Hornsea Project Four: Environmental Statement (ES)

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Volume A5, Annex 5.5: Offshore Ornithology Migratory Birds Report

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Glossary

Term	Definition
Broad front	Term used to describe migratory corridor which birds may fly through, with an assumed even or skewed distribution across the width of the area considered.
Collision	An instance of one moving object or individual striking violently against another.
Collision Risk Model (CRM)	General term to describe the method of estimating the collision risk of seabirds (estimated mortality) to operational turbines, which could be either deterministic or stochastic.
Commitment	A term used interchangeably with mitigation and enhancement measures. The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSEs), in EIA terms. Primary (Design) or Tertiary (Inherent) are both embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, Preliminary Environmental Information Report (PEIR) or Environmental Statement (ES)). Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e. so that residual effects are acceptable.
Flyway population	The number of individuals travelling along a flight path whilst on migration.
Hornsea Four array area	The proposed area for Hornsea Four within which the Wind Turbine Generators (WTGs) would be installed
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Order Limits	The limits within which Hornsea Four may be carried out.
Orsted Hornsea Project Four Ltd	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Special Protection Area (SPA)	Protected areas for birds in the UK classified in accordance with European Council Directive 2009/147/EC on the conservation of wild birds, known as the Birds Directive.
Statutory Nature Conservation Bodies (SNCBs)	Comprised of Joint Nature Conservation Committee (JNCC), Natural Resources Wales, Department of Agriculture, Environment and Rural Affairs/Northern Ireland Environment Agency, Natural England and Scottish Natural Heritage these agencies provide advice in relation to nature conservation to government.

Acronyms

Acronym	Definition
AfL	Agreement for Lease
BDMPS	Biologically Defined Minimum Population Scales
BO1 / BO2	Band Option 1 / Band Option 2
BTO	British Trust for Ornithology
CL	Confidence Limits
CRM	Collision Risk Model
DCO	Development Consent Order
EIA	Environmental Impact Assessment
EP	Evidence Plan
ES	Environmental Statement
ESAS	European Seabirds at Sea
GB	Great Britain
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
HAT	Highest Astronomical Tide
PCH	Potential Collision Height
PEIR	Preliminary Environmental Information Report
RIAA	Report to Inform Appropriate Assessment
RSPB	Royal Society for the Protection of Birds
sCRM	Stochastic Collision Risk Modelling
SNCBs	Statutory Nature Conservation Bodies
SPA	Special Protection Area
UK	United Kingdom
WeBS	Wetland Bird Survey
WWT	Wildfowl and Wetlands Trust

Units

Unit	Definition
m	Metre (distance)
km	Kilometre (distance)
km^2	Kilometre squared (area)
ms^{-1}	Metres per second (speed)
rpm	Revolutions per minute (speed)
o	Degrees (angle)
%	Percentage (proportion)

1 Introduction

1.1 Project Background

1.1.1.1 Orsted Hornsea Project Four Limited (hereafter 'the Applicant') is proposing to develop the Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four'). Hornsea Four is located approximately 69 km offshore from the coastline of the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network (please see **Volume A1, Chapter 4: Project Description** for full details on the Project Design).

1.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 846 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project has given due consideration to the size and location (within the existing AfL area) of the final project that is being taken forward to Development Consent Order (DCO) application. This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting, and commercial considerations with technical feasibility for construction. It has also involved further consideration of project design so as to reduce the risk to birds from collision with wind turbines through engineering solutions. One such measure has been to increase the air gap between the sea surface and the lowest swept area of the turbines (from a minimum of 35 m to 42.43 m measured against the lowest astronomical tide (LAT) in order to provide an increased space for birds to fly without the risk of colliding with wind turbines. This is secured by Co138 (see **Volume A4, Annex 5.2: Commitment Register**).

1.1.1.3 The combination of Hornsea Four's Proportionality in EIA and Developable Area Process has resulted in a marked reduction in the array area taken forward at the point of DCO application. Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the Hornsea Four Order Limits is detailed in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**.

1.1.1.4 APEM Ltd (hereafter APEM) was commissioned by the Applicant to undertake a study of offshore and intertidal ornithology that characterises the area that may be influenced by Hornsea Four. A separate report (**Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**) provides the findings from offshore and intertidal ornithology data to determine the receptors that characterise the baseline and which are of relevance to the assessment of potential impacts from Hornsea Four. This technical annex has been produced to support **Volume A2, Chapter 5: Offshore and Intertidal Ornithology** and considers the potential risk to migratory birds that are not typically recorded in monthly surveys, which may interact with Hornsea Four. Additionally, assessment of collision risk to migratory birds associated with the Humber Estuary Special Protection Area (SPA) and RAMSAR is also included within this annex and the results of which are presented in **Appendix I** to support **B2.2 Report to Inform Appropriate Assessment**.

1.1.1.5 The consideration of offshore and intertidal ornithology for Hornsea Four has been discussed with consultees through the Hornsea Four Evidence Plan (EP) process; specifically, with the Offshore and Intertidal Ornithology Evidence Plan Technical Panel (hereafter EP Technical Panel) of which Natural England and the Royal Society for the Protection of Birds (RSPB) are members. Agreements made with consultees within the EP process are set out in the topic specific EP Logs which are appendices to the Hornsea Four Evidence Plan (**Volume B1, Annex 1.1: Evidence Plan**), an annex of the Hornsea Four Consultation Report (**Volume B1, Chapter 1: Consultation Report**). All agreements within the EP Logs have unique identifier codes which have been used throughout this document to signpost to the specific agreements made (e.g. OFF-ORN-2.1).

1.2 Potential Collision Risk to Migratory Birds

1.2.1.1 As part of a proportional assessment, it is necessary to identify bird species at risk of potential impact from collisions with wind turbines. The level of risk to any bird species from collisions with wind turbines is typically estimated by way of Collision Risk Modelling (CRM. Species that are not likely to be at risk from this potential impact can be screened out and excluded from more detailed modelling.

1.2.1.2 HiDef BioConsult has conducted field surveys of the Hornsea Four array area and 4 km buffer via high resolution digital aerial video surveys (HiDef BioConsult 2018). While the results of these surveys provide information on the likely abundance and distribution of key seabird species for each biological period, they also have limitations. In particular, neither these surveys nor any other existing generally applied survey methods are guaranteed to provide reliable estimates of bird numbers during migration periods, particularly non-seabirds. This is due to some birds moving through in short pulses, in poor weather or at night (when no surveys take place), or at high altitudes, which makes recording their numbers extremely complex using standard methods.

1.2.1.3 One solution is to model migratory bird movements. APEM has developed the bespoke software model 'Migropath' to provide estimates of such movements. This builds on the work carried out by the British Trust for Ornithology (BTO) for the SOSS-05 project (Wright et al. 2012). Migropath can be used to estimate the proportion of a given population passing through a site's footprint, assuming point-to-point migration (for example from the coastline of continental Europe to designated SPAs within the UK). Further details are given below in **Section 3.1**.

1.2.1.4 The use of Migropath is not suitable for all species, in particular species which do not follow a point-to-point migration pattern (Alerstam, 1990). Many seabirds fall into this category (Wernham et al. 2002), with some seabirds known to take longer routes, for example following the coastline in preference to a more direct route over land. For such species, a 'broad front' pathway might better describe the movements that these birds are making within the North Sea. Consequently, the risks to which the population is exposed relates to the proportion of the 'broad front' pathway crossing, in this instance, the location of the Hornsea Four array area. Within that 'broad front', birds might be distributed evenly, or they might have distribution that is skewed, such as a bias towards the coast. Further details on 'broad front' modelling are presented in **Section 4.1**.

2 Species Selection / Screening Process

2.1 Screening Methodology

2.1.1.1 A combination of data sources – field surveys, literature review, Migropath modelling, and migratory apportionment – have been used to screen migratory species for more detailed impact assessments for collision risk. Where species have been screened in, the results also quantify inputs for use in CRM, in particular the timing and numbers of birds migrating through the area of interest. The standard threshold for migratory birds used is that the species will be screened in if at least 1% of the UK population is expected to pass through the site footprint each year, in this case the Hornsea Four array area. Migratory species may also be screened in if there is species-specific evidence of an elevated risk of a significant impact from collisions. Note that the focus of this report is to assess potential interaction of migratory species passing through the Hornsea Four array area and not for species present in the project area for longer periods (for example, breeding birds which may fly through the project on regular foraging trips), which are considered separately in **Annex 5.3: Offshore and Intertidal Ornithology Collision Risk Modelling Report**. This is summarised in the flowchart below (**Figure 1**).

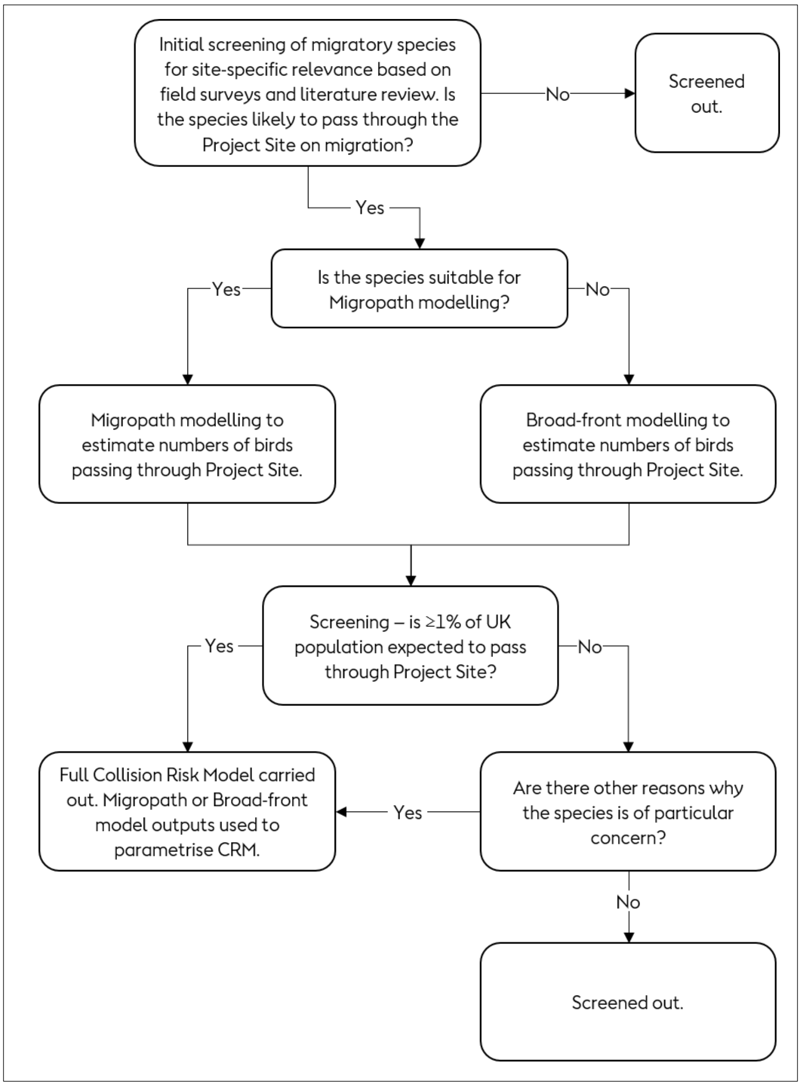

Figure 1: Flowchart showing approach to screening and collision risk modelling for migratory species.

2.2 Screening Results

2.2.1.1 An initial screening exercise was completed to identify any migratory species that may pass through or nearby to the Hornsea Four array area. A review of site-specific boat and aerial survey data, migration surveys, local bird reports and other ornithological literature helped identify the birds to take on to the next stage of modelling. This is detailed in **Appendix H** – Screening Matrix.

2.2.1.2 For the purposes of initial screening, the above sources of information were considered as well as expert judgement and experience of undertaking previous assessments of migratory birds for the purpose of assessing potential risk from collision with wind turbines. The objective was to screen out species which are unlikely to pass through the Hornsea Four array area in any meaningful numbers on migration.

2.2.1.3 The results of this initial screening process were presented at the Ornithology Technical Panel Meeting Ten for which Natural England provided a written response (Natural England Document Reference 319443). Within their written response, Natural England provided clarification on the appropriateness of the screening process and requested further consideration be given to a number of additional species. These additional species have now been considered and agreement was reached with Natural England on the inclusion of all species screened in (OFF-ORN-2.41), apart from pink-footed goose.

2.2.1.4 Natural England requested that pink-footed goose be included due to the potential interaction between Hornsea Four and populations associated with Humber Estuary SPA, The Wash SPA, North Norfolk Coast SPA and Broadland SPA (OFF-ORN-2.41**).** However, telemetry studies (WWT & Orsted 2019) and radar studies (Plonczkier and Simms 2012) both suggest that the vast majority of individuals follow a coastal route to staging areas in north-west England before moving north towards Iceland and Greenland. This is reflected in the flyway map presented in a substantial review of relevant studies (Mitchell & Hearn 2004). Therefore, very few birds are believed to migrate across offshore areas of the North Sea and the risk from collisions is deemed to be negligible. As such, pink-footed goose has been screened out from further analysis.

2.2.1.5 **Table 1** lists the species screened in following this process.

Table 1: Migratory Birds Screened in for Hornsea Four and modelling approach.

Migropath modelling		
Dark-bellied Brent Goose	Hen harrier	Bar-tailed godwit
Taiga Bean Goose	Oystercatcher	Black-tailed godwit
White-fronted goose	Avocet	Turnstone
Bewick's Swan	Lapwing	Knot
Shelduck	Golden plover	Ruff
Gadwall	Grey plover	Sanderling
Wigeon	Ringed plover	Dunlin
Teal	Whimbrel	Redshank
Goldeneye	Curlew	

'Broad front' modelling		
Little gull	Common tern	Arctic skua
Sandwich tern	Arctic tern	
Roseate tern	Great skua	

3 Migropath Modelling Methodology (Migratory Non-Seabirds)

3.1 Migropath Modelling Approach

3.1.1.1 The non-breeding waterbird populations of UK SPAs (Natura 2000 sites) are regularly surveyed annually by the Wetland Bird Survey (Frost et al. 2020). Occasional surveys of non-breeding seabirds have been carried out, for example the inshore 2000/01 and 2001/02 Joint Nature Conservation Committee (JNCC) Winter Seaduck Survey (Dean et al. 2003). Each SPA has its original designation figures. There is therefore information on the numbers of birds over-wintering or breeding on these sites. From ringing / tagging data, as well as other literature, there is also information on the likely origin of some or all of these populations, including transboundary migrations (Wernham et al. 2002). A general migration route or zone can therefore be defined for a given population of birds. Furthermore, data from continental sites (e.g. staging posts, observatories) can be used to further refine the likely fronts, as well as provide information on temporal components of migration (for example, daily passage rate and duration of migration events).

3.1.1.2 It is therefore possible to estimate the numbers of birds associated with one SPA, with a defined group of SPAs, or with a regional suite of SPAs that will encounter one or more wind farms by defining appropriate migratory corridors.

3.1.1.3 The approach is a relatively uncomplicated method to answer a pressing set of questions. In order to develop more complex models simulating bird movement, additional environmental variables such as weather and photoperiod, and biological factors such as flight speed, energy budget, flocking behaviour and manoeuvrability would need to be considered. APEM has been involved in similar simulations for fish passage at tidal barrage locations (Willis and Teague 2014), using hydrodynamic and behavioural modelling, but at present, no such models exist for UK birds.

3.2 Migropath Modelling Assumptions

3.2.1.1 Migropath has been developed alongside BTO's SOSS-05 project (Wright et al. 2012) and therefore is limited to the species considered in that project, specifically species that are either designated features of UK SPAs ('SPA species'), or other rare or vulnerable species listed in Annex 1 of the EU Birds Directive ('Annex 1 species') that regularly migrate across UK waters. Annex 1 species that only occasionally migrate across UK waters are excluded.

3.2.1.2 Migropath inevitably makes several assumptions. Chief amongst these is the assumption that migration is in a straight line between the SPA of interest and a given point (or defined area) outside the UK. However, for the purpose of this modelling exercise, not all birds are from or going to UK SPAs, and thus we have used Migropath to estimate the number of birds from a continental area/location flying through or across the North Sea, where this falls within the known migration corridors of the study species.

3.2.1.3 Birds migrating between continental areas and UK SPAs that do not pass through the Hornsea Four array area are not considered to be at collision risk from Hornsea Four, based on the assumption of straight-line migration. Such no-risk (no risk from Hornsea Four) movements can be factored in to estimated proportions of birds arriving on / departing from SPAs (or other continental areas) but not encountering the Hornsea Four array area.

