Information to inform HRA

Refinement to the assessment of in-combination effects on great black-backed gull feature of East Caithness Cliffs SPA

Moray Offshore Windfarm (West) Limited

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1 Refinement to the assessment of in-combination effects on great black-backed gull feature of the East Caithness Cliffs SPA

1.1 Introduction

It was concluded in the Moray West Report to Inform an Appropriate Assessment (RIAA) submitted in support of Moray West's Offshore Wind Farm and Offshore Transmission Infrastructure (OfTI) consent application (July 2018) that the great black-backed gull feature of the East Caithness Cliffs SPA should be screened out of the RIAA for collision impacts. This was on the basis that results from a gull tracking study undertaken in the East Caithness Cliffs SPA in 2014 indicated that great black-back gull foraging activities during the breeding season were limited to coastal waters, with no foraging in the Moray West Site. It was therefore concluded that there was no connectivity between the Moray West Site and the great black-back gull population of the East Caithness Cliffs SPA (see RIAA Chapter 4 – Table 4.5.1 and Chapter 6 Section 6.6.6.13).

Consequently, no further assessment of potential effects on the great black-backed gull feature of the East Caithness Cliffs SPA for either the Moray West Site alone or in-combination effects was undertaken in the RIAA.

Comments received from SNH, MSS and RSPB following consultation on the RIAA, questioned whether the information provided on great black-back gulls was sufficient to inform an assessment of effects on the East Caithness Cliffs SPA. This was on the basis that the conclusions from the gull tagging study alone may not, in their opinion, be sufficient to support the conclusion of no connectivity and therefore the screening out of the great black-backed gull feature of the East Caithness Cliffs SPA from the RIAA.

In response to these comments, further information on the great black-backed gull feature of the East Caithness Cliffs SPA was provided in the Moray West Addendum Document (November, 2018). This included an assessment of the potential effects of Moray West on the great black-backed gull interest feature of the East Caithness Cliffs SPA. This assessment concluded that the Moray West project alone would have no adverse effect on this interest feature. This was determined through the application of a number of refinements to the calculation of collision mortality considered together with evidence of no or very limited connectivity to the East Caithness Cliffs SPA breeding colony based on results from the gull tagging study and other evidence. Of the 0 – 1.6 adult birds in the breeding season calculated to be at risk from collision, it was concluded that the total number of collisions that can be apportioned back to the East Caithness Cliffs SPA will be 0 or close to 0. Furthermore, it was also calculated that no more than 0.14 of an adult plumaged bird associated with the colony at East Caithness Cliffs SPA is predicted to collide during the non-breeding season.

It was therefore concluded in the Addendum Document (PART 1, Chapter 3 Section 3.7) that Moray West alone makes no (or no material) contribution to any in-combination effects on the great black-backed gull breeding colony of the East Caithness Cliffs SPA.

SNH, in their consultation response to the information presented in the Addendum Document[1], advised that insufficient information was available to reach a conclusion on in-combination effects on the great black-backed gull qualifying feature of the East Caithness Cliffs SPA (SNH, 2019). Moreover, Marine

[1] Letter dated 4th January 2019 from Scottish Natural Heritage to Marine Scotland titled *Moray West Offshore Wind Farm Addendum Document.*

Scotland Science (MSS) advised that apportioning both breeding and non-breeding impacts for the three Moray Firth developments, in-combination, for the breeding and non-breeding season to East Caithness Cliffs SPA, together with a recalculation of collision mortality for Beatrice Offshore Wind Farm (BOWL) and Moray East for as built scenarios[2] would further aid in the assessment.

Within the Addendum Document, PART 1, Chapter 3 (Moray West, 2018), a series of refinements were applied to the calculation of collision mortality for great black-backed gull at Moray West. This approach is developed further in this document by applying similar refinements to Moray East and BOWL (for further details of information sources see Section 1.3.1 below) such as the use of updated project designs for Moray East and the removal of sabbaticals and immature birds from collisions apportioned to the East Caithness Cliffs SPA from these projects. Population Viability Analysis (PVA) modelling outputs are also presented to inform potential effects on the East Caithness Cliffs SPA at a population level. The PVA has been performed in single bird increments of bird deaths across the range of assessed in-combination impacts, as advised by Marine Scotland[2].

1.2 Great black-backed gull

As discussed in the Addendum Document (Moray West, 2018), great black-back gulls are omnivorous, preying on anything from fish, other (sea)birds and/or their eggs, marine invertebrates, small terrestrial mammals, insects, eggs, berries, carrion to occasional larger prey such as sickly livestock. Their diet range means they are able to forage in offshore, coastal and terrestrial environments.

Breeding great black-backed gulls in the UK are mainly sedentary, and are rarely found far from their coastal breeding locations. This is reflected in the low numbers of great black-backed gull observed at the Moray West Site during the breeding season.

During the non-breeding season, local birds are supplemented by an influx of adult birds from more northern breeding locations in Arctic Norway, the Murmansk region on the northern coast of Russia, and the Faroes (small numbers) (Furness 2015, Wernham *et al.* 2002, Wright *et al.* 2012). Offshore dispersal of great black-backed gulls from breeding sites in northern Scotland is less common (Wernham *et al.* 2002) with evidence that UK breeding adults in the non-breeding season move only short distances from their breeding colonies, with a maximum range of up to 60 km[3] (based on ringing recoveries - Migration Atlas; Wernham *et al.* 2002). This would mean that birds from East Caithness Cliffs SPA are likely to remain within the confines of the Moray Firth region.

1.3 Assessment of in-combination collision mortality effects on the great black-backed gull feature of the East Caithness Cliffs SPA

This note provides information on the effects on the great black-backed gull feature of the East Caithness Cliffs SPA from Moray West alone and in-combination with other projects. The following section discusses key parameters used to inform the assessment of in-combination effects from collision mortality and the various refinements that can be applied to the collision risk modelling to take account of emerging evidence in relation to the assessment of effect and up to date information on other projects included in the in-combination assessment.

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[2] Letter dated 17th January 2019 from Marine Scotland Science to Marine Scotland Licensing Operations Team titled *Moray West: Moray Offshore Windfarm (West) Limited: Addendum Consultation.*

[3] Use of 60 km foraging range for great black-backed gull during non-breeding season confirmed with SNH (6th March 2019).

1.3.1 Key parameters included in the assessment of in-combination collision mortality effects on the great black-backed gull feature of the East Caithness Cliffs SPA

The collision mortality rates presented in Table 1.2 Part A - collision risk modelling parameters and assumptions are taken directly from the Moray West EIA Report Volume 2 Chapter 10 Table 10.8.19 (Moray West, 2018). These collision mortality rates provide the starting point for the in-combination assessment and the application of the various refinement factors discussed in Section 1.3.2 below.

It should be noted that no refinements have been applied to these collision mortality rates (as presented in Table 1.2 Part A). The avoidance rates, nocturnal activity factors and flight speeds also presented in this part of the table (Part A) are the parameters that were used in the original calculations of collision mortality rates as presented in the Moray West EIA Report – Volume 2, Chapter 10, Table 10.8.9.

The collision mortality rates for the Moray East and Beatrice Offshore Wind Farms presented in Table 1.2 Part A (and also presented in Moray West EIA Report Volume 2 Chapter 10 Table 10.8.19) are based on outputs from Collision Risk Modelling (CRM) undertaken by Moray East in 2017 to inform a decision on the scope of the work required with respect to ornithology as part of the EIA for the Moray East Alternative Design Parameters application. Results from the CRM were included in Appendix 5 of the subsequent Moray East Alternative Design Parameters EIA Scoping Opinion Addendum: Ornithology, which was issued by Marine Scotland in June 2017.

The CRM for Moray East included in the Scoping Opinion (Marine Scotland, 2017) presented a comparison of collision mortality rates for the consented Moray East project based on the assessed worst case scenario which was 159 x 7 MW turbines (Moray East, 2012; MSLOT, 2014) and the proposed Alternative Design Parameters. The design parameters presented for the BOWL (also presented in the Moray East Alternative Design Parameters EIA Scoping Opinion Addendum: Ornithology) are based on the 'as built' parameters included in their Development Specification and Layout Plan (DSLP) (Marine Scotland, 2017).

1.3.1.1 Band model option and Avoidance Rates

Collision mortality rates for Moray West have been calculated using 'Basic' Band model Option 2 (Band, 2012). The Band (2012) model incorporates two approaches to calculating the risk of collision. These are 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 flight height distributions of seabirds. The Basic model assumes a uniform distribution of flights across the rotor with a consistent risk of collision across the whole rotor swept area, whereas 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.

Both the Basic and Extended models of Band (2012) allow for the use of two 'Options'. Under the Basic model these are referred to as Options 1 and 2 and under the Extended model these are Options 3 and 4. Options 2 and 3 use generic flight height data derived from Johnston *et al.* (2014) whereas Options 1 and 4 use flight height data derived from site specific surveys. Although there is flight height data available for the Moray West Site, it was agreed with SNH and MSS that due to concerns with the confidence in the data that it is unsuitable to use in the CRM (Moray West, 2018). It was therefore agreed that the CRM for the worst case scenario of 85 Model 2 turbines (Moray West EIA Report (2018) Volume 2, Chapter 10 Paragraph 10.5.4.61 and Table 10.6.1) would use the Basic Band model (Option 2) for all species including great black-backed gull (Moray West, 2018).

