Appendix 11.2, Annex B: Offshore Ornithology Migratory CRM Estimates

Array EIA Report

2024

SSE Renewables Marubeni CIP Copenhagen Infrastructure Partners

ossian

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1. INTRODUCTION

1. This annex covers the potential impacts as a result of collision risk from the Ossian Array, hereafter referred to as "the Array", on migratory waterbirds, seabirds, and terrestrial birds that are features of United Kingdom (UK) Special Protection Areas (SPAs) and migrate over the open sea. Only migratory species which are not adequately characterised through the site-specific Digital Aerial Surveys (DAS) are considered in this analysis (i.e. species where sufficient coverage was not obtained during the DAS to enable their potential status as a valued ornithological receptor (VOR) to be determined in volume 3, appendix 11.1) Refer to Table 3.2 for a list of species included in this annex. For the purposes of this analysis, migratory waterbirds refers to species of ducks and geese (Anatidae), waders (*Charadriiformes*) that are features of UK SPAs. Migratory seabirds refers to species of tern (Sternidae), petrel (Procellariidae*)*, skua (Stercorariidae) and little gull *Hydrocoloeus minutus*. In addition, a small number of terrestrial raptors known to migrate across waters and potentially be at risk from collision with wind turbines are also included (such as hen harrier *Circus cyaneus* and short-eared owl *Asio flammeus*). This migratory bird collision risk modelling annex provides numbers of predicted collisions of migratory waterbird and seabird species based on the species/populations identified that could potentially cross the Array. The results of collision risk modelling for regularly occurring seabirds are provided in volume 3, appendix 11.2.

2. This annex provides a quantitative estimate of the potential collision risk to migratory birds, based on the Strategic Ornithological Support Services Migration Assessment Tool (SOSSMAT) (Wright *et al*., 2012). At the time this annex was produced, the Scottish Government had commissioned a project to deliver updated tools to assess the potential collision risk to migratory birds. An updated review of birds on migration in Scottish waters has been published (Woodward *et al*., 2023), the findings of which will be considered in the EIA to inform the assessment. In addition, a new quantitative migration Collision Risk Model (mCRM) is under development, but currently undergoing testing and seeking approval, and therefore not yet ready to be used for assessment (mCRM Authors, 2021). The SOSSMAT therefore represents the best available tool currently available to provide quantitative estimates of the collision risk to migratory birds.

2. ARRAY OFFSHORE ORNITHOLOGY STUDY AREA

3. The migratory collision risk modelling undertaken within this annex have utilised information that identifies connectivity between the migratory routes of migratory waterbirds and seabirds and the Array only. The Array is located in the North Sea, approximately 80 km south-east of Aberdeen at the nearest point. The Array is 859 km^2 in size, and is illustrated in Figure 2.1. The areas utilised by species of relevance to this annex are species-specific and much larger than the geographic area of the Array illustrated on Figure 2.1. This figure therefore focusses on the area in which impacts will occur (i.e. the Array).

