Appendix 11-6:
Offshore Ornithology Migratory Non-Seabirds Collision Risk Modelling

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

rps
A TETRA TECH COMPANY

PARK WIND
JERA GROUP

ESB
Energy for generations

ORIEL WIND FARM PROJECT

Environmental Impact Assessment Report
Appendix 11-6: Offshore Ornithology Migratory Non-Seabirds Collision Risk Modelling

MDR1520B
EIAR – Appendix 11-6
A1 C01
March 2024

rpsgroup.com

Contents

Figures

Tables

Acronyms

Term	Meaning
BTO	British Trust for Ornithology
CRM	Collision Risk Model
GIS	Geographical Information System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
RoI	Republic of Ireland
SOSS	Strategic Ornithological Support Services
SOSSMAT	Strategic Ornithological Support Services Migration Assessment Tool
SPA	Special Protected Area
UK	United Kingdom
WTG	Wind Turbine Generator

1 INTRODUCTION

1.1 Oriel Wind Farm Project

Oriel Windfarm Limited ('the Applicant') is proposing to develop the Oriel Wind Farm Project, an offshore wind farm, hereafter referred to as 'the Project". The Project is located in the northern Irish Sea, off the coast of County Louth (approximately 22 km east of Dundalk town centre and 18 km east of Blackrock). The Project will comprise both offshore and onshore infrastructure including 25 offshore wind turbine generators (WTGs), associated foundations and inter-array cables, offshore substation, offshore cable within a defined offshore cable corridor, a landfall, onshore cable within a defined onshore cable route and an onshore substation for connection to the electricity transmission network. The closest wind turbine will be approximately 6 km from the closest shore on the Cooley Peninsula. The offshore cable corridor extends approximately 11 km southwest from the wind farm area to the landfall south of Dunany Point.

1.2 Ornithological background

The islands of Britain and Ireland are located along the east Atlantic flyway - a migration route that connects bird species' breeding sites to wintering sites (Boere *et al.*, 2006; Wright *et al.*, 2012). Therefore, the islands of Britain and Ireland are of key importance for many over-wintering and migrating birds that move through the area in large numbers during the spring and autumn passage periods. Ireland supports a large over-wintering population of waterbirds (Crowe *et al.*, 2008; Burke *et al.*, 2018), originating from the Arctic and sub-Artic regions (e.g. Iceland and Scandinavia). Whilst some bird species will follow the coastline during their migration journey, other groups of species (e.g. waders and passerines) will undertake long journeys across open seas, often flying at high altitudes depending on the weather conditions. Wildfowl species are known to follow a coastal route during their migration (when in sight of land). However, many wildfowl species do undertake open-sea movements to reach their wintering or moulting grounds (e.g. Shelduck *Tadorna tardorna*; Green *et al.*, 2019).

Through bird global positioning system (GPS) tracking studies, there is a greater understanding of sea crossing movements and the interactions of migratory birds with the landscape, including artificial structures. Because of the development of offshore wind energy and possible interactions with migrating birds, concerns have been raised about the potential risk of collision of migrating birds with offshore wind farms, in particular non-seabird species which may use the UK and the Irish network of Special Protected Areas (SPAs).

The Strategic Ornithological Support Services (SOSS) Migration Assessment Tool (hereafter referred to as SOSSMAT) was developed to identify non-seabird migratory species at risk of collision with offshore wind farms (Wright *et al.*, 2012). An extensive review of migratory movements, combined with the use of geographical information system (GIS)/worksheet tool, generate the number of migratory birds expected to fly through a proposed development site. The derived parameters from the SOSSMAT tool can be subsequently used in a Collision Risk Model (CRM) to calculate the probability of collision (e.g. using the Band *et al.* (2012) CRM).

To address the concerns about the potential collision risk of the Project with migratory non-seabird species flying along and across the Irish Sea, collision risk has been assessed using the SOSSMAT tool and the Band *et al.* (2012) CRM.

1.3 Purpose of the report

This technical report provides estimates of the collision risk to migratory non-seabird species (excluding "true seabirds", gulls, cormorants and divers) as a result of the Project. The report has been produced in support of chapter 11: Offshore Ornithology. RPS has undertaken the collision modelling which is based on species/populations identified to be at risk of crossing the Project during migratory movements.

