Partners in UK offshore wind

MORGAN OFFSHORE WIND PROJECT: GENERATION ASSETS

Environmental Statement

Volume 4, Annex 5.4: Offshore ornithology migratory bird collision risk modelling technical report

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Image of an offshore wind farm

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Glossary

Term	Meaning
Avoidance	Probability that a bird takes successful evasive action to avoid collision with a turbine.
Collision risk	Risk of a bird lethally colliding with a wind turbine within a wind farm.
Collision risk model	A model that calculates collision risk for a species within a wind farm based on a set of turbines and bird species specific parameters. Collision risk models can be run deterministically or stochastically.
Lowest Astronomical Tide	The lowest level of the sea surface with respect to the land.
Maximum Design Scenario	The wind farm design scenario that is considered the worst case from the perspective of collision risk.
Mean Sea Level	The average level of the sea surface with respect to the land.
Ornithology	Ornithology is a branch of zoology that concerns the study of birds.
Parameter	Parameters are the input elements of a model that together affect the output of a model. In collision risk models, examples of parameters are the number of wind turbines and the length of the bird. All input parameters are described in Table 1.4 and Table 1.5.

Acronyms

Term	Meaning
BDMPS	Biologically Defined Minimum Population Scales
BTO	British Trust for Ornithology
CRM	Collision Risk Model
GIS	Geographical Information System
LAT	Lowest Astronomical Tide
MAT	Migration Assessment Tool
MDS	Maximum Design Scenario
MSL	Mean Sea Level
RPM	Rotations Per Minute
SOSSMAT	Strategic Ornithological Support Services Migration Assessment Tool
SPA	Special Protection Area

Units

Unit	Description
km	Kilometres
m	Metres
m/s	Metres per second
%	Percentage

1 Offshore ornithology migratory bird Collision Risk Modelling technical report

1.1 Introduction

1.1.1.1 This technical report covers the potential impacts as a result of collision risk from the Morgan Offshore Wind Project Generation Assets, hereafter referred to as the Morgan Generation Assets, on migratory waterbird and seabird species. For the purposes of this analysis migratory waterbirds refers to species of ducks, geese, waders and terrestrial birds that are features of UK Special Protection Areas (SPAs). Migratory seabirds refers to species of tern, petrel, skua and little gull.

1.1.1.2 During the operations and maintenance phase of the Morgan Generation Assets, the turning rotors of the wind turbines may present a risk of collision for birds that cross the Morgan Generation Assets during their migration. Stationary structures, such as offshore substation platforms, the wind turbine tower, nacelle or when rotors are not operating, are not expected to result in a material risk of collision. When a collision occurs between the turning rotor blade and the bird, it is assumed to result in direct mortality of the bird, which potentially could result in population level impacts.

1.1.1.3 This migratory waterbird and seabird collision risk modelling technical report provides numbers of predicted collisions of migratory waterbird and seabird species based on the species/populations identified to be at risk of crossing the Morgan Generation Assets. The results of collision risk modelling for regularly occurring seabirds are provided in Volume 4, Annex 5.3: Offshore ornithology collision risk modelling technical report of the Environmental Statement.

1.2 Morgan offshore ornithology study area

1.2.1.1 The collision risk analyses undertaken within this technical report have utilised information that identifies connectivity between the migratory routes of migratory waterbirds and seabirds and the Morgan Array Area only. The Morgan Array Area is located in the east Irish Sea, approximately 22.22 km (12 nm) from the Isle of Man and 37.13 km (20.1 nm) from the northwest coast of England. The Morgan Array Area is 280 km^2 in size. The Morgan Array Area is illustrated in Figure 1.1. The areas utilised by species of relevance to this technical report are species-specific and much larger than the geographic area illustrated on Figure 1.1 therefore focuses on the area in which impacts will occur.