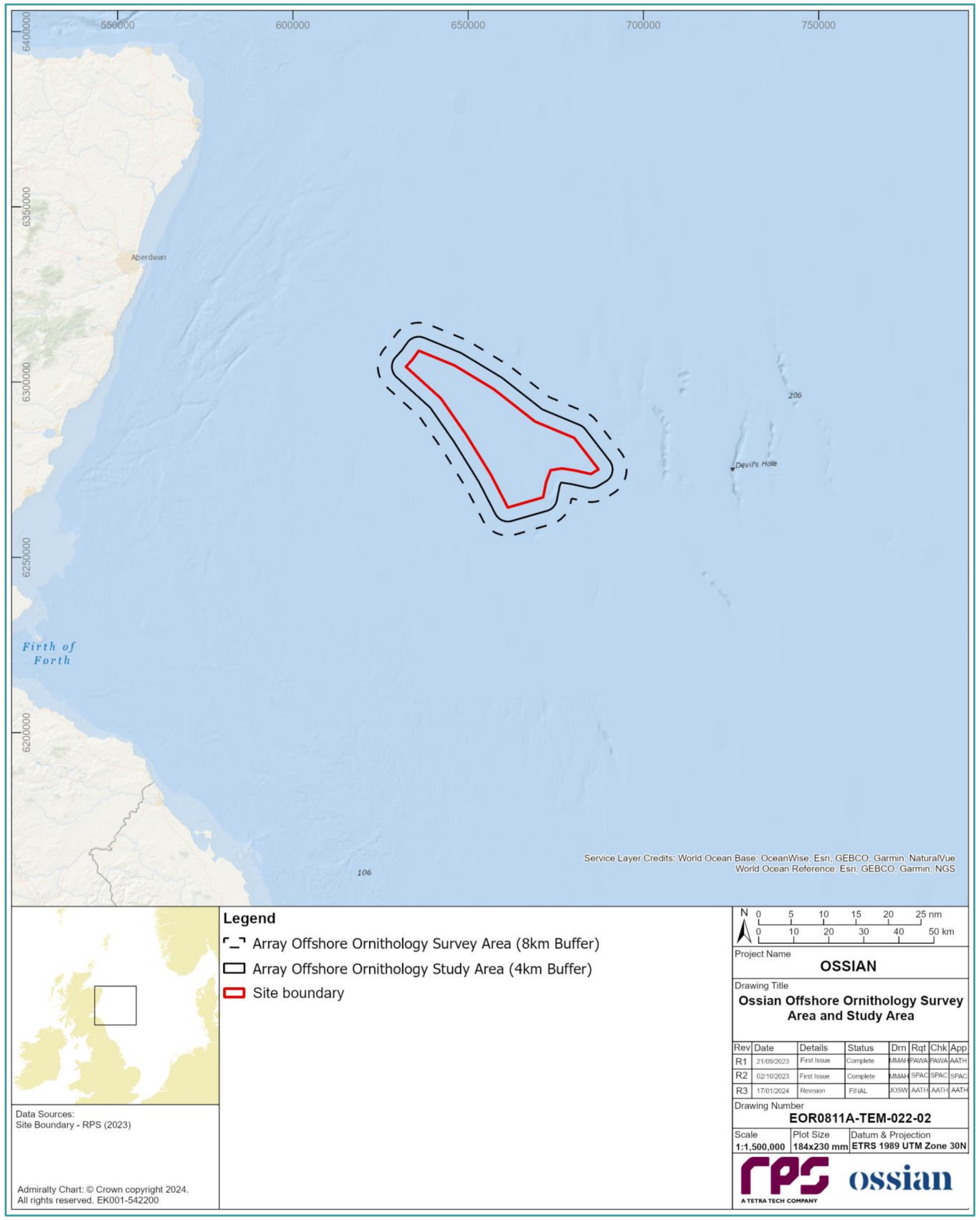

Figure 2.1: Offshore Ornithology Study Areas Used for Collision Risk Modelling for Migratory Waterbirds and Seabirds

3. METHODOLOGY

3.1. OVERVIEW

4. The Strategic Ornithological Support Services Migration Assessment Tool (SOSSMAT) (hereafter referred to as the shortened acronym Migration Assessment Tool, "MAT") (Wright *et al*., 2012) was used to assess the population size of migratory waterbird species designated as features of the UK SPA network that may cross the Array during migration periods.

5. The study area for the migratory collision modelling is the footprint of the Array, as collision with offshore wind turbines can only take place within the Array itself. The resulting number of migratory birds estimated to cross the Array was inputted into the Band (2012) single transit Collision Risk Model (CRM).

3.2. MIGRATORY ROUTE MODELLING

3.2.1. INTRODUCTION

6. The modelling of migratory routes for collision assessment uses guidance from the British Trust for Ornithology (BTO) (Wright *et al*., 2012), relating to the MAT which details a method in which the migration passages of migratory species can be calculated.

7. The MAT tool is based on generic flightlines between the UK coast and other coastlines (Europe, Scandinavia, Iceland and Greenland) and assumes migratory birds approximately follow such a straight line migration path between landmasses. Therefore, the guidance (Wright *et al*., 2012) states that, as a general rule, the use of the MAT is not relevant for pelagic seabirds or land based seabirds that follow the coastline during migration. For those seabirds that follow the coastline, it would be more realistic to use the banded approach set out in WWT Consulting and MacArthur Green (2014). However, that approach assumes all such seabirds fly within 60 km of the coast (plus a deviation when crossing inlets and bays). Under this approach, the Array is outside the migratory route of all seabirds considered and therefore has zero potential for impact. However, in order to provide a greater level of precaution to the assessment, seabirds that would not be adequately characterised through DAS (such as Manx shearwater *Puffinus puffinus*, which is typically active at night) have therefore also been included in the MAT approach, which provides a quantitative estimate of migratory passages that can be used for CRM.

3.2.2. MIGRATION ROUTES

8. The MAT utilises 251,599 lines of connectivity which were constructed as line of sight sea crossings for migratory waterbirds travelling across UK waters. These lines were then assigned on a species-specific basis based on the migration routes presented in Wright *et al*. (2012).

