Cerulean Winds Aspen Project Limited

Aspen Offshore Wind Farm

Offshore Environmental Impact Assessment Report

Volume 3, Appendix 12.2: Offshore Ornithology Collision Risk Modelling Technical Report

August 2025

COMMERCIAL IN CONFIDENCE

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Defined Terms

Term	Definition
Applicant	Cerulean Winds Aspen Project Limited.
Aspen Array Area	The area in which the generation infrastructure for Aspen Offshore Wind Farm (OWF), including Wind Turbine Generators (WTGs) and Offshore Substation Platforms (OSPs) will be located.
Aspen Lease Area	The site for which Cerulean Winds (UKCS) Ltd was awarded an Exclusivity Agreement. The Aspen Lease Area totals 333 km^2 in which the Aspen Array Area will be sited.
Environmental Impact Assessment (EIA)	A statutory process whereby planned projects must be assessed before a formal decision to proceed can be made. It involves assessment requirements outlined in the EIA Regulations, including the collection and consideration of environmental information, which fulfils the publication of an Environmental Impact Assessment Report (EIAR).
Floating Foundations	The foundations on which the Wind Turbine Generators (WTGs) are installed.
Foundation Anchors	The structure which anchors the moorings to the seabed.
Foundation Moorings	The chains/synthetics that connect the Floating Foundations to the Foundation Anchors to maintain floater station.
High Voltage Alternating Current (HVAC)	Refers to where the flow of electric current reverses direction in a regular frequency. HVAC supports bulk power flow over short to medium transmission distances.
High Voltage Direct Current (HVDC)	Refers to high voltage electricity in direct current form where current flows in one direction only. HVDC supports longer transmission infrastructure due to not experiencing reactive losses.
Inter-array Cables (IACs)	Cables which link the Wind Turbine Generators (WTGs) to each other and to the Offshore Substation Platforms (OSPs) within the Aspen Array Area.
Inter-link Cables	Cables that will link Offshore Substation Platforms (OSPs) within the Aspen Array Area.
Landfall	The area between Mean Low Water Spring (MLWS) and Mean High Water Spring (MHWS) where the Offshore Transmission Cables (OTCs) will connect onshore to offshore.
Offshore Environmental Impact Assessment Report (Offshore EIAR)	The published report of the Environmental Impact Assessment (EIA) that will be undertaken for the Proposed Development.
Offshore Substation Platform (OSP)	Offshore platform consisting of High Voltage Alternating Current (HVAC) substations or High Voltage Direct Current (HVDC) substations.
Offshore Transmission Cable Corridor (OTC Corridor)	The area within which the Offshore Transmission Cables (OTCs) will be installed.
Offshore Transmission Cables (OTCs)	The subsea electricity cables running from Landfall in the region of Stonehaven to the Offshore Substation Platform(s) (OSP(s)) in Aspen Array Area. The OTCs will act as both a demand and supply cable. The OTCs will provide both traditional supply of power to grid but also ensures robust secure power supply to oil and gas assets when the Aspen

Term	Definition
	Array Area is not generating sufficient renewable power to support their demand.
Offshore Transmission Cables (OTCs)	The subsea electricity cables running from Landfall in the region of Stonehaven to the Offshore Substation Platform(s) (OSP(s)) in Aspen Array Area. The OTCs will act as both a demand and supply cable. The OTCs will provide both traditional supply of power to grid but also ensures robust secure power supply to oil and gas assets when the Aspen Array Area is not generating sufficient renewable power to support their demand.
Offshore Wind Farm (OWF)	The proposed generation infrastructure comprising of Wind Turbine Generators (WTGs) and associated, Offshore Substation Platform(s) (OSP(s)), foundations and substructures and Inter-array Cables (IACs).
Project	Aspen Offshore Wind Farm (OWF) - comprises the wind farm and all associated offshore and onshore components.
Proposed Development	The offshore components of the Project (Aspen Offshore Wind Farm) which include all offshore infrastructure associated with Aspen Array Area and the Offshore Transmission Cables (OTCs).
Wind Turbine Generator (WTG)	The wind turbine that generates electricity consisting of tubular towers and blades attached to a nacelle housing mechanical and electrical generating equipment.
Worst-case Design Scenario	The maximum design parameters of each offshore asset of the Proposed Development considered to be a worst case for any given assessment.

Acronyms

Term	Definition
BDMPS	Biologically Defined Minimum Population Scales
CI	Confidence Interval
CRM	Collision Risk Modelling
DAS	Digital Aerial Survey
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IAC	Inter-array Cable
IOF	Important Ornithological Feature
LCI	Lower Confidence Interval
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MRSea	Marine Renewable Strategic Environmental Assessment
OSP	Offshore Substation Platform
OTC	Offshore Transmission Cable
OWF	Offshore Wind Farm
sCRM	Stochastic Collision Risk Model
SD	Standard Deviation
SNCB	Statutory Nature Conservation Body
UCI	Upper Confidence Interval
WTGs	Wind Turbine Generators

Units

Unit	Definition
°	Degree
%	Percentage
km	Kilometre
m	Metre
rpm	Rotations per minute
s	Seconds

1 Introduction

1.1 Project Background

1.1.1 Cerulean Winds Aspen Project Limited (hereafter referred to as the 'Applicant') is proposing to develop the Aspen Offshore Wind Farm (hereafter referred to as 'the Project'). The Project is made up of both offshore and onshore components. The subject of the Offshore Environmental Impact Assessment Report (Offshore EIAR) is the offshore infrastructure of the Project seaward of Mean High Water Springs (MHWS) which is hereafter referred to as 'the Proposed Development'.

1.1.2 The Aspen Array Area covers an area of approximately 333 km2 and is located approximately 84 km east of Peterhead on the east coast of Scotland. The offshore infrastructure of the Proposed Development includes Wind Turbine Generators (WTGs) and associated floating foundations, Offshore Substation Platform(s) (OSP(s)) and associated foundations, the Inter-array Cables (IACs), Inter-link Cables, Offshore Transmission Cables (OTCs) and Landfall.

1.1.3 This report presents the background information relating to, and methodology used to undertake Collision Risk Modelling (CRM) for the Aspen Array Area.

