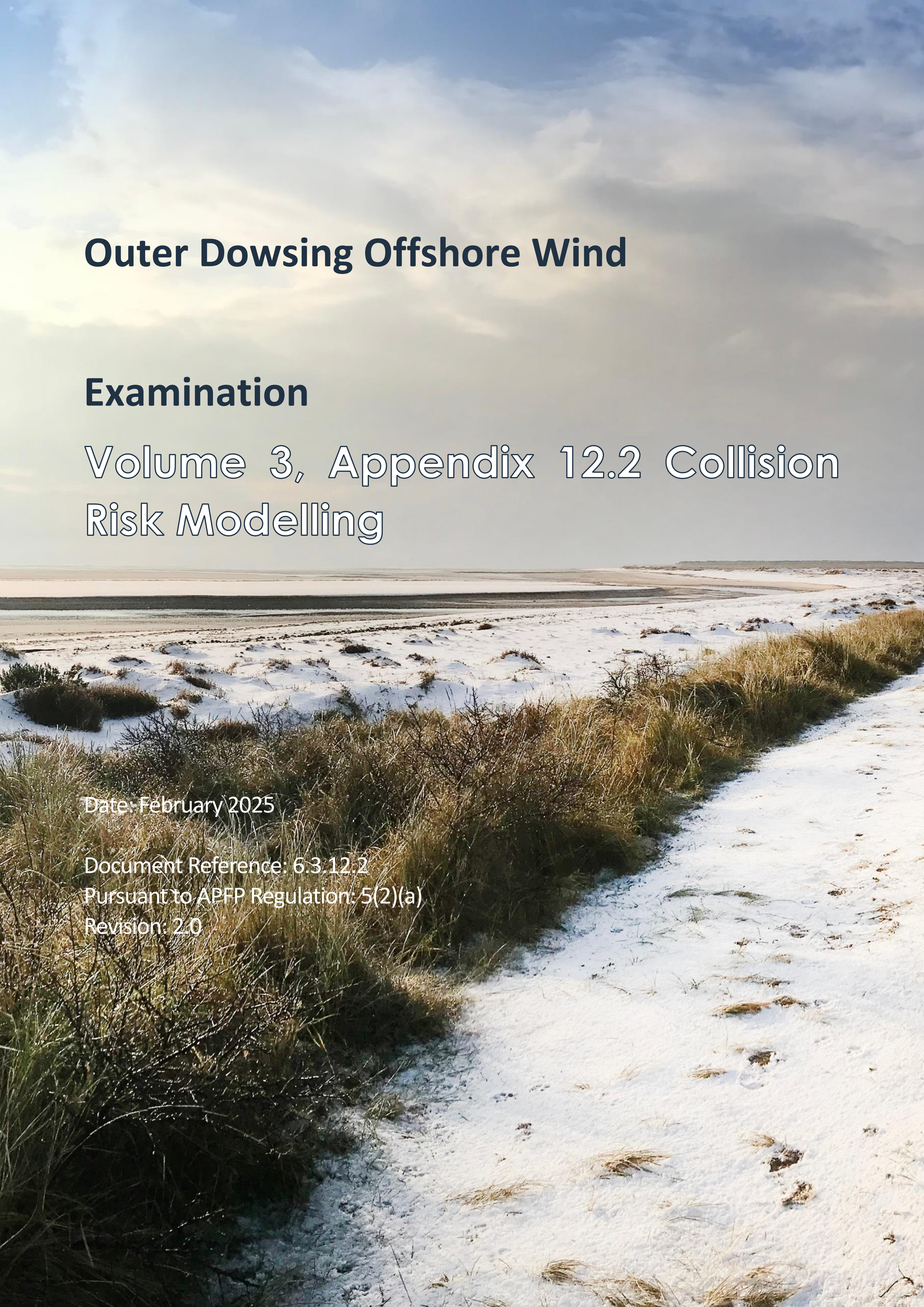

Outer Dowsing Offshore Wind

Examination

Volume 3, Appendix 12.2 Collision Risk Modelling

Date: February 2025

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1.0	March 2024	DCO submission	GoBe	GoBe	Shepherd & Wedderburn	Outer Dowsing
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Change Log

- Examination Update: updates to reflect, where relevant: clarifications to date in Examination; correcting errata; additional commitments made through Examination; and changes to status of or addition of cumulative projects.

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Acronyms & Definitions

Abbreviations / Acronyms

Abbreviation / Acronym	Description
ANS	Artificial Nesting Structures
CI	Confidence Interval
CRM	Collision Risk Model
DAS	Digital Aerial Survey
DCO	Development Consent Order
EIA	Environmental Impact Assessment
ECC	Export Cable Corridor
EPP	Evidence Plan Process
ES	Environmental Statement
FFC SPA	Flamborough and Filey Coast Special Protection Area
GT R4 Ltd	The Applicant. The special project vehicle created in partnership between Corio Generation (a wholly owned Green Investment Group portfolio company), Gulf Energy Development and TotalEnergies.
HAT	Highest Astronomical Tide
JNCC	Joint Nature Conservation Committee
MCA	Maritime and Coastguard Agency
MDS	Maximum Design Scenario
MMO	Marine Management Organisation
MRSea	Marine Renewables Strategic environment assessment
MSL	Mean Sea Level
NAF	Nocturnal Activity Factors
NSIP	Nationally Significant Infrastructure Project
ODOW	Outer Dowsing Offshore Wind (The Project)
OP	Offshore Platform
ORBA	Offshore Restricted Build Area
ORCP	Offshore Reactive Compensation Platform
OWF	Offshore Wind Farm
PCH	Potential Collision Height
RPM	Revolutions per minute
RSPB	Royal Society for the Protection of Birds
sCRM	Stochastic Collison Risk Model
SD	Standard Deviation
SNCBs	Statutory Nature Conservation Bodies
TCE	The Crown Estate
UKHO	United Kingdom Hydrographic Office
WTG	Wind turbine generators

Terminology

Term	Definition
Array area	The area offshore within which the generating station (including wind turbine generators (WTG) and inter array cables), offshore accommodation platforms, offshore transformer substations and associated cabling will be positioned, including the ORBA.
Baseline	The status of the environment at the time of assessment without the development in place.
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Regulations, including the publication of an Environmental Statement (ES).
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Intertidal	The area between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS)
Landfall	The location at the land-sea interface where the offshore export cables and fibre optic cables will come ashore.
Maximum Design Scenario	The project design parameters, or a combination of project design parameters that are likely to result in the greatest potential for change in relation to each impact assessed
Offshore Restricted Build Area (ORBA)	The area within the array area, where no wind turbine generator, offshore transformer substation or offshore accommodation platform shall be erected.
Offshore Reactive Compensation Platform (ORCP)	A structure attached to the seabed by means of a foundation, with one or more decks (including bird deterrents) housing electrical reactors and switchgear for the purpose of the efficient transfer of power in the course of HVAC transmission by providing reactive compensation.
Outer Dowsing Offshore Wind (ODOW)	The Project.
Receptor	A distinct part of the environment on which effects could occur and can be the subject of specific assessments. Examples of receptors include species (or groups) of animals or plants, people (often categorised further such as 'residential' or those using areas for amenity or recreation), watercourses etc.
The Applicant	GTR4 Limited (a joint venture between Corio Generation (and its affiliates), TotalEnergies and Gulf Energy Development), trading as Outer Dowsing Offshore Wind.
The Project	Outer Dowsing Offshore Wind, an offshore wind generating station together with associated onshore and offshore infrastructure.
Wind turbine generator (WTG)	A structure comprising a tower, rotor with three blades connected at the hub, nacelle and ancillary electrical and other equipment which may include J-tube(s), transition piece, access and rest platforms, access

Term	Definition
	ladders, boat access systems, corrosion protection systems, fenders and maintenance equipment, helicopter landing facilities and other associated equipment, fixed to a foundation
Wind turbine generator (WTG) area	The area within the order limits where Wind Turbine Generators (WTG), offshore transformer substations and offshore accommodation platform can be located following the introduction of the Offshore Restricted Build Area (ORBA).