9. Provided with the BTO guidance, is a Geographic Information System (GIS) shapefile which is used to determine those lines of connectivity which interact with an offshore wind farm site. A dataset which details those lines which interact with the offshore wind farm site can then be extracted from GIS and imported into the MAT. For the Array, this dataset contained 5,254 lines of connectivity.

10. The next stage in the process is to decide which sea crossings are pertinent to the wind farm being assessed. The routes selected within the MAT model are shown in Table 3.1 (for example code FAENOR means that a migration route between Faeroe Islands (FAE) and Norway (NOR) exists). These routes followed the broad migrating patterns known to occur across the British Isles and are summarised below:

- Birds that breed in Scandinavia and northern Russia and migrate to Britain or Ireland for winter.
- Birds that breed in Britain or Ireland and migrate to Europe for winter.
- Birds that use Britain and Ireland on passage, for example migrating between Iceland and southern Europe.

11. Note that the MAT is not directional and therefore the route "Start" and "End" are interchangeable. The portions of coastline which are considered for the "Start" and "End" of migration routes are presented in Figure 3.1.

Table 3.1: Migration Routes Selected and Corresponding MAT Code

MAT Code	Start Migration	End Migration
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
NIHSHE	Northern Ireland Hebridean Seas coast	Shetland
NORENS	Norway	England North Sea coast
NORORK	Norway	Orkney
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
SHESHS	Shetland	Scottish mainland Hebridean Seas coast

MAT Code	Start Migration	End Migration
SHESNS	Shetland	Scottish mainland North Sea coast

