
# Environmental Impact Assessment Report

## Volume 4

Appendix 10.3 Collision Risk Modelling


# Technical Appendix 10.3: Collision Risk Modelling

## Offshore and Intertidal Ornithology

19 April 2024

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**Codling Wind Park Limited**

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# 1. Introduction

## 1.1. Background

Codling Wind Park Limited (hereafter the ‘Applicant’) is proposing to develop the Codling Wind Park (CWP) Project, which is located in the Irish Sea approximately 13 - 22 km off the east coast of Ireland, at County Wicklow (Figure 1-1, **Volume 4, Appendix 10.5 Ornithology Baseline Characterisation Report**). This is a Technical Appendix to the Ornithology chapter of the Environmental Impact Assessment Report (EIAR) for the CWP Project (**Volume 3, Chapter 10 Ornithology**).

The purpose of the EIAR is to provide the decision-maker, stakeholders and all interested parties with the environmental information required to develop an informed view of any likely significant effects resulting from the CWP Project, as required by the European Union (EU) Directive 2011/92/EU (as amended by Directive 2014/52/EU) (the Environmental Impact Assessment (EIA) Directive). This has been transposed into Irish law in the Planning and Development Act (2000-2020), the Planning and Development Regulations (2001-2020) (as amended by S.I. No. 296 of 2018), and the Maritime Area Planning Act 2021.

There is potential for avian mortality arising from collisions with the rotating blades of wind turbines (Drewitt and Langston, 2006). The magnitude of this impact can be predicted using avian collision risk models. This technical appendix supports Volume 3, Chapter 10: Ornithology and provides detailed methods and results of avian collision risk modelling (CRM) carried out for the CWP Project for six seabird species and thirty-eight migratory species.

## 1.2. Species considered to be at risk of collision

### 1.2.1. Seabird species

Six key seabird species were identified for which potential collision risk should be considered in relation to the CWP Project.

These species are:

- Gannet (*Morus bassanus)*;
- Kittiwake (*Rissa tridactyla)*;
- Herring gull (*Larus argentatus);*
- Great black-backed gull (*Larus marinus*);
- Common gull (*Larus canus*); and
- Common tern (*Sterna hirundo*)

These were identified on the basis of a desk-based review of species sensitivity to collision mortality, generic proportions of species flight activity corresponding with project rotor swept altitude ranges and flight densities recorded within the Array Site during baseline surveys. This review is presented within the Impact Screening section of the Impact Assessment for Collision (Offshore - Operation and Maintenance: Impact 6: Collision) of **Volume 3, Chapter 10: Ornithology**.

### 1.2.2. Migratory non-seabird species

Thirty-eight migratory species were identified for which potential collision risk should be considered in relation to the CWP Project.

These species are:

- Whooper swan (*Cygnus cygnus*)
- Bewick’s swan (*Cygnus columbianus bewicki*)

- Canadian pale-bellied brent goose (*Branta bernicla hrota*)
- Greenland white-fronted goose (*Anser albifrons flavirostris*)
- Shelduck (*Tadorna tadorna*)
- Common scoter (*Melanitta nigra*)
- Pintail (*Anas acuta*)
- Shoveler (*Spatula clypeata*)
- Wigeon (*Mareca penelope*)
- Mallard (*Anas platyrhynchos*)
- Teal (*Anas crecca*)
- Pochard (*Aythya farina*)
- Tufted duck (*Aythya fuligula*)
- Scaup (*Aythya marila*)
- Goldeneye (*Bucephala clangula*)
- Eider (*Somateria mollissima*)
- Red-breasted merganser (*Mergus serrator*)
- Red-throated diver (*Gavia stellata*)
- Great northern diver (*Gavia immer*)
- Great crested grebe (*Podiceps cristatus*)
- Golden plover (*Pluvialis apricaria*)
- Grey plover (*Pluvialis squatarola*)
- Ringed plover (*Charadrius hiaticula*)
- Oystercatcher (*Haematopus ostralegus*)
- Bar-tailed godwit (*Limosa lapponica*)
- Black-tailed godwit (*Limosa limosa*)
- Curlew (*Numenius arquata*)
- Knot (*Calidris canutus*)
- Turnstone (*Arenaria interpres*)
- Dunlin (*Calidris alpina*)
- Greenshank (*Tringa nebularia*)
- Redshank (*Tringa totanus*)
- Sanderling (*Calidris alba*)
- Lapwing (*Vallenus vallenus*)
- Snipe (*Gallinago gallinago*)
- Corncrake (*Crex crex*)
- Hen harrier (*Circus cyaneus*)
- Merlin (*Flaco columbarius*)

These were identified on the basis of being migratory Special Protection Area feature species (as per Wright *et al*.'s, 2012 assessment of offshore wind farm risk to UK migratory species), not previously considered during the assessment of collision mortality to seabird species and known to breed or winter in Ireland. One additional species, not in Wright *et al*., 2012, is also included; namely great northern diver, as it is a migratory species and qualifying interest of the nearby North-west Irish Sea SPA.

## 1.3. **Scenarios modelled**

Two proposed turbine configurations are being considered at the CWP Project. The first comprises 75 x 250 m diameter turbines (Design Option A) and the second comprises 60 x 276 m diameter turbines (Design Option B). All collision risk models were run for both Design Options.

# 2. Methods

## 2.1. Collision Risk Modelling (seabird species)

Collision risk modelling for seabird species was carried out using the stochastic collision risk model (sCRM) tool developed by Marine Scotland (MacGregor *et al*. 2018). This tool implements a version of the Band (2012) offshore avian collision risk model, based on work by Masden (2015) to incorporate stochasticity. The Band model predicts monthly collision rates for a proposed development using densities of flying seabirds derived from site-specific boat-based or aerial survey data, along with either site-based or generic species-specific flight height data, bird biometric and behavioural data derived from published literature, and the proposed wind farm specifications. The stochastic model builds on this by allowing incorporation of uncertainty in the input parameters and using this to generate confidence intervals around the monthly collision predictions.

The collision risk modelling was run based on densities derived from aerial survey data collected within the CWP Project Array Site between May 2020 and April 2022 (see Technical Appendix 10.5: Baseline Characterisation Report for methods used for density estimation). Boat-based survey campaigns were also carried out at the site between April 2013 and April 2014, and October 2018 and August 2020. The data have been used to inform flight height analysis, and are considered to be robust for this purpose, but were not included in the density estimation in order to avoid additional uncertainty in the estimates arising from the different biases associated with the different survey platforms, and to ensure that the most recent dataset was utilised.

The sCRM tool allows implementation of two different methods of dealing with bird flight height data – the basic approach and the extended approach. The basic approach assumes that the distribution of bird flight height is uniform within the range of rotor-swept heights so that the only required input parameter is the proportion of flights of a given species at rotor-swept height. The extended approach uses data on the flight height distribution of a species to allow the model to incorporate differential collision risk at different heights relative to a turbine rotor within the rotor-swept range, reflecting the fact that collision risk varies across the height of the rotor. For each approach, either site specific, or generic flight height data can be used, giving rise to four possible options:

- Option 1 (BO1): Site-specific data are used to derive the proportion of birds at collision height which are then assumed to be uniformly distributed over the range of heights that are rotor-swept.
- Option 2 (BO2): Generic data are used to derive the proportion of birds at collision height which are then assumed to be uniformly distributed over the range of heights that are rotor-swept.
- Option 3 (BO3): Generic data on flight height distribution are used to model collision risk based on varying collision risk and bird density across the range of heights that are rotor-swept.
- Option 4 (BO4): Site-specific data on flight height distribution are used to model collision risk based on varying collision risk and bird density across the range of heights that are rotor-swept.

BO3 and BO4 require different avoidance rates than BO1 and BO2 due to differences in the way that the model is implemented, with appropriate avoidance rates for BO3 and BO4 being unavailable for many species (Cook *et al*., 2014). There are also concerns regarding the sensitivity of the method underlying BO3 and BO4 to the flight height distribution data and the effect of this on uncertainty around the collision estimates (UK SNCBs, 2014). Therefore, only BO1 and BO2 were considered for use at the CWP Project. Since seabirds generally fly within the lower range of the rotor-swept height range where collision risk is lower, collision estimates based on BO3 and BO4 tend to produce lower predicted mortalities than collision estimates based on BO1 and BO2. Therefore use of BO1 and BO2 can be considered to be precautionary.

Currently, BO2 is generally carried out using generic flight height distributions published by Johnston *et al.* (2014a, b). These flight height distributions were modelled from pre-construction survey data collected at 32 offshore wind farm sites around the UK and the southern North Sea. These generic data were used to implement BO2 for all key species at CWP.

BO1 can only be utilised in CRM if suitable site-specific flight height information is available. If no such data have been collected during baseline ornithological surveys of the proposed array area, or if that information is not considered to be sufficiently accurate, then CRM must be undertaken using generic flight height distribution curves (i.e. BO2 or BO3 models). Since aerial survey data cannot currently be used to generate robust estimates of flight height (CWP, 2022), aerial survey data could not be used to derive BO1 estimates. However, data from the previous boat-based survey campaigns were used to provide this information where possible.

Site-specific boat-based survey data for the CWP Project were collected within height bands rather than continuously (see Technical Appendix 10.5: Baseline Characterisation Report for survey methodology) and these did not coincide exactly with rotor-swept height, therefore it was not possible to calculate an exact proportion of birds at flight height from the raw survey data. Instead, bird flight height distributions were modelled to derive flight height curves, and proportion of birds at collision height was then calculated from these curves (CWP, 2022).

Johnston *et al.,* 2014a, observed a large degree of uncertainty around modelled flight height distributions where sample sizes were less than 100 individuals. Site-specific flight height curves were therefore only used to inform CRM for species for which the number of records (rather than individuals) attributed a flight height during the site-specific boat-based surveys was greater than 100. Number of records was used in preference to number of individuals to avoid trying to fit a curve to data comprising a small number of large groups.

Of the species for which CRM was undertaken, the number of records exceeded 100 for four species: kittiwake, gannet, herring gull and common tern (Table 2.1). BO1 was therefore applied for these species only.