3.2.1.4 Another key assumption is that all migration of a particular species to a particular suite of SPAs can be defined within a set corridor. This corridor should aim to realistically represent the area across which birds must move.

3.2.1.5 Migropath does not take into account any macro-avoidance behaviour of birds (i.e. birds may alter their route to avoid the array area). It therefore represents the number of birds expected to pass through the Hornsea Four array area in the absence of any turbines. This ensures avoidance is not double-counted, as the CRM model includes an avoidance factor. The potential for macro-avoidance to impact migratory birds by increasing the length of their migration and energy expenditure (barrier effect) is considered in **Volume A2, Chapter 5: Offshore and Intertidal Ornithology**.

3.2.1.6 Migropath does not consider flight height, and as a precautionary assumption where the migratory route intersects the Hornsea Four array area, it is assumed that this leads to a potential for collisions to occur. The proportion of birds at potential collision height is included as an input into the CRM model.

3.3 Migropath Modelling Technical Methodology

3.3.1.1 The centroid of each SPA was calculated using the geometry function within ESRI® ArcMapTM 9.2 or QGIS 3.10. The coastline of Continental Europe was split into 1 km segments, and each segment labelled with a unique ID. Using the ET Geowizard or MMQGIS Hub Lines tool, each segment along the European coast was joined to the centre of each SPA, with each line classified as either passing within or out from the Hornsea Four array area.

3.3.1.2 A list of SPAs that each of the species is associated with was collated (JNCC, no date; Stroud et al. 2001). This information, along with the migratory pathways, was then fed into the statistical software 'R' (R Core Team 2020).

3.3.1.3 Shapefiles produced as part of the SOSS_05 project (Wright et al. 2012) were used to determine which parts of the European coastline migrants of each species are expected to use. Where species have known staging sites in Europe, the locations of these were also extracted from the shapefiles.

3.3.1.4 Within R, all possible flight paths for each species determined in the previous step were then considered – i.e. all flight paths between the portion the European coast identified for each species and SPAs associated with each species. The proportion of birds following each individual flight path was allocated randomly across those flight paths. For species which are known to stage or moult in the Wadden Sea, an extra step was carried out to ensure that the proportion of birds departing from the staging area equalled the proportion of the population known to use the staging area (Laursen et al. 2010).

3.3.1.5 Note that the model is not directional and can be run separately for autumn and spring migrations, allowing these to be parameterised differently if appropriate. For example, the proportion of birds using staging areas may differ between migration periods.

3.3.1.6 For some species, distinct races, sub-species, or populations were modelled separately, where there is evidence that migratory patterns differ between them.

3.3.1.7 The proportion of birds modelled to pass through the Hornsea Four array area in one year was then calculated. The model re-runs the random allocation of flight paths 200 times in order to estimate the confidence surrounding this result.

3.3.1.8 Where the proportion of birds passing through the Hornsea Four array area exceeded the threshold of 1% of the UK population, this was then converted to absolute numbers of birds to feed into CRM. Estimates of the flyway population were obtained from the SOSS-05 project (Wright et al. 2012) while estimates for the UK population were from Woodward et al. (2020).

4 'Broad Front' Modelling (Migratory Seabirds)

4.1 Approach

4.1.1.1 This method is based on a basic calculation utilising species-specific information on population estimates and migration behaviour derived from desk-based study, with the key findings summarised in **Section 6.2**. The method used to calculate 'broad front' migration follows a stepwise methodology outlined below:

- Identify the population of birds undertaking the 'broad front' migration;
- Identify the width of the 'broad front' based on the migratory pathway or corridor that is being used;
- Calculate the proportion of the 'broad front' occupied by the Hornsea Four array area perpendicular to the direction of flight;
- Where possible, identify if there is any skewed distribution of birds within the 'broad front' such as a preference to fly along the coast; and
- Calculate the numbers of birds flying across the array area based on the proportion of the 'broad front' occupied by the array area factoring in any skewed migratory distribution.

4.1.1.2 To ensure the estimates are precautionary, the 'broad front' corridor is assumed to extend from the UK coast to the edge of the UK waters boundary, where populations have been based on the same assumed corridor. This represents the width intersecting the array area perpendicular to birds migrating in a North/South flight pattern and was measured as being 189 km. The width of the array area within that corridor is calculated to be 38.1 km based on the maximum design scenario. This is the widest point across the array area and when presuming an even distribution of birds migrating within the 'broad front' represents the worst-case scenario for collision risk.

5 Results of Migropath Modelling (Migratory Non-Seabirds)

5.1.1.1 The total number of bird species determined to be required to be screened in for Migropath modelling was 26 (see **Table 1**) as agreed with the EP Technical Panel (OFF-ORN-2.41). Other than hen harrier, these were all waterfowl and waders. The majority were included due to the importance of the populations which migrate to the UK for the non-breeding seasons; however, for species which also breed in the UK, the breeding population was also included in the model.

5.1.1.2 Full results from Migropath modelling and further explanatory details are presented in **Appendix A**. The mean proportion of the UK population expected to pass through the Hornsea Four array area and the number of birds this equates to is presented in **Table 2**. As a precautionary assumption, where more than one separate population may be present, the total number of birds passing through the Hornsea Four array area is assessed against the smallest population.

5.1.1.3 Where the UK population is uncertain, the range of outputs has been presented in Table 2. The mean number of birds was then used for the CRM results presented in Table 6. Additional CRM results using the possible range of population sizes are presented in Appendix B.

5.1.1.4 Where different populations or seasons were modelled separately in Migropath, all results were included in the CRM to give an annual total across all populations for each species.

Table 2: Results from Migropath modelling to estimate the number of birds of each species passing through the Hornsea Four array area on migration (and the proportion of the migratory population it represents). Species screened out are shown in *italics*.

Species/ Population	UK Population	Migration Season	Number of birds passing through the Hornsea Four array area each migration (mean; see Appendix A for details)	Percentage of migratory population passing through the Hornsea Four array area each migration (mean; see Appendix A for details)	Percentage of UK population passing through Hornsea Four array area annually (mean)
Dark-bellied Brent Goose (Wintering)	98,000	Spring	-	0.00%	0.00%
		Autumn	-	0.00%	
Taiga Bean Goose (Wintering)	230	Spring/Autumn	2	0.94%	1.74%
White-fronted goose (Wintering)	14,000	Spring/Autumn	-	0.00%	0.00%
Bewick's Swan (Wintering)	4,350	Spring/Autumn	85	1.96%	3.91%
Shelduck (Wintering)	51,000	Spring	1,931	5.47%	10.80%
		Autumn	2,630	5.16%	
		Moult	969	6.17%	
Gadwall (Wintering)	31,000	Spring/Autumn	336	1.08%	2.16%
Wigeon (Wintering)	450,000	Spring/Autumn	22,474	4.99%	9.99%
Teal (Wintering)	435,000	Spring/Autumn	21,297	4.90%	9.79%
Goldeneye (Wintering)	21,000	Spring/Autumn	1,169	5.56%	11.10%
Hen harrier (Wintering)	273	Spring/Autumn	8	1.40%	5.86%
Oystercatcher (Wintering)	305,000	Spring/Autumn	14,192	4.65%	9.30%
Avocet (Wintering)	8,700	Spring/Autumn	-	0.00%	0.00%
Lapwing (Wintering)	635,000	Spring/Autumn	29,539	4.65%	9.30%
Golden plover (Breeding)	65,000 – 101,000	Spring/Autumn	-	0.00%	45.10%
Golden plover (Wintering)	410,000	Spring/Autumn	14,647	3.57%	
Grey plover (Wintering)	33,500	Spring/Autumn	1,515	4.52%	9.04%
Ringed plover (Breeding)	10,500 – 11,200	Spring/Autumn	44 – 47	0.41%	27.50%
Ringed plover (Passage)	73,000	Spring	-	0.00%	
		Autumn	2,844	3.90%	
Whimbrel (Passage)	3,840	Spring/Autumn	304	7.92%	15.80%
Curlew (Breeding)	117,000	Spring/Autumn	-	0.00%	13.40%
Curlew (Wintering)	125,000	Spring/Autumn	7,865	6.29%	
Bar-tailed godwit (Wintering)	53,500	Spring/Autumn	3,347	6.26%	12.50%

Species/ Population	UK Population	Migration Season	Number of birds passing through the Hornsea Four array area each migration (mean; see Appendix A for details)	Percentage of migratory population passing through the Hornsea Four array area each migration (mean; see Appendix A for details)	Percentage of UK population passing through Hornsea Four array area annually (mean)
Black-tailed godwit (Icelandic; Wintering)	41,000	Spring/Autumn	613	1.50%	2.99%
Turnstone (Wintering)	43,000	Spring/Autumn	1,750	4.07%	8.14%
Knot (Wintering)	265,000	Spring/Autumn	11,944	4.51%	9.01%
Ruff (Wintering)	920	Spring/Autumn	52	5.65%	11.30%
Sanderling (Wintering)	20,500	Spring/Autumn	1,390	6.78%	13.60%
Dunlin (Wintering)	350,000	Spring/Autumn	14,252	4.07%	8.14%
Redshank (Britannica; Breeding)	44,000	Spring/Autumn	304	0.69%	
Redshank (robusta; Wintering)	150,000 – 400,000	Spring/Autumn	3,900 – 10,408	2.60%	92.90%
Redshank (totanus; Wintering)	25,000	Spring/Autumn	896	3.58%	

6 Results of 'Broad Front' Modelling (Migratory Seabirds)

6.1 Species Screened In

6.1.1.1 The total number of bird species determined to be required to be screened in for 'broad front' modelling was seven seabirds (see **Table 1**). These were: Arctic skua, great skua, little gull, common tern, Arctic tern, Sandwich tern and roseate tern, as agreed with the EP Technical Panel (OFF-ORN-2.41). To determine the number of migratory seabirds that are considered within the 'broad front' modelling process, a full literature review was undertaken for each species. A summary of these literature reviews that form the basis of the evidence for each species and how these populations are apportioned for CRM are presented in the following sections.

6.1.2 Little gull

6.1.2.1 Little gulls are primarily passage migrants to Britain and Ireland, occurring in both spring and autumn (Stone et al. 1995). The numbers of little gulls on passage through Britain and Ireland, and passing Helgoland Bight, have increased dramatically since the 1970s. This increase matches a documented westward expansion in breeding range that has taken place over a similar time period. This range expansion also resulted in a pair breeding in Scotland in 2016 (Birdguides 2016), which represented the first successful breeding attempt in the UK for little gull. There has also been a recent northerly extension to the wintering range (Hagemeijer & Blair 1997). Passage during migration is usually rapid and judging from observations at sea, most gulls remain closely inshore (Skov et al. 1995). The little gull is listed in Stienen et al. (2007) as an inshore species that is most abundant within 20 km from the shoreline.

6.1.2.2 The great majority (40-100%) of the flyway population of little gull use the English Channel to leave the North Sea (Stienen et al. 2007). Movements of little gulls out of the North Sea take place in October, with birds moving to wintering areas in the western Mediterranean, with seemingly smaller numbers in the Irish Sea, the English Channel and off northwest Africa. Relatively large numbers cross the North Sea in autumn, and internationally important numbers occur near the River Tees (Skov et al. 1995). Within the Irish Sea, the largest numbers are associated with the County Wicklow coast, with numbers reported to be steadily increasing matching the recent Northernly extension to the wintering range (Wenham et al. 2012). As numbers reported from Wicklow fall off in early spring, an increase in the numbers reported on passage overland across the North of England to reach the North Sea during April and May is noted (Messenger 1993).

6.1.2.3 The number of little gulls that migrate via the North Sea has not been assessed by Furness (2015) or Musgrove et al. (2013); the standard sources used for population estimates. A population estimate for little gull using the UK waters of the North Sea has been prepared from a review of the literature and available databases relating to north-west Europe. This has considered both breeding populations from which the number of non-breeding individuals can be derived, and non-breeding individuals recorded using particular sites or on migration along the coast, a copy of the literature review can be found in **Appendix C** of this report. The findings of the literature review proposed an estimate of the autumn migration BDMPS for use in assessments of offshore wind farms (OWFs) occurring in English waters of the North Sea as 30,500 individuals.

6.1.2.4 Another assessment of little gull migration undertaken by WWT and MacArthur Green (2013) concluded that the majority of UK little gull migrate within 20 km from the UK coastline based on observations from coastal watches and offshore surveys.

6.1.2.5 During the 24 months of site-specific aerial digital video surveys conducted for Hornsea Four (detailed in **Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**), little gulls were recorded in two surveys: October 2016 and July 2017, with raw counts of five and four, respectively, within the Hornsea Four array area. Little gulls were also recorded in one survey within the 4 km buffer surrounding the Hornsea Four array area: October 2017, with raw count of eight.

6.1.3 Sandwich tern

6.1.3.1 The Sandwich tern has a circumpolar distribution and can be found breeding in most of Europe, Asia and North America except to the extreme north and south, with a total population at least 100,000 pairs, consisting of approximately 40,000 pairs in Europe and 45,000 pairs in North America, an estimated 40,000 pairs in the Caspian Sea (based on counts in 1995) and between 75,000 and 80,000 pairs in the former USSR (del Hoyo et al. 1992-2013).

6.1.3.2 Sandwich terns are a strictly coastal and a mainly warm-water species (del Hoyo et al., 1992-2013). After the breeding season, birds move north and south to favourable feeding grounds, dispersing around the coasts of Britain and Ireland and across the North Sea to the Netherlands and Denmark in late-June, July and August before southward migration begins in mid-September to wintering grounds (Wernham et al. 2002; del Hoyo et al. 1992-2013). Birds from Europe follow the coasts of the Netherlands, France, and Iberia towards the western coasts of Africa (BirdGuides 2011), wintering mainly in the tropics with a few remaining in Western Europe (del Hoyo et al. 1992-2013). Return migration occurs between March and May and is more direct than in autumn, with many fewer birds going via the eastern North Sea (Wright et al. 2012).

6.1.3.3 In Britain and Ireland, Sandwich terns are concentrated in three main areas along the east coast of Britain: Northeast Scotland, Northumberland, and Norfolk. Sandwich tern is listed in Stienen et al. (2007) as an inshore species that is most abundant within 20 km from the shoreline. An assessment of Sandwich tern migration undertaken by WWT and MacArthur Green (2013) concluded that the majority of UK Sandwich terns migrate within 10 km from the UK coastline based on observations from coastal watches and offshore surveys.

6.1.3.4 The BDMPS for Sandwich terns is defined by Furness (2015) as 38,051 for both migration seasons (July to September and March to May). Understanding of Sandwich tern movements is relatively poor, due to limited ring recoveries in the UK and no studies conducted using geolocators.

6.1.3.5 During the 24 months of site-specific aerial digital video surveys conducted for Hornsea Four (detailed in **Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**) no Sandwich terns were recorded to species level within the Hornsea Four array area; however Sandwich terns were recorded during two surveys within the surrounding 4 km buffer; September 2016 and August 2017, with raw counts of one and two, respectively.

6.1.4 Roseate tern

6.1.4.1 Roseate terns are among the most marine of terns, with inland records extremely rare. In North West Europe, the species is predominantly found in the Irish Sea, although breeding colonies also occur along the East coast of the UK in Northumberland and Lothian (Wernham et al. 2002). Breeding occurs on offshore islands or islets in coastal lagoons within foraging range of sandeels and sprats which they feed upon during the breeding season. Juveniles fledge in July and pre-migratory dispersal occurs in August. Migration south to wintering grounds occurs between August to October, a rapid migration to the wintering grounds with no discrete staging areas en-route is suggested by the decline and broadly dispersed ring recoveries along the western Iberian and West African coastlines (Wernham et al. 2002). All roseate terns from Britain and Ireland share the same migration route and wintering grounds (Wernham et al. 2002). Adults begin the return migration back to Britain and Ireland during summer, with birds arriving at the earliest in April and in Europe return in late June and July. Although there are less ring recoveries during spring migration, the available evidence suggests they follow a similar route to that in autumn (Wernham et al. 2002).

6.1.4.2 The BDMPS for roseate terns off the East coast and Channel is defined by Furness (2015) as 251 for both the spring and autumn migration seasons (late April to May and August to September). Roseate terns although scarce, are monitored intensively in the UK and Ireland which gives high confidence in the BDMPS estimate, coupled with the unlikely exchange between Irish and North Sea populations, due to little evidence of roseate terns migrating overland in the way that common terns often do (Furness 2015).