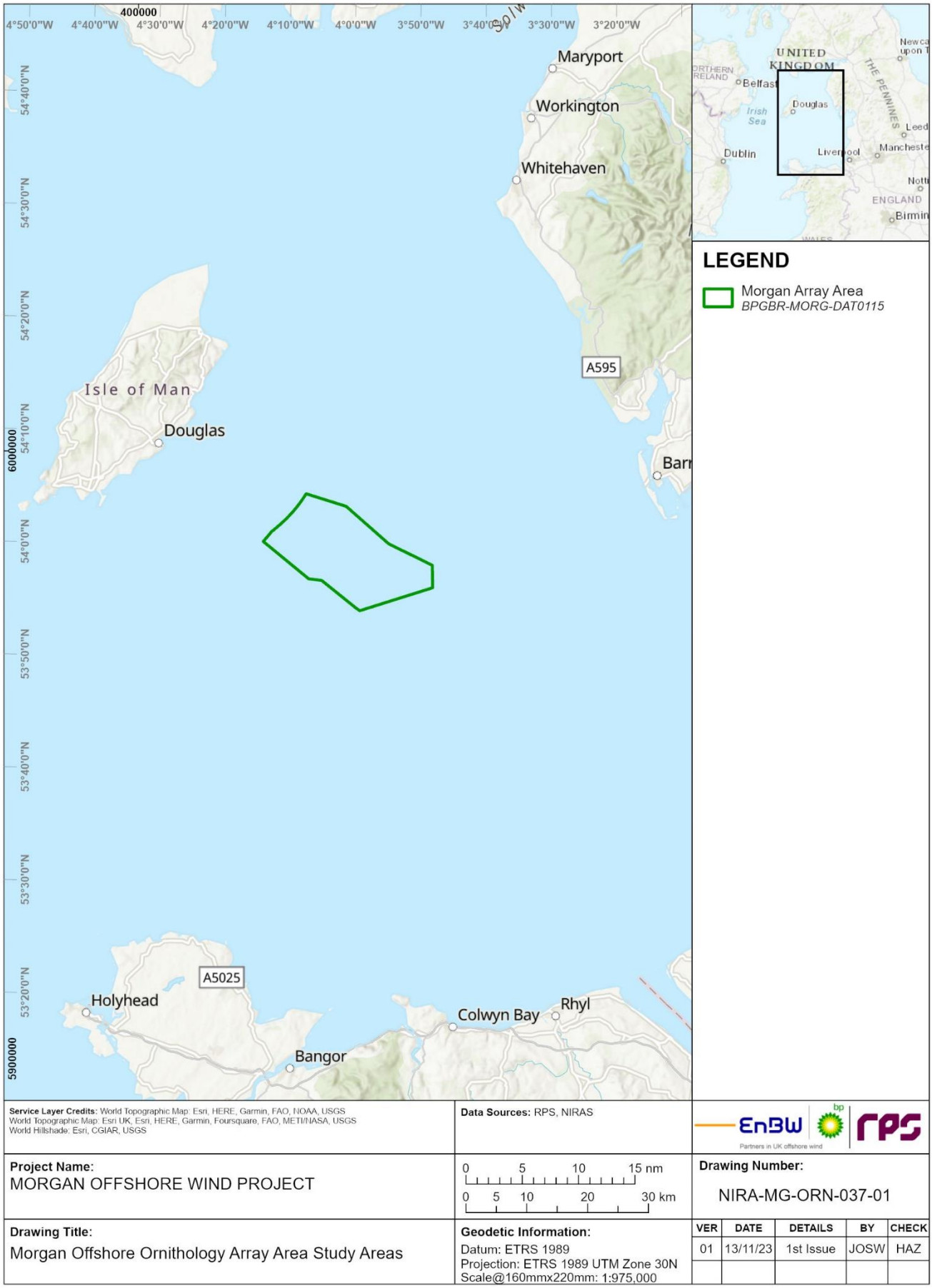

Figure 1.1: Morgan offshore ornithology study area (Morgan Array Area) used for collision risk modelling for migratory waterbirds and seabirds.

1.3 Consultation

1.3.1 Overview

1.3.1.1 A summary of the key matters raised during consultation activities undertaken to date specific to offshore ornithology is presented in Table 1.1 below, together with how these comments have been considered in the production of this technical report.

1.3.2 Evidence Plan process

1.3.2.1 The purpose of the Evidence Plan process is to agree the information the Morgan Generation Assets needs to supply to the Secretary of State, as part of the Development Consent Order (DCO) application for the Morgan Generation Assets. The Evidence Plan seeks to ensure compliance with the process for undertaking a Habitats Regulations Assessment. The development and monitoring of the Evidence Plan and its subsequent progress is being undertaken by the Steering Group. The Steering Group is comprised of the Planning Inspectorate, the Applicant, NRW, Natural England, JNCC and the MMO as the key regulatory and Statutory Nature Conservation Bodies (SNCBs). To inform the EIA and HRA process during the pre-application stage of the Morgan Generation Assets, Expert Working Groups (EWGs) were also set up to discuss and agree topic specific issues with the relevant stakeholders. Consultation was undertaken via the Offshore Ornithology EWG, with meetings held in February 2022, July 2022, November 2022, February 2023, June 2023, October 2023 and December 2023.

1.3.2.2 The responses provided and changes suggested by the stakeholders through the EWG are summarized in Table 1.1, together with changes implemented in this technical report.

1.3.3 Section 42 Consultation

1.3.3.1 A number of comments were received during the S42 consultation following submission of the Preliminary Environmental Information Report (PEIR) chapter. All the responses provided, and changes suggested by the stakeholders are presented in the consultation report (Document Reference E.3) together with changes implemented in the technical reports underpinning the Environmental Statement.

1.3.3.2 A summary of the key responses with changes implemented in this technical report of the Environmental Statement are presented in Table 1.1.

Table 1.1: Consultation responses relevant to the Technical Appendix

Date	Consultee and type of response	Comment	Response to comment raised and/or where considered in this chapter
June 2022	Scoping Opinion The Planning Inspectorate	It is noted that the approach to obtaining density and spatial abundance estimates will be discussed within the Evidence Plan process. The Inspectorate advises that given the fundamental importance of this discussion to the outcomes of the EIA process, the Applicant should seek to agree the modelling parameters used and the methodology applied with the relevant consultees, giving careful consideration to the sharing of information through the Evidence Plan process.	Modelling parameters have been taken from appropriate sources as used on previous offshore wind projects and agreed with the stakeholders as part of the EWG.
June 2023	S42 Consultation Log Natural England / NRW	Annex 10.3 does not include a collision risk assessment for migratory seabird species (e.g. skuas, terns). Natural England notes that collision risk assessments for migratory non-seabirds have been made using SOSSMAT. However, this may not be appropriate for migratory seabirds. We recommend that an alternative approach is required for migratory seabirds. More information is available in 'Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase III: Expectations for data analysis and presentation at examination for offshore wind applications'. See also WWT Consulting Ltd (2014). hiip://www gov scot/Resource/0046/00461026. pdf	Collision risk modelling for migratory seabird species is included in the Technical Report following the standard approach for these species discussed and agreed with the EWG.
		Natural England do not consider low numbers detected during baseline characterisation surveys to be adequate justification for scoping out seabird species that that may pass through the Morgan site on migration from assessments (e.g., terns and skuas). Natural England recognise that it may not be appropriate to use SOSSMAT for these species. An alternative approach is to consider a broad migratory front and apportion impacts to the project area. For example, see the Marine Scotland project on strategic assessment of collision risk of OWFs to migrating birds (WWT Consulting Ltd 2014). hiip://www gov scot/Resource/0046/00461026. pdf	Collision risk modelling for migratory seabird species is included in this Technical Report following the standard approach for these species discussed and agreed with the EWG.

