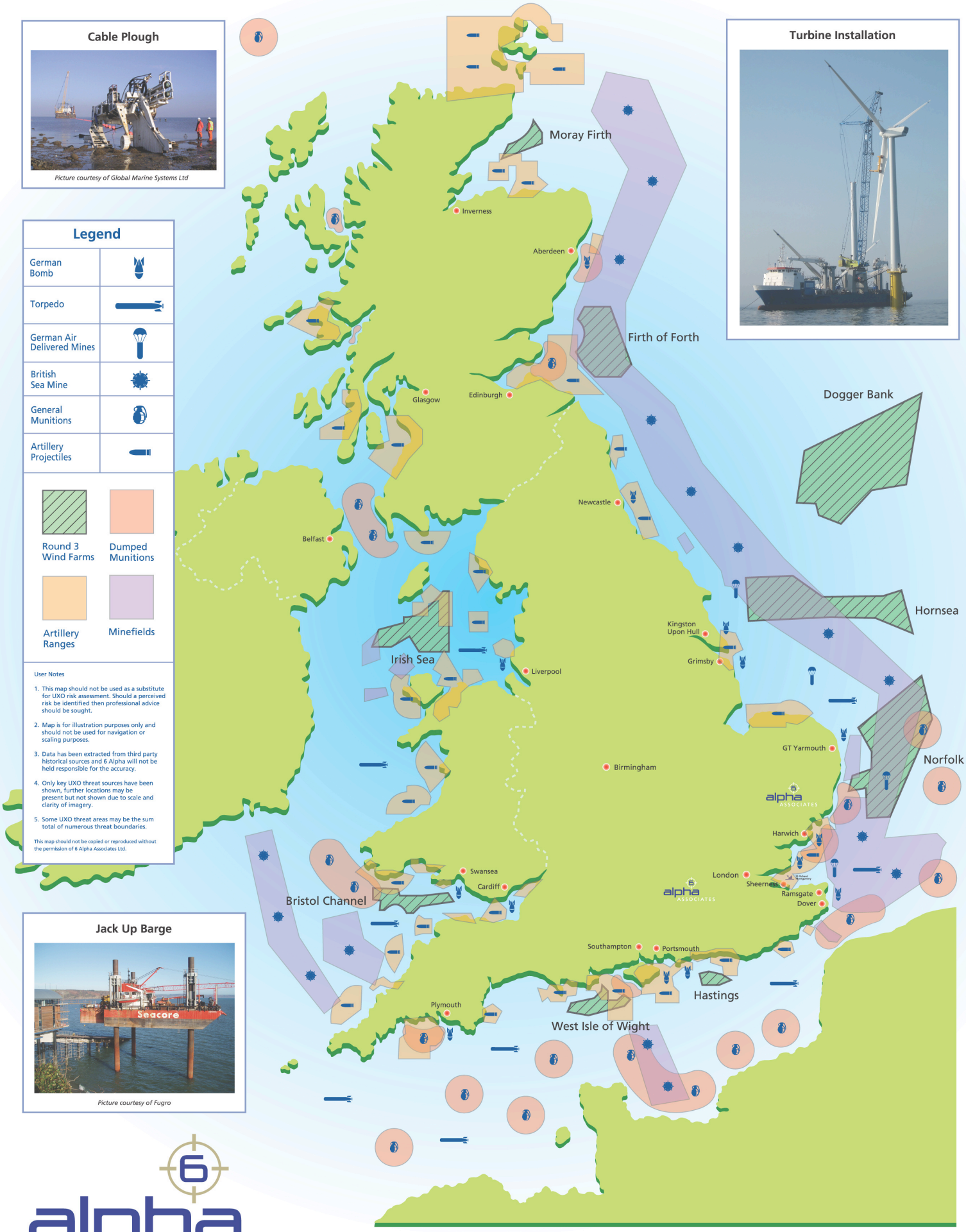

Jack Up Barge

Picture courtesy of Fugro

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5.8A70

