Environmental Impact
Assessment Report

NISA
North Irish Sea Array

Volume 9: Appendices (Offshore)

Appendix 15.4
Offshore and Intertidal Ornithology Migratory Collision Risk Modelling

Statkraft
CIP Copenhagen Infrastructure Partners
GoBe APEM Group
ARUP

North Irish Sea Array Windfarm Ltd

Offshore Ornithology Migratory Collision Risk Modelling

North Irish Sea Array Offshore Wind Farm

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Acronyms

Term	Definition
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
GIS	Geographical Information System
JNCC	Joint Nature Conservation Committee
km	Kilometres
mCRM	Migratory collision risk model
MW	Megawatt
NPWS	National Parks and Wildlife Service
O&M	Operations and maintenance
RWE	RWE Renewables Ireland Ltd (a wholly owned subsidiary of RWE AG)
SPA	Special Protection Area
UK	United Kingdom
WTG	Wind turbine generator

1. Introduction

1.1 Project Background

1.1.1 This document has been prepared by Arup and GoBe Consultants Limited (GoBe) on behalf of North Irish Sea Array Limited (NISA Ltd) to accompany Volume 3, Chapter 15: Offshore and Intertidal Ornithology (hereafter referred to as the 'Offshore and Intertidal Ornithology Chapter').

1.1.2 The North Irish Sea Array Offshore Wind Farm (OWF) (hereafter the 'proposed development') is proposed for construction 11.3 km off the east coast of Ireland (at their nearest points to the mainland). The proposed development will consist of offshore wind turbines generators (WTG), an offshore substation platform (OSP), inter-array cables, export cables taking power to an onshore converter station. The area considered in the context of offshore ornithological receptors includes the entire array area, covering 89 km^2, an asymmetric 4 km buffer surrounding the array area, and the offshore Export Cable Corridor (ECC) covering a further 67.9 km^2.

1.1.3 During the breeding season, the Irish Sea region provides foraging, loafing and preening habitat for a range of seabirds, including (but not limited to) northern gannet, *Morus bassanus*, various gull species, and several species of auks and terns. An overview of key species that are present within and in close proximity to the proposed development is presented in Volume 9, Appendix 15.1: Offshore Ornithology Technical Baseline (hereafter referred to as the 'Technical Baseline').

1.2 Migratory Collision Risk Modelling

1.2.1 This technical appendix has been produced to support the EIAR Offshore Ornithology chapter (Volume 3, Chapter 15: Offshore Ornithology) and considers the potential impact to migratory birds that are not typically recorded in site specific monthly surveys due to their movements over a short period of time and often at night or during bad weather (Woodward *et al*., 2023; Wright *et al.,* 2012).

1.2.2 The Irish Sea is subject to pronounced passages of birds travelling to and from the UK, Europe and further afield (Stienen *et al*., 2007). This includes the migratory movements of non-seabirds such as waders, wildfowl, passerines and non-passerines. Due to the mix of birds present, the NISA array area is used at different times of the year by birds (i) overwintering in the area; (ii) foraging from nearby breeding coastal colonies; and (iii) on Autumn migration (post-breeding dispersal), and Spring migration (return).

1.2.3 Assessing the potential impact from collision risk with WTGs 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 the modelling.

1.2.4 Site specific digital aerial surveys (DAS) were conducted for the Maritime Area Consent (MAC) +4km buffer. The results provide information for key seabird species abundance throughout the year but are limited when it comes to migratory species, particularly non-seabirds. This is due to the snapshot nature of baseline surveys which has the potential to miss some species 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.

1.2.5 To model the movements of migratory birds for the proposed development the Marine Scotland Avian Migration Collision Risk Model Shiny Application ("mCRM App"; HiDef Aerial Surveying Ltd., 2024[1]) was used.

1.2.6 The mCRM App is not suitable for the modelling of all species, particularly species that do not follow a point-to-point migration pattern (Alerstam, 1990). Some species take longer routes to follow the coastline in preference to a direct route over land. The analysis of these species can be carried out using the 'broad front' pathway method, which better describes the species' movement within western waters. The risk to the population caused by the presence of the Project, relates to the proportion of the 'broad front' pathway crossing the Project array area. Further details are provided in Section 3.