2 METHODOLOGY

The SOSSMAT tool was used to assess the risk of offshore wind farm development to migratory birds designated as features of SPAs in the UK and Ireland. Instructions are given in Wright *et al.* (2012). The resulting number of birds estimated to interact with the offshore wind farm area was inputted into the Band (2012) single transit collision risk model to estimate the collision risk to each species.

2.1 Selecting connectivity lines with development in SOSSMAT

First, the SOSSMAT GIS tool was used to define lines of migration (as identified by Wright *et al*., 2012), which intersected with the offshore wind farm area. According to the sections of the coastline defined in the SOSSMAT tool (Table 2-1; Figure 2-1) and the position of the offshore wind farm area, the migration routes that included a start or end point bordering the Irish Sea were selected. The routes selected are shown in Table 2-1. These routes followed the broad migrating patterns known to occur across Britain and Ireland as described below:

- 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 Britain and over-wintering in Ireland; and
- Birds from Arctic and sub-Arctic moving through Ireland to winter further south (e.g. Spain).

Table 2-1: Migration routes selected and corresponding SOSSMAT code.

Start Migration	End Migration	SOSSMAT Code
England and Wales Irish Sea	Northern Ireland Celtic Seas coast	EWINIC
Northern Ireland Celtic Seas coast	Scottish mainland Celtic Seas coast	NICSCS
Northern Ireland Celtic Seas coast	Scottish mainland Hebridean Seas coast	NICSHS
Republic of Ireland - Celtic Seas eastern coast	Republic of Ireland - Celtic Seas eastern coast	RIERIE
Republic of Ireland - Celtic Seas eastern coast	England and Wales Bristol Channel	RIEEWB
Republic of Ireland - Celtic Seas eastern coast	England and Wales Irish Sea	RIEEWI
Republic of Ireland - Celtic Seas eastern coast	Scottish mainland Celtic Seas coast	RIESCS
Republic of Ireland - Celtic Seas eastern coast	Spanish north coast	RIESPA
Spanish north coast	Northern Ireland Celtic Seas coast	SPANIC
England and Wales Irish Sea	Northern Ireland Celtic Seas coast	EWINIC