To inform the assessment of in-combination effects, collision mortality rates for Moray East and BOWL have been presented for both Band Option 1 and Option 3 'Extended'. The basis for this is that the collision risk modelling undertaken to inform the Environmental Statement (ES) submitted for both the Moray East and BOWL projects in 2012, was based on Band (2011), which pre-dates the existence of the

'Extended' Band model (Band, 2012). The numbers presented in the ESs for both these projects were calculated using Option 1 of what has, on publication of Band (2012), become defined as the 'Basic' Band model.

Additional Ornithology Information submitted to the Scottish Ministers for Moray East in June 2013 (Moray East, 2013) re-visited the collision risk modelling presented in the ES (Moray East, 2012), using the revised Band model (2012) presenting both the number of collisions when using the Basic and Extended models with Option 1 and Option 3 respectively. In guidance provided to the Moray East project by Marine Scotland in relation to the Appropriate Assessment carried out for the project in 2014 (MSLOT, 2014), collision risk modelling using the Extended model Option 3 was accepted. Similarly the Extended model Option 3 was used by Marine Scotland in the BOWL Appropriate Assessment.

CRM also requires the application of avoidance rates. These vary depending on the different Band models used in the CRM. Great black-backed gull was rated as having a relatively high vulnerability to collision impacts by Wade *et al.* (2016), due to the proportion of flights likely to occur at potential risk height and percentage of time in flight. However, the published report for Marine Scotland (Cook *et al.*, 2014) considers that a 99.5% avoidance rate is appropriate for the 'Basic' Band model (Options 1 and 2) (Band, 2012).

The ORJIP BCA study, 2014 – 2017 (Skov *et al.*, 2018), was designed to improve the evidence base for seabird avoidance behaviour and collisions around offshore wind farms. This study generated the most extensive dataset of observations of seabird behaviour in and around an operational offshore wind farm that is currently available. Bowgen & Cook (2018) by comparing collision rates recorded by the ORJIP BCA study to those that would have been predicted by the Band model in the absence of avoidance behaviour, also recommended avoidance rates for use in the deterministic Band model of 0.995 for large gulls in relation to Option 1 of the Band model. As this aligns with existing SNH advice (JNCC *et al.,* 2014), an avoidance rate of 99.5% has been used in this case for both 'Basic' Band model Options 1 and 2.

For the Extended Band model Option 3 (used for Moray East and BOWL), an avoidance rate of 98.9% is used. This is also in line with existing advice from SNH (JNCC *et al.,* 2014).

1.3.1.2 Nocturnal activity

There is considerable uncertainty about levels of bird flight activity by night and in consequence the nocturnal activity factors to be used in collision risk modelling. The collision risk modelling undertaken to calculate collision mortality rates for great black-backed gull at the three Moray Firth projects used a nocturnal activity level of 2 in the Basic and Extended Band models as advised by Marine Scotland as part of the common currency approach (MSLOT, 2014). This parameter of the common currency approach has therefore already been accounted for within the collision risk modelling.

1.3.2 Further refinements to the in-combination collision risk assessment

There are a range of further refinements that can be applied to the collision rate predictions for each project (where relevant). These include:

- Updated project designs;
- Flight speeds;
- Apportioning including consideration of:
    - Boat based bias;
    - Apportioning of collisions to adult birds;
    - SPA apportioning based on SNH approach to apportioning;
    - Accounting for sabbaticals;

- o Winter influx birds; and
- o Biologically Defined Minimum Population Scales (BDMPS).

The rationale for these refinements and the corrections made are each described below. Results from the application of these refinements are presented in Table 1.2 Part B: Application of Refinements.

1.3.2.1 Updated project designs (refinement 1)

Bird collisions predicted for the in-combination assessments presented in the Report to Inform an Appropriate Assessment (RIAA) submitted in support of Moray West's consent application (2018) were based on the Moray East project as consented (e.g. 186 turbines – although, as discussed in Section 1.3.1 above, the worst case scenario for ornithology was 159 turbines). Although at the time of the consent application (July 2018) Moray East had submitted their DSLP for a revised project design comprising up to 100 turbines, this had not been approved. It was not, therefore, considered appropriate to include the revised project design for Moray East in any quantitative assessment.

Moray East has since received approval of their DSLP and it is now considered appropriate to consider the effect of the finalised project design (100 turbines) in the in-combination assessment. The application of the finalised design parameters for Moray East, including a reduction in turbine numbers leads to a 54% reduction in collision mortality for great black-back gull attributed to the Moray East project. Further information on the finalised design parameters influencing this reduction in collision mortality is provided in Annex A.

1.3.2.2 Flight speed (refinement 2)

Previously, flight speed data for use in CRM has relied on published data (Alerstram *et al.*, 2007) which is based on a very small sample size of four for great black-backed gull. On the other hand, the laser rangefinder track data recorded by Skov *et al.* (2018) at Thanet Offshore Wind Farm, off the Kent coast, offer species-specific empirical data on flight speeds from large numbers of individuals (790 large gull species), albeit in non-adverse weather conditions. The Skov *et al.* (2018) data are therefore considered a valuable source of information on more realistic mean flight speeds and associated variability in offshore wind farms necessary for improving estimates of the flux of birds for the species in question.

When compared to the larger sample size of the Skov *et al.* (2018), the very small sample sizes of flight speed data used at present in collision risk modelling are not considered behaviourally representative of bird flight at sea. Against this background, the flight speeds from Skov *et al.* (2018) are therefore considered the best available evidence to inform the collision risk assessments.

Collision mortality rates for Moray West have previously been calculated using both Skov *et al.* (2018) and Alerstram *et al.* (2007) (Moray West, 2018). For the purpose of this assessment, and in line with advice from SNH provided in their response to consultation on the original application dated 7th September 2018 and reiterated in their response to the Addendum Document dated 4th January 2019, collision mortality rates for Moray West have been calculated using the flight speeds for large gull species presented in Skov *et al.* (2018) i.e. 9.8 m/s. Given that this flight speed was introduced as a modelled parameter in Part A of Table 1.2, no further refinement of Moray West collision mortality rates is required.

In terms of Moray East and BOWL, collision mortality rates presented in Table 1.2 Part A were calculated using original flight speeds based on Alerstram *et al.* (2007). As confirmed with SNH[4], the predicted collision mortality rates for Moray East and BOWL have been recalculated using the updated flight speed from Skov *et al.* (2018).

[4] Approach confirmed with SNH and Marine Scotland Science (MSS) (6th March 2019).

1.3.2.3 Boat-based bias (refinement 3)

Gulls often forage on discards from fishing activities, with large numbers of gulls often occurring in close proximity to fishing vessels. There is also evidence that gulls are attracted to survey vessels, presumably in the expectation of feeding opportunities, and abundance estimates can in consequence be artificially inflated. To account for gull attraction to survey vessels used in the seabird surveys for Moray East and BOWL a correction factor of 2 (reducing the abundance by 50% (0.5)) has been applied to the collision mortality rates. The corrected rates are presented in Table 1.2 Part B. Application of this correction factor is in line with advice provided as part of the common currency approach[5] (MSLOT, 2014).

1.3.2.4 Apportionment of collisions to adult birds (refinement 4)

This refinement ensures that only collisions relating to adult birds are taken forward. The proportion of adults in the observed population is based on the at-sea survey data gathered for each wind farm site.

For BOWL and Moray East, the proportions applied are the same as those used in the "common currency" approach presented in the Moray East Appropriate Assessment – Appendix 1 – GBBGU (MSLOT, 2014). For Moray West, the proportion is as set out in PART 1, Chapter 3, Section 3.7.4 of the Moray West Addendum Document (Moray West, 2018).

1.3.2.5 SPA apportioning – breeding season (refinement 5)

The two-stage apportioning process, following SNH guidance (2018), has been applied to apportion breeding season effects from each of the three Moray Firth projects (Moray West, Moray East and BOWL) to relevant SPAs. This two stage approach is summarised below:

- Stage 1: This first stage apportions impacts between SPA and non-SPA breeding colonies within foraging range of the wind farm. This is done on the basis of Seabird 2000 data.
- Stage 2: The impacts assigned to the SPA component in Stage 1 are further apportioned between the individual SPAs within foraging range of the wind farm. In this regard, the most recent counts are used (as provided to Moray West by SNH or if not, Seabird Monitoring Programme Online Database http://jncc.defra.gov.uk/smp/).

Further detail on the application of this approach is provided in Annex C.

A foraging range of 60 km has been applied in the breeding season based on BTO (2013)[6].

During the non-breeding season, a different approach is taken (see refinement 7 below).