1.2.7 There is potential risk to migratory birds flying through NISA to collide with the wind turbines and associated infrastructure. Collision risk is higher if turbines are located in areas where bird densities are high and where there is a high level of flight activity. Areas with a high density of flying birds may be associated with locations of concentrated food availability, or where there is a high turnover of individuals (possibly commuting daily between nesting and feeding areas or passing through the area on seasonal migrations). The potential collision risk to each species can be estimated throughout the year by using collision risk modelling (CRM).

1.2.8 Broad front modelling for migratory seabirds was not used in this assessment as the main migratory seabird species were covered in the main CRM analysis and/or the relevant species were recorded in low numbers in the array area during the DAS surveys (Appendix 15.2: Offshore and Intertidal Ornithology Collision Risk Modelling Assessment).

[1] Available at: https://hidefdevo.shinyapps.io/mCRM/ [Accessed March 2024].

2. Species selection and screening process

2.1 Screening methodology

2.1.1 Migratory tern, gull and waterbird species have been screened in for the assessment of operational phase to assess the potential impact from collision during migration for the regional populations and from specific Special Protection Areas (SPAs), which were determined in using a quantitative screening methodology outlined in 'Supporting Information: Screening for Appropriate Assessment (SISAA)'.

2.1.2 In order to screen-in relevant SPAs to the project array, a quantifiable approach was used that captured the percentage of bird migration pathways that could intersect with the project array boundary. All geometry and data manipulation functions utilised within this method were carried out within the software QGIS 3.34.

2.1.3 United Kingdom (UK) and Republic of Ireland (ROI) SPA boundary data was obtained from relevant sources (JNCC and NPWS). A centroid value was then calculated for each SPA, by using the geometry tool "Centroids". This algorithm creates a new point layer that represents the centroid of the geometrics of an input layer. The coastlines of Continental Europe and Iceland were split into 1km points, with each point being labelled with a unique ID, to capture representative southern and northern bird migratory endpoints.

2.1.4 Using the "MMQGIS Hub Lines tool", each point along these coastlines were joined to the centre of each SPA. For each SPA this created a unique vector layer of lines from the SPA to each individual endpoint that represented all possible migratory pathways. Using the geoprocessing tool "Intersection" the number of lines, from each SPA to the north and south endpoints, that directly passed through the project array area could be counted. The "Intersection" algorithm extracts the overlapping proportions of features in an input layer (SPA lines shapefile) that overlap with an overlay layer (project array boundary). This process was done for each individual SPA.

2.1.5 Each individual SPA intersection was then combined into a single output by utilising the processing toolbox function "Merge vector layers". The "Statistics by categories" function was then used to create an exportable attributes table containing a list of all SPAs that intersected with the array area, and the number of lines to do so. SPAs that had no lines intersecting with the project array area were screened out at this point.

2.1.6 Utilising the number of northern (7311) and southern (7110) migratory endpoints, a percentage of lines intersecting, for each relevant SPA, with the project array area could then be calculated from the exported attributes table. In order for relevant SPAs to be included within following assessments, only those with migratory features with at least 10% of lines intersecting with the project array were carried forward. SPAs with a lower percentage of intersections passing through the project array area were screened out because bird migrations from these SPAs are likely to result in negligible numbers passing through the site, and any associated collisions would be minimal.

2.1.7 The standard threshold used for screening in migratory bird species was if at least 1% of the Irish population is expected to pass through the footprint of the array area each year. Species can also be screened in if there is evidence of increased risk of collision at the site/in the area. This assessment is to identify the potential interaction of migratory species passing through NISA and not species that are in the area for long periods of time. This has been assessed in Section 17. The screening in process is summarised in the flowchart below (Figure 2-1)