Before attempting to fit flight height distribution curves, flight heights recorded by observers were ‘re-binned’, since some heights were recorded to the nearest metre rather than within the broader bins set out in the established methodology. Bins used were 0 - 2.5 m, followed by 5 m increments subsequently, up until 57.5 m – 62.5 m. The greatest height recorded was 60 m, with the exception of herring gull, for which there was a single observation of four individuals at 125m. For this reason, an additional bin of 62.5 m – 125 m was included for herring gull. The number of animals within a bin was summed and divided by the width of the bin to account for variable bin widths.

Flight height curves for each species were generated by fitting linear regression models with a log link of the form log(N) ~ Y, where N was the number of birds per altitudinal bin divided by the bin width, and Y was the mid-point of the altitudinal bin. Model fit was assessed by visually comparing fitted lines to raw data, and by considering $R^2$ values, a measure of goodness of fit. $R^2$ values can range from 0 to 1, with values closer to 0 indicating a poor fit, and a value of 1 indicating a perfect fit to the data. As stochastic CRM models allow the input of a standard deviation around the proportion of birds at collision risk height, models were bootstrapped to derive uncertainty. The data for each species were resampled with replacement 1000 times and the model refitted to each dataset to provide 1000 flight height curves from which standard deviations were derived.

Modelled curves were used to predict bird flight activity at 1 m increments between 1 m and 300 m, to match the range predicted across by Johnston *et al*., 2014a. Over this 300 m range, the number of animals per 1 m altitude was divided by the sum of the total animals, to provide a proportion of birds at that height. This was then summed across the range of rotor-swept heights to estimate the total proportion of birds at risk height.

Table 2.1 summarises the model fitted to flight height data for each of the four species at CWP where boat-based ESAS survey sample sizes were sufficient to permit model fitting (with a sample size greater than 100 records), along with sample sizes and $R^2$ goodness of fit values.

Table 2.1: Model type, sample sizes and goodness of fit for flight height models constructed for seabirds at CWP.

| Species | Modelled curve | Number of observations | Number of individuals | Goodness of fit ($R^2$) |
|---|---|---|---|---|
| Kittiwake | Exponential linear regression | 1,184 | 2,117 | 0.84 |
| Gannet | Exponential linear regression | 456 | 538 | 0.92 |
| Herring gull | Exponential linear regression | 281 | 378 | 0.73 |
| Common tern | Exponential linear regression | 136 | 310 | 0.68 |

## 2.1.1. sCRM input parameters

The sCRM was run for 1,000 iterations and with the large array correction option turned off, since the predicted collision rates are not so high that bird density would be expected to decline significantly as birds pass through the windfarm.

### 2.1.1.1. Turbine parameters

Turbine parameters for the CWP Project Design Options A and B used in the collision risk modelling are presented in Table 2.2, and operational time (a combined figure accounting for estimated wind availability and maintenance downtime) assumed for the model in

| Month | Time operational (%) | |
|---|---|---|
| | Design Option A | Design Option B |
| January | 89.4 | 89.5 |
| February | 89.8 | 89.7 |
| March | 86.5 | 86.8 |
| April | 83.6 | 84.1 |
| May | 82.5 | 83.0 |
| June | 81.5 | 82.0 |
| July | 81.1 | 81.6 |
| August | 82.7 | 83.2 |
| September | 85.3 | 85.8 |
| October | 88.7 | 89.0 |
| November | 89.5 | 89.4 |
| December | 90.6 | 90.5 |

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Table 2.2: Turbine parameters used for collision risk modelling. Numbers in brackets are standard deviations.

| Parameter | Design Option A | Design Option B |
|---|---|---|
| Number of turbines | 75 | 60 |

| Parameter | Design Option A | Design Option B |
|---|---|---|
| Latitude (degrees) | 53.1 | 53.1 |
| Number of blades | 3 | 3 |
| Rotor radius (m) | 125 | 138 |
| Air gap (m)* | 36 | 36 |
| Tidal offset | 0 | 0 |
| Blade width (m) | 7 | 7.9 |
| Rotation speed (rpm) | 6.804 (1.246) | 5.591 (1.402) |
| Pitch (degrees) | 6.738 (5.044) | 7.248 (6.923) |

** Relative to Mean Sea Level (MSL)*

**Table 2.3: Percentage of time per month that turbines are predicted to be operational. Design Option A is 70 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines.**

| Month | Time operational (%) | |
|---|---|---|
| | Design Option A | Design Option B |
| January | 89.4 | 89.5 |
| February | 89.8 | 89.7 |
| March | 86.5 | 86.8 |
| April | 83.6 | 84.1 |
| May | 82.5 | 83.0 |
| June | 81.5 | 82.0 |
| July | 81.1 | 81.6 |
| August | 82.7 | 83.2 |
| September | 85.3 | 85.8 |
| October | 88.7 | 89.0 |
| November | 89.5 | 89.4 |
| December | 90.6 | 90.5 |

*Source: CWP Project*

#### 2.1.1.2. **Species biometrics**

Species biometric data used for the CWP collision risk modelling are presented inTable 2.4.

**Table 2.4: Seabird biometric data used for collision risk modelling Numbers in brackets are standard deviations).**

| Species | Body length (m) | Wingspan (m) | Flight speed (m/s) | Nocturnal activity (0-1) | Flight type | References |
|---|---|---|---|---|---|---|
| Kittiwake | 0.390 (0.0050) | 1.080 (0.0625) | 13.1 (0.40) | 0.375 (0.0637) | Flapping | Snow and Perrins, 1987, Alerstam, 1997, NatureScot, 2023 |

| Species | Body length (m) | Wingspan (m) | Flight speed (m/s) | Nocturnal activity (0-1) | Flight type | References |
|---|---|---|---|---|---|---|
| Common gull | 0.410 (0.0050) | 1.200 (0.0500) | 13.4 (2.90) | 0.250 (0.0637) | Flapping | NatureScot, 2023 |
| Common tern | 0.330 (0.0100) | 0.870 (0.0000) | 10.5 (0.00) | 0.000 (0.0000) | Flapping | NatureScot, 2023 |
| Great black-backed gull | 0.710 (0.0350) | 1.580 (0.0375) | 13.7 (1.20) | 0.375 (0.0637) | Flapping | Snow and Perrins, 1987, Alerstam, 1997, NatureScot, 2023 |
| Herring gull | 0.595 (0.0225) | 1.440 (0.0300) | 12.8 (1.80) | 0.375 (0.0637) | Flapping | Snow and Perrins, 1987, Alerstam, 1997, NatureScot, 2023 |
| Gannet | 0.935 (0.0325) | 1.720 (0.0375) | 14.9 (0.00) | 0.080 (0.0000) | Flapping* | Snow and Perrins, 1987, Pennycuick, 1997, Furness *et al.*, 2018 |

**Gliding was also investigated since for Northern gannet since it can display both flight types. However, flapping gave slightly higher collision rates and was therefore taken forward for analysis as a precautionary approach.*

#### 2.1.1.3. **Avoidance rates**

Avoidance rates used for the CWP collision risk modelling are presented in Table 2.5. All avoidance rates are those recommended in the most recent guidance issued by NatureScot (2023).

**Table 2.5: Avoidance rates used for collision risk modelling. Numbers in brackets are standard deviations.**

| Species | Avoidance rates |
|---|---|
| Kittiwake | 0.993 (0.0003) |
| Common gull | 0.995 (0.0002) |
| Common tern | 0.991 (0.0004) |
| Great black-backed gull | 0.994 (0.0004) |
| Herring gull | 0.994 (0.0004) |
| Gannet | 0.993 (0.0003) |

*Source: NatureScot, 2023*

#### 2.1.1.4. **Flight densities**

Flight densities derived from aerial survey data collected at CWP (see Section Collision Risk Modelling (seabird species)2.1) and used in the collision risk modelling are presented in Table 2.6.

Table 2.6: Monthly densities of birds in flight within the Codling Wind Park footprint. Numbers in brackets are standard deviations.

| Species | Black-legged kittiwake | Common gull | Common tern | Great black-backed gull | Herring gull | Northern gannet |
|---|---|---|---|---|---|---|
| Jan | 1.101 (0.000) | 0.050 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.150 (0.000) |
| Feb | 0.801 (0.849) | 0.150 (0.212) | 0.000 (0.000) | 0.000 (0.000) | 0.100 (0.071) | 0.050 (0.071) |
| Mar | 0.767 (0.226) | 0.067 (0.058) | 0.000 (0.000) | 0.000 (0.000) | 0.033 (0.029) | 0.033 (0.029) |
| Apr | 0.576 (0.177) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.025 (0.035) | 0.075 (0.035) |
| May | 1.401 (0.283) | 0.000 (0.000) | 0.134 (0.190) | 0.192 (0.193) | 0.876 (1.180) | 0.175 (0.248) |
| Jun | 0.676 (0.035) | 0.000 (0.000) | 0.017 (0.024) | 0.000 (0.000) | 0.000 (0.000) | 0.025 (0.035) |
| Jul | 0.841 (0.128) | 0.000 (0.000) | 0.084 (0.000) | 0.000 (0.000) | 0.025 (0.035) | 0.025 (0.035) |
| Aug | 1.110 (0.326) | 0.000 (0.000) | 1.825 (1.143) | 0.000 (0.000) | 0.150 (0.212) | 0.025 (0.035) |
| Sep | 0.223 (0.315) | 0.001 (0.002) | 0.727 (1.028) | 0.000 (0.000) | 0.000 (0.000) | 0.075 (0.035) |
| Oct | 0.926 (0.318) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.000 (0.000) | 0.025 (0.035) |
| Nov | 2.024 (0.393) | 0.076 (0.034) | 0.000 (0.000) | 0.000 (0.000) | 0.001 (0.001) | 0.075 (0.035) |
| Dec | 3.773 (1.601) | 0.103 (0.076) | 0.000 (0.000) | 0.025 (0.035) | 0.025 (0.035) | 0.200 (0.212) |

*Source: Natural Power*

#### 2.1.1.5. **Proportion of flight activity at Potential Collision Height (PCH)**

Site-specific proportions of flight activity derived from curves modelled from boat-based survey data collected at CWP (see Section Collision Risk Modelling (seabird species)2.1) and used for BO1 are presented in Table 2.7.