1 Introduction

1.1 Project Background

1. GT R4 Limited (trading as Outer Dowsing Offshore Wind) hereafter referred to as the 'Applicant', is proposing to develop The Project. The Project will be located approximately 54km from the Lincolnshire coastline in the southern North Sea. The Project will include both offshore and onshore infrastructure including an offshore generating station (windfarm), export cables to landfall, Offshore Reactive Compensation Platforms (ORCPs), onshore cables, connection to the electricity transmission network, ancillary and associated development and areas for the delivery of up to two Artificial Nesting Structures (ANS) and the creation of a biogenic reef (if these compensation measures are deemed to be required by the Secretary of State) (see Volume 1, Chapter 3: Project Description (Document Reference 6.1.3) for full details.

1.2 Overview

2. This technical annex has been produced to provide the methodology and results of the collision risk modelling (CRM) that forms part of the ornithological assessment completed to date, and supports Volume 1, Chapter 12: Offshore and Intertidal Ornithology (document reference 6.1.12).
3. This document has been updated to introduce two changes which have been made by the Applicant to the proposed Outer Dowsing Offshore Wind (the Project):
   - the introduction of an Offshore Restricted Build Area (ORBA) over the northern section of the Project array area; and
   - the removal of the northern section of the offshore Export Cable Corridor (ECC).
4. This document was first updated to introduce these changes made by the Applicant during the Examination at the Procedural Deadline 1 (PD1) and was submitted as 15.9E Offshore Restricted Build Area and Revision to the Offshore Export Cable Corridor Appendix E Collision Risk Modelling (PD1-087). The version submitted at PD1 included updated collision risk modelling for the reduced array area, referred to hereafter as 'WTG area'.
5. Following the Examination Authority acceptance of the Change Request, the EIA and HRA assessments have been updated and the version submitted at PD1 has been used as a basis and amended further to incorporate terminology changes and include updated document references.
6. As a result of continuing engagement with stakeholders, and enabled by progress on engineering design, the area within which the Wind Turbine Generators (WTGs) and Offshore Platforms (OPs) will be positioned has been refined. The ORBA has been introduced to reduce the impact from the presence of the WTGs on auk species (specifically common guillemot), informed by a consideration of geophysical and geotechnical data.

7. The ORBA was introduced during examination and covers the northern section of the array area, restricting the installation of WTGs and OPs. This change necessitated an update to the assessments made, which necessitated an update to version 1 of the CRM appendix. For the avoidance of doubt, the ORBA area may still be used for cable installation and ancillary operations during construction (and decommissioning) and operations and maintenance. Additionally, Project parameters including number of structures, foundation types, and cable parameters will remain unchanged. As such, no change has been made to the extent of the array area, as defined within the draft Development Consent Order (DCO).
8. Further engineering design and procurement work, informed by additional geophysical, geotechnical and environmental survey work, undertaken post-consent (if granted), will confirm the final layout of infrastructure. Final details will be set out in a design plan to be submitted to and approved by the MMO, following consultation with Trinity House, the Maritime and Coastguard Agency (MCA) and United Kingdom Hydrographic Office (UKHO) prior to commencement of the licensed works, in line deemed Marine Licence condition 13 (see condition 13(1)(a), Part 2, Schedule 10 of the dDCO (document 3.1).
9. The location and size of the ORBA was decided using various factors. MRSea based analysis was used to generate estimates of distribution and abundance, underpinned by observations of guillemot recorded in the DAS imagery (Scott -Hayward et al., 2014). This produced month by month density distribution mapping for the period March 2021 to August 2023 that identified hotspots within the array area plus 2 km buffer.
10. There were some commonality in the hotspots between the 2021 and 2022 surveys with denser concentrations of guillemots recorded in the north and east of the area of interest (Figures 3.1 - 3.4 Appendix 12.6) particularly within the months of April and August both in 2021 and 2022.
11. The MRSea data (Appendix 12.6) strongly agreed with the design based density estimates, which also show a general pattern of higher densities of guillemot and razorbill to the north of the array area (see Figures 3.31 - 3.33 and 3.37 - 3.39 of Appendix 12.1 Offshore Ornithology Technical Baseline (document 6.3.12.1).
12. The introduction and size of the ORBA has been made possible through continued engagement with the relevant oil and gas operators who have interests which overlap with the Project, i.e. due to the presence of oil and gas platforms within or adjacent to the array area. Since the Application, the Applicant has been able to agree the principles for co-existence between the Project and access arrangements to the Malory platform with Perenco, specifically for helicopter transfers to and from this platform. Confidence in the likely final protective provisions for this operator within the DCO for the Project has therefore allowed further engineering work to be undertaken to support additional mitigation of the impact to auk species through a reduction in the area within which WTGs and OPs may be placed.
13. The introduction of the ORBA has resulted in a reduction in the summed mean seasonal peak abundance of guillemot from 27,653.3 birds in the array area plus 2 km buffer (Appendix 12.1 Offshore and Intertidal Ornithology Technical Baseline AS1-064 Version 1) to a summed mean seasonal peak abundance of 23,586 guillemot in the WTG area plus 2km buffer,(Appendix 12.1 Offshore and Intertidal Ornithology Technical Baseline Version 2 (document reference 6.3.12.1).

14. The offshore ECC presented within the Environmental Statement (ES) that supported the DCO Application included two routeing options within the inshore area of the cable route, a northern and a southern route. The northern route was included as it is situated north of the Inner Dowsing sandbank and thus avoided impacts to this designated feature. The southern route was also included as the northern route passes through aggregates Area 1805 which has an option and exploration area agreement with The Crown Estate, although this was due to expire on 31st August 2024. In the event that the option agreement was not taken up by the holder, this seabed area would have become available, thus allowing the Project to avoid crossing the Inner Dowsing sandbank.
15. It has now been confirmed that the option on this area has been extended by TCE until 2025 (pers. comms. Hansons via email 1st May 2024), with a Marine Licence Application (MLA/2024/00227) having been made by the agreement holder on 25th April 2024 to permit aggregates extraction within the site. As such, it is clear that the agreement holder intends to take up the option over this area of the seabed for aggregate extraction, and therefore it is no longer a viable option for the Project to pursue. Consequently, the Project has excluded the northern route from the offshore ECC.

1.3 Document Purpose

16. This technical annex has been produced to provide the methodology and results of the collision risk modelling (CRM) that forms part of the ornithological assessment completed to date, and supports Volume 1, Chapter 12: Offshore and Intertidal Ornithology (document reference 6.1.12). A separate report (Volume 1, Chapter 12.1: Offshore and Intertidal Ornithology Technical Baseline (document reference 6.3.12.1)) provides the findings from offshore and intertidal ornithology data to determine the receptors that characterise the baseline and are of relevance to the assessment of potential impacts from The Project.
17. The consideration of offshore and intertidal ornithology for The Project has been discussed with consultees (Natural England and the Royal Society for the Protection of Birds (RSPB)) through the Project Evidence Plan Process (EPP). The latest Natural England advice has been followed (Parker *et al*., 2022c; Natural England, 2022). Where there is deviation from this guidance, any agreements made with consultees during the EPP regarding the CRM methodology can be found within document 6.1.12, Section 12.3.
18. The methodology and input parameters used within the modelling have been updated to follow the recent JNCC (2024) guidance.