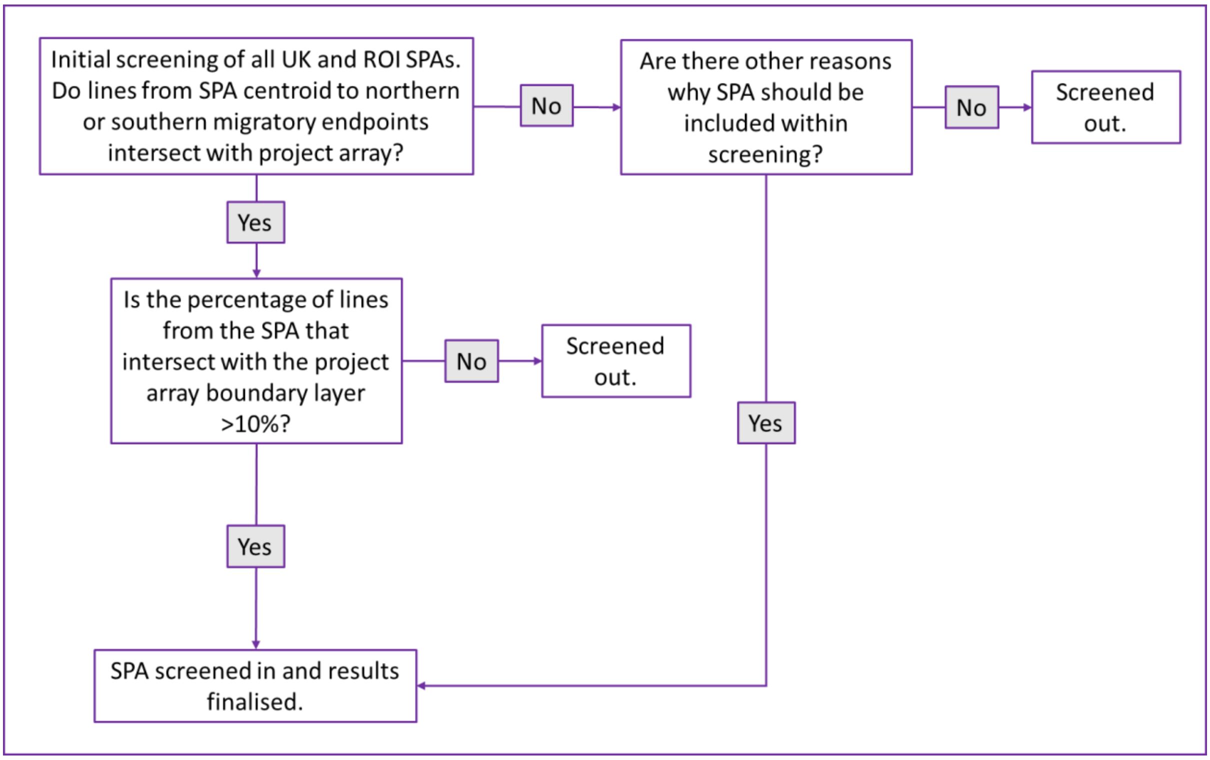

Figure 2-1 Flowchart illustrating the approach to screening for mCRM.

2.1.8 The initial screening was carried out to consider the migratory species designated to sites with >10% of migratory flight lines intersecting with the proposed array area. These are presented in Table 2.1.

2.1.9 The migratory species that are suitable for mCRM analysis were included in the assessment and the results are displayed in

2.1.11 Table 2.2. The species that have <1% proportion of the All-Ireland population at risk of collision within proposed development array area were screened out at this stage.

Table 2.1: SPAs designated for migratory birds relevant to the Project (>10% intersecting migratory flight lines).

Designated site	Distance to Array (km)	Features screened in for collision risk
Rockabill SPA	0.2	Purple sandpiper (*Calidris maritima*)
Skerries Islands SPA	9.3	Light-bellied brent goose (*Branta bernicla horta*), purple sandpiper, turnstone (*Arenaria interpres*)
Rogerstown Estuary SPA	15.6	Light-bellied brent goose, greylag goose (*Anser anser*), shelduck (*Tadorna tadorna*), shoveler (*Spatula clypeata*), oystercatcher (*Haematopus ostralegus*), ringed plover (*Charadrius hiaticula*), grey plover (*Pluvialis squatarola)*, knot (*Calidris canutus*), dunlin (*Calidris alpina*), black-tailed godwit (*Limosa limosa*), redshank (*Tringa totanus*)
Boyne Estuary SPA	16.2	Shelduck, oystercatcher, golden plover (*Pluvialis apricaria)*, grey plover, lapwing (*Vanellus vanellus*), knot, sanderling (*Calidris alba*), black-tailed godwit, redshank, turnstone
River Nanny Estuary and Shore SPA	16.9	Oystercatcher, ringed plover, golden plover, knot, sanderling
Malahide Estuary SPA	21.7	Great crested grebe (*Podiceps cristatus*), light-bellied brent goose, shelduck, pintail (*Anas acuta*), goldeneye (*Bucephala clangula*) , red-breasted merganser (*Mergus serrator*), oystercatcher, golden plover, grey plover, knot, dunlin, black-tailed godwit, bar-tailed godwit (*Limosa lapponica*), redshank
Baldoyle Bay SPA	26.4	Light-bellied brent goose, shelduck, ringed plover, golden plover, grey plover, bar-tailed godwit
Poulaphouca Reservoir SPA	61.5	Greylag goose
Blackwater Callows SPA	202.5	Bewick's swan (*Cygnus columbianus*), wigeon (*Anas Penelope*), teal (*Anas crecca*), mallard (*Anas platyrhynchos)*, shoveler, black-tailed godwit, lapwing, curlew (*Numenius Arquata*)
Cork Harbour SPA	243.6	Shelduck, wigeon, teal, mallard, pintail, shoveler, red-breasted merganser, great crested grebe, oystercatcher, black-tailed godwit, bar-tailed godwit, redshank, golden plover, grey plover, lapwing, dunlin, curlew
Courtmacsherry Bay SPA	286.5	Shelduck, wigeon, red-breasted merganser, black-tailed godwit, bar-tailed godwit, golden plover, lapwing, dunlin, curlew
Clonakilty Bay SPA	298.7	Shelduck, black-tailed godwit, curlew, dunlin