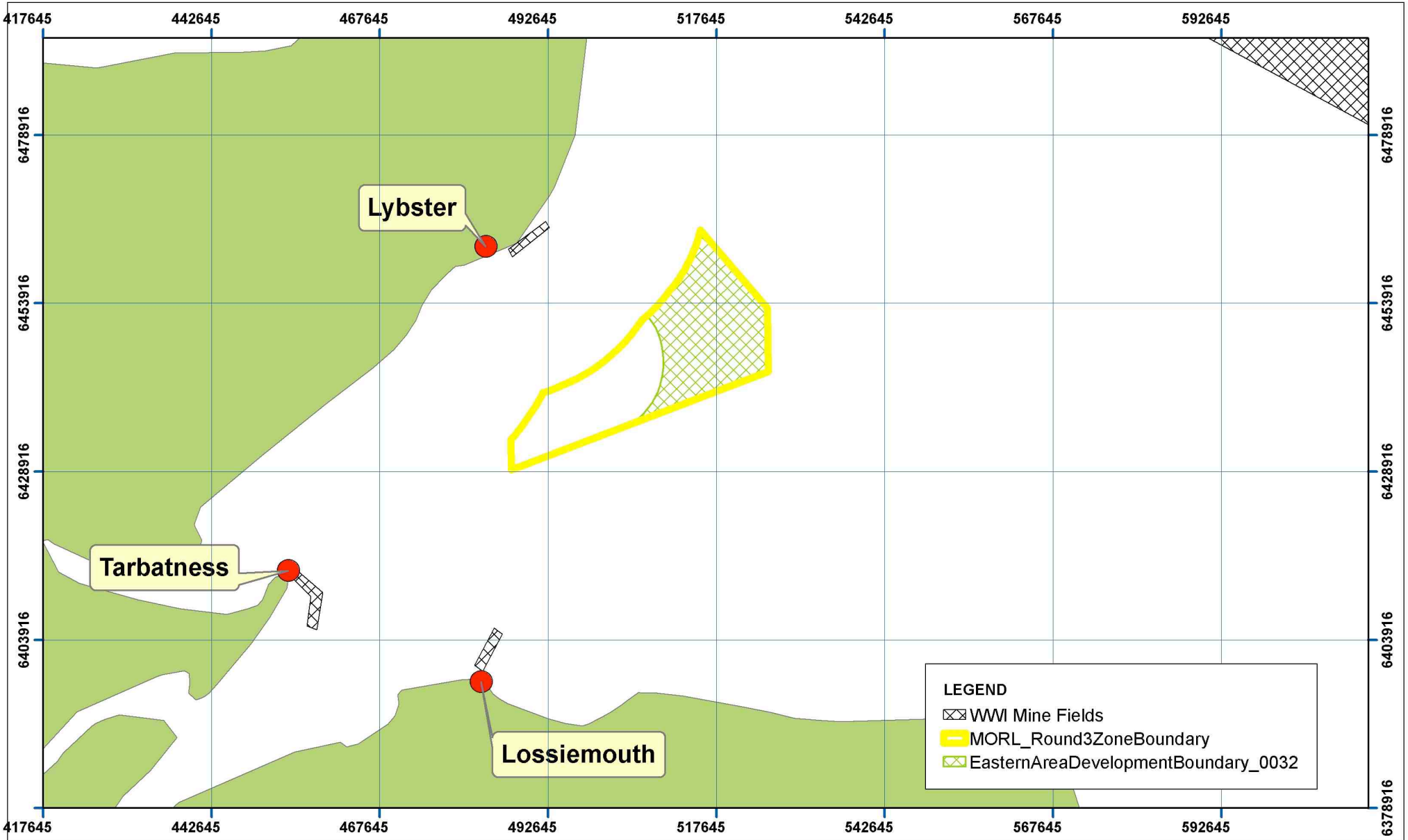
Appendix 06

WWI Allied Minefields

5.8A72

Offshore Wind Farm - Moray Firth