2 Collision Risk Modelling

19. There is a potential risk that birds flying through the array area could collide with the operational WTGs. The risk of collision with WTG blades is increased if they are located in areas of higher bird densities and in areas in which there is a high level of flight activity. High levels of flight activity can be associated with locations where food supplies are concentrated or with areas where there is a high turnover of individuals (possibly commuting daily between nesting and feeding areas or passing through the area on seasonal migrations).
20. This appendix presents the methodology and results from the CRM for seabirds that regularly use the site. A separate appendix lays out the approach to assessing collision impacts on migratory bird species (Volume 3, Chapter 12.5: Migratory Bird Report (document reference 6.3.12.5)).
21. Investigation of the site-specific survey data identified six seabird species to be considered for collision risk. These species are also highlighted within current guidance and have been agreed with relevant stakeholders through the EPP (Volume 3, Chapter 12: Offshore and Intertidal Ornithology, Section 12.3 (document reference 6.3.12.3)). These species are:
22. Kittiwake, *Rissa tridactyla*;
    - Greater black-backed gull, *Larus marinus*;
    - Herring gull, *Larus argentatus*;
    - Lesser black-backed gull, *Larus fuscus*;
    - Sandwich tern, *Thalasseus sandvicensis*;
    - Gannet, *Morus bassanus*.
23. Other species were recorded in small numbers during the 30 months of digital aerial survey (DAS) data collected within the array area. Some were not considered to be collision risk species because their flight height distribution does not overlap with the area of collision risk (i.e., they fly below the rotor swept area) (Johnston *et al.,* 2014). These species have not been included within the CRM to inform the assessments presented in the Environmental Impact Assessment (EIA), since predicted mortality would be expected to be too low to make a material contribution to increases on baseline mortality. A detailed account of species included within the CRM are shown in the screening table which presents a rationale on a species-by-species basis (document 6.1.12).
24. The results presented in the main body of this appendix are calculated for the Maximum Design Scenario (MDS) (i.e., the project design scenario giving rise to the greatest level of collision risk) and are used to subsequently inform the worst-case assessment within document 6.1.12.
25. A range of WTG’s are being considered for The Project (in terms of size and number) at this stage. The collision estimates for two WTG options, representing the worst-case and the best-case, are also presented in the annex to this appendix (Annex A) to provide an indication of the range of collision mortalities that might occur.

2.1 Methodology

2.1.1 Guidance and Models

26. CRM was undertaken using the Marine Science Scotland Stochastic Collision Risk Model Shiny Application ("sCRM App"; Donovan, 2018), as recommended by the latest Natural England guidance (Parker *et al*., 2022c; JNCC *et al.,* 2024). The sCRM builds on the Band (2012) offshore CRM, together with code written by Masden (2015) to incorporate variation or uncertainty surrounding the input parameters into calculations of collision frequency. The sCRM was accessed via the "Shiny App" interface, which is a user-friendly graphical interface accessible via a standard web-browser or within R statistical software (R Core Team, 2021) that uses an R code to estimate collision risk (Caneco, 2022). The advantage of the sCRM over the Band (2012) model is that it provides a clear and transparent audit trail for all modelling runs, which enables regulators and stakeholders to easily access and reproduce the results of any modelling scenario. A full report on the sCRM was published by Marine Scotland in 2018 to accompany the User Guide (McGregor *et al*., 2018).
27. The sCRM, as with Band (2012), can generate collision estimates using two different methods (basic and extended models), with both methods having two further options based on flight height data. The basic model (Options 1 & 2) assumes the flight height distribution across the rotor swept heights is uniform, whilst the extended model accounts for variation in flight height distributions by using species-specific modelled flight height distributions (Band, 2012; Johnston *et al*., 2014). Since seabird flight height distributions tend to be skewed towards lower rotor swept heights, and extended models (Option 3) gives rise to considerably lower collision estimates than Option 2 (Band, 2012). Latest guidance from SNCB's (JNCC et al., 2024) does not recommend use of either of the extended models and therefore current SNCB guidance is to use Option 1 or 2.
28. Both the basic and extended models can also be run using either site-specific flight height data (i.e. collected from the proposed WTG area), or generic flight height data derived from pre-construction surveys for wind farm developments across 32 sites in the UK and Europe (Johnston *et al*., 2014). This produces four model options: Option 1 (site-specific flight height data) and 2 (generic flight height data) for the basic model, and Option 3 (generic flight height data) and 4 (site-specific flight height data) for the extended model (Band, 2012).
29. Due to the lack of sufficient site-specific flight height data for all species, large uncertainties in the height calculation methodology, and the lack of guidance on using Option 3 within the latest tool, results are only presented for Option 2 at this stage as agreed at ETG (AS1-040).

2.1.2 CRM Input Parameters

30. Models were run stochastically for each species. Uncertainty in each relevant parameter was incorporated into the model using distributions set by standard deviations (SD). A total of 1000 simulations were run for each scenario, as per Natural England guidance, to ensure that any outputs were robust. The latest Joint advice note from the Statutory Nature Conservation Bodies (SNCBs) regarding bird collision risk modelling for offshore wind developments (JNCC *et al*., 2024), was used to determine model input parameters for each species. The mean density of flying birds within The Project WTG area formed the basis of the modelling. SNCB advocated seabird parameters, including biometrics, nocturnal activity factors (NAF) and avoidance rates, were used throughout based on the latest guidance (JNCC *et al.,* SNCB advocated seabird parameters, including biometrics, nocturnal activity factors (NAF) and avoidance rates, were used throughout based on the latest guidance (JNCC *et al.,* 2024).
31. The stochastic model output provides a mean, median and an upper and lower 95% Confidence intervals (CI) as a measure of variance in the outputs.

2.1.3 Turbine Parameters

32. The WTG and windfarm parameters used within the CRM are summarised in Table 2.1 and Table 2.2. These values are based on the maximum design scenario (MDS) parameter values, as described in (Document Reference 6.1.3). The values for revolutions per minute (RPM) and pitch have a standard deviation (SD) associated with them.

Table 2.1. Offshore wind farm and WTG parameters used for CRM. HAT = Highest Astronomical Tide.