Date	Consultee and type of response	Comment	Response to comment raised and/or where considered in this chapter
		NRW (A) welcome that assessment of collision risk has been made for the key sensitive species seabird species and also for non-seabird migrant species that may have been missed by digital aerial surveys within Section 10.8.4 of Chapter 10 and in Annexes 10.3 and 10.4. However, seabird species that that may pass through the Morgan Generation Assets site on migration (e.g. skuas, terns etc) shouldn't be excluded from assessments based on low numbers recorded during site-based surveys alone. It would not be appropriate to use SOSSMAT (Strategic Ornithological Support Services Migration Assessment Tool) for these species as they often migrate following coastlines at a distance offshore, rather than straight lines between point of origin and destination, which is an assumption of SOSSMAT/Migropath. Alternative approaches are therefore required, such as estimating the abundance of a species of bird migrating through a wind farm footprint area based on an apportionment of migrant bird numbers across a broad migratory front. So as an example, for a species that might pass through the Irish Sea as part of a longer migratory route (such as great skua), the risks to which the population is exposed relates to the proportion of the broad migratory front that passes across the proposed wind farm area. For a species that migrates exclusively over the sea, the broad migratory front could be defined as the width of the Irish Sea. Consideration should also be given to the distribution of birds within the broad migratory front: birds could be distributed evenly, or they might have a skewed distribution – e.g., if the species tends to avoid the coast on migration through the Irish Sea, then distribution could be biased towards the centre of the Irish Sea. This approach is broadly consistent with the approach taken in the report for the Marine Scotland project on strategic assessment of collision risk of OWFs to migrating birds (WWT Consulting Ltd., 2014) hiip://www.gov.scot/Resource/0046/00461026.pdf	Collision risk modelling for migratory seabird species is included in this Technical Report following the standard approach for these species discussed and agreed with the EWG.
February 2023	**Offshore Ornithology Expert Working Group 4 –** Natural England, Joint Nature Conservation Committee (JNCC), and the Royal Society for the Protection of Birds (RSPB), Isle of Man .	Have whooper swan and hen harrier been checked as migrants?	The SOSSMAT tool has been used to identify species for inclusion in modelling. This tool includes flight lines across UK waters for all migratory waterbird species. Whooper swan and hen harrier have flightlines intersecting the Morgan Array Area and are therefore included in modelling.

1.4 Methodology

1.4.1 Overview

1.4.1.1 Two approaches/tools were followed to quantify the number of birds that may cross the Morgan Generation Assets during migration periods:

- The Strategic Ornithological Support Services Migration Assessment Tool (SOSSMAT) (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 Morgan Generation Assets
- The approach used in the Strategic assessment of collision risk of Scottish offshore wind (WWT Consulting and MacArthur Green, 2014) to estimate proportions of the seabird population likely to pass through Scottish offshore wind farm sites.

1.4.1.2 The resulting number of migratory seabirds or waterbirds estimated to cross the Morgan Generation Assets was inputted into the Band (2012) single transit Collision Risk Model (CRM).

1.4.2 Migratory waterbirds

Overview

1.4.2.1 This modelling process uses guidance from the British Trust for Ornithology (BTO) (Wright *et al.*, 2012), relating to the SOSSMAT, which details a method in which the migration passages of migratory species can be calculated. This guidance (Wright *et al.*, 2012) states that, as a general rule, the use of the MAT is not relevant for pelagic seabirds, such as gannet, or land-based seabirds that follow the coastline during migration. However, this approach was used, where appropriate, in the collision risk modelling process for other species based on the guidance in Wright *et al.* (2012).

Migration passages

1.4.2.2 The MAT utilises 251,599 lines of connectivity which were constructed as the line of sight sea crossings for migrants 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).

1.4.2.3 Provided with the BTO guidance, is a Geographic Information System (GIS) shapefile which is used to determine those lines of connectivity which interact with a wind farm site. A dataset which details those lines which interact with the wind farm site can then be extracted from GIS and imported into the MAT. For the Morgan Generation Assets this dataset contained 2,523 lines of connectivity.

1.4.2.4 The next stage in the process is to decide which sea crossings are pertinent to the wind farm being assessed. The routes selected are shown in Table 1.2. These routes followed the broad migrating patterns known to occur across the British Isles and are described below and in Figure 1.2:

- Birds from Iceland, Canada and Greenland moving through and overwintering in Ireland
- Birds from the Arctic and sub-Arctic (further to the east) moving through the British Isles and over-wintering in Ireland

- Birds from the Arctic and sub-Arctic moving through Ireland to winter further south (e.g. Spain).

Table 1.2: Migration routes selected and corresponding SOSSMAT code.

SOSSMAT Code	Start Migration	End Migration
EWBEWI	England and Wales Bristol Channel	England and Wales Irish Sea
EWBNIC	England and Wales Bristol Channel	Northern Ireland Celtic Seas coast
EWBSCS	England and Wales Bristol Channel	Scottish mainland Celtic Seas coast
EWIEWI	England and Wales Irish Sea	England and Wales Irish Sea
EWINIC	England and Wales Irish Sea	Northern Ireland Celtic Seas coast
EWISCS	England and Wales Irish Sea	Scottish mainland Celtic Seas coast
RIEEWI	Republic of Ireland - Celtic Seas east coast	England and Wales Irish Sea
RIESCS	Republic of Ireland - Celtic Seas east coast	Scottish mainland Celtic Seas coast
SPAEWI	Spanish north coast	England and Wales Irish Sea
SPASCS	Spanish north coast	Scottish mainland Celtic Seas coast