6.1.4.3 During the 24 months of site-specific aerial digital video surveys conducted for Hornsea Four (detailed in **Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**) no roseate terns were recorded to species level within the Hornsea Four array area or surrounding 4 km buffer.

6.1.5 Common tern

6.1.5.1 The common tern has a circumpolar distribution and can be found breeding in most of Europe, Asia and North America except the extreme north and south with a total population at least 250,000 pairs, possibly 500,000 pairs, consisting of 140,000 pairs in Europe, ~35,000 pairs in North America and several 100,000's pairs in the former USSR (del Hoyo et al. 1992-2013). Birds that breed in the British Isles, Netherlands, Belgium, France, Spain, Switzerland, Austria, and western Germany winter principally along the West African coast (BirdGuides 2011) and those from eastern Europe along the east and southern African coast. Birds from eastern Europe take an easterly route through north east Africa and then along the coast or overland through the Rift Valley to their wintering grounds (del Hoyo et al. 1992-2013).

6.1.5.2 Between 30-70% of the summer resident terns use the English Channel to leave the North Sea (Stienen et al. 2007). Post-fledging dispersal of juveniles occurs between July and October, with adults migrating mainly between August and October. Much of the movement of these coastal birds within Britain may be overland (Ward 2000; Wernham et al. 2012). During September, and especially October, there is a strong southward movement of common terns along the coast of southwest Europe and away from Britain and Ireland, migration follows the coasts (Wernham et al. 2012). Many UK breeding birds are back at their breeding areas by April. The lack of records at west coast observatories implies that there is little movement through the Irish Sea to the Scottish colonies, and the frequency of inland sightings suggests that much of the spring passage takes place directly overland to the breeding sites. In fact, the only British observatories to record substantial numbers in spring are Dungeness and Portland Bill. At both sites, spring passage peaks in late April and early May and is mainly eastward, suggesting that these birds are most likely to be on their way to breeding areas elsewhere in northern Europe (Wernham et al. 2012).

6.1.5.3 Another assessment of common tern migration undertaken by WWT and MacArthur Green (2013) concluded that the majority of UK common terns migrate within 10 km of the UK coastline based on observations from coastal watches and offshore surveys.

6.1.5.4 The BDMPS for common terns is defined by Furness (2015) as 144,911 for both the spring and autumn migration seasons (April to May and late July to early September). Understanding of common tern movements is relatively poor, especially with regards to overseas populations due to limited ring recoveries in the UK and no studies conducted using geolocators.

6.1.5.5 During the 24 months of site-specific aerial digital video surveys conducted for Hornsea Four (detailed in **Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**), no common terns were recorded to species level within the Hornsea Four array area. However, common and / or Arctic terns were recorded in two surveys: August 2016 and August 2017 with raw counts of one and 11, respectively, within the Hornsea Four array area. Common and / or Arctic terns were also recorded in two surveys within the 4 km buffer surrounding the Hornsea Four array area: September 2016 and August 2017, with raw counts of one and nine, respectively.

6.1.6 Arctic tern

6.1.6.1 Britain is at the southern edge of the breeding range of the Arctic tern, and colonies are concentrated in the north of England and Scotland (Wright et al. 2012). At the end of the breeding season, the main post-breeding movement of adult birds is southwards. Movements through Britain and Ireland are thought to occur mainly offshore (Wernham et al. 2012). The migration continues southwards via the coast of western and southern Africa to wintering sites around the Antarctic along the West African coast (Wright et al. 2012). The return passage begins in March, with birds heading for European colonies heading northwards through the eastern Atlantic, with a similar route to that undertaken in autumn taken in spring (Wernham et al. 2012). In Britain, overland northward movements of Arctic terns are indicated by observations of hundreds or even thousands of birds during some spring months at reservoirs in central England. These observations may be the result of poor flying conditions at sea or at high altitudes over land (Kramer 1995).

6.1.6.2 An assessment of Arctic tern migration undertaken by WWT and MacArthur Green (2013) concluded that the majority of UK Arctic terns migrate within 20 km from the UK coastline based on observations from coastal watches and offshore surveys.

6.1.6.3 The BDMPS for Arctic terns is defined by Furness (2015) as 163,930 for both the spring and autumn migration seasons (late April to May and July to early September). Artic tern in most UK SPA colonies are monitored frequently. There has been a considerable decline in numbers from UK SPAs; if the same decline is apparent in non-SPA colonies then the estimated number quoted could be smaller. Understanding of Arctic tern movements is relatively poor, due to limited ring recoveries in the UK and no studies conducted using geolocators with birds connected to UK waters.

6.1.6.4 During the 24 months of site-specific aerial digital video surveys conducted for Hornsea Four (detailed in **Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**), no Arctic terns were recorded to species level within the Hornsea Four array area. However, Arctic and / or common tern were recorded in two surveys: August 2016 and August 2017 with a raw count of one and 11, respectively, within the Hornsea Four array area. Arctic and / or common terns were also recorded in one survey within the 4 km buffer surrounding the Hornsea Four array area: August 2017, with a raw count of nine.

6.1.7 Great skua

6.1.7.1 Great skua breed in northern Scotland, Iceland, Faeroes, Norway, Svalbard, Jan–Mayen and Russia, with the majority (98%) of the population breeding in Scotland and Iceland (del Hoyo et al., 1992-2013). This species spends the winter in the North Atlantic with different breeding colonies using different wintering areas - birds from Scotland winter in the waters to the south and west of Europe and off western Africa whilst birds from Iceland winter off eastern Canada and birds from Norway use both the east and west sides of the Atlantic (Furness et al. 2006; Magnusdottir et al. 2012). Great skua using breeding colonies on the west coast of Scotland are considered to migrate north-south along the Atlantic coast of Europe (Wright et al. 2012). Birds using colonies on the Scottish Northern Isles are considered to use a migratory route that differs between spring and autumn (Wernham et al. 2002; BirdGuides 2011). In the autumn, a greater proportion of the birds use the more western pathway around Scotland and Ireland than in spring when a greater proportion fly through the English Channel and the North Sea (Wernham et al. 2002; BirdGuides 2011).

6.1.7.2 Overall, great skua are considered to avoid coasts except during periods of bad weather, but the extent of that avoidance has been described differently by different authors. Wright et al. (2012) describe great skuas on migration as tending to avoid the coast, Wernham et al. (2002) suggests they remains at least 2-5km from the shore, whilst Stienen et al., (2007) states that they are an offshore species that is rarely observed within 20 km from the shoreline. Whilst avoiding the coast, great skua are considered to travel rarely into pelagic waters, tending to remain over the shallow seas of the continental shelf (Wernham et al. 2002). The most recent assessment of great skua migration undertaken by WWT and MacArthur Green (2013), concluded that the majority of UK great skua migrate within 40 km from the UK coastline based on observations from coastal watches and offshore surveys.

6.1.7.3 The BDMPS for great skua is defined by Furness (2015) for the autumn migration (August to October) as being an estimated population of 19,556 passing through UK North Sea and Channel, and for the spring migration (March to April) as an estimated population of 8,485 passing through English Channel and UK North Sea. There is greater uncertainty around numbers on passage during spring due to movements occurring over a shorter time period and because movements tend to occur in western waters which have fewer consistently watched migration sites.

6.1.7.4 During the 24 months of site-specific aerial digital video surveys conducted for Hornsea Four (detailed in **Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**), great skua were recorded in three surveys: August 2017, September 2017, and October 2017, with a raw count of one within the Hornsea Four array area in each month. Great skua were also recorded in three surveys within the 4 km buffer surrounding the Hornsea Four array area: September 2017, August 2017, and September 2017 with raw counts of one in each month.

6.1.8 Artic skua

6.1.8.1 Arctic skua breed at high latitudes around the northern hemisphere including northern Scotland, Norway, Faeroes, Iceland, Greenland, Svalbard, Russia, Canada, and Alaska. Birds from northern Europe spend the winter in Atlantic waters off western and southern Africa and some cross the Atlantic to South American wintering grounds (Wernham et al. 2002). The Biologically Defined Minimum Population Scales (BDMPS) for Artic skua is defined by Furness (2015) for the autumn migration (August to October) as being an estimated population of 6,427 passing through the UK North Sea and English Channel, and for the spring migration (April to May) with an estimated population of 1,227 passing through English Channel and UK North Sea. The number of birds on passage through UK waters has been estimated from sources such as seawatching data and the European Seabirds at Sea (ESAS) data as specified in Furness (2015), although these numbers are relatively uncertain, with year on year variation.

6.1.8.2 Arctic skua occur in two plumage phases: dark and light. In Scotland, dark birds predominate, in southern Scandinavia up to 95% of birds may be dark-phase, but at high latitudes nearly all birds are light-phase. The migrations of these birds differ in timing and so the proportions of light and dark birds on coasts change through the migration seasons (Arcos 1997). Most birds seen at sea in the North Sea in autumn were classified as dark-phase (Tasker et al. 1987), suggesting that few Arctic breeders pass through the North Sea in autumn. Scottish birds leave their breeding sites mainly in August and birds may follow a migration route through the North Sea (where migration peaks in August and September) and English Channel and then down the coasts of Europe and Africa, though some may cross the Atlantic to South American wintering grounds (Tasker et al. 1987; Wernham et al. 2012).

6.1.8.3 Scottish adult Arctic skua return to colonies during late April, but birds breeding in the Arctic may not occupy breeding grounds until June, and some of these may occur along both British and Irish coasts in May. This is the month when the percentage of dark-phase birds is lowest in the North Sea (Tasker et al. 1987). In Sussex it has been observed that the proportion of light-phase birds increases during the spring, as later migrating birds head for progressively more northerly breeding grounds (Newnham, 1984).

6.1.8.4 Arctic skua tend to migrate and winter along coasts, often lingering for some time where there are aggregations of terns and small gulls such as in estuaries (Taylor 1979). The birds that migrate along the coasts of Britain and Ireland comprise both UK-breeding birds and those that breed in the north of Europe (Furness, 1987). The most recent assessment of Arctic skua migration undertaken by Wildfowl and Wetlands Trust (WWT) and MacArthur Green (2013), concluded that the majority of UK Arctic skua migrate within 20 km from the UK coastline based on observations from coastal watches and offshore surveys.

6.1.8.5 During the 24 months of aerial digital video surveys conducted for Hornsea Four (detailed in **Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**). Arctic skua were recorded in two surveys: September 2016, with a raw count of one within the Hornsea Four array area; and August 2017, with a raw count of one bird within the 4 km buffer.

6.2 Summary of 'Broad Front' Modelling Assumptions

6.2.1.1 The Hornsea Four array area is located 65 km offshore at its nearest point, this is considerably further offshore than any of the migration corridors summarised above. Following the same methodology for apportioning migratory seabirds used by Norfolk Boreas (2019) in their final DCO application submissions, it can be concluded that none of the UK population of migratory seabirds are at risk of collision from Hornsea Four due to evidence supporting their migratory flights being closer to the coast (See **Sections 6.1.8** to **6.1.4**). Therefore, in relation to the assessment of collision risk to migratory seabirds, only the overseas populations presented in Furness (2015) have been included in this assessment.

6.2.1.2 An estimate of the number of individuals predicted to be migrating through the Hornsea Four array area for all seabird species based on an even distribution within the 'broad front' corridor are presented in **Table 3**. Due to the uncertainty regarding population size of little gull on migration, a range of values have been used in the assessment based on the lower, upper and median estimates from the literature review (**Appendix C**); the median value is presented here, with CRM results using the upper and lower values given in **Appendix B**.

Table 3: Estimated number of non-UK migratory seabirds predicted to pass through the Hornsea Four array area in spring and autumn.

Species	Spring Migration	Autumn Migration
Little gull	0	6,148
Sandwich tern	2,034	2,034
Roseate tern	1	1
Common tern	25,394	25,394
Arctic tern	16,547	16,547
Great skua	198	432
Arctic skua	117	1,051

7 Collision Risk Modelling for Migratory Birds

7.1 Collision Risk Modelling Methodology

7.1.1.1 There is potential risk to migratory birds from OWFs through collision with wind turbines and associated infrastructure. The risk to migratory birds can occur when passing through the area on seasonal migrations. The potential collision risk can be estimated using CRM.

7.1.1.2 CRM was carried out using the Band (2012) model. The Band (2012) model is still the most recent and only available model that can be used to estimate collision risk for migratory species, where the density of birds cannot be reliably estimated from site-specific surveys.

7.2 CRM Input Parameters

7.2.1.1 The CRM input parameters for each species run through the Band (2012) model are presented in **Table 4**. Species biometrics for all species were obtained from Robinson (2005).

7.2.1.2 Flight speeds for species were derived from Alterstam et al. (2007), where possible. Flight speeds given in Alterstam et al. (2007) are generally regarded as suitable for this purpose. For species not included in Alterstam et al. (2007), alternative published species-specific flight speeds were used if available, detailed in **Table 4**. If no species-specific flight speeds were available, flight speeds for the most similar co-generic species included in Alterstam et al. (2007) were substituted, as detailed in **Table 4**.

7.2.1.3 The Large Array Correction factor was applied, using the longest line through the array area as the width (41.56 km).

7.2.1.4 The "width of migration corridor" value used within the Band model for calculating migrant flux density was calculated as the width of the Hornsea Four array area perpendicular to the direction of migration. For seabirds migrating predominately in a north-south direction, this was 38.1 km. For waders and waterfowl migrating in a predominately east-west direction, this was 25.6 km.

Table 4: Species biometrics used in the migratory collision risk modelling of the proposed Hornsea Four for all species selected.

Species	Body Length (m)	Wingspan (m)	Flight Speed (ms^{-1})	Nocturnal Activity	Flight Type
Taiga bean goose	0.75	1.58	17.3	5	Flapping
Bewick's swan	1.21	1.96	18.5	5	Flapping
Shelduck	0.62	1.12	15.4	5	Flapping
Gadwall	0.51	0.9	19.6[1]	5[2]	Flapping
Wigeon	0.48	0.8	20.6	5	Flapping
Teal	0.36	0.61	19.7	5	Flapping
Goldeneye	0.46	0.72	20.3	3	Flapping
Hen harrier	0.48	1.1	9.1	2[3]	Flapping
Oystercatcher	0.42	0.83	13	5	Flapping

[1] McDuie *et al.* (2019)

[2] LeShack (1997)

[3] Russell (1991)

Species	Body Length (m)	Wingspan (m)	Flight Speed (ms^{-1})	Nocturnal Activity	Flight Type
Lapwing	0.3	0.84	12.8	5	Flapping
Golden plover	0.28	0.72	13.7[4]	5	Flapping
Grey plover	0.28	0.77	17.9	5	Flapping
Ringed plover	0.19	0.52	19.5	5	Flapping
Whimbrel	0.41	0.82	16.3	5	Flapping
Curlew	0.55	0.9	16.3	5	Flapping
Bar-tailed godwit	0.38	0.75	18.3	5	Flapping
Black-tailed godwit	0.42	0.76	18.3[5]	5	Flapping
Turnstone	0.23	0.54	14.9	5[6]	Flapping
Knot	0.24	0.59	20.1	5	Flapping
Ruff	0.25	0.53	13.6	5	Flapping
Sanderling	0.2	0.42	21.4[7]	5	Flapping
Dunlin	0.18	0.4	15.3	5	Flapping
Redshank	0.28	0.62	12.3[8]	5	Flapping
Little gull	0.26	0.78	11.5	2	Flapping
Sandwich tern	0.38	1	10.0[9]	1	Flapping
Roseate tern	0.36	0.76	10.0[10]	1	Flapping
Common tern	0.33	0.88	10.05	1	Flapping
Arctic Tern	0.34	0.8	10.9	1	Flapping
Great skua	0.56	1.36	14.9	1	Flapping
Arctic skua	0.44	1.18	13.8	1	Flapping

[4] Used Pluvialis dominica value

[5] Used Limosa lapponica value
[6] Used Calidris spp. value (C. alpina, C. alba and C. canutus all have nocturnal activity rating of 5)
[7] Howell et al. (2020)
[8] Used Tringa nebularia value
[9] Cook et al. (2014)
[10] Used Sterna hirundo value

7.2.2 Avoidance Rates

7.2.2.1 A bird's ability to avoid colliding with a wind turbine's rotating blades is a critical factor in predicting mortality rates. This ability will vary between species and is a measure of how sensitive each species is to those turbines and the wind farm in its entirety.