Parameter	High	Low
No. WTGs	100	50
Rotor diameter (m)	236	340
Rated RPM	8.11	5.63
Rated RPM SD	0.40	0.28
No. Blades	3	3
Latitude (deg)	53.6	53.6
Wind farm width (km)	32.9	32.9
Max blade width (m)	6.0	9.0
Average Pitch (^{o})	6.5	6.5
Average Pitch SD	1.75	1.75
Min Tip Clearance HAT (m)	37.67	37.67
Tidal offset (HAT-MSL) (m)	2.33	2.33

Table 2.2: Operational parameters used within the CRM

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind availability (%)	92.1	91.1	90.7	87.7	86.7	83.1	83.6	84.7	87.7	91.4	92.8	91.7
Mean downtime (%)	2.8	2.7	2.7	2.6	2.6	2.5	2.5	2.5	2.6	2.7	2.8	2.8

SD downtime (%)	0	0	0	0	0	0	0	0	0	0	0	0

2.1.4 Density of Birds in Flight

33. Density of birds in flight within the array area +4km buffer were provided by DAS data collected between February 2021 and August 2023 (Appendix 12.1 Ornithology Technical Baseline Summary (document 6.11.3.1). For the purposes of collision modelling the density of flying birds was used within the area that will contain WTGs. Therefore, the relevant area is the WTG area.
34. In December 2023 Natural England provided updated advice to developers for entering seabird density and associated standard deviations for use in collision risk modelling. Following this advice, corrected bootstrap density estimates for birds in flight, derived from Project DAS data, were used as an input to the sCRM tool (as opposed to using a monthly mean and SD). This approach ensures that the full distribution of abundance estimates from each monthly survey can be sampled in sCRM simulations. One thousand bootstrapped samples, corrected by apportioning any unidentified species within relevant groups, were produced for each survey. Where more than one survey was conducted per month the densities were combined. A density of zero was used in the model for surveys when densities of birds were too low for bootstrapped estimates to be produced. Given that 30 months of surveys were conducted and there were two monthly surveys during the 2022 breeding season some months had up to 4,000 bootstrapped samples, while some winter months contained 2,000 samples.
35. A comparison of the results based on the old methodology of using a mean monthly density and associated SD was provided in Appendix B of the application collision risk modelling report (APP-163).

2.1.5 Avoidance Rates

36. Most birds exhibit some avoidance of WTGs, and the inclusion of this behaviour is a key element of CRM. Avoidance behaviour can occur at three scales (Cook *et al.,* 2014); macro-avoidance (avoiding the whole wind farm), meso-avoidance (avoiding WTGs but not the rotor-swept area), and micro-avoidance (last-second changes to avoid collision with WTG blades). Different species exhibit varying degrees of avoidance behaviours towards offshore wind farms and therefore species-specific avoidance rates are used within the CRM (Table 2.3). The most recent guidance on avoidance rates, provided by SNCB's (JNCC *et al*., 2024) based on a review of the latest evidence bases (Cook, 2021), and a re-analysis of avoidance rates (Ozsanlev-Harris *et al*. 2023), were used within the CRM as agreed through the ETGs (document 6.1.12, Section 12.3). However, there is further evidence that the standard CRM avoidance rates used within assessments are precautionary; for example the findings from the recent Vattenfall (2023) study indicated that seabirds were exposed to very low risks of collision and no collisions or narrow escapes were recorded.

Table 2.3: Species-specific mean avoidance rates and associated standard deviation (SD) used for CRM.

Species	Mean	SD
Kittiwake	0.9929	0.0003
Greater black-backed gull	0.994	0.0004
Herring gull	0.994	0.0004
Lesser black-backed gull	0.994	0.0004
Sandwich tern	0.991	0.0004
Gannet	0.9929	0.0003

2.1.6 Species Biometrics

37. Physical and behavioural biometric input parameters were determined for each species and used to inform the CRM (Table 2.4). Biometric data (bird length and wingspan) were derived from Snow & Perrins (1987) for each species as displayed in the latest guidance (Natural England, 2022). SDs have been considered within the model as advised by the latest SNCB guidance (JNCC *et al.*, 2024).

Table 2.4: Species-specific mean biometrics parameters and associated standard deviations (SD) used for CRM of anticipated key species.

Species	Body Length (m)	Wingspan (m)
Gannet	0.94 (0.0325)	1.72 (0.0375)
Kittiwake	0.39 (0.005)	1.08 (0.0625)
Herring gull	0.60 (0.0225)	1.44 (0.03)
Great black-backed gull	0.71 (0.035)	1.58 (0.0375)
Lesser black-backed gull	0.58 (0.03)	1.42 (0.0375)
Sandwich tern	0.38 (0.005)	1.00 (0.04)

2.1.7 Nocturnal Activity

38. The NAFs used within the models followed the latest Joint SNCB guidance (Table 2.5; JNCC *et al.,* 2024). This recent guidance is supported by Natural England and supersedes the previous agreements made at ETGs.

39. It should be noted that data presented by Cook *et al.* (2023) from Flamborough and Filey Coast Special Protection Area (FFC SPA) show that for kittiwake, nocturnal activity is generally much lower in birds from this colony than the others sampled, although nocturnal activity fluctuated annually. In five of the six years studied, nocturnal activity ranged between 0.25 and 0.37, averaging at 0.30. One year presented a nocturnal activity proportion of 0.61 but this is so far outside the rather consistent range demonstrated for other years that it is considered an outlier.

40. The potential for strong variation between years, and the difference between the relatively low proportions demonstrated by birds from FFC SPA compared to more northerly colonies, suggest that standard rates used for nocturnal activity may not be representative of nocturnal activity in birds from FFC SPA, and as such, use of these recommended rates should be considered a precautionary approach.

Table 2.5: Mean nocturnal activity factor and associated standard deviation (SD) used within the CRM assessment.

Species	Mean	SD
Gannet	0.14	0.1000
Kittiwake	0.40	0.12
Herring gull	0.375	0.0637
Great black-backed gull	0.375	0.0637
Lesser black-backed gull	0.30	0.18
Sandwich tern	0.125	0.0000

2.1.8 Seabird Flight Speeds

41. Flight speed is an important parameter in CRM because both the flux of birds (derived from predicted density of birds in flight) and probability of collision are sensitive to it. Notably, sensitivity acts in opposite directions i.e. increased speed increases flux and consequently the number of collisions, while increased speed also reduces the probability of collision for birds passing through the rotor swept area. These two contrasting effects of flight speeds do not necessarily balance out (Masden et al. 2021), and, in general, increased flight speeds increase the predicted number of collisions.

42. There is mounting evidence that flight speed is influenced by seabird behaviour. For example, lower flight speeds are recorded during foraging activity in comparison with commuting flight (Cook et al. 2023). However, the current models do not yet incorporate information on different behaviours and therefore only one flight speed can be inputted.

43. Mean flight speeds for species included in the CRM were taken from the latest SNCB guidance (JNCC *et al.,* 2024) which supersedes previous advice (Table 2.6)). The guidance uses flight speeds derived from Pennycuick (1997) for gannet, Fijn and Gyimesi (2018) for sandwich tern and Alerstam et al. (2007) for all other species. However, some flight speeds are considered to be precautionary. For kittiwake, the flight speed recommended for use in CRM by Natural England of 13.1 m/s is taken from a study that uses data for two birds and presents speed through the air rather than speed over the ground. The speed recommended (13.1 m/s) is substantially higher than the mean ground speed measured over eight studies of kittiwake ground speed (10.8 m/s). As such use of this flight speed for kittiwake is likely to overestimate collisions.

Table 2.6: Species-specific mean flight speeds and associated standard deviations (SD) used for CRM.

Species	Mean	SD
Gannet	14.9	0.00
Kittiwake	13.1	0.40
Herring gull	12.8	1.80
Great black-backed gull	13.7	1.20
Lesser black-backed gull	13.1	1.90
Sandwich tern	10.3	3.40

2.1.9 Other Parameters

44. Following the JNCC *et al.* (2024) guidance it was assumed that all birds were flapping while flying and that an even proportion (50%) of flights occurred in the upwind and downwind directions.

2.2 Results

45. This section presents the outputs from the CRM analysis for each of the six seabird species considered. A summary of the monthly breakdown of collisions for each species is presented in Table 2.7. The 95% CIs provide an indication of the level of certainty or uncertainty in the results.

Table 2.7: Summary of average monthly collisions by species based on the High scenario.