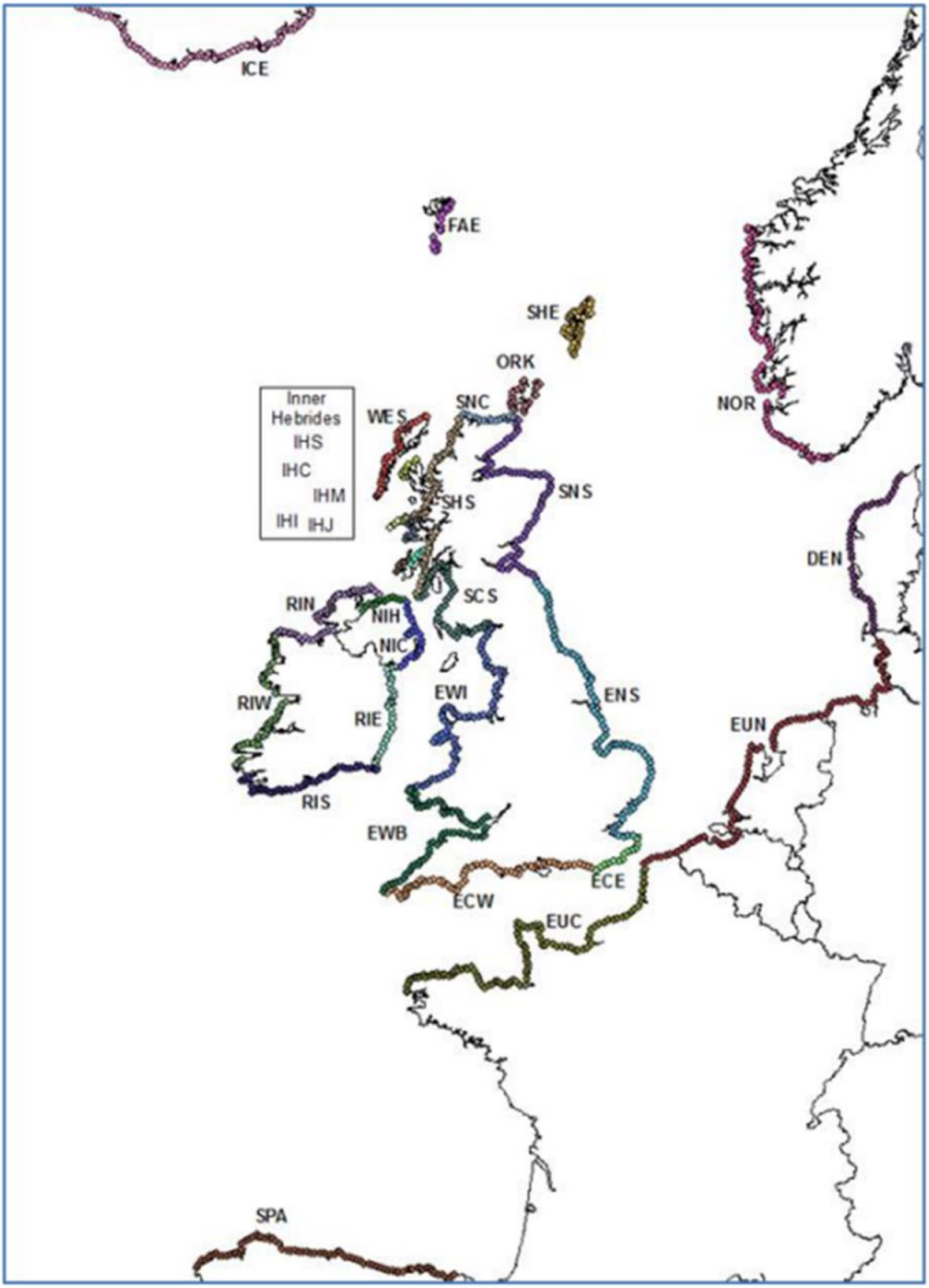

Figure 1.2: Coastal zones defined for the SOSSMAT. The thirty different coastal zones defined for the purpose of the migration assessment are labelled and shown in different colours in the figure above (Source: Wright *et al*., 2012).

Population size and population correction factor

1.4.2.5 The percentage of lines crossing the Morgan Generation Assets was derived for each species known to migrate along the route selected in SOSSMAT. In the SOSSMAT worksheets, the number of birds crossing the Morgan Generation Assets was calculated by adding parameters such as population size and population correction factor (% of the population using the relevant sea crossing).

1.4.2.6 The population of each species predicted to interact with the footprint of the Morgan Array Area (i.e. the population correction factor) was estimated using the information and maps presented in Wright *et al*. (2012). To determine the population size used for each species information of the route of each species across the Irish Sea in relation to the Morgan Generation Assets was sourced and the population defined in relation to this. For example, whooper swans move from Iceland to the UK and therefore the population used is the UK wintering population. For Bewick's swan, birds move to the UK from the east and therefore there is no connectivity between Bewick's swans that winter in the UK and the Morgan Generation Assets, however, there is connectivity between the Morgan Generation Assets and Bewick's swans that winter in Ireland and therefore the Irish population is used for this species. These population parameters are presented in Table 1.3.

Table 1.3: 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)	Notes and reference
Light-bellied brent goose (Canadian population)	*Branta bernicla hrota*	710	50	GB population (Wright *et al.,* 2012)
Greenland white-fronted goose	*Anser albifrons flavirostris*	13,000	50	GB population (Wright *et al.,* 2012)
Bewick's swan	*Cygnus columbianus bewickii*	380	50	Irish population (Wright *et al.,* 2012)
Whooper swan	*Cygnus cygnus*	19,500	50	UK winter population (Woodward *et al.,* 2020)
Shelduck	*Tadorna tadorna*	14,610	50	Irish population (Wright *et al.,* 2012)
Shoveler	*Spatula clypeata*	2,545	50	Irish population (Wright *et al.,* 2012)
Gadwall	*Mareca strepera*	630	100	Irish population (Wright *et al.,* 2012)
Wigeon	*Mareca penelope*	82,370	50	Irish population (Wright *et al.,* 2012)
Mallard	*Anas platyrhynchos*	38,250	50	Irish population (Wright *et al.,* 2012)

Species	Scientific name	Population size	Population correction factor (percent of population estimated to be using relevant sea-crossings)	Notes and reference
Pintail	*Anas acuta*	21,235	60	UK winter population (Woodward *et al.,* 2020) plus Irish population (Wright *et al.,* 2012)
Teal	*Anas crecca*	480,010	60	UK winter population (Woodward *et al.,* 2020) plus Irish population (Wright *et al.,* 2012)
Pochard	*Aythya ferina*	37,780	50	Irish population (Wright *et al.,* 2012)
Tufted duck	*Aythya fuligula*	176,610	60	UK winter population (Woodward *et al.,* 2020) plus Irish population (Wright *et al.,* 2012)
Scaup	*Aythya marila*	6,400	50	UK winter population (Woodward *et al.,* 2020)
Common scoter	*Melanitta nigra*	135,000	50	UK winter population (Woodward *et al.,* 2020)
Long-tailed duck	*Clangula hyemalis*	13,500	10	UK winter population (Woodward *et al.,* 2020)
Goldeneye	*Bucephala clangula*	9,665	50	Irish population (Wright *et al.,* 2012)
Red-breasted merganser	*Mergus serrator*	11,000	50	UK winter population (Woodward *et al.,* 2020)
Corncrake	*Crex crex*	2,200	80	UK breeding population (Woodward *et al.,* 2020)
Great crested grebe	*Podiceps cristatus*	5,385	50	Irish population (Wright *et al.,* 2012)
Slavonian grebe	*Podiceps auritus*	995	50	UK winter population (Woodward *et al.,* 2020)
Oystercatcher (breeding)	*Haematopus ostralegus*	191,000	50	UK breeding population (Woodward *et al.,* 2020)
Oystercatcher (non-breeding)	*Haematopus ostralegus*	305,000	50	UK winter population (Woodward *et al.,* 2020)
Lapwing	*Vanellus vanellus*	207,700	50	Irish population (Wright *et al.,* 2012)
Golden plover (breeding)	*Pluvialis apricaria*	101,000	50	UK breeding population (Woodward *et al.,* 2020)
Golden plover (non-breeding)	*Pluvialis apricaria*	410,000	50	UK breeding population (Woodward *et al.,* 2020)

