Bowdun Offshore Wind Farm, Offshore EIA Report

Volume 3, Technical Appendix 11.5: Offshore Ornithology Migratory Bird Collision Risk Model Technical Report

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Contents

List of Tables

List of Figures

Glossary

Defined Term	Definition
Applicant (the)	Bowdun Offshore Wind Farm Limited (BOWFL).
Array Area	The Array Area is the area in which the Offshore Generation Assets will be located.
Collision	The effect by which a bird may be impacted by direct collision. Birds passing through an offshore wind farm are at risk of colliding with the Wind Turbines (moving and stationary parts).
Effect	Term used to express the consequence of an impact (i.e. the result of change or changes) on specific environmental resources or receptors. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity of the receptor or resource in accordance with defined significance criteria.
Environmental Impact Assessment (EIA)	Process for the assessment of likely significant environmental effects of a project on the physical, biological, and human environment during construction, Operation and Maintenance (O&M) and decommissioning.
Export Cable Corridor	The area of seabed seaward of Mean High Water Springs (MHWS) which connects the Array Area with the Landfall within which the Offshore Export Cables will be installed.
Impact	A change caused by an action that occurs during a project's lifetime.
Inter-Array Cables (IAC)	Cables which link the Wind Turbines to each other and with the Offshore Substation Platforms (OSPs).
Interconnector Cables	Cables which will connect individual OSPs to each other to provide redundancy against cable failure elsewhere.
Offshore Export Cables	Subsea cables used to transmit electricity generated offshore by the Wind Turbines from the OSPs to shore. The Transition Joint Bay (TJB) is the location where the Offshore Export Cable terminates, and the onshore cabling begins.
Offshore Substation Platform(s) (OSPs)	OSPs comprise the support structure, topside and electrical components used for collecting and/or converting electricity generated by the Wind Turbines for transmission by the Offshore Export Cables.
Project (the)	An overarching term for the Bowdun Offshore Wind Farm (Bowdun OWF) comprising the offshore and onshore infrastructure required to generate and transmit electricity from the Array Area to the onshore Grid Connection Point. The Project includes the Offshore Generation Assets, the Offshore Transmission Assets and the Onshore Transmission Assets.
Proposed Development	Term used to define the Offshore Infrastructure associated with the Project seaward of MHWS for which consent is being sought. Further details of the parameters are included in Volume 1, Chapter 3: Project Description.
Sectoral Marine Plan (SMP)	A plan developed by the Scottish Government which provides the strategically planned spatial footprint for offshore wind development in Scotland.

Defined Term	Definition
Site Boundary	The boundary within which all elements of the Proposed Development will be located. The Site Boundary comprises the Array Area and Export Cable Corridor which ends at MHWS.
Study Area	For each environmental topic, the baseline environment will be characterised, and the potential environmental impacts will be described within a topic-specific study area. Specific study areas are defined for each topic and are based on the maximum spatial extent across which potential impacts of the Project may be experienced by the relevant receptors (i.e. Zone of Influence).
Thistle Wind Partners (TWP)	Company established for the development of the Project.
Wind Turbines	Structures comprising of a tubular tower, rotor blades, and a nacelle which houses the Wind Turbine generator.

Acronyms

Acronym	Definition
BTO	British Trust for Ornithology
CRM	Collision Risk Modelling
EIA	Environmental Impact Assessment
HRA	Habitats Regulations Appraisal
MAT	Migration Assessment Tool
mCRM	Migratory Collision Risk Modelling
O&M	Operation and Monitoring
OWF	Offshore Wind Farm
PCF	Population Correction Factor
PCH	Percentage at Collision Risk Height
SOSSMAT	Strategic Ornithological Support Services Migration Assessment Tool
SPA	Special Protection Area
UK	United Kingdom

Table of Units

Units	Definition
km	Kilometre
km^2	Square kilometre
m	Metre
m/s	Metre per second
rpm	Rotations per minute
°	Degree
%	Percent