1.3.2.6 Accounting for sabbaticals (refinement 6)

During every breeding season a proportion of adults skip breeding and take a sabbatical. Therefore, to include impacts on sabbatical birds is likely to lead to an overestimate of the effects to these species / populations (Marine Scotland 2017a, b), as breeding colony population size estimates do not include these sabbatical birds. Therefore, in accordance with Marine Scotland guidance (Marine Scotland 2017a, b), the impacts assigned to sabbaticals are removed from the assessment. Based on advice from SNH (Moray West RIAA Technical Appendix 4.2: Phenology and Apportioning) the proportion of adult great black-backed gulls taking sabbaticals from breeding in a given year is 35%. This percentage has been applied as

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[5] The common currency approach refers to guidance provided to the Moray East and BOWL projects by MSLOT in relation to the Appropriate Assessment carried out for these projects in 2014 (MSLOT, 2014).

[6] 60 km = foraging range of breeding adult GBBGU. GBBGU was not reviewed by Thaxter *et al.* (2012), therefore a separate review was conducted by British Trust for Ornithology (BTO 2013), giving a maximum value of 60 km reported from Seys *et al.* (2001) based on density of birds from at-sea surveys. However, since this was only one study, with foraging ranges albeit unknown but potentially above this value, BTO concluded 60 km was a representative foraging range for this species.

a refinement to the calculation of collision mortality rates with the corrected rates presented in Table 1.2 Part B. This approach is in accordance with the common currency approach (e.g. MSLOT, 2014).

1.3.2.7 Non-breeding season apportioning and winter influx of birds (refinement 7)

Apportioning during the non-breeding season needs to take into account both the likely dispersal of SPA birds within the Moray Firth as well as the influx of birds from other locations.

As discussed in Section 1.2 above, there is evidence that UK breeding adults in the non-breeding season move only short distances from the breeding colony during the non-breeding season (e.g. up to 60 km based on ringing recoveries - Migration Atlas; Wernham *et al.* 2002). This would mean that birds from East Caithness Cliffs SPA are likely to remain within the confines of the Moray Firth region.

The total breeding population of great black-backed gull within the Moray Firth region is 454 pairs based on data from Seabird 2000 (Mitchell *et al.,* 2004) as summarised in Table 1.1 below.

Table 1.1 Breeding population of great black-backed gull within the Moray Firth region

Admin area	Colony size (pairs)
East coast Caithness	181
East coast Sutherland	1
East coast Ross & Cromarty	220
Nairn	0
Moray	10
Banff & Buchan	37
Inverness	5
TOTAL	**454**

Based on information presented in Furness (2015), the total number of great black-backed gulls in the UK North Sea waters (BDMPS) during the non-breeding season is 91,399. Of these 62,736 (69%) are from overseas e.g. Arctic Norway, the Murmansk region on the northern coast of Russia and Faroes (Furness 2015, Wernham *et al.* 2002, Wright *et al.* 2012). Of the 62,736 great black-backed gulls from overseas, 20,400 are adults (33%) and 42,336 are immatures (67%).

The 20,400 overseas adults comprise 63.6% of all adult great black-backed gulls in UK North Sea waters during the non-breeding season (32,070). The remaining 59,329 birds (65% of the total 91,399) are immatures.

Based on the assumption that the local breeding birds of 454 pairs (908 individuals) represent 36.4% of the total Moray Firth region non-breeding season population of adult birds, the 63.6% non-UK breeding adults apportioned by Furness (2015) in UK North Sea waters, is therefore approximately 1,587 birds. The total Moray Firth region non-breeding season population of adult birds is therefore estimated at 2,495.

The East Caithness Cliffs SPA breeding population of great black-backed gulls is 266 pairs (SNH, 2017) or 180 pairs based on counts from Seabird 2000. This equates to 532 and 360 adult individuals respectively.

In line with SNH guidance on apportioning[4], the percentage contribution of East Caithness Cliffs SPA to the Moray Firth region non-breeding season population of adult birds needs to be based on data from the same time period as the calculations of pairs in the Moray Firth area i.e. Seabird 2000 and not the 2015 population count.

On this basis, the 360 breeding adult birds from the East Caithness Cliffs SPA (based on the Seabird 2000 population count) represents 0.1443 (360/2,495) of the Moray Firth region population of adults in the non-breeding season.

This proportion is applied to non-breeding season collisions to determine the number of those collisions that should be apportioned to East Caithness Cliffs SPA whilst also taking account of the winter influx of non-UK breeding birds into the Moray Firth region.

For further information on this approach and the calculations see Annex C.

1.3.3 Identification of other projects requiring consideration in terms of in-combination effects during the non-breeding season

An assessment of in-combination effects on great black-backed gulls during the non-breeding season due to impacts from other projects within the wider North Sea BDMPS region has been undertaken as part of this assessment. Results from this assessment, which follows the approach set out in the Moray West RIAA for other species (Moray West, 2018) in terms of other projects requiring inclusion in the assessment and the apportioning of impacts to those projects, are provided in Annex C.

These results have, however, not been used to inform the assessment of in-combination effects on the great black-backed gull feature of the East Caithness Cliffs SPA as presented in Table 1.2 and Section 1.5. This is on the basis that, as discussed in Section 1.2, great black-back gulls from the East Caithness Cliffs SPA are expected to remain within the confines of the Moray Firth region. It is therefore concluded that, given there is no potential for any interaction between birds from the East Caithness Cliffs SPA and any other projects in the North Sea BDMPS region, the assessment of in-combination effects during the non-breeding season should be limited to those projects within the Moray Firth (Moray West, Moray East and BOWL) as per the assessment of in-combination effects during the breeding season.

The assessment of in-combination effects on the great black-backed gull feature of the East Caithness Cliffs SPA therefore assume that collision mortality during the non-breeding season is limited to the Moray Firth region only as presented in Table 1.2.

Calculations used to inform the assessment of in-combination effects during the non-breeding season for the Moray Firth Region are presented in Annex C.

1.4 Results from the assessment of in-combination effects on great black-backed gull feature of the East Caithness Cliffs SPA

In-combination collision mortality rates calculated for the Moray West, Moray East and BOWL projects, and the application of the refinements discussed in Section 1.3.2 above to those collision mortality rates are presented in Table 1.2 below. As discussed in Section 1.3.3, the refinement have been applied to the three Moray Firth projects only.

Table 1.2 Application of refinements to in-combination collision rates for great black-backed gull					
Stage	**Moray West**	**Moray East**		**BOWL**	
		Option 1	**Option 3**	**Option 1**	**Option 3**
Part A - Collision risk modelling parameters and assumptions					
Source of information (configuration)	Moray West EIA Report 2018, Table 10.7.10	Original consent (159 x 7 MW) and Moray East Alternative Design Parameters Scoping Opinion Addendum: Ornithology (Marine Scotland, 2017)		As built - in DSLP (Marine Scotland, 2017)	
Model option	2	1	3	1	3
Avoidance rate	99.5%	99.5%	98.9%	99.5%	98.9%
Nocturnal activity	2	2	2	2	2
Flight speed	9.8 m/s	13.7 m/s	13.7 m/s	13.7 m/s	13.7 m/s
Annual collision mortality rate[Note 1]	**9**	**35**	**31**	**45**	**22**
Part B - Application of Refinements					
Refinement 1 Updated project design	N/A	See Annex A for CRM parameters		N/A	
Revised collision rate following application Refinement 1	**9**	**16**	**10**	**45**	**22**
Refinement 2 Updated flight speeds	N/A	Apply 9.8 m/s		Apply 9.8 m/s	
Revised collision mortality rate following application of Refinement 2[Note 2]	**9.30**	**13.06**	**9.19**	**37.01**	**16.01**

Table 1.2 Application of refinements to in-combination collision rates for great black-backed gull

Stage		Moray West		Moray East				BOWL			
				Option 1		Option 3		Option 1		Option 3	
Part B - Application of Refinements Continued		Refinement	Running total	Refinement	Running total	Refinement	Running total	Refinement	Running total	Refinement	Running total
Application of refinements to breeding season collisions (Apr - Aug)	***Breeding season collisions (Apr-Aug)*** *Note 3*	-	***4.00***	-	***4.34***	-	***3.06***	-	***11.36***	-	***4.91***
	Refinement 3 Boat-based bias correction	N/A	4.00	0.5	2.17	0.5	1.53	0.5	5.68	0.5	2.46
	Refinement 4 Proportion of adults	0.64	2.58	0.49	1.06	0.49	0.75	0.375	2.13	0.375	0.92
	Refinement 5 Proportion from SPA	0.92	2.37	0.79	0.84	0.79	0.59	0.83	1.77	0.83	0.76
	Refinement 6 Exclude sabbaticals	0.65	1.54	0.65	0.55	0.65	0.39	0.65	1.15	0.65	0.50
Revised collision mortality rate during the breeding season (Apr-Aug) following application of refinements 3 to 6		-	**1.54**	-	**0.55**	-	**0.39**	-	**1.15**	-	**0.50**
Application of refinements to non-breeding season collisions (Sept - Mar)	***Non-breeding season collisions (Apr-Aug)*** *Note 3*	-	***5.30***	-	***8.71***	-	***6.14***	-	***25.65***	-	***11.09***
	Refinement 3 Boat-based bias correction	N/A	5.30	0.5	4.36	0.5	3.07	0.5	12.82	0.5	5.55
	Refinement 4 Proportion of adults	0.55	2.94	0.49	2.14	0.49	1.50	0.375	4.81	0.375	2.08
	Refinement 7 Apportioning & winter influx	0.14	0.42	0.14	0.31	0.14	0.22	0.14	0.69	0.14	0.30