Table 2.7: Proportion of flight activity estimated to be at collision height for Band Option 1. Design Option A is 70 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines. Numbers in brackets are standard deviations.

| Species | Proportion of flights at potential collision height | |
|---|---|---|
| | Design Option A | Design Option B |
| Kittiwake | 0.0183 (0.0060) | 0.0183 (0.0060) |
| Herring gull | 0.1991 (0.0551) | 0.1991 (0.0551) |
| Gannet | 0.0112 (0.0044) | 0.0112 (0.0044) |

*Source: Natural Power*

## 2.2. **Collision Risk Modelling (migratory species)**

Collision risk modelling for migratory species was carried out using the beta version of the stochastic avian migration collision risk model (mCRM) tool developed by Marine Scotland (Caneco *et al.*, 2022). This tool implements a version of the Band (2012) offshore avian collision risk model for migratory species, using the Band Option 2 approach. It has been developed for UK populations and estimates the proportion of migration flights within migration pathways between the UK and other countries that will pass through a proposed wind farm footprint (assuming straight line paths between the UK and non-UK coastlines), using bootstrapping to derive uncertainty around that estimate. It then uses this along with details of the size of the population migrating, the wind farm parameters, the migratory periods to be modelled and biometric and behavioural data relating to the species being modelled to predict the number of collisions within each migratory bio-season specified.

In order to make the tool applicable for use for an OWF in the Irish Sea it was necessary to alter the defined populations using migratory pathways within the region of the Array Site so that flyway population sizes and proportion of those flyway populations potentially passing through the Irish Sea were appropriately parameterised. To determine appropriate flyway populations and proportions passing through the Irish Sea, reference was made to flyway populations and 'all Ireland' population estimates of migratory waterbird species from Burke et al., 2018.

- For species following predominantly eastward migratory pathways to and from Ireland (for example, Bewick's swan) the potential population overflying the Irish Sea was set as the all-Ireland population.
- For species where migratory pathways included northward or north-westerly routes to and from Ireland (for example Greenland white-fronted goose) the potential population overflying the Irish Sea was set as the all-Ireland population, plus 25% of the Great British (GB) population (to correspond with individuals from south-western regions of GB overflying the Irish Sea), with GB population estimates from those built in to the tool (Caneco *et al*., 2022). Where all Ireland plus 25% of GB population estimates exceeded the total flyway population it was assumed to be a large overlap in GB and all Ireland populations and that all birds within the flyway may pass through the Irish Sea (i.e., proportion of flyway population passing through the Irish Sea was set to 1).
- Where all Ireland and flyway populations were not provided in Burke et al., 2018, mCRM default parameters were used with the following treatments applied:
    - For migratory raptor species (hen harrier and merlin) and snipe it was assumed that 50% of the GB population may overfly the Irish sea during each migration period. As GB populations of each of these receptors are much larger than Irish populations, and the number of individuals undertaking migratory movements within GB and between GB and continental Europe is much greater than the number of individuals migrating between GB and Ireland, this flyway population estimate is considered highly conservative.
    - For corncrake, a north-westerly distributed breeding species within Britain and Ireland, which migrates to and from African wintering grounds to the south, it was assumed that 100% of the GB population may overfly the Irish sea during each migration period.

Treatment of flyway and GB and Ireland population size data to determine appropriate inputs to mCRM tool for Irish Sea are summarised in **Table 2.8** (mCRM input parameters are shown in bold).

**Table 2.8: Determination of proportion of flyway populations potentially passing through Irish Sea.**

| Species | Flyway population (Burke *et al*., 2018 unless stated) | All Ireland population (Burke et al., 2018) | Proportion of GB population considered to potentially overfly Irish sea (%) | Total GB population (default in mCRM tool – Caneco *et al*., 2022) | All Ireland population + proportion of GB pop (up to max of flyway pop) | Proportion of flyway population potentially passing through Irish Sea |
|---|---|---|---|---|---|---|
| Bewick's Swan | **21,000** | 20 | 0 | 4,382 | 20 | **0.000952** |
| Canadian Light-Bellied Brent Goose | **36,500** | 35,150 | 25 | 40,000 | 36,500 | **1.000000** |
| Greenland White-fronted Goose | **20,529** | 9,590 | 0 | 21,500 | 9,590 | **0.467144** |
| Shelduck | **250,000** | 10,160 | 0 | 62,500 | 10,160 | **0.040640** |
| Whooper Swan | **34,000** | 15,370 | 25 | 39,990 | 25,367 | **0.746103** |
| Common Scoter | **751,000** | 7,500 | 25 | 135,180 | 41,295 | **0.054987** |
| Great Northern Diver | **5,700** | 2,240 | 25 | 11,000 | 4,990 | **0.875439** |
| Pintail | **65,000** | 1,570 | 25 | 20,942 | 6,805.5 | **0.104700** |
| Red-breasted Merganser | **87,500** | 2,430 | 25 | 15,840 | 6,390 | **0.073029** |
| Red-throated Diver | **322,500** | 770 | 25 | 34,000 | 9,270 | **0.028744** |
| Shoveler | **65,000** | 2,240 | 0 | 22,960 | 2,240 | **0.034462** |
| Teal | **500,000** | 35,740 | 25 | 435,500 | 144,615 | **0.289230** |
| Golden Plover | **930,000** | 92,060 | 25 | 3,296,500 | 916,185 | **0.985145** |
| Great crested Grebe | **638,500** | 2,930 | 0 | 1,380 | 2,930 | **0.004589** |
| Grey Plover | **200,000** | 2,940 | 0 | 124,000 | 2,940 | **0.014700** |
| Oystercatcher | **900,000** | 60,540 | 25 | 358,900 | 150,265 | **0.166961** |
| Ringed Plover | **54,500** | 11,660 | 25 | 289,520 | 54,500 | **1.000000** |

| Species | Flyway population (Burke *et al*., 2018 unless stated) | All Ireland population (Burke et al., 2018) | Proportion of GB population considered to potentially overfly Irish sea (%) | Total GB population (default in mCRM tool – Caneco *et al*., 2022) | All Ireland population + proportion of GB pop (up to max of flyway pop) | Proportion of flyway population potentially passing through Irish Sea |
|---|---|---|---|---|---|---|
| Bar-tailed Godwit | **150,000** | 16,530 | 0 | 680,000 | 16,530 | **0.110200** |
| Black-tailed Godwit | **116,000** | 19,800 | 25 | 303,000 | 95,550 | **0.823707** |
| Curlew | **756,500** | 35,240 | 25 | 141,100 | 70,515 | **0.093212** |
| Knot | **532,300** | 16,270 | 25 | 360,000 | 10,6270 | **0.199643** |
| Turnstone | **150,000** | 9,480 | 25 | 347,000 | 96,230 | **0.641533** |
| Dunlin | **1,330,000** | 45,760 | 25 | 2,021,808 | 551,212 | **0.414445** |
| Greenshank | **350,000** | 1,320 | 0 | 7,200 | 1,320 | **0.003771** |
| Redshank | **361,500** | 23,800 | 25 | 420,000 | 128,800 | **0.356293** |
| Sanderling | **200,000** | 8,420 | 25 | 200,000 | 58,420 | **0.292100** |
| Corncrake | **2,120,000*** | Not defined | 100 | 16,960 | 16,960 | **0.008000** |
| Hen Harrier | **108,800*** | Not defined | 50 | 2,176 | 1,088 | **0.010000** |
| Merlin | **103,200*** | Not defined | 50 | 8,256 | 4,128 | **0.040000** |
| Wigeon | **1,400,000** | 55,730 | 25 | 480,000 | 175,730 | **0.125521** |
| Pochard | **200,000** | 11,150 | 0 | 28,500 | 11,150 | **0.055750** |
| Tufted duck | **900,000** | 27,470 | 25 | 155,000 | 66,220 | **0.073578** |
| Scaup | **212,500** | 2,485 | 0 | 7,000 | 2,485 | **0.011694** |
| Eider | **930,000** | 5,660 | 25 | 106,720 | 32,340 | **0.034774** |
| Lapwing | **7,500,000** | 84,690 | 0 | 3,942,500 | 84,690 | **0.011292** |

| Species | Flyway population (Burke *et al*., 2018 unless stated) | All Ireland population (Burke et al., 2018) | Proportion of GB population considered to potentially overfly Irish sea (%) | Total GB population (default in mCRM tool – Caneco *et al*., 2022) | All Ireland population + proportion of GB pop (up to max of flyway pop) | Proportion of flyway population potentially passing through Irish Sea |
|---|---|---|---|---|---|---|
| Snipe | **11,100,000*** | Not defined | 50 | 6,105,001 | 3,052,500.5 | **0.275000** |
| Mallard | **5,450,000** | 28,230 | 0 | 823,600 | 28,230 | **0.005180** |
| Goldeneye | **1,150,000** | 3,820 | 25 | 37,500 | 13,195 | **0.011474** |

* Default flyway population as set in beta version of mCRM tool (Caneco *et al*., 2022)

During an initial review of all input parameters it was noted that the inbuilt migration corridors included for black-tailed godwit did not overlap with the CWP footprint, when in reality some birds will pass over this area (note: no such discrepancies were identified in relation to the other 37 species modelled). This issue was raised with and acknowledged by the tool developers and, since the migration pathways used by the tool are internal and cannot be modified, the agreed solution was to run the analysis for black-tailed godwit using a proxy species with similar migration pathways to those expected for this species (Grant Humphries, personal communication). The species with the most similar migration pathways through the Irish Sea was found to be Canadian light-bellied Brent goose so black-tailed godwit was run as Canadian light-bellied Brent goose within the tool. All other species-specific parameters used by the tool can be modified by the user, with the exception of the migration season definitions, so this was done so that all other parameters related directly to black-tailed godwit. It was noted that the migration season definition does differ between Canadian light-bellied Brent goose and black-tailed godwit but the only model parameter that differs with season definition is the wind availability assumed during migration (Grant Humphries, personal communication). (This is calculated as the average wind-availability across the months that are included in each migration season.) For both species, pre-breeding migration is defined as March until May inclusive. However, for black-tailed godwit, post-breeding migration is defined as June to October whereas for Canadian light-bellied Brent goose, post-breeding migration is defined as August to October. For design option A, this will result in operational time during that season to be estimated at 85.7% for black-tailed godwit rather than 83.5% for the June to October period, and for design option B, these values are 86.0% operational time versus 84.3% operational time for the June to October period. This will result in black-tailed godwit collision estimates being slightly higher than they would have been if the correct season definition could have been used.