Table 2.2: Species screened in for assessment and modelling approach

mCRM tool		
Light-bellied brent goose	Greylag goose	Bewick's swan
Shelduck	Shoveler	Wigeon
Mallard	Pintail	Teal
Goldeneye	Red-breasted merganser	Great crested grebe
Oystercatcher	Lapwing	Golden plover
Grey plover	Ringed plover	Curlew
Bar-tailed godwit	Black-tailed godwit	Turnstone
Knot	Sanderling	Dunlin
Purple sandpiper	Redshank	

2.1.12 Species that are not prone to collision or have been recorded in negligible numbers within the array area have been screened out. Rationale behind these decisions can be found in the screening report (Supporting Information: Screening for Appropriate Assessment (SISAA)).

3. mCRM

3.1 mCRM methodology

3.1.1 There is potential for migratory birds to be subjected to collision risk mortalities whilst on seasonal migrations through the Project array area. The potential collision risk can be estimated using collision risk modelling (CRM).

3.1.2 The mCRM was undertaken using the Marine Scotland Avian Migration Collision Risk Model Shiny Application ("mCRM App"; HiDef Aerial Surveying Ltd., 2024). The mCRM shiny application is a stochastic adaptation of the Band (2012) migration collision risk worksheet. The mCRM was accessed via the 'Shiny App' interface, which is a user-friendly graphical interface accessible via a standard web-browser or within R statistical software (R Core Team, 2021) that uses an R code to estimate migratory collision risk (Donovan 2018). For this assessment the latest version of the model was downloaded and run locally within R (v0.4.1). The advantage of the mCRM over the Band (2012) model is that it provides a clear and transparent audit trail for all modelling runs, which enables regulators to easily access and reproduce the results of any modelling scenario.

3.1.3 The mCRM tool provides two functions:

- Creates population estimates in wind farms by sampling migratory pathways via straight lines drawn between Ireland and non-UK countries; and
- Runs a stochastic version of the migratory collision risk model based on the population estimates and use-input parameters.

3.2 mCRM inputs

Turbine parameters

3.2.1 A GIS shapefile of the OWF footprint was added to the mCRM shiny application. The OWF and turbine parameters used in the mCRM are presented in Table 3.1 and Table 3.2. These values are based on the project option with the greatest potential for a likely significant effect for WTG 1 & 2, as described in Chapter 15 - Offshore Ornithology. A 'Large Array Correction' factor was applied to the mCRM.

Table 3.1:Turbine parameters used for the two project options in all CRM scenarios.

Parameter	WTG 1	WTG 2
No. WTGs	49	35
Latitude (°N)	53.7	53.7
Width of array (km)	17.8	17.8
Tidal offset (m)	2.71	2.71
No. Blades	3	3
Rotor radius (m)	125	138
Max Chord (m)	7	7.5
Average RPM	8.3 (SD 1.45)	7.5 (SD 1.45)
Average Pitch (°)	5.6 (SD 0.5)	5.6 (SD 0.5)
Tip Clearance HAT (m)	34.44	A = 34.44, B = 29.44

Table 3.2: Predicted mean wind availability and downtime for all CRM scenarios.

