FIVE ESTUARIES OFFSHORE WIND FARM

ENVIRONMENTAL STATEMENT

VOLUME 6, PART 5, ANNEX 4.14: MIGRATORY BIRD COLLISION RISK MODELLING

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Project	Five Estuaries Offshore Wind Farm
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DEFINITION OF ACRONYMS

Term	Definition
AOE	Alde-Ore Estuary
CGR	Counterfactual of Population Growth
CPS	Counterfactual of Population Size
EIA	Environmental Impact Assessment
FFC	Flamborough and Filey Coast
HRA	Habitats Regulations Assessment
OWF	Offshore Wind Farm
PVA	Population Viability Analysis
RIAA	Report to Inform Appropriate Assessment
SPA	Special Protection Area
VE	Five Estuaries Offshore Wind Farm
WTG	Wind Turbine Generators

GLOSSARY OF TERMS

Term	Definition
The Project	Refers to the Five Estuaries Offshore Wind Project
Array area	The area offshore within the order limits within which the generating stations will be situated (including wind turbine generators (WTG), offshore platforms and Inter-array cables).
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Wind turbine generator (WTG)	All the components of a wind turbine, including the tower, nacelle, and rotor.

1 INTRODUCTION

1.1 VE BACKGROUND

1.1.0 Five Estuaries Offshore Wind Farm (VE) is a proposed extension to the operational Galloper Offshore Wind Farm. VE covers an area of 128km^2, split between north and south array areas which extend eastwards from the operational Galloper offshore wind farm. At the closest point the array areas are located approximately 37km off the Suffolk coast.

1.1.1 GoBe Consultants Ltd (hereafter "GoBe") was commissioned by the Applicant to undertake a modelling exercise to assess the potential for collision risk to migratory bird species from VE alone through the use of collision risk modelling (CRM). This annex presents the approach to CRM and results of the analysis and was produced to support the Report to Inform Appropriate Assessment (RIAA) (Volume 5, Report 4).

1.2 POTENTIAL COLLISION RISK TO MIGRATORY BIRDS

1.2.1 Assessing the potential impact from collision risk with wind turbines is an essential part of the EIA assessment process. The level of risk from collisions with turbines is estimated using Collision Risk Modelling (CRM). The species that are unlikely to be impacted are screened out and excluded from modelling.

1.2.2 Site specific digital aerial surveys (DAS) were conducted in the VE array area plus a 2km buffer. The results of these surveys provide information on the estimated abundance and density of birds in the area for each bio-season. This however has limitations as the survey methods are not guaranteed to provide reliable estimates of birds in the area during migration periods, particularly seabirds. This can be due to species moving through the area in poor weather, in short time periods or at night, making the recording of numbers complex using the standard methods.

1.2.3 To model the movement of migratory birds, the VE have used the software model 'Migropath', developed by APEM, to provide estimates of such movements. Migropath is the most advanced tool, currently supported by Natural England, to assess the risk of collisions to migratory species (Parker *et al.,* 2022c). This builds on the work carried out by the British Trust for Ornithology (BTO) for the SOSS-05 VE (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.

1.2.4 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. The risk to the population caused by the presence of the VE development relates to the proportion of the 'broad front' pathway crossing the VE array area. Further details are provided in Section 4.

2 SPECIES SELECTION/SCREENING PROCESS

2.1 SCREENING METHODOLOGY

2.1.1 Migratory tern, gull and waterbird species that are features of SPAs within 100 km of the VE array area have been screened in for the assessment of potential impact from collision during migration for the O&M phase. Based on a combination of data sources (field surveys, literature reviews and migropath modelling) bird species are unlikely to intersect with the array area beyond this range.

2.1.2 The standard threshold for migratory birds used is that the species is to be screened in if at least 1% of the UK population is expected to pass through the VE footprint each year. Species can also be screened in if there is evidence of increased risk of collision at the site, for example from site-specific data. This assessment is to identify the potential interaction of migratory species passing the VE array and not species that are in the area for long periods of time. A separate annex (Volume 6, Part 5, Annex 4.8: Collision Risk Modelling Inputs and Outputs) lays out the approach to assessing collision impacts on seabird bird species that regularly use the site.