1.1.4 The Proposed Development will consist of the following components:

- Up to 72 offshore WTGs and associated infrastructure (nacelle and blades), floating foundations, foundation moorings and foundation anchors;
- Up to three OSPs and foundations;
- IACs - Cables which link the WTGs to each other and to the OSP(s) within Aspen Array Area;
- Inter-link Cables - Cables which link OSPs;
- OTCs - The subsea electricity cable running from Landfall to the OSP(s) in Aspen Array Area; and
- Cable protection on unburied or shallow buried sections of cables and at cable crossings as and when required.

1.1.5 This report is an Appendix to **Volume 2, Chapter 12: Offshore and Intertidal Ornithology**. Results pertain only to seabird species identified as requiring consideration (see Section 2.2), comprising of those that occur within the Aspen Array Area at potential collision risk height.

1.2 Collision Risk Modelling

1.2.1 Collision with WTGs presents a threat to certain seabird species that fly through the Proposed Development, potentially leading to mortality or injury (Drewitt and Langston, 2006). Susceptibility to collision risk depends on various factors, including species' flight height in relation to rotor blades, flight manoeuvrability, and flight time (Wade *et al.*, 2016; Furness and Wade, 2012; Garthe and Hüppop, 2004). Additionally, the WTG design such as rotor speed, blade size, pitch angle and height above sea surface can influence collision risk. As part of the Environmental Impact Assessment (EIA) process, CRM is used to estimate the level of risk associated with WTG collisions. This is done by estimating the number of collisions per year, based on species specific occurrence within the Aspen Array Area, from densities informed by Digital Aerial Survey (DAS).

2 Methodology

2.1 Guidance and Models

2.1.1 In accordance with the updated NatureScot Guidance Note 7 (NatureScot, 2023; updated 2025), both stochastic and deterministic CRM was conducted using the stochastic collision risk model (sCRM) created by Marine Science Scotland (McGregor, 2018). The stochastic model builds on the Band (2012) model, which estimates collision rates for a development, taking into consideration the WTGs parameters, bird density within the array area, species-specific flight height, biometrics and behaviour data. The stochastic model includes uncertainty in the WTGs and species-specific parameters, incorporating random samples of distributions and Standard Deviation (SD) for each relevant input parameter, allowing the model to produce more accurate collision estimates. The web-browser interface of the model, referred to as the 'Shiny App' (Caneco *et al.*, 2022), was utilised as it is user-friendly, free to use and publicly accessible via a standard web-browser, using R code to estimate collision risk (Donovan, 2017).

2.1.2 The model can be run two ways; the basic model assumes that there is uniform flight height distribution across the rotor swept area, while the extended model assumes a skew towards the lower flight heights based on species flight height distributions (Johnston *et al.*, 2014a; Band, 2012). Both the basic and extended model can be run using either generic flight height data, or site-specific data. The generic flight height data is obtained from pre-construction surveys of 32 OWF developments across the Baltic, North and Irish Sea, providing the flight height distribution for 25 marine bird species (Johnston *et al.*, 2014a; 2014b). There are four possible model options:

- Option 1: basic Band (2012) model, using a simple proportion of birds at collision height, distributed uniformly over the rotor (using either generic or site-specific data);
- Option 2: basic Band (2012) model, using generic or site-specific flight height distribution, but uses the proportion of birds flying at risk height band instead; and
- Option 3: extended model, using generic or site-specific flight height distribution, however, includes a flux value within the rotor swept area based on flight height distribution;
- Option 4: extended model, site-specific flight height distribution.

2.1.3 For the Project, the sCRM 'Shiny App' modelling was undertaken using Option 2. There was insufficient site-specific flight height data, which prevented the calculation of robust estimates to be inputted into Option 1 and 4 and as such these options have been excluded. Option 3 was not undertaken as it is no longer required as per the most recent NatureScot guidance (NatureScot, 2023; updated 2025).

2.1.4 To ensure replicability and consistent model outputs, a fixed seed of 1234 was set. The model was then ran over 1,000 iterations, enabling the generation of multiple scenarios to allow for the quantification and reduction of estimation uncertainty.

2.1.5 There are aspects of the OWF design that require future refinement, and as such, a worst-case design scenario is considered on a precautionary basis to allow for flexibility in the EIA process. The seasonal mortality estimates for the worst-case design scenario has been presented for each species in Section 3. Confidence Intervals (CI) are included to account for uncertainty within the outputs.

2.1.6 In addition to modelling the worst-case design scenario, NatureScot (2025) advises modelling the most-likely scenario. There remains uncertainty around the most-likely scenario at the time of writing, and therefore only the precautionary worst-case design scenario was modelled.

2.2 Model Input Parameters

Wind Turbine Generator Parameters

2.2.1 The WTG parameters that informed the CRM assessment are shown in Table 2.1. Input parameters for the monthly operational time of the WTGs are presented in Table 2.2.

2.2.2 The predicted mortalities resulting from marine bird collisions with WTGs are provided on a worst-case design scenario basis, considering the worst-case design scenario (highest number of the largest WTGs), as presented within the Design Envelope detailed in **Volume 1, Chapter 3: Project Description**. As such, if the final design parameters of the WTGs deviate from those presented here, the resulting impacts would be less than the worst-case design scenario impacts provided.

Table 2.1 The WTG and Turbine Parameters Used to Inform CRM

Parameter	Design Envelope
Maximum Number of WTG	72
Latitude	57.8
Tidal Offset (m)	0
Number of Blades	3
Maximum Rotor Radius (m)	140
Air Gap (m)	22
Maximum Blade Width (m)	8
Average Pitch (˚)	10
Average Pitch SD (˚)	0
Rotation Speed (rotations per minute (rpm))	7
Rotation Speed SD (rpm)	0

Table 2.2 Monthly Operational Parameters Used Within the CRM

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind Availability (%)	96.2	96.0	95.8	93.3	91.4	90.5	89.6	90.5	94.0	95.9	96.0	95.7
Mean Downtime (%)	0	0	0	0	0	0	0	0	0	0	0	0
SD Downtime (%)	0	0	0	0	0	0	0	0	0	0	0	0

Species Considered

2.2.3 Marine bird species have been scoped in for the assessment of potential impacts resulting from collisions with WTGs during the operation and maintenance phase. Twenty-four months of site-specific DAS have been undertaken for the Proposed Development, with the results presented in the **Volume 3, Appendix 12.1: Offshore and Intertidal Ornithology Technical Baseline Report**. It should be noted that two surveys were carried out in April 2024 with the earlier of these being a proxy for the March data. The DAS provides information on the abundance and density of bird species within the Aspen Array Area plus 4km buffer and allows for the classification of certain species as Important Ornithological Features (IOFs) based on the numbers recorded and their known vulnerabilities to impacts from OWFs.