7.2.2.2 CRM following the standard Band model (Band 2012) was carried out using the following range of avoidance rates, 95%, 98%, 99%, and 99.5% for all species. For species where no specific avoidance rate has been calculated, Cook et al. (2014) recommend using an avoidance rate of 98% for evaluation of collision risk. For little gull, an additional avoidance rate of 99.2% has been selected as recommended by Cook et al. (2014).

7.2.3 Proportion at Potential Collision Height

7.2.3.1 Band Option 1 (BO1) and / or Band Option 2 (BO2) have been used to carry out all of the CRM. BO1 uses a fixed proportion at Potential Collision Height (PCH). For all species considered in this report, the proportions of birds at PCH from literature sources have been used as the sample sizes from site-based survey data were too low these species (**Table 5**). For BO1, for Arctic skua, great skua, little gull, common tern, Arctic tern and Sandwich tern, proportion at PCH values were taken from Cook et al. (2012), which assessed the flight height data from 32 OWFs. For the remaining species, the generic species group values put forward by Wright et al. (2012) were selected in the absence of any species-specific proportion at PCH data. BO2 uses flight height distribution data and turbine parameters (air gap and rotor radius) to calculate the proportion of birds at PCH. BO2 is therefore reliant on availability of flight height distribution data. For great skua, Arctic skua, little gull, common tern, Arctic tern, and Sandwich tern, BO2 CRM was run using the maximum likelihood values in the Johnson et al. (2014) flight height spreadsheets, which supplemented the SOSS-02 project (Cook et al. 2012).

Table 5: Proportion at Potential Collision Height (PCH) for all migratory species used for BO1 CRM.

Species	Proportion at PCH (%)
Taiga bean goose	30.0
Bewick's swan	50.0
Shelduck	15.0
Gadwall	15.0
Wigeon	15.0
Teal	15.0
Goldeneye	15.0
Hen harrier	50.0
Oystercatcher	25.0
Lapwing	25.0
Golden plover	25.0
Grey plover	25.0
Ringed plover	25.0
Whimbrel	25.0

Species	Proportion at PCH (%)
Curlew	25.0
Bar-tailed godwit	25.0
Black-tailed godwit	25.0
Turnstone	25.0
Knot	25.0
Ruff	25.0
Sanderling	25.0
Dunlin	25.0
Redshank	25.0
Little gull	5.5
Sandwich tern	3.6
Roseate tern	7.0
Common tern	12.7
Arctic Tern	2.8
Great skua	4.3
Arctic skua	3.8

7.2.4 Turbine Parameters

7.2.4.1 Input parameters for the wind turbine specifications used within the CRM are presented in Section 2.2.6 of **Annex 5.3: Offshore Ornithology Collision Risk Modelling**.

7.3 CRM Results

7.3.1.1 Species for which less than 1% of the UK population are expected to pass through the Hornsea Four array area were screened out, and the Band (2012) CRM was run for remaining species. The species screened out were dark-bellied Brent goose, white-fronted goose, and avocet. The annual total number of collisions for each species, using the most appropriate avoidance rates for each species and based on the mean population size and mean results from Migropath and 'broad front' modelling, are presented in **Table 6**. Results are presented using both Band Option 1 (BO1) and Band Option 2 (BO2), where possible. A more detailed results table, including results based on different population estimates, avoidance rates and the range of modelled confidence limits (CLs) is included in **Appendix B** – Collision Risk Modelling Results.

Table 6: Summary of annual collision risk for species screened-in.

Species	Avoidance Rate	Annual Collision Rate BO1	Annual Collision Rate BO2
Taiga bean gooses	98.0%	0.00	N/A
Bewick's swan	98.0%	0.12	N/A
Shelduck	98.0%	0.97	N/A
Gadwall	98.0%	0.10	N/A

Species	Avoidance Rate	Annual Collision Rate BO1	Annual Collision Rate BO2
Wigeon	98.0%	6.74	N/A
Teal	98.0%	5.99	N/A
Goldeneye	98.0%	0.35	N/A
Hen harrier	98.0%	0.01	N/A
Oystercatcher	98.0%	7.68	N/A
Lapwing	98.0%	14.89	N/A
Golden plover	98.0%	7.08	N/A
Grey plover	98.0%	0.71	N/A
Ringed plover	98.0%	0.63	N/A
Whimbrel	98.0%	0.15	N/A
Curlew	98.0%	4.32	N/A
Bar-tailed godwit	98.0%	1.63	N/A
Black-tailed godwit	98.0%	0.30	N/A
Turnstone	98.0%	0.79	N/A
Knot	98.0%	5.26	N/A
Ruff	98.0%	0.02	N/A
Sanderling	98.0%	0.59	N/A
Dunlin	98.0%	6.25	N/A
Redshank	98.0%	4.09	N/A
Little gull	99.2%	0.09	0.03
Sandwich tern	98.0%	0.11	0.02
Roseate tern	98.0%	0.00	N/A
Common tern	98.0%	4.72	0.20
Arctic Tern	98.0%	0.67	0.04
Great skua	98.0%	0.02	0.00
Arctic skua	98.0%	0.03	0.00

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Appendix A – Migropath Results

Table A-1: Full results of Migropath modelling. Upper and Lower CL based on 95% confidence. Where population estimates are uncertain, results have been presented showing the range of possible results.

Species/ Population	Flyway Population[11]	UK Population[12]	Percentage staging/ moulting at Wadden Sea[13]	Migration Season	Percentage of UK population passing through the array area each migration[14]			Number of birds from UK population passing through the array area each migration			Percentage of flyway population passing through the array area each migration[15]		
					Mean	Lower CL	Upper CL	Mean	Lower CL	Upper CL	Mean	Lower CL	Upper CL
Bewick's Swan (Wintering)	21,500	4,350	-	Spring/Autumn	1.96%	1.86%	2.07%	85	81	90	0.40%	0.38%	0.42%
Taiga Bean Goose (Wintering)	40,000 – 45,000	230	-	Spring/Autumn	0.94%	0.83%	1.08%	2	2	2	0.00 – 0.01%	0.00%	0.01%
Dark-bellied Brent Goose (Wintering)	200,000 – 280,000	98,000[16]	99.8%	Spring	0%	0%	0%	0	0	0	0%	0%	0%
			41.6%	Autumn	0%	0%	0%	0	0	0	0%	0%	0%
	300,000	51,000	43.8%	Spring	5.47%	5.37%	5.56%	1,931	1,896	1,963	0.64%	0.63%	0.65%
			81.9%	Autumn	5.16%	5.08%	5.22%	2,630	2,591	2,661	0.88%	0.86%	0.89%

[11] From Wright et al. (2012) unless specified otherwise.

[12] From Woodward et al. (2020) unless specified otherwise.

[13] It is assumed the proportion of UK migrants which stage in the Wadden Sea equals the total proportion of the flyway population that stage at the Wadden Sea (Laursen et al. 2010)

[14] The proportion of the population passing through the array area on an annual basis will be double this for most species, as the same proportion is expected to pass through on spring and autumn migrations. For some species, the annual proportion will be the sum of spring, autumn and moult (if relevant) migrations, as the number and direction of birds varies between migration seasons.

[15] This figure excludes passage migrants which might pass through the array area but neither breed nor overwinter in the UK.

[16] Great Britain (GB) population from Frost et al. (2019) as Woodward et al. (2020) does not distinguish between races of Brent goose. NB – the number of dark-bellied Brent geese overwintering in Northern Ireland is negligible and therefore this GB population estimate is assumed to be equal to the UK population.

Species/ Population	Flyway Population[11]	UK Population[12]	Percentage staging/ moulting at Wadden Sea[13]	Migration Season	Percentage of UK population passing through the array area each migration[14]			Number of birds from UK population passing through the array area each migration			Percentage of flyway population passing through the array area each migration[15]		
					Mean	Lower CL	Upper CL	Mean	Lower CL	Upper CL	Mean	Lower CL	Upper CL
Shelduck (Wintering)[17]			100%	Moult	6.17%	5.99%	6.35%	969	940	997	0.32%	0.31%	0.33%
Wigeon (Wintering)	1,500,000	450,000	-	Spring/Autumn	4.99%	4.94%	5.05%	22,474	22,226	22,724	1.50%	1.48%	1.51%
Ringed plover (Breeding)[18]	73,000	10,500 – 11,200	-	Spring/Autumn	0.41%	0.35%	0.48%	44–47	37–40	51–53	0.06%	0.05%	0.07%
Ringed plover (Passage)[19]	73,000	73,000	-	Spring	0%	0%	0%	0	0	0	0%	0%	0%
				Autumn	3.90%	3.83%	3.96%	2,844	2,797	2,890	3.90%	3.83%	3.96%
Golden plover (Breeding)[20]	140,000 – 210,000[21]	65,000 – 101,000	-	Spring/Autumn	0.0%	0.0%	0.0%	0	0	0	0.0%	0.0%	0.0%
Golden plover (Wintering)[9]	1,570,000 – 2,140,000[22]	410,000	-	Spring/Autumn	3.57%	3.46%	3.70%	14,647	14,185	15,155	0.68 – 0.93%	0.66 – 0.90%	0.71 – 0.97%

[17] Wintering shelduck include both UK breeding birds as well as migrants breeding elsewhere. Many UK breeding birds also carry out a moult migration to the Helgoland Bight region of the Wadden Sea. As a precautionary assumption, all UK breeding birds are assumed to carry out a moult migration to the Wadden Sea (Wright et al. 2012). The numbers of birds are based on the approach suggested in Wright et al. (2012) but revised using the figures from Woodward et al. (2020); i.e. the total wintering population of 51,000 consists of 15,700 UK-breeding birds supplemented with 35,300 additional birds. Spring migration consists of non-UK breeding birds migrating away from the UK to their breeding grounds. The row for moult migration is for the outbound flight of UK breeding birds to the Wadden Sea. The autumn migration row is for inbound migration to the UK in autumn and therefore includes both UK breeding birds returning after moulting and non-UK breeding birds migrating from breeding grounds elsewhere.

[18] As a precautionary assumption, the entire breeding population has been modelled as migrating. It is thought that a large proportion of the breeding population in fact remain in the UK (with some movement around the UK) to form the wintering population (Wright et al. 2012).

[19] The UK is important for passage migrants migrating between breeding grounds in arctic Canada, Greenland, Iceland and Scandinavia and wintering sites in Spain and West Africa. Following (Wright et al. 2012), it is assumed the entire international population migrates across the UK, following different routes in spring and autumn.

[20] As a precautionary assumption, breeding and wintering populations are considered to be entirely separate, with the entire breeding population migrating out of the UK for winter and the entire wintering population migrating in. This is precautionary as it is thought many British breeding birds remain in the UK overwinter and therefore the total number of birds migrating and potentially at risk from collisions is lower than presented here (Wright et al. 2012).

[21] Population of *Pluvialis apricaria*. All UK-breeding birds are this sub-species (Wright et al. 2012).

[22] Combined population of *P. a. apricaria* and *P. a. altifrons*. A proportion of both sub-species overwinters in the UK (Wright et al. 2012).

Species/ Population	Flyway Population[11]	UK Population[12]	Percentage staging/ moulting at Wadden Sea[13]	Migration Season	Percentage of UK population passing through the array area each migration[14]			Number of birds from UK population passing through the array area each migration			Percentage of flyway population passing through the array area each migration[15]		
					Mean	Lower CL	Upper CL	Mean	Lower CL	Upper CL	Mean	Lower CL	Upper CL
Grey plover (Wintering)	250,000	33,500	-	Spring/Autumn	4.52%	4.47%	4.59%	1,515	1,496	1,537	0.61%	0.60%	0.61%
Lapwing (Wintering)	5,500,000 – 9,500,000	635,000	-	Spring/Autumn	4.65%	4.60%	4.70%	29,539	29,235	29,851	0.31 – 0.54%	0.31 – 0.53%	0.31 – 0.54%
Knot (Wintering)	450,000	265,000	-	Spring/Autumn	4.51%	4.44%	4.56%	11,944	11,775	12,092	2.65%	2.62%	2.69%
Sanderling (Wintering)	120,000	205,000	-	Spring/Autumn	6.78%	6.69%	6.88%	1,390	1,371	1,411	1.16%	1.14%	1.18%
Dunlin (Wintering)	1,330,000	350,000	-	Spring/Autumn	4.07%	3.97%	4.15%	14,252	13,910	14,541	1.07%	1.05%	1.09%
Black-tailed godwit (Icelandic; Wintering)	50,000 – 75,000	41,000[23]	-	Spring/Autumn	1.50%	1.46%	1.54%	613	597	630	0.82 – 1.23%	0.80 – 1.20%	0.84 – 1.27%
Bar-tailed godwit (Wintering)	120,000	53,500	-	Spring/Autumn	6.26%	6.17%	6.33%	3,347	3,302	3,389	2.79%	2.75%	2.82%
Curlew (Breeding)[9]	700,000 – 1,000,000	117,000	-	Spring/Autumn	0.0%	0.0%	0.0%	0	0	0	0.0%	0.0%	0.0%
Curlew (Wintering)[9]	700,000 – 1,000,000	125,000	-	Spring/Autumn	6.29%	6.19%	6.41%	7,865	7,732	8,013	0.79 – 1.12%	0.77 – 1.10%	0.80 – 1.15%
Redshank (Britannica; Breeding)[24]	95,000 – 135,000	44,000	-	Spring/Autumn	0.69%	0.63%	0.75%	304	278	330	0.23 – 0.32%	0.21 – 0.29%	0.24 – 0.35%

[23] Woodward et al. (2020) does not distinguish between races; however, it is thought that most, if not all, of the continental race *Limosa limosa limosa* migrate to sub-Saharan Africa or Iberia for winter and therefore the entire wintering population in the UK is assumed to be *L. l. islandica*.

[24] Based on the approach given in Wright et al. (2012) although with updated figures from Woodward et al. (2020) where applicable. Half of the UK-breeding population of *Tringa totanus britannica* is assumed to migrate elsewhere for winter. The entirety of the overwintering population of *T. t. britannica* is assumed to consist of resident UK-breeding individuals with no inwards migration for the winter season, and therefore the wintering population is not exposed to any collision risk. The entirety of the global population of *T. t. robusta* and approximately 10% of the global population of *T. t. totanus* is assumed to migrate to the UK for the winter season.

Species/ Population	Flyway Population[11]	UK Population[12]	Percentage staging/ moulting at Wadden Sea[13]	Migration Season	Percentage of UK population passing through the array area each migration[14]			Number of birds from UK population passing through the array area each migration			Percentage of flyway population passing through the array area each migration[15]		
					Mean	Lower CL	Upper CL	Mean	Lower CL	Upper CL	Mean	Lower CL	Upper CL
Redshank (robusta; Wintering)[14]	150,000 – 400,000	150,000 – 400,000	-	Spring/Autumn	2.60%	2.55%	2.65%	3,900 – 10,408	3,826 – 10,249	3,977 – 10,617	2.60%	2.55%	2.65%
Redshank (totanus; Wintering)[14]	200,000 – 300,000	25,000	-	Spring/Autumn	3.58%	3.54%	3.63%	896	884	908	0.30 – 0.45%	0.29 – 0.44%	0.30 – 0.45%
White-fronted goose (wintering)	1,200,000	14,000	-	Spring/Autumn	0%	0%	0%	0	0	0	0%	0%	0%
Teal (wintering)	500,000	435,000	-	Spring/Autumn	4.90%	4.83%	4.96%	21,297	20,991	21,567	4.26%	4.20%	4.31%
Gadwall (wintering)	60,000	31,000	-	Spring/Autumn	1.08%	1.04%	1.14%	336	321	353	0.56%	0.54%	0.59%
Goldeneye (wintering)	1,000,000 – 1,300,000	21,000	-	Spring/Autumn	5.56%	5.47%	5.68%	1,169	1,148	1,192	0.09 – 0.12%	0.09 – 0.11%	0.09 – 0.13%
Oystercatcher (wintering)	820,000	305,000	-	Spring/Autumn	4.65%	4.58%	4.73%	14,192	13,958	14,419	1.73%	1.70%	1.76%
Avocet (wintering)	73,000	8,700	-	Spring/Autumn	0%	0%	0%	0	0	0	0%	0%	0%
Ruff (wintering)	1,000,000 – 1,500,000	920	-	Spring/Autumn	5.65%	5.51%	5.78%	52	51	53	0.00 – 0.01%	0.00 – 0.01%	0.00 – 0.01%
Whimbrel (passage)	790,000 – 1,090,000	3,840	-	Spring/Autumn	7.92%	7.64%	8.22%	304	293	316	0.03 – 0.04%	0.03 – 0.04%	0.03 – 0.04%
Turnstone (wintering)	145,000 – 320,000	43,000	-	Spring/Autumn	4.07%	3.99%	4.15%	1,750	1,716	1,786	0.55 – 1.21%	0.54 – 1.18%	0.56 – 1.23%
Hen harrier(wintering)[25]	8,500	545	-	Spring/Autumn	1.40%	1.37%	1.43%	8	7	8	0.09%	0.09%	0.09%

[25] As per Wright et al. (2012), it is assumed that half of the British-wintering population is formed of international migrants, with the other half being British-breeding birds. The UK-wintering population is the updated figure from Woodward et al. (2020).