2.1.3 The screening process is summarized in the flowchart below (Figure 2.1).

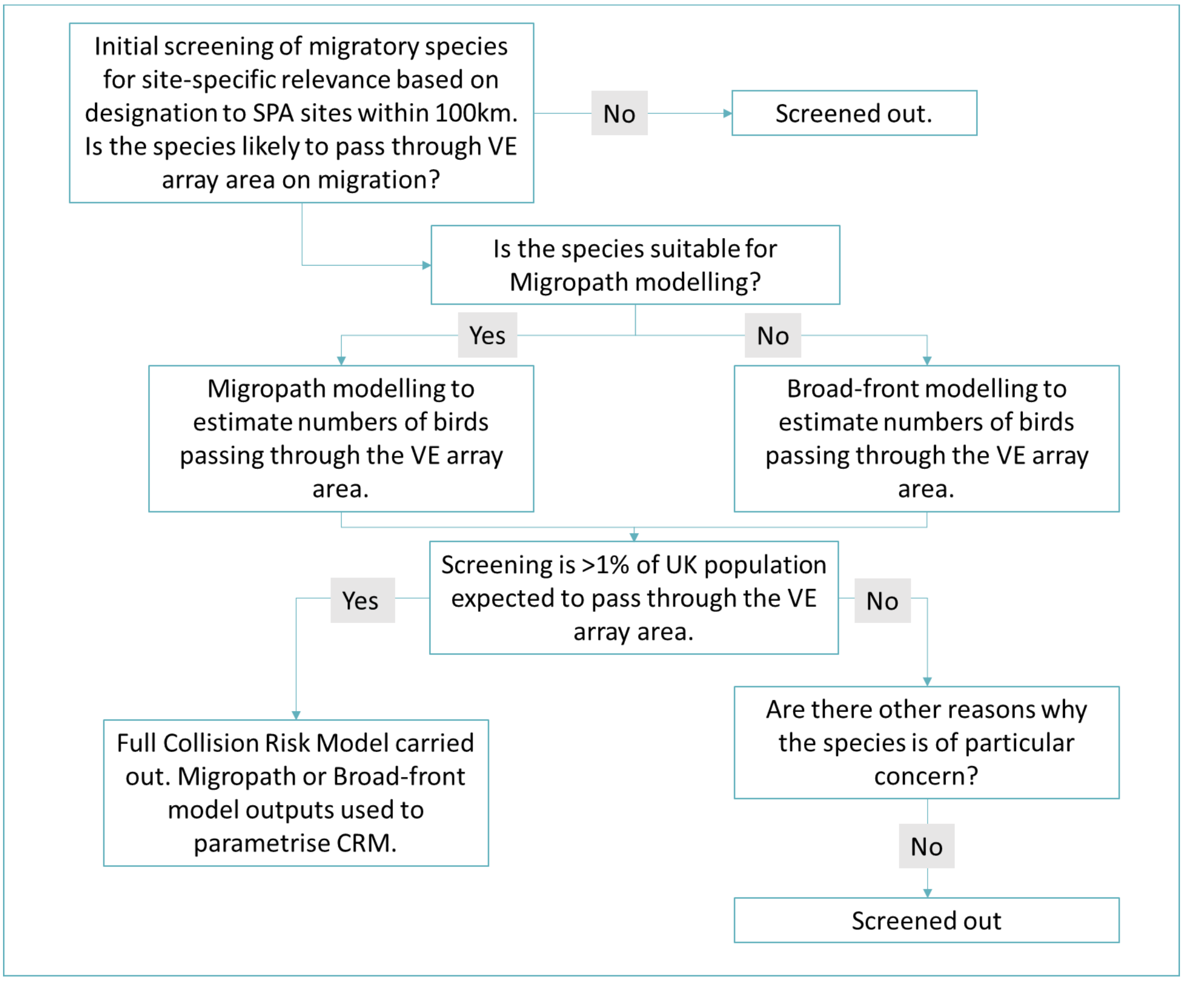

Figure 2.1 Flowchart illustrating the approach to screening for migratory collision risk modelling

2.2 SCREENING RESULTS

2.2.1 The initial screening was carried out to consider the migratory species designated to sites within 100km of the VE arrays. These are presented in Table 2.1.

2.2.2 The migratory species that are suitable for mCRM analysis were included in the assessment and the results are found in Section 5. The species that have <1% proportion of UK population at risk of collision within the VE array area were screened out at this stage (Table 2.2).

