MORAY WEST
OFFSHORE WINDFARM

Moray West Onshore Transmission Infrastructure Environmental Impact Assessment (EIA)

Moray Offshore Windfarm (West) Limited

Technical Appendix 6.3: Intertidal Survey Report

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Acronyms	
Acronym	**Expanded Term**
AADT	24 hour Annual Average Daily Traffic flow
AC	Aberdeenshire Council
AIL	Abnormal Indivisible Load
ALTS	Aberdeenshire Local Transport Strategy
ATC	Automatic Traffic Counts
DMRB	Design Manual for Roads and Bridges
EIA	Environmental Impact Assessment Report
FCPMS	Framework Core Path Management Strategy
GIS	Geographic Information System
HDD	Horizontal Directional Drilling
HGV	Heavy goods vehicles
HRTS	Hitrans Regional Transport Strategy
HVAC	High voltage alternating current
MC	Moray Council
MLTS2	Second Moray Local Transport Strategy
MLWS	Mean Low Water Spring
Moray West	Moray Offshore Wind Farm (West) Limited West
NCN	National Cycle Network
NETS	National Electricity Transmission System
NPF3	National Planning Framework
NRTF	National Road Traffic Forecasts
NRTS	Nestrans Regional Transport Strategy
NTEM	National Trip End Model
NTS	Scotland's National Transport Strategy
OnTI	Moray Onshore Transmission Infrastructure
OS	Ordinance Surveys
PAB	Planning application boundary
PAN 75	Planning Advice Note 75: Planning for transport
PCTMP	Preliminary Construction Traffic Management Plan
PIA	Personal Injury Accidents
SGT	Super grid transformer
SPA	Swept Path Analysis
SPP	Scottish Planning Policy
STAG	Scottish Transport Appraisal Guidance

Acronyms	
Acronym	**Expanded Term**
TA	Transport Assessment
TEMPRO	Trip End Model Presentation Program version 7.2
TP	Travel Plan
TPC	Travel Plan Coordinator
Wood	Wood Environment & Infrastructure Solutions UK Limited

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 applications for offshore and onshore consents within Environmental Reports.

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**Error! Reference source not found.**) 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**Error! Reference source not found.**).

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**Error! Reference source not found.**) 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**Error! Reference source not found.**) 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.