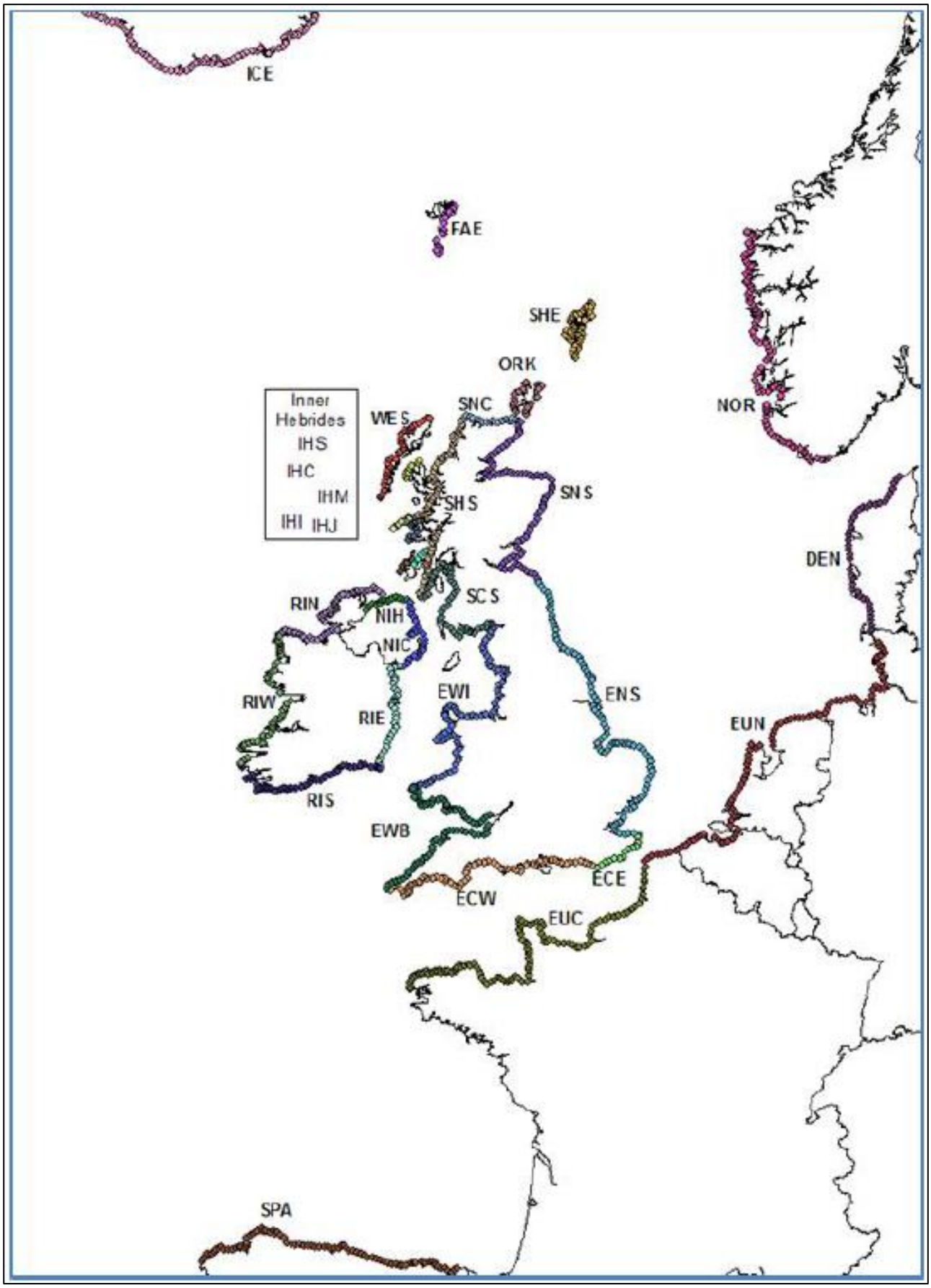

Figure 2-1: Coastal zones defined for the SOSSMAT.

2.2 Population size and population correction factor

The percentage of lines crossing the offshore wind farm area was derived for each species known to migrate along the route selected in SOSSMAT. At this stage, 'true seabirds', all gull species, cormorants and diver species were excluded, to focus the assessment on migratory non-seabird species. In SOSSMAT, the numbers of birds crossing the offshore wind farm area were calculated by adding parameters for population size and population correction factor (% of the population using the relevant sea crossing). Population size estimates were input into SOSSMAT using the Irish winter population (which included both Northern Ireland and the Republic of Ireland (RoI)) (Burke *et al*., 2018), British winter estimate (Frost *et al*., 2019) or the most recent international estimate from BirdLife International (BirdLife International, 2022) or Wetlands International (Wetlands International, 2022). Breeding population estimates were input from the United Kingdom (UK) and RoI combined from Article 12 species trend reports (European Union, 2022). As a precautionary approach, assumptions taken in Wright *et al*. (2012) were followed where the scale and magnitude of the migration were unknown. Therefore, in most instances, the entire population estimation presented in Table 2-2 was used.

Table 2-2: Species vernacular name (including scientific name), population size, and geographic population selected in the SOSSMAT tool.