Table 2.1. SPAs designated for migratory birds relevant to VE (within 100km).

Designated site	Distance to Array (km)	Features screened in for collision risk
Alde-Ore Estuary	37.4	Avocet, Marsh harrier, Redshank, Ruff
Deben Estuary	48.5	Avocet, Dark-bellied brent goose
Minsmere-Walberswick	41.9	Avocet, Bittern, Gadwall, Greater white-fronted goose, Hen harrier, Marsh harrier, Nightjar, Shoveler, Teal, Little tern
Outer Thames Estuary	17.2	Red-throated diver, Little tern
Hamford Water	51.0	Little tern
Thanet Coast and Sandwich Bay	57.6	Little tern

Table 2.2. Species Screened in for assessment and modelling approach.

Migropath modelling		
Avocet (*Recurvirostra avosetta*)	Bittern (*Botaurus stellaris*)	Dark-bellied brent goose (*Branta bernicla*)
Gadwall (*Anas strepera*)	Greater white-fronted goose (*Anser albifrons*)	Hen harrier (*Circus cyaneus*)
Marsh harrier (*Circus aeruginosus*)	Nightjar (*Caprimulgus europaeus*)	Redshank (*Tringa tetanus*)
Red-throated diver (*Gavia stellata*)	Ruff (*Philomachus pugnax*)	Shoveler (*Anas clypeata*)
Teal (*Anas crecca*)		
'Broad front' modelling		
Common Tern (*Sterna hirundo*)	Little Tern (*Sterna albifrons*)	

3 MIGROPATH MODELLING METHODOLOGY (MIGRATORY NON-SEABIRDS)

3.1 MIGROPATH MODELLING APPROACH

3.1.1 The non-breeding waterbird populations of UK SPAs (UK National Site Network) are regularly surveyed annually by the Wetland Bird Survey (Frost *et al*. 2020). Occasional surveys of non-breeding SPA features 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).

3.1.2 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.

3.1.3 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.

3.2 MIGROPATH MODELLING ASSUMPTIONS

3.2.1 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.

3.2.2 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. Birds migrating between breeding/wintering grounds outside the UK and UK SPAs that do not pass through the VE array area are not considered to be at collision risk from the project, based on the assumption of straight-line migration. Consequently, no-risk movements (migrations with no risk from the project) can be factored in to estimated proportions of birds arriving on/ departing from SPAs but not encountering the VE array area.

3.2.3 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.

3.2.4 Migropath does not consider 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 VE array area in the absence of any turbines. This ensures avoidance is not double counted, as the CRM model includes an avoidance factor.

3.2.5 Migropath does not consider flight height, and as a precautionary assumption where the migratory route intersects the VE 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 The centroid of each SPA was calculated using the geometry function within ESRI® ArcMapTM 9.2 or QGIS 3.10. The coastlines of continental Europe and Iceland were 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 or Icelandic coast was joined to the centre of each SPA, with each line classified as either passing within or out from the VE array area. Flight pathways connecting the UK to Iceland are referred to as the North route, while flight pathways to continental Europe are referred to as the South route (notwithstanding that continental Europe includes Scandinavia and therefore some flight pathways on the South route have a northerly bearing).

3.3.2 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 2021).

3.3.3 Shapefiles produced as part of the SOSS_05 project (Wright *et al*. 2012) were used to determine which parts of the European or Icelandic 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.

3.3.4 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 of European or Icelandic 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 known staging sites, an extra step was carried out to ensure that the proportion of birds departing from the staging area equaled the proportion of the population known to use the staging area. For birds staging in the Wadden sea, this proportion was extracted from Laursen *et al*. (2010).

3.3.5 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.

3.3.6 To capture instances of distinct races, sub-species, or breeding and wintering populations, migropath modelling was run separately where there is evidence that migratory patterns differ. This was done for the following species: Gadwall (breeding and wintering), Redshank (*britannica*, *robustica* and *totanus*) and Teal (breeding and wintering).

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

3.3.8 Where the proportion of birds passing through the VE 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 and UK populations were obtained from Woodward *et al*. (2023).

4 'BROAD FRONT' MODELLING (MIGRATORY SEABIRDS)

4.1 METHODOLOGY

4.1.1 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. 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 VE 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.