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind availability (%)	95.7	95.7	95.7	95.7	95.7	93	93	93	95.7	95.7	95.7	95.7
Mean downtime (%)	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3

Bird parameters

3.2.2 The species population estimates and proportion of birds at risk of collision provided within the mCRM tool defaults to the UK population sizes, which are not representative of Irish populations. To make it applicable to an OWF in the Irish Sea the defined populations in the tool were altered to reflect a truer representation of the migratory pathways within the region of the array area. To determine appropriate populations and proportions passing the Irish Sea several methods were used, the Irish population used was taken from Burke *et al*. (2018) and for species with an easterly migration pathway to and from Ireland (e.g. Bewick's swan) the population was set at the Irish population in Burke *et al.* (2018) For species with a northerly or north-westerly migratory route to and from Ireland (e.g. light-bellied brent goose) a precautionary measure was used by adding 25% of the UK population (found in the Shiny App) to the Irish population to include any individuals from the south-western regions of the UK populations overflying the Irish Sea. If the Irish population plus the 25% of the UK population exceeded the flyway population, then the proportion of the population passing through the proposed development was set to one. Where the all Ireland populations were not provided in Burke *et al*. (2018), the default UK populations in the Shiny App were used with the following caveats applied. For migratory raptor species and snipe it was assumed that a conservative 50% of the UK population may fly over the Irish Sea during the migration period and for corncrake, which migrates north/south from its breeding range in the north-west of the UK that a precautionary 100% of the UK population was assumed to fly over the Irish Sea. The proportion of birds passing through the wind farm footprint was adjusted to include the calculated Irish populations. Where Irish populations plus the additional 25% of the UK population exceeded the flyway population, the total proportion of birds passing through the wind farm footprint was set to 1. The species population estimates and proportion of birds at risk of collision from the proposed development (for WTG 1 & 2) that were calculated and used in the mCRM tool are present in Table 3.3 and Table 3.4.

3.2.3 The defined pre-breeding and post-breeding migration seasons used for mCRM are defined in Table 3.5. The species-specific biometric parameters used within mCRM are presented in Table 3.6. The parameters are preloaded using the mCRM tool which collates biometric information including Robinson (2017). Each flight type was set as "flapping".

Table 3.3: The population estimates passing through the windfarm and the proportion of birds at risk of collision for the assessed species for Project Option 1.

Species	Population estimate	SD	% at collision risk	Screened in/out
Bar-tailed godwit	47	18	0.3	Out
Bewick's swan	1	0	5.0	In
Black-tailed godwit	2228	321	2.3	In
Curlew	873	161	1.2	In
Dunlin	7208	1414	1.3	In
Golden plover	10757	2280	1.2	In
Goldeneye	204	37	1.5	In
Great crested grebe	72	11	2.4	In
Grey plover	40	8	1.3	In
Greylag goose	0	0	0	Out
Knot	1307	290	1.2	In
Lapwing	1284	227	1.5	In
Light-bellied brent goose	821	111	2.2	In
Mallard	377	71	1.3	In
Oystercatcher	2400	396	1.6	In
Pintail	93	20	1.4	In
Purple Sandpiper	101	17	1.5	In
Red-breasted merganser	94	17	1.5	In
Redshank	1837	336	1.4	In
Ringed plover	589	121	1.1	In
Sanderling	657	140	1.1	In
Shelduck	130	24	1.3	In
Shoveler	35	6	1.5	In
Teal	1639	344	1.1	In
Turnstone	1121	252	1.2	In
Wigeon	2061	407	1.2	In

Table 3.4: The population estimates passing through the windfarm and the proportion of birds at risk of collision for the assessed species for Project Option 2.

Species	Population estimate	SD	% at collision risk	Screened in/out
Bar-tailed godwit	47	19	0.3	Out
Bewick's swan	1	0	5.0	In
Black-tailed godwit	2224	330	2.3	In
Curlew	871	157	1.2	In
Dunlin	7180	1362	1.3	In
Golden plover	10780	2231	1.2	In
Goldeneye	204	38	1.5	In
Great crested grebe	72	11	2.4	In
Grey plover	40	8	1.3	In
Greylag goose	0	0	0	Out
Knot	1308	261	1.2	In
Lapwing	1283	203	1.5	In
Light-bellied brent goose	820	120	2.2	In
Mallard	377	75	1.3	In
Oystercatcher	2407	409	1.6	In
Pintail	93	19	1.4	In
Purple Sandpiper	101	20	1.5	In
Red-breasted merganser	94	18	1.5	In
Redshank	1837	381	1.4	In
Ringed plover	588	119	1.1	In
Sanderling	659	141	1.1	In
Shelduck	129	27	1.3	In
Shoveler	35	7	1.5	In
Teal	1634	368	1.1	In
Turnstone	1122	248	1.2	In
Wigeon	2069	412	1.2	In

Table 3.5: Defined migration seasons used in the mCRM tool.