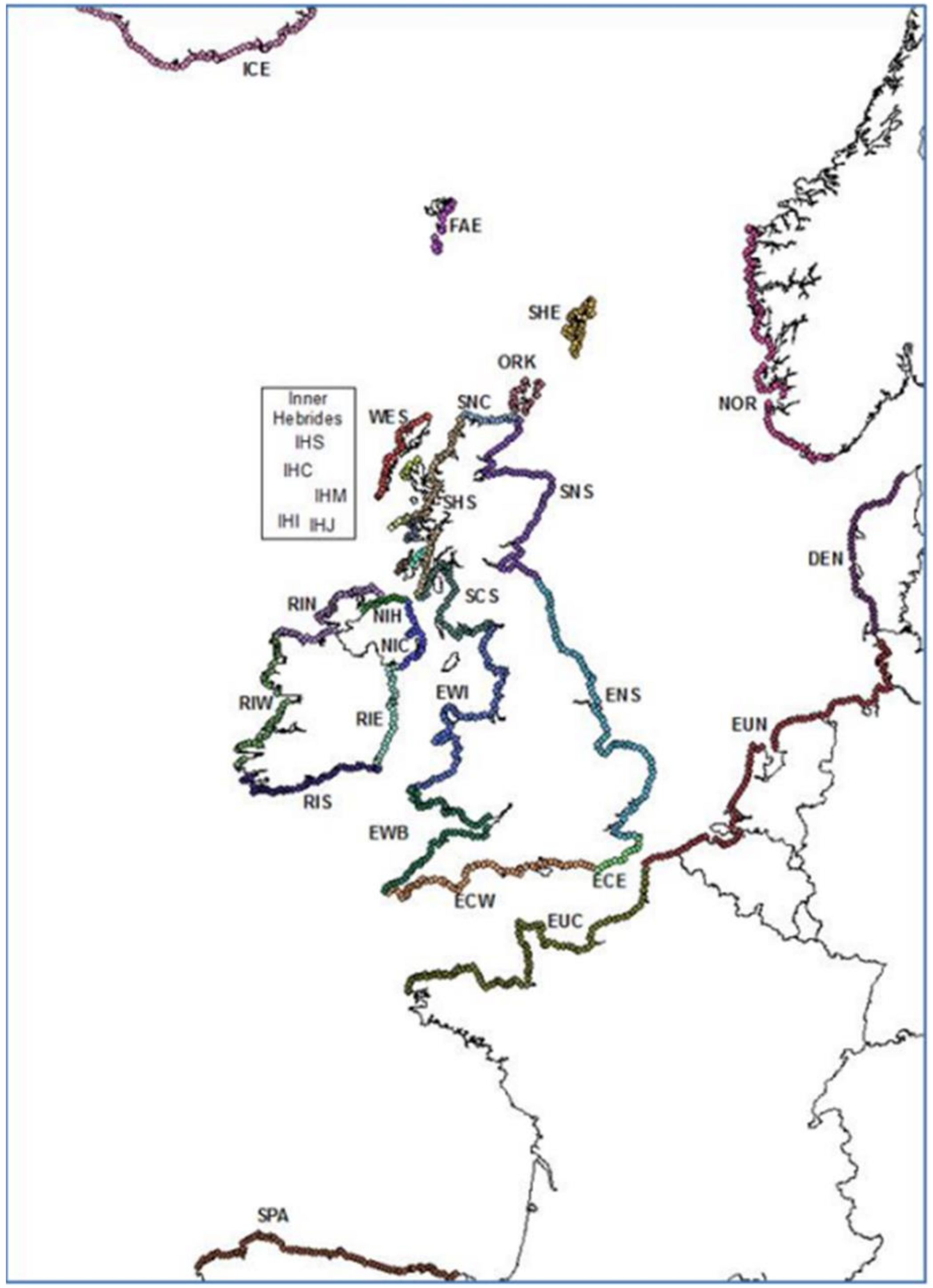

Figure 3.1: Coastal Zones Defined for the MAT. The Thirty Different Coastal Zones Defined for the Purpose of the Migration Assessment are Labelled and Shown in Different Colours in the Figure Above (Source: Wright *et al*., 2012)

3.2.3. POPULATION SIZE AND POPULATION CORRECTION FACTOR

12. The percentage of lines crossing the Array was derived for each species known to migrate along the route selected in MAT. In the MAT worksheets, the number of birds crossing the Array was calculated by adding parameters such as population size and population correction factor (% of the population using the relevant sea crossing). The MAT tool only covers migratory birds which are features of UK SPAs and commonly occurring Annex I species (Wright *et al.*, 2012).

13. The migration patterns of passerines and near passerines, particularly far offshore, can be difficult to discern as individuals are small and hard to spot in a marine environment (Blew *et al*., 2008). Furthermore, passerines may migrate at night and during conditions of poor visibility. For species with less defined migration routes, the MAT cannot be used. A qualitative assessment of all migratory birds potentially passing through the Array is set out in volume 2, chapter 11.

14. The proportion of each species' population predicted to migrate along the selected routes (i.e. the population correction factor) was estimated using the information and maps presented in Wright *et al*. (2012). Updated population counts were taken from Woodward *et al.* (2020), with the most relevant population count used. Not all populations had a Great Britain estimate (i.e. excluding the Northern Ireland population), with only a UK estimate given (i.e. including the Northern Ireland population). These population parameters are presented in Table 3.2.

Table 3.2: Population Sizes and Population Correction Factors Used for Each Species

Species	Scientific Name	Population Size	Population Correction Factor (Percent of Population Estimated to be Using Relevant Sea-Crossings)	Source
Whooper Swan	*Cygnus cygnus*	19,500	50	Woodward *et al*. 2020 – Great Britain (GB) population
Bean Goose	*Anser fabalis*	230	100	Woodward *et al*. 2020 - GB population
Pink-footed Goose	*Anser brachyrhynchus*	510,000	50	Woodward *et al*. 2020 - GB population
Barnacle Goose (Svalbard population)	*Branta leucopsis*	33,000	100	Woodward *et al*. 2020 - GB population
Shelduck	*Tadorna tadorna*	51,000	50	Woodward *et al*. 2020 - GB population
Wigeon	*Anas penelope*	450,000	20	Woodward *et al*. 2020 - GB population
Teal	*Anas crecca*	435,000	20	Woodward *et al*. 2020 - GB population
Mallard	*Anas platyrhynchos*	675,000	20	Woodward *et al*. 2020 - GB population
Pintail	*Anas acuta*	20,000	10	Woodward *et al*. 2020 - GB population
Shoveler	*Anas clypeata*	19,500	20	Woodward *et al*. 2020 - GB population
Pochard	*Aythya ferina*	29,000	20	Woodward *et al*. 2020 - GB population
Tufted Duck	*Aythya fuligula*	140,000	20	Woodward *et al*. 2020 - GB population
Scaup	*Aythya marila*	6,400	10	Woodward *et al*. 2020 - GB population
Eider	*Somateria mollissima*	49,000	90	Woodward *et al*. 2020 - GB population