2.2.4 The IOFs scoped in for CRM were evaluated based on their collision risk vulnerability and associated uncertainty (Dierschke *et al.*, 2016; Wade *et al.*, 2016; Bradbury *et al.*, 2014) (Table 2.3), their density in flight in the Aspen Array Area plus 4 km buffer and species-specific conservation status (Stanbury *et al.*, 2021). Species that are unlikely to be vulnerable to collision risk have been scoped out and, consequently, have been excluded from the modelling. The following species were considered for CRM in relation to the Proposed Development:

- Black-legged kittiwake (*Rissa tridactyla*), hereafter 'kittiwake';
- Herring gull (*Larus argentatus*);
- Great black-backed gull (*Larus marinus*);
- Northern gannet (*Morus bassanus,* hereafter 'gannet').

Table 2.3 Criteria for Screening in IOFs Within the Aspen Array Area Plus 2 Km Buffer for Displacement. Vulnerability Index Based on Dierschke *et al.* (2016) and Bradbury *et al.* (2014) With Uncertainty Level Based on Wade *et al.* (2016). Conservation Status Taken From the Birds of Conservation Concern 5 (Stanbury *et al.*, 2024)

Species	Collision Risk Vulnerability	Uncertainty in the Collision Risk Vulnerability	Conservation status
Kittiwake	High	Very low	BoCC5 Red listed
Herring gull	High	Very low	BoCC5 Red listed
Great black-backed gull	High	Low	BoCC5 Red listed
Northern gannet	High	Very low	BoCC5 Amber listed

Biometric Parameters

2.2.5 This section sets out the biometric parameters used in the modelling. An Applicant Approach to CRM input parameters is presented alongside the Guidance Approach advocated by NatureScot (2025). The Applicant is presenting CRM results using a range of evidence-based input variables. The Applicant considers that these models present a more accurate account of likely collisions, while remaining appropriately precautionary, than those using the input variables advocated by Statutory Nature Conservation Bodies (SNCBs).

Guidance Approach

2.2.6 The species-specific physical and behavioural characteristics outlined in the updated NatureScot (2025) guidance were used to inform the CRM as presented in Table 2.4. Bird length and wingspan for all species were derived from Robinson (2005), flight height distribution was taken from Johnston *et al.*, (2014a) and flight speeds from Alterstam *et al.* (2007). Nocturnal Activity Factors are derived from Garthe and Hüppop, 2004, except for gannet which are based on Furness *et al.* (2018) as that paper presents an evidence-led correction factors based on multiple tracking studies.

Table 2.4 IOFs Biometric Parameters Used to Inform CRM

Species	Bird Length (m)	Wingspan (m)	Flight Speed (m/s) (SD)	Nocturnal Activity (%) (SD)	Flight Type
Kittiwake	0.39	1.08	13.1 (0.40)	40 (0.12)	Flapping
Herring gull	0.60	1.44	12.8 (1.80)	37 (0.064)	Flapping
Great black-backed gull	0.71	1.58	13.7 (1.20)	37 (0.064)	Flapping
Gannet	0.94	1.72	14.9 (0)	14 (0.10)	Gliding

2.2.7 The parameters used for the Applicant Approach, and the rationale for their selection, are discussed below and shown in Table 2.5.

2.2.8 The nocturnal activity values for all CRM species are obtained from tracking loggers deployed for East Anglia THREE (MacArthur Gren, APEM and Royal HaskoningDHV, 2015). The nocturnal activity level during both the breeding and non-breeding season was found to be significantly lower than previously suggested by Gathe and Hüppop (2004), which based their nocturnal activity rate recommendation on a generalised scoring index. The findings from the East Anglia THREE study are regarded as more representative of actual nocturnal activity rates, which is support by the ORJIP collision avoidance study results (Skov *et al.*, 2018).

2.2.9 Flight speeds for the Applicant Approach are taken from Cook *et al.*, 2023. The flight speeds in the Applicant Approach represent the means of the commuting and foraging flight speeds for the species (or, in the case of herring and greater black-backed gull, the means of the commuting and foraging flight speeds for a suitable proxy, in this case lesser black-backed gull). These flight speeds reflect speed over ground (as opposed to speed through the air) and use a larger sample size than many of the estimates presented in Garthe and Huppop (2004), from which the SNCB-advised flight speeds are taken. The Applicant considers the Cook *et al.*, 2023 flight speeds to be more appropriate than the advised flight speeds, as the advised flight speeds can be measures of speed through the air (for example for kittiwake) or drawn from very small sample sizes or less accurate means of estimating speed than through analysis of tagged birds.

2.2.10 Flight heights for the Applicant Approach are also taken from Cook *et al.*, 2023. The numbers used are the means of the percentage of flight heights occurring at rotor swept height, taken from altitudinal data from tagged birds. These are considered to be much more representative of real life flight heights compared with those presented in Johnston *et al.,* (2014), given that the 2014 data are based upon estimates of flight height made by boat-based observers.

Table 2.5 IOFs Biometric Parameters Used to Inform CRM (Applicant Approach)

Species	Bird Length (m)	Wingspan (m)	Flight Speed (m/s)	Nocturnal Activity (%)	Flight Type
Kittiwake	0.39	1.08	7.9	40	Flapping
Herring gull	0.60	1.44	9.06	24	Flapping
Great black-backed gull	0.71	1.58	9.06	24	Flapping
Gannet	0.94	1.72	12.4	17.5	Gliding

Avoidance Rates

2.2.11 Avoidance rates are a key parameter in CRM as the majority of birds will undertake avoidance behaviours in the presence of WTG. Avoidance behaviour can occur over three scales; micro-avoidance (avoiding individual blades); meso-scale (avoiding whole wind turbines) and macro-avoidance (avoiding whole wind farm array areas and buffers) (Cook *et al.*, 2014). Avoidance rates used for assessments are based on the updated Joint SNCB (SNCB, 2024) guidance, which utilises the report by Ozsanlev-Harris *et al.* (2023). The UK SNCB guidance advises generic avoidance rates for gull species (kittiwake and gannet) and large gull species (great black-backed gull); these have been applied using the basic Band (2012) and stochastic model ± SD (Table 2.6).