Vernacular name	Scientific name	Population Estimate	Geographic Population
Whooper swan	*Cygnus cygnus*	15,370	Irish
Greenland white-fronted goose	*Anser albifrons flavirostris*	9,590	Irish
Light-bellied brent goose (Canadian population)	*Branta bernicla hrota*	37,000	International
Shelduck	*Tadorna tadorna*	10,160	Irish
Wigeon	*Mareca penelope*	55,730	Irish
Gadwall	*Mareca strepera*	890	Irish
Teal	*Anas crecca*	35,740	Irish
Mallard	*Anas platyrhynchos*	28,230	Irish
Pintail	*Anas acuta*	1,570	Irish
Shoveler	*Spatula clypeata*	2,020	Irish
Pochard	*Aythya ferina*	11,150	Irish
Tufted duck	*Aythya fuligula*	27,470	Irish
Scaup	*Aythya marila*	2,650	Irish
Long-tailed duck	*Clangula hyemalis*	13,071	British and RoI
Common scoter	*Melanitta nigra*	10,640	Irish
Goldeneye	*Bucephala clangula*	3,820	Irish
Red-breasted merganser	*Mergus serrator*	2,430	Irish
Great crested grebe	*Podiceps cristatus*	2,930	Irish
Slavonian grebe	*Podiceps auritus*	86	Irish
Hen harrier (breeding)	*Circus cyaneus*	702	UK and RoI
Merlin	*Falco columbarius*	61,750	International
Corncrake (breeding)	*Crex crex*	153	UK and RoI
Oystercatcher (breeding)	*Haematopus ostralegus*	196,714	UK and RoI
Oystercatcher (non-breeding)	*Haematopus ostralegus*	60,540	Irish
Ringed plover (breeding)	*Charadrius hiaticula*	12,966	UK and RoI
Ringed plover (non-breeding)	*Charadrius hiaticula*	11,660	Irish
Golden plover (breeding)	*Pluvialis apricaria*	101,242	UK and RoI
Golden plover (non-breeding)	*Pluvialis apricaria*	92,060	Irish
Grey plover	*Pluvialis squatarola*	2,940	Irish

Vernacular name	Scientific name	Population Estimate	Geographic Population
Lapwing	*Vanellus vanellus*	84,690	Irish
Knot	*Calidris canutus*	16,270	Irish
Sanderling	*Calidris alba*	8,420	Irish
Purple sandpiper	*Calidris maritima*	660	Irish
Dunlin (wintering)	*Calidris alpina alpina*	45,760	Irish
Dunlin (passage and breeding)	*Calidris alpina schinzii and Calidris alpina arctica*	848,740	International
Snipe	*Gallinago gallinago*	1,000,000	British
Black-tailed godwit	*Limosa limosa*	19,800	Irish
Bar-tailed godwit	*Limosa lapponica*	16,530	Irish
Whimbrel	*Numenius phaeopus*	3,840[1]	British
Curlew (breeding)	*Numenius arquata*	117,744	UK and RoI
Curlew (non-breeding)	*Numenius arquata*	35,240	Irish
Greenshank	*Tringa nebularia*	1,320	Irish
Redshank (breeding)	*Tringa totanus*	23,800	
Redshank (non-breeding)	*Tringa totanus robusta*	9,480	
Turnstone	*Arenaria interpres*	4,360	
Short-eared owl (breeding)	*Asio flammeus*		

1. Population estimate presented for Whimbrel is from Wright *et al.* (2012) for spring passage.

2.3 Collision risk modelling and avoidance rates

As recommended in the SOSSMAT guidance, the Band (2012) single transit CRM was used. Input parameters for the WTG specifications used within the CRM are shown in Table 2-3. These values are based on the project design parameters as described in volume 2A, chapter 5: Project Description. Species/populations input parameters are shown in Table 2-4. While species biometrics (length and wingspan) were taken from the British Trust for Ornithology (BTO) BirdFacts resource (Robinson, 2005), flight speeds from Alerstam *et al*. (2007) were used for most species. For a few species, there were no estimations in Alerstam *et al*. (2007). As such, the same assumptions were made following Marine Scotland (2014) in their document *Strategic assessment of collision risk of Scottish offshore wind farms to migrating birds*, whereby 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*).

Proportion flying at rotor height given for a species group (e.g. wildfowl, wader etc.) in Wright *et al*. (2012) were used in the CRM. At-risk population resulted from the calculations in the SOSSMAT worksheet (see section 2.2).

Table 2-3: Parameters used within mCRM.

Item	Value
WTG capacity (MW)	15
Number of Turbines	25
No. of Blades	3
Rotation Speed (rpm)	8.1 (± 0.3)
Rotor Radius (m)	118
Minimum Air Gap (m) (LAT)	27
Hub Height (m) (LAT)	145-152

Item	Value
Max. Blade Width (m)	7
Pitch (°)	10
Tidal Offset (m) (MSL)	2.75
Width of Wind Farm (km)[1]	7.37
Latitude (°)[2]	54.05486

1. Maximum width (northwest corner to southeast corner).

2. Latitude was calculated from the centroid of the offshore wind farm area.

Table 2-4: Species/populations parameters used in the Band *et al*. (2012) single transit CRM.