Table 1.2 Application of refinements to in-combination collision rates for great black-backed gull

Stage	Moray West		Moray East				BOWL			
			Option 1		Option 3		Option 1		Option 3	
Revised collision mortality rate (non-breeding season) following application of refinements 3, 4 and 7	**-**	**0.42**	**-**	**0.31**	**-**	**0.22**	**-**	**0.69**	**-**	**0.30**
Revised collision mortality rate (annual)	-	**1.96**	-	**0.86**	-	**0.60**	-	**1.84**	-	**0.80**
TOTAL in-combination collision mortality (annual)										
Moray West (Option 2) Moray East & BOWL (Option 1)	**4.66**									
Moray West (Option 2) Moray East & BOWL (Option 3)	**3.36**									

Note 1: These collision mortality rates are based on information presented in the Moray West EIA Report – Volume 2, Chapter 10, Table 10.8.9. The collision mortality rates included in this table for Moray East and Beatrice are derived information presented in the Moray East Alternative Design Parameters Scoping Opinion Addendum: Ornithology (Marine Scotland, 2017). For the Moray East original consent rates were only presented for Option 1 at 98%. These rates have therefore been re-calculated for 99.5% (for 98% it was 140 and for 99.5% it was 35). Similarly, collision rates presented for Option 3 were also recalculated for 98.9% (for 98% it was 56 and the value for 98.9% was re-calculated at 31). No other refinements have been applied to these collision mortality rates at this stage e.g. the nocturnal activity factors and flight speeds listed in the preceding rows are the parameters that were used to calculate the original collision mortality rates as presented in the Moray West EIA Report – Volume 2, Chapter 10, Table 10.8.9 and the Moray East Alternative Design Parameters Scoping Opinion Addendum: Ornithology (Marine Scotland, 2017).
Note 2: Numbers presented to two decimal places following application of Refinement 2 – updated flight speeds. For Moray West the collision mortality rate presented changes from 9 to 9.30. The 9.30 value was rounded down to the nearest single figure (9) in the Moray West EIA and RIAA as presented in Part A.
Note 3: Derived from revised collision mortality rates following application of Refinement 2.

1.5 Implications for the East Caithness Cliffs SPA

Population Viability Analysis (PVA) has been undertaken in line with advice from MSS and SNH on information to be provided to inform an Appropriate Assessment of the Project (Marine Scotland, 2016). PVA outputs for great black-backed gull have been provided in single bird increments as advised by MSS in their response to the Addendum Document[2]. Table 1.3 presents the PVA outputs for the great black-backed gull feature of East Caithness Cliffs SPA for the 25 years operational scenario for up to 6 additional mortalities. Table 1.4 presents the PVA results for the assessed Moray West alone and in-combination impacts for the great black-backed gull feature of East Caithness Cliffs SPA.

Table 1.3 PVA results (over 25 years) for the great black-backed gull feature of East Caithness Cliffs SPA

Additional mortalities	Median growth rate	Ratio of Impacted to Unimpacted Growth Rate (CGR)	Ratio of Impacted to Unimpacted Population Size (CSP25)	Centile for Impacted Population
0	1.088	1	1	0.5
1	1.086	0.998	0.948	0.421
2	1.083	0.996	0.898	0.349
3	1.081	0.994	0.851	0.284
4	1.079	0.991	0.806	0.22
5	1.076	0.989	0.764	0.174
6	1.074	0.987	0.724	0.129

Table 1.4 PVA results (over 25 years) for the assessed Moray West alone and in-combination impacts for the great black-backed gull feature of East Caithness Cliffs SPA

Impact Scenario	Predicted annual collisions	Median Growth Rate	Ratio of Impacted to Unimpacted Growth Rate (CGR)	Ratio of Impacted to Unimpacted Population Size (CSP25)	Centile for Impacted Population
Unimpacted	0	1.088	1.000	1.000	0.500
Impacted – Moray West alone	1.96	1.083	0.996	0.898	0.349
Impacted – In-combination (when using Option 3 for Moray East & BOWL)	3.36	1.081	0.994	0.851	0.284
Impacted – In-combination (when using Option 1 for Moray East & BOWL)	4.66	1.076	0.989	0.764	0.174

It should be noted that the PVA results presented above should be interpreted carefully.

The level of predicted effect at 3.36 to 4.66 birds per annum for all three Moray Firth Projects is considered to be small. Furthermore, the predicted effects are considered to be over-estimated due to lack of evidence of connectivity between the Moray West Site and the East Caithness Cliffs SPA as reported in the Moray West Addendum Document, PART 1, Chapter 3, Section 3.7 (Moray West, 2018). Where there is evidence on the specific foraging behaviour of individuals from this colony, this indicates that birds tend to forage within more coastal areas and this observation is consistent with an understanding of the species' dietary requirements (Moray West, 2018).

Assuming connectivity, however, and an in-combination impact of 3.36 to 4.66 collisions per annum, the counterfactual of impacted to unimpacted population size after 25 years (CPS25) is predicted to be 0.851 to 0.764 and the counterfactual of growth rate (CGR) is 0.994 to 0.989 for the same level of impact. The model also predicts a positive rate of growth for the population based on a median growth rate of 1.081 to 1.076 (or 8.1% to 7.6%) per annum at that level of impact, compared to 1.088 (or 8.8%) within the unimpacted population.

The great black-backed gull population at East Caithness Cliffs SPA is observed to be growing, and has increased by 47.8% between 1999 to 2015 (from 180 to 266 pairs) (see Section 1.3.2 above). This equates to an average annual increase of 2.5% per annum for the breeding adult population. The difference in growth rate predicted by the PVA model to the observed increase of 2.5% per annum is likely due to assumptions that have to be made about great black-backed gull demographics, which are less well documented than for some other species.

For the purposes of this assessment, therefore, it is assumed that the population will continue to grow, in the absence of any additional mortality, at a rate between 2.5% per annum (observed rate) and 8.8% per annum (PVA modelled rate). If the additional in-combination mortality predicted to arise for Moray West, BOWL and Moray East combined (3.36 to 4.66 birds per year from 2025) is included, then the PVA model indicates that the final population of great black-backed gull within the SPA will, after 25 years of wind farm operation, be lower than that which would otherwise have arisen in the absence of those impacts. Nevertheless, at the growth rates observed within the colony and those predicted by the model, the population is still expected to continue to grow and will be larger than that which the SPA currently supports.

2 Conclusions

It was concluded in the Moray West Addendum Document (Moray West, 2018) that there is limited evidence of any connectivity between the breeding colony of great black-backed gull at the East Caithness Cliffs SPA and the Moray West Site. However, in response to comments received following consultation on the Addendum Document, a precautionary assessment has been undertaken that assumes that there is connectivity with breeding colony of great black-backed gull at East Caithness Cliffs and which takes into account the effects of other wind farms within the Moray Firth (Moray East and BOWL), in-combination.

During the non-breeding season it is considered that birds from East Caithness Cliffs will remain in the Moray Firth (although supplemented by an influx of birds from elsewhere). Therefore the assessment of in-combination effects in that season is focused on the same three Moray Firth projects.

With the application of various refinements such as updated project designs and removal of immature and sabbatical birds the predicted in-combination collision mortality is 3.36 to 4.66 birds per annum. Although this is a very low rate of mortality for a seabird population, the PVA outputs for the East Caithness Cliffs great black-backed gull population indicate a reduction in population growth rate and final population, at 25 years, of approximately 85% to 76% of that which is predicted to arise without additional wind farm mortality. However, PVA modelling for this population also indicates that the population will continue to grow at this level of in-combination effect and this, taken together with recent population trends, which indicate an observed growth rate of 2.5%, provides no indication that the population will decline nor that the additional mortality will prevent the population from growing further.

On this basis it is concluded that even with a precautionary assessment of collision mortality, Moray West will not adversely affect the integrity of the East Caithness Cliffs SPA alone or in-combination with other relevant plans and projects.

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Annex A CRM Design Parameters

Table A1 Parameters used for collision risk modelling for each project scenario

Parameters	Moray West	Moray East (original consented worst case)	Moray East (DSLP)	BOWL (As built)
Turbine	12 MW	7 MW	9.525 MW	7 MW
Number of turbines	85	159	100	84
Rotor radius (m)	82	86	82	77
Rotor speed (rpm)	See Table A2 below	See Table A2 below	See Table A2 below	11.8
Hub height (m)	117	108 (HAT)	108 (HAT)	105.5 (HAT)
Max blade width (m)	5.4	5.8	5.4	4.98
Pitch (°)	8	30	8[Note 1]	7
Monthly proportion of time operational (%)	85	80	80	85
Tidal offset	2.24	2.24	2.52	2.5

[Note 1] Based on data provided to Moray West from MVOW in relation to 9.525MW turbine design parameters.

Table A2 Rotor speed quartiles for each project scenario and the proportion of time for which each quartile will operate at the site.