Species	Scientific Name	Population Size	Population Correction Factor (Percent of Population Estimated to be Using Relevant Sea-Crossings)	Source
Long-tailed Duck	*Clangula hyemalis*	13,500	50	Woodward *et al*. 2020 - GB population
Common Scoter	*Melanitta nigra*	135,000	30	Woodward *et al*. 2020 - GB population
Velvet Scoter	*Melanitta fusca*	3,350	70	Woodward *et al*. 2020 - GB population
Goldeneye	*Bucephala clangula*	21,000	20	Woodward *et al*. 2020 - GB population
Red-breasted Merganser	*Mergus serrator*	11,000	10	Woodward *et al*. 2020 - GB population
Goosander (non-breeding)	*Mergus merganser*	14,500	30	Woodward *et al*. 2020 - GB population
Goosander (breeding male moult migration)	*Mergus mergus*	4,800	100	Woodward *et al*. 2020 - GB population
Red-throated Diver (breeding)	*Gavia stellata*	2,500	20	Woodward *et al*. 2020 - GB population
Red-throated Diver (non-breeding)	*Gavia stellata*	21,500	30	Woodward *et al*. 2020 - GB population
Manx Shearwater	*Puffinus puffinus*	600,000	20	Woodward *et al*. 2020 - GB population
Cormorant	*Phalacrocorax carbo*	64,500	10	Woodward *et al*. 2020 - GB population
Shag	*Phalacrocorax aristotelis*	110,000	20	Woodward *et al*. 2020 - GB population
Great Crested Grebe	*Podiceps cristatus*	18,000	10	Woodward *et al*. 2020 - GB population
Slavonian Grebe	*Podiceps auritus*	995	20	Woodward *et al*. 2020 - GB population
Hen Harrier (breeding)	*Circus cyaneus*	1,090	20	Woodward *et al*. 2020 - GB population
Hen Harrier (non-breeding)	*Circus cyaneus*	545	20	Woodward *et al*. 2020 - UK population
Merlin	*Falco columbarius*	2,300	20	Woodward *et al*. 2020 - GB population
Oystercatcher (breeding)	*Haematopus ostralegus*	191,000	30	Woodward *et al*. 2020 - GB population
Oystercatcher (non-breeding)	*Haematopus ostralegus*	305,000	20	Woodward *et al*. 2020 - GB population
Ringed Plover (breeding)	*Charadrius hiaticula*	10,900	20	Woodward *et al*. 2020 - GB population
Ringed Plover (non-breeding)	*Charadrius hiaticula*	42,500	20	Woodward *et al*. 2020 - GB population
Golden Plover (breeding)	*Pluvialis apricaria*	101,000	20	Woodward *et al*. 2020 - GB population
Golden Plover (non-breeding)	*Pluvialis apricaria*	410,000	20	Woodward *et al*. 2020 - GB population
Grey Plover	*Pluvialis squatarola*	33,500	20	Woodward *et al*. 2020 - GB population
Lapwing	*Vanellus vanellus*	635,000	20	Woodward *et al*. 2020 - GB population
Knot	*Calidris canutus*	265,000	20	Woodward *et al*. 2020 - GB population
Sanderling	*Calidris alba*	20,500	20	Woodward *et al*. 2020 - GB population
Purple Sandpiper	*Calidris maritima*	9,900	20	Woodward *et al*. 2020 - GB population
Dunlin (passage)	*Calidris alpina schinzii and C.a.arctica*	979,000	20	Passage population from Wright *et al*. (2012)
Dunlin (passage and winter)	*Calidris alpina alpina*	350,000	20	Woodward *et al*. 2020 - GB population
Ruff	*Philomachus pugnax*	920	20	Woodward *et al*. 2020 - GB population
Snipe	*Gallinago gallinago*	1,100,000	20	Woodward *et al*. 2020 - GB population
Black-tailed Godwit	*Limosa limosa islandica*	41,000	20	Woodward *et al*. 2020 - GB population
Bar-tailed Godwit	*Limosa lapponica*	53,500	20	Woodward *et al*. 2020 - GB population
Whimbrel	*Numenius phaeopus*	41	20	Woodward *et al*. 2020 - UK population
Curlew (breeding)	*Numenius arquata*	117,000	20	Woodward *et al*. 2020 - GB population
Curlew (non-breeding)	*Numenius arquata*	125,000	20	Woodward *et al*. 2020 - GB population
Greenshank	*Tringa nebularia*	920	20	Woodward *et al*. 2020 - UK population
Redshank (breeding)	*Tringa totanus britannica*	44,000	30	Woodward *et al*. 2020 - GB population
Redshank (Icelandic population) (non-breeding)	*Tringa totanus robusta*	100,000	20	Woodward *et al*. 2020 - GB population
Turnstone	*Arenaria interpres*	43,000	20	Woodward *et al*. 2020 - GB population
Red-necked Phalarope	*Phalaropus lobatus*	128	10	Woodward *et al*. 2020 - GB population
Short-eared Owl	*Asio flammeus*	4,400	20	Woodward *et al*. 2020 - GB population