Species	Scientific name	Population size	Population correction factor (percent of population estimated to be using relevant sea-crossings)	Notes and reference
Grey plover	*Pluvialis squatarola*	6,315	50	Irish population (Wright *et al.,* 2012)
Ringed plover (breeding)	*Charadrius hiaticula*	10,900	50	UK breeding population (Woodward *et al.,* 2020)
Ringed plover (non-breeding)	*Charadrius hiaticula*	42,500	50	UK winter population (Woodward *et al.,* 2020)
Dotterel	*Charadrius morinellus*	850	50	UK breeding population (Woodward *et al.,* 2020)
Whimbrel	*Numenius phaeopus*	3,840	50	Spring passage population Wright *et al.,* (2012)
Curlew (breeding)	*Numenius arquata*	117,000	50	UK breeding population (Woodward *et al.,* 2020)
Curlew (non-breeding)	*Numenius arquata*	54,650	50	Irish population (Wright *et al.,* 2012)
Bar-tailed godwit	*Limosa lapponica*	16,280	50	UK winter population (Woodward *et al.,* 2020)
Black-tailed godwit (Icelandic race)	*Limosa limosa islandica*	41,000	50	UK winter population (Woodward *et al.,* 2020)
Turnstone	*Arenaria interpres*	43,000	50	UK winter population (Woodward *et al.,* 2020)
Knot	*Calidris canutus*	265,000	50	UK winter population (Woodward *et al.,* 2020)
Ruff	*Calidris pugnax*	920	25	UK winter population (Woodward *et al.,* 2020)
Sanderling	*Calidris alba*	20,500	50	UK winter population (Woodward *et al.,* 2020)
Dunlin (sub-species schinzii and arctica)	*Calidris alpina schinzii/arctica*	1,000,500	50	International population (Wright *et al.,* 2012)
Dunlin (sub-species alpina)	*Calidris alpina alpina*	88,480	50	Irish population (Wright *et al.,* 2012)
Purple sandpiper	*Calidris maritima*	9,900	50	UK winter population (Woodward *et al.,* 2020)
Snipe	*Gallinago gallinago*	1,100,000	50	UK winter population (Woodward *et al.,* 2020)
Red-necked phalarope	*Phalaropus lobatus*	128	50	UK breeding population (Woodward *et al.,* 2020)
Redshank (breeding)	*Tringa totanus*	44,000	50	UK breeding population (Woodward *et al.,* 2020)

Species	Scientific name	Population size	Population correction factor (percent of population estimated to be using relevant sea-crossings)	Notes and reference
Redshank (Icelandic race - non-breeding)	*Tringa totanus*	400,000	50	Iceland and Faeroese populations (Wright *et al.,* 2012)
Wood sandpiper	*Tringa glareola*	60	50	UK breeding population (Woodward *et al.,* 2020)
Greenshank	*Tringa nebularia*	1,265	50	Irish population (Wright *et al.,* 2012)
Bittern	*Botaurus stellaris*	795	10	UK winter population (Woodward *et al.,* 2020)
Osprey	*Pandion haliaetus*	480	25	UK breeding population (Woodward *et al.,* 2020)
Hen harrier	*Circus cyaneus*	1,090	25	UK breeding population (Woodward *et al.,* 2020)
Short-eared owl	*Asio flammeus*	4,400	50	UK breeding population (Woodward *et al.,* 2020)
Merlin	*Falco columbarius*	49,000	25	International population (Wright *et al.,* 2012)

Collision risk modelling and avoidance rates

1.4.2.7 As recommended in the SOSSMAT guidance, the Band (2012) CRM was used. Input parameters for the wind turbine specifications used within the CRM are shown in Table 1.4. These values are based on the Maximum Design Scenario (MDS) parameter values for the worst-case collision risk. Species/populations input parameters are shown in Table 1.5. While species biometrics (length and wingspan) were taken from the BTO BirdFacts resource (Robinson, 2005), flight speeds were taken from Alerstam *et al*. (2007) for most species. For some species (Table 1.4), 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 *Pluvialis apricaria* and American golden plover *Pluvialis dominica*).

1.4.2.8 The width of the migration corridor, required for the migratory stage of the CRM, was calculated using ArcPro. The migration corridor was taken as the longest width of Morgan Array Area across which a species migratory route would cross. For birds migrating north to south, a migration corridor of 27.34 km was used with a migration corridor of 19.22 km used for birds migrating east to west. The proportion of flights upwind for migratory species was assumed to be 50% for all species.

1.4.2.9 The Band (2012) CRM includes two models (basic and extended) which both incorporate two ‘Options’. Generic flight height distributions, used for Options 2 and 3 of Band (2012) are unavailable for the species considered in this technical report and

therefore it is not possible to use these model options. Therefore Option 1 is used incorporating the Proportion of birds at Collision Height (PCH) values from Wright *et al*. (2012).

1.4.2.10 Collision risk estimates are calculated using a range of avoidance rates including a default avoidance rate of 98%, as recommended by SNH guidance (SNH, 2010).

Table 1.4: The Morgan Generation Assets configuration and turbines parameters.

[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).

Parameter[a]	Parameter value	Source/Reference
Max. number of turbines	96	Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.
Number of rotor blades per turbine	3	Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.
Max. chord width (m)	6.8	Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.
Average blade pitch (degrees)	10	Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.
Max. rotor radius (m)	125	Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.
Average rotation speed (revolutions per minute)	6.2	Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.
Minimum hub height (m) (LAT)	159	Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.
Tidal offset (m) (mean sea level)	+/- 4	Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.
Lower blade tip height above Lowest Astronomical Tide LAT (m)	34	Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.
Morgan Generation Assets width (km)	19.2 (East to West flight direction) 27.4 (North to South flight direction)	Calculated in ArcPro
Latitude	54.00	Calculated in ArcPro
Monthly proportion of time operational (%)	94	Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.

Table 1.5: Species and population parameters used in the Band (2012) single transit collision risk model. Species are ranked according to their taxonomic order.