1 Introduction

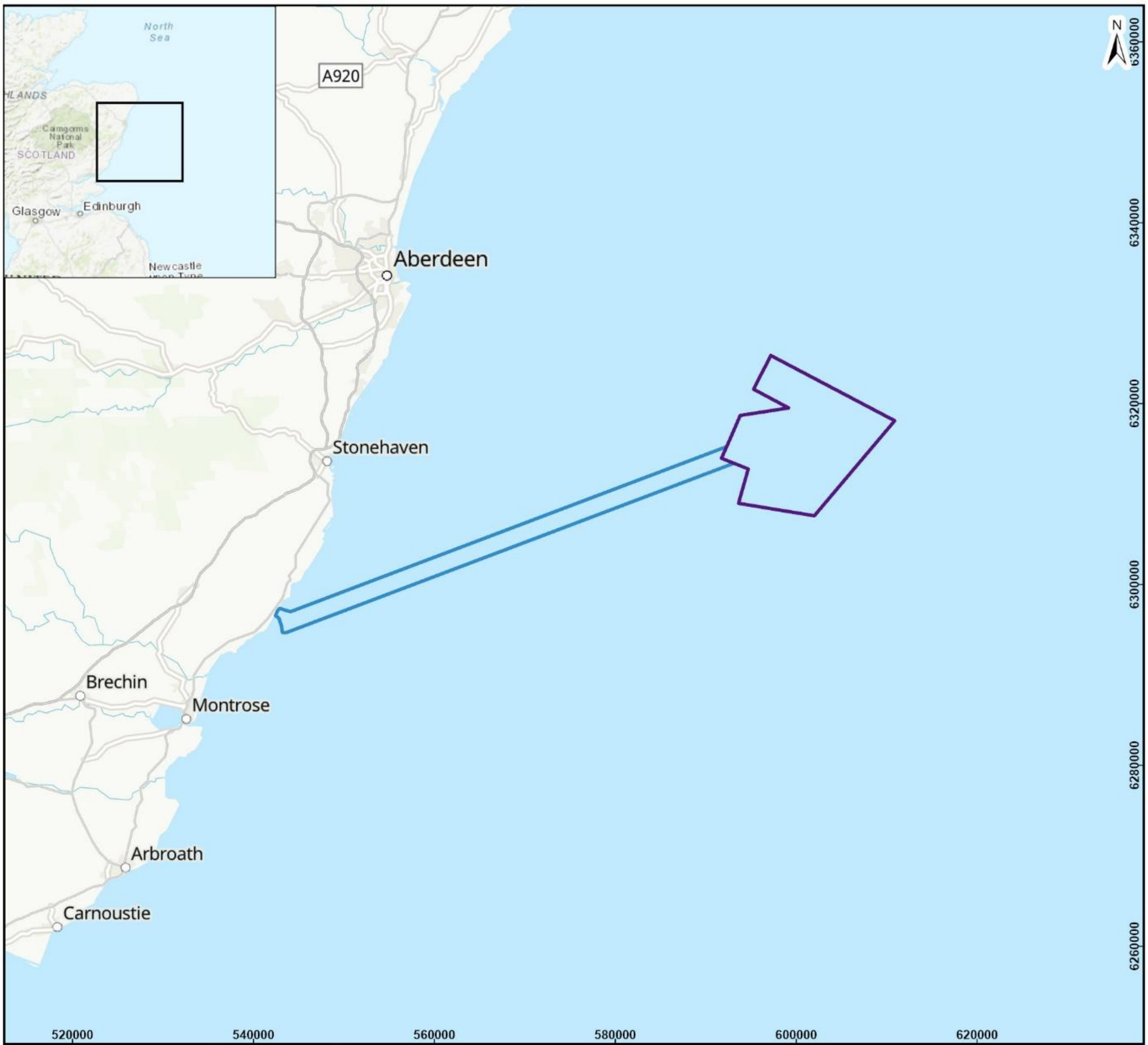
1.1.1 This Offshore Ornithology Migratory Bird Collision Risk Model Technical Report presents the migratory birds collision risk impacts for the offshore elements of the Bowdun Offshore Wind Farm (OWF) Project (hereafter referred to as the Proposed Development). The Proposed Development covers the Option Lease Area and comprises the Array Area, which is located in the E3 Plan Option Area detailed in the Scottish Sectoral Marine Plan (Scottish Government, 2020), and the Export Cable Corridor. The Array Area is located 38 km from the Aberdeenshire coast at its closest point, covering an area of 187 km^2 (Figure 1.1). The Proposed Development will comprise Wind Turbines (fixed foundations), Inter-Array Cables, Offshore Substation Platforms, Interconnector Cables, Offshore Export Cables and any necessary scour/cable protection. The Export Cable Corridor will include a maximum of three High Voltage Alternating Current Offshore Export Cables, each with a length of up to 70 km and will make Landfall at Benholm, Aberdeenshire.

1.1.2 Migratory birds can potentially be impacted by OWF developments in a number of ways, namely collision, displacement, barrier effects and disturbance (the latter three often referred to as ‘distributional responses’ due to impossibility of quantifying each impact separately), as well as indirect impacts, such as changes to prey availability.

1.1.3 Due to species-specific life histories, some bird species are at risk of colliding with offshore Wind Turbines during migration (Furness *et al.,* 2013), with collisions resulting in injury or death. Migratory Collision Risk Modelling (mCRM) predicts the number of migratory bird collisions that are potentially caused by an OWF development.

1.1.4 This mCRM technical report presents the method and results of the mCRM for migratory birds within the Array Area. This is for the assessment of collision risk resulting from the Proposed Development during the Operation and Maintenance (O&M) phase.

1.1.5 This mCRM technical report informs the Environmental Impact Assessment (EIA) and Habitats Regulations Appraisal (HRA) of the Proposed Development on migratory offshore ornithological receptors. This report accompanies the EIA provided in Volume 2, Chapter 11: Offshore Ornithology to support the consent application for the Proposed Development.



Project Title: Bowdun Offshore Wind Farm	**Figure Title:** Proposed Development Site Boundary

LEGEND

- Array Area
- Export Cable Corridor

0 5 10 nm
0 5 10 20 km

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N

VER	DATE	DETAILS	BY	CHK
00	29/04/25	First Issue	MJ	JC
01	24/10/25	Revision	PE	JS
-	-	-	-	-
-	-	-	-	-

Drawing Number: EOR0770A-ES-MISC-0001-01

Data Sources: Client

Service Layer Credits: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, HERE, Garmin, FAO, NOAA, USGS

THISTLE WIND PARTNERS
TETRA TECH RPS ENERGY

Figure 1.1: Proposed Development Site Boundary

2 Methodology

2.1 Overview

2.1.1 The Strategic Ornithological Support Services Migration Assessment Tool (SOSSMAT), hereafter referred to as the Migration Assessment Tool (MAT) (Wright *et al*., 2012), was used to assess the fraction of migratory bird populations that may pass through the Array Area during migration periods.