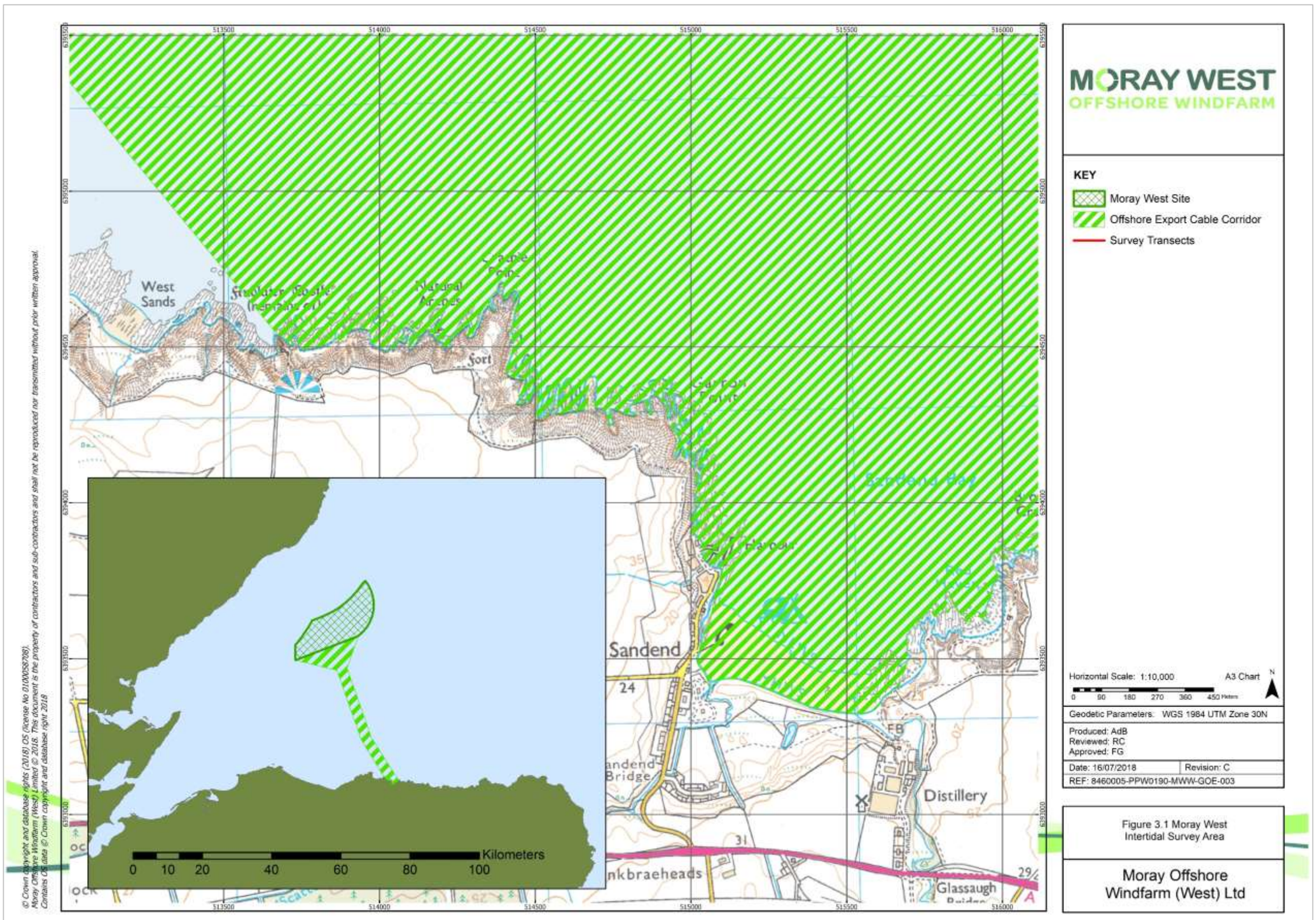

Figure 3.1: Moray West Intertidal Survey Area

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 Appendix 1 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
SKEWNESS	0.017	-0.001	-0.011
	Symmetrical	Symmetrical	Symmetrical
% GRAVEL:	0.003	0.159	0.032
% SAND:	99.997	99.841	99.918

Table 4.1. Summary of PSD parameters and taxa recorded from phase 2 sampling at Transect SE1

PARAMETER	SE1 Upper	SE1 Mid	SE1 Low
% MUD:	0.000	0.000	0.050
Taxa	**Abundance per 0.01m²**		
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

Table 4.3. Summary of PSD parameters and taxa recorded from phase 2 sampling at Transect SE2			
PARAMETER	**SE1 Upper**	**SE1 Mid**	**SE1 Low**
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 0.01m²**		
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 Table 4.6 whilst photographs of some of the other adjacent features (rock, stones) are given in Table 4.7.

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 0.01m²**		
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


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
 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
		
Transect SE5. Image: P1170687	Transect SE5. Image: P1170688	Transect SE5. Image: P1170698