Species	Length (m)	Wingspan (m)	Flight speed (m/s^{-1})	Proportion at rotor height (%)	Number crossing Morgan Generation Assets per annum
Light-bellied brent goose (Canadian population)	0.58	1.15	17.7	30	23
Greenland white-fronted goose	0.72	1.46	16.1	30	460
Bewick's swan	1.21	1.96	18.5	50	22
Whooper swan	1.52	2.30	17.3	50	577
Shelduck	0.62	1.12	15.4	15	430
Shoveler	0.48	0.77	20.6	15	79
Gadwall	0.51	0.90	20.6	15	41
Wigeon	0.48	0.80	20.6	15	2,425
Mallard	0.58	0.90	18.5	15	1,126
Pintail	0.58	0.88	20.6	15	750
Teal	0.36	0.61	19.7	15	16,958
Pochard	0.46	0.77	23.6	15	1,170
Tufted duck	0.44	0.70	21.1	15	6,239
Scaup	0.46	0.78	21.3	15	199
Common scoter	0.49	0.84	22.1	1	3,974
Long-tailed duck	0.44	0.76	22.0	15	79
Goldeneye	0.46	0.72	20.3	15	285
Red-breasted merganser	0.55	0.78	20.0	15	327
Corncrake	0.28	0.50	13.9	50	110
Great crested grebe	0.48	0.88	18.6	10	194
Slavonian grebe	0.34	0.62	15.4	10	29
Oystercatcher (breeding)	0.42	0.83	13.0	25	5,629
Oystercatcher (non-breeding)	0.42	0.83	13.0	25	8,979
Lapwing	0.30	0.84	11.9	25	6,115
Golden plover (breeding)	0.28	0.72	13.7	25	2,973
Golden plover (non-breeding)	0.28	0.72	13.7	25	12,071
Grey plover	0.28	0.77	17.5	25	186

Species	Length (m)	Wingspan (m)	Flight speed (m/s^{-1})	Proportion at rotor height (%)	Number crossing Morgan Generation Assets per annum
Ringed plover (breeding)	0.19	0.52	19.5	25	321
Ringed plover (non-breeding)	0.19	0.52	19.5	25	1,251
Dotterel	0.21	0.60	13.7	25	41
Whimbrel	0.41	0.82	16.3	25	113
Curlew (breeding)	0.55	0.90	16.3	25	3,446
Curlew (non-breeding)	0.55	0.90	16.3	25	1,609
Bar-tailed godwit	0.38	0.75	18.3	25	592
Black-tailed godwit (Icelandic race)	0.42	0.76	18.3	25	1,207
Turnstone	0.23	0.54	14.9	25	1,266
Knot	0.24	0.59	20.1	25	7,802
Ruff	0.25	0.53	13.6	25	22
Sanderling	0.20	0.42	15.3	25	604
Dunlin (sub-species schinzii and arctica)	0.18	0.40	15.3	25	29,587
Dunlin (sub-species alpina)	0.18	0.40	15.3	25	3,474
Purple sandpiper	0.21	0.44	15.3	25	319
Snipe	0.26	0.46	17.1	25	32,384
Red-necked phalarope	0.20	0.38	13.1	25	3
Redshank (breeding)	0.28	0.62	12.3	25	1,295
Redshank (Icelandic race - non-breeding)	0.28	0.62	12.3	25	11,776
Wood sandpiper	0.20	0.56	9.6	25	2
Greenshank	0.32	0.69	12.3	25	39
Bittern	0.75	1.30	8.8	50	8
Osprey	0.56	1.58	11.4	50	4
Hen harrier	0.48	1.10	9.1	50	18
Short-eared owl	0.38	1.02	8.4	50	130
Merlin	0.28	0.56	12.2	50	68

1.4.3 Migratory seabirds

1.4.3.1 The identification of migratory seabird species for which collision risk modelling is required has utilised the migratory corridors defined in WWT Consulting and MacArthur Green (2014) (Figure 1.3). Where the species-specific migratory corridor overlaps with the Morgan Generation Assets, then collision risk modelling has been undertaken for that species. This process is summarised in Table 1.6.