WWI Mine Fields

Appendix 6



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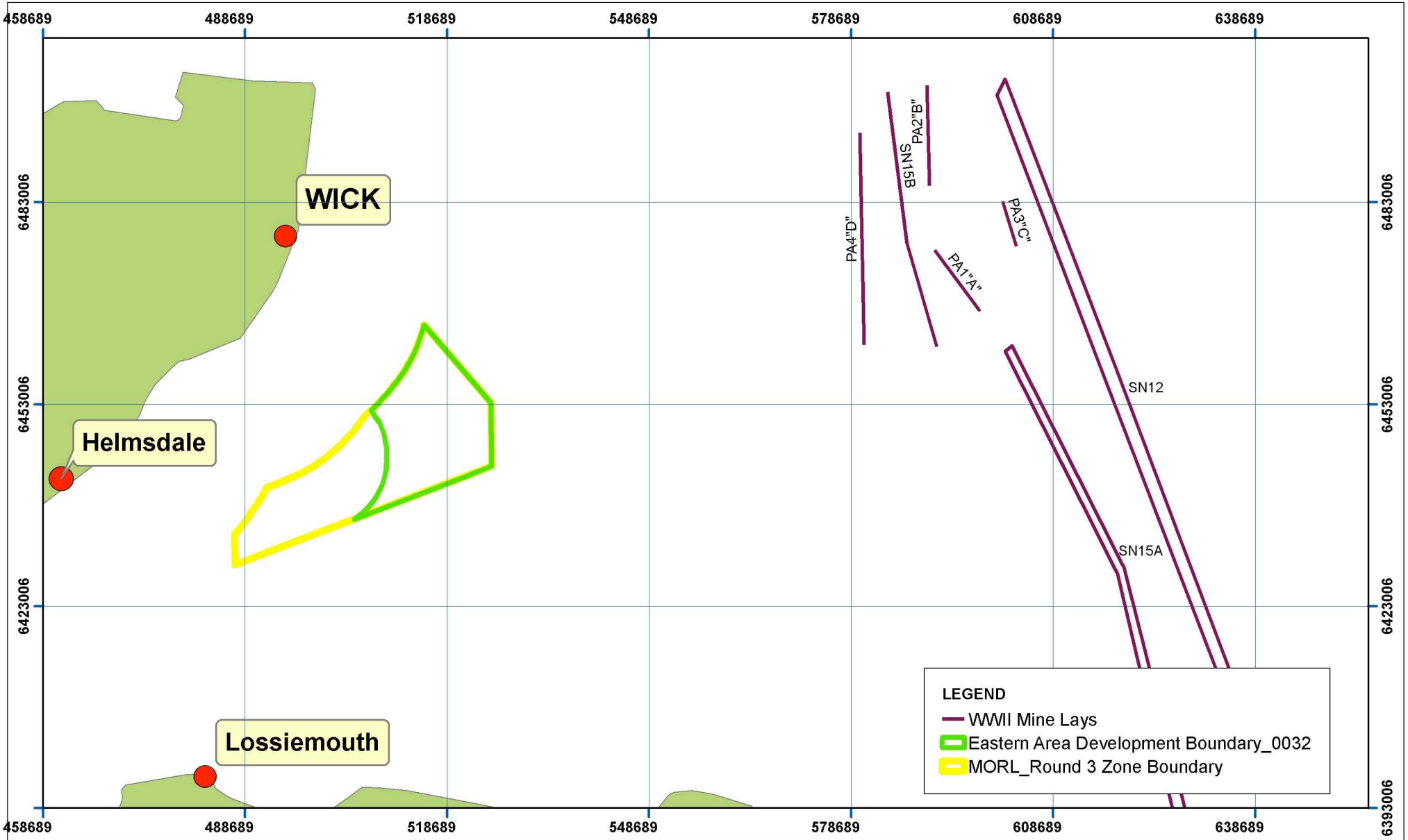
Appendix 07