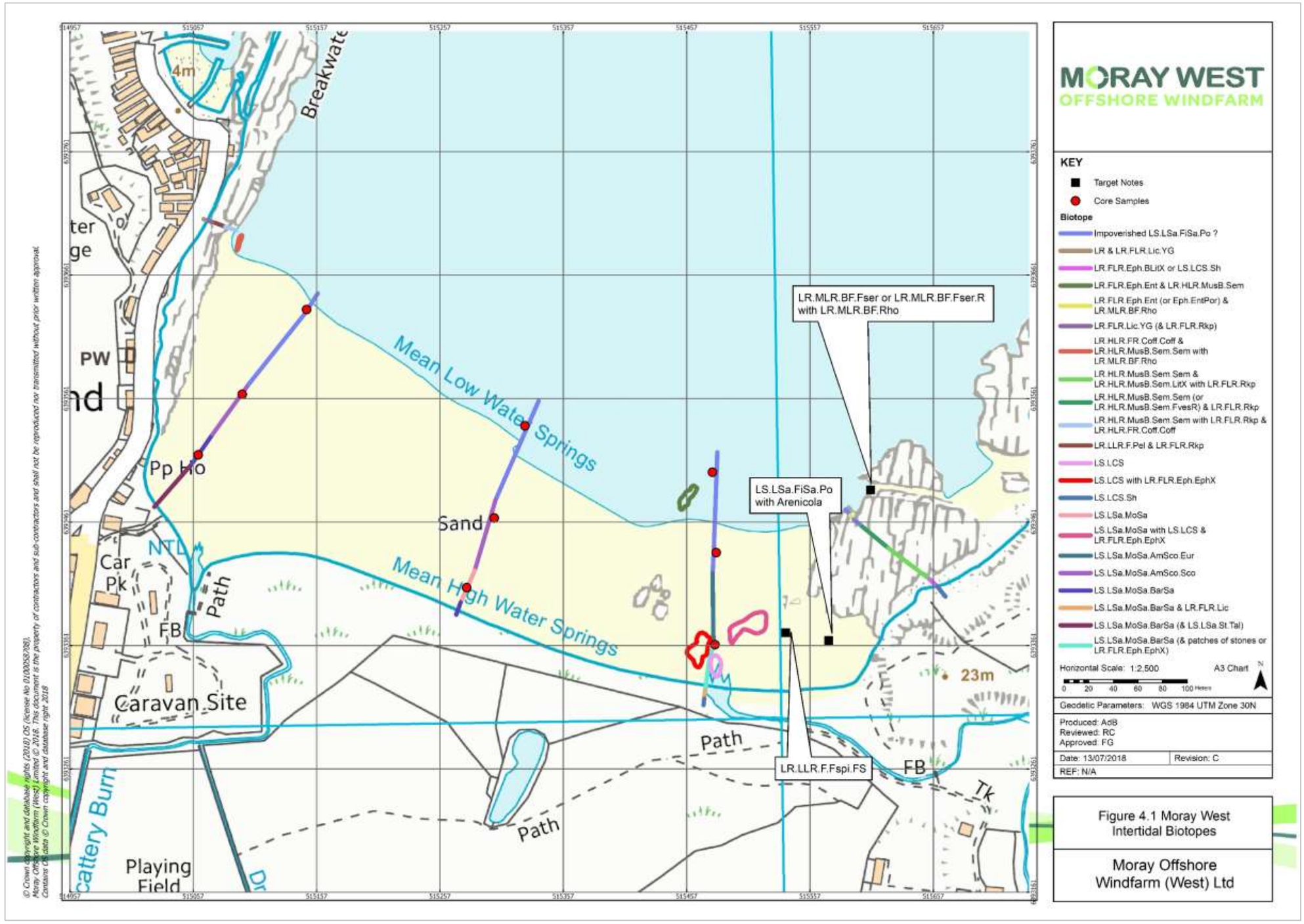

Figure 4.1: Moray West Intertidal Biotopes

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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Appendix A: Phase 2 Core Sample Positions.

Table A.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

Appendix B: Results of PSD

Table B.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
	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

Table B.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**
	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

Appendix C: PSD Summary Statistics

Table C.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
FOLK AND WARD METHOD (μm)	MEDIAN GRAIN SIZE D_{50} (μm)	255.3	281.54	269.47	302.5	297.1	308.292
	MEAN GRAIN SIZE (μm)	254.4	283.42	272.3	303.7	299.0	309.3
	SORTING	1.417	1.481	1.50	1.569	1.568	1.6
	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
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	1.970	1.829	1.892	1.725	1.751	1.7
	MEAN GRAIN SIZE (phi):	1.975	1.819	1.876	1.719	1.742	1.7
	SORTING	0.503	0.566	0.589	0.650	0.649	0.7
	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
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand	Medium Sand	Medium Sand	Medium Sand	Medium Sand	Medium Sand
	SORTING:	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted
	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

Table C.1: PSD Summary Statistics							
SAMPLE	**PARAMETER**	**SE1 Upper**	**SE1 Mid**	**SE1 Low**	**SE2 Upper**	**SE2 Mid**	**SE2 Low**
	% 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
	% 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 C. 2: PSD Summary Statistics Continued.					
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
FOLK AND WARD METHOD (µm)		MEDIAN GRAIN SIZE D_{50} (µm)	281.7	284.1	286.4
		MEAN GRAIN SIZE (µm)	283.088	284.525	288.065
		SORTING	1.456	1.438	1.506
		SKEWNESS	-0.017	-0.027	0.008
		KURTOSIS	0.972	0.972	0.981
FOLK AND WARD METHOD (phi)		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
		SKEWNESS	0.017	0.027	-0.008
		KURTOSIS	0.972	0.972	0.981
FOLK AND WARD METHOD (Description)		MEAN:	Medium Sand	Medium Sand	Medium Sand
		SORTING:	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted
		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
		% MUD:	0.000	0.000	0.000
		% V COARSE GRAVEL:	0.000	0.000	0.000

Table C. 2: PSD Summary Statistics Continued.

SAMPLE	PARAMETER	SE3 Upper	SE3 Mid	SE3 Low
	% 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^{o}C		0.50	0.59	0.66

Appendix D: Species Data from Phase 2 Core Sampling

Table D.1: Species Data from Phase 2 Core Sampling										
	Abundance per 0.01m²									
Taxa	**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
	Biomass (wet weight in g) per 0.01m²									
Taxa	**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				
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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