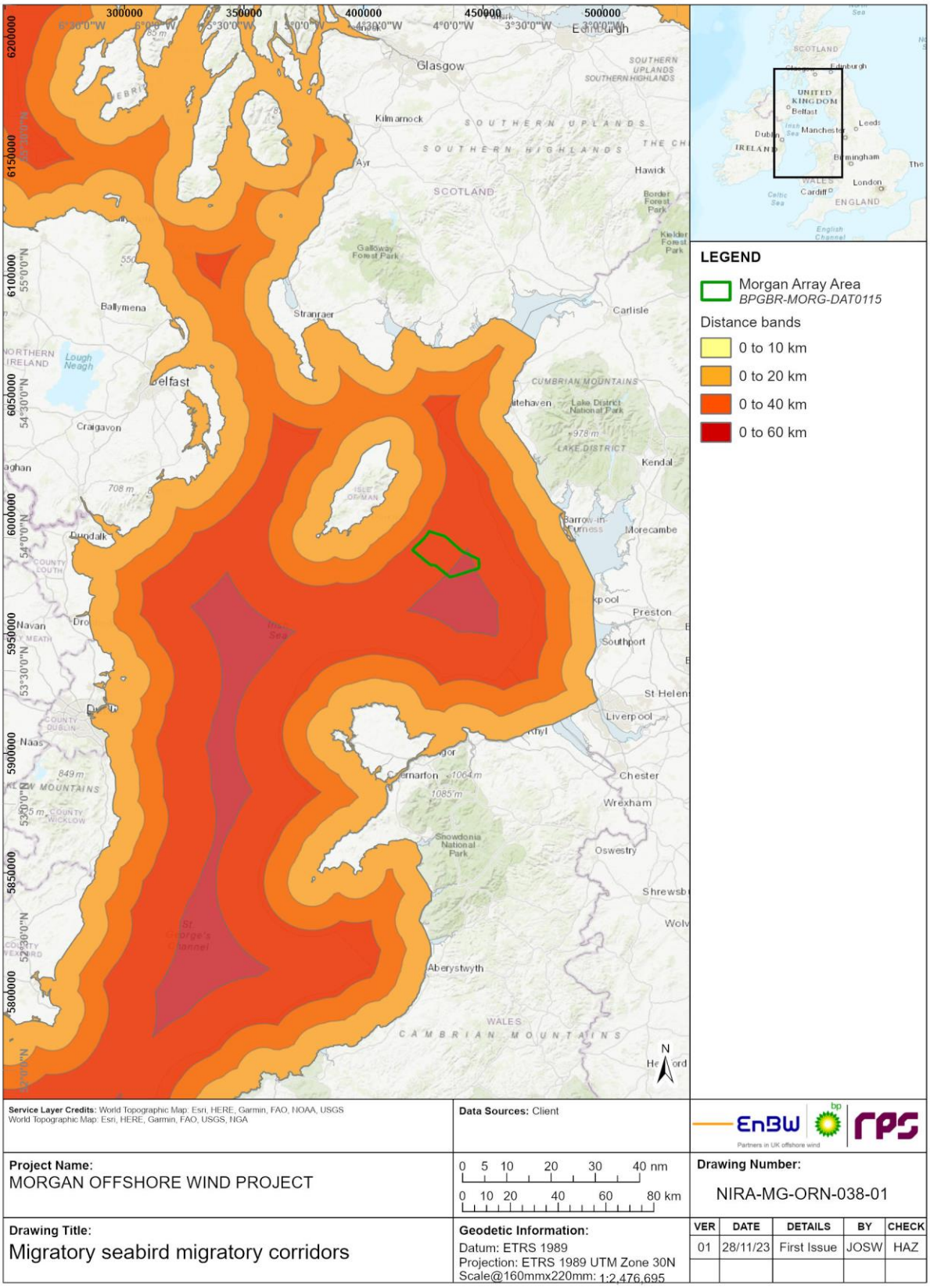

Figure 1.3: Migratory seabird migratory corridors.

Table 1.6: Identification of migratory seabird species for which there is connectivity with the Morgan Generation Assets.

Species	Latin name	Migratory corridor (km)	Overlap with Morgan Generation Assets (Yes/No)
Little gull	*Hydrocoloeus minutus*	0 to 20	No
Sandwich tern	*Thalasseus sandvicensis*	0 to 10	No
Little tern	*Sternula albifrons*	0 to 10	No
Roseate tern	*Sterna dougallii*	0 to 10	No
Common tern	*Sterna hirundo*	0 to 10	No
Arctic tern	*Sterna paradisaea*	0 to10	No
Great skua	*Stercorarius skua*	0 to 40	Yes
Arctic skua	*Stercorarius parasiticus*	0 to 20	No
European storm petrel	*Hydrobates pelagicus*	0 to 60	Yes
Leach's petrel	*Oceanodroma leucorhoa*	0 to 60	Yes

1.4.3.2 Unlike the collision risk modelling approach applied for regularly occurring seabird species, density data collected during site-specific surveys is deemed to be unsuitable to estimate the impact of collision for migratory seabird species. This is due to the snapshot nature of site-specific surveys and consequential limitations in recording sporadic movements of migratory species. Therefore the collision risk modelling approach used for migratory seabirds incorporates species-specific information relating to population estimates and migratory behaviour. A generic 'migratory front' is then defined which is then used to calculate the number of birds that have the potential to interact with the Morgan Generation Assets during spring and autumn migration.

1.4.3.3 In order to identify the interacting population for use in collision risk modelling the following stages are applied:

1. Define relevant seasonal Biologically Defined Minimum Population Scales (BDMPS) populations for each species considered
2. Define a migratory front that incorporates the longest width of the Morgan Generation Assets across which migration will occur
3. Calculate the proportion of the migratory front represented by the Morgan Generation Assets
4. Calculate interacting populations for each species in each migratory season.

1.4.3.4 The interacting populations are then incorporated into collision risk modelling to provide a collision risk estimate for each species.

1.4.3.5 Collision risk modelling has been undertaken using the Band (2012) CRM which allows for consideration of birds on migration.

Calculation of interacting populations

1.4.3.6 In most cases the BDMPS population represents those birds that migrate through the Irish Sea between breeding and wintering areas. For great skua the BDMPS

population is sourced from Furness (2015). For the two petrel species the BDMPS population represents the proportion of the passage population estimated to utilise UK western waters on migration (WWT Consulting and MacArthur Green, 2014).

1.4.3.7 The proportion of this population that may interact with the Morgan Generation Assets is calculated based on the proportion of the migratory front represented by the Morgan Generation Assets. The migratory front represents a hypothetical line across which the whole BDMPS population will cross, incorporating the greatest width of the Morgan Array Area. It is assumed that birds are equally distributed across this front, however it should be noted that the migratory movements of some species may be biased towards inshore or offshore waters (Stienen *et al*., 2007).

1.4.3.8 The migratory front to be used to estimate the population of migratory seabirds passing through the Morgan Generation Assets is 40 km for great skua and 60 km for the two petrel species. The populations of migratory seabird species considered to have potential to interact with the Morgan Generation Assets are calculated using the following formula:

*Interacting population = Width of development area / width of migration route * species populations*

1.4.3.9 The Morgan Generation Assets represent 27.4 km. The Morgan Generation Assets therefore represent 45.6 to 68.5% of the total migratory front with this proportion applied to the BDMPS populations in Table 1.7.

Table 1.7: Migratory seabird BDMPS populations and the proportion of these populations predicted to have potential to interact with the Morgan Generation Assets.

Species	Season	BDMPS population	Interacting population
Great skua	Autumn	16,336	11,190
	Spring	25,090	17,187
European storm petrel	Autumn	180,000	82,200
	Spring	90,000	41,100
Leach's petrel	Autumn	450,000	205,500
	Spring	180,000	82,200

Peak migratory movements

1.4.3.10 To populate a collision risk model, single months are selected to represent autumn movements and spring movements respectively. In the Band (2012) CRM these months are populated with the populations in Table 1.7, while the months selected are presented in Table 1.8.

Table 1.8: Months populated with potentially interacting populations for collision risk modelling.

Species	Post-breeding peak migratory month	Pre-breeding peak migratory month
Great skua	September	April
European storm petrel	October	May
Leach's petrel	October	May

Collision risk modelling

1.4.3.11 To quantify collision risk, collision risk modelling has been undertaken using the Band (2012) CRM. Band (2012) uses information derived from population estimation, bird behaviour, biological parameters and project specific turbine information to calculate monthly collision risk values.

1.4.3.12 The wind farm and turbine parameters used for migratory seabird collision risk modelling are consistent with those used for migratory waterbirds (see Table 1.4).

1.4.3.13 The species-specific parameters used in the Band (2012) collision risk model for migratory seabirds are presented in Table 1.9.

Table 1.9: Species input parameters used in collision risk modelling.