2.2.12 In addition, gannet have been scoped in for both distributional responses and collision analysis. Gannet show strong avoidance of OWFs (Pavat *et al.*, 2023; Furness and Wade, 2012), and this can lead to a significant overestimation of collisions where assumptions of bird presence post construction are made. CRM has therefore been undertaken with the density of birds reduced to account for macro-avoidance of 70% during the non-breeding season only as per the NatureScot Guidance Note 7 (NatureScot, 2025), referred to as the Guidance Approach.

2.2.13 Avoidance rates used within the Applicant Approach are the species-specific rates presented in the latest SNCB guidance. Species-specific avoidance rates offer a more realistic position than the avoidance rates advised in the latest SNCB guidance, which pools species into wider groups (due to uncertainties regarding specific avoidance rates).

2.2.14 For gannet, this report also includes a scenario with the use of a macro-avoidance rate of 70% applied to all collision impact estimates across all seasons, as it is considered that gannet continue to avoid OWFs to reach foraging sites throughout the breeding season (Skov *et al.*, 2018; Vanermen *et al.*, 2016).

Table 2.6 IOFs Avoidance Rates Used for sCRM Input Parameters

Species	Rate Name	Avoidance Rate (SD) (Guidance Approach)	Avoidance Rate (Applicant Approach)
Kittiwake	All gulls	0.9929 (0.0003)	0.997
Herring gull	Large gulls	0.9940 ±0.0004)	0.995
Great black-backed gull	Large gulls	0.9940 (0.0004)	0.9991
Gannet	All gulls	0.9929 (0.0003)	0.9929

To note: Ozsanlev-Harris *et al.* (2023) values have SDs for all avoidance rates and presented here as per SNCBs (2024). However, these are not inputted into the Band (2012) model.

2.2.15 The monthly density estimate of birds in flight were determined from the site-specific DAS conducted over 24 months between April 2023 to February 2025 (with data collected in early April acting as a proxy for March in 2024). The density estimates were calculated using a design-based and a model-based (Marine Renewable Strategic Environmental Assessment (MRSea)) approach. MRSea has been used to produce spatially accounted prediction of density and abundance for certain species or months (Scott-Hayward *et al.*, 2014). Herring gull and great black-backed gull observations were insufficient to produce reliable models from MRSea, as such only design-based estimates were used for CRM for those species. MRSea density estimates have been included for the relevant months for both kittiwake and gannet. For more detail regarding the methodology of the DAS in the array area, along with the population estimates derived from the data see **Volume 3, Appendix 12.1: Offshore and Intertidal Ornithology Technical Baseline Report**.

2.2.16 In accordance with the updated NatureScot (2025) guidance, the sCRM used a monthly distribution of 2,000 density estimates of bird in flight within the Aspen Array Area only for each species. These bootstrapped density datasets are available upon request to allow reproducibility. Mean collision impact estimates are presented with the Lower Confidence Interval (LCI; 2.5th percentile) and the Upper Confidence Interval (UCI; 97.5th percentile), to quantify uncertainty in the data. As deterministic models do not incorporate uncertainty, only the mean densities from the DAS data were used. The deterministic density estimates used for CRM are presented in Table 2.7.

Table 2.7 Monthly Mean Density Estimates (Birds/km^2) of Birds in Flight in the Aspen Array Area for all Species Included in the Deterministic CRM Assessment

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kittiwake	0.02	0.00	0.06	0.21	0.13	0.20	0.05	0.01	0.00	0.05	0.02	0.02
Herring gull	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.13
Great black-backed gull	0.12	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.15
Gannet	0.00	0.11	0.07	0.12	0.05	0.38	0.19	0.09	0.08	0.27	0.00	0.03

2.3 Seasonal Definition

2.3.1 Collision impacts estimates have been categorised for both the breeding and non-breeding season. As per the updated NatureScot guidance, (2025), the non-breeding seasons collision impacts have been assessed in relation to the regional population published by Furness (2015). Within Furness (2015), the regional populations have been apportioned to their defined Biologically Defined Minimum Population Scale (BDMPS). As such the collision impact estimates have been appropriately apportioned to their seasonal definitions using the NatureScot (2020) defined seasons, as described in the distributional response annex (**Volume 3, Appendix 12.3: Offshore Ornithology Distributional Response Analysis Technical Report**). The same approach has been applied in this annex, with the modified seasonal definitions presented in Table 2.8.

2.3.2 The updated NatureScot (2025) guidance states that for species with a breeding and non-breeding seasonal overlap as seen in NatureScot (2020), the collision estimates should be applied proportionally for the allocated seasons. For example, for gannet, March is included in both the breeding and pre-breeding season, as such the collision estimates have been split between each seasonal definition. Macro-avoidance of 70% has been applied for the non-breeding half of March under the Guidance Approach.

Table 2.8 Seasonal Definitions for Species Based on NatureScot (2020) Seasons and Furness (2015) BDMPS.

Species	Breeding	Post-breeding Migration	Non-breeding	Pre-breeding Migration
Kittiwake	**Mid-April to August**	**September to December** (August to December)	N/A	**January to mid-April** (January to April)
Great black-backed gull	**April to August**	N/A	**September to March**	N/A
Gannet	**Mid-March to September**	**October to November** (September to November)	N/A	**December to mid-March** (December to March)

Table note: bold text denotes season to be used in the sCRM. Original Furness (2015) BDPMS seasons are provided within brackets if deviated from.

3 Results

3.1.1 This section details the monthly and annual predicted mortalities associated with collision for all key species in the worst-case design scenario, presented below. A summary of all CRM results is provided in Table 4.1 and **Volume 2, Chapter 12: Offshore and Intertidal Ornithology**.

3.2 NatureScot Approach

Kittiwake

3.2.1 The predicted seasonal collision mortalities for kittiwake are presented in Table 3.1, and the monthly predicted mortalities are provided in Table 3.2 and Table 3.3.

Table 3.1 Predicted Seasonal Collision for Kittiwake Using Deterministic and Stochastic Band Option 2. Seasonal Definitions Based on NatureScot (2020) and Furness (2015).