## 2.2.1. mCRM Input parameters

Parameters used for migratory collision risk modelling (mCRM) at CWP are presented in the sections below.

### 2.2.1.1. Turbine parameters

Turbine parameters used in collision risk modelling for migratory species are presented in **Table 2.9** and the percentage of time the turbines are expected to be operational in **Table 2.10** (a combined figure accounting for estimated wind availability and maintenance downtime).

**Table 2.9: Turbine parameters used for collision risk modelling. Design Option A is 70 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines. Numbers in brackets are standard deviations.**

| Parameter | Design Option A | Design Option B |
|---|---|---|
| Number of turbines | 75 | 60 |
| Latitude (degrees) | 53 | 53 |
| Number of blades | 3 | 3 |
| Rotor radius (m) | 125 | 138 |
| Air gap (m) * | 36 | 36 |
| Tidal offset | 0 | 0 |
| Blade width (m) | 7 | 7.9 |
| Rotation speed (rpm) | 6.804 (1.246) | 5.591 (1.402) |
| Pitch (degrees) | 6.738 (5.044) | 7.248 (6.923) |

**Relative to MSL*

Table 2.10: Percentage of time per month that turbines are predicted to be operational. Design Option A is 70 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines.

| Month | Operational time (%) | |
|---|---|---|
| | Design Option A | Design Option B |
| January | 89.4 | 89.5 |
| February | 89.8 | 89.7 |
| March | 86.5 | 86.8 |
| April | 83.6 | 84.1 |
| May | 82.5 | 83.0 |
| June | 81.5 | 82.0 |
| July | 81.1 | 81.6 |
| August | 82.7 | 83.2 |
| September | 85.3 | 85.8 |
| October | 88.7 | 89.0 |
| November | 89.5 | 89.4 |
| December | 90.6 | 90.5 |

### 2.2.1.2. **Species biometrics**

Species biometric data used for the migration collision risk modelling is presented in **Table 2.11**.

Table 2.11: Migratory species biometric data used in collision risk modelling. Numbers in brackets are standard deviations.

| Species | Body length (m) | Wingspan (m) | Flight speed (m/s) | Flight type |
|---|---|---|---|---|
| Bewick's swan | 1.21 (0.04) | 1.96 (0.04) | 24.00 (7.60) | Flapping |
| Canadian light-bellied brent goose | 0.58 (0.02) | 1.15 (0.02) | 17.90 (6.10) | Flapping |
| Greenland white-fronted goose | 0.72 (0.06) | 1.48 (0.06) | 18.75 (7.19) | Flapping |
| Shelduck | 0.62 (0.02) | 1.12 (0.02) | 18.20 (4.30) | Flapping |
| Whooper swan | 1.52 (0.04) | 2.30 (0.04) | 17.50 (4.20) | Flapping |
| Common scoter | 0.49 (0.03) | 0.84 (0.03) | 22.10 (4.00) | Flapping |
| Great northern diver | 0.80 (0.02) | 1.37 (0.02) | 19.50 (1.60) | Flapping |
| Red-throated diver | 0.61 (0.02) | 1.11 (0.02) | 18.60 (3.90) | Flapping |
| Pintail | 0.58 (0.02) | 0.88 (0.02) | 21.90 (2.00) | Flapping |

| Species | Body length (m) | Wingspan (m) | Flight speed (m/s) | Flight type |
|---|---|---|---|---|
| Red-breasted merganser | 0.55 (0.01) | 0.78 (0.01) | 22.00 (2.90) | Flapping |
| Shoveler | 0.48 (0.02) | 0.77 (0.02) | 18.30 (2.00) | Flapping |
| Teal | 0.36 (0.015) | 0.61 (0.015) | 17.40 (1.60) | Flapping |
| Golden plover | 0.28 (0.01) | 0.72 (0.01) | 16.50 (1.80) | Flapping |
| Great crested grebe | 0.48 (0.02) | 0.88 (0.02) | 21.13 (1.55) | Flapping |
| Grey plover | 0.28 (0.01) | 0.77 (0.01) | 16.50 (1.80) | Flapping |
| Oystercatcher | 0.42 (0.02) | 0.83 (0.02) | 13.00 (2.50) | Flapping |
| Ringed plover | 0.19 (0.01) | 0.52 (0.01) | 16.00 (1.10) | Flapping |
| Bar-tailed godwit | 0.38 (0.02) | 0.75 (0.02) | 18.30 (2.10) | Flapping |
| Black-tailed godwit | 0.42 (0.02) | 0.76 (0.02) | 18.10 (6.00) | Flapping |
| Curlew | 0.55 (0.02) | 0.90 (0.02) | 15.40 (3.30) | Flapping |
| Knot | 0.24 (0.01) | 0.59 (0.01) | 24.60 (3.30) | Flapping |
| Turnstone | 0.23 (0.01) | 0.54 (0.01) | 10.00 (3.30) | Flapping |
| Dunlin | 0.18 (0.01) | 0.40 (0.01) | 15.30 (1.90) | Flapping |
| Greenshank | 0.32 (0.01) | 0.69 (0.01) | 12.30 (3.30) | Flapping |
| Redshank | 0.28 (0.01) | 0.62 (0.01) | 15.30 (4.10) | Flapping |
| Sanderling | 0.20 (0.01) | 0.42 (0.01) | 21.40 (1.10) | Flapping |
| Corncrake | 0.28 (0.02) | 0.50 (0.02) | 13.00 (2.00) | Flapping |
| Hen harrier | 0.48 (0.02) | 1.10 (0.02) | 11.40 (1.10) | Flapping |
| Merlin | 0.28 (0.02) | 0.56 (0.02) | 12.70 (5.80) | Flapping |

| Species | Body length (m) | Wingspan (m) | Flight speed (m/s) | Flight type |
|---|---|---|---|---|
| Wigeon | 0.48 (0.02) | 0.80 (0.02) | 18.50 (2.00) | Flapping |
| Pochard | 0.46 (0.01) | 0.77 (0.01) | 23.60 (2.00) | Flapping |
| Tufted duck | 0.44 (0.01) | 0.70 (0.01) | 21.10 (1.10) | Flapping |
| Scaup | 0.46 (0.01) | 0.78 (0.01) | 21.10 (2.00) | Flapping |
| Eider | 0.60 (0.03) | 0.94 (0.03) | 17.34 (2.40) | Flapping |
| Lapwing | 0.30 (0.01) | 0.84 (0.01) | 12.80 (1.30) | Flapping |
| Snipe | 0.26 (0.01) | 0.46 (0.01) | 17.10 (2.70) | Flapping |
| Mallard | 0.58 (0.02) | 0.90 (0.02) | 15.86 (2.00) | Flapping |
| Goldeneye | 0.46 (0.01) | 0.72 (0.01) | 20.30 (3.80) | Flapping |

*Source: Caneco et al., 2022*

#### 2.2.1.3. **Avoidance rates**

Avoidance rates used for the migration collision risk modelling is presented in **Table 2.12**.

**Table 2.12: Avoidance rates used for collision risk modelling. Numbers in brackets are standard deviations.**

| Species | Avoidance rates |
|---|---|
| Bewick's swan | 0.9880 (0.00090) |
| Canadian light-bellied brent goose | 0.9990 (0.00010) |
| Greenland white-fronted goose | 0.9990 (0.00010) |
| Shelduck | 0.9850 (0.00080) |
| Whooper swan | 0.9880 (0.00090) |
| Common scoter | 0.9850 (0.00080) |
| Great northern diver | 0.9950 (0.00001) |
| Red-throated diver | 0.9950 (0.00001) |
| Pintail | 0.9850 (0.00080) |
| Red-breasted merganser | 0.9850 (0.00080) |
| Shoveler | 0.9850 (0.00080) |
| Teal | 0.9850 (0.00080) |
| Golden plover | 0.9990 (0.00000) |
| Great crested grebe | 0.9950 (0.00001) |

| Species | Avoidance rates |
|---|---|
| Grey plover | 0.9990 (0.00000) |
| Oystercatcher | 0.9990 (0.00000) |
| Ringed plover | 0.9990 (0.00000) |
| Bar-tailed godwit | 0.9990 (0.00000) |
| Black-tailed godwit | 0.9990 (0.00000) |
| Curlew | 0.9990 (0.00000) |
| Knot | 0.9990 (0.00000) |
| Turnstone | 0.9990 (0.00000) |
| Dunlin | 0.9990 (0.00000) |
| Greenshank | 0.9990 (0.00000) |
| Redshank | 0.9990 (0.00000) |
| Sanderling | 0.9990 (0.00000) |
| Corncrake | 0.9950 (0.00001) |
| Hen harrier | 0.9950 (0.00010) |
| Merlin | 0.9890 (0.00030) |
| Wigeon | 0.9850 (0.00080) |
| Pochard | 0.9850 (0.00080) |
| Tufted duck | 0.9850 (0.00080) |
| Scaup | 0.9850 (0.00080) |
| Eider | 0.9850 (0.00080) |
| Lapwing | 0.9990 (0.00000) |
| Snipe | 0.9990 (0.00000) |
| Mallard | 0.9850 (0.00080) |
| Goldeneye | 0.9850 (0.00080) |

*Source: Caneco et al., 2022*

#### 2.2.1.4. **Biogeographic population and proportion in Ireland**

Biogeographic population data and the proportion of total populations in Ireland used for the migration collision risk modelling are presented in **Table 2.13**.