Species	Pre-breeding	Post-breeding	Other
Bar-tailed godwit	Mar - Apr	Jul - Oct	-
Bewick's swan	Feb - Mar	Oct - Dec	-
Black-tailed godwit	Mar - May	Aug - Oct	-
Curlew	Mar - May	Jun - Oct	-
Dunlin	Mar - May	Jun - Oct	-
Golden plover	Feb - May	Jul - Oct	-
Goldeneye	Feb - May	Aug - Dec	-
Great crested grebe	Mar - Jun	Jul - Nov	Feb - Mar
Grey plover	Mar - May	Jul - Sep	-
Greylag goose	Mar - Apr	Oct - Nov	-
Knot	Feb - May	Jun - Oct	-
Lapwing	Jan - May	Oct - Nov	-
Light-bellied brent goose	Mar - May	Aug - Oct	-
Mallard	Apr - Jun	Sep - Oct	Jan - Mar
Oystercatcher	Jan - Mar	Jul - Nov	-
Pintail	Mar - May	Aug - Nov	-
Purple Sandpiper	Mar - May	Jul - Nov	-
Red-breasted merganser	Apr - Jul	Aug - Nov	-
Redshank	Mar - May	Jul - Sep	-
Ringed plover	Mar - May	Aug - Oct	-
Sanderling	Apr - Jun	Jul - Oct	-
Shelduck	Jan - Feb	Jun - Jul	Aug - Dec
Shoveler	Mar - Jun	Jul - Aug	Sep - Dec
Teal	Feb - May	Jul - Dec	-
Turnstone	Jan - Jun	Jul - Aug	-
Wigeon	Mar - Apr	Aug - Nov	-

Table 3.6: Species biometrics used in the mCRM tool. Standard deviation (SD) included in brackets.

Species	Body length (m)	Wingspan (m)	Flight speed (ms^{-1})	Proportion at PCH (%)	Avoidance Rate
Bar-tailed godwit	0.38 (0.02)	0.75 (0.02)	18.3 (2.1)	1.0	0.999 (0.0000)
Bewick's swan	1.21 (0.04)	1.96 (0.04)	24.0 (7.6)	0.5	0.988 (0.0009)
Black-tailed godwit	0.42 (0.02)	0.76 (0.02)	18.1 (6.0)	1.0	0.999 (0.00003)
Curlew	0.55 (0.02)	0.90 (0.03)	15.4 (3.3)	1.0	0.999 (0.0000)
Dunlin	0.18 (0.01)	0.40 (0.01)	15.3 (1.9)	1.0	0.999 (0.0000)
Golden plover	0.28 (0.01)	0.72 (0.01)	16.5 (1.8)	1.0	0.999 (0.0000)
Goldeneye	0.46 (0.01)	0.72 (0.01)	20.3 (3.8)	1.0	0.985 (0.0008)
Great crested grebe	0.48 (0.02)	0.88 (0.02)	21.1 (1.6)	1.0	0.995 (0.00001)
Grey plover	0.28 (0.01)	0.77 (0.01)	16.5 (1.8)	1.0	0.999 (0.0000)
Greylag goose	0.82 (0.03)	1.64 (0.03)	12.0 (4.9)	0.5	0.9996 (0.0000)
Knot	0.24 (0.01)	0.59 (0.01)	24.6 (3.3)	1.0	0.999 (0.0000)
Lapwing	0.30 (0.01)	0.84 (0.01)	12.8 (1.3)	1.0	0.999 (0.0000)
Light-bellied brent goose	0.58 (0.02)	1.15 (0.02)	17.9 (6.1)	0.5	0.999 (0.0001)
Mallard	0.58 (0.02)	0.90 (0.02)	15.9 (2.0)	1.0	0.985 (0.0008)
Oystercatcher	0.42 (0.02)	0.83 (0.02)	13.0 (2.5)	1.0	0.999 (0.0000)
Pintail	0.58 (0.02)	0.88 (0.02)	21.9 (2.0)	1.0	0.985 (0.0008)
Purple Sandpiper	0.21 (0.01)	0.44 (0.01)	15.3 (1.9)	1.0	0.999 (0.0000)
Red-breasted merganser	0.55 (0.01)	0.78 (0.01)	22.0 (2.9)	1.0	0.985 (0.0008)
Redshank	0.28 (0.01)	0.62 (0.01)	15.3 (4.1)	1.0	0.999 (0.0000)
Ringed plover	0.19 (0.01)	0.52 (0.01)	16.0 (1.1)	1.0	0.999 (0.0000)
Sanderling	0.20 (0.01)	0.42 (0.01)	21.4 (1.1)	1.0	0.999 (0.0000)
Shelduck	0.62 (0.02)	1.12 (0.02)	18.2 (4.3)	0.5	0.985 (0.0008)
Shoveler	0.48 (0.02)	0.77 (0.02)	18.3 (2.0)	1.0	0.985 (0.0008)
Teal	0.36 (0.015)	0.61 (0.015)	17.4 (1.6)	1.0	0.985 (0.0008)
Turnstone	0.23 (0.01)	0.54 (0.01)	10.0 (3.3)	1.0	0.999 (0.0000)
Wigeon	0.48 (0.02)	0.80 (0.02)	18.5 (2.0)	1.0	0.985 (0.0008)