Parameter	Source	Great skua	European storm petrel	Leach's petrel
Bird length (m)	Robinson (2005)	0.56	0.16	0.20
Wingspan (m)	Robinson (2005)	1.36	0.38	0.46
Flight speed (m/s)	Pennycuick *et al.* (1987) and Alerstam (1993)	14.9	8.8	8.8
Flight type	-	Flapping	Flapping	Flapping
Proportion at collision height (%)	Johnston *et al.* (2014) and Furness *et al.* (2013)	Flight height distribution from Johnston *et al.* (2014)	2	2

1.4.3.14 Generic flight height data from Johnston *et al.* (2014) has been used to inform Options 2 and 3 of the Band (2012) CRM for great skua with Option 1 and flight height data from Furness *et al.* (2013) used for the two petrel species.

Avoidance rates

1.4.3.15 No species-specific avoidance rates are available for the migratory seabird species considered however, Natural England have recommended that a default 99% avoidance rate be used for seabird species other than gannet, gull species and Sandwich tern based on the avoidance rates presented in Ozanlav-Harris *et al.* (2023). In addition, collision risk estimates have been presented at a range of other avoidance rates.

1.5 Results

1.5.1 Migratory waterbirds

1.5.1.1 Table 1.10 presents the number of birds crossing the site annually and 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 area.

Table 1.10: Number of each species and percentage of the population crossing the Morgan Generation Assets per annum. Species are ranked according to their taxonomic order.

Species	No. crossing Morgan Generation Assets per annum	Collision risk estimates (Avoidance rate (%))				
		No avoidance	95	98	99	99.5
Light-bellied brent goose (Canadian population)	23	0.80	0.04	0.02	0.01	0.00
Greenland white-fronted goose	460	17.35	0.87	0.35	0.17	0.09
Bewick's swan	22	2.25	0.11	0.04	0.02	0.01
Whooper swan	577	46.49	2.32	0.93	0.46	0.23
Shelduck	430	11.06	0.55	0.22	0.11	0.06
Shoveler	79	1.79	0.09	0.04	0.02	0.01
Gadwall	41	0.95	0.05	0.02	0.01	0.00
Wigeon	2,425	55.22	2.76	1.10	0.55	0.28
Mallard	1,126	27.13	1.36	0.54	0.27	0.14
Pintail	750	12.40	0.62	0.25	0.12	0.06
Teal	16,958	258.42	12.92	5.17	2.58	1.29
Pochard	1,170	25.97	1.30	0.52	0.26	0.13
Tufted duck	6,239	97.32	4.87	1.95	0.97	0.49
Scaup	199	3.14	0.16	0.06	0.03	0.02
Common scoter	3,974	4.45	0.22	0.09	0.04	0.02
Long-tailed duck	79	1.31	0.07	0.03	0.01	0.01
Goldeneye	285	10.71	0.54	0.21	0.11	0.05
Red-breasted merganser	327	5.35	0.27	0.11	0.05	0.03
Corncrake	110	5.62	0.28	0.11	0.06	0.03
Great crested grebe	194	3.08	0.15	0.06	0.03	0.02
Slavonian grebe	29	0.30	0.02	0.01	0.00	0.00
Oystercatcher (breeding)	5,629	158.84	7.94	3.18	1.59	0.79
Oystercatcher (non-breeding)	8,979	253.38	12.67	5.07	2.53	1.27
Lapwing	6,115	236.45	11.82	4.73	2.36	1.18
Golden plover (breeding)	2,973	77.20	3.86	1.54	0.77	0.39
Golden plover (non-breeding)	12,071	313.46	15.67	6.27	3.13	1.57
Grey plover	186	6.75	0.34	0.14	0.07	0.03

Species	No. crossing Morgan Generation Assets per annum	Collision risk estimates (Avoidance rate (%))				
		No avoidance	95	98	99	99.5
Ringed plover (breeding)	321	7.68	0.38	0.15	0.08	0.04
Ringed plover (non-breeding)	1,251	29.94	1.50	0.60	0.30	0.15
Dotterel	41	1.10	0.05	0.02	0.01	0.01
Whimbrel	113	3.04	0.15	0.06	0.03	0.02
Curlew (breeding)	3,446	98.42	4.92	1.97	0.98	0.49
Curlew (non-breeding)	1,609	65.58	3.28	1.31	0.66	0.33
Bar-tailed godwit	592	22.03	1.10	0.44	0.22	0.11
Black-tailed godwit (Icelandic race)	1,207	31.93	1.60	0.64	0.32	0.16
Turnstone	1,266	31.39	1.57	0.63	0.31	0.16
Knot	7,802	190.39	9.52	3.81	1.90	0.95
Ruff	22	0.56	0.03	0.01	0.01	0.00
Sanderling	604	14.60	0.73	0.29	0.15	0.07
Dunlin (sub-species schinzii and arctica)	29,587	707.75	35.39	14.15	7.08	3.54
Dunlin (sub-species alpina)	3,474	118.59	5.93	2.37	1.19	0.59
Purple sandpiper	319	7.76	0.39	0.16	0.08	0.04
Snipe	32,384	796.96	39.85	15.94	7.97	3.98
Red-necked phalarope	3	0.06	0.00	0.00	0.00	0.00
Redshank (breeding)	1,295	34.00	1.70	0.68	0.34	0.17
Redshank (Icelandic race - non-breeding)	11,776	309.15	15.46	6.18	3.09	1.55
Wood sandpiper	2	0.05	0.00	0.00	0.00	0.00
Greenshank	39	1.50	0.07	0.03	0.01	0.01
Bittern	8	0.91	0.05	0.02	0.01	0.00
Osprey	4	0.26	0.01	0.01	0.00	0.00
Hen harrier	18	1.20	0.06	0.02	0.01	0.01
Short-eared owl	130	8.41	0.42	0.17	0.08	0.04
Merlin	68	3.56	0.18	0.07	0.04	0.02

1.5.2 Migratory seabirds

1.5.2.1 Table 1.11 presents the collision risk estimates for migratory seabird species for a range of avoidance rates.

Table 1.11: Collision risk estimate for migratory seabird species.

Species	Model option	Collision risk estimates (Avoidance rate (%))				
		No avoidance	95	98	99	99.5
Great skua	2	12.01	0.60	0.24	0.12	0.06
European storm petrel	1	65.08	3.25	1.30	0.65	0.33
Leach's petrel	1	157.28	7.86	3.15	1.57	0.79

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