**Table 2.13: Biogeographic population and Irish proportion used in migration collision risk modelling for CWP.**

| Species | Biogeographic population | Proportion in Ireland |
|---|---|---|
| Bewick’s swan | 21,000 | 0.0010 |
| Canadian light-bellied Brent goose | 36,500 | 1.0000 |
| Greenland white-fronted goose | 20,529 | 0.4671 |
| Shelduck | 250,000 | 0.0406 |
| Whooper swan | 34,000 | 0.7461 |
| Common scoter | 751,000 | 0.0550 |
| Great northern diver | 5,700 | 0.8754 |
| Red-throated diver | 322,500 | 0.0287 |

| Species | Biogeographic population | Proportion in Ireland |
|---|---|---|
| Pintail | 65,000 | 0.1047 |
| Red-breasted merganser | 87,500 | 0.0730 |
| Shoveler | 65,000 | 0.0345 |
| Teal | 500,000 | 0.2892 |
| Golden plover | 930,000 | 0.9851 |
| Great crested grebe | 638,500 | 0.0046 |
| Grey plover | 200,000 | 0.0147 |
| Oystercatcher | 900,000 | 0.1670 |
| Ringed plover | 54,500 | 1.0000 |
| Bar-tailed godwit | 150,000 | 0.1102 |
| Black-tailed godwit | 116,000 | 0.8237 |
| Curlew | 756,500 | 0.0932 |
| Knot | 532,300 | 0.1996 |
| Turnstone | 150,000 | 0.6415 |
| Dunlin | 1,330,000 | 0.4144 |
| Greenshank | 350,000 | 0.0038 |
| Redshank | 361,500 | 0.3563 |
| Sanderling | 200,000 | 0.2921 |
| Corncrake | 2,120,000 | 0.0080 |
| Hen harrier | 108,800 | 0.0100 |
| Merlin | 103,200 | 0.0400 |
| Wigeon | 1,400,000 | 0.1255 |
| Pochard | 200,000 | 0.0558 |
| Tufted duck | 900,000 | 0.0736 |
| Scaup | 212,500 | 0.0117 |
| Eider | 930,000 | 0.0348 |
| Lapwing | 7,500,000 | 0.0113 |
| Snipe | 11,100,000 | 0.2750 |
| Mallard | 5,450,000 | 0.0052 |
| Goldeneye | 1,150,000 | 0.0115 |

#### 2.2.1.5. **Proportion of flight activity at Potential Collision Height (PCH)**

The proportion of flights expected to be at collision height for each species used for the migration collision risk modelling are presented in **Table 2.14**. These are default values within the mCRM tool (Caneco *et al*., 2022). As

**Table 2.14: Proportion of flight activity estimated to be at collision height.**

| Species | Design Options A and B |
|---|---|
| Bewick's swan | 0.50 |
| Canadian light-bellied brent goose | 0.50 |

| Species | Design Options A and B |
|---|---|
| Greenland white-fronted goose | 1.00 |
| Shelduck | 0.50 |
| Whooper swan | 0.50 |
| Common scoter | 1.00 |
| Great northern diver | 0.25 |
| Red-throated diver | 0.25 |
| Pintail | 1.00 |
| Red-breasted merganser | 1.00 |
| Shoveler | 1.00 |
| Teal | 1.00 |
| Golden plover | 1.00 |
| Great crested grebe | 1.00 |
| Grey plover | 1.00 |
| Oystercatcher | 1.00 |
| Ringed plover | 1.00 |
| Bar-tailed godwit | 1.00 |
| Black-tailed godwit | 1.00 |
| Curlew | 1.00 |
| Knot | 1.00 |
| Turnstone | 1.00 |
| Dunlin | 1.00 |
| Greenshank | 1.00 |
| Redshank | 1.00 |
| Sanderling | 1.00 |
| Corncrake | 1.00 |
| Hen harrier | 1.00 |
| Merlin | 1.00 |
| Wigeon | 1.00 |
| Pochard | 1.00 |
| Tufted duck | 1.00 |
| Scaup | 1.00 |
| Eider | 0.25 |
| Lapwing | 1.00 |
| Snipe | 1.00 |
| Mallard | 1.00 |
| Goldeneye | 1.00 |

*Source: Caneco et al., 2022*

### 2.2.1.6. **Species-specific migration periods**

The species-specific migratory season definitions used in the mCRM for CWP are presented in Table 2.15. These are default values within the mCRM tool (Caneco *et al.*, 2022).

**Table 2.15: Definitions of Migration Seasons used in Migratory Collision Risk Modelling.**

| Species | Pre-breeding Migration | Post-breeding Migration | Other migration |
|---|---|---|---|
| Bewick's swan | Feb – Mar | Oct – Dec | - |
| Canadian light-bellied Brent goose | Mar - May | Aug - Oct | - |
| Greenland white-fronted goose | Mar - Apr | Sep - Nov | - |
| Shelduck | Jan - Feb | Jun - Jul | Aug - Dec |
| Whooper swan | Feb - Apr | Sep - Nov | - |
| Common scoter | Apr - May | Jun - Oct | - |
| Great northern diver | Dec - Jun | Aug - Nov | - |
| Red-throated diver | Feb - Jun | Jul - Sep | - |
| Pintail | Mar - May | Aug - Nov | - |
| Red-breasted merganser | Apr - Jul | Aug - Nov | - |
| Shoveler | Mar - Jun | Jul - Aug | Sep - Dec |
| Teal | Feb - May | Jul - Dec | - |
| Golden plover | Feb - May | Jul - Oct | - |
| Great crested grebe | Mar - Jun | Jul - Nov | Feb - Mar |
| Grey plover | Mar - May | Jul - Sep | - |
| Oystercatcher | Jan - Mar | Jul - Nov | - |
| Ringed plover | Mar - May | Aug - Oct | - |
| Bar-tailed godwit | Mar - Apr | Jul - Oct | - |
| Black-tailed godwit | Mar - May | Aug – Oct* | - |
| Curlew | Mar - May | Jun - Oct | - |
| Knot | Feb - May | Jun - Oct | - |
| Turnstone | Jan - Jun | Jul - Aug | - |
| Dunlin | Mar - May | Jun - Oct | - |
| Greenshank | Mar - Jun | Aug - Nov | - |
| Redshank | Mar - May | Jul - Sep | - |
| Sanderling | Apr - Jun | Jul - Oct | - |
| Corncrake | Apr - May | Jul - Aug | - |
| Hen harrier | Mar - May | Sep - Nov | - |
| Merlin | Mar - May | Aug - Nov | - |
| Wigeon | Mar - Apr | Aug - Nov | - |
| Pochard | Mar - May | Aug - Nov | - |
| Tufted duck | Apr - Jun | Sep - Oct | - |
| Scaup | Feb - May | Sep - Nov | - |
| Eider | Mar - Apr | Oct - Nov | - |

| Species | Pre-breeding Migration | Post-breeding Migration | Other migration |
|---|---|---|---|
| Lapwing | Jan - May | Oct - Nov | - |
| Snipe | Mar - May | Aug - Oct | Oct - Dec |
| Mallard | Apr - Jun | Sep - Oct | Jan - Mar |
| Goldeneye | Feb - May | Aug - Dec | - |
| Bewick’s swan | Feb – Mar | Oct – Dec | - |
| Canadian light-bellied Brent goose | Mar - May | Aug - Oct | - |
| Greenland white-fronted goose | Mar - Apr | Sep - Nov | - |
| Shelduck | Jan - Feb | Jun - Jul | Aug - Dec |
| Whooper swan | Feb - Apr | Sep - Nov | - |

*Source: Caneco* et al.*, 2022*

**Species run as Canadian light-bellied Brent goose so season definition is based on that rather than the June to October season definition that would usually be used for black-tailed godwit (See section 2.2)*

# 3. Results

## 3.1. sCRM

### 3.1.1. Gannet

Monthly predicted gannet collision rates for Band Options 1 and 2, for Design Options A and B are presented in Table 3.1. Table 3.2 shows the bio-seasonal and annual predicted gannet collision rates for Band Options 1 and 2, for Design Options A and B. Table 3.3 shows bio-seasonal gannet collision risk estimate impacts to population mortality rates for Design Option B (bio-seasonal collision risk estimate impacts to population mortality rates for Design Option A are presented in the impact assessment in **EIAR Volume 4, Chapter 10: Ornithology**). Bio-seasonal collision risk estimate impacts to population mortality rates are given before and after the application of a 70% macro-avoidance rate for this species.

Table 3.1: Predicted monthly collision rates for northern gannet. Design Option A is 75 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines.

| Band Option | Design Option | Median predicted monthly collisions (95% confidence intervals) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 1 | A | 0.102 (0.037 - 0.213) | 0.051 (0.003 - 0.18) | 0.031 (0.002 - 0.111) | 0.069 (0.01 - 0.207) | 0.258 (0.017 - 1.024) | 0.034 (0.002 - 0.145) | 0.037 (0.002 - 0.136) | 0.034 (0.002 - 0.128) | 0.062 (0.013 - 0.189) | 0.027 (0.002 - 0.109) | 0.047 (0.009 - 0.139) | 0.142 (0.006 - 0.568) |
| 1 | B | 0.082 (0.032 - 0.178) | 0.038 (0.002 - 0.153) | 0.024 (0.002 - 0.091) | 0.057 (0.009 - 0.167) | 0.225 (0.017 - 0.818) | 0.032 (0.002 - 0.116) | 0.03 (0.001 - 0.132) | 0.028 (0.001 - 0.114) | 0.054 (0.009 - 0.155) | 0.022 (0.001 - 0.085) | 0.04 (0.006 - 0.11) | 0.13 (0.009 - 0.46) |
| 2 | A | 0.305 (0.079 - 0.726) | 0.147 (0.006 - 0.698) | 0.091 (0.004 - 0.415) | 0.199 (0.024 - 0.727) | 0.725 (0.039 - 3.726) | 0.1 (0.005 - 0.506) | 0.102 (0.007 - 0.562) | 0.096 (0.005 - 0.453) | 0.189 (0.029 - 0.693) | 0.08 (0.005 - 0.38) | 0.137 (0.019 - 0.528) | 0.389 (0.018 - 1.849) |

| Band Option | Design Option | Median predicted monthly collisions (95% confidence intervals) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 2 | B | 0.253 (0.064 - 0.596) | 0.108 (0.005 - 0.518) | 0.073 (0.004 - 0.33) | 0.162 (0.019 - 0.619) | 0.644 (0.044 - 2.86) | 0.094 (0.005 - 0.418) | 0.086 (0.004 - 0.413) | 0.079 (0.003 - 0.415) | 0.158 (0.019 - 0.557) | 0.062 (0.003 - 0.309) | 0.118 (0.016 - 0.41) | 0.396 (0.018 - 1.687) |

**Table 3.2:** Predicted northern gannet mortality rates by bio-season and annually. Design Option A is 75 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines. Numbers in brackets are sums of the monthly 95% confidence intervals.