Rotor speed	Proportion of time (%)	Moray West	Moray East (original consented)	Moray East (DSLP)
Minimum	-	6.0	4.25	6.5
1st rotor quartile	8	6.5	5.32	7.29
2nd rotor quartile	6	7.4	7.46	8.86
3rd rotor quartile	9	8.4	9.59	10.43
4th rotor quartile	77	9.3	11.73	12.01
Maximum	-	9.8	12.8	12.8

Annex B Population Viability Analysis Methodology

Overview

This annex provides the methodology used for the Population Viability Analysis (PVA). The analysis was performed for the breeding colony of great black-backed gull in East Caithness Coast Special Protected Areas (SPA). Stochastic, density independent, age-structured matrix models were used to simulate population trends over time for a range of impacts scenarios.

Methods

The potential impacts of the Moray West Offshore Wind Farm on the population growth and size of the population of great black-backed gull at East Caithness Cliffs SPA. Table B1 describes the population analysed as part of the PVA.

Table B1 Population considered for analysis, and corresponding initial population size used in the modelling.

Species	SPA	Initial population size (breeding individuals)	Year	Source
Great black-backed gull	East Caithness Cliffs	532	2015	Marine Scotland Scoping Opinion, Appendix A

The age-structured matrix model (Caswell, 2001) was built to simulate the population's progress through time in terms of abundance and age distribution, based on the species-specific demographic rates and count estimates. The model assumes individuals to be grouped into discrete year age-classes, and all members of an age-class are considered equal with respect to their demographic vital rates (i.e. survival, growth and reproduction). The model dynamics involves predicting the population numbers at age in the next year given its previous year's numbers and vital rates.

The generic population model can be written in compact form as

$$\mathbf{n}_{y+1} = \mathbf{L}\mathbf{n}_y$$

where $\mathbf{n}_y$ is the population vector with elements $n_{a,y}$ denoting the number of individuals at each age-class $a = 1, \ldots, A$ at year y, $\mathbf{n}_{y+1}$ is the numbers at age-class in the following year, and $\mathbf{L}$ represents the $A \times A$ projection matrix (also known as the Leslie matrix). The projection matrix $\mathbf{L}$ defines the expected contribution of individuals in each age-class in a given year to each age-class in the subsequent year.

Models used in this analysis were built under the following assumptions, for all considered species:

- models represent an annual post-breeding census over a period of $y = 1, \ldots, Y$ year steps. Therefore, the model annual cycle comprises a census immediately after fledging on the first day of the biological year, with the first age-class ($a = 1$) containing newly hatched birds, followed by a 12 months period of survival. Then, on the first day of the subsequent year, surviving animals increment in age, adult age-classes reproduce and resultant newborns fledge, and the next census is carried out.

- reproduction is considered to be confined to adult birds, with age of first breeding being species-specific.
- population size is density independent, and therefore projections will either increase to infinity or decrease to extinction.
- population is considered to be closed system, i.e. age distributions are not affected by migration exchanges between neighbouring colonies
- the final age-class A is a aggregated age group, representing A years-old birds and older. This implies the absence of senescence, i.e. the survival and reproductive performances of the oldest animals remain constant over time. The value of A, and hence the size of the projection matrix, of each species is determined by either the age of first breeding or the oldest adult age-class for which survival data is available (the largest of the two values).

Based on the above assumptions, the expanded version of the generic population model used in this analysis can be expressed as

$$\begin{bmatrix} n_{1,t+1} \\ n_{2,t+1} \\ n_{3,t+1} \\ \vdots \\ n_{A,t+1} \end{bmatrix} = \begin{bmatrix} 0 & \cdots & 0 & P_{A-1}(0.5)S_{A-1\to A} & P_A(0.5)S_A \\ S_{1\to 2} & 0 & 0 & \cdots & 0 \\ 0 & S_{2\to 3} & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ 0 & 0 & 0 & S_{A-1\to A} & S_A \end{bmatrix} \times \begin{bmatrix} n_{1,t} \\ n_{2,t} \\ n_{3,t} \\ \vdots \\ n_{A,t} \end{bmatrix}$$

where P_A denotes the annual productivity rate of age-class A, expressed as the annual average number of fledged young per breeding pair; and $S_{a\to a+1}$ represents the annual survival transition rate of animals of age-class a, i.e. the average proportion of birds in age-class a that will survive the whole year and trasition to age-class $a+1$. Elements in the top row of the projection matrix $\mathbf{L}$ (i.e. half of the productivity rate multiplied by the survival rate) reflect the annual fecundity rate per capita of each adult age-class.

Environmental stochasticity, which accounts for the variation arising from environmental changes affecting individuals in the same group (e.g. between-year differences in weather conditions), was incorporated in the models at the level of productivity and survival rates. For each simulated year, a value for each demographic rate was randomly generated from a probability distribution defined by the mean and standard deviation estimates of that rate for the population under consideration.

Random survival rates, which are theoretically bounded at 0 and 1, were drawn from beta distributions. Stretched beta distributions were used to generate productivity rates as it allows an upper limit greater than one, which was set based on the maximum number of eggs laid per pair per year for the species. These two distributions are considered to provide biologically reasonable random values of each vital rate (Morris and Doak, 2002).

Demographic stochasticity, which accounts for individual-level variation affecting transition probabilities between age-classes, was not included in the models.

Table B2 provides the demographic parameters used to specify the models for great black-backed gull. With exception of maximum number of eggs per pair (taken from Snow and Perrins, 1998), all remaining parameter were obtained from Horswill and Robinson (2015).

Table B2 Species features and demographic rates used in the population models (Snow & Perrins, 1998; Horswill & Robinson, 2015).											
Species	**Age first breeding**	**Final age (A)**	**Eggs/ pair**		$S_{1\rightarrow2}$	$S_{2\rightarrow3}$	$S_{3\rightarrow4}$	$S_{4\rightarrow5}$	S_A	P_{A-1}	P_A
Great black-backed gull	5	5	2	Mean	0.82	0.885	0.885	0.885	0.885	0	1.139
				SD	0.022	0.022	0.022	0.022	0.022	0	0.533

Annual productivity rates were selected from regional-specific estimates available in Horswill and Robinson (2015). Thus, for the Moray West Site, U.K. north-eastern productivity estimates were used whenever possible (Table B3). Single survival estimates attributed to multiple age-classes were split evenly into annual survival rates, with associated standard deviations computed via simulation (Table B3).

Table B3 Comments on values selected for demographic rates		
Species		
Great black-backed gull	Productivity	Average UK rates
	All survivals	Survival rates largely unknown for this species. Following Horswill and Robinson's (2015) advice, survival rates from the Lesser Black-backed Gull used instead

For the model, assuming the population was at equilibrium before the wind farm development, the initial population size in terms of breeding individuals (Table B1) was converted to total size (i.e. number of birds in the whole population) using the proportion of breeders under the population's stable age distribution (i.e. the proportion of individuals per age-class). The stable age distribution was provided by the right eigenvector associated with the dominant eigenvalue of the population projection matrix using the mean of the demographic rates (Table B2). The (average) stable age distribution for each species is provided in Table B4. The initial population vector ($\mathbf{n_1}$) was then obtained by multiplying the initial total size by the stable age distribution vector.

Starting with the initial population vector for the first simulated year, new population vectors were calculated by multiplying the previous year's population vector by a new projection matrix generated from sampling each demographic rate (i.e. different projection matrices prevailing in each simulated year).

Models were run for 25 years, representing the likely lifespan of the wind farm. Each 25-year simulation was run 1,000 times to obtain indicative population trends and estimates of uncertainty surrounding those trends.

Table B4 Stable age structure for great black-backed gull.	
Age-class	**Great black-backed gull**
1	0.199
2	0.15

Table B4 Stable age structure for great black-backed gull.	
Age-class	**Great black-backed gull**
3	0.122
4	0.099
5	0.43

Effects of the wind farm on great black-backed gull in terms of collision were incorporated into the model in terms of additional mortalities. Additional mortalities were assumed to be applied to all age classes in proportion to their presence (i.e. the likelihood of a bird being killed due to wind farm effects assumed to be independent of its age).

Additional adult mortalities per annum are presented in increments of individual bird deaths from 0 to a species-specific maximum value (impact scenarios). The related absolute number of additional deaths over all ages was derived via the stable age distribution. While these impact scenarios are expressed in terms of absolute annual deaths, this is not expected to remain constant as population sizes change over time. As such, the absolute number of additional deaths only strictly applies in the first year of simulation. It is converted to per-capita mortality rate for projection forwards i.e. the number of additional deaths in a year will increase proportionately with an increase in the simulated population size and vice-versa.

Implementation

All modelling was done in the R statistical programming environment v3.3.x (R Core Team, 2017). All code was bespoke.

Key outputs

Outputs are focused on reference points indicated in the relevant scoping document (Marine Scotland 2017). The principal metrics indicated in the scoping document follow recommendations by Jitlal *et al.* (2017) and are the:

1. median of the ratio of impacted to unimpacted annual growth rate.
2. median of the ratio of impacted to unimpacted population size.
3. centile for unimpacted population that matches the 50th centile for impacted population.

Where annual population growth rate was required, this was calculated as the average over years 5 to 25 of the simulations, as per scoping recommendations – the first 5 years being discarded to mitigate against effects of starting conditions.