Species	Month	Mean	Median	SD	CV	2.5% CI	97.5% CI
Kittiwake	Jan	1.05	0.64	0.95	90.18	0.11	3.34
	Feb	1.87	1.76	0.88	47.08	0.57	3.68
	Mar	5.87	5.11	2.91	49.53	2.31	13.56
	Apr	10.04	8.39	5.22	52.02	3.50	21.26
	May	3.97	2.22	4.00	100.75	0.36	13.55
	Jun	2.40	1.61	1.95	80.99	0.48	7.02
	Jul	1.99	1.28	2.02	101.39	0.07	7.00
	Aug	2.93	2.26	2.49	85.08	0.26	9.56
	Sep	0.98	0.72	0.94	96.44	0.00	3.05
	Oct	0.42	0.37	0.26	61.10	0.08	0.99
	Nov	0.56	0.51	0.25	44.55	0.19	1.10
	Dec	1.07	0.99	0.45	41.67	0.42	2.07
	Totals	**33.16**				**8.33**	**86.18**
Great black-backed gull	Jan	1.29	0.51	1.58	122.60	0.00	5.45
	Feb	0.00	0.00	0.00		0.00	0.00
	Mar	0.26	0.23	0.25	97.54	0.00	0.88
	Apr	0.00	0.00	0.00		0.00	0.00
	May	0.00	0.00	0.00		0.00	0.00
	Jun	0.14	0.00	0.25	173.72	0.00	0.83
	Jul	0.00	0.00	0.00		0.00	0.00
	Aug	0.40	0.29	0.46	116.14	0.00	1.62
	Sep	0.62	0.44	0.64	103.24	0.00	2.12
	Oct	0.25	0.22	0.27	105.79	0.00	0.89
	Nov	0.56	0.44	0.51	91.40	0.00	1.82
	Dec	0.46	0.39	0.38	83.56	0.00	1.40
	Totals	**3.98**				**0.00**	**15.01**
Herring gull	Jan	0.27	0.19	0.30	110.76	0.00	1.10

Species	Month	Mean	Median	SD	CV	2.5% CI	97.5% CI
	Feb	0.00	0.00	0.00		0.00	0.00
	Mar	0.27	0.19	0.31	114.07	0.00	1.13
	Apr	0.22	0.00	0.33	154.05	0.00	1.21
	May	0.23	0.15	0.29	128.18	0.00	0.94
	Jun	1.24	0.96	1.15	92.59	0.00	4.27
	Jul	0.30	0.15	0.41	137.84	0.00	1.35
	Aug	0.00	0.00	0.00		0.00	0.00
	Sep	0.00	0.00	0.00		0.00	0.00
	Oct	0.00	0.00	0.00		0.00	0.00
	Nov	0.09	0.00	0.16	178.49	0.00	0.53
	Dec	0.33	0.00	0.41	125.84	0.00	1.28
	Totals	**2.94**				**0.00**	**11.81**
Lesser black-backed gull	Jan	0.00	0.00	0.00		0.00	0.00
	Feb	0.00	0.00	0.00		0.00	0.00
	Mar	0.15	0.00	0.22	205.93	0.00	0.97
	Apr	0.39	0.23	0.39	114.96	0.00	1.61
	May	0.08	0.00	0.15	238.68	0.00	0.58
	Jun	1.02	0.42	1.09	125.96	0.00	4.11
	Jul	0.29	0.16	0.30	125.07	0.00	1.24
	Aug	0.70	0.07	0.94	176.19	0.00	3.97
	Sep	0.00	0.00	0.00		0.00	0.00
	Oct	0.19	0.12	0.17	111.26	0.00	0.70
	Nov	0.18	0.11	0.15	110.21	0.00	0.64
	Dec	0.00	0.00	0.00		0.00	0.00
	Totals	**2.43**				**0.00**	**11.99**
Gannet	Jan	0.02	0.02	0.03	120.10	0.00	0.10
	Feb	0.06	0.02	0.08	123.88	0.00	0.25
	Mar	0.12	0.09	0.11	88.76	0.01	0.41
	Apr	0.38	0.25	0.35	93.04	0.03	1.25

Species	Month	Mean	Median	SD	CV	2.5% CI	97.5% CI
	May	0.22	0.07	0.37	169.59	0.00	1.36
	Jun	0.13	0.09	0.12	94.91	0.00	0.44
	Jul	0.14	0.08	0.16	120.61	0.00	0.58
	Aug	0.12	0.09	0.11	87.79	0.01	0.40
	Sep	0.06	0.04	0.08	124.55	0.00	0.29
	Oct	0.14	0.10	0.12	88.90	0.02	0.44
	Nov	0.28	0.10	0.34	123.67	0.01	1.22
	Dec	0.00	0.00	0.00		0.00	0.00
	Totals	**1.65**				**0.07**	**6.74**
Sandwich tern	Jan	0.00	0.00	0.00		0.00	0.00
	Feb	0.00	0.00	0.00		0.00	0.00
	Mar	0.00	0.00	0.00		0.00	0.00
	Apr	0.05	0.00	0.13	242.23	0.00	0.44
	May	0.26	0.17	0.27	106.02	0.02	1.10
	Jun	0.06	0.00	0.12	218.42	0.00	0.47
	Jul	0.00	0.00	0.01	319.02	0.00	0.04
	Aug	0.01	0.00	0.02	329.22	0.00	0.08
	Sep	0.03	0.02	0.03	107.13	0.00	0.11
	Oct	0.00	0.00	0.00		0.00	0.00
	Nov	0.00	0.00	0.00		0.00	0.00
	Dec	0.00	0.00	0.00		0.00	0.00
	Totals	**0.41**				**0.02**	**2.25**

Table 2.8: Summary of average monthly collisions by species based on the Low scenario.

Species	Month	Mean	Median	SD	CV	2.5% CI	97.5% CI
Kittiwake	Jan	0.70	0.33	0.67	94.85	0.07	2.40
	Feb	1.29	1.16	0.66	51.07	0.36	2.76
	Mar	3.97	3.40	1.97	49.73	1.71	9.51
	Apr	6.99	5.82	3.66	52.39	2.50	15.44
	May	2.54	1.44	2.65	104.00	0.25	8.98
	Jun	1.73	1.25	1.35	77.91	0.36	5.05
	Jul	1.43	0.96	1.42	98.91	0.05	4.87
	Aug	1.98	1.50	1.73	87.00	0.19	6.62
	Sep	0.67	0.47	0.64	95.31	0.00	2.05
	Oct	0.29	0.24	0.18	63.27	0.06	0.67
	Nov	0.38	0.35	0.18	46.07	0.13	0.77
	Dec	0.74	0.68	0.32	43.62	0.28	1.47
	Totals	**22.73**				**5.96**	**60.59**
Great black-backed gull	Jan	0.87	0.30	1.10	126.93	0.00	3.83
	Feb	0.00	0.00	0.00		0.00	0.00
	Mar	0.17	0.15	0.16	94.68	0.00	0.55
	Apr	0.00	0.00	0.00		0.00	0.00
	May	0.00	0.00	0.00		0.00	0.00
	Jun	0.09	0.00	0.16	171.33	0.00	0.53
	Jul	0.00	0.00	0.00		0.00	0.00
	Aug	0.26	0.22	0.28	105.29	0.00	1.00
	Sep	0.43	0.31	0.41	95.66	0.00	1.43
	Oct	0.17	0.15	0.16	97.28	0.00	0.54
	Nov	0.38	0.31	0.31	83.02	0.00	1.11
	Dec	0.29	0.23	0.26	90.61	0.00	0.92
	Totals	**2.66**				**0.00**	**9.91**
Herring gull	Jan	0.18	0.13	0.20	109.27	0.00	0.73