2.1.2 The area of interest for the mCRM is confined to the footprint of the Array Area, as collisions with Wind Turbines can only occur within this area. The estimated number of migratory birds projected to cross the Array Area was subsequently entered into the Band (2012) single transit CRM.

2.1.3 It is important to note that the MAT tool is specifically designed for migratory birds that are features of United Kingdom (UK) Special Protection Areas (SPAs) and commonly occurring Annex I species, as outlined by Wright *et al*. (2012).

2.1.4 To test the robustness of the MAT tool, population numbers that were expected to cross the Array Area were compared to the newly developed mCRM Shiny application (HiDef Aerial Surveying Limited, 2025). The mCRM Shiny application is a stochastic adaptation of the Band (2012) migration collision risk worksheet. This mCRM Shiny application can be accessed at https://hidefdevo.shinyapps.io/mCRM. However, at the time of writing this technical report, the application is currently still undergoing beta testing.

2.1.5 The mCRM Shiny application includes default values for 70 species of migratory birds, along with polygons that represent their approximate migratory pathways.

2.1.6 The mCRM Shiny application generates population estimates within OWFs by sampling migratory pathways. This is achieved by drawing straight lines between UK and non-UK coastlines, effectively modelling the potential migratory routes of the species.

2.1.7 The benefit of generating results from the Shiny application was that it provided the opportunity to compare results and sense check results from the MAT tool. Moreover, in instances where it generated a higher predicted population, this could be used, if relevant, to add an additional degree of precaution.

2.2 Migratory Route Modelling

2.2.1 The modelling of migratory routes for collision assessment followed the guidance from the British Trust for Ornithology (BTO) (Wright *et al*., 2012), which outlines a methodology for calculating the migration passages of migratory species.

2.2.2 The MAT tool uses generic flightlines connecting the UK coast with other coastlines (including Europe, Scandinavia, Iceland, and Greenland) and operates under the assumption that migratory birds generally follow straight-line migration paths between coastlines.

2.2.3 The MAT tool has 251,599 lines of connectivity, constructed as sea crossings for migratory birds traversing UK waters. These lines were assigned on a species-specific basis according to the migration routes detailed in Wright *et al*. (2012).

2.2.4 Accompanying the MAT tool is a Geographic Information System shapefile, which facilitates the identification of connectivity lines that intersect with the Array Area. A dataset detailing these intersecting lines was extracted and imported into the MAT Excel tool. For the Array Area, this dataset comprised 2,552 lines of connectivity.

2.2.5 The subsequent step involves determining which sea crossings are relevant to the OWF under assessment. The selected routes within the MAT tool are listed in Table 2.1. These routes align with migratory patterns observed across the UK.

Table 2.1: Start and End Codes Selected for the Bowdun mCRM

MAT code	Start	End
EUNECE	Central Europe North Sea coast	England eastern English Channel coast
EUNENS	Central Europe North Sea coast	England North Sea coast
EUNNOR	Central Europe North Sea coast	Norway
EUNORK	Central Europe North Sea coast	Orkney
EUNSNS	Central Europe North Sea coast	Scottish mainland North Sea coast
EUNSHE	Central Europe North Sea coast	Shetland
DENEUN	Denmark	Central Europe North Sea coast
DENENS	Denmark	England North Sea coast
DENFAE	Denmark	Faeroe Islands
DENICE	Denmark	Iceland
DENORK	Denmark	Orkney
DENSNS	Denmark	Scottish mainland North Sea coast
DENSHE	Denmark	Shetland
ENSORK	England North Sea coast	Orkney
ENSSNS	England North Sea coast	Scottish mainland North Sea coast
ENSSHE	England North Sea coast	Shetland
FAENOR	Faeroe Islands	Norway
FAEORK	Faeroe Islands	Orkney
FAESNC	Faeroe Islands	Scottish mainland northern coast
FAESHE	Faeroe Islands	Shetland
ICENOR	Iceland	Norway
ICEORK	Iceland	Orkney
ICESNC	Iceland	Scottish mainland northern coast
ICESHE	Iceland	Shetland
NORENS	Norway	England North Sea coast
NORORK	Norway	Orkney

MAT code	Start	End
NORSNS	Norway	Scottish mainland North Sea coast
NORSHE	Norway	Shetland
ORKSNS	Orkney	Scottish mainland North Sea coast
ORKSNC	Orkney	Scottish mainland northern coast
ORKSHE	Orkney	Shetland
SHESNS	Shetland	Scottish mainland North Sea coast

2.3 Populations and Population Correction Factor

2.3.1 For each species, the number of birds estimated to cross the Array Area was derived by incorporating various parameters, including the population size and the Population Correction Factor (PCF), which represents the percentage of the population utilising the relevant sea crossing.

2.3.2 The PCF was estimated using relevant information and maps (Wright *et al.,* 2012; Woodward *et al.*, 2023). Updated population counts were sourced from Woodward *et al.* (2020; 2023). The population parameters used are summarised in Table 2.2.

2.3.3 This approach ensured the assessment reflected the most current understanding of migratory bird populations and their potential interactions with the Array Area.