Season	Population Estimate			
	Stochastic Mean	LCI	UCI	Deterministic Mean
Breeding	7.33	1.25	18.21	8.08
Pre-breeding	2.55	0.47	6.61	2.74
Post-breeding	1.13	0.00	4.75	1.20
Annual Total	11.01	1.72	29.58	12.01

Table 3.2 Predicted Monthly Collision for Kittiwake Using Deterministic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.25	0.00	0.89	3.20	2.16	3.32	0.83	0.16	0.00	0.70	0.25	0.24

Table 3.3 Predicted Monthly Collision for Kittiwake Using Stochastic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.27	0.00	0.80	2.94	1.90	3.10	0.69	0.16	0.00	0.63	0.25	0.25
LCI	0.00	0.00	0.00	0.93	0.50	0.28	0.00	0.00	0.00	0.00	0.00	0.00
UCI	0.87	0.00	2.80	5.89	4.72	7.12	2.46	0.97	0.00	2.46	1.13	1.17

3.2.2 The predicted seasonal collision mortalities for herring gull are presented in Table 3.4, and the monthly predicted mortalities are provided in Table 3.5 and Table 3.6.

Table 3.4 Predicted Seasonal Collision Mortalities for Herring Gull Using Deterministic and Stochastic Band Option 2. Seasonal Definitions Based on NatureScot (2020) and Furness (2015)

Season	Population Estimate			
	Stochastic Mean	LCI	UCI	Deterministic Mean
Breeding	0.00	0.00	0.00	0.00
Non-breeding	3.84	0.00	17.46	4.68
Annual total	3.84	0.00	17.46	4.68

Table 3.5 Predicted Monthly Collision for Herring Gull Using Deterministic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.79	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	3.31

Table 3.6 Predicted Monthly Collision for Herring Gull Using Stochastic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	3.01
LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCI	2.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	13.41

3.2.3 The predicted seasonal collision mortalities for great black-backed gull are presented in Table 3.7, and the monthly predicted mortalities are provided in Table 3.8 and Table 3.9.

Table 3.7 Predicted Seasonal Collision Mortalities for Great Black-backed Gull Using Deterministic and Stochastic Band Option 2. Seasonal Definitions Based on NatureScot (2020) and Furness (2015)

Season	Population Estimate			
	Stochastic Mean	LCI	UCI	Deterministic Mean
Breeding	0.43	0.00	2.47	0.37
Non-breeding	9.29	1.10	27.17	9.17
Annual total	9.72	1.10	29.63	9.54

Table 3.8 Predicted Monthly Collision for Great Black-backed Gull Using Deterministic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	3.57	0.59	0.36	0.37	0.00	0.00	0.00	0.00	0.35	0.00	0.00	4.30

Table 3.9 Predicted Monthly Collision for Great Black-Backed Gull Using Stochastic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	3.33	0.73	0.37	0.43	0.00	0.00	0.00	0.00	0.39	0.00	0.00	4.46
LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
UCI	9.76	2.26	2.43	2.47	0.00	0.00	0.00	0.00	2.39	0.00	0.00	10.32

Gannet (macro-avoidance to non-breeding seasons only)

3.2.4 The predicted seasonal collision mortalities for gannet are presented in Table 3.10, and the monthly predicted mortalities are provided in Table 3.11 and Table 3.12.

Table 3.10 Predicted Seasonal Collision Mortalities for Gannet, With Macro-Avoidance for Non-Breeding Seasons Only, Using Deterministic and Stochastic Band Option 2. Seasonal Definitions Based on NatureScot (2020) and Furness (2015).

Season	Population Estimate			
	Stochastic Mean	LCI	UCI	Deterministic Mean
Breeding	15.58	2.38	42.32	15.56
Pre breeding	0.58	0.00	2.05	0.57
Post breeding	1.00	0.24	2.47	1.01
Annual total	17.17	2.62	46.84	17.13

Table 3.11 Predicted Monthly Collision for Gannet (Macro-avoidance to Non-breeding Season Only) Using Deterministic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.00	0.34	0.95[1]	1.79	0.85	6.61	3.29	1.42	1.11	1.01	0.00	0.08

Table 3.12 Predicted Monthly Collision for Gannet (Macro-avoidance to Non-breeding Season Only) Using Stochastic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.00	0.33	1.04[2]	1.79	0.87	6.61	3.24	1.47	1.09	1.00	0.00	0.09
LCI	0.00	0.00	0.00	0.00	0.00	1.52	0.85	0.00	0.00	0.24	0.00	0.00
UCI	0.00	1.24	3.28[3]	5.56	3.55	16.27	8.66	3.71	2.92	2.47	0.00	0.32

[1] Raw gannet collision outputs (without macro-avoidance) are presented for March. March collisions are split between the breeding season and the pre-breeding season (0.48 collisions in the breeding season and 0.48 collisions in the pre-breeding season. Macro-avoidance is applied only to the non-breeding seasons. Therefore, the predicted gannet collisions for March (without macro-avoidance) during the breeding season are 0.48. The predicted gannet collisions for March (with macro-avoidance) during the pre-breeding season are 0.14.

[2] Raw gannet collision outputs (without macro-avoidance) are presented for March. March collisions are split between the breeding season and the pre-breeding season (0.52 collisions in the breeding season and 0.52 collisions in the pre-breeding season. Macro-avoidance is applied only to the non-breeding seasons. Therefore, the predicted gannet collisions for March (without macro-avoidance) during the breeding season are 0.52. The predicted gannet collisions for March (with macro-avoidance) during the pre-breeding season are 0.16.

[3] Raw gannet collision outputs (without macro-avoidance) are presented for March. March collisions are split between the breeding season and the pre-breeding season (1.64 collisions in the breeding season and 1.64 collisions in the pre-breeding season. Macro-avoidance is applied only to the non-breeding seasons. Therefore, the predicted gannet collisions for March (without macro-avoidance) during the breeding season are 1.64. The predicted gannet collisions for March (with macro-avoidance) during the pre-breeding season are 0.49.

3.2.5 The predicted seasonal collision mortalities for gannet, with macro-avoidance for all seasons, are presented in Table 3.13, and the monthly predicted mortalities are provided in Table 3.14 and Table 3.15.