Species	Length (m)	Wingspan (m)	Flight speed (ms^{-1})	Proportion at rotor height (%)	At-risk population (population estimate/number of crossings in footprint of Project)
Dunlin (passage and breeding)	0.18	0.4	15.3	25	2,263
Snipe	0.27	0.47	17.1	25	1,777
Oystercatcher (breeding)	0.42	0.83	13	25	350
Golden plover (non-breeding)	0.28	0.72	13.7	25	327
Lapwing	0.3	0.84	11.9	25	301
Oystercatcher (non-breeding)	0.42	0.83	13	25	215
Curlew (breeding)	0.55	0.9	16.3	25	209
Golden plover (breeding)[1]	0.28	0.72	13.7	25	180
Wigeon	0.48	0.8	20.6	15	198
Dunlin (wintering)	0.18	0.4	15.3	25	163
Light-bellied brent goose (Canadian population)	0.58	1.15	17.7	30	155
Teal	0.36	0.61	19.7	15	127
Curlew (non-breeding)	0.55	0.9	16.3	25	125
Mallard	0.65	0.98	18.5	15	100
Tufted duck	0.44	0.7	21.1	15	98
Redshank (non-breeding)[1]	0.28	0.62	12.3	25	85
Bar-tailed godwit	0.38	0.75	18.3	25	81
Redshank (breeding)	0.28	0.62	12.3	25	79
Whooper swan	1.525	2.305	17.3	50	75
Black-tailed godwit[1]	0.42	0.76	18.3	25	70
Greenland white-fronted goose	0.72	1.46	16.1	30	60
Knot	0.24	0.59	20.1	25	58
Merlin[1]	0.28	0.56	10.1	50	55
Pochard	0.46	0.77	23.6	15	44
Ringed plover (non-breeding)	0.19	0.52	19.5	25	41
Common scoter	0.49	0.84	22.1	1	38
Shelduck	0.67	1.33	15.4	15	36
Turnstone	0.23	0.54	14.9	25	34
Sanderling	0.2	0.42	15.3	25	30
Long-tailed duck	0.44	0.76	20.3	15	23

Species	Length (m)	Wingspan (m)	Flight speed (ms^{-1})	Proportion at rotor height (%)	At-risk population (population estimate/number of crossings in footprint of Project)
Ringed plover (breeding)	0.19	0.52	19.5	25	23
Short-eared owl[1]	0.38	1.02	9.1	50	15
Goldeneye	0.46	0.72	20.3	15	14
Great crested grebe[1]	0.48	0.88	18.6	10	14
Whimbrel	0.41	0.82	16.3	25	14
Scaup	0.51	0.84	21.3	15	11
Grey Plover	0.28	0.77	17.9	25	10
Red-breasted merganser	0.55	0.78	19.7	15	9
Shoveler[1]	0.48	0.77	18.5	15	8
Pintail	0.58	0.88	20.6	15	6
Greenshank	0.32	0.69	12.3	25	5
Purple sandpiper[1]	0.21	0.44	15.3	25	4
Gadwall[1]	0.51	0.9	18.5	15	4
Hen harrier	0.48	1.1	9.1	50	2
Corncrake[1]	0.28	0.5	10	50	<1
Slavonian grebe[1]	0.45	0.86	18.6	10	<1

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).

As birds may avoid the offshore wind farm area (through macro, meso or micro avoidance), an avoidance rate must be applied to the collision risk model theoretical predictions. There is currently no detailed Irish guidance regarding the use of collision risk models or avoidance rates in the assessment of offshore wind farms on birds. Rather than using species-specific avoidance rates, a range of avoidance rates (i.e. 95.00%, 98.00%, 99.00% and 99.50%) has been applied, as recommended by Band (2012).