3.2.4. COLLISION RISK MODELLING AND AVOIDANCE RATES

15. As recommended in the MAT guidance, the Band (2012) model was used for the CRM. Input parameters for the wind turbine specifications used within the CRM are shown in Table 3.3. These values are based on the Maximum Design Scenario (MDS) parameter values for collision risk. Species/populations input parameters are shown in Table 3.4. While species biometrics (length and wingspan) were taken from the BTO Bird Facts resource (Robinson, 2005), flight speeds were taken from Alerstam *et al*. (2007) for most species. For some species (Table 3.3), there were no estimations in Alerstam *et al*. (2007). As such, the same assumptions were followed as those used by WWT Consulting and MacArthur Green (2014). In this document, flight speed of species for which insufficient evidence existed were derived from species of similar genus and flight characteristics (e.g. European golden plover and American golden plover *Pluvialis dominica*).

16. The width of the migration corridor, required for the migratory stage of the CRM, was calculated using ArcGIS Pro v3.1.3. The migration corridor was taken as the longest width of the Array across which a species migratory route would cross and was calculated to be 83.5 km. The width of the migration corridor is crucial for defining the spatial extent of the area where collision risks are assessed. It ensures that the

model considers a broader zone, accounting for the potential interaction of birds across a wider area and allowing for a more accurate assessment of collision risk. The proportion of flights upwind for migratory species was assumed to be 50% for all species. This is a standard approach, based on the assumption that migratory birds will fly from their wintering grounds to their breeding grounds and back again in a single year. The relevance of considering upwind flights lies in the significant influence of wind direction on the energy expenditure and flight strategies of these birds. Birds often capitalise on upwind conditions during migration, as flying with the wind can reduce the energy cost of long distance flights. It is assumed a 50% proportion of upwind flights is a practical approximation, acknowledging the expected variability in flight patterns influenced by prevailing wind directions. This consideration is crucial for accurately assessing the energy requirements, flight dynamics, and potential collision risks associated with migratory bird movements.

17. The Band (2012) model incorporates two approaches to calculating the risk of collision referred to as the 'Basic' and 'Extended' versions of the model. A key difference between these versions is the extent to which flight height patterns of seabirds are accounted (Band, 2012). The distribution of seabird flights across the sea is generally skewed towards lower altitudes. As outlined by Band (2012), there are three consequences of a skewed flight height distribution:

- the proportion of birds flying at risk height decreases as the height of the rotor (i.e. air gap) is increased;
- a greater proportion of birds miss the rotor where flights lie close to the bottom of the rotor swept area; and
- the collision risk, for birds passing through the lower parts of a rotor, is less than the average collision risk for the whole rotor.

18. Both the Basic and Extended models of Band (2012) allow for the use of four 'Options' termed Options 1 to 4. Options 1 and 2 use the Basic model with Options 3 and 4 utilising the Extended model. The difference between the two Options under each model is linked to the use of flight height data. Options 2 and 3 use generic data from Johnston *et al.* (2014) whereas Options 1 and 4 use site-specific data derived from site-specific surveys.

19. Generic flight height distributions, used for Options 2 and 3 of Band (2012), are unavailable for most of the species considered in this annex and therefore it has not been possible to use these model options. Therefore, Option 2 has been used. For most species, the generic Proportion of birds at Collision Height (PCH) values from Wright *et al*. (2012) was used, but where available the PCH was extracted from Johnston *et al* (2014).

20. Collision risk estimates were calculated using a range of avoidance rates including a default avoidance rate of 98%, as recommended by NatureScot (formerly Scottish Natural Heritage (SNH)) guidance (SNH, 2010).