Species	Month	Mean	Median	SD	CV	2.5% CI	97.5% CI
	Feb	0.00	0.00	0.00		0.00	0.00
	Mar	0.18	0.14	0.19	105.95	0.00	0.69
	Apr	0.13	0.00	0.21	162.73	0.00	0.75
	May	0.15	0.07	0.20	137.80	0.00	0.64
	Jun	0.81	0.58	0.81	100.44	0.00	3.06
	Jul	0.18	0.00	0.27	147.68	0.00	0.90
	Aug	0.00	0.00	0.00		0.00	0.00
	Sep	0.00	0.00	0.00		0.00	0.00
	Oct	0.00	0.00	0.00		0.00	0.00
	Nov	0.05	0.00	0.09	172.96	0.00	0.30
	Dec	0.20	0.00	0.27	132.68	0.00	0.84
	Totals	**1.89**				**0.00**	**7.92**
Lesser black-backed gull	Jan	0.00	0.00	0.00		0.00	0.00
	Feb	0.00	0.00	0.00		0.00	0.00
	Mar	0.09	0.00	0.14	218.86	0.00	0.52
	Apr	0.25	0.13	0.23	112.98	0.00	0.94
	May	0.04	0.00	0.08	251.89	0.00	0.35
	Jun	0.67	0.37	0.74	114.40	0.00	2.75
	Jul	0.18	0.11	0.17	118.54	0.00	0.67
	Aug	0.40	0.07	0.58	173.78	0.00	2.40
	Sep	0.00	0.00	0.00		0.00	0.00
	Oct	0.12	0.08	0.11	114.11	0.00	0.43
	Nov	0.12	0.07	0.10	115.40	0.00	0.45
	Dec	0.00	0.00	0.00		0.00	0.00
	Totals	**1.61**				**0.00**	**7.54**
Gannet	Jan	0.01	0.01	0.02	115.72	0.00	0.06
	Feb	0.04	0.02	0.05	120.28	0.00	0.16
	Mar	0.08	0.05	0.06	84.73	0.01	0.23
	Apr	0.23	0.17	0.21	89.12	0.02	0.74

Species	Month	Mean	Median	SD	CV	2.5% CI	97.5% CI
	May	0.14	0.04	0.24	170.78	0.00	0.87
	Jun	0.08	0.06	0.08	94.79	0.00	0.29
	Jul	0.08	0.05	0.11	124.46	0.00	0.37
	Aug	0.08	0.05	0.07	89.63	0.01	0.26
	Sep	0.04	0.02	0.05	120.65	0.00	0.19
	Oct	0.09	0.06	0.07	83.53	0.01	0.27
	Nov	0.17	0.08	0.20	117.18	0.01	0.68
	Dec	0.00	0.00	0.00		0.00	0.00
	Totals	**1.04**				**0.05**	**4.13**
Sandwich tern	Jan	0.00	0.00	0.00		0.00	0.00
	Feb	0.00	0.00	0.00		0.00	0.00
	Mar	0.00	0.00	0.00		0.00	0.00
	Apr	0.04	0.00	0.09	254.27	0.00	0.31
	May	0.19	0.12	0.20	105.72	0.01	0.79
	Jun	0.04	0.00	0.09	229.51	0.00	0.27
	Jul	0.00	0.00	0.01	310.79	0.00	0.03
	Aug	0.01	0.00	0.02	316.56	0.00	0.05
	Sep	0.02	0.01	0.02	106.69	0.00	0.07
	Oct	0.00	0.00	0.00		0.00	0.00
	Nov	0.00	0.00	0.00		0.00	0.00
	Dec	0.00	0.00	0.00		0.00	0.00
	Totals	**0.29**				**0.01**	**1.52**

2.2.1 Kittiwake

46. The kittiwake collision rate (High scenario) for Band Option 2 estimated a mean of 33.16 annual collisions (Table 2.8). The monthly distribution of collision estimates for kittiwake (High scenario) are displayed in Figure 2.1, with the error bars displaying the upper and lower 95% CIs.

Table 2.8: Summary of annual kittiwake collisions following SNCB guidance for Option 2.

Scenario	Mean estimate	2.5% CI	97.5% CI
High	33.16	8.33	86.18
Low	22.73	5.96	60.59

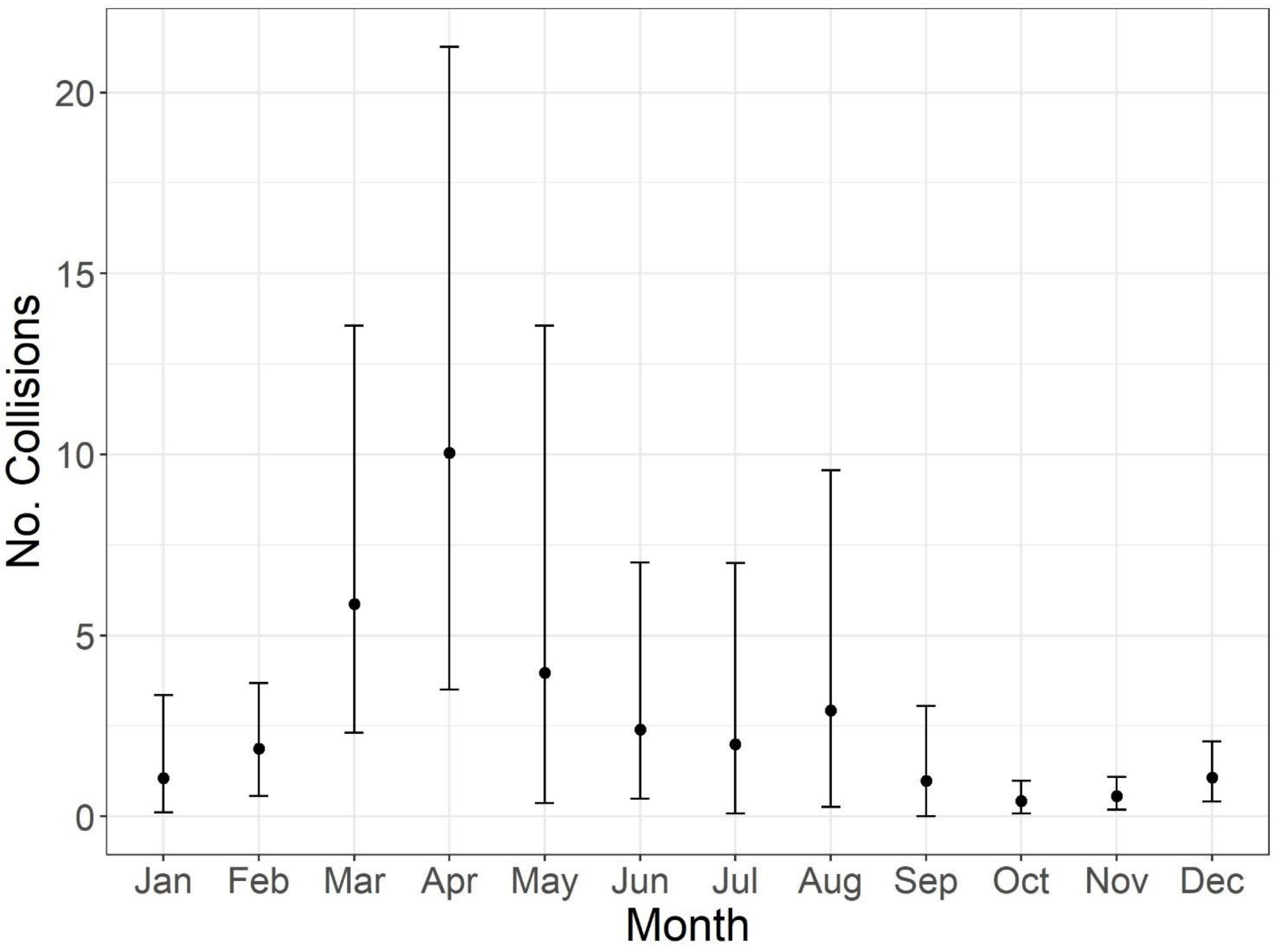

Figure 2.1: Monthly kittiwake collisions following SNCB guidance for Option 2 (High scenario).