3 RESULTS

3.1 Migratory non-seabird species

The species presented in Table 3-1 were considered in the Band (2012) single transit CRM. Wader species, which predominately breed in the Arctic and sub-Arctic regions, were estimated to move through the offshore wind farm area in the highest numbers. For all species, it was assumed that there were two migration periods per year (e.g. spring and autumn) through the area. Table 3-1 presents the number of birds crossing the site annually, considering the spring and autumn passage.

Table 3-1: Percentage of the population and total numbers (ranked by abundance) crossing the offshore wind farm area per annum.

Species	Percentage crossing	Estimated number crossing
Dunlin (passage and breeding)	0.18	2,263
Snipe	0.18	1,777
Oystercatcher (breeding)	0.18	350
Golden plover (non-breeding)	0.18	327
Lapwing	0.18	301
Oystercatcher (non-breeding)	0.18	215
Curlew (breeding)	0.18	209
Wigeon	0.18	198
Golden plover (breeding)	0.18	180
Dunlin (wintering)	0.18	163
Light-bellied brent Goose (Canadian population)	0.21	155
Teal	0.18	127
Curlew (non-breeding)	0.18	125
Mallard	0.18	100
Tufted duck	0.18	98
Redshank (non-breeding)	0.18	85
Bar-tailed godwit	0.24	81
Redshank (breeding)	0.18	79
Whooper swan	0.25	75
Black-tailed godwit	0.18	70
Greenland white-fronted goose	0.31	60
Knot	0.18	58
Merlin	0.18	55
Pochard	0.20	44
Ringed plover (non-breeding)	0.18	41
Common scoter	0.18	38
Shelduck	0.18	36
Turnstone	0.18	34
Sanderling	0.18	30
Long-tailed duck	0.18	23
Ringed plover (breeding)	0.18	23
Short-eared owl	0.18	15
Goldeneye	0.18	14
Great crested grebe	0.25	14
Whimbrel	0.18	14

Species	Percentage crossing	Estimated number crossing
Scaup	0.20	11
Grey plover	0.18	10
Red-breasted merganser	0.18	9
Shoveler	0.20	8
Pintail	0.18	6
Greenshank	0.21	5
Purple sandpiper	0.28	4
Gadwall	0.21	4
Hen harrier	0.27	2
Corncrake	0.20	<1
Slavonian grebe	0.18	<1

3.2 Numbers of collisions predicted using a range of avoidance rates

Even assuming a highly precautionary avoidance rate of 95%, the numbers of collisions were very low and predicted to be below one bird per annum for all species considered (Table 3-2). Because of their breeding population size and migration routes through the Irish Sea, wader species were at the greatest risk of collision. Of the species/populations considered, passage and breeding dunlin were predicted to be the most at risk, with a predicted 0.42 collisions per year assuming a 95% avoidance rate.

Wildfowl species (swan, ducks and geese) were well represented in this assessment, but the resulting predictions were very low. Of the wildfowl species, whopper swan had the highest predicted number of collisions although this was negligible at one collision estimated approximately every 14 years.

Other migrant species considered in the assessment were raptors, and this group included merlin, short-eared owl and hen harrier. For those species, there is insufficient information on migratory routes and population size. Therefore, a highly precautionary approach was taken when assuming population size and proportion of population moving through the Irish Sea. Despite the highly precautionary assumptions, the numbers of collisions were predicted to be negligible for all species (less than one bird per year). Unlike wader and wildfowl species, the number of raptors species breeding and wintering in Ireland and the UK is relatively low. However, when considering the fatalities in the context of the overall population size of raptors, the number of total annual estimated collisions for raptors is undetectable.

Table 3-2: Migrant non-seabird annual collision risk for the Project.