Table 3.3: Wind Turbine Parameters for the Array

Parameter	Parameter value
Latitude (centre of Array)	56.7°
Maximum number of wind turbines	265
Tidal offset (m) (Mean Sea Level (MSL))	1.8
Number of rotor blades per wind turbine	3
Maximum chord width (m)	6.7
Average blade pitch (degrees)	10
Maximum rotor radius (m)	118
Maximum rotor speed (rpm)	8.4
Lower blade tip height above Highest Astronomical Tide (HAT) (m)	32.3
Minimum air gap at Lowest Astronomical Tide (LAT) (m)	36

Table 3.4: Species and Population Parameters Used in the Band (2012) Single Transit CRM

Species	Length (m)	Wingspan (m)	Flight Speed (m/s)[1]	Proportion at PCH
Whooper Swan	1.52	2.3	17.5	50%
Bean Goose	0.75	1.58	15.8	30%
Pink-footed Goose	0.68	1.52	16.9	30%
Svalbard Barnacle Goose	0.64	1.38	17.4	30%
Shelduck	0.62	1.12	18.2	15%
Wigeon	0.48	0.8	18.5	15%
Teal	0.36	0.61	17.4	15%
Mallard	0.58	0.9	15.86	15%
Pintail	0.58	0.88	21.9	15%
Shoveler	0.48	0.77	18.3	15%
Pochard	0.46	0.77	23.6	15%
Tufted Duck	0.44	0.7	21.1	15%
Scaup	0.46	0.78	21.1	15%
Eider	0.6	0.94	17.34	35%
Long-tailed Duck	0.44	0.76	19.7	15%
Common Scoter	0.49	0.84	22.1	2%
Velvet Scoter	0.54	0.94	20.1	15%
Goldeneye	0.46	0.72	20.3	15%
Red-breasted Merganser	0.55	0.78	22	15%
Goosander	0.62	0.9	19.7	15%
Red-throated Diver	0.61	1.11	18.6	6%
Manx Shearwater	0.34	0.83	11.3	0%
Cormorant	0.9	1.45	15.2	2%
Shag	0.725	1.03	15.4	13%
Great Crested Grebe	0.48	0.88	21.13	10%
Slavonian Grebe	0.34	0.62	21.13	10%
Hen Harrier	0.48	1.1	11.4	50%
Merlin	0.28	0.56	12.7	50%
Oystercatcher	0.42	0.83	13	25%
Ringed Plover	0.19	0.52	16	25%
Golden Plover	0.28	0.72	16.5	25%
Grey Plover	0.28	0.77	16.5	25%
Lapwing	0.3	0.84	12.8	25%
Knot	0.24	0.59	24.6	25%
Sanderling	0.2	0.42	21.4	25%
Purple Sandpiper	0.21	0.44	15.3	25%
Dunlin (*C.a.schinzii* and *C.a.arctica*) (passage) Dunlin (*C.a.alpina*) (passage and winter)	0.18	0.4	15.3	25%
Ruff	0.25	0.53	16.9	25%
Snipe	0.26	0.46	17.1	25%
Black-tailed Godwit	0.42	0.76	18.1	25%
Bar-tailed Godwit	0.38	0.75	18.3	25%
Whimbrel	0.41	0.82	13.8	25%
Curlew (breeding) Curlew (non-breeding)	0.55	0.9	15.4	25%
Greenshank	0.32	0.69	12.3	25%
Redshank (breeding) Redshank (Icelandic population) (non-breeding)	0.28	0.62	15.3	25%
Turnstone	0.23	0.54	10	25%
Red-necked Phalarope	0.18	0.36	10.2	25%
Short-eared Owl	0.38	1.02	9.7	50%

[1] In the absence of data in Alerstam et al. (2007), the flight speed was from a bird species of a similar genus/group and with similar biometrics (i.e. wingspan and length).

3.3. RESULTS

21. Table 3.5 presents the proportion of the relevant population and expected number of migratory seabirds and waterbirds crossing the Array annually, as well as collision risk estimates for a range of avoidance rates. For all species, it was assumed that there were two migration periods per year (i.e. spring and autumn) through the Array.

Table 3.5: Number of Each Species Crossing the Array per Annum and Collision Risk Mortality Estimates