Following the MAT tool (Wright *et al.*, 2012) and mCRM guidance (HiDef Aerial Surveying Limited., 2025), a comparison of the percentages of the population crossing the Array Area using the MAT tool and the mCRM Shiny application is presented in

2.3.4 Table 2.3.

2.3.5 As a precautionary measure, the highest number of birds passing through the Array Area was taken forward to the mCRM. Species with no connectivity to the Array Area (zero passages) were not taken forward to mCRM.

Table 2.2: Population Sizes (Woodward *et al.*, 2020; 2023) of Relevant Species and PCF Applied in the SOSSMAT Tool

Species	Population	PCF
Bewick's Swan *Cygnus columbianus bewickii*	4,382	50
Whooper Swan *Cygnus cygnus*	39,990	50
Bean Goose *Anser fabalis*	970	100
Pink-footed Goose *Anser brachyrhynchus*	510,000	50
European White-fronted Goose *Anser albifrons albifrons*	12,000	99
Greenland White-fronted Goose *A. a. flavirostris*	21,500	99
Icelandic Greylag Goose *Anser anser*	68,400	50
Greenland Barnacle Goose *Branta leucopsis*	72,000	99
Svalbard Barnacle Goose	43,500	100
Dark-bellied Brent Goose *Branta bernicla bernicla*	99,170	99
Canadian Light-bellied Brent Goose *B. b. hrota*	37,000	99
Svalbard Light-bellied Brent Goose *B. b. hrota*	13,400	99
Shelduck *Tadorna tadorna*	77,500	50
Wigeon *Mareca penelope*	544,000	20
Gadwall *Anas strepera*	30,940	99
Teal *Anas crecca*	435,500	20
Mallard *Anas platyrhynchos*	823,600	20
Pintail *Anas acuta*	20,942	10
Shoveler *Anas clypeata*	22,960	20
Pochard *Aythya ferina*	28,500	20
Tufted Duck *Aythya fuligula*	155,000	20
Scaup *Aythya marila*	7,000	10
Eider *Somateria mollissima*	133,400	90
Long-tailed Duck *Clangula hyemalis*	12,800	50
Common Scoter *Melanitta nigra*	146,700	30
Velvet Scoter *Melanitta fusca*	4,510	70
Goldeneye *Bucephala clangula*	30,000	20
Red-breasted Merganser *Mergus serrator*	15,840	10
Goosander (non-breeding) *Mergus merganser*	17,420	30
Goosander (Breeding Male moult migration)	4,800	100
Red-throated Diver (breeding) *Gavia stellata*	2,500	20
Red-throated Diver (non-breeding)	34,000	30

Species	Population	PCF
Manx Shearwater *Puffinus puffinus*	600,000	20
Storm Petrel *Hydrobates pelagicus*	51,000	50
Leach's Petrel *Oceanodroma leucorhoa*	48,000	50
Cormorant *Phalacrocorax carbo*	64,500	10
Shag *Phalacrocorax aristotelis*	110,000	20
Bittern *Botaurus stellaris*	713	99
Great Crested Grebe *Podiceps cristatus*	1,380	10
Slavonian Grebe *Podiceps auritus*	1,561	20
Honey-buzzard *Pernis apivorus*	137	99
Marsh Harrier *Circus aeruginosus*	2,576	99
Hen Harrier (breeding) *Circus cyaneus*	2,176	20
Hen Harrier (non-breeding)	545	20
Montagu's Harrier *Circus pygargus*	18	99
Osprey *Pandion haliaetus*	664	99
Merlin *Falco columbarius*	8,256	20
Corncrake *Crex crex*	16,960	99
Oystercatcher (breeding) *Haematopus ostralegus*	191,000	30
Oystercatcher (non-breeding)	305,000	20
Avocet (breeding) *Recurvirostra avosetta*	3,900	99
Avocet (non-breeding)	8,700	99
Stone-curlew *Burhinus oedicnemus*	880	99
Ringed Plover (breeding) *Charadrius hiaticula*	10,900	20
Ringed Plover (non-breeding)	42,500	20
Dotterel (breeding and passage) *Charadrius morinellus*	390	50
Dotterel (within breeding season)	850	50
Golden Plover (breeding) *Pluvialis apricaria*	101,000	20
Golden Plover (non-breeding)	410,000	20
Grey Plover *Pluvialis squatarola*	124,000	20
Lapwing *Vanellus vanellus*	3,942,500	20
Knot *Calidris canutus*	360,000	20
Sanderling *Calidris alba*	200,000	20
Purple Sandpiper *Calidris maritima*	24,400	20
Dunlin (passage) *Calidris alpina schinzii* and *C. a. arctica*	908,000	20

Species	Population	PCF
Dunlin (passage and winter) *C. a. alpina*	350,000	20
Ruff *Philomachus pugnax*	31,000	20
Snipe *Gallinago gallinago*	6,105,000	20
Black-tailed Godwit *Limosa limosa limosa*	204,000	99
Black-tailed Godwit *L. l. islandica*	99,000	20
Bar-tailed Godwit *Limosa lapponica*	680,000	20
Whimbrel *Numenius phaeopus*	11,700	20
Curlew (breeding) *Numenius arquata*	117,000	20
Curlew (non-breeding)	141,100	20
Greenshank *Tringa nebularia*	7,200	20
Wood Sandpiper *Tringa glareola*	0	99
Redshank (breeding) *Tringa totanus britannica*	44,000	30
Redshank (Icelandic, non-breeding) *T. t. robusta*	230,000	50
Redshank (mainland Europe, non-breeding) *T. t. totanus*	450,000	20
Turnstone *Arenaria interpres*	347,000	20
Red-necked Phalarope *Phalaropus lobatus*	19	10
Arctic Skua *Stercorarius parasiticus*	785	50
Great Skua *Stercorarius skua*	9,650	50
Short-eared Owl *Asio flammeus*	14,880	20
Nightjar *Caprimulgus europaeus*	7,700	99