2.2.2 Greater black-backed gull

47. The greater black-backed gull collision rate (High scenario) for Band Option 2 estimated a mean of 3.98 annual collisions (Table 2.9). The monthly distribution of collision estimates for greater black-backed gull (High scenario) are displayed in Figure 2.2, with the error bars displaying the upper and lower 95% CIs.

Table 2.9: Summary of annual great black-backed gull collisions following SNCB guidance for Option 2.

Scenario	Mean estimate	2.5% CI	97.5% CI
High	3.98	0.00	15.01
Low	2.66	0.00	9.91

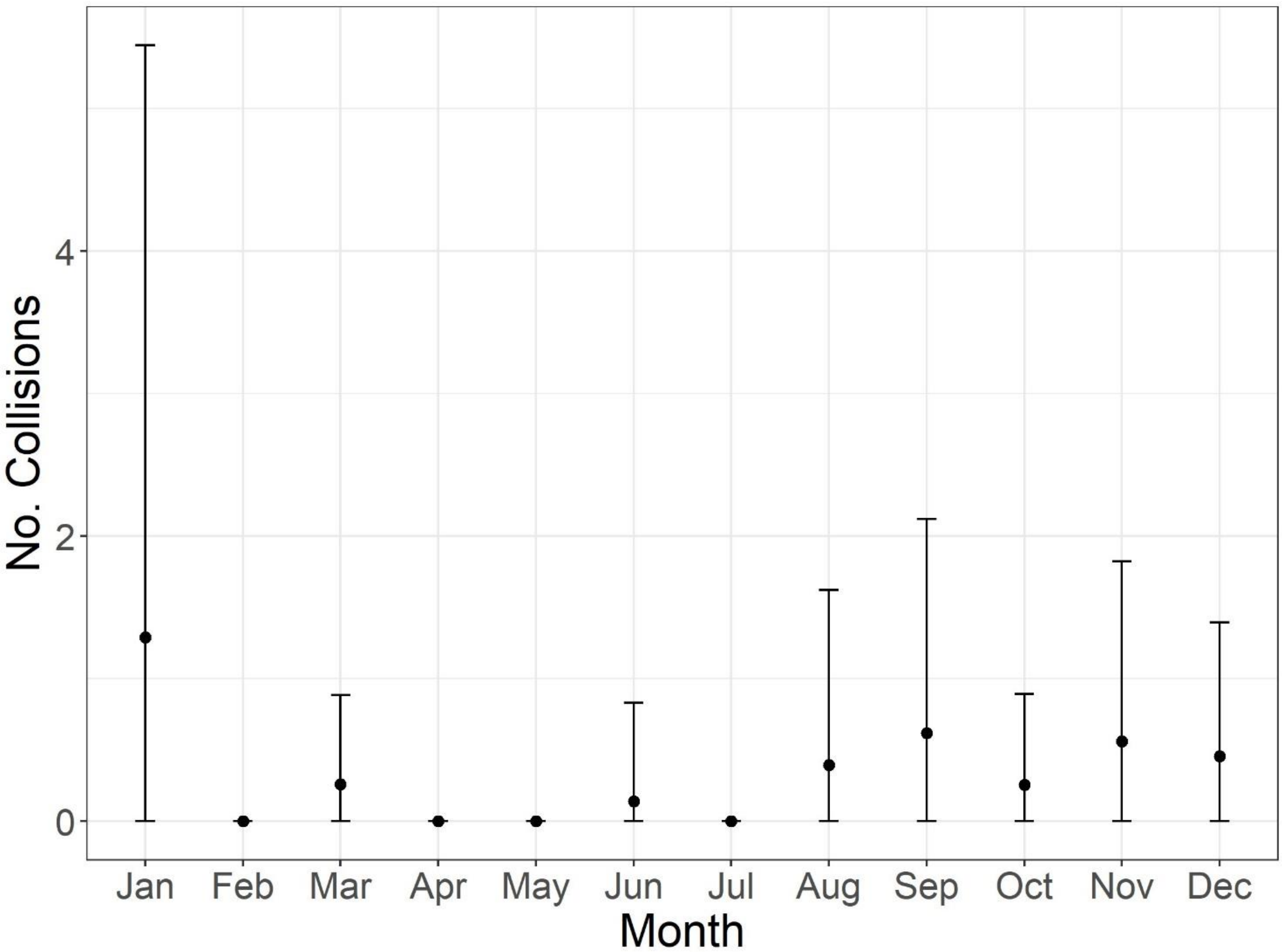

Figure 2.2: Monthly great black-backed gull collisions following SNCB guidance for Option 2 (High scenario).

2.2.3 Herring gull

48. The herring gull collision rate (High scenario) for Band Option 2 estimated a mean of 2.94 annual collisions (Table 2.10). The monthly distribution of collision estimates for herring gull (High scenario) are displayed in Figure 2.3, with the error bars displaying the upper and lower 95% CIs.

Table 2.10: Summary of annual herring gull collisions following SNCB guidance for Option 2.