Furthermore, each unimpacted to impacted metric was derived following a matched runs approach (Green, 2014), whereby stochasticity is applied to the population before wind farm impacts are applied (i.e. survival and productivity rates sampled at each time step are the same for the unimpacted and impacted populations, with additional impact mortalities being subsequently deducted from sampled survivals).

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Annex C Calculations used to inform assessment of in-combination effects on great black-backed gull feature of East Caithness Cliffs SPA

Overview

This annex presents PDF copies of the spreadsheets that were used to calculate the in-combination effects on the great black-backed gull feature of the East Caithness Cliffs SPA.

In total four separate MS Excel worksheets have been prepared these are summarised below:

1. *Worksheet 1: Moray Firth Region ME BOWL Option 1* - calculations for in-combination effects using the Band Basic model option 1 for Moray East (ME) and BOWL and assuming collision mortality during the non-breeding season is limited to the Moray Firth region only as discussed in Section 1.3.3.
2. *Worksheet 2: BDMPS Region ME BOWL Option 1* – calculations for in-combination assuming that, during the non-breeding season there is potential for interaction between great black-back gulls from the East Caithness Cliffs SPA and other projects within the wider BDMPS North Sea region (this spreadsheet has been provided for information only and has not been used to inform the overall assessment of effects on the great black-backed gull feature of the East Caithness Cliffs SPA).
3. *Worksheet 3: Moray Firth Region ME BOWL Option 3* – As above for (1) but with Moray East and BOWL collision mortality modelled using the Extended Band model Option 3.
4. *Worksheet 4: BDMPS Region ME BOWL Option 3* - As above for (2) but with Moray East and BOWL collision mortality modelled using the Extended Band model Option 3.

Worksheet 1: Moray Firth Region ME and BOWL Option 1

Line	Refinements		Moray West		Moray East		BOWL		Comments
2		**CRM**							
3		*Source*							
4		Flight speed	9.8 m/s		13.7 m/s		13.7 m/s		9.8 m/s sourced from **Skov *et al.* (2018**; ORJIP BCA study), 13.7 m/s from **Alerstram *et al.* (2007)**
5		Nocturnal activity	2		2		2		
6		Band (2012) model option	2		1		1		
7		Avoidance rate	99.5%		99.5%		99.5%		Avoidance rate as per SNH guidance
8		Wind farm scenario	Moray West EIA Report 2018 - Volume 2, Chapter 10, Table 10.7.10		Original consent 159 x 7 MW		As built - in DSLP		Based on information for consented Moray East project and BOWL as built presented in Moray East Alternative Design Parameters Scoping Opinion Addendum: Ornithology (Marine Scotland, 2017).
9		Annual collisions	9		35		45		
10									
11	1	**Updated Project Design**			See Annex A				See Annex A of this Document for Moray East Design Parameters.
12		Annual collisions	9		16		45		
13									
14	2	**Flight speed update (Skov *et al.* 2018)**			9.8 m/s		9.8 m/s		
15		Annual collisions	9.30		13.06		37.01		
16		Breeding season	Apr-Aug		Apr-Aug		Apr-Aug		Breeding season defined as per SNH guidance
17		Breeding season collisions	4.00		4.34		11.36		
18		Non-breeding season collisions	5.30		8.71		25.65		
19									
20		**Collision Apportioning (breeding season**	**Moray West**	Running total	**Moray East**	Running total	**BOWL**	Running total	
21		CRM collisions (breeding season)		4.00		4.34		11.36	
22	3	Boat-based bias		4.00	0.5	2.17	0.5	5.68	A correction factor of 2 was included in the "common currency" approach to account for gull attraction to survey vessels used in the seabird surveys for Moray West and BOWL, thus halving the original abundance estimate (e.g. **MS-LOT 2014**).
23	4	Prop adults	0.64	2.58	0.49	1.06	0.375	2.13	Age structure based on at-sea survey data gathered for the wind farm site. For BOWL and Moray East, the proportions applied are those proposed as part of the "Common currency" approach (**MS-LOT 2014**). For Moray West, the proportion as set out in Section 3.7.4 of the Volume 1 of the Moray West Addendum to Section 36 Consent and Marine Licence Application.
24	5	Prop from ECC SPA (SNH 2 step approach)	0.92	2.37	0.79	0.84	0.83	1.77	Note 1
25	6	exclude sabbatical	0.65	1.54	0.65	0.55	0.65	1.15	35% adult birds take sabbatical as per SNH guidance
26		Sub-total SPA adult birds (breeding season)		**1.54**		**0.55**		**1.15**	*Collisions used to populate Worksheet 2*
27									
28									
29		**Collision Apportioning (non-br season)**	**Moray West**	Running total	**Moray East**	Running total	**BOWL**	Running total	
30		CRM collisions (non-br season)		5.30		8.71		25.65	
31	3	Boat-based bias		5.30	0.5	4.36	0.5	12.82	Common currency correction (**MS-LOT 2014**). *Collisions used to populate Worksheet 2*
32	4	Prop adults	0.55	2.94	0.49	2.14	0.375	4.81	Proportions applied at BOWL and Moray East are those used for the "Common currency" approach (**MS-LOT 2014**), whilst for Moray West it's the proportion as set out in Section 3.7.5 of the Moray West Addendum. Based on site-specific survey data.
33	5 & 7	Prop from ECC SPA & remove winter influx	0.14	0.42	0.14	0.31	0.14	0.69	Note 2 - SNH agreed approach 6th March 2019
34		Sub-total SPA adult birds (non-br season)		**0.42**		**0.31**		**0.69**	
35									
36		**Total (SPA, adults)**		**1.96**		**0.86**		**1.84**	
37									
38			**Annual Collisions**						
			4.66						

	Comments
Note 1	As advised by SNH & MSS, when apportioning breeding season effects from a Project between relevant SPAs for GBBGU, a two-stage apportioning process was followed i.e. following SNH guidance (2018) for Step One which is then repeated but only for the SPAs and using the most recent count data.
Note 2	Furness (2015) estimates that 63.6% of adult birds in winter in the UK North Sea Region are from outside the UK breeding population. However, Wernham *et al.* (2002) states that most of the birds arriving from Norway reach more southerly areas (i.e. the east coast of England). This is because birds move along the Norwegian coast south before crossing the North Sea, arriving on the east coast of the UK, and especially the south east. Forester *et al*. (2007) estimated that there were between 7,500 and 10,000 birds in Scotland in winter, based on coastal counts. The Furness BDMPS estimate for the North Sea GBBGU population is 91,399 birds. Given that most non-UK birds in the North Sea winter in England and yet most breeding birds are in Scotland it seems very likely that the percentage of UK to non-UK birds declines north to south. However, there is no available measure of this, and Furness (2015) at least supplies some basis for an estimate. SNH accept the percentage of birds in the Moray Firth is the same as across the whole North Sea on that basis. As the calculations of pairs in the Moray Firth area are taken from Seabird 2000, SNH have advised that the percentage contribution of East Caithness Cliffs SPA is based on the same time period (i.e. Seabird 2000 and not the 2015 population count). If more recent counts are available for all areas of the Moray Firth, then it may be possible to use these instead of the Seabird 2000 counts. If we assume that Moray Firth has 454 pairs of birds (908 adults), then there would be approximately 2,495 birds in the Moray Firth area in winter (i.e. 1587 (63.4%) + 908 (36.4%) = 2495). The percentage of Moray Firth birds in winter that are from the East Caithness Cliffs SPA would then be 360 (taken from Seabird 2000) / 2495 = 14.4%

References

Alerstam, T., Rosén, M., Bäckman, J., Ericson, P.G. and Jellgren, O. (2007). Flight speeds among bird species: allometric and phylogenetic effects. PLoS Biology, [e-journal], 5(8): e197. https://doi.org/10.1371/journal.pbio.0050197.

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Worksheet 2: BDMPS Region ME and BOWL Option 1

Seasonal Breakdown of Predicted Cumulative Collision Mortality for great black-backed gull

Offshore Wind Farm	Option	Avoidance Rate (%)	Annual Collisions	Breeding for ECC SPA	Non-Breeding for all colonies	Applying turbine scenario correction factors from MacArthur Green (2017): Non-Breeding - refinement 1	Proportion of BDMPS represented by adults from ECC SPA: Non-Breeding - refinement 2
	Breeding and Non-Breeding Season					for all colonies	for ECC SPA
			All ages *Note 1*	Adults *Note 2*	All ages *Note 3*	All ages *Note 4*	Breeding adults *Note 5*
Moray West	2	99.5	9	1.54	5.30	5.30	0.02
Moray East	1	99.5	35	0.55	4.36	4.36	0.02
Beatrice	1	99.5	45	1.15	12.82	12.82	0.05
Non-Breeding Season Only							
Aberdeen Demo	2	99.5	3		2	2	0.01
Blyth Demo	1	99.5	8		5	5	0.02
Dogger Bank Creyke Beck A and B	2	99.5	33		28	28	0.11
Dogger Bank Teesside A and Sofia	2	99.5	37		29	29	0.11
East Anglia ONE	2	99.5	124		122	122	0.47
East Anglia Three	2	99.5	42		37	37	0.14
Galloper	1	99.5	22		21	9	0.03
Hornsea Project One	1	99.5	86		71	71	0.27
Hornsea Project Two	2	99.5	23		18	18	0.07
Humber Gateway	1	99.5	6		4	2	0.01
Hywind	1	99.5	5		5	5	0.02
Inchcape	1	99.5	37		37	37	0.14
Kentish Flats Extension	1	99.5	0		0	0	0.00
Neart na Gaoithe	1	99.5	8		7	7	0.03
Seagreen Alpha	2	99.5	37		31	31	0.12
Seagreen Bravo	2	99.5	30		23	23	0.09
Teesside	1	99.5	44		35	24	0.09
Thanet	1	99.5	0		0	0	0.00
Triton Knoll	1	99.5	122		106	106	0.41
Westermost Rough	1	99.5	0		0	0	0.00
Total			**756**	**3.24**	**603**	**578**	**2.22**