4.1.2 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 183 km. The width of the array area within that corridor is calculated to be 17.7 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 The total number of bird species determined to be required to be screened in for Migropath modelling was 30 (see Table 3). Other than hen harrier and marsh harrier, these were all waterfowl and waders. The majority were included due to the importance of populations which migrate to the UK for the non-breeding seasons; however, for species which breed in the UK, the breeding population was also included in the model.

5.1.2 The mean proportion of the UK population expected to pass through the VE array area and the number of birds this equates to is presented in Table 5.1. As a precautionary assumption, where more than one separate population may be present, the total number of birds passing through the VE array area is assessed against the smallest population.

5.1.3 Where the UK population is uncertain, and a range is available, the lowest number of birds was used for the CRM results presented in Table 5.1 to provide a worst-case scenario.

5.1.4 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 5.1. Results from Migropath modelling to estimate the number of birds, of each species, passing through the VE 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 VE array area each migration (mean; see Appendix x for details)**	**Percentage (%) of migratory population passing through the VE array area each migration (mean; see Appendix x for details)**	**Percentage (%) of UK population passing through the VE array area annually (mean**
Avocet (Wintering)	8,700	Spring/Autumn	1,340	1.34	15.40
Bittern (Wintering)	795	Spring/Autumn	28	0.39	3.51
Dark-bellied brent goose (Wintering)	98,500	Spring/Autumn	14,839	7.03	15.06
Gadwall (Breeding)	6,400	Spring/Autumn	266	0.19	4.15
Gadwall (Wintering)	31,000	Spring/Autumn	1,290	0.92	4.16
Greater white-fronted goose (Wintering)	2,100	Spring/Autumn	172	0.02	8.20
Hen harrier (Wintering)	1,090	Spring/Autumn	40	0.13	3.68
Marsh harrier (Wintering)	1,390	Spring/Autumn	-	-	-
Nightjar (Wintering)	4,600	Spring/Autumn	209	0.03	4.54
Redshank robustica (Wintering)	100,000	Spring/Autumn	4,491	1.95	4.49
Redshank totanus (Wintering)	100,000	Spring/Autumn	4,492	2.81	4.49

Species/ Population	UK Population	Migration Season	Number of birds passing through VE array area each migration (mean; see Appendix x for details)	Percentage (%) of migratory population passing through the VE array area each migration (mean; see Appendix x for details)	Percentage (%) of UK population passing through the VE array area annually (mean
Red-throated diver (Wintering)	21,500	Spring/Autumn	385	0.18	1.79
Ruff (Wintering)	920	Spring/Autumn	28	0.00	3.05
Shoveler (Wintering)	19,500	Spring/Autumn	769	1.10	3.94
Teal (Breeding)	9,500	Spring/Autumn	286	0.04	3.01

6 RESULTS OF ‘BROAD FRONT’ MODELLING (MIGRATORY SEABIRDS)

6.1 SPECIES SCREENED IN

6.1.1 The total number of bird species determined to be required to be screened in for ‘broad front’ modelling was two seabirds (see Table 6.1). These were: common tern and little tern. 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.

COMMON TERN

6.1.2 The common tern has a widespread 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 (del Hoyo *et al*. 1992-2013). The birds that breed in western Europe, including Britain and Ireland, winter principally along the West African coast (BirdGuides 2011). Common terns breeding in eastern Europe winter along the east and southern African coast, taking an easterly route through northeast Africa and then along the coast or overland through the Rift Valley to their wintering grounds (del Hoyo *et al*. 1992-2013).

6.1.3 The English Channel is an important migratory route for breeding terns with between 30-70% using the 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. There is the possibility that a large number of these coastal birds within Britain may be overland (Ward 2000; Wernham *et al*. 2002). During the autumn (September and October), there is a strong southward movement of common terns along the coasts of southwest Europe (Wernham *et al*. 2002). Common terns arrive back on their breeding grounds in Britain and Ireland by April. The frequency of inland sightings suggests that much of the spring passage takes place directly overland to the breeding sites. Bird observatories in the west coast record low numbers in the spring, suggesting that the west coast and Scottish colonies migrate overland rather than along the west coast and Irish Sea. Dungeness and Portland Bill observatories on the south coast record substantial numbers in spring with peak passage of easterly moving birds occurring in late April to early May. 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.

6.1.4 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.