Table 3.13 Predicted Seasonal Collision Mortalities for Gannet, With Macro-Avoidance for all Seasons, Using Deterministic and Stochastic Band Option 2. Seasonal Definitions Based on NatureScot (2020) and Furness (2015)

Season	Population Estimate			
	Stochastic Mean	LCI	UCI	Deterministic Mean
Breeding	4.67	0.71	12.70	4.67
Pre breeding	0.58	0.00	2.05	0.57
Post breeding	1.00	0.24	2.47	1.01
Annual total	6.26	0.96	17.21	6.24

Table 3.14 Predicted Monthly Collision for Gannet (With Macro-avoidance) Using Deterministic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.00	0.34	0.29	0.54	0.26	1.98	0.99	0.43	0.33	1.01	0.00	0.08

Table 3.15 Predicted Monthly Collision for Gannet (With Macro-avoidance) Using Stochastic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.00	0.33	0.31	0.54	0.26	1.98	0.97	0.44	0.33	1.00	0.00	0.09
LCI	0.00	0.00	0.00	0.00	0.00	0.46	0.26	0.00	0.00	0.24	0.00	0.00
UCI	0.00	1.24	0.98	1.67	1.07	4.88	2.60	1.11	0.88	2.47	0.00	0.32

3.3 Applicant Approach Results

Kittiwake

3.3.1 The predicted seasonal collision mortalities for kittiwake are presented in Table 3.16, and the monthly predicted mortalities are provided in Table 3.17 and Table 3.18.

Table 3.16 Predicted Seasonal Collision Mortalities for Kittiwake Using Deterministic and Stochastic Band Option 2. Seasonal Definitions Based on NatureScot (2020) and Furness (2015).

Season	Population Estimate			
	Stochastic Mean	LCI	UCI	Deterministic Mean
Breeding	2.41	0.42	6.09	2.43
Pre-breeding	0.83	0.16	2.26	0.82
Post-breeding	0.37	0.00	1.56	0.36
Annual total	3.61	0.58	9.91	3.61

Table 3.17 Predicted Monthly Collision for Kittiwake Using Deterministic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.08	0.00	0.27	0.96	0.65	1.00	0.25	0.05	0.00	0.21	0.07	0.07

Table 3.18 Predicted Monthly Collision for Kittiwake Using Stochastic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.09	0.00	0.25	0.97	0.63	1.01	0.23	0.05	0.00	0.20	0.08	0.09
LCI	0.00	0.00	0.00	0.31	0.16	0.10	0.00	0.00	0.00	0.00	0.00	0.00
UCI	0.30	0.00	0.92	2.09	1.56	2.41	0.78	0.30	0.00	0.78	0.38	0.40

3.3.2 The predicted seasonal collision mortalities for herring gull are presented in Table 3.19, and the monthly predicted mortalities are provided in Table 3.20 and Table 3.21.

Table 3.19 Predicted Seasonal Collision Mortalities for Herring Gull Using Deterministic and Stochastic Band Option 2. Seasonal Definitions Based on NatureScot (2020) and Furness (2015).

Season	Population Estimate			
	Stochastic Mean	LCI	UCI	Deterministic Mean
Breeding	0.00	0.00	0.00	0.00
Non-breeding	2.31	0.00	9.82	2.58
Annual total	2.31	0.00	9.82	2.58

Table 3.20 Predicted Monthly Collision for Herring Gull Using Deterministic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.44	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	1.80

Table 3.21 Predicted Monthly Collision for Herring Gull Using Stochastic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	1.81
LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCI	1.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	7.31

3.3.3 The predicted seasonal collision mortalities for great black-backed gull are presented in Table 3.22, and the monthly predicted mortalities are provided in Table 3.23 and Table 3.24.

Table 3.22 Predicted Seasonal Collision Mortalities for Great Black-backed Gull Using Deterministic and Stochastic Band Option 2. Seasonal Definitions Based on NatureScot (2020) and Furness (2015).

Season	Population Estimate			
	Stochastic Mean	LCI	UCI	Deterministic Mean
Breeding	0.05	0.00	0.32	0.04
Non-breeding	0.96	0.08	3.53	0.89
Annual total	1.02	0.08	3.86	0.93

Table 3.23 Predicted Monthly Collision for Great Black-backed Gull Using Deterministic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.34	0.06	0.04	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.41

Table 3.24 Predicted Monthly Collision for Great Black-backed Gull Using Stochastic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.35	0.08	0.04	0.05	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.45
LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
UCI	1.32	0.33	0.29	0.32	0.00	0.00	0.00	0.00	0.28	0.00	0.00	1.31

Gannet (macro-avoidance to non-breeding seasons only)

3.3.4 The predicted seasonal collision mortalities for gannet are presented in Table 3.25, and the monthly predicted mortalities are provided in Table 3.26 and Table 3.27.

Table 3.25 Predicted Seasonal Collision Mortalities for Gannet, With Macro-Avoidance for Non-Breeding Seasons Only, Using Deterministic and Stochastic Band Option 2. Seasonal Definitions Based on NatureScot (2020) and Furness (2015).

Season	Population Estimate			
	Stochastic Mean	LCI	UCI	Deterministic Mean
Breeding	14.22	2.26	38.64	13.24
Pre breeding	0.54	0.00	1.98	0.50
Post breeding	0.96	0.20	2.18	0.88
Annual total	15.73	2.46	42.80	14.61

Table 3.26 Predicted Monthly Collision for Gannet (macro-avoidance to non-breeding season only) Using Deterministic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.00	0.30	0.82[4]	1.53	0.72	5.60	2.79	1.21	0.95	0.88	0.00	0.07

Table 3.27 Predicted Monthly Collision for Gannet (macro-avoidance to Non-breeding season only) Using Stochastic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.00	0.31	0.95[5]	1.67	0.84	5.94	2.98	1.31	1.01	0.96	0.00	0.09
LCI	0.00	0.00	0.00	0.00	0.00	1.51	0.75	0.00	0.00	0.20	0.00	0.00
UCI	0.00	1.18	3.15[6]	4.86	3.38	15.24	7.50	3.23	2.85	2.18	0.00	0.33

[4] Raw gannet collision outputs (without macro-avoidance) are presented for March. March collisions are split between the breeding season and the pre-breeding season (0.41 collisions in the breeding season and 0.41 collisions in the pre-breeding season. Macro-avoidance is applied only to the non-breeding seasons. Therefore, the predicted gannet collisions for March (without macro-avoidance) during the breeding season are 0.41. The predicted gannet collisions for March (with macro-avoidance) during the pre-breeding season are 0.12.

[5] Raw gannet collision outputs (without macro-avoidance) are presented for March. March collisions are split between the breeding season and the pre-breeding season (0.47 collisions in the breeding season and 0.47 collisions in the pre-breeding season. Macro-avoidance is applied only to the non-breeding seasons. Therefore, the predicted gannet collisions for March (without macro-avoidance) during the breeding season are 0.47. The predicted gannet collisions for March (with macro-avoidance) during the pre-breeding season are 0.14.