Avoidance rates

3.2.4 Avoidance rates (AR) are a key parameter in the mCRM, they take into consideration that birds will undertake avoidance behaviour in response to the presence of a windfarm to prevent collision. This can occur at three scales (Cook *et al.*, 2014); micro-avoidance (avoiding individual turbine blades); meso-avoidance (avoiding whole wind turbines, not just the rotor-swept area) and macro-avoidance (avoiding the whole wind farm array area and buffer). This adjustment is required since baseline survey data are collected before turbines are present. The AR used in CRM for each species, presented in Table 3.6, are set in the mCRM tool as recommended by NatureScot and checked by Cook (pers comm). The AR used in the tool are based upon the most recent evidence (Cook, 2014).

Species biometrics

3.2.5 The species-specific biometric input parameters used in the mCRM are provided in Table 3.6. The biometrics for all species (body length and wingspan) were taken as presented in Natural England's most recent guidance (Natural England, 2022), which are derived from the biometric data from Snow and Perrins (1998).

Seabird flight speeds

3.2.6 Species-specific flight speeds used in the mCRM assessment are presented in Table 3.6. Flight speeds were taken from Pennycuick (1997) for gannet and Alerstam *et al*. (2007) for all other species, as per the latest interim guidance from Natural England (Natural England, 2022).

4. mCRM Results

4.1.1 This section presents the outputs from the CRM analysis for each of the migratory species. A summary of the results for each species (for WTG 1 & 2) is presented in Table 4.1 and Table 4.2.

Table 4.1: Summary of annual collision estimates following the project approach for WTG1.