LITTLE TERN

6.1.5 The little tern is a widespread species with a breeding range across the Paleartic, Afrotropic and Australasian regions. The nominate *Sternula albifrons* breeds in Britain and Ireland and across most of Europe, Central Asia, Northern India and North Africa (Wernham *et al*, 2002). The breeding population in Britain and Ireland is strictly coastal. The European population is estimated to be 17,000-22,000 pairs, with a worldwide population of 70,000-100,000 pairs (Wernham *et al*, 2002; Mitchel *et al* , 2004). The northern populations are highly migratory with the majority of the western European breeding population wintering off west Africa (Furness, 2015; Wernham *et al*, 2002).

6.1.6 Ringing recoveries in southern Europe have shown the post breeding migration to be quick (Wernham *et al*, 2002) and ringing recoveries from Scotland have been recovered in Denmark and English ringed birds have been recovered in the Netherlands, suggesting an easterly migration rather than southerly to start with (Furness, 2015; Wernham *et al*, 2002). The first little terns arrive in Britain and Ireland in April, with the majority back on their breeding grounds by May (Furness, 2015).

6.1.7 There are large numbers breeding Fennoscandia, Baltic states, Germany and the Netherlands (Mitchell *et al*, 2004) however there is no evidence that these populations cross the North Sea into British and Irish waters. Ringing recoveries suggest these populations migrate through continental Europe (Furness, 2015; Wernham *et al*, 2002). A study carried out by WWT and MacArthur Green (2014) found that the majority of little tern migration tracks are between 0 to 10 km from the coastlines.

6.2 SUMMARY OF 'BROAD FRONT' MODELLING ASSUMPTIONS

6.2.1 The VE array area is located approximately 37 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 determined that none of the UK population of migratory seabirds are at risk of collision from VE due to the evidence that their migratory flights are considerably closer to the coast. 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.

6.2.2 An estimate of the number of individuals predicted to be migrating through the VE array area for all seabird species based on an even distribution within the 'broad front' corridor are presented in Table 6.1. The BDMPS for little tern is defined by Furness (2015) as 3,524 for both spring and autumn migration seasons in UK North Sea and Channel (mid-April to May and late July to early September).

Table 6.1. Estimated number of non-UK migratory seabirds predicted to pass through the VE array area in migration periods.

Species	Pre-breeding migration	Post-breeding migration
Common Tern	14,016	14,016
Little Tern	341	341

7 COLLISION RISK MODELLING (CRM) FOR MIGRATORY BIRDS

7.1 COLLISION RISK MODELLING METHODOLOGY

7.1.1 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.

7.1.2 CRM was carried out using the Band (2012) model. The Band (2012) model is still the most recent tool, supported by Natural England (Parker *et al.*, 2022c), 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 The CRM input parameters for each species run through the Band (2012) model are presented in Table 7.1. Species biometrics for all species were obtained from the Marine Scotland Science Stochastic Collision Risk Model Shiny Application ("mCRM App"; Donovan, 2017). The mCRM tool collates biometric information from multiple sources including Robinson (2005).

7.2.2 The Large Array Correction factor was applied, using the longest line through the array area as the width (17.7 km). The "width of migration corridor" value used within the Band model for calculating migrant flux density was also calculated as the width of the VE array area (17.7 km).

Table 7.1. Species biometrics used in the migratory collision risk modelling of the proposed VE array area for all species selected.

Species	Body Length (m)	Wingspan (m)	Flight Speed (ms^{-1})	Nocturnal Activity	Flight Type
Avocet	0.44	0.78	13.0	5	Flapping
Bittern	0.75	1.30	8.8	5[1]	Flapping
Dark-bellied brent goose	0.58	1.15	17.9	5	Flapping
Gadwall	0.51	0.90	19.6	5[2]	Flapping
Greater white-fronted goose	0.72	1.48	19.0	5[3]	Flapping
Hen harrier	0.48	1.10	11.4	2	Flapping
Nightjar	0.27	0.60	9.72	5[4]	Flapping
Redshank	0.28	0.62	15.3	5	Flapping

Species	Body Length (m)	Wingspan (m)	Flight Speed (ms^{-1})	Nocturnal Activity	Flight Type
Red-throated diver	0.61	1.11	18.6	1	Flapping
Ruff	0.25	0.53	16.9	5	Flapping
Shoveler	0.48	0.77	18.3	5[2]	Flapping
Teal	0.36	0.61	17.4	5	Flapping
Common Tern	0.33	0.88	10.1	1	Flapping
Little Tern	0.24	0.56	10.3	1	Flapping