| Band Option | Design Option | Median predicted bio-seasonal collisions | | | Median predicted annual collisions |
|---|---|---|---|---|---|
| | | Return Migration (Dec – Mar) | Migration-free Breeding Season (Apr – Aug) | Post-breeding Migration (Sep – Nov) | |
| 1 | A | 0.326 (0.048 - 1.072) | 0.432 (0.033 - 1.64) | 0.136 (0.024 - 0.437) | 0.894 (0.105 - 3.149) |
| 1 | B | 0.274 (0.045 - 0.882) | 0.372 (0.03 - 1.347) | 0.116 (0.016 - 0.35) | 0.762 (0.091 - 2.579) |
| 2 | A | 0.932 (0.107 - 3.688) | 1.222 (0.08 - 5.974) | 0.406 (0.053 - 1.601) | 2.56 (0.24 - 11.263) |
| 2 | B | 0.83 (0.091 - 3.131) | 1.065 (0.075 - 4.725) | 0.338 (0.038 - 1.276) | 2.233 (0.204 - 9.132) |

Table 3.3: Gannet bio-season collision risk impacts to baseline mortality rates for Design Option B.

| Design Option | Band Option | Bio-season (months) | Regional baseline populations and baseline mortality rates (individuals per annum) | | Gannet collision estimates and baseline mortality increases before consideration of macro-avoidance | | Gannet collision estimates and baseline mortality increases after correction for macro-avoidance (assuming 70% macro-avoidance rate) | |
|---|---|---|---|---|---|---|---|---|
| | | | Population | Baseline mortality | Collisions (95% CI) | Increase in baseline mortality (%) | Collisions (95% CI) | Increase in baseline mortality (%) |
| | | Return migration (Dec – Mar) | 644,739 | 116,698 | 0.274 (0.045 – 0.882) | 0.000 (0.000 – 0.001) | 0.082 (0.014 – 0.265) | 0.000 (0.000 – 0.000) |
| | | Migration-free breeding (Apr – Aug) | Method 1: 517,233 | 93,619 | 0.372 (0.03 – 1.347) | 0.000 (0.000 – 0.001) | 0.112 (0.009 – 0.404) | 0.000 (0.000 – 0.000) |
| | | | Method 2: 420,257 | 76,067 | | 0.000 (0.000 – 0.000) | | 0.000 (0.000 – 0.001) |
| B | 1 | Post-breeding migration (Sep – Nov) | 536,005 | 97,017 | 0.116 (0.016 – 0.35) | 0.000 (0.000 – 0.000) | 0.035 (0.005 – 0.105) | 0.000 (0.000 – 0.000) |
| | | Annual (BDMPS) | 644,739 | 116,698 | 0.762 (0.091 – 2.579) | 0.001 (0.000 – 0.002) | 0.229 (0.027 – 0.774) | 0.000 (0.000 – 0.001) |
| | | Annual (Biogeographic) | 1,180,000 | 213,580 | | 0.000 (0.000 – 0.001) | | 0.000 (0.000 – 0.000) |

### 3.1.2. Kittiwake

Monthly predicted kittiwake collision rates for Band Options 1 and 2, for Design Options A and B are presented in Table 3.4. Table 3.5 shows the bio-seasonal and annual predicted kittiwake collision rates for Band Options 1 and 2, for Design Options A and B. **Table 3.6** shows bio-seasonal kittiwake collision risk estimate impacts to population mortality rates for Design Option B (bio-seasonal collision risk estimate impacts to population mortality rates for Design Option A are presented in the impact assessment in **EIAR Volume 4, Chapter 10: Ornithology**).

**Table 3.4: Predicted monthly collision rates for black-legged kittiwake. Design Option A is 75 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines**

| Band Option | Design Option | Median predicted monthly collisions (95% confidence intervals) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 1 | A | 1.322 (0.603 - 2.579) | 1.099 (0.062 - 3.812) | 1.001 (0.346 - 2.374) | 0.761 (0.245 - 1.686) | 2.011 (0.846 - 4.188) | 0.996 (0.455 - 1.905) | 1.242 (0.514 - 2.589) | 1.567 (0.491 - 3.679) | 0.379 (0.023 - 1.523) | 1.191 (0.322 - 2.946) | 2.372 (0.987 - 5.1) | 4.341 (0.787 - 11.099) |
| 1 | B | 1.148 (0.52 - 2.295) | 0.95 (0.054 - 3.326) | 0.877 (0.301 - 2.133) | 0.664 (0.213 - 1.529) | 1.747 (0.738 - 3.714) | 0.867 (0.399 - 1.675) | 1.085 (0.448 - 2.223) | 1.362 (0.425 - 3.164) | 0.331 (0.02 - 1.325) | 1.044 (0.278 - 2.562) | 2.052 (0.851 - 4.452) | 3.786 (0.684 - 9.782) |
| 2 | A | 3.038 (1.852 - 4.359) | 2.516 (0.139 - 7.478) | 2.278 (0.997 - 4.335) | 1.704 (0.631 - 3.165) | 4.645 (2.396 - 7.557) | 2.277 (1.393 - 3.236) | 2.794 (1.64 - 4.346) | 3.553 (1.362 - 6.696) | 0.893 (0.058 - 2.921) | 2.702 (0.871 - 5.38) | 5.287 (2.969 - 9.045) | 9.863 (2.004 - 21.554) |
| 2 | B | 2.656 (1.619 - 3.872) | 2.197 (0.121 - 6.486) | 2 (0.856 - 3.814) | 1.505 (0.55 - 2.808) | 4.078 (2.089 - 6.76) | 1.997 (1.222 - 2.868) | 2.471 (1.43 - 3.975) | 3.146 (1.19 - 5.92) | 0.788 (0.051 - 2.574) | 2.382 (0.76 - 4.73) | 4.615 (2.578 - 7.912) | 8.549 (1.736 - 19.088) |

Table 3.5: Predicted black-legged kittiwake mortality rates by bio-season and annually. Design Option A is 75 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines. Numbers in brackets are sums of the monthly 95% confidence intervals.

| Band Option | Design Option | Median predicted bio-seasonal collisions | | | Median predicted annual collisions |
|---|---|---|---|---|---|
| | | Return Migration (Jan – Apr) | Migration-free Breeding Season (May – Jul) | Post-breeding migration (Aug – Dec) | |
| 1 | A | 4.183 (1.256 - 10.451) | 4.249 (1.815 - 8.682) | 9.85 (2.61 - 24.347) | 18.282 (5.681 - 43.48) |
| 1 | B | 3.639 (1.088 - 9.283) | 3.699 (1.585 - 7.612) | 8.575 (2.258 - 21.285) | 15.913 (4.931 - 38.18) |
| 2 | A | 9.536 (3.619 - 19.337) | 9.716 (5.429 - 15.139) | 22.298 (7.264 - 45.596) | 41.55 (16.312 - 80.072) |
| 2 | B | 8.358 (3.146 - 16.98) | 8.546 (4.741 - 13.603) | 19.48 (6.315 - 40.224) | 36.384 (14.202 - 70.807) |

Table 3.6: Kittiwake bio-season collision risk impacts to baseline mortality rates for Design Option B.

| Design Option | Band Option | Bio-season (months) | Regional baseline populations and baseline mortality rates (individuals per annum) | | Collisions (min – max) | Increase in baseline mortality (%) |
|---|---|---|---|---|---|---|
| | | | Population | Baseline mortality | | |
| B | 1 | Return migration (Jan – Apr) | 708,147 | 110,471 | 3.639 (1.088 – 9.283) | 0.003 (0.001 – 0.008) |
| | | Migration-free breeding (May – Jul) | Method 1: 404,443 | 63,093 | 3.699 (1.585 – 7.612) | 0.006 (0.003 – 0.012) |
| | | | Method 2: 131,860 | 20,570 | | 0.018 (0.008 – 0.037) |
| | | Post-breeding migration (Aug – Dec) | 928,207 | 144,800 | 8.575 (2.258 – 21.285) | 0.006 (0.002 – 0.015) |
| | | Annual (BDMPS) | 928,207 | 144,800 | 15.913 (4.931 – 38.18) | 0.011 (0.003 – 0.026) |
| | | Annual (Biogeographic) | 5,100,000 | 795,600 | | 0.002 (0.001 – 0.005) |

### 3.1.3. Herring gull

Monthly predicted herring gull collision rates for Band Options 1 and 2, for Design Options A and B are presented in **Table 3.7**.

**Table** 3.8 shows the bio-seasonal and annual predicted herring gull collision rates for Band Options 1 and 2, for Design Options A and B. [Bio-seasonal collision risk estimate impacts to population mortality rates for Design Options A and B are presented in the impact assessment in **EIAR Volume 4, Chapter 10: Ornithology**]

**Table 3.7: Predicted monthly collision rates for herring gull. Design Option A is 75 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines.**

| Band Option | Design Option | Median predicted monthly collisions (95% confidence intervals) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 1 | A | 0 (0 - 0) | 1.308 (0.113 - 4.219) | 0.586 (0.053 - 1.762) | 0.543 (0.041 - 1.833) | 20.339 (0.824 - 75.582) | 0 (0 - 0) | 0.622 (0.04 - 2.175) | 3.514 (0.234 - 12.604) | 0 (0 - 0) | 0 (0 - 0) | 0.016 (0.001 - 0.055) | 0.483 (0.028 - 1.657) |
| 1 | B | 0 (0 - 0) | 1.179 (0.11 - 3.68) | 0.505 (0.042 - 1.641) | 0.472 (0.034 - 1.681) | 17.27 (1.261 - 62.677) | 0 (0 - 0) | 0.516 (0.033 - 1.861) | 2.92 (0.145 - 10.624) | 0 (0 - 0) | 0 (0 - 0) | 0.014 (0.001 - 0.045) | 0.407 (0.025 - 1.372) |
| 2 | A | 0 (0 - 0) | 1.046 (0.086 - 3.054) | 0.453 (0.042 - 1.294) | 0.414 (0.032 - 1.297) | 15.16 (0.657 - 53.107) | 0 (0 - 0) | 0.473 (0.034 - 1.461) | 2.713 (0.151 - 9.594) | 0 (0 - 0) | 0 (0 - 0) | 0.012 (0.001 - 0.038) | 0.365 (0.02 - 1.14) |
| 2 | B | 0 (0 - 0) | 0.911 (0.089 - 2.688) | 0.373 (0.03 - 1.121) | 0.353 (0.024 - 1.192) | 12.723 (0.896 - 42.857) | 0 (0 - 0) | 0.378 (0.025 - 1.246) | 2.27 (0.121 - 7.557) | 0 (0 - 0) | 0 (0 - 0) | 0.01 (0.001 - 0.034) | 0.302 (0.019 - 0.964) |

**Table 3.8: Predicted herring gull mortality rates by bio-season and annually. Design Option A is 75 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines. Numbers in brackets are sums of the monthly 95% confidence intervals.**

| Band Option | Design Option | Median predicted bio-seasonal collisions | | Median predicted annual collisions |
|---|---|---|---|---|
| | | Breeding (Apr – Aug) | Non-breeding (Sept – Mar) | |
| 1 | A | 25.018 (1.139 - 92.194) | 2.393 (0.195 - 7.693) | 27.411 (1.334 - 99.887) |
| 1 | B | 21.178 (1.473 - 76.843) | 2.105 (0.178 - 6.738) | 23.283 (1.651 - 83.581) |
| 2 | A | 18.76 (0.874 - 65.459) | 1.876 (0.149 - 5.526) | 20.636 (1.023 - 70.985) |
| 2 | B | 15.724 (1.066 - 52.852) | 1.596 (0.139 - 4.807) | 17.32 (1.205 - 57.659) |

### 3.1.4. Great black-backed gull

Monthly predicted great black-backed gull collision rates for Band Option 2, for Design Options A and B are presented in **Table 3.9**.