	Comments	Annual Collisions
Note 1	Collisions for all age classes as presented in (1) Table 10.8.19 of the Moray West EIA Report - Volume 2, Chapter 10, and repeated in (2) line 9 of *"Worksheet 1"*	**5.45**
Note 2	No. of collision in the breeding season apportioning to breeding adults from ECC SPA following the refinements tabulated on *"Worksheet 1"* (Line 26)	
Note 3	No. of collision in the non-breeding season apportioning to birds from all colonies following the refinements tabulated on *"Worksheet 1"* (Line 31) for updated project design (Moray East), revised flight speed and boat-based bias (Moray East and Beatrice).	
Note 4	As-built turbine scenario correction factors taken from TCE 'headroom' estimates in MacArthur Green (2017) applied to the collisions highlighted in blue, as presented in Table 10.8.17 of the Moray West EIA Report - Volume 2, Chapter 10.	

Note 5	The calculation of apportioning values for non-breeding seasons follows the approach used previously in the application and examination documentation for multiple offshore wind farms (e.g. East Anglia THREE Ltd. 2015, Forewind 2013, SMart Wind 2015a) and Moray West for other species (Appendix 4.4 Phenology and apportioning within the RIAA of the HRA submitted by Moray West). The contribution of adult birds from an individual SPA, as estimated by Furness (see Table 44 reproduced in *worksheet "Furness (2015) page 344*), to the relevant BDMPS population for GBBGU in the non-breeding season is divided by the total BDMPS population to calculate the proportion of the BDMPS population represented by adult birds from the SPA considered. **The number of East Caithness Cliffs SPA adult birds in the BDMPS** = (East Caithness Cliffs SPA adult population in the BDMPS region) multiplied by (proportion of East Caithness Cliffs SPA adult population present in the non-breeding season in the BDMPS region) = 350 * 1.0 = 350 The proportion adults of the non-breeding BDMPS comprising East Caithness Cliffs SPA birds = (No. of East Caithness Cliffs SPA adult birds in the BDMPS) / (Total no. of birds in the BDMPS) = 350 / 91,399 = 0.004 (to three significant figures). By multiplying this proportion with the number of collision for all birds in the non-breeding season (second to last column) gives the number of those collisions that can be apportioned to adult birds from ECC SPA

References

Furness, R.W. (2015). Non-breeding season populations of seabirds in UK waters. [Online]. Available at: http://publications.naturalengland.org.uk/publication/6427568802627584 (Accessed November 2018).

MacArthur Green (2017). Estimates of Ornithological Headroom in Offshore Wind Farm Collision Mortality. The Crown Estate.

Worksheet 3: Moray Firth Region ME and BOWL Option 3

Line	Refinements		Moray West	Running total	Moray East	Running total	BOWL	Running total	Comments
2		**CRM**							
3		*Source*							
4		Flight speed	9.8 m/s		13.7 m/s		13.7 m/s		9.8 m/s sourced from **Skov *et al.* (2018**; ORJIP BCA study), 13.7 m/s from **Alerstram *et al.* (2007)**
5		Nocturnal activity	2		2		2		
6		Band (2012) model option	2		3		3		
7		Avoidance rate	99.5%		98.9%		98.9%		Avoidance rate as per SNH guidance
8		Wind farm scenario	Moray West EIA Report 2018 - Volume 2, Chapter 10, Table 10.7.10		Original consent 159 x 7 MW		As built - in DSLP		Based on information for consented Moray East project and BOWL as built presented in Moray East Alternative Design Parameters Scoping Opinion Addendum: Ornithology (Marine Scotland, 2017).
9		Annual collisions	9		30.8		22		
10									
11	1	**Updated Project Design**			See Annex A				See Annex A of this Document for Moray East Design Parameters.
12		Annual collisions	9		10.10		22		
13									
14	2	**Flight speed update (Skov *et al.* 2018)**			9.8 m/s		9.8 m/s		
15		Annual collisions	9.30		9.19		16.01		
16		Breeding season	Apr-Aug		Apr-Aug		Apr-Aug		Breeding season defined as per SNH guidance
17		Breeding season collisions	4.00		3.06		4.91		
18		Non-breeding season collisions	5.30		6.14		11.09		
19									
20		**Collision Apportioning (breeding season**	**Moray West**	Running total	**Moray East**	Running total	**BOWL**	Running total	
21		CRM collisions (breeding season)		4.00		3.06		4.91	
22	3	Boat-based bias		4.00	0.5	1.53	0.5	2.46	A correction factor of 2 was included in the "common currency" approach to account for gull attraction to survey vessels used in the seabird surveys for Moray West and BOWL, thus halving the original abundance estimate (e.g. **MS-LOT 2014**).
23	4	Prop adults	0.64	2.58	0.49	0.75	0.375	0.92	Age structure based on at-sea survey data gathered for the wind farm site. For BOWL and Moray East, the proportions applied are those proposed as part of the "Common currency" approach (**MS-LOT 2014**). For Moray West, the proportion as set out in Section 3.7.4 of the Volume 1 of the Moray West Addendum to Section 36 Consent and Marine Licence Application.
24	5	Prop from ECC SPA (SNH 2 step approach)	0.92	2.37	0.79	0.59	0.83	0.76	Note 1
25	6	exclude sabbatical	0.65	1.54	0.65	0.39	0.65	0.50	35% adult birds take sabbatical as per SNH guidance
26		Sub-total SPA adult birds (breeding season)		**1.54**		**0.39**		**0.50**	*Collisions used to populate Worksheet 4*
27									
28									
29		**Collision Apportioning (non-br season)**	**Moray West**	Running total	**Moray East**	Running total	**BOWL**	Running total	
30		CRM collisions (non-br season)		5.30		6.14		11.09	
31	3	Boat-based bias		5.30	0.5	3.07	0.5	5.55	Common currency correction (**MS-LOT 2014**). *Collisions used to populate Worksheet 4*
32	4	Prop adults	0.55	2.94	0.49	1.50	0.375	2.08	Proportions applied at BOWL and Moray East are those used for the "Common currency" approach (**MS-LOT 2014**), whilst for Moray West it's the proportion as set out in Section 3.7.5 of the Moray West Addendum. All site-specific survey data based.
33	5 & 7	Prop from ECC SPA & remove winter influx	0.14	0.42	0.14	0.22	0.14	0.30	Note 2 - SNH agreed approach 6th March 2019
34		Sub-total SPA adult birds (non-br season)		**0.42**		**0.22**		**0.30**	
35									
36		**Total (SPA, adults)**		**1.96**		**0.60**		**0.80**	
37									
38					**Annual Collisions**				
					3.36				

	Comments
Note 1	As advised by SNH & MSS, when apportioning breeding season effects from a Project between relevant SPAs for GBBGU, a two-stage apportioning process was followed i.e. following SNH guidance (2018) for Step One which is then repeated but only for the SPAs and using the most recent count data.
Note 2	Furness (2015) estimates that 63.6% of adult birds in winter in the UK North Sea Region are from outside the UK breeding population. However, Wernham *et al.* (2002) states that most of the birds arriving from Norway reach more southerly areas (i.e. the east coast of England). This is because birds move along the Norwegian coast south before crossing the North Sea, arriving on the east coast of the UK, and especially the south east. Forester et al. (2007) estimated that there were between 7,500 and 10,000 birds in Scotland in winter, based on coastal counts. The Furness BDMPS estimate for the North Sea GBBGU population is 91,399 birds. Given that most non-UK birds in the North Sea winter in England and yet most breeding birds are in Scotland it seems very likely that the percentage of UK to non-UK birds declines north to south. However, there is no available measure of this, and Furness (2015) at least supplies some basis for an estimate. SNH accept the percentage of birds in the Moray Firth is the same as across the whole North Sea on that basis. As the calculations of pairs in the Moray Firth area are taken from Seabird 2000, SNH have advised that the percentage contribution of East Caithness Cliffs SPA is based on the same time period (i.e. Seabird 2000 and not the 2015 population count). If more recent counts are available for all areas of the Moray Firth, then it may be possible to use these instead of the Seabird 2000 counts. If we assume that Moray Firth has 454 pairs of birds (908 adults), then there would be approximately 2,495 birds in the Moray Firth area in winter (i.e. 1587 (63.4%) + 908 (36.4%) = 2495). The percentage of Moray Firth birds in winter that are from the East Caithness Cliffs SPA would then be 360 (taken from Seabird 2000) / 2495 = 14.4%

References

Alerstam, T., Rosén, M., Bäckman, J., Ericson, P.G. and Jellgren, O. (2007). Flight speeds among bird species: allometric and phylogenetic effects. PLoS Biology, [e-journal], 5(8): e197. https://doi.org/10.1371/journal.pbio.0050197.