WWII Allied Minefields

5.8A74

Offshore Wind Farm - Moray Firth
WWII Mine Lays

Appendix 6



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Date: 19th November 2010

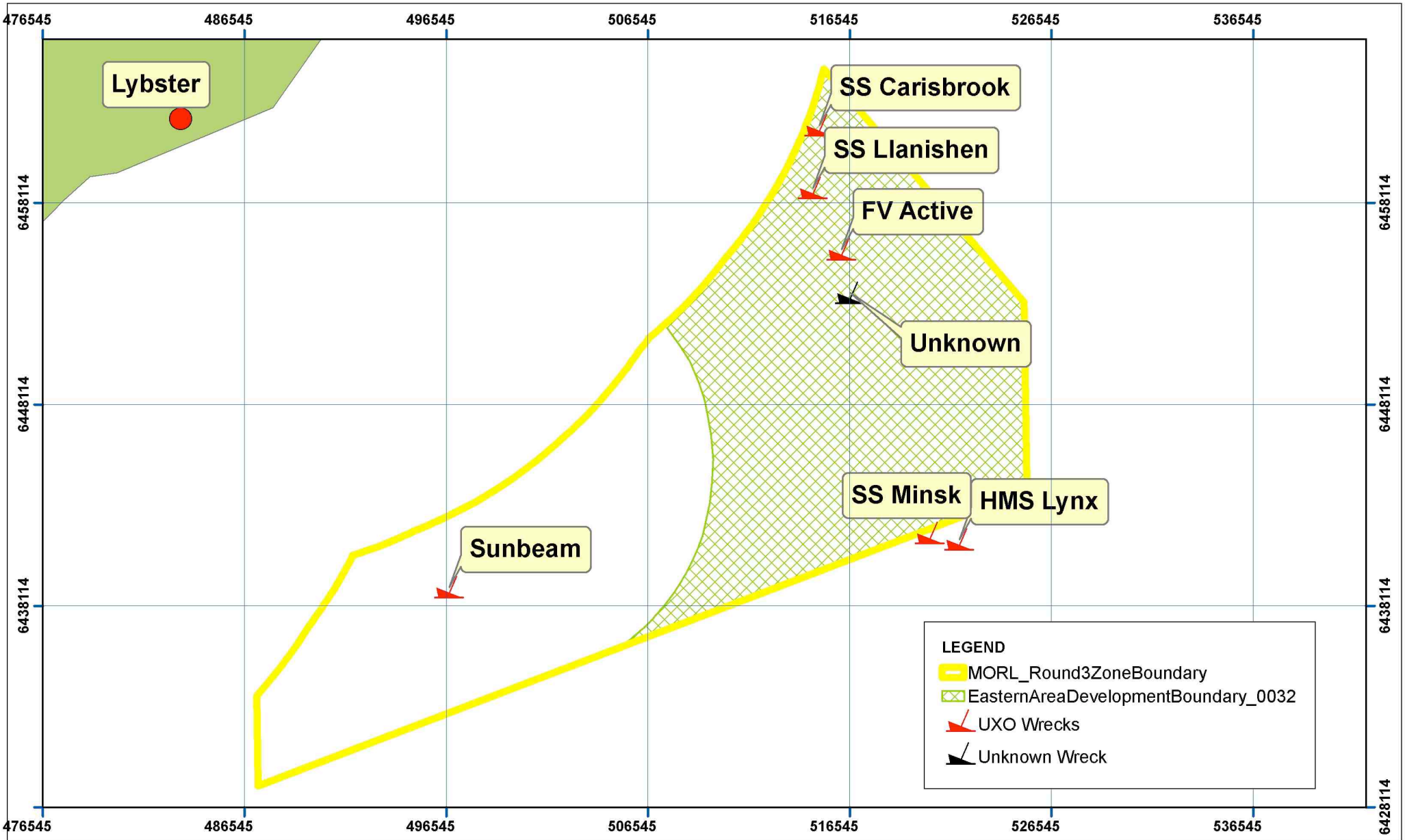
Appendix 08

All Shipwrecks

5.8A76

Offshore Wind Farm - Moray Firth
UXO Wrecks

Appendix 08



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Checked by: Lee Gooderham
Date: 24th November 2010

Appendix 09

Ordnance Characteristics

WWII Sea Mines				
Ordnance Variant	**Shape**	**Width**	**Length**	**Charge Weight**
German Contact Mine. Code EMA/EMB British Designation: GU	Ovoid	EMA: 1600mm EMB: ~1400mm	EMA: 800mm EMB: 900mm	EMA: 220kg EMB: 150kg
German Contact Mine. Code BMC British Designation: GM	Cylindrical with hemispherical top and bottom	660mm	1000mm	50kg
German Contact Mine. Code EMC British Designation: GY	Spherical	1120m diameter	1120mm diameter	300kg
German Contact Mine. Code KMA British Designation: GJ	Spherical	380mm diameter	380mm diameter	12kg
German Influence Mine. Code KMA British Designation: GA/GD	Cylindrical with hemispherical nose and rear parachute housing	660mm diameter	1800mm	300kg
German Influence Mine. Code LMF British Designation: GT	Cylindrical, finned	530mm diameter	2700mm	230kg
German Influence Mine. Type LMB British Designation: GB/GC	Cylindrical with hemispherical nose and rear parachute housing	660mm diameter	Up to 3200mm	700kg
German Influence Mine. Type GMB British Designation: GN & GS	Cylindrical with hemispherical ends	GN: 530mm diameter GS: 530mm diameter	GN: 3100mm GS: 2300mm	GN: 900kg GS: 420 to 560kg
German "Mine-bomb". Type BM1000 British Designation: GG	Cylindrical	660mm diameter	~2000mm long depending on tail unit	725kg
British Contact Mine Mk XIV & XV	Ovoid	1016mm diameter	1016mm diameter	145kg or 295kg
British Contact Mine. Mk XVII	Ovoid	1016mm diameter	1016mm diameter	145kg
British Contact Mine. Mk XIX & XIXS	Spherical	790mm diameter	790mm diameter	45kg