[6] Raw gannet collision outputs (without macro-avoidance) are presented for March. March collisions are split between the breeding season and the pre-breeding season (1.58 collisions in the breeding season and 1.58 collisions in the pre-breeding season. Macro-avoidance is applied only to the non-breeding seasons. Therefore, the predicted gannet collisions for March (without macro-avoidance) during the breeding season are 1.58. The predicted gannet collisions for March (with macro-avoidance) during the pre-breeding season are 0.47.

Gannet (macro-avoidance for all seasons)

3.3.5 The predicted seasonal collision mortalities for gannet, with macro-avoidance for all seasons, are presented in Table 3.28, and the monthly predicted collision mortalities are provided in Table 3.29 and Table 3.30.

Table 3.28 Predicted Seasonal Collision Mortalities for Gannet, With Macro-avoidance for all Seasons, Using Deterministic and Stochastic Band Option 2. Seasonal Definitions Based on NatureScot (2020) And Furness (2015)

Season	Population Estimate			
	Stochastic Mean	LCI	UCI	Deterministic Mean
Breeding	4.27	0.68	11.59	3.97
Pre breeding	0.54	0.00	1.98	0.50
Post breeding	0.96	0.20	2.18	0.88
Annual total	5.77	0.88	15.76	5.34

Table 3.29 Predicted Monthly Collision for Gannet (With Macro-avoidance for All Seasons) Using Deterministic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.00	0.30	0.25	0.46	0.22	1.68	0.84	0.36	0.29	0.88	0.00	0.07

Table 3.30 Predicted Monthly Collision for Gannet (With Macro-avoidance for All Seasons) Using Stochastic Band Option 2

Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.00	0.31	0.28	0.50	0.25	1.78	0.89	0.39	0.30	0.96	0.00	0.09
LCI	0.00	0.00	0.00	0.00	0.00	0.45	0.22	0.00	0.00	0.20	0.00	0.00
UCI	0.00	1.18	0.95	1.46	1.01	4.57	2.25	0.97	0.85	2.18	0.00	0.33

4 Summary

4.1.1 All results from the potential worst-case design scenario based on data provided in this appendix are presented in Table 4.1.

Table 4.1 Summary of the Predicted Collision Mortalities of Key Species From the Aspen Array Area, Using the NatureScot (2023) Seasonal Definitions

Species	Model	Avoidance Rate	Breeding	Post-breeding	Non-breeding	Pre-breeding	Annual Total
Guidance Approach							
Kittiwake	Deterministic	0.9929 (±0.0003)	8.08	1.20	N/A	2.74	12.01
	Stochastic	0.9929 (±0.0003)	7.33 (1.25-18.21)	1.13 (0.00-4.75)	N/A	2.55 (0.47-6.61)	11.01 (1.72-29.58)
Herring gull	Deterministic	0.9940 (±0.0004)	0.00	N/A	4.68	N/A	4.68
	Stochastic	0.9940 (±0.0004)	0.00 (0.00-0.00)	N/A	3.84 (0.00-17.46)	N/A	3.84 (0.00-17.46)
Great black-backed gull	Deterministic	0.9940 (±0.0004)	0.37	N/A	9.17	N/A	9.54
	Stochastic	0.9940 (±0.0004)	0.43 (0.00-2.47)	N/A	9.29 (1.10-27.17)	N/A	9.72 (1.10-29.63)
Gannet (Macro-avoidance in the non-breeding season only)	Deterministic	0.9929 (±0.0003)	15.56	1.01	N/A	0.57	17.13
	Stochastic	0.9929 (±0.0003)	15.58 (2.38-42.32)	1.00 (0.24-2.47)	N/A	0.58 (0.00-2.05)	17.17 (2.62-46.84)
Gannet (Macro-avoidance in all seasons)	Deterministic	0.9929 (±0.0003)	4.67	1.01	N/A	0.57	6.24
	Stochastic	0.9929 (±0.0003)	4.67 (0.71-12.70)	1.00 (0.24-2.47)	N/A	0.58 (0.00-2.05)	6.26 (0.96-17.21)
Applicant Approach							
Kittiwake	Deterministic	0.997 (±0.0003)	2.43	0.36	N/A	0.82	3.61
	Stochastic	0.997 (±0.0003)	2.41 (0.42-6.09)	0.37 (0.00-1.56)	N/A	0.83 (0.16-2.26)	3.61 (0.58-9.91)
Herring gull	Deterministic	0.995 (±0.0004)	0.00	N/A	2.58	N/A	2.58
	Stochastic	0.995 (±0.0004)	0.00 (0.00-0.00)	N/A	2.31 (0.00-9.82)	N/A	2.31 (0.00-9.82)
	Deterministic	0.9991 (±0.0004)	0.04	N/A	0.89	N/A	0.93

Species	Model	Avoidance Rate	Breeding	Post-breeding	Non-breeding	Pre-breeding	Annual Total
Great black-backed gull	Stochastic	0.9991 (±0.0004)	0.05 (0.00-0.32)	N/A	0.96 (0.08-3.53)	N/A	1.02 (0.08-3.86)
Gannet (Macro-avoidance in the non-breeding season only)	Deterministic	0.9929 (±0.0003)	13.24	0.88	N/A	0.50	14.61
	Stochastic	0.9929 (±0.0003)	14.22 (2.26-38.64)	0.96 (0.20-2.18)	N/A	0.54 (0.00-1.98)	15.73 (2.46-42.80)
Gannet (Macro-avoidance in all seasons)	Deterministic	0.9929 (±0.0003)	3.97	0.88	N/A	0.50	5.34
	Stochastic	0.9929 (±0.0003)	4.27 (0.68-11.59)	0.96 (0.20-2.18)	N/A	0.54 (0.00-1.98)	5.77 (0.88-15.76)

Table Note: SD and the range of 25% LCI and 95% UCI shown in brackets

5 References

Alerstam, T., Rosén, M., Bäckman, J., Ericson, P.G.P., Hellgren, O. (2007), 'Flight speeds among bird species: allometric and phylogenetic effects', PloS Biology, 5/8: 1656-1662.

Band, W. (2012), 'Using a Collision Risk Model to Assess Bird Collision Risks for Offshore Wind Farms', Report by BTO. Report for The Crown Estate.