Appendix B – Collision Risk Modelling Results

Table B-1: Results of CRM parametrised using a range of avoidance rates and the mean (as presented in main text), lower CL and upper CL estimates from Migropath modelling of the number of birds expected to pass through the Hornsea Four array area on migration. Where the UK population size is uncertain (Woodward et al. 2020) the results are presented for both low and high UK population estimates.

Species	Avoidance Rate	Annual Collision Rate BO1		
		Model estimate for number of birds		
		Mean	Lower CL	Upper CL
Taiga Bean Goose	95.0%	0.00	0.00	0.00
	98.0%	0.00	0.00	0.00
	99.0%	0.00	0.00	0.00
	99.5%	0.00	0.00	0.00
Bewick's Swan	95.0%	0.31	0.27	0.33
	98.0%	0.12	0.11	0.13
	99.0%	0.06	0.05	0.07
	99.5%	0.03	0.03	0.03
Shelduck	95.0%	2.43	2.21	2.47
	98.0%	0.97	0.89	0.99
	99.0%	0.49	0.44	0.49
	99.5%	0.24	0.22	0.25
Gadwall	95.0%	0.26	0.25	0.28
	98.0%	0.10	0.10	0.11
	99.0%	0.05	0.05	0.06
	99.5%	0.03	0.03	0.03
Wigeon	95.0%	16.84	15.46	17.03
	98.0%	6.74	6.19	6.82
	99.0%	3.37	3.09	3.41
	99.5%	1.69	1.55	1.70
Teal	95.0%	14.96	14.75	15.15
	98.0%	5.99	5.90	6.06
	99.0%	2.99	2.95	3.03
	99.5%	1.50	1.48	1.52
Goldeneye	95.0%	0.87	0.86	0.89
	98.0%	0.35	0.34	0.36
	99.0%	0.17	0.17	0.18

Species	Avoidance Rate	Annual Collision Rate BO1		
		Model estimate for number of birds		
		Mean	Lower CL	Upper CL
	99.5%	0.09	0.09	0.09
Hen harrier	95.0%	0.03	0.02	0.03
	98.0%	0.01	0.01	0.01
	99.0%	0.01	0.00	0.01
	99.5%	0.00	0.00	0.00
Oystercatcher	95.0%	19.19	18.88	19.50
	98.0%	7.68	7.55	7.80
	99.0%	3.84	3.78	3.90
	99.5%	1.92	1.89	1.95
Lapwing	95.0%	37.20	34.17	37.60
	98.0%	14.89	13.67	15.04
	99.0%	7.44	6.84	7.52
	99.5%	3.72	3.42	3.76
Golden plover	95.0%	17.69	15.89	18.30
	98.0%	7.08	6.36	7.32
	99.0%	3.54	3.18	3.66
	99.5%	1.77	1.59	1.83
Grey plover	95.0%	1.77	1.62	1.66
	98.0%	0.71	0.65	0.67
	99.0%	0.35	0.32	0.33
	99.5%	0.18	0.16	0.17
Ringed plover (low)	95.0%	1.57	1.42	1.60
	98.0%	0.63	0.57	0.64
	99.0%	0.31	0.28	0.32
	99.5%	0.16	0.14	0.16
Ringed plover (high)	95.0%	1.57	1.43	1.60
	98.0%	0.63	0.57	0.64
	99.0%	0.31	0.29	0.32
	99.5%	0.16	0.14	0.16
Whimbrel	95.0%	0.39	0.37	0.40
	98.0%	0.15	0.15	0.16
	99.0%	0.08	0.07	0.08

Species	Avoidance Rate	Annual Collision Rate BO1		
		Model estimate for number of birds		
		Mean	Lower CL	Upper CL
	99.5%	0.04	0.04	0.04
Curlew	95.0%	10.80	9.85	11.00
	98.0%	4.32	3.94	4.40
	99.0%	2.16	1.97	2.20
	99.5%	1.08	0.99	1.10
Bar-tailed godwit	95.0%	4.07	3.73	4.12
	98.0%	1.63	1.49	1.65
	99.0%	0.81	0.75	0.82
	99.5%	0.41	0.37	0.41
Black-tailed godwit	95.0%	0.76	0.68	0.78
	98.0%	0.30	0.27	0.31
	99.0%	0.15	0.14	0.16
	99.5%	0.08	0.07	0.08
Turnstone	95.0%	1.99	1.95	2.03
	98.0%	0.79	0.78	0.81
	99.0%	0.40	0.39	0.41
	99.5%	0.20	0.19	0.20
Knot	95.0%	13.15	12.03	13.32
	98.0%	5.26	4.81	5.33
	99.0%	2.63	2.41	2.66
	99.5%	1.32	1.20	1.33
Ruff	95.0%	0.06	0.06	0.06
	98.0%	0.02	0.02	0.02
	99.0%	0.01	0.01	0.01
	99.5%	0.01	0.01	0.01
Sanderling	95.0%	1.48	1.36	1.51
	98.0%	0.59	0.54	0.60
	99.0%	0.30	0.27	0.30
	99.5%	0.15	0.14	0.15
Dunlin	95.0%	15.62	14.15	15.94
	98.0%	6.25	5.66	6.38
	99.0%	3.13	2.83	3.19

Species	Avoidance Rate	Annual Collision Rate BO1		
		Model estimate for number of birds		
		Mean	Lower CL	Upper CL
	99.5%	1.56	1.42	1.59
Redshank (low)	95.0%	6.27	5.69	6.41
	98.0%	2.51	2.28	2.57
	99.0%	1.25	1.14	1.28
	99.5%	0.63	0.57	0.64
Redshank (high)	95.0%	14.27	13.02	14.57
	98.0%	5.71	5.21	5.83
	99.0%	2.86	2.60	2.92
	99.5%	1.43	1.30	1.46

Table B-2: Results of CRM for seabirds parametrised using a range of avoidance rates. For little gull, results also presented for a range of population estimates (0).

Species	Avoidance Rate	Annual Collision Rate BO1	Annual Collision Rate BO2
Little gull (Median)	95.00%	0.56	0.22
	98.00%	0.23	0.09
	99.00%	0.11	0.04
	99.20%	0.09	0.03
Little gull (Lower)	99.50%	0.06	0.02
	95.00%	0.43	0.17
	98.00%	0.17	0.07
	99.00%	0.09	0.03
Little gull (Upper)	99.20%	0.07	0.03
	99.50%	0.04	0.02
	95.00%	0.69	0.27
	98.00%	0.28	0.11
	99.00%	0.14	0.05
Sandwich tern	99.20%	0.11	0.04
	99.50%	0.07	0.03
	95.00%	0.28	0.04
	98.00%	0.11	0.02
	99.00%	0.06	0.01
	99.50%	0.03	0.00

Species	Avoidance Rate	Annual Collision Rate BO1	Annual Collision Rate BO2
Roseate tern	95.00%	0.00	N/A
	98.00%	0.00	N/A
	99.00%	0.00	N/A
	99.50%	0.00	N/A
Common tern	95.00%	11.79	0.50
	98.00%	4.72	0.20
	99.00%	2.36	0.10
	99.50%	1.18	0.05
Arctic Tern	95.00%	1.66	0.09
	98.00%	0.67	0.04
	99.00%	0.33	0.02
	99.50%	0.17	0.01
Great skua	95.00%	0.05	0.00
	98.00%	0.02	0.00
	99.00%	0.01	0.00
	99.50%	0.01	0.00
Arctic skua	95.00%	0.08	0.00
	98.00%	0.03	0.00
	99.00%	0.02	0.00
	99.50%	0.01	0.00

Appendix C – Estimate of Little Gull *Hydrocoloeus minutus* Population within the UK North Sea

Summary

Based on a literature and data review, the population of little gull occurring on autumn passage in English North Sea waters is most probably in the range of 23,500 to 37,500 individuals. A proposed estimate of the autumn migration BDMPS for use in assessments of OWFs occurring in English waters of the North Sea is 30,500 individuals.

Introduction

The proposed Hornsea Four Offshore Wind Farm (here after Hornsea Four), as part of the preparation for the submission of an DCO application to the Planning Inspectorate, has undertaken an initial assessment of the potential impacts on offshore and intertidal ornithology receptors and that EIA was published for consultation (Chapter 5 of the PEIR) and, with respect to interest features of European Sites, a Draft Report to Inform Appropriate Assessment (RIAA) was also published for consultation. In their response to that consultation, Natural England requested that more detail be provided on the assessment of potential impacts on little gull. As part of that information provision, this note on the little gull population of the UK North Sea has been prepared.

The standard source for population estimates for seabirds used in UK OWF baseline studies and impact assessments is Furness (2015), this being a report on population estimates commissioned by Natural England. The other widely used standard source for population estimates for all birds occurring in GB/United Kingdom (UK) is Musgrove et al. (2013). Neither of these standard sources provide a population estimate for little gull. In response to this lack of information, a population estimate is derived from other source material.

Approach

A population estimate for little gull using the UK waters of the North Sea has been prepared from a review of the literature and available databases relating to north-west Europe. This has considered both breeding populations from which the number of non-breeding individuals can be derived, and non-breeding individuals recorded using particular sites or on migration along the coast.

Breeding population estimates

Global population: The global population is estimated to number 97,000 - 270,000 individuals (Delany & Scott 2006).

European population: The European population is estimated at 23,700 - 45,200 pairs (BirdLife International 2015), which equates to 47,400 - 90,500 mature individuals. An earlier estimate of 72,000 – 147,000 breeding birds for the period 1990 - 2000 suggests a recent decline (Wetlands International 2013).

UK population: Little gull breeds only sporadically in the UK with the most recent record being a single pair from the Loch of Strathbeg in 2016 (Holling & RBBP 2018).

Table C-1: Summary of breeding population estimates.

Spatial scale	Number (mature individuals)	Source
Global	97,000 - 270,000	Delany & Scott 2006
European	47,400 - 90,500	BirdLife International 2015
European	72,000 - 147,000	Wetlands International 2013
EU 27	25,600 – 36,800	European Environment Agency 2015

Note: These estimates are based on converting breeding pairs to mature individuals

Non-breeding (passage / wintering) population estimates

Southern North Sea passage population: Stienen et al. (2007) provides an estimate for the population of little gull moving through the whole of the North Sea in autumn and passing out through the Straits of Dover. That population estimate is 30,000 - 75,000 individuals. That population would be divided between UK and continental waters. If equally divided, then the population passing through UK waters would be 15,000 - 37,500 individuals each autumn. The evidence available is that numbers are concentrated along the continental seaboard rather than spread evenly between the UK coast and the continent (see **Appendix D** that provides a map of hourly average passage from the bird migration monitoring database Trektellen https://www.trektellen.org).

Scottish waters passage population: In a study for the Scottish Government concerning an assessment of the collision risk to migratory birds from proposed OWFs in Scottish Waters, WWT Consulting (2014) provided an estimate of 3,000 individuals passing through the North Sea waters off the Scottish coasts on autumn migration.

Population estimates produced for the classification of marine SPAs

Population estimates have been made for areas of UK waters for the purposes of the classification of marine SPAs including specifically for English waters of the North Sea. These population estimates are based on aerial surveys contracted by Government departments and agencies.

Greater Wash SPA: For the Greater Wash SPA (Natural England & JNCC 2016), an area of search was defined as waters off the coast of East Yorkshire to Norfolk within which, based on two seasons of aerial survey data (2004/05 and 2005/06), a population of 2,153 individuals was identified based on the mean of the peak over those two seasons. The largest population estimate in that programme of surveys was of 2,645 individuals in October/November 2004 (Lawson et al. 2016a).

Outer Thames Estuary SPA: The parallel survey and assessment for the Outer Thames Estuary SPA (Lawson et al. 2016b), based on an area of search of waters off the coast of Norfolk to Kent identified a population of 258 individuals, being the mean peak of estimates from 2004/05 and 2005/06. The largest population estimate in that programme of surveys was of 379 individuals in November 2005.

Adding the two individual peak counts together from these two SPA surveys gives a total of 3,024 individuals (noting that figure is the sum of two different years).

Non-breeding population estimates from coastal counts

BTO Wetland Bird Survey (WeBS) data: The BTO WeBS online database[26] was examined for data held on counts of little gull. The counts listed include both the 'core' counts from the pre-defined days each month and 'supplementary counts'. Both sets of counts were examined. The database was ordered starting from the site with the largest mean peak of the most recent five years. Those sites bordering the North Sea and with a 5 year mean peak greater than 5 little gulls were identified. Those sites are (in alphabetical order):

- Forth Estuary, Fife and Lothian;
- Hornsea Mere, Yorks;
- Humber Estuary, Lincs and Yorks;
- Minsmere, Suffolk;
- North Norfolk Coast, Norfolk;
- Pegwell Bay, Kent;
- Swale Estuary, Kent;
- The Wash, Lincs and Norfolk;

[26] https://app.bto.org/webs-reporting/

- Tay Estuary, Fife and Tayside; and
- Ythan Estuary to Collieston, Aberdeen.

The annual peak count from each of these sites was identified over the period late summer 2000 to early summer 2018 (the WeBS 'year' runs from July to June). For each year, a total peak count was calculated from the peak count made at each site and a five-year running average for the peaks calculated. The full data set that was used is presented in **Appendix E**.

The WeBS data provides the following counts that can be used to inform a population estimate for UK North Sea waters (**Table C-2**).

Table C-2: WeBS data used to inform population estimate of little gull for UK North Sea waters.

Measure	Count	Location/Date
Peak annual total UK East coast 2000-2018	21,594	2007-08
Peak site count 2000-2018	21,500	Hornsea Mere 2007-08
Peak 5 year mean	9,356	2003-04 to 2007-08
Recent 5 year mean	2,106	2013-14 to 2017-18

Note that the Greater Wash SPA is classified on the basis of counts made of little gull in 2004-06. The five- year mean peak spanning that period was 2,695.

Trektellen migration count data for the UK east coast: The Trektellen database[27] holds records of counts of birds on migration across Europe (noting that for reasons of its history and observer distribution, the data comes mainly from sites in Spain, France and countries around the North Sea and the Baltic Sea). That database was examined for records of little gull and filtered to extract those records coming from sites along the English North Sea and Channel coast. Peak counts were extracted for a single day at a site and for the annual totals at a site (note that counts from different sites in a single autumn were not added together since this would result in the same 'pulse' of passage birds being repeatedly summed as they moved south down the east coast). Since submitting migration records to the Trektellen database, it has a more recent history in the UK than recording for WeBS, the Trektellen data set is therefore the most comprehensive for recent years. The period of the decade 2009-2018 was used to identify peaks and within that period, five-year mean peaks were calculated. The full data set that was used is presented in **Appendix F**.

The Trektellen data provides the following counts that can be used to inform a population estimate for UK North Sea waters (**Table C-3**).

Table C-3: Trektellen data used to inform population estimate of little gull for UK North Sea waters.

Measure	Count	Location/Date
Peak site annual total 2009-2018	23,548	Flamborough Head 2014
Peak site one day count 2009-2018	7,824	Flamborough Head 2014
Peak 5 year mean across annual site counts	12,323	2003-04 to 2011-15
Recent peak 5 year mean	7,530	2014 to 2018

[27] https://www.trektellen.org

Note that these annual totals almost wholly relate to birds on passage in the autumn – see Appendix G that provides a graph of the phenology of little gull passage through UK waters.

Non-breeding population estimates from OWF surveys

Hornsea Three: Little gulls were recorded during five of the aerial surveys conducted across the Hornsea Three offshore ornithology study area. The peak abundance estimate was of 78 individuals in October 2017 (Orsted 2018).