WWII High Explosive Bombs				
Ordnance Variant	**Bomb Shape**	**Dimensions**	**Body Diameter**	**Charge Weight**
German SC 50	Cylindrical	1090 x 280mm	200mm	25kg
German SC 250	Cylindrical	1640 x 512mm	368mm	125-130kg
German SC 500	Cylindrical	1957 x 640mm	470mm	250-260kg
German SC 1000	Cylindrical	2580 x 654mm	654mm	530-590kg
German SC 1800	Cylindrical	3500 x 670mm	670mm	1000kg
German SC 2500	Cylindrical	3895 x 829mm	829mm	1700kg

Appendix 10

Project Risk Assessment Tables

Risk Assessment Table notes (applicable to all segments):

1. Risk level is prior to risk mitigation actions for that specific operation but in operational order i.e. previous action may have reduced cumulative risk level;
2. Values for both probability and consequence to be found in main report;
3. Risk mitigation measures are cumulative and assumes that previous stage has been undertaken;

Moray Firth Offshore Wind Farm – UXO Risk Assessment
Orange Zone – Highly Likely

Phase	Activity	Ordnance Variant	Probability of Encounter	Consequence of Initiation	Risk Level (Note 1)	Risk Mitigation lower risk to
Site Investigation	Geophysical Survey	Sea Mines/Torpedoes	1	2	2	Ensure survey a not encounter
		Air-delivered Bombs	1	2	2	
		AAA Projectiles	1	1	1	
		Practice Bombs	1	2	2	
	Geotechnical Investigation	Sea Mines/Torpedoes	2	4	8	Geophysical survey and target avoidance – employing either camera survey and/or focused SSS (for BH/CPS - not jack-up legs)
		Air-delivered Bombs	2	4	8	
		AAA Projectiles	1	1	1	
		Practice Bombs	2	1	2	
Cable Installation	PLGR seabed operations	Sea Mines/Torpedoes	3	3	9	UXO focussed survey and target avoidance
		Air-delivered Bombs	4	3	12	
		AAA Projectiles	2	1	2	
		Practice Bombs	3	3	9	
	PLGR equipment recovery to vessel	Sea Mines/Torpedoes	2	5	10	Safety procedures to be followed in the event of item recovery
		Air-delivered Bombs	1	5	5	
		AAA Projectiles	1	3	3	
		Practice Bombs	2	5	10	
	Barge Anchor Deployment	Sea Mines/Torpedoes	2	3	6	Existing Geophysical survey and target avoidance
		Air-delivered Bombs	2	3	6	
		AAA Projectiles	1	1	2	
		Practice Bombs	2	3	6	
	Cable Installation (Array Seabed Operations)	Sea Mines/Torpedoes	1	4	4	No further action - subject to the previous cable installation ameliorative measures having been taken
		Air-delivered Bombs	1	4	4	
		AAA Projectiles	2	1	2	
		Practice Bombs	1	4	4	
Turbine Installation	Foundation Installation	Sea Mines/Torpedoes	3	4	12	UXO Focussed Survey & Target Investigation (latter if required)
		Air Delivered Bombs	4	4	16	
		Artillery Projectiles	2	1	2	
		Practice Bombs	3	4	12	