Table 2.3: Comparison of Percentages of the Population Crossing the Array Area Using the SOSSMAT Tool and the mCRM Shiny Application. Boldface Values: Taken Forward to CRM

Species	Percent crossing Array Area SOSSMAT	Percent crossing Array Area mCRM Shiny Application	Number crossing Array Area SOSSMAT	Number crossing Array Area mCRM Shiny Application
Bewick's Swan	0.00%	0.00%	0	0
Whooper Swan	2.03%	2.66%	405	531
Bean Goose	1.91%	4.43%	19	43
Pink-footed Goose	2.06%	0.07%	5,250	172
European White-fronted Goose	0.00%	0.00%	0	0
Greenland White-fronted Goose	0.00%	0.00%	0	0
Icelandic Greylag Goose	0.03%	0.00%	12	0

Species	Percent crossing Array Area SOSSMAT	Percent crossing Array Area mCRM Shiny Application	Number crossing Array Area SOSSMAT	Number crossing Array Area mCRM Shiny Application
Barnacle Goose (Greenland)	0.00%	0.00%	0	0
Barnacle Goose (Svalbard)	3.54%	7.74%	1,540	3,366
Dark-bellied Brent Goose	0.00%	0.00%	0	0
Light-bellied Brent Goose (Canadian)	0.00%	0.00%	0	0
Light-bellied Brent Goose (Svalbard)	0.00%	2.54%	0	337
Shelduck	2.41%	1.93%	932	748
Wigeon	1.95%	1.87%	2,119	2,032
Gadwall	0.00%	0.00%	0	0
Teal	1.94%	1.03%	1,688	899
Mallard	2.41%	1.97%	3,963	3,238
Pintail	1.94%	1.85%	41	39
Shoveler	2.65%	1.56%	122	72
Pochard	2.65%	0.00%	151	0
Tufted Duck	1.83%	1.96%	568	608
Scaup	1.90%	1.31%	13	9
Eider	3.95%	2.02%	4,748	2,421
Long-tailed Duck	2.41%	1.98%	154	127
Common Scoter	1.94%	1.72%	853	755
Velvet Scoter	2.70%	2.54%	85	80
Goldeneye	2.41%	1.98%	144	119
Red-breasted Merganser	2.53%	-	40	-
Goosander (non-breeding)	2.61%	3.67%	136	192
Goosander (Breeding male moult)	3.56%	-	171	-
Red-throated Diver (breeding)	3.41%	-	17	-
Red-throated Diver (non-breeding)	1.98%	2.05%	202	209
Manx Shearwater	1.82%	-	2,179	-
Storm Petrel	1.82%	-	463	-
Leach's Petrel	1.82%	-	436	-
Cormorant	2.38%	0.00%	153	0

Species	Percent crossing Array Area SOSSMAT	Percent crossing Array Area mCRM Shiny Application	Number crossing Array Area SOSSMAT	Number crossing Array Area mCRM Shiny Application
Shag	2.80%	-	617	-
Bittern	0.00%	1.26%	0	9
Great Crested Grebe	1.29%	0.36%	2	1
Slavonian Grebe	1.94%	1.72%	6	5
Honey-buzzard	0.00%	0.00%	0	0
Marsh Harrier	0.00%	2.10%	0	53
Hen Harrier (breeding)	3.30%	-	14	-
Hen Harrier (non-breeding)	2.76%	2.02%	3	2
Montagu's Harrier	0.00%	0.00%	0	0
Osprey	0.00%	2.26%	0	15
Merlin	1.59%	1.24%	26	20
Corncrake	0.93%	2.00%	155	336
Oystercatcher (breeding)	2.80%	-	1,607	-
Oystercatcher (non-breeding)	1.94%	1.70%	1,182	1,037
Avocet (breeding)	0.00%	-	0	-
Avocet (non-breeding)	0.00%	0.00%	0	0
Stone-curlew	0.00%	0.00%	0	0
Ringed Plover (breeding)	2.83%	-	62	-
Ringed Plover (non-breeding)	2.19%	1.39%	186	118
Dotterel (breeding and passage)	1.00%	-	2	-
Dotterel (within breeding season)	1.85%	2.56%	8	11
Golden Plover (breeding)	2.82%	-	570	-
Golden Plover (non-breeding)	2.46%	1.78%	2,013	1,457
Grey Plover	2.41%	1.73%	597	429
Lapwing	2.41%	1.57%	18,975	12,364
Knot	1.95%	1.72%	1,400	1,235
Sanderling	1.95%	1.75%	778	700
Purple Sandpiper	1.72%	2.03%	84	99
Dunlin C. a. schinzii and C. a. arctica (passage)	1.94%	1.48%	3,528	2,688