Norfolk Boreas: The estimated Norfolk Boreas mean peak wind farm population, including unidentified birds, was 203 (MacArthur Green 2019).

Norfolk Vanguard: The estimated Norfolk Vanguard East and Norfolk Vanguard West mean peak wind farm populations, including unidentified birds, were 62 (August) and 18 (November), respectively (MacArthur Green 2018).

Westermost Rough: The surveys over the baseline characterisation, pre-, during and post-construction periods (summarised in Percival & Ford 2017) provided a peak population estimate for the wind farm + buffer of 3,522 in 2012-13 with a further 1,610 in the reference area.

Conclusion

The evidence available from the available literature and databases indicates that (with population estimates given to two or three significant figures):

- The extreme ranges of estimates for the population of little gull occurring on autumn passage in English North Sea waters is:
    - Extreme upper limit 75,000 individuals
    - Extreme lower limit 21,600 individuals
- The weight of evidence points to a population that occurs regularly in English North Sea waters in the range of:
    - Upper range 37,500 individuals
    - Lower range 23,500 individuals
- A proposed estimate of the autumn migration BDMPS for use in assessments of OWFs occurring in English waters of the North Sea is 30,500 individuals. Note that in the manner of Furness (2015) only a single value is given.

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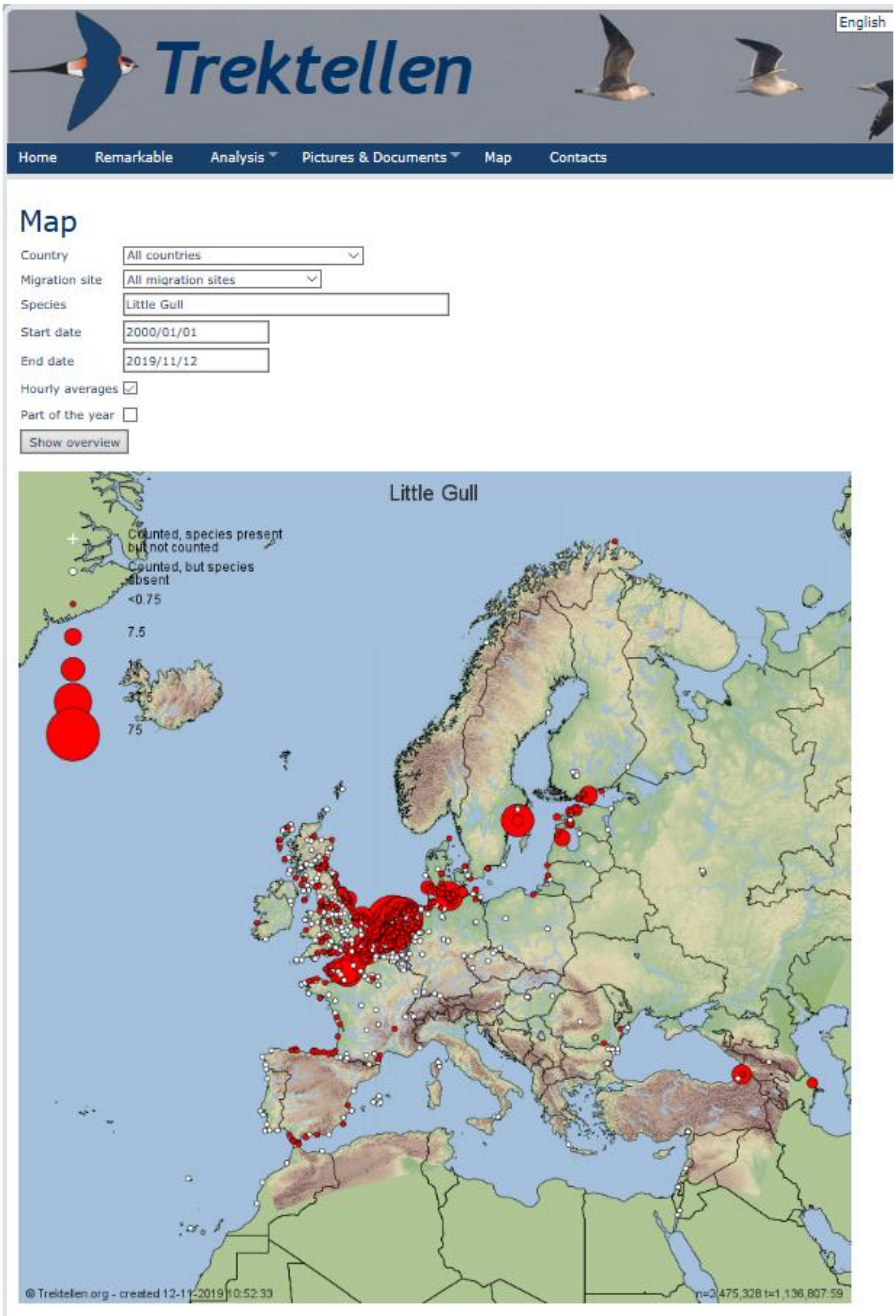
Appendix D – Little gull migration – hourly average passage counts



Source: https://www.trektellen.org All little gull migration counts 2000 – 2019.

Note that the size of each red circle relates to the hourly average count of birds on migration.

Appendix E - Little gull peak counts recorded by WeBS for sites along the North Sea coast

Table E-1: Little gull peak counts recorded by WeBS for sites along the North Sea coast.

	2017-2018	2016-2017	2015-2016	2014-2015	2013-2014	2012-2013	2011-2012	2010-2011	2009-2010	2008-2009	2007-2008	2006-2007	2005-2006	2004-2005	2003-2004	2002-2003	2001-2002	2000-2001
Hornsea Mere	4,100	84	1,680	2,660	1,540	7,180	3,500	500	610	134	21,500	16,000	160	7,000	940	1,350	3,150	163
Minsmere	10	34	39	13	30	0	20	2	0	2	15	0	8	1	73	15	2	1
The Wash	0	2	80	1	15	2	10	1	4	2	3	4	3	4	1	2	1	1
Tay Estuary	0	4	0	69	0	0	28	0	1	0	3	206	26	28	36	50	22	0
N Norfolk Coast	14	10	6	9	6	8	103	2	4	10	30	176	32	8	38	9	70	17
Ythan to Collieston	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Humber Estuary	2	4	4	20	3	16	290	3	5	2	33	0	3	0	12	2	0	10
Swale Estuary	0	0	0	37	0	0	0	0	0	1	0	0	4	1	1	2	2	0
Forth Estuary	2	1	2	23	0	26	5	1	2	3	9	25	0	321	75	41	22	1
Pegwell Bay	0	0	1	0	16	1	19	5	2	8	1	0	0	0	0	1	3	0
Annual total	4,128	148	1,812	2,832	1,610	7,233	3,975	514	628	162	21,594	16,411	236	7,363	1,176	1,472	3,272	193
Five-year mean	2,106	2,727	3,492	3,233	2,792	2,502	5,375	7,862	7,806	9,153	9,356	5,332	2,704	2,695				

Appendix F – Little gull peak counts on migration recorded in the Trektellen database for sites along the North Sea and Channel coast

Table F-1: Peak count of birds in a single day on passage along the English North Sea coast.

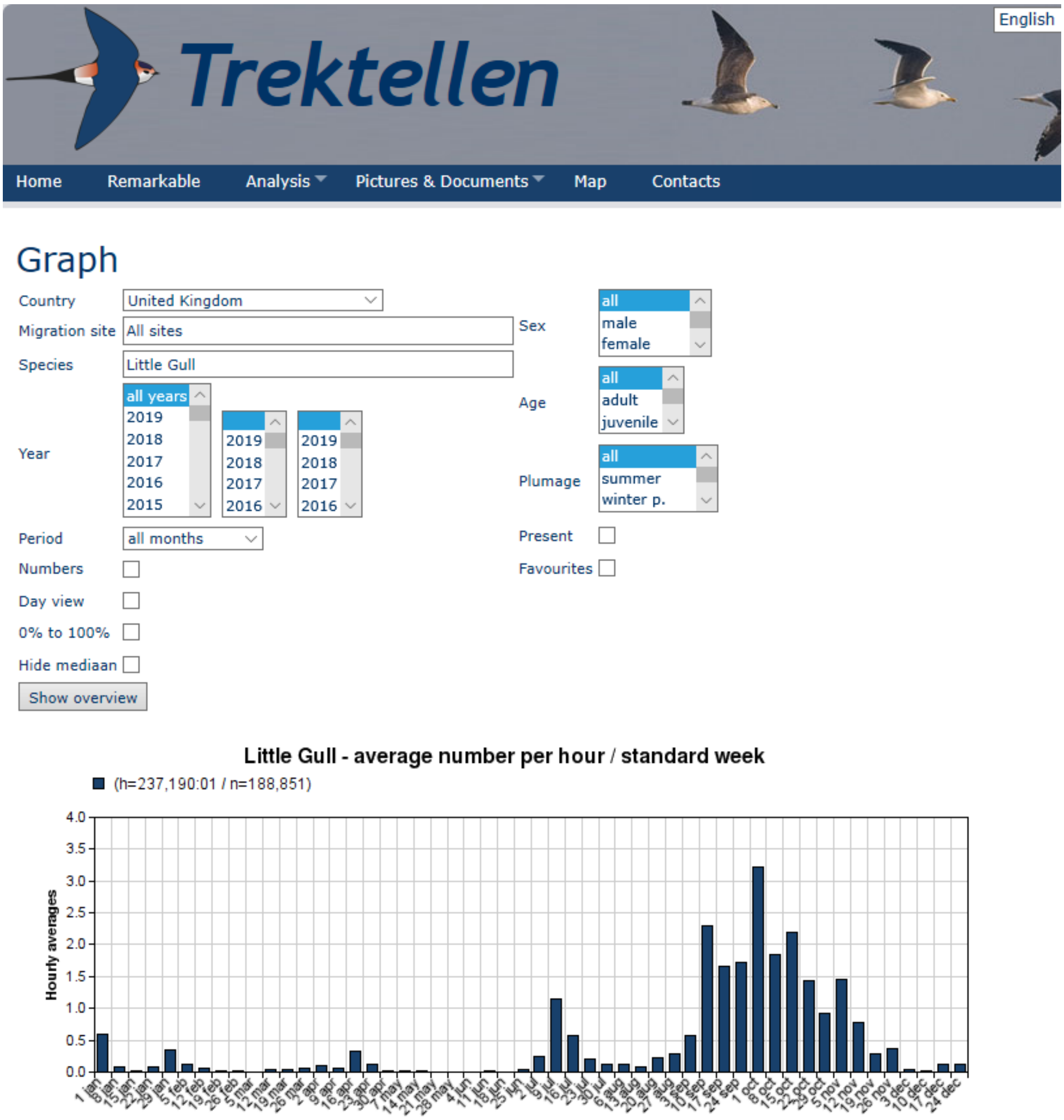
Site	Count	Date
Flamborough Head	7,824	22 September 2014
Flamborough Head	6,675	11 September 2011
Flamborough Head	5,200	10 September 2011
Spurn Point Bird Observatory	3,734	30 September 2019
Flamborough Head	2,730	15 September 2013
Flamborough Head	2,730	15 September 2013
Flamborough Head	1,748	29 September 2015
Spurn Point Bird Observatory	1,320	26 September 2012
Flamborough Head	1,271	23 September 2014
Spurn Point Bird Observatory	1,059	14 September 2012
Flamborough Head	1,006	21 September 2015
Long Nab, Burniston	1,003	22 September 2014

These counts extracted from the Trektellen database are the top ten peak counts over the last decade and are also all one-day counts held in the data base that are >1,000.

Table F-2: Peak annual sum count at any one site on the English North Sea or Channel coast over the last decade.

Year	Annual total	Site
2018	1,130	Flamborough Head
2017	3,387	Mundesley
2016	1,879	Flamborough Head
2015	7,708	Flamborough Head
2014	23,548	Flamborough Head
2013	6,058	Flamborough Head
2012	5,411	Flamborough Head
2011	18,889	Flamborough Head
2010	871	Dungeness
2009	3,091	Spurn Point

Appendix G – Phenology of little gull passage through UK waters



Appendix H – Screening Matrix

Table H-1: Screening matrix used to determine migratory species for inclusion in Migropath or 'broad front' modelling. Decision based on expert judgement of the information presented. Key to row colours: Green = screened in; Purple = screened out as migratory flight path does not cross Hornsea Four array area; Yellow = screened out for other reasons; Grey = species considered in main ES Chapter (and therefore not considered in this Annex); White = insufficient data (unable to assess risk).

Species / Sub-Species	Flight Path Intersection of Array Area (SOSS 05)		Observations from surveys			Local Bird Reports	Literature Review	SOSS 02 Flight Heights		Species of CRM Concern (SOSS 03A)		Perceived Risk from Collision		Humber Estuary SPA Qualifying feature?	Screened in?	Comments
	Full	Partial	Hornsea Four Aerial Surveys	Hornsea Three Aerial Surveys	Hornsea Zone Boat Surveys	Yorkshire Bird Report	Wernham et al. (2002)	Percentage of Birds flying at Potential Collision Height (PCH)	Confidence Level attached to PCH	Spring	Autumn	Langston (2010)	Furness & Wade (2012)			
Bewick's Swan	No	Yes	No	No	No	N/A	Low/Mod	0.50	N/A	N/A	N/A	High	N/A	No	Yes	Not a qualifying feature of any North East coast SPA associated with Hornsea Four. Not recorded in any Hornsea boat or aerial surveys. Selected for modelling only due to having been selected for previous assessments.
Whooper Swan	No	Yes	No	No	No	N/A	Low	N/A	N/A	Low / Mod	Mod	High	N/A	No	No	Not recorded in any Hornsea boat or aerial surveys. Only a small number of birds ~200 (Wright et al. 2012) migrate across the Southern North Sea. Qualifying feature of North East Coast SPA to the north of Hornsea Four, so not at risk.
Bean Goose	Yes	No	No	No	Yes	N/A	N/A	N/A	N/A	N/A	N/A	Mod	N/A	No	Yes	Recorded during the former Hornsea Zone boat-based surveys, but less than one collision estimated in Hornsea Three CRM modelling. Selected for modelling only due to having been selected for previous assessments.
Pink-footed Goose	No	Yes	No	No	Yes	N/A	Low	N/A	N/A	Low	Low /Mod	Mod	N/A	Yes (assemblage)	No	Migratory flight path only partially overlaps the Hornsea Four array area. Recorded during the Hornsea Zone boat-based surveys, but majority of birds from East Anglia follow a coastal route to staging posts in NW England before moving north, so would not fly over North Sea at all. This is supported by telemetry studies (WWT & Orsted 2016 - 2019) and radar studies (Plonczkier and Simms 2012). Therefore, unlikely that any significant numbers would pass through Hornsea Four array area.
European White-fronted Goose	No	Yes	No	No	No	Low	Low	N/A	N/A	Low	Low	Mod	N/A	Yes (assemblage)	Yes	Species can be described as a scare winter visitor and passage migrant, with majority of population concentrating in Seven Estuary, Kent and East Anglia. Unlikely to be at risk but screened in following consultation.