**Table** 3.10 shows the bio-seasonal and annual predicted great black-backed gull collision rates for Band Option 2, for Design Options A and B. **Table 3.11** shows bio-seasonal great black-backed gull collision risk estimate impacts to population mortality rates for Design Option B (bio-seasonal collision risk estimate impacts to population mortality rates for Design Option A are presented in the impact assessment in **EIAR Volume 4, Chapter 10: Ornithology**).

**Table 3.9: Predicted monthly collision rates for great black-backed gull. Design Option A is 75 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines.**

| Band Option | Design Option | Median predicted monthly collisions (95% confidence intervals) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 2 | A | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 3.659 (0.383 - 11.04) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0.488 (0.028 - 1.453) |
| 2 | B | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 3.303 (0.276 - 9.563) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0.366 (0.017 - 1.272) |

**Table 3.10: Predicted great black-backed gull mortality rates by bio-season and annually. Design Option A is 75 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines. Numbers in brackets are sums of the monthly 95% confidence intervals.**

| Band Option | Design Option | Median predicted bio-seasonal collisions | | Median predicted annual collisions |
|---|---|---|---|---|
| | | Breeding (Apr – Aug) | Non-breeding (Sept – Mar) | |
| 2 | A | 3.659 (0.383 - 11.04) | 0.488 (0.028 - 1.453) | 4.147 (0.411 - 12.493) |
| 2 | B | 3.303 (0.276 - 9.563) | 0.366 (0.017 - 1.272) | 3.669 (0.293 - 10.835) |

**Table 3.11: Great black-backed gull bio-season collision risk impacts to baseline mortality rates for Design Option B.**

| Design Option | Band Option | Bio-season (months) | Regional baseline populations and baseline mortality rates (individuals per annum) | | Collisions (min – max) | Increase in baseline mortality (%) |
|---|---|---|---|---|---|---|
| | | | Population | Baseline mortality | | |
| B | 1 | Breeding (Apr – Aug) | Method 1: 33,032 | 3,238 | 3.303 (0.276 – 9.563) | 0.102 (0.009 – 0.295) |
| | | | Method 2: 2,041 | 194 | | 1.703 (0.142 – 4.929) |
| | | Non-breeding (Sep – Oct) | 53,181 | 5,052 | 0.366 (0.017 – 1.272) | 0.007 (0.000 – 0.025) |
| | | Annual (BDMPS) | 53,181 | 5,052 | 3.669 (0.293 – 10.835) | 0.073 (0.006 – 0.214) |
| | | Annual (Biogeographic) | 440,000 | 42,180 | | 0.009 (0.001 – 0.026) |

### 3.1.5. Common gull

Monthly predicted common gull collision rates for Band Option 2, for Design Options A and B are presented in **Table 3.12**.

**Table** 3.13 shows the bio-seasonal and annual predicted common gull collision rates for Band Option 2, for Design Options A and B. **Table 3.14** shows bio-seasonal common gull collision risk estimate impacts to population mortality rates for Design Option B (bio-seasonal collision risk estimate impacts to population mortality rates for Design Option A are presented in the impact assessment in **EIAR Volume 4, Chapter 10: Ornithology**).

**Table 3.12: Predicted monthly collision rates for common gull. Design Option A is 75 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines.**

| Band Option | Design Option | Median predicted monthly collisions (95% confidence intervals) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 2 | A | 0.228 (0.127 - 0.406) | 0.912 (0.047 - 3.415) | 0.391 (0.029 - 1.237) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0.009 (0 - 0.031) | 0 (0 - 0) | 0.345 (0.079 - 0.828) | 0.474 (0.045 - 1.453) |
| 2 | B | 0.198 (0.11 - 0.362) | 0.809 (0.036 - 2.783) | 0.343 (0.029 - 1.018) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0.008 (0 - 0.028) | 0 (0 - 0) | 0.302 (0.065 - 0.707) | 0.413 (0.042 - 1.309) |

**Table 3.13: Predicted common gull mortality rates by bio-season and annually. Design Option A is 75 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines. Numbers in brackets are sums of the monthly 95% confidence intervals.**

| Band Option | Design Option | Median predicted bio-seasonal collisions | | | Median predicted annual collisions |
|---|---|---|---|---|---|
| | | Return Migration (Jan - Apr) | Migration-free Breeding Season (May – Jul) | Post-breeding Migration (Aug – Dec) | |
| 2 | A | 1.531 (0.203 - 5.058) | 0 (0 - 0) | 0.828 (0.124 - 2.312) | 2.359 (0.327 - 7.37) |
| 2 | B | 1.35 (0.175 - 4.163) | 0 (0 - 0) | 0.723 (0.107 - 2.044) | 2.073 (0.282 - 6.207) |

**Table 3.14: Common gull bio-season collision risk impacts to baseline mortality rates for Design Option B.**

| Design Option | Band Option | Bio-season (months) | Regional baseline populations and baseline mortality rates (individuals per annum) | | Collisions (min – max) | Increase in baseline mortality (%) |
|---|---|---|---|---|---|---|
| | | | Population | Baseline mortality | | |
| B | 2 | Return migration (Jan – Apr) | 67,500 | 17,078 | 1.350 (0.175 – 4.163) | 0.008 (0.001 – 0.024) |
| | | Migration-free breeding (May – Jul) | Method 1: 26,779 | 6,775 | 0 (0 – 0) | 0.000 (0.000 – 0.000) |
| | | | Method 2: 5,657 | 1,431 | | 0.000 (0.000 – 0.000) |
| | | Post-breeding (Aug – Dec) | 67,500 | 17,078 | 0.723 (0.107 – 2.044) | 0.004 (0.001 – 0.012) |
| | | Annual (BDMPS) | 67,500 | 17,078 | 2.073 (0.282 – 6.207) | 0.012 (0.002 – 0.036) |
| | | Annual (Biogeographic) | 1,725,000 | 436,425 | | 0.000 (0.000 – 0.001) |

### 3.1.6. Common tern

Monthly predicted common tern collision rates for Band Option 2, for Design Options A and B are presented in **Table 3.15**.

**Table** 3.16 shows the bio-seasonal and annual predicted common tern collision rates for Band Option 2, for Design Options A and B. **Table 3.17** shows bio-seasonal common tern collision risk estimate impacts to population mortality rates for Design Option B (bio-seasonal collision risk estimate impacts to population mortality rates for Design Option A are presented in the impact assessment in **EIAR Volume 4, Chapter 10: Ornithology**).

**Table 3.15: Predicted monthly collision rates for common tern. Design Option A is 75 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines.**

| Band Option | Design Option | Median predicted monthly collisions (95% confidence intervals) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 2 | A | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0.147 (0.008 - 0.531) | 0.019 (0.001 - 0.062) | 0.072 (0.031 - 0.144) | 1.366 (0.151 - 3.936) | 0.669 (0.039 - 2.128) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) |
| 2 | B | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) | 0.129 (0.007 - 0.417) | 0.017 (0.001 - 0.058) | 0.063 (0.024 - 0.119) | 1.246 (0.119 - 3.532) | 0.578 (0.037 - 2.029) | 0 (0 - 0) | 0 (0 - 0) | 0 (0 - 0) |

**Table 3.16: Predicted common tern mortality rates by bio-season and annually. Design option A is 75 x 250 m diameter turbines and Design Option B is 60 x 276 m diameter turbines. Numbers in brackets are sums of the monthly 95% confidence intervals.**

| Band Option | Design Option | Median predicted bio-seasonal collisions | | | Median predicted annual collisions |
|---|---|---|---|---|---|
| | | Return Migration (Apr - May) | Migration-free Breeding (Jun) | Post-breeding Migration (Jul - Sep) | |
| 2 | A | 0.147 (0.008 - 0.531) | 0.019 (0.001 - 0.062) | 2.107 (0.221 - 6.208) | 2.273 (0.23 - 6.801) |
| 2 | B | 0.129 (0.007 - 0.417) | 0.017 (0.001 - 0.058) | 1.887 (0.18 - 5.68) | 2.033 (0.188 - 6.155) |

**Table 3.17: Common tern bio-season collision risk impacts to baseline mortality rates for Design Option B.**

| Design Option | Band Option | Bio-season (months) | Regional baseline populations and baseline mortality rates (individuals per annum) | | Collisions (min – max) | Increase in baseline mortality (%) |
|---|---|---|---|---|---|---|
| | | | Population | Baseline mortality | | |
| B | 2 | Return migration (Apr - May) | 71,030 | 13,567 | 0.129 (0.007 – 0.417) | 0.001 (0.000 – 0.003) |
| | | Migration-free breeding (Jun) | Method 1: 30,254 | 5,779 | 0.017 (0.001 – 0.058) | 0.000 (0.000 – 0.001) |
| | | | Method 2: 1,684 | 322 | | 0.005 (0.000 – 0.018) |
| | | Post-breeding migration (Jul – Sep) | 71,030 | 13,567 | 1.887 (0.18 – 5.68) | 0.014 (0.001 – 0.042) |
| | | Annual (BDMPS) | 71,030 | 13,567 | 2.033 (0.188 – 6.155) | 0.015 (0.001 – 0.045) |
| | | Annual (Biogeographic) | 480,000 | 91,680 | | 0.002 (0.000 – 0.007) |