Species	Percent crossing Array Area SOSSMAT	Percent crossing Array Area mCRM Shiny Application	Number crossing Array Area SOSSMAT	Number crossing Array Area mCRM Shiny Application
Dunlin *C. a. alpina* (passage and winter)	2.46%	-	1,723	-
Ruff	1.79%	1.69%	111	105
Snipe	1.95%	1.85%	23,794	22,638
Black-tailed Godwit *L. l. limosa*	0.00%	-	0	-
Black-tailed Godwit *L. l. islandica*	2.32%	0.00%	460	0
Bar-tailed Godwit	2.63%	2.10%	3,577	2,862
Whimbrel	1.88%	1.41%	44	33
Curlew (breeding)	2.80%	-	654	-
Curlew (non-breeding)	2.58%	2.06%	727	582
Greenshank	2.22%	2.07%	32	30
Wood Sandpiper	0.55%	3.70%	0	0
Redshank *T. t. britannica* (breeding)	3.10%	-	409	-
Redshank *T. t. robusta* (non-breeding)	2.34%	-	2,693	-
Redshank *T. t. totanus* (non-breeding)	2.73%	1.43%	2,458	1,290
Turnstone	1.94%	1.79%	1,344	1,245
Red-necked Phalarope	2.84%	0.00%	0	0
Arctic Skua	2.38%	-	9	-
Great Skua	2.25%	-	109	-
Short-eared Owl	2.28%	1.92%	68	57
Nightjar	0.00%	2.60%	0	198

2.4 Collision Risk Modelling

2.4.1 Following the MAT tool guidance, the Band (2012) model was employed for the mCRM. Input parameters for Wind Turbine specifications are detailed in Table 2.4 and Table 2.5 based on the offshore ornithology Maximum Design Scenario (Volume 2, Chapter 11: Offshore Ornithology) values for collision risk. Species-specific parameters are shown in Table 2.6, with biometrics sourced from the BTO Bird Facts resource (Robinson, 2005) and flight speeds primarily from Alerstam *et al*. (2007). For some species lacking data in Alerstam *et al*. (2007), assumptions were made based on similar genera.

2.4.2 Given the variability in flight height data, it is often impractical to specify an exact proportion of birds at collision risk height. Therefore, Woodward *et al*. (2023) categorise the proportion of birds at risk into rough categories of 0%, 25%, 50%, 75%, or 100%, referencing published estimates. Where no value was given, a precautionary value of 100% (or one as a proportion) was chosen.

2.4.3 Collision rates were modelled using recommended avoidance rates (Woodward *et al*., 2023).

2.4.4 It should be noted that using the maximum rotor speed gives a highly precautionary output. It is not possible for a Wind Turbine to run at maximum speed for more than short periods due to engineering, and grid constraints.

2.4.5 A correction for curtailment has not been applied during mCRM due to the low magnitude of impacts. Curtailment refers to reducing or stopping production of energy from Wind Turbines due to external factors. Typically, this is applied when the amount of energy being produced exceeds the capacity of the electrical grid to distribute that energy. As agreed with NatureScot on 29 July 2025, a precautionary 5% of downtime has been applied where appropriate to account for curtailment (see Volume 3, Technical Appendix 11.4: Offshore Ornithology Collision Risk Modelling Technical Report).

Table 2.4: Wind Turbine Parameters Used in the mCRM

Parameter	Value
Number of Wind Turbines (n)	67
Number of rotor blades (n)	3
Maximum chord width (m)	6.5
Average blade pitch (°)	5.1
Maximum rotor radius (m)	118
Maximum rotation speed (rpm)	8.4
Wind farm width (km)	18.4
Latitude	56.98

Table 2.5: Wind Parameters Used in the mCRM

Month	Wind availability	Downtime	Total
January	97.6%	3.0%	94.7%
February	96.8%	3.0%	93.9%
March	95.3%	3.0%	92.5%
April	94.7%	3.0%	91.9%
May	92.7%	3.0%	89.9%
June	93.5%	3.0%	90.7%
July	92.1%	3.0%	89.4%
August	92.6%	3.0%	89.8%
September	95.6%	3.0%	92.7%
October	96.8%	3.0%	93.9%
November	95.0%	3.0%	92.2%
December	97.3%	3.0%	94.4%
Average	95.0%	3.0%	92.2%

Table 2.6: Species Parameters Used in mCRM

Species	Body Length (m)	Wingspan (m)	Flight Speed (m/s)	PCH[1]	Avoidance rate[1]
Whooper Swan	1.52	2.3	17.5	50%	0.9874
Bean Goose	0.75	1.58	15.8	100%	0.9998
Pink-footed Goose	0.68	1.52	16.9	50%	0.9999
Icelandic Greylag Goose	0.82	1.64	12	50%	0.9998
Svalbard Barnacle Goose	0.64	1.38	17.4	100%	0.9998