Species / Sub-Species	Flight Path Intersection of Array Area (SOSS 05)		Observations from surveys			Local Bird Reports	Literature Review	SOSS 02 Flight Heights		Species of CRM Concern (SOSS 03A)		Perceived Risk from Collision		Humber Estuary SPA Qualifying feature?	Screened in?	Comments
	Full	Partial	Hornsea Four Aerial Surveys	Hornsea Three Aerial Surveys	Hornsea Zone Boat Surveys	Yorkshire Bird Report	Wernham et al. (2002)	Percentage of Birds flying at Potential Collision Height (PCH)	Confidence Level attached to PCH	Spring	Autumn	Langston (2010)	Furness & Wade (2012)			
Greenland White-fronted Goose	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site
Icelandic Greylag Goose	No	No	No	No	Yes	N/A	N/A	N/A	N/A	Low	Low	N/A	N/A	No	No	Not selected for modelling as flight path not over site
Greenland Barnacle Goose	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site
Svalbard Barnacle Goose	No	Yes	No	No	No	N/A	Low	N/A	N/A	Low	Low	N/A	N/A	No	No	Not recorded in any Hornsea boat or aerial surveys. Only partial flight path through the Hornsea Four area and majority of population recorded to the north of Hornsea Four.
Dark-bellied Brent Goose	Yes	No	No	No	Yes	High	Mod/High	N/A	N/A	Low	Low/Mod	Mod	N/A	Yes	Yes	Linked to Humber Estuary SPA saltmarshes. Migration staging posts in Wadden Sea, means concentrated flights across the North Sea. However, majority of flightpath would not pass over Hornsea Four and only included as was assessed in previous projects.
Canadian Light-bellied Brent Goose	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site
Svalbard Light-bellied Brent Goose	No	Yes	No	No	No	N/A	Low	N/A	N/A	N/A	N/A	Mod	N/A	No	No	Not recorded in any Hornsea boat or aerial surveys. Occurs in nationally important numbers at North East coast SPA to the north of Hornsea Four. Only partial flight path through the Hornsea Four array area and majority of population recorded to north of Hornsea Four.
Shelduck	Yes	No	No	No	Yes	Mod	Low	N/A	N/A	Low	Low	N/A	N/A	Yes	Yes	Qualifying feature of North East coast SPAs. Humber estuary SPA fifth most important site for this species in 2012/2013.
Wigeon	Yes	No	No	No	Yes	Mod	low	N/A	N/A	Low	Low	N/A	N/A	Yes	Yes	Qualifying feature of North East coast SPAs, linked to saltmarshes.
Gadwall	Yes	No	No	No	No	Low	Low	N/A	N/A	Low	Low	N/A	N/A	No	Yes	Occurs in nationally important numbers at Hornsea Mere SPA. Not recorded in any Hornsea aerial or boat-based surveys. Not a qualifying feature of any North East coast SPA and most in SE England SPAs. Perceived to be at low risk of collision on migration.

Species / Sub-Species	Flight Path Intersection of Array Area (SOSS 05)		Observations from surveys			Local Bird Reports	Literature Review	SOSS 02 Flight Heights		Species of CRM Concern (SOSS 03A)		Perceived Risk from Collision		Humber Estuary SPA Qualifying feature?	Screened in?	Comments
	Full	Partial	Hornsea Four Aerial Surveys	Hornsea Three Aerial Surveys	Hornsea Zone Boat Surveys	Yorkshire Bird Report	Wernham et al. (2002)	Percentage of Birds flying at Potential Collision Height (PCH)	Confidence Level attached to PCH	Spring	Autumn	Langston (2010)	Furness & Wade (2012)			
Teal	Yes	No	No	No	Yes	Mod	low	N/A	N/A	Low	Low	N/A	N/A	Yes (assemblage)	Yes	Recorded during the Hornsea Zone boat-based surveys. Not a qualifying feature of any North East SPAs associated with Hornsea Four. Perceived to be at low risk of collision during migration.
Mallard	Yes	No	No	No	Yes	Mod	Low	N/A	N/A	Low	Low	N/A	N/A	No	No	Recorded during the Hornsea Zone boat-based surveys but perceived to be at low risk of collision during migration.
Pintail	Yes	No	No	No	No	Low	Low	N/A	N/A	Low	Low	N/A	N/A	No	No	Migration route mainly via the English Channel or Southern North Sea (below the Hornsea Four array area) from Europe.
Shoveler	Yes	No	No	No	Yes	Low	Low	N/A	N/A	Low	Low	N/A	N/A	No	No	Nationally important numbers associated with North East SPA. Recorded during the Hornsea Zone boat-based surveys, but evidence from previous migration modelling and associated CRM found very low risk from collision.
Pochard	Yes	No	No	No	Yes	Low	Low/Mod	N/A	N/A	Low	Low	N/A	N/A	No	No	Occurs in nationally important numbers at North East Coast SPAs. Recorded during the Hornsea Zone boat-based surveys but evidence from previous migration modelling and associated CRM found very low risk from collision.
Tufted Duck	Yes	No	No	No	Yes		Mod	N/A	N/A	Low	Low	N/A	N/A	No	No	Occurs in nationally important numbers at North East Coast SPAs. Recorded during the Hornsea Zone boat-based surveys, but evidence from previous migration modelling and associated CRM found very low risk from collision.
Scaup	Yes	No	No	No	No	N/A	Low	N/A	N/A	Low	Low	Low	Mod	No	No	Main Migration route from Iceland to GB and Ireland.
Eider	Yes	No	No	No	Yes	N/A	Low	11.54	V Low	Low	Low	Low	Mod	No	No	Recorded during the Hornsea Zone boat-based surveys. Occur in nationally important numbers at North East coast SPA to the north of Hornsea Four, which are not considered likely to interact with array area.
Long-tailed Duck	Yes	No	No	No	No	N/A	N/A	N/A	N/A	Low	Low	Low	Low	No	No	Not recorded in any Hornsea boat or aerial surveys. Occurs in nationally important numbers at North East coast SPA to the north of Hornsea Four, which are not

Species / Sub-Species	Flight Path Intersection of Array Area (SOSS 05)		Observations from surveys			Local Bird Reports	Literature Review	SOSS 02 Flight Heights		Species of CRM Concern (SOSS 03A)		Perceived Risk from Collision		Humber Estuary SPA Qualifying feature?	Screened in?	Comments
	Full	Partial	Hornsea Four Aerial Surveys	Hornsea Three Aerial Surveys	Hornsea Zone Boat Surveys	Yorkshire Bird Report	Wernham et al. (2002)	Percentage of Birds flying at Potential Collision Height (PCH)	Confidence Level attached to PCH	Spring	Autumn	Langston (2010)	Furness & Wade (2012)			
																considered likely to interact with array area.
Common Scoter	Yes	No	No	No	Yes	Low/Mod	N/A	0.04	V High	Low	Low	Low	Low	No	No	Recorded during the Hornsea Zone boat-based surveys. Occurs in nationally important numbers at North East coast SPA to the north of Hornsea Four, which are not considered likely to interact with array area.
Velvet Scoter	Yes	No	No	No	No	Low	N/A	N/A	N/A	Low	Low	Low	Low	No	No	Scarce species in UK waters. Not recorded in any Hornsea boat or aerial surveys.
Goldeneye	Yes	No	No	No	Yes	Low	Low	N/A	N/A	Low	Low	Low	Low	No	No	Nationally important numbers associated with North East SPA. Recorded during the Hornsea Zone boat-based surveys, but evidence from previous migration modelling and associated CRM found very low risk from collision.
Smew	N/A	N/A	No	No	No	N/A	N/A	N/A	N/A	Low	Low	N/A	N/A	No	No	No flight path.
Red-breasted Merganser	No	Yes	No	No	Yes	N/A	N/A	N/A	N/A	Low	Low	Low	N/A	No	No	Occurs in nationally important numbers at North East coast SPA to the north of Hornsea Four. Recorded during the Hornsea Zone boat-based surveys, but evidence from previous migration modelling and associated CRM found very low risk from collision.
Goosander	Yes	No	No	No	Yes	Low	Low	N/A	N/A	Low	Low	N/A	N/A	No	No	Recorded during the Hornsea Zone boat-based surveys, but not considered at risk from collision risk.
Red-throated Diver	No	Yes	Yes	Yes	Yes	Low	Low	N/A	N/A	N/A	N/A	Low	Mod	No	No	Reliable survey data used in EIA for this species. Does not require modelling and is considered in **Volume A2, Chapter 5: Offshore and Intertidal Ornithology.**
Black-throated Diver	N/A	N/A	No	No	Yes	N/A	N/A	0.61	Mod	N/A	N/A	N/A	Mod/ High	No	No	No flight path.
Fulmar	Yes	No	Yes	Yes	Yes	N/A	Low	N/A	N/A	Low	Low	Low	N/A	No	No	Reliable survey data used in EIA for this species. Does not require modelling and is considered in **Volume A2, Chapter 5: Offshore and Intertidal Ornithology.**
Manx Shearwater	Yes	No	Yes	Yes	Yes	N/A	Low	0.00	Mod	N/A	N/A	Low	Low	No	No	Not considered a risk from collision with turbines due to low flight behaviour.

Species / Sub-Species	Flight Path Intersection of Array Area (SOSS 05)		Observations from surveys			Local Bird Reports	Literature Review	SOSS 02 Flight Heights		Species of CRM Concern (SOSS 03A)		Perceived Risk from Collision		Humber Estuary SPA Qualifying feature?	Screened in?	Comments
	Full	Partial	Hornsea Four Aerial Surveys	Hornsea Three Aerial Surveys	Hornsea Zone Boat Surveys	Yorkshire Bird Report	Wernham et al. (2002)	Percentage of Birds flying at Potential Collision Height (PCH)	Confidence Level attached to PCH	Spring	Autumn	Langston (2010)	Furness & Wade (2012)			
Storm Petrel	Yes	No	No	Yes	Yes	N/A	Low	N/A	N/A	N/A	N/A	Low	Low	No	No	Recorded during Hornsea Three aerial surveys and Hornsea Zone boat-based surveys. Migration mainly along west coast of GB from Africa.
Leach's Petrel	Yes	No	No	No	Yes		Low			N/A	N/A	Low	Low	No	No	Recorded during the Hornsea Zone boat-based surveys. Migration mainly along west coast of GB from Africa.
Gannet	Yes	No	Yes	Yes	Yes	N/A	Low/Mod	N/A	N/A	Mod/ High	Mod/ High	Mod	High	No	No	Reliable survey data used in EIA for this species. Does not require modelling and is considered in **Volume A2, Chapter 5: Offshore and Intertidal Ornithology.**
Cormorant	Yes	No	No	No	Yes	N/A	Low	0.03	V Low	N/A	N/A	Mod	Low/ Mod	No	No	Not considered to be at risk.
Shag	Yes	No	No	No	Yes	N/A	Low	1.45	Mod	N/A	N/A	Low	Mod	No	No	Not considered to be at risk.
Bittern	Yes	No	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	No	Occurs in nationally important numbers at North East Coast SPAs, but not considered to be at risk from collision.
Little Egret	No	No	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site.
Great Crested Grebe	Yes	No	No	No	No	Low	Low	N/A	N/A	N/A	N/A	N/A	Low	No	No	Not recorded in any Hornsea boat or aerial surveys.
Slavonian Grebe	Yes	No	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	Low	Mod	No	No	Not recorded in any Hornsea boat or aerial surveys.
Honey-buzzard	No	No	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site
White-tailed Eagle	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	High	No	No	Not selected for modelling as flight path not over site
Marsh Harrier	No	No	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	No	Not selected for modelling as flight path not over site
Hen Harrier	Yes	No	No	No	No	Low	Low/Mod	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Occurs in nationally important numbers at North East Coast SPAs, with birds potentially arriving from continental Europe over North Sea to these locations.
Montagu's Harrier	No	No	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site
Osprey	No	No	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site
Merlin	No	Yes	No	No	No	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Westerly Bias for migration from Europe.
Spotted Crake	N/A	N/A	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	No flight path
Corncrake	No	No	No	No	No	N/A	N/A	N/A	N/A	Low	Low	High	N/A	No	No	Not selected for modelling as flight path not over site

Species / Sub-Species	Flight Path Intersection of Array Area (SOSS 05)		Observations from surveys			Local Bird Reports	Literature Review	SOSS 02 Flight Heights		Species of CRM Concern (SOSS 03A)		Perceived Risk from Collision		Humber Estuary SPA Qualifying feature?	Screened in?	Comments
	Full	Partial	Hornsea Four Aerial Surveys	Hornsea Three Aerial Surveys	Hornsea Zone Boat Surveys	Yorkshire Bird Report	Wernham et al. (2002)	Percentage of Birds flying at Potential Collision Height (PCH)	Confidence Level attached to PCH	Spring	Autumn	Langston (2010)	Furness & Wade (2012)			
Coot	Yes	No	No	No	No	Mod	Low	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Migration route mainly via the English channel or Southern North Sea from Europe.
Oystercatcher	Yes	No	No	No	Yes	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A	Yes (assemblage)	No	Westerly bias for migration from Europe.
Avocet	No	No	No	No	Yes	Low		N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Non-breeding population considered at risk due to migratory route passing between Europe and the East coast of England.
Stone-curlew	No	No	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site.
Ringed Plover	Yes	Yes	No	No	Yes	Mod	Low/Mod	N/A	N/A	N/A	N/A	N/A	N/A	No	Yes	Occurs in nationally important numbers at North East Coast SPA to the north of Hornsea Four. Recorded during the Hornsea Zone boat-based surveys.
Dotterel	No	No	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site.
Golden Plover	Yes	No	No	No	Yes	Low/Mod	Low	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Occurs in nationally important numbers at North East Coast SPAs.
Grey Plover	Yes	No	No	No	Yes	Mod	Low	N/A	N/A	N/A	N/A	N/A	N/A	No	Yes	Occurs in nationally important numbers at North East Coast SPAs.
Lapwing	Yes	No	Yes	No	Yes	Mod	Low	N/A	N/A	N/A	N/A	N/A	N/A	No	Yes	Occurs in nationally important numbers at North East Coast SPAs.
Knot	Yes	No	No	No	Yes	Mod	Low	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Occurs in nationally important numbers at North East Coast SPAs.
Sanderling	Yes	No	No	No	No	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A	No	Yes	Occurs in nationally important numbers at North East Coast SPAs to the north of Hornsea Four and recorded along coast to west of Hornsea Four, so potentially at risk.
Purple Sandpiper	No	No	No	No	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site.
Dunlin (breeding and passage populations)	No	Yes	No	No	Yes	Mod	Low	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not considered at risk.
Dunlin (wintering population)	Yes	No	No	No	Yes	Mod	Mod	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Occurs in internationally important numbers at North East Coast SPAs.
Ruff	Yes	No	No	No	No	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Occurs in nationally important numbers at North East Coast SPAs, although only very low numbers of this species occur in the UK.

Species / Sub-Species	Flight Path Intersection of Array Area (SOSS 05)		Observations from surveys			Local Bird Reports	Literature Review	SOSS 02 Flight Heights		Species of CRM Concern (SOSS 03A)		Perceived Risk from Collision		Humber Estuary SPA Qualifying feature?	Screened in?	Comments
	Full	Partial	Hornsea Four Aerial Surveys	Hornsea Three Aerial Surveys	Hornsea Zone Boat Surveys	Yorkshire Bird Report	Wernham et al. (2002)	Percentage of Birds flying at Potential Collision Height (PCH)	Confidence Level attached to PCH	Spring	Autumn	Langston (2010)	Furness & Wade (2012)			
Snipe	Yes	No	No	No	Yes	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Recorded during the Hornsea Zone boat-based surveys.
Black-tailed Godwit (breeding population)	No	No	No	No	Yes	Low/Mod		N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site.
Black-tailed Godwit (Icelandic)	Yes	No	No	No	Yes	low/Mod	Low	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Occurs in nationally important numbers at North East Coast SPAs.
Bar-tailed Godwit	Yes	No	No	No	No	Low	Low/Mod	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Occurs in internationally important numbers at North East Coast SPAs.
Whimbrel	No	Yes	No	No	Yes	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A	Yes (assemblage)	Yes	
Curlew	Yes	No	Yes	No	Yes	Mod	Mod	N/A	N/A	N/A	N/A	N/A	N/A	Yes (assemblage)	Yes	Component of the seabird assemblage for the Humber Estuary SPA associated with the intertidal mudflats. Recorded during aerial and boat surveys.
Greenshank	Yes	No	No	No	Yes	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Scarce migrant that is not considered at risk
Wood Sandpiper	No	No	No	No	No	Low		N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site.
Redshank	Yes	No	No	No	No	Mod	Low	N/A	N/A	N/A	N/A	N/A	N/A	Yes	Yes	Migratory pathways cross Hornsea Four array area and considered at potential risk of collision.
Turnstone	Yes	No	No	No	Yes	Low/Mod	Low	N/A	N/A	N/A	N/A	N/A	N/A	Yes (assemblage)	No	Westly bias for Migration from Greenland and Iceland.
Red-necked Phalarope	No	Yes	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Scarce bird in the UK and migration routes largely unknown with a Westerly bias for migration routes. SPAs in Scotland, as no wintering SPAs for this species, so not suitable for modelling purposes.
Arctic Skua	Yes	No	Yes	Yes	Yes	Low	Low	0.07	Mod	Low/ Mod	Mod/ High	Mod	High	No	Yes	Not through Migropath, but considered through apportionment methods.
Great Skua	Yes	No	Yes	Yes	Yes	Low	Low	0.34	High	Low/ Mod	Mod/ High	Mod	High	No	Yes	Not through Migropath, but considered through apportionment methods.
Kittiwake	Yes	No	Yes	Yes	Yes	N/A	Low	N/A	N/A	N/A	N/A	N/A	High	No	No	Reliable survey data used in EIA for this species. Does not require modelling and is considered in **Volume A2, Chapter 5: Offshore and Intertidal Ornithology.**
Black-headed Gull	Yes	No	Yes	Yes	Yes	N/A	Mod	2.01	V High	Low	Low	N/A	High	No	No	Species appropriately assessed in **Volume A2, Chapter 5: Offshore and Intertidal Ornithology.**