Moray Firth Offshore Wind Farm – UXO Risk Assessment
Yellow Zone – Likely

Phase	Activity	Ordnance Variant	Probability of Encounter	Consequence of Initiation	Risk Level (Note 1)	Risk Mitigation Actions to lower risk to ALARP
Site Investigation	Geophysical Survey	Sea Mines/Torpedoes	1	2	2	Ensure survey array does not encounter seabed
		Air-delivered Bombs	1	2	2	
		AAA Projectiles	1	1	1	
		Practice Bombs	1	2	2	
	Geotechnical Investigation	Sea Mines/Torpedoes	3	4	12	**Western Zone** Geophysical survey and target avoidance –employing either camera survey and/or focused SSS (for BH/CPS - not jack-up legs) **Eastern Zone** Existing Geophysical survey and target avoidance
		Air-delivered Bombs	2	4	8	
		AAA Projectiles	1	1	1	
		Practice Bombs	2	1	2	
Cable Installation	PLGR seabed operations	Sea Mines/Torpedoes	3	3	9	**Western Zone** UXO focussed survey and target avoidance **Eastern Zone** Existing Geophysical survey and target avoidance
		Air-delivered Bombs	3	3	9	
		AAA Projectiles	2	1	2	
		Practice Bombs	2	3	6	
	PLGR equipment recovery to vessel	Sea Mines/Torpedoes	2	5	10	Safety procedures to be followed in the event of item recovery
		Air-delivered Bombs	1	5	5	
		AAA Projectiles	1	3	3	
		Practice Bombs	2	5	10	
	Barge Anchor Deployment	Sea Mines/Torpedoes	3	3	9	Existing Geophysical survey and target avoidance
		Air-delivered Bombs	2	3	6	
		AAA Projectiles	1	1	2	
		Practice Bombs	2	3	6	
	Cable Installation (Array Seabed Operations)	Sea Mines/Torpedoes	1	4	4	No further action - subject to the previous cable installation ameliorative measures having been taken
		Air-delivered Bombs	1	4	4	
		AAA Projectiles	2	1	2	
		Practice Bombs	1	4	4	
Turbine Installation	Foundation Installation	Sea Mines/Torpedoes	4	4	16	**Western Zone** UXO focussed survey and target investigation **Eastern Zone** Existing Geophysical survey and target avoidance
		Air Delivered Bombs	3	4	16	
		Artillery Projectiles	2	1	2	
		Practice Bombs	2	4	8	