Species	Body Length (m)	Wingspan (m)	Flight Speed (m/s)	PCH[1]	Avoidance rate[1]
Svalbard Light-bellied Brent Goose	0.58	1.15	17.9	50%	0.9998
Shelduck	0.62	1.12	18.2	50%	0.9851
Wigeon	0.48	0.8	18.5	100%	0.9851
Teal	0.36	0.61	17.4	100%	0.9851
Mallard	0.58	0.9	15.86	100%	0.9851
Pintail	0.58	0.88	21.9	100%	0.9851
Shoveler	0.48	0.77	18.3	100%	0.9851
Pochard	0.46	0.77	23.6	100%	0.9851
Tufted Duck	0.44	0.7	21.1	100%	0.9851
Scaup	0.46	0.78	21.1	100%	0.9851
Eider	0.6	0.94	17.34	25%	0.9851
Long-tailed Duck	0.44	0.76	19.7	100%	0.9851
Common Scoter	0.49	0.84	22.1	100%	0.9851
Velvet Scoter	0.54	0.94	20.1	100%	0.9851
Goldeneye	0.46	0.72	20.3	100%	0.9851
Red-breasted Merganser	0.55	0.78	22	100%	0.9851
Goosander	0.62	0.9	19.7	100%	0.9851
Red-throated Diver	0.61	1.11	18.6	25%	0.9954
Manx Shearwater	0.34	0.83	11.3	100%[2]	0.990[3]
Storm Petrel	0.16	0.38	4.1	100%[2]	0.990[3]
Leach's Petrel	0.2	0.46	4.1	100%[2]	0.990[3]
Cormorant	0.9	1.45	15.2	100%[2]	0.990[3]
Shag	0.725	1.03	15.4	100%[2]	0.990[3]
Bittern	0.75	1.3	8.8	100%	0.9928
Great Crested Grebe	0.48	0.88	21.13	100%	0.9954
Slavonian Grebe	0.34	0.62	21.13	100%	0.9954
Marsh Harrier	0.52	1.22	13.2	50%	0.9957
Hen Harrier	0.48	1.1	11.4	100%	0.9957
Osprey	0.56	1.58	10.6	50%	0.9957
Merlin	0.28	0.56	12.7	100%	0.9891
Corncrake	0.28	0.5	13	100%	0.9875
Oystercatcher	0.42	0.83	13	100%	0.9996
Ringed Plover	0.19	0.52	16	100%	0.9996
Dotterel	0.21	0.6	16.5	100%	0.9996
Golden Plover	0.28	0.72	16.5	100%	0.9996
Grey Plover	0.28	0.77	16.5	100%	0.9996

Species	Body Length (m)	Wingspan (m)	Flight Speed (m/s)	PCH[1]	Avoidance rate[1]
Lapwing	0.3	0.84	12.8	100%	0.9996
Knot	0.24	0.59	24.6	100%	0.9996
Sanderling	0.2	0.42	21.4	100%	0.9996
Purple Sandpiper	0.21	0.44	15.3	100%	0.9996
Dunlin	0.18	0.4	15.3	100%	0.9996
Ruff	0.25	0.53	16.9	100%	0.9996
Snipe	0.26	0.46	17.1	100%	0.9996
Black-tailed Godwit	0.42	0.76	18.1	100%	0.9996
Bar-tailed Godwit	0.38	0.75	18.3	100%	0.9996
Whimbrel	0.41	0.82	13.8	100%	0.9996
Curlew	0.55	0.9	15.4	100%	0.9996
Greenshank	0.32	0.69	12.3	100%	0.9996
Redshank	0.28	0.62	15.3	100%	0.9996
Turnstone	0.23	0.54	10	100%	0.9996
Arctic Skua	0.725	1.03	11	100%	0.995[4]
Great Skua	0.54	1.33	11	100%	0.995[4]
Short-eared Owl	0.38	1.02	9.7	100%	0.9957
Nightjar	0.27	0.6	9.72	100%	0.9954

1 Percentage at Collision Risk Height, value taken from Woodward *et al.* (2023)
2 Precautionary value of 100% chosen, because value not available for this species
3 Value taken from NatureScot (2023) offshore collision risk guidance note
4 Value taken from Furness (2015)

2.5 Results

2.5.1 Collision risk estimates for the Array Area are presented in Table 2.7. This includes the estimate for a single passage and for two passages, expected from two distinct migratory periods (spring and autumn migration).

Table 2.7: Outputs From the Migratory Collision Risk Model

Species	Number crossing Array Area	Collisions (no avoidance)	Avoidance rate	Collisions (single passage)	Collisions (two passages)
Whooper Swan	531	12.4	98.74%	0.16	0.31
Bean Goose	43	1.5	99.98%	0.00	0.00
Pink-footed Goose	5,250	87.4	99.99%	0.01	0.02
Icelandic Greylag Goose	12	0.3	99.98%	0.00	0.00
Barnacle Goose (Svalbard)	3,366	108.3	99.96%	0.04	0.09
Light-bellied Brent Goose (Svalbard)	337	5.5	98.51%	0.08	0.16
Shelduck	932	14.7	98.51%	0.22	0.44
Wigeon	2,119	60.9	98.51%	0.91	1.81
Teal	1,688	45.8	98.51%	0.68	1.36
Mallard	3,963	124.6	98.51%	1.86	3.71
Pintail	41	1.2	98.51%	0.02	0.03
Shoveler	122	3.4	98.51%	0.05	0.10
Pochard	151	4.1	98.51%	0.06	0.12
Tufted Duck	608	16.6	98.51%	0.25	0.49
Scaup	13	0.4	98.51%	0.01	0.01
Eider	4,748	37.0	98.51%	0.55	1.10
Long-tailed Duck	154	4.3	98.51%	0.06	0.13
Common Scoter	853	23.6	98.51%	0.35	0.70
Velvet Scoter	85	2.5	98.51%	0.04	0.07
Goldeneye	144	4.0	98.51%	0.06	0.12
Red-breasted Merganser	40	1.1	98.51%	0.02	0.03
Goosander (non-breeding)	192	5.7	99.54%	0.03	0.05
Goosander (Breeding male moult)	171	5.1	99.54%	0.02	0.05
Red-throated Diver (breeding)	17	0.1	99.96%	0.00	0.00