Species	Number of collisions per year				
	No avoidance	95.0%	98.0%	99.0%	99.5%
Dunlin (passage and breeding)	8.32	0.42	0.17	0.08	0.04
Snipe	7.67	0.38	0.15	0.08	0.04
Oystercatcher (breeding)	0.84	0.04	0.02	0.01	< 0.01
Golden Plover (non-breeding)	1.35	0.07	0.03	0.01	0.01
Lapwing	1.30	0.06	0.03	0.01	0.01
Oystercatcher (non-breeding)	1.02	0.05	0.02	0.01	0.01
Curlew (breeding)	1.12	0.06	0.02	0.01	0.01
Wigeon	0.63	0.03	0.01	0.01	< 0.01
Golden plover (breeding)	0.75	0.04	0.02	0.01	< 0.01
Dunlin (wintering)	0.60	0.03	0.01	0.01	< 0.01
Light-bellied brent goose (Canadian population)	1.04	0.05	0.02	0.01	< 0.01
Teal	0.36	0.02	0.01	< 0.01	< 0.01

Species	Number of collisions per year				
	No avoidance	95.0%	98.0%	99.0%	99.5%
Curlew (non-breeding)	0.68	0.03	0.01	0.01	< 0.01
Mallard	0.36	0.02	0.01	< 0.01	< 0.01
Tufted duck	0.29	0.01	0.01	< 0.01	< 0.01
Redshank (non-breeding)	0.36	0.02	0.01	< 0.01	< 0.01
Bar-tailed godwit	0.39	0.02	0.01	< 0.01	< 0.01
Redshank (breeding)	0.34	0.02	0.01	< 0.01	< 0.01
Whooper swan	1.39	0.07	0.03	0.01	0.01
Black-tailed godwit	0.34	0.02	0.01	< 0.01	< 0.01
Greenland white-fronted goose	0.43	0.02	0.01	< 0.01	< 0.01
Knot	0.25	0.01	0.01	< 0.01	< 0.01
Merlin	0.49	0.02	0.01	< 0.01	< 0.01
Pochard	0.13	0.01	< 0.01	< 0.01	< 0.01
Ringed plover (non-breeding)	0.19	0.01	< 0.01	< 0.01	< 0.01
Common scoter	0.01	< 0.01	< 0.01	< 0.01	< 0.01
Shelduck	0.11	0.01	< 0.01	< 0.01	< 0.01
Turnstone	0.13	0.01	< 0.01	< 0.01	< 0.01
Sanderling	0.11	0.01	< 0.01	< 0.01	< 0.01
Long-tailed duck	0.07	< 0.01	< 0.01	< 0.01	< 0.01
Ringed plover (breeding)	0.10	< 0.01	< 0.01	< 0.01	< 0.01
Short-eared owl	0.16	0.01	< 0.01	< 0.01	< 0.01
Goldeneye	0.04	< 0.01	< 0.01	< 0.01	< 0.01
Great crested grebe	0.03	< 0.01	< 0.01	< 0.01	< 0.01
Whimbrel	0.07	< 0.01	< 0.01	< 0.01	< 0.01
Scaup	0.03	< 0.01	< 0.01	< 0.01	< 0.01
Grey plover	0.05	< 0.01	< 0.01	< 0.01	< 0.01
Red-breasted merganser	0.03	< 0.01	< 0.01	< 0.01	< 0.01
Shoveler	0.02	< 0.01	< 0.01	< 0.01	< 0.01
Pintail	0.02	< 0.01	< 0.01	< 0.01	< 0.01
Greenshank	0.03	< 0.01	< 0.01	< 0.01	< 0.01
Purple sandpiper	0.01	< 0.01	< 0.01	< 0.01	< 0.01
Gadwall	0.01	< 0.01	< 0.01	< 0.01	< 0.01
Hen harrier	0.02	< 0.01	< 0.01	< 0.01	< 0.01
Corncrake	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Slavonian grebe	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

4 DISCUSSION

The SOSSMAT tool, developed by Wright *et al*. (2012), was used to identify non-seabird migratory species at risk of collision with the Project. The number crossing the site was estimated (as a proportion of the overall population flying along the migratory corridor) and used in a single transit collision risk model (Band, 2012). Even under a highly precautionary approach of bird movements and avoidance, the number of collisions did not exceed one per annum for any of the species considered in this assessment.

Based on this assessment, it is concluded that the Project will have a negligible effect (almost undetectable) on migratory non-seabird species. This lack of effect could be explained by the relatively small size of the Project and the low likelihood of the offshore wind farm area intersecting with known migration routes – as identified by Wright *et al*. (2012). The number of potential migration routes through the Project was between 0.18 and 0.35 % of all potential migration routes.