## 3.2. mCRM

**Table 3.18: Predicted collision rates for Design Options A and B for migratory species.**

| Species | Design Option | Collisions in each migratory period (±SD) | | | Annual collisions (±SD) |
|---|---|---|---|---|---|
| | | Pre-breeding | Post-breeding | Other periods | |
| Whooper swan | A | 0.097 ± 0.036 | 0.098 ± 0.037 | - | 0.195 ± 0.052 |
| | B | 0.077 ± 0.028 | 0.078 ± 0.028 | - | 0.155 ± 0.040 |
| Bewick's swan | A | 0.000 ± 0.000 | 0.000 ± 0.000 | - | 0.000 ± 0.000 |
| | B | 0.000 ± 0.000 | 0.000 ± 0.000 | - | 0.000 ± 0.000 |
| Greenland white-fronted goose | A | 0.011 ± 0.008 | 0.012 ± 0.009 | - | 0.023 ± 0.012 |
| | B | 0.010 ± 0.007 | 0.010 ± 0.007 | - | 0.020 ± 0.010 |
| Canadian light-bellied brent goose | A | 0.020 ± 0.009 | 0.020 ± 0.009 | - | 0.040 ± 0.013 |
| | B | 0.017 ± 0.007 | 0.018 ± 0.007 | - | 0.035 ± 0.010 |
| Shelduck | A | 0.055 ± 0.015 | 0.050 ± 0.013 | 0.054 ± 0.014 | 0.159 ± 0.024 |
| | B | 0.049 ± 0.013 | 0.045 ± 0.012 | 0.048 ± 0.013 | 0.142 ± 0.022 |
| Pintail | A | 0.061 ± 0.014 | 0.063 ± 0.014 | - | 0.124 ± 0.020 |
| | B | 0.052 ± 0.013 | 0.054 ± 0.013 | - | 0.106 ± 0.018 |
| Common scoter | A | 0.325 ± 0.083 | 0.329 ± 0.084 | - | 0.654 ± 0.118 |
| | B | 0.271 ± 0.070 | 0.273 ± 0.071 | - | 0.544 ± 0.100 |
| Great northern diver | A | 0.004 ± 0.001 | 0.004 ± 0.001 | - | 0.008 ± 0.001 |
| | B | 0.003 ± 0.001 | 0.003 ± 0.001 | - | 0.006 ± 0.001 |
| Red-throated diver | A | 0.006 ± 0.001 | 0.006 ± 0.001 | - | 0.012 ± 0.001 |
| | B | 0.006 ± 0.001 | 0.005 ± 0.001 | - | 0.011 ± 0.001 |
| Red-breasted merganser | A | 0.053 ± 0.012 | 0.056 ± 0.013 | - | 0.109 ± 0.018 |
| | B | 0.047 ± 0.011 | 0.049 ± 0.012 | - | 0.096 ± 0.016 |
| Shoveler | A | 0.022 ± 0.005 | 0.022 ± 0.005 | 0.023 ± 0.006 | 0.067 ± 0.009 |
| | B | 0.019 ± 0.005 | 0.019 ± 0.005 | 0.020 ± 0.005 | 0.058 ± 0.009 |
| Teal | A | 1.390 ± 0.290 | 1.402 ± 0.293 | - | 2.792 ± 0.412 |
| | B | 1.218 ± 0.249 | 1.228 ± 0.251 | - | 2.446 ± 0.354 |
| Golden plover | A | 0.417 ± 0.095 | 0.411 ± 0.094 | 0 ± 0 | 0.828 ± 0.134 |
| | B | 0.368 ± 0.094 | 0.363 ± 0.093 | - | 0.731 ± 0.132 |
| Great crested grebe | A | 0.020 ± 0.003 | 0.021 ± 0.003 | 0.021 ± 0.003 | 0.062 ± 0.005 |
| | B | 0.018 ± 0.003 | 0.018 ± 0.003 | 0.019 ± 0.003 | 0.055 ± 0.005 |
| Grey plover | A | 0.002 ± 0.000 | 0.002 ± 0.000 | - | 0.004 ± 0.000 |
| | B | 0.002 ± 0.000 | 0.002 ± 0.000 | - | 0.004 ± 0.000 |
| Oystercatcher | A | 0.127 ± 0.030 | 0.123 ± 0.029 | - | 0.250 ± 0.042 |
| | B | 0.110 ± 0.028 | 0.107 ± 0.027 | - | 0.217 ± 0.039 |
| Ringed plover | A | 0.030 ± 0.007 | 0.031 ± 0.007 | - | 0.061 ± 0.010 |
| | B | 0.027 ± 0.006 | 0.027 ± 0.006 | - | 0.054 ± 0.008 |

| Species | Design Option | Collisions in each migratory period (±SD) | | | Annual collisions (±SD) |
|---|---|---|---|---|---|
| | | Pre-breeding | Post-breeding | Other periods | |
| Bar-tailed godwit | A | 0.005 ± 0.002 | 0.005 ± 0.002 | - | 0.010 ± 0.003 |
| | B | 0.004 ± 0.001 | 0.004 ± 0.001 | - | 0.008 ± 0.001 |
| Black-tailed godwit | A | 0.094 ± 0.063 | 0.096 ± 0.064 | - | 0.190 ± 0.090 |
| | B | 0.083 ± 0.052 | 0.084 ± 0.053 | - | 0.167 ± 0.074 |
| Curlew | A | 0.046 ± 0.011 | 0.046 ± 0.011 | - | 0.092 ± 0.016 |
| | B | 0.040 ± 0.010 | 0.040 ± 0.010 | - | 0.080 ± 0.014 |
| Knot | A | 0.055 ± 0.012 | 0.054 ± 0.012 | - | 0.109 ± 0.017 |
| | B | 0.049 ± 0.010 | 0.048 ± 0.009 | - | 0.097 ± 0.013 |
| Turnstone | A | 0.054 ± 0.036 | 0.051 ± 0.034 | - | 0.105 ± 0.050 |
| | B | 0.048 ± 0.035 | 0.046 ± 0.033 | - | 0.094 ± 0.048 |
| Dunlin | A | 0.309 ± 0.066 | 0.308 ± 0.066 | - | 0.617 ± 0.093 |
| | B | 0.275 ± 0.065 | 0.274 ± 0.065 | - | 0.549 ± 0.092 |
| Greenshank | A | 0.001 ± 0.000 | 0.001 ± 0.000 | - | 0.002 ± 0.000 |
| | B | 0.001 ± 0.000 | 0.001 ± 0.000 | - | 0.002 ± 0.000 |
| Redshank | A | 0.074 ± 0.019 | 0.073 ± 0.019 | - | 0.147 ± 0.027 |
| | B | 0.065 ± 0.017 | 0.064 ± 0.017 | - | 0.129 ± 0.024 |
| Sanderling | A | 0.027 ± 0.006 | 0.028 ± 0.006 | - | 0.055 ± 0.008 |
| | B | 0.024 ± 0.006 | 0.025 ± 0.006 | - | 0.049 ± 0.008 |
| Corncrake | A | 0.050 ± 0.010 | 0.049 ± 0.010 | - | 0.099 ± 0.014 |
| | B | 0.044 ± 0.010 | 0.044 ± 0.010 | - | 0.088 ± 0.014 |
| Hen harrier | A | 0.004 ± 0.001 | 0.004 ± 0.001 | - | 0.008 ± 0.001 |
| | B | 0.004 ± 0.001 | 0.004 ± 0.001 | - | 0.008 ± 0.001 |
| Merlin | A | 0.035 ± 0.040 | 0.037 ± 0.041 | - | 0.072 ± 0.057 |
| | B | 0.031 ± 0.034 | 0.032 ± 0.035 | - | 0.063 ± 0.049 |
| Wigeon | A | 1.657 ± 0.352 | 1.687 ± 0.359 | - | 3.344 ± 0.503 |
| | B | 1.438 ± 0.295 | 1.462 ± 0.300 | - | 2.900 ± 0.421 |
| Pochard | A | 0.097 ± 0.022 | 0.100 ± 0.023 | - | 0.197 ± 0.032 |
| | B | 0.084 ± 0.018 | 0.086 ± 0.018 | - | 0.170 ± 0.025 |
| Tufted duck | A | 0.502 ± 0.132 | 0.530 ± 0.140 | - | 1.032 ± 0.192 |
| | B | 0.439 ± 0.118 | 0.462 ± 0.125 | - | 0.901 ± 0.172 |
| Scaup | A | 0.032 ± 0.006 | 0.033 ± 0.006 | - | 0.065 ± 0.008 |
| | B | 0.028 ± 0.005 | 0.029 ± 0.006 | - | 0.057 ± 0.008 |
| Eider | A | 0.086 ± 0.018 | 0.09 ± 0.019 | - | 0.176 ± 0.026 |
| | B | 0.074 ± 0.018 | 0.078 ± 0.018 | - | 0.152 ± 0.025 |
| Lapwing | A | 0.050 ± 0.012 | 0.052 ± 0.013 | - | 0.102 ± 0.018 |
| | B | 0.044 ± 0.010 | 0.046 ± 0.010 | - | 0.090 ± 0.014 |
| Snipe | A | 1.685 ± 0.376 | 1.713 ± 0.382 | 1.793 ± 0.400 | 5.191 ± 0.669 |

| Species | Design Option | Collisions in each migratory period (±SD) | | | Annual collisions (±SD) |
|---|---|---|---|---|---|
| | | Pre-breeding | Post-breeding | Other periods | |
| | B | 1.497 ± 0.316 | 1.521 ± 0.321 | 1.585 ± 0.335 | 4.603 ± 0.561 |
| Mallard | A | 0.254 ± 0.058 | 0.268 ± 0.061 | 0.272 ± 0.062 | 0.794 ± 0.105 |
| | B | 0.219 ± 0.055 | 0.23 ± 0.058 | 0.234 ± 0.059 | 0.683 ± 0.099 |
| Goldeneye | A | 0.146 ± 0.030 | 0.149 ± 0.030 | - | 0.295 ± 0.042 |
| | B | 0.127 ± 0.025 | 0.129 ± 0.026 | - | 0.256 ± 0.036 |

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