1 Based off: Frommolt, K. H., & Tauchert, K. H. (2014). Applying bioacoustic methods for long-term monitoring of a nocturnal wetland bird. Ecological Informatics, 21, 4-12
2 *Anas platyrhynchos* value used.
3 *Anser brachyrhynchus* value used.
4 Based off: Reino, L., Porto, M., Santana, J., & Osiejuk, T. S. (2015). Influence of moonlight on nightjars' vocal activity: a guideline for nightjar surveys in Europe. Biologia, 70(7), 968-973.

AVOIDANCE RATES

7.2.3 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.

7.2.4 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.

PROPORTION AT POTENTIAL COLLISION HEIGHT

7.2.5 Band Option 1 (BO1) and/ or Band Option 2 (BO2) have been used to carry out all 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 7.2). For all species, the generic species group values put forward by the mCRM Tool, utilising BTO 2021 data, 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 little tern and common 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). As no PCH value was available for little tern an average was taken from all other tern species listed.

Table 7.2. Proportion at Potential Collision Height (PCH[1]) for all migratory species used for BO1 CRM.

Species	Proportion at PCH (%)
Avocet	100
Bittern	100
Dark-bellied brent goose	50
Gadwall	100
Greater white-fronted goose	100
Hen harrier	100
Nightjar	100
Redshank	100
Red-throated diver	25
Ruff	100
Shoveler	100
Teal	100
Common Tern	12.7
Little Tern	6.5[2]

[1] For non-seabird species PCH utilises a simple proportion of birds within the rotor reach that is applied uniformly over the rotor. They don't consider turbine height or size because robust flight height distributions for migratory species are not available. These are industry accepted values that are highly precautionary to account for the associated uncertainties.

[2] Average taken across four tern species proportion at PCH values.

TURBINE PARAMETERS

7.2.6 The input parameters for the wind turbine specifications used within in the CRM are presented in Table 7.3 and Table 7.4. These values are based on the MDS WTGs, as described in Volume 6, Part 2, Chapter 1: Offshore Project Description. A 'Large Array Correction' factor was applied to the mCRM.

Table 7.3. Windfarm and turbine parameters used for mCRM.

Parameter	Value
No. WTGs	79
Wind farm width (km)	17.7
Latitude (deg)	51.88
Proportion of upwind flight	50
Rotor radius (m)	129.6
Hub height (m)	157.6
No. blades	3
Blade width	9.4
Rotation speed (RPM)	7.3
Rotation speed SD	0
Blade pitch	15
Blade pitch SD	0

Table 7.4. Wind availability, time operational and downtime windfarm parameters.

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind availability (%)	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0
Time operational (%)	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0
Mean downtime (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean downtime SD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

7.3 CRM RESULTS

7.3.1 Species for which less than 1% of the UK population are expected to pass through the VE array area were screened out, and the Band (2012) CRM was run for remaining species. The only species screened out was marsh harrier (wintering). 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 7.5. Results are presented using both Band Option 1 (BO1) and Band Option 2 (BO2), where possible.

Table 7.5. Summary of annual collision risk for species screened-in.

Species	Avoidance Rate (%)	Annual Collision Rate BO1	Annual Collision Rate BO2
Avocet	98.0	2.89	NA
Bittern	98.0	0.09	NA
Dark-bellied brent goose	98.0	14.78	NA
Gadwall (Breeding)	98.0	0.45	NA
Gadwall (Wintering)	98.0	2.18	NA
Greater white-fronted goose	98.0	0.36	NA
Hen harrier	98.0	0.10	NA
Nightjar	98.0	0.49	NA
Redshank *robustica* (Wintering)	98.0	8.35	NA
Redshank *totanus* (Wintering)	98.0	8.35	NA
Red-throated diver	98.0	0.19	NA
Ruff	98.0	0.05	NA

Species	Avoidance Rate (%)	Annual Collision Rate BO1	Annual Collision Rate BO2
Shoveler	98.0	2.18	NA
Teal (Breeding)	98.0	0.52	NA
Common Tern	98.0	4.28	0.69
Little Tern	98.0	0.05	0.02

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