Bradbury, G., Trinder, M., Furness, B., Banks, A.N., Caldow, R.W. and Hume, D. (2014), 'Mapping seabird sensitivity to offshore wind farms', PloS one, 9/9, p.e106366.

Caneco, B. (2022), 'A Shiny App for a stochastic Collision Risk Model (sCRM) for seabirds', https://dmpstats.shinyapps.io/sCRM/ [Accessed: March 2025].

Cook, A.S.C.P., Burton, N.H.K., Humphreys, E.M. and Masden, E.A. (2014), 'The Avoidance Rates of Collision Between Birds and Offshore Turbines', Scottish Marine and Freshwater Science, Vol 5 No 16. Edinburgh: Scottish Government, 247.

Cook, A.S.C.P., Thaxter, C.D., Davies, J., Green, R.M.W., Wischnewski, S., and Boersch-Supan, P. (2023) Understanding seabird behaviour at sea part 2: improved estimates of collision risk model parameters. https://www.gov.scot/publications/understanding-seabird-behaviour-sea-part-2-improved-estimates-collision-risk-model-parameters/pages/4/ (Accessed May 2025)

Dierschke, V., Furness, R.W. and Garthe, S. (2016), 'Seabirds and offshore wind farms in European waters: Avoidance and attraction', Biological Conservation, 202: 59-68.

Donovan, C. (2018), 'Stochastic Band CRM – GUI User Manual, Draft V1.0, 31/03/2017'.

Drewitt, A.L. and Langston, R.H. (2006), 'Assessing the impacts of wind farms on birds', Ibis, 148: 29-42.

Furness, R.W. and Wade, H.M. (2012), Vulnerability of Scottish seabirds to offshore wind turbines - Report to Marine Scotland, (Glasgow: MacArthur Green Ltd).

Garthe, S. and Huppop, O. (2004), 'Scaling possible adverse effects of marine wind farms on seabirds: Developing and applying a vulnerability index', Journal of Applied Ecology, 41(4): 724–734.

Johnston, A., Cook, A.S.C.P., Wright, L.J., Humphreys, E.M. and Burton, N.H.K. (2014a), 'Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines', Journal of Applied Ecology, 51: 31–41.

Johnston, A., Cook, A.S.C.P., Wright, L.J., Humphreys, E.M. and Burton, N.H.K. (2014b), 'Corrigendum to Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines', Journal of Applied Ecology, 51: 1126–1130.

Joint Nature Conservation Committee (JNCC) (2024b), 'Joint advice note from the Statutory Nature Conservation Bodies (SNCBs) regarding bird collision risk modelling for offshore wind developments', https://hub.jncc.gov.uk/assets/f7892820-0f84-4e96-9eff-168f93bd343d [Accessed: March 2025].

Marine Directorate (2023), 'Marine Directorate - Licensing Operations Team Scoping Opinion. Scoping Opinion adopted by the Scottish Ministers under: The Electricity Works (Environmental Impact

Assessment) (Scotland) Regulations 2017 and The Marine Works (Environmental Impact Assessment) Regulations 2007. Morven Offshore Wind Array Project. 30 November 2023'.

McGregor, R.M., King, S., Donovan, C.R., Caneco, B. and Webb, A. (2018), 'A Stochastic Collision Risk Model for Seabirds in Flight', Marine Scotland Report. HiDef BioConsult Scientific Report to Marine Scotland, 06/04/2018, Issue I, 59.

NatureScot (2020), 'Guidance Note 9: Seasonal definitions for birds in the Scottish marine environment', https://www.nature.scot/doc/guidance-note-9-guidance-support-offshore-wind-applications-seasonal-periods-birds-scottish-marine [Accessed: March 2025].

NatureScot (2023, updated 2025), 'Guidance Note 7: Guidance to support Offshore Wind Applications: Marine Ornithology - Advice for assessing collision risk of marine birds', https://www.nature.scot/doc/guidance-note-7-guidance-support-offshore-wind-applications-marine-ornithology-advice-assessing#avoidance-rates [Accessed: March 2025].

Ozsanlav-Harris, L., Inger, R. and Sherley, R. (2022), 'Review of data used to calculate avoidance rates for collision risk modelling of seabirds', JNCC Report 732 (Research and review report), JNCC, Peterborough.

Pavat, D., Harker, A.J., Humphries, G., Keogan, K., Webb, A. and Macleod, K. (2023), 'Consideration of avoidance behaviour of northern gannet (Morus bassanus) in collision risk modelling for offshore wind farm impact assessments', NECR490. Natural England.

Pennycuick, C.J. (1997), 'Actual and 'optimum' flight speeds: field data reassessed', The Journal of Experimental Biology, 200: 2355-2361.

Robinson, R.A. (2005), 'BirdFacts: profiles of birds occurring in Britain & Ireland (BTO Research Report 407)'. BTO, Thetford, https://www.bto.org/understanding-birds/welcome-birdfacts [Accessed: March 2025].

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, 247.

Stanbury, A.J., Eaton, M.A., Aebischer, N.J., Balmer, D., Brown, A.F., Douse, A., Lindley, P., McCulloch, N., Noble, D.G. and Win, I. (2021), 'The status of our bird populations: the fifth Birds of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man and second IUCN Red List assessment of extinction risk for Great Britain', British Birds, 114: 25.

Stanbury, A.J., Burns, F., Aebischer, N.J., Baker, H., Balmer, D.E., Brown, A., Dunn, T., Lindley, P., Murphy, M., Noble, D.G. and Owens, R. (2024), The status of our bird populations: the fifth Birds of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man and second IUCN Red List assessment of extinction risk for Great Britain', British Birds, 117,471-487.

Vanermen, N., Courtens, W., Van de walle, M., Verstraete, H. and Stienen, E.W.M. (2016), 'Seabird monitoring at offshore wind farms in the Belgian part of the North Sea: Updated results for the Bligh Bank and first results for Thorntonbank', Rapporten van het Instituut voor Natuur- en Bosonderzoek 2016 (INBO.R.2016.11861538), Instituut voor Natuur- en Bosonderzoek, Brussels.

Wade, H.M., Masden, E.M., Jackson, A.C. and Furness, R.W. (2016), 'Incorporating data uncertainty when estimating potential vulnerability of Scottish seabirds to marine renewable energy developments', Marine Policy, 70, 108-113.

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