Species	Number crossing Array Area	Collisions (no avoidance)	Avoidance rate	Collisions (single passage)	Collisions (two passages)
Red-throated Diver (non-breeding)	209	1.6	99.96%	0.00	0.00
Manx Shearwater	2,179	6.5	99.00%	0.07	0.13
Storm Petrel	463	2.3	99.00%	0.02	0.05
Leach's Petrel	436	2.3	99.00%	0.02	0.05
Cormorant	153	1.5	99.00%	0.01	0.03
Shag	617	5.3	99.00%	0.05	0.11
Bittern	9	0.4	99.28%	0.00	0.01
Great Crested Grebe	2	0.0	99.54%	0.00	0.00
Slavonian Grebe	6	0.2	99.54%	0.00	0.00
Marsh Harrier	53	0.9	99.57%	0.00	0.01
Hen Harrier (breeding)	14	0.5	99.98%	0.00	0.00
Hen Harrier (non-breeding)	3	0.1	99.98%	0.00	0.00
Osprey	15	0.3	99.57%	0.00	0.00
Merlin	26	0.8	98.91%	0.01	0.02
Corncrake	336	9.0	98.75%	0.11	0.22
Oystercatcher (breeding)	1,607	49.3	99.99%	0.00	0.01
Oystercatcher (non-breeding)	1,182	36.3	99.99%	0.00	0.01
Ringed Plover (breeding)	62	1.5	99.96%	0.00	0.00
Ringed Plover (non-breeding)	186	4.6	99.96%	0.00	0.00
Dotterel (breeding and passage)	2	0.3	99.96%	0.00	0.00
Dotterel (within breeding season)	11	0.0	99.96%	0.00	0.00
Golden Plover (breeding)	570	15.0	98.51%	0.22	0.45
Golden Plover (non-breeding)	2,013	53.1	98.51%	0.79	1.58
Grey Plover	597	15.7	99.96%	0.01	0.01
Lapwing	18,975	538.1	99.96%	0.22	0.43

Species	Number crossing Array Area	Collisions (no avoidance)	Avoidance rate	Collisions (single passage)	Collisions (two passages)
Knot	1,400	34.5	99.96%	0.01	0.03
Sanderling	778	18.6	99.96%	0.01	0.01
Purple Sandpiper	99	2.5	99.96%	0.00	0.00
Dunlin C. a. schinzii and C. a. arctica (passage)	3,528	86.6	98.51%	1.29	2.58
Dunlin *C. a. alpina* (passage and winter)	1,723	42.3	98.51%	0.63	1.26
Ruff	111	2.8	99.96%	0.00	0.00
Snipe	23,794	609.2	99.96%	0.24	0.49
Black-tailed Godwit *L. l. islandica*	460	13.2	98.51%	0.20	0.39
Bar-tailed Godwit	3,577	97.7	99.96%	0.04	0.08
Whimbrel	44	1.3	99.96%	0.00	0.00
Curlew (breeding)	654	20.5	99.96%	0.01	0.02
Curlew (non-breeding)	727	22.8	99.96%	0.01	0.02
Greenshank	32	0.9	99.96%	0.00	0.00
Redshank *T. t. britannica* (breeding)	409	10.9	99.54%	0.05	0.10
Redshank *T. t. robusta* (non-breeding)	2,693	71.9	99.54%	0.33	0.66
Redshank *T. t. totanus* (non-breeding)	2,458	65.6	99.54%	0.30	0.60
Turnstone	1,344	38.7	99.96%	0.02	0.03
Arctic Skua	9	0.4	99.50%	0.00	0.00
Great Skua	109	3.8	99.50%	0.02	0.04
Short-eared Owl	68	2.2	99.57%	0.01	0.02
Nightjar	198	6.1	99.54%	0.03	0.06

3 Summary

3.1.1 This report has combined the MAT tool and mCRM Shiny application to calculate the most robust estimate of collision risk for migratory birds crossing the Array Area during migration, using precautionary parameters.

3.1.2 Table 3.1 gives a summary of collision impacts that were higher than zero when rounded to the nearest bird (impacts equal to or exceeding 0.5 birds). This demonstrates that most migratory bird species have a collision estimate of zero, except for wigeon (2), teal (1), mallard (4), eider (1), common scoter (1), golden plover (2), dunlin (4), and redshank (1).

3.1.3 As no correction has been applied for curtailment (see Paragraph 2.3.5), the number of collisions presented within this Technical Report are considered a worst case scenario for migratory species.

Table 3.1: Migratory Species With a Collision Impact Larger Than Zero

Species	Number crossing Array Area	Collisions (two passages)
Wigeon	2,119	1.81
Teal	1,688	1.36
Mallard	3,963	3.71
Eider	4,748	1.10
Common Scoter	853	0.70
Golden Plover (combined)	2,583	2.03
Dunlin (combined)	5,251	3.84
Redshank (combined)	5,560	1.36

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