APPENDIX 5.8 A

Moray Firth Offshore Wind Farm – UXO Risk Assessment
Green Zone – Possible

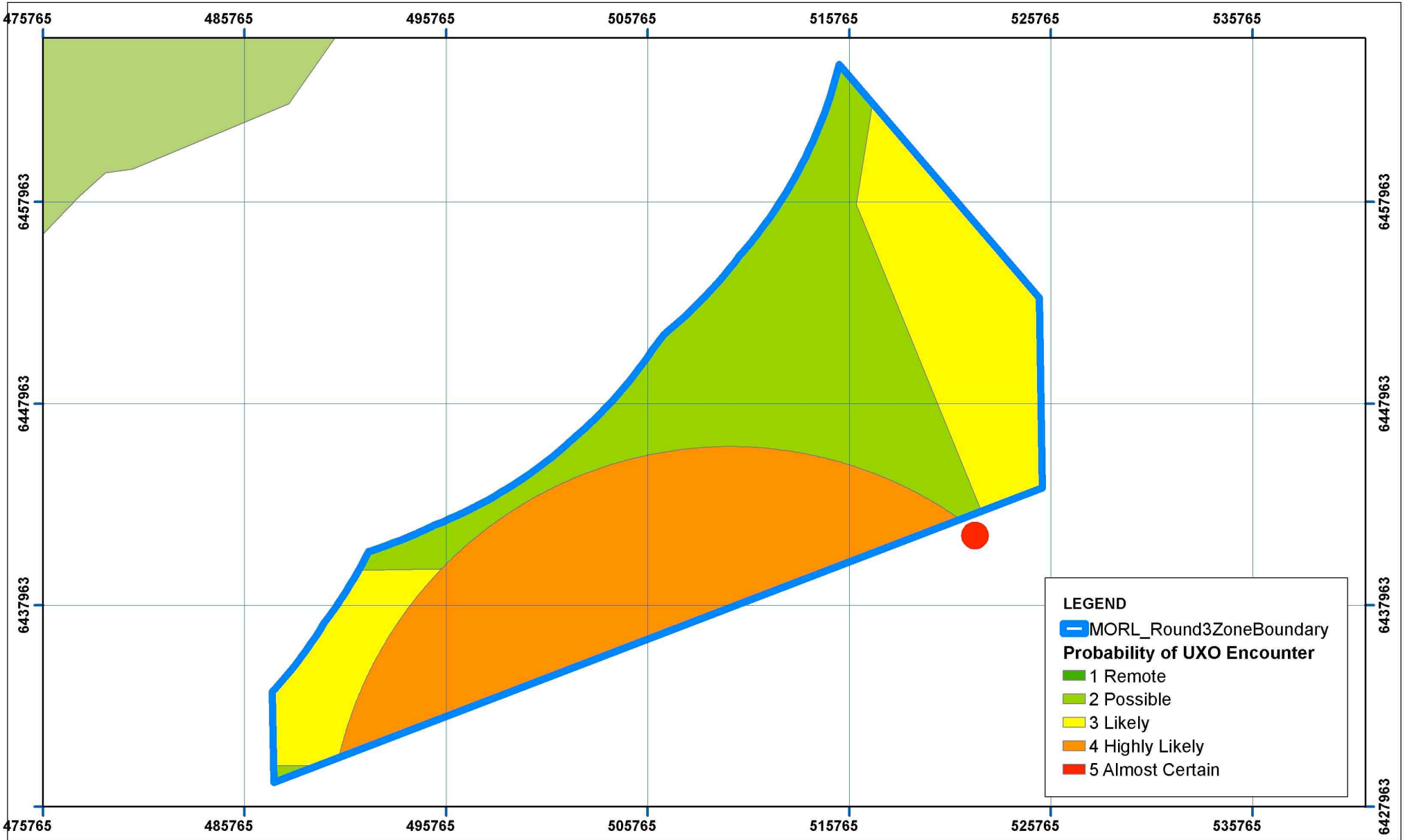
Phase	Activity	Ordnance Variant	Probability of Encounter	Consequence of Initiation	Risk Level (Note 1)	Risk Mitigati to lower risk
Site Investigation	Geophysical Survey	Sea Mines/Torpedoes	1	2	2	Ensure sur does not e seabe
		Air-delivered Bombs	1	2	2	
		AAA Projectiles	1	1	1	
		Practice Bombs	1	2	2	
	Geotechnical Investigation	Sea Mines/Torpedoes	2	4	8	Existing Geophysical survey and target avoidance
		Air-delivered Bombs	2	4	8	
		AAA Projectiles	1	1	1	
		Practice Bombs	2	1	2	
Cable Installation	PLGR seabed operations	Sea Mines/Torpedoes	2	3	6	Existing Geophysical survey and target avoidance
		Air-delivered Bombs	2	3	6	
		AAA Projectiles	2	1	2	
		Practice Bombs	2	3	6	
	PLGR equipment recovery to vessel	Sea Mines/Torpedoes	2	5	10	Safety procedures to be followed in the event of item recovery
		Air-delivered Bombs	1	5	5	
		AAA Projectiles	1	3	3	
		Practice Bombs	2	5	10	
	Barge Anchor Deployment	Sea Mines/Torpedoes	2	3	6	Existing Geophysical survey and target avoidance
		Air-delivered Bombs	2	3	6	
		AAA Projectiles	1	1	2	
		Practice Bombs	2	3	6	
	Cable Installation (Array Seabed Operations)	Sea Mines/Torpedoes	1	4	4	No further action - subject to the previous cable installation ameliorative measures having been taken
		Air-delivered Bombs	1	4	4	
		AAA Projectiles	2	1	2	
		Practice Bombs	1	4	4	
Turbine Installation	Foundation Installation	Sea Mines/Torpedoes	2	4	8	Existing Geophysical survey and target investigation
		Air Delivered Bombs	2	4	8	
		Artillery Projectiles	2	1	2	
		Practice Bombs	2	4	8	

Appendix 11

UXO Probability Map

Offshore Wind Farm - Moray Firth
Probability of UXO Encounter

Appendix 11



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Scale @ A4: 1:250,000
Revision: 000

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Produced by and Copyright to 6 Alpha Associates Ltd. Users noting any errors please forward to 6 Alpha. Development zone (in GIS format) obtained from Crown Estates Website.

Projection System: UTM Zone 30N
Datum: WGS84
Spheriod: WGS84

Project Number: P2295
Drawn By: Gary Hubbard
oderham
ber 2010

APPENDIX 5.8 A

5.8A85

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