Species / Sub-Species	Flight Path Intersection of Array Area (SOSS 05)		Observations from surveys			Local Bird Reports	Literature Review	SOSS 02 Flight Heights		Species of CRM Concern (SOSS 03A)		Perceived Risk from Collision		Humber Estuary SPA Qualifying feature?	Screened in?	Comments
	Full	Partial	Hornsea Four Aerial Surveys	Hornsea Three Aerial Surveys	Hornsea Zone Boat Surveys	Yorkshire Bird Report	Wernham et al. (2002)	Percentage of Birds flying at Potential Collision Height (PCH)	Confidence Level attached to PCH	Spring	Autumn	Langston (2010)	Furness & Wade (2012)			
Mediterranean Gull	Yes	No	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	Mod	N/A	No	No	Not recorded in any Hornsea boat or aerial surveys.
Common Gull	No	No	Yes	Yes	Yes	N/A	N/A	N/A	N/A	Low	Low	N/A	High	No	No	Not selected for modelling as flight path not over site.
Lesser Black-backed Gull	Yes	No	Yes	Yes	Yes	N/A	Low	N/A	N/A	Mod	Mod	Mod	High	No	No	Reliable survey data used in EIA for this species. Does not require modelling and is considered in **Volume A2, *Chapter 5: Offshore and Intertidal Ornithology.***
Herring Gull	Yes	No	Yes	Yes	Yes	N/A	Mod	N/A	N/A	Mod	Mod	Mod	High	No	No	Reliable survey data used in EIA for this species. Does not require modelling and is considered in **Volume A2, *Chapter 5: Offshore and Intertidal Ornithology.***
Great Black-backed Gull	Yes	No	Yes	Yes	Yes	N/A	Mod	N/A	N/A	Mod	Mod	Mod	High	No	No	Reliable survey data used in EIA for this species. Does not require modelling and is considered in **Volume A2, *Chapter 5: Offshore and Intertidal Ornithology.***
Little Tern	Yes	No	No	No	No	Low	Low	N/A	N/A	Low/ Mod	Low/Mod	Low	Mod	Yes	No	Occurs in nationally important numbers at North East Coast SPAs. Considered to be very low risk as migrates close to coast.
Black Tern	No	Yes	No	No	Yes	Low	N/A	N/A	N/A	Low/ Mod	Low/Mod	N/A	N/A	No	No	Scarce, non-breeding bird, in UK.
Sandwich Tern	Yes	No	Yes	Yes	Yes	Low	Mod	0.48	Mod	Low/ Mod	low/Mod	Mod	Mod/ High	No	Yes	Occurs in nationally important numbers at North East Coast SPAs. Not through Migropath, but considered through apportionment methods.
Common Tern	Yes	No	Yes	Yes	Yes	Low/Mod	Mod	0.54	low	Low/ Mod	low/Mod	Mod	Mod	No	Yes	Occurs in nationally important numbers at North East Coast SPAs. Not through Migropath but considered through apportionment methods.
Roseate Tern	No	Yes	No	No	No	Low	low	N/A	N/A	Low/ Mod	low/Mod	Mod	Mod	No	Yes	93% of GB breeding population occurs in Northumberland Marine SPA. Only partial connection to Hornsea Four. Not through Migropath but considered through apportionment methods.
Arctic Tern	Yes	No	Yes	Yes	Yes	Low	Low	0.14		Low/ Mod	Low/Mod	Mod	Mod	No	Yes	Occurs in nationally important numbers at North East Coast SPAs. Not through Migropath but considered through apportionment methods.

Species / Sub-Species	Flight Path Intersection of Array Area (SOSS 05)		Observations from surveys			Local Bird Reports	Literature Review	SOSS 02 Flight Heights		Species of CRM Concern (SOSS 03A)		Perceived Risk from Collision		Humber Estuary SPA Qualifying feature?	Screened in?	Comments
	Full	Partial	Hornsea Four Aerial Surveys	Hornsea Three Aerial Surveys	Hornsea Zone Boat Surveys	Yorkshire Bird Report	Wernham et al. (2002)	Percentage of Birds flying at Potential Collision Height (PCH)	Confidence Level attached to PCH	Spring	Autumn	Langston (2010)	Furness & Wade (2012)			
Guillemot	Yes	No	Yes	Yes	Yes	N/A	Mod	N/A	N/A	Low	Low	Low	Mod	No	No	Reliable survey data used in EIA for this species. Does not require modelling and is considered in **Volume A2, Chapter 5: Offshore and Intertidal Ornithology.**
Razorbill	Yes	No	Yes	Yes	Yes	N/A	Mod	N/A	N/A	Low	Low	Low	Mod	No	No	Reliable survey data used in EIA for this species. Does not require modelling and is considered in **Volume A2, Chapter 5: Offshore and Intertidal Ornithology.**
Puffin	Yes	No	Yes	Yes	Yes	N/A	Low	N/A	N/A	Low	Low	Low	Low	No	No	Reliable survey data used in EIA for this species. Does not require modelling and is considered in **Volume A2, Chapter 5: Offshore and Intertidal Ornithology.**
Short-eared Owl	Yes	No	No	No	Yes	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Recorded during the Hornsea Zone boat-based surveys.
Nightjar	Yes	No	No	No	No	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not considered to be at risk from collision in this area of North Sea.
Woodlark	No	No	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site.
Dartford Warbler	No	No	No	No	No	Low	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site.
Aquatic Warbler	No	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	Not selected for modelling as flight path not over site.
Great Northern Diver	N/A	N/A	No	No	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Mod/ High	No	No	No flight path.
Long-tailed Skua	N/A	N/A	No	No	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	No flight path.
Pomarine Skua	N/A	N/A	No	No	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	No flight path.
Sabine's Gull	N/A	N/A	No	No	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	No flight path.
Little Gull	N/A	N/A	No	Yes	Yes	N/A	N/A	2.14	Mod	Low	Low	N/A	N/A	No	Yes	Occurs in nationally important numbers at North East Coast SPAs. Not through Migropath, but considered through apportionment method.
Little auk	N/A	N/A	No	No	Yes	N/A	N/A	0.13	High	Low	Low	N/A	Low	No	No	No flight path.

Appendix I – Humber Estuary SPA Migrapath and CRM Results

Table I-1: Migropath modelling of number of birds from Humber Estuary SPA expected to fly through Hornsea Four Array Area

Species	Humber Esturary SPA population[28]	Migratory Season	Proportion staging in Wadden Sea[29]	Number passing through Hornsea Four Array Area per migration (95% confidence limits)
Dark-bellied brent goose	2,098	Spring	99.8%	0
		Autumn	41.6%	0
White-fronted goose	6.4	Spring/Autumn	N/A	0
Shelduck[30]	4,989	Spring	43.8%	271 (259 – 284)
		Moult	100%	0
		Autumn	18.9%	594 (568 – 631)
Wigeon	5,039	Spring/Autumn	N/A	449 (428 – 471)
Mallard	2,361	Spring/Autumn	N/A	211 (201 – 222)
Teal	1,977	Spring/Autumn	N/A	176 (167 – 184)
Pochard	712	Spring/Autumn	N/A	78 (74 – 82)
Scaup	127	Spring/Autumn	N/A	21 (20 – 22)
Goldeneye	467	Spring/Autumn	N/A	56 (53 – 59)
Oystercatcher	4,002	Spring/Autumn	N/A	481 (461 – 509)
Avocet	128 (breeding); 59 (non-breeding)	Spring/Autumn	N/A	0
Lapwing	22,765	Spring/Autumn	N/A	2,025 (1,937 – 2,122)
Golden plover	30,709	Spring/Autumn	N/A	0
Grey plover	2,018	Spring/Autumn	N/A	179 (170 – 188)
Ringed plover	1,766	Spring/Autumn	N/A	157 (149 – 165)
Whimbrel	101	Spring/Autumn	N/A	9.0 (8.6 – 9.5)
Curlew	3,565	Spring/Autumn	N/A	486 (458 – 509)
Bar-tailed godwit	2,752	Spring/Autumn	N/A	311 (296 – 327)
Black-tailed godwit	1,113	Spring/Autumn	N/A	44 (40 – 48)
Turnstone	530	Spring/Autumn	N/A	47 (45 – 49)
Knot	28,165	Spring/Autumn	N/A	2,511 (2,386 – 2,633)
Ruff	128	Spring/Autumn	N/A	12 (11 – 13)
Sanderling	916	Spring/Autumn	N/A	82 (77 – 86)
Dunlin	22,222	Spring/Autumn	N/A	640 (540 – 747)
Redshank[31]	7,462	Spring/Autumn	N/A	124 (112 – 137)
Greenshank	90	Spring/Autumn	N/A	11 (10 – 12)
Little tern	102	Spring/Autumn	N/A	11 (10 – 11)
Bittern (non-breeding)	4	Spring/Autumn	N/A	0.5 (0.4 – 0.5)
Marsh harrier	20	Spring/Autumn	N/A	0
Hen harrier[32]	8	Spring/Autumn	N/A	0.4 (0.3 – 0.4)

[28] From SPA citation or JNCC standard data form where given; otherwise average of peak WeBS count 1996/97 – 2000/01 (Contains Wetland Bird Survey (WeBS) data from Waterbirds in the UK 2019/20 © copyright and database right 2021. WeBS is a partnership jointly funded by the BTO, RSPB and JNCC, in association with WWT, with fieldwork conducted by volunteers.) Unless specified otherwise, as a precautionary assumption it is assumed that all birds are potentially international migrants.

[29] Assumed equal to proportion of flyway population recorded in Wadden Sea as reported by Laursen et al. (2010).

[30] Assumed SPA population consists of a mix of British and international breeding birds in equal proportion to the national average given in Wright et al. (2012). Assume all British-breeders fly to Wadden Sea on moult migration (this is precautionary as significant numbers moult in Humber Estuary). Autumn migration is post-moult British breeders and international breeders. Spring is just international breeders departing.

[31] SPA citation is for brittanica sub-species on pasasge. Assumed half of citation population is international migrants, with the other half being UK-breeding birds moving around the UK, following Wright et al. (2012).

[32] Assumed half of wintering population is international migrants following Wright et al. (2012).

Table I-2: CRM outputs for migratory birds from Humber Estuary SPA

Species	Avoidance Rate	Annual Collision Rate BO1 Model estimate for number of birds		
		Mean	Lower CL	Upper CL
Dark-bellied brent goose	95.0%	0	0	0
	98.0%	0	0	0
	99.0%	0	0	0
	99.5%	0	0	0
White-fronted goose	95.0%	0	0	0
	98.0%	0	0	0
	99.0%	0	0	0
	99.5%	0	0	0
Shelduck	95.0%	0.38	0.36	0.40
	98.0%	0.15	0.15	0.16
	99.0%	0.08	0.07	0.08
	99.5%	0.04	0.04	0.04
Wigeon	95.0%	0.34	0.32	0.35
	98.0%	0.13	0.13	0.14
	99.0%	0.07	0.06	0.07
	99.5%	0.03	0.03	0.04
Mallard	95.0%	0.28	0.27	0.30
	98.0%	0.11	0.11	0.12
	99.0%	0.06	0.05	0.06
	99.5%	0.03	0.03	0.03
Teal	95.0%	0.12	0.12	0.13
	98.0%	0.05	0.05	0.05
	99.0%	0.02	0.02	0.03
	99.5%	0.01	0.01	0.01
Pochard	95.0%	0.09	0.09	0.10
	98.0%	0.04	0.04	0.04
	99.0%	0.02	0.02	0.02
	99.5%	0.01	0.01	0.01
Scaup	95.0%	0.03	0.02	0.03
	98.0%	0.01	0.01	0.01
	99.0%	0.01	0.00	0.01
	99.5%	0.00	0.00	0.00
Goldeneye	95.0%	0.04	0.04	0.04
	98.0%	0.02	0.02	0.02
	99.0%	0.01	0.01	0.01
	99.5%	0.00	0.00	0.00
Oystercatcher	95.0%	0.65	0.62	0.69
	98.0%	0.26	0.25	0.28
	99.0%	0.13	0.12	0.14
	99.5%	0.07	0.06	0.07
Avocet	95.0%	0	0	0
	98.0%	0	0	0
	99.0%	0	0	0
	99.5%	0	0	0
Lapwing	95.0%	2.55	2.44	2.67
	98.0%	1.02	0.98	1.07

Species	Avoidance Rate	Annual Collision Rate BO1		
		Model estimate for number of birds		
		Mean	Lower CL	Upper CL
	99.0%	0.51	0.49	0.53
	99.5%	0.26	0.24	0.27
Golden plover	95.0%	0	0	0
	98.0%	0	0	0
	99.0%	0	0	0
	99.5%	0	0	0
Grey plover	95.0%	0.21	0.20	0.22
	98.0%	0.08	0.08	0.09
	99.0%	0.04	0.04	0.04
	99.5%	0.02	0.02	0.02
Ringed plover	95.0%	0.08	0.08	0.09
	98.0%	0.03	0.03	0.04
	99.0%	0.02	0.02	0.02
	99.5%	0.01	0.01	0.01
Whimbrel	95.0%	0.01	0.01	0.01
	98.0%	0.00	0.00	0.00
	99.0%	0.00	0.00	0.00
	99.5%	0.00	0.00	0.00
Curlew	95.0%	0.67	0.63	0.70
	98.0%	0.27	0.25	0.28
	99.0%	0.13	0.13	0.14
	99.5%	0.07	0.06	0.07
Bar-tailed godwit	95.0%	0.38	0.36	0.40
	98.0%	0.15	0.14	0.16
	99.0%	0.08	0.07	0.08
	99.5%	0.04	0.04	0.04
Black-tailed godwit	95.0%	0.05	0.05	0.06
	98.0%	0.02	0.02	0.02
	99.0%	0.01	0.01	0.01
	99.5%	0.01	0.00	0.01
Turnstone	95.0%	0.05	0.05	0.06
	98.0%	0.02	0.02	0.02
	99.0%	0.01	0.01	0.01
	99.5%	0.01	0.01	0.01
Knot	95.0%	2.76	2.63	2.90
	98.0%	1.11	1.05	1.16
	99.0%	0.55	0.53	0.58
	99.5%	0.28	0.26	0.29
Ruff	95.0%	0.01	0.01	0.01
	98.0%	0.01	0.01	0.01
	99.0%	0.00	0.00	0.00
	99.5%	0.00	0.00	0.00
Sanderling	95.0%	0.09	0.08	0.09
	98.0%	0.03	0.03	0.04
	99.0%	0.02	0.02	0.02
	99.5%	0.01	0.01	0.01
Dunlin	95.0%	0.70	0.59	0.82

Species	Avoidance Rate	Annual Collision Rate BO1		
		Model estimate for number of birds		
		Mean	Lower CL	Upper CL
	98.0%	0.28	0.24	0.33
	99.0%	0.14	0.12	0.16
	99.5%	0.07	0.06	0.08
Redshank	95.0%	0.15	0.14	0.17
	98.0%	0.06	0.05	0.07
	99.0%	0.03	0.03	0.03
	99.5%	0.02	0.01	0.02
Greenshank	95.0%	0.01	0.01	0.01
	98.0%	0.01	0.01	0.01
	99.0%	0.00	0.00	0.00
	99.5%	0.00	0.00	0.00
Little tern	95.0%	0.01	0.00	0.01
	98.0%	0.00	0.00	0.00
	99.0%	0.00	0.00	0.00
	99.5%	0.00	0.00	0.00
Bittern	95.0%	0.00	0.00	0.00
	98.0%	0.00	0.00	0.00
	99.0%	0.00	0.00	0.00
	99.5%	0.00	0.00	0.00
Marsh harrier	95.0%	0.00	0.00	0.00
	98.0%	0.00	0.00	0.00
	99.0%	0.00	0.00	0.00
	99.5%	0.00	0.00	0.00
Hen harrier	95.0%	0.00	0.00	0.00
	98.0%	0.00	0.00	0.00
	99.0%	0.00	0.00	0.00
	99.5%	0.00	0.00	0.00