It is noted that there is a degree of uncertainty about migration routes at sea, although new findings from tracking studies are contributing to increasing the knowledge of bird migration. A number of species which can be fitted with fine-resolution tracking devices (e.g. GPS/GSM) are the focus of these studies and the number of studies is ever increasing. It is widely accepted that migratory movements of birds in offshore waters tend to occur over a broad front, hence the predictions in this assessment that collision risk to all migratory non-seabird species will be negligible. However, waterbird species may use the coast as a sightline to migrate, with inshore areas possibly acting as migratory corridors. Without fine-resolution GPS tracking data and insight into local migratory movement patterns at SPAs, uncertainty around migration routes associated with local populations will persist. Studies into flight behaviour of birds around offshore wind farms will help resolve these uncertainties (e.g. Skov *et al.*, 2018 and studies at Aberdeen Offshore Wind Farm and Neart na Gaoithe Offshore Wind Farm). The Project offers an opportunity to contribute to such strategic monitoring and knowledge base through a targeted post-construction monitoring study, if deemed required.

References

Alerstam T, Rosén M, Bäckman J, Ericson PGP, Hellgren O. (2007) Flight speeds among bird species: Allometric and phylogenetic effects. PLoS Biol 5(8): e197. doi:10.1371/journal.pbio.0050197.

Band, W. (2012) Using a collision risk model to assess bird collision risks for offshore windfarms. The Crown Estate Strategic Ornithological Support Services (SOSS) report SOSS-02. http://www.bto.org/science/wetland-and-marine/soss/projects. Original published Sept 2011, extended to deal with flight height distribution data March 2012.

BirdLife International (2022) BirdLife International Data Zone. Available online at: http://datazone.birdlife.org/home. Accessed November 2022

Boere, G. C., Galbraith, C. A. and Stroud, D. A. (2006) Waterbirds around the world. Edinburgh, UK: The Stationery Office.

Burke, B., Lewis, L. J., Fitzgerald, N., Frost, T., Austin, G., & Tierney, T. D. (2018) Estimates of waterbird numbers wintering in Ireland, 2011/12–2015/16. Irish Birds, 11, 1-12.Crowe, O., Austin, G.E., Colhoun, K., Cranswick, P.A., Kershaw, M. & Musgrove, A.J. (2008). Estimates and trends of waterbird numbers wintering in Ireland, 1994/95 to 2003/04. Bird Study 55: 66-77.

European Union (2022) Article 12 Web Tool - Species trends at the Member State level. Available online at: https://nature-art12.eionet.europa.eu/article12/. Accessed November 2022.

Frost, T., Austin, G.E., Hearn, R.D., McAvoy, S., Robinson, A., Stroud, D.A., Woodward, I., Wotton, S.R. and Allen, R. (2019) Population estimates of wintering waterbirds in British. British Birds, 112(March 2019), pp.130-145.

Green, R.M.W., Niall H.K. Burton & Aonghais S.C.P. Cook (2019) Migratory movements of British and Irish Common Shelduck Tadorna tadorna: a review of ringing data and a pilot tracking study to inform potential interactions with offshore wind farms in the North Sea, Ringing & Migration, 34:2, 71-83, DOI: 10.1080/03078698.2019.1887670

Robinson, R.A (2005) BirdFacts: profiles of birds occurring in Britain & Ireland (BTO Research Report 407). BTO, Thetford (http://www.bto.org/birdfacts).

Skov, H., Heinanen, S., Norman, T., Ward, R.M., Mendex-Roldan, S. and Ellis, I. (2018) ORJIP Bird Collision and Avoidance Study. Final report – April 2018. The Carbon Trust. United Kingdom. 247pp.

Wetlands International (2022) Waterbird Population Estimates – Eighth Edition. Available online at: wpe.wetlands.org. Accessed November 2022

Wright, L.J., Ross-Smith, V.H., Massimino, D., Dadam, D., Cook, A.S.C.P. and Burton, N.H.K. (2012) Assessing the risk of offshore wind farm development to migratory birds designated as features of UK Special Protection Areas (and other Annex I species). Strategic Ornithological Support Services. Project SOSS-05. BTO Research Report No. 592.