Species	Proportion of Migrants Crossing the Array per Migration (%)	No. Crossing the Array per Annum	Collision Risk Estimates (Avoidance Rate (%))				
			No avoidance	95	98	99	99.5
Whooper Swan	3.29	642	13	1	0	0	0
Bean Goose	3.73	18	0	0	0	0	0
Pink-footed Goose	3.80	1,9354	168	8	3	2	1
Svalbard Barnacle Goose	6.91	4,560	38	2	1	0	0
Shelduck	4.49	2,290	9	0	0	0	0
Wigeon	3.64	6,544	25	1	0	0	0
Teal	3.62	6,292	22	1	0	0	0
Mallard	4.49	12,120	50	2	1	0	0
Pintail	3.62	144	1	0	0	0	0
Shoveler	3.28	256	1	0	0	0	0
Pochard	3.28	380	1	0	0	0	0
Tufted Duck	3.52	1,972	7	0	0	0	0
Scaup	2.16	28	0	0	0	0	0
Eider	16.50	14,550	137	3	1	1	0
Long-tailed Duck	4.49	606	2	0	0	0	0
Common Scoter	3.62	2,930	1	0	0	0	0
Velvet Scoter	5.04	236	1	0	0	0	0
Goldeneye	4.49	378	1	0	0	0	0
Red-breasted Merganser	3.52	78	0	0	0	0	0
Goosander (non-breeding)	4.87	424	2	0	0	0	0
Goosander (Breeding Male moult migration)	6.88	660	3	0	0	0	0
Red-throated Diver (breeding)	5.35	54	0	0	0	0	0
Red-throated Diver (non-breeding)	3.53	456	1	0	0	0	0
Manx Shearwater	3.49	8,372	0	0	0	0	0
Cormorant	4.43	572	0	0	0	0	0
Shag	5.24	2,304	9	0	0	0	0
Great Crested Grebe	1.20	44	0	0	0	0	0
Slavonian Grebe	3.62	14	0	0	0	0	0
Hen Harrier (breeding)	2.04	8	0	0	0	0	0
Hen Harrier (non-breeding)	5.15	12	0	0	0	0	0
Merlin	3.35	30	0	0	0	0	0
Oystercatcher (breeding)	5.24	6,000	40	2	1	0	0
Oystercatcher (non-breeding)	3.62	4,412	30	1	1	0	0
Ringed Plover (breeding)	5.32	232	1	0	0	0	0
Ringed Plover (non-breeding)	4.04	686	4	0	0	0	0
Golden Plover (breeding)	5.30	2142	12	1	0	0	0
Golden Plover (non-breeding)	3.99	6,546	38	2	1	0	0
Grey Plover	4.50	604	4	0	0	0	0
Lapwing	4.50	11,438	72	4	1	1	0
Knot	3.61	3,830	21	1	0	0	0
Sanderling	3.61	296	2	0	0	0	0
Purple Sandpiper	2.54	100	1	0	0	0	0
Dunlin (*C.a.schinzii and C.a.arctica*) (passage)	3.64	14,238	77	4	2	1	0
Dunlin (*C.a.alpina*) (passage and winter)	2.66	3,724	20	1	0	0	0
Ruff	3.26	12	0	0	0	0	0
Snipe	3.62	15,926	89	4	2	1	0
Black-tailed Godwit	3.70	608	4	0	0	0	0
Bar-tailed Godwit	4.91	1,052	6	0	0	0	0
Whimbrel	3.66	0	0	0	0	0	0
Curlew (breeding)	5.38	2,516	17	1	0	0	0
Curlew (non-breeding)	4.55	2,274	15	1	0	0	0
Greenshank	2.40	8	0	0	0	0	0
Redshank (breeding)	4.95	1,308	8	0	0	0	0
Redshank (Icelandic population) (non-breeding)	3.72	1,486	9	0	0	0	0
Turnstone	3.61	622	4	0	0	0	0
Red-necked Phalarope	5	2	0	0	0	0	0
Short-eared Owl	4.26	74	1	0	0	0	0

3.4. SUMMARY OF COLLISION RISK ESTIMATE RESULTS

22. As can be seen in Table 3.5 at a 99.5% avoidance rate, all migratory waterbird species have a collision estimate of zero, apart from pink-footed goose and eider, which both have a collision estimate of one.

23. At an avoidance rate of 95%, the majority of migratory waterbirds species have a collision estimate of zero. However, 18 species have a collision estimate of one or more, with pink-footed goose having the highest collision estimate of eight, followed by dunlin with five, lapwing and snipe with four, and eider, oystercatcher and golden plover with three. At the default recommended avoidance rate of 98% by SNH guidance (SNH, 2010), collision estimates for pink-footed goose drop to three birds per annum, dunlin, oystercatcher and snipe drop to two birds per annum, while Svalbard barnacle goose, mallard, eider, golden plover and lapwing estimates drop to one bird per annum.

24. The Scottish Government published report "Strategic study of collision risk for birds on migration and further development of the stochastic collision risk modelling tool" provides a review of birds on migration in Scottish waters, with all species within the report having a minimum avoidance rate of 98% (Woodward *et al.,* 2023). For a precautionary approach, a mortality estimate based on a 98% avoidance rate has been taken forward to the assessment for all species.

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