	WTG 1			
Species	Pre-breeding	Post-breeding	Other	Total
Bewick's swan	0 ± 0	0 ± 0	-	0 ± 0
Black-tailed godwit	0.054 ± 0.012	0.053 ± 0.011	-	0.107 ± 0.016
Curlew	0.023 ± 0.005	0.023 ± 0.005	-	0.046 ± 0.007
Dunlin	0.149 ± 0.029	0.147 ± 0.029	-	0.296 ± 0.041
Golden plover	0.238 ± 0.051	0.235 ± 0.050	-	0.473 ± 0.071
Goldeneye	0.071 ± 0.014	0.070 ± 0.014	-	0.141 ± 0.020
Great crested grebe	0.008 ± 0.001	0.008 ± 0.001	0.008 ± 0.001	0.024 ± 0.002
Grey plover	0.001 ± 0	0.001 ± 0	-	0.002 ± 0
Knot	0.027 ± 0.006	0.027 ± 0.006	-	0.054 ± 0.008
Lapwing	0.03 ± 0.005	0.03 ± 0.005	-	0.06 ± 0.007
Light-bellied brent goose	0.011 ± 0.005	0.011 ± 0.005	-	0.022 ± 0.007
Mallard	0.145 ± 0.03	0.146 ± 0.03	0.146 ± 0.03	0.437 ± 0.052
Oystercatcher	0.061 ± 0.011	0.06 ± 0.011	-	0.121 ± 0.016
Pintail	0.033 ± 0.007	0.033 ± 0.007	-	0.066 ± 0.01
Purple Sandpiper	0.002 ± 0	0.002 ± 0	-	0.004 ± 0
Red-breasted merganser	0.033 ± 0.006	0.033 ± 0.006	-	0.066 ± 0.008
Redshank	0.042 ± 0.008	0.041 ± 0.008	-	0.083 ± 0.011
Ringed plover	0.012 ± 0.003	0.012 ± 0.002	-	0.024 ± 0.004
Sanderling	0.013 ± 0.003	0.013 ± 0.003	-	0.026 ± 0.004
Shelduck	0.025 ± 0.005	0.025 ± 0.005	0.025 ± 0.005	0.075 ± 0.009
Shoveler	0.012 ± 0.002	0.012 ± 0.002	0.012 ± 0.002	0.036 ± 0.003
Teal	0.554 ± 0.12	0.549 ± 0.119	-	1.103 ± 0.169
Turnstone	0.028 ± 0.009	0.027 ± 0.009	-	0.055 ± 0.013
Wigeon	0.735 ± 0.152	0.73 ± 0.151	-	1.465 ± 0.214

Table 4.2: Summary of annual collision estimates following the project approach for WTG2.

	WTG 2			
Species	Pre-breeding	Post-breeding	Other	Total
Bewick's swan	0 ± 0	0 ± 0	-	0 ± 0
Black-tailed godwit	0.04 ± 0.009	0.04 ± 0.009	-	0.08 ± 0.013
Curlew	0.017 ± 0.003	0.017 ± 0.003	-	0.034 ± 0.004
Dunlin	0.113 ± 0.021	0.111 ± 0.021	-	0.224 ± 0.03
Golden plover	0.18 ± 0.037	0.178 ± 0.037	-	0.358 ± 0.052
Goldeneye	0.053 ± 0.011	0.053 ± 0.011	-	0.106 ± 0.016
Great crested grebe	0.006 ± 0.001	0.006 ± 0.001	0.006 ± 0.001	0.018 ± 0.002
Grey plover	0.001 ± 0	0.001 ± 0	-	0.002 ± 0
Knot	0.021 ± 0.004	0.02 ± 0.004	-	0.041 ± 0.006

Lapwing	0.023 ± 0.004	0.023 ± 0.004	-	0.046 ± 0.006
Light-bellied brent goose	0.008 ± 0.004	0.008 ± 0.004	-	0.016 ± 0.006
Mallard	0.108 ± 0.023	0.109 ± 0.023	0.109 ± 0.023	0.326 ± 0.04
Oystercatcher	0.046 ± 0.009	0.045 ± 0.008	-	0.091 ± 0.012
Pintail	0.025 ± 0.005	0.025 ± 0.005	-	0.05 ± 0.007
Purple Sandpiper	0.002 ± 0	0.002 ± 0	-	0.004 ± 0
Red-breasted merganser	0.025 ± 0.005	0.025 ± 0.005	-	0.05 ± 0.007
Redshank	0.031 ± 0.007	0.031 ± 0.007	-	0.062 ± 0.01
Ringed plover	0.009 ± 0.002	0.009 ± 0.002	-	0.018 ± 0.003
Sanderling	0.01 ± 0.002	0.01 ± 0.002	-	0.02 ± 0.003
Shelduck	0.019 ± 0.004	0.018 ± 0.004	0.019 ± 0.004	0.056 ± 0.007
Shoveler	0.009 ± 0.002	0.009 ± 0.002	0.009 ± 0.002	0.027 ± 0.003
Teal	0.416 ± 0.096	0.413 ± 0.095	-	0.829 ± 0.135
Turnstone	0.021 ± 0.007	0.02 ± 0.006	-	0.041 ± 0.009
Wigeon	0.555 ± 0.116	0.551 ± 0.115	-	1.106 ± 0.163

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GoBe Consultants Ltd
Suites B2 & C2, Higher Mill
Higher Mill Lane
Buckfastleigh
Devon
TQ11 0EN

GoBe Consultants Ltd
5/2 Merchant's House
7 West George Street
Glasgow
Scotland
G2 1BA

www.gobeconsultants.com