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Skov, H., Heinänen, S., Norman, T., Ward, R.M., Méndez-Roldán, S. and Ellis, I. (2018). ORJIP Bird Collision and Avoidance Study. Final report – April 2018. The Carbon Trust. United Kingdom. 247 pp.

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Worksheet 4: BDMPS Region ME and BOWL Option 3

Seasonal Breakdown of Predicted Cumulative Collision Mortality for great black-backed gull						Applying turbine scenario correction factors from MacArthur Green (2017)	Proportion of BDMPS represented by adults from ECC SPA
Offshore Wind Farm	**Option**	**Avoidance Rate (%)**	**Annual Collisions**	**Breeding for ECC SPA**	**Non-Breeding for all colonies**	**Non-Breeding - refinement 1**	**Non-Breeding - refinement 2**
	Breeding and Non-Breeding Season					**for all colonies**	**for ECC SPA**
			All ages *Note 1*	**Adults** *Note 2*	**All ages** *Note 3*	**All ages** *Note 4*	**Breeding adults** *Note 5*
Moray West	2	99.5	9	1.54	5.30	5.30	0.02
Moray East	3	98.9	31	0.39	3.07	3.07	0.01
Beatrice	3	98.9	22	0.50	5.55	5.55	0.02
Non-Breeding Season Only							
Aberdeen Demo	2	99.5	3		2	2	0.01
Blyth Demo	1	99.5	8		5	5	0.02
Dogger Bank Creyke Beck A and B	2	99.5	33		28	28	0.11
Dogger Bank Teesside A and Sofia	2	99.5	37		29	29	0.11
East Anglia ONE	2	99.5	124		122	122	0.47
East Anglia Three	2	99.5	42		37	37	0.14
Galloper	1	99.5	22		21	9	0.03
Hornsea Project One	1	99.5	86		71	71	0.27
Hornsea Project Two	2	99.5	23		18	18	0.07
Humber Gateway	1	99.5	6		4	2	0.01
Hywind	1	99.5	5		5	5	0.02
Inchcape	1	99.5	37		37	37	0.14
Kentish Flats Extension	1	99.5	0		0	0	0.00
Neart na Gaoithe	1	99.5	8		7	7	0.03
Seagreen Alpha	2	99.5	37		31	31	0.12
Seagreen Bravo	2	99.5	30		23	23	0.09
Teesside	1	99.5	44		35	24	0.09
Thanet	1	99.5	0		0	0	0.00
Triton Knoll	1	99.5	122		106	106	0.41
Westermost Rough	1	99.5	0		0	0	0.00
Total			**729**	**2.42**	**595**	**570**	**2.18**

	Comments	**Annual Collisions**
Note 1	Collisions for all age classes as presented in (1) Table 10.8.19 of the Moray West EIA Report - Volume 2, Chapter 10, and repeated in (2) line 9 of *"Worksheet 3"*	**4.60**
Note 2	No. of collision in the breeding season apportioning to breeding adults from ECC SPA following the refinements tabulated on *"Worksheet 3"* (Line 26)	
Note 3	No. of collision in the non-breeding season apportioning to birds from all colonies following the refinements tabulated on *"Worksheet 3"* (Line 31) for updated project design (Moray East), revised flight speed and boat-based bias (Moray East and Beatrice).	
Note 4	As-built turbine scenario correction factors taken from TCE ‘headroom’ estimates in MacArthur Green (2017) applied to the collisions highlighted in blue, as presented in Table 10.8.17 of the Moray West EIA Report - Volume 2, Chapter 10.	

Note 5	The calculation of apportioning values for non-breeding seasons follows the approach used previously in the application and examination documentation for multiple offshore wind farms (e.g. East Anglia THREE Ltd. 2015, Forewind 2013, SMart Wind 2015a) and Moray West for other species (Appendix 4.4 Phenology and apportioning within the RIAA of the HRA submitted by Moray West). The contribution of adult birds from an individual SPA, as estimated by Furness (see table 44 reproduced in *worksheet "Furness (2015*) *page 344*), to the relevant BDMPS population for GBBGU in the non-breeding season is divided by the total BDMPS population to calculate the proportion of the BDMPS population represented by adult birds from the SPA considered. **The number of East Caithness Cliffs SPA adult birds in the BDMPS** = (East Caithness Cliffs SPA adult population in the BDMPS region) multiplied by (proportion of East Caithness Cliffs SPA adult population present in the non-breeding season in the BDMPS region) = 350 * 1.0 = 350 The proportion adults of the non-breeding BDMPS comprising East Caithness Cliffs SPA birds = (No. of East Caithness Cliffs SPA adult birds in the BDMPS) / (Total no. of birds in the BDMPS) = 350 / 91,399 = 0.004 (to three significant figures). By multiplying this proportion with the number of collision for all birds in the non-breeding season (second to last column) gives the number of those collisions that can be apportioned to adult birds from ECC SPA

References

Furness, R.W. (2015). Non-breeding season populations of seabirds in UK waters. [Online]. Available at: http://publications.naturalengland.org.uk/publication/6427568802627584 (Accessed November 2018).

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Mitchell, P.I., Newton, S.F., Ratcliffe, N. and Dunn, T.E. (2004). Seabird populations of Britain and Ireland. Poyser, London.

Moray Firth region as defined by current assessment following SNH advice to Moray West (6th March 2019)

Admin area	**Seabird 2000**
East coast Caithness	181
East coast Sutherland	1
East coast Ross & Cromarty	220
Nairn	0
Moray	10
Banff & Buchan	37
Inverness	5
Moray Firth population =	454

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Table 1 Numbers of coastal-breeding Great Black-backed Gulls (AON) in Britain and Ireland 1969–2002. Numbers breeding inland and on the coast during Seabird 2000 (1998–2002) are also given.

Administrative area or country	*Coastal colonies only*[1]						*Seabird 2000 inland and coastal*
	Operation Seafarer (1969–70)[2]	*SCR Census (1985–88)*[2]	*Seabird 2000 (1998–2002)*	*Percentage change since Seafarer*	*Percentage change since SCR*	*Annual percentage change since SCR*	
Shetland	2,674	3,094	2,875	8%	−7%	−0.5%	2,875
Orkney	5,999	5,657	5,505	−8%	−3%	−0.2%	5,505
North coast Caithness		171	30		−82%	−12.4%	30
East coast Caithness		842	181		−79%	−11.1%	181
Caithness total	*1,048*	*1,013*	*211*	*−80%*	*−79%*	*−11.3%*	*211*
Northwest coast Sutherland		805	1,058		31%	2.1%	1,058
East coast Sutherland		16	1		−94%	−18.6%	1
Sutherland total	*1,360*	*821*	*1,059*	*−22%*	*29%*	*1.9%*	*1,059*
West coast Ross & Cromarty		197	159		−19%	−1.5%	159
East coast Ross & Cromarty		9	220		2344%	27.6%	220
Ross & Cromarty total	*660*	*206*	*379*	*−43%*	*84%*	*4.6%*	*379*
Inverness	1	47	5	400%	−89%	−14.9%	5
Nairn	20			−100%			
Moray	4	12	10	150%	−17%	−1.4%	11
Banff & Buchan	16	15	37	131%	147%	6.3%	37
Gordon	2	12	5	150%	−58%	−5.7%	5
City of Aberdeen			9				9

Reproduced from:

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Table 44. BDMPS for great black-backed gull in non-breeding season (September to March) in 'UK North Sea waters'.

Population	Most recent count	Pairs	Breeding adults	Immatures	Proportion of adults in UK North Sea waters non-breeding season	Proportion of immatures in UK North Sea waters non-breeding season	UK N Sea Number adults	UK N Sea Number immatures	UK N Sea Total birds
Barents Sea	1990s*	33000	66000	83160	0.3	0.5	19800	41580	61380
Faroe	2012	1000	2000	2520	0.3	0.3	600	756	1356
Ireland	2000	2000	4000	5040	0	0	0	0	0
Calf of Eday	2006	281	562	708	1	1	562	708	1270
Copinsay	2010	218	436	549	1	1	436	549	985
Hoy	2011	60	120	151	1	1	120	151	271
East Caithness Cliffs	1999	175	350	441	1	1	350	441	791
UK North Sea non-SPA colonies	2000	5000	10000	12600	1	1	10000	12600	22600
North Rona & Sula Sgeir	2012	191	382	481	0.01	0.1	4	48	52
Isles of Scilly	2006	901	1802	2271	0.01	0.1	18	227	245
UK western non-SPA colonies	2000	9000	18000	22680	0.01	0.1	180	2268	2448
Total overseas							20,400	42,336	62,736
Total UK							11,670	16,993	28,663
Total							32,070	59,329	91,399

*updated to 2012 by R.T. Barrett pers. comm.