Scenario	Mean estimate	2.5% CI	97.5% CI
High	2.94	0.00	11.81
Low	1.89	0.00	7.92

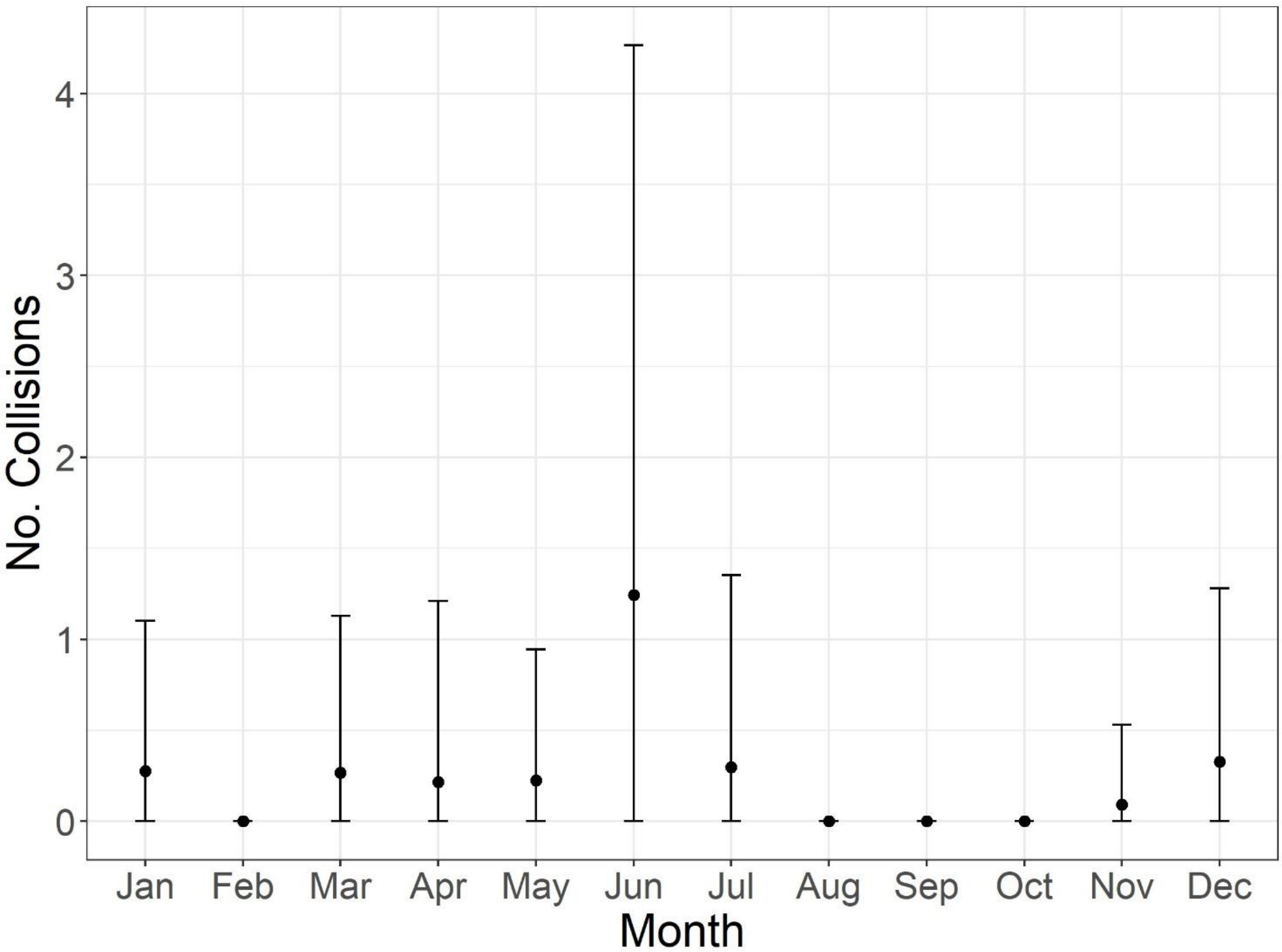

Figure 2.3: Monthly herring gull collisions following SNCB guidance for Option 2 (High scenario).

2.2.4 Lesser black-backed gull

49. The lesser black-backed gull collision rate (High scenario) for Band Option 2 estimated a mean of 2.43 annual collisions (Table 2.11). The average monthly collision rates for lesser black-backed gull (High scenario) are displayed in Figure 2.4 with the error bars displaying the upper and lower 95% CIs.

Table 2.11: Summary of annual lesser black-backed gull collisions following SNCB guidance for Option 2.

Scenario	Mean estimate	2.5% CI	97.5% CI
High	2.43	0.00	11.99
Low	1.61	0.00	7.54

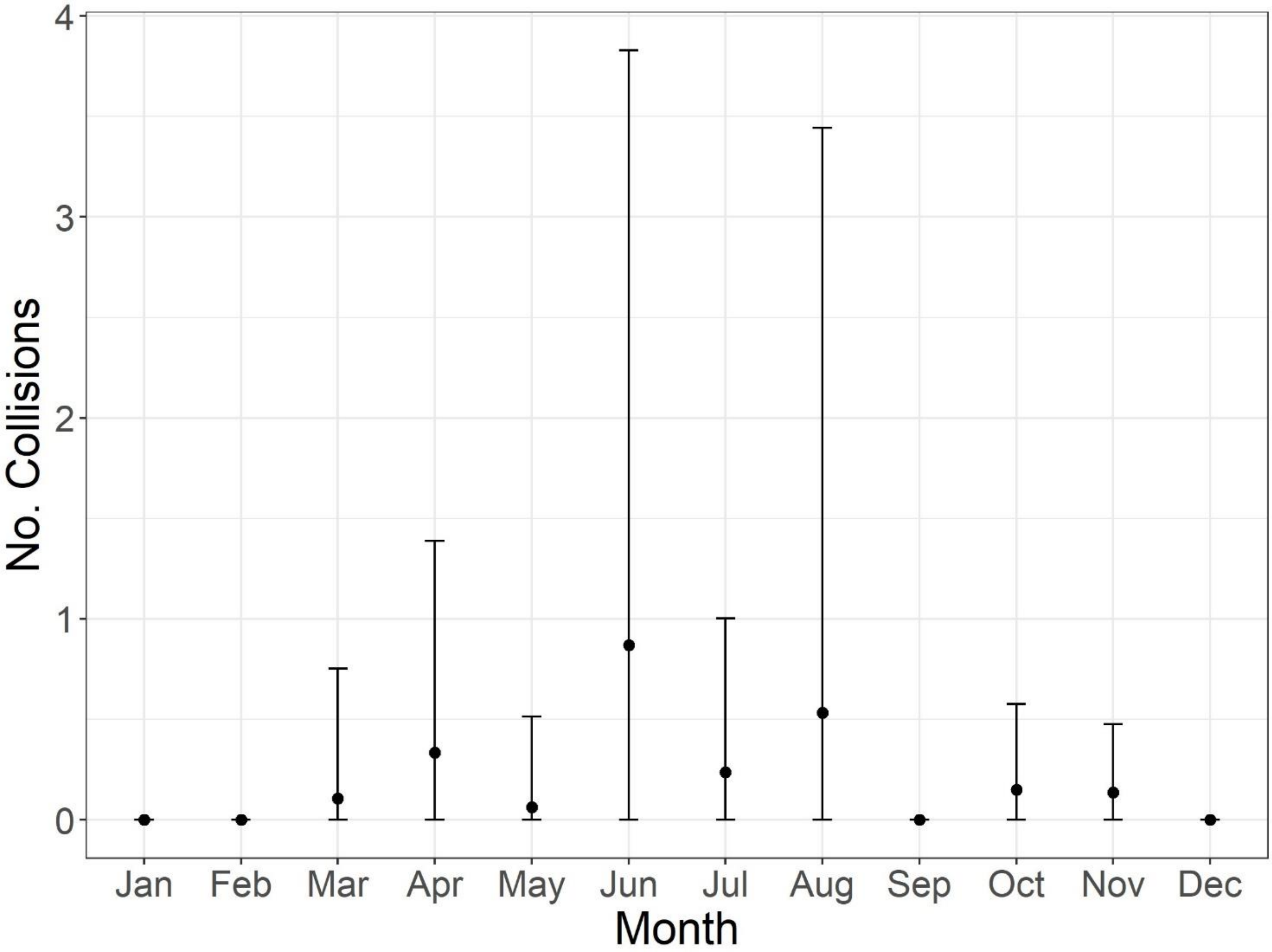

Figure 2.4: Monthly lesser black-backed gull collisions follow SNCB guidance for Option 2 (High scenario).

2.2.5 Sandwich tern

50. The Sandwich tern collision rate (High scenario) for Band Option 2 estimated a mean of 0.41 annual collisions (Table 2.12). The monthly distribution of collision estimates for Sandwich tern (High scenario) are displayed in Figure 2.5, with the error bars displaying the upper and lower 95% CIs.

Table 2.12: Summary of Sandwich tern annual collisions following SNCB guidance for Option 2.

Scenario	Mean estimate	2.5% CI	97.5% CI
High	0.41	0.02	2.25
Low	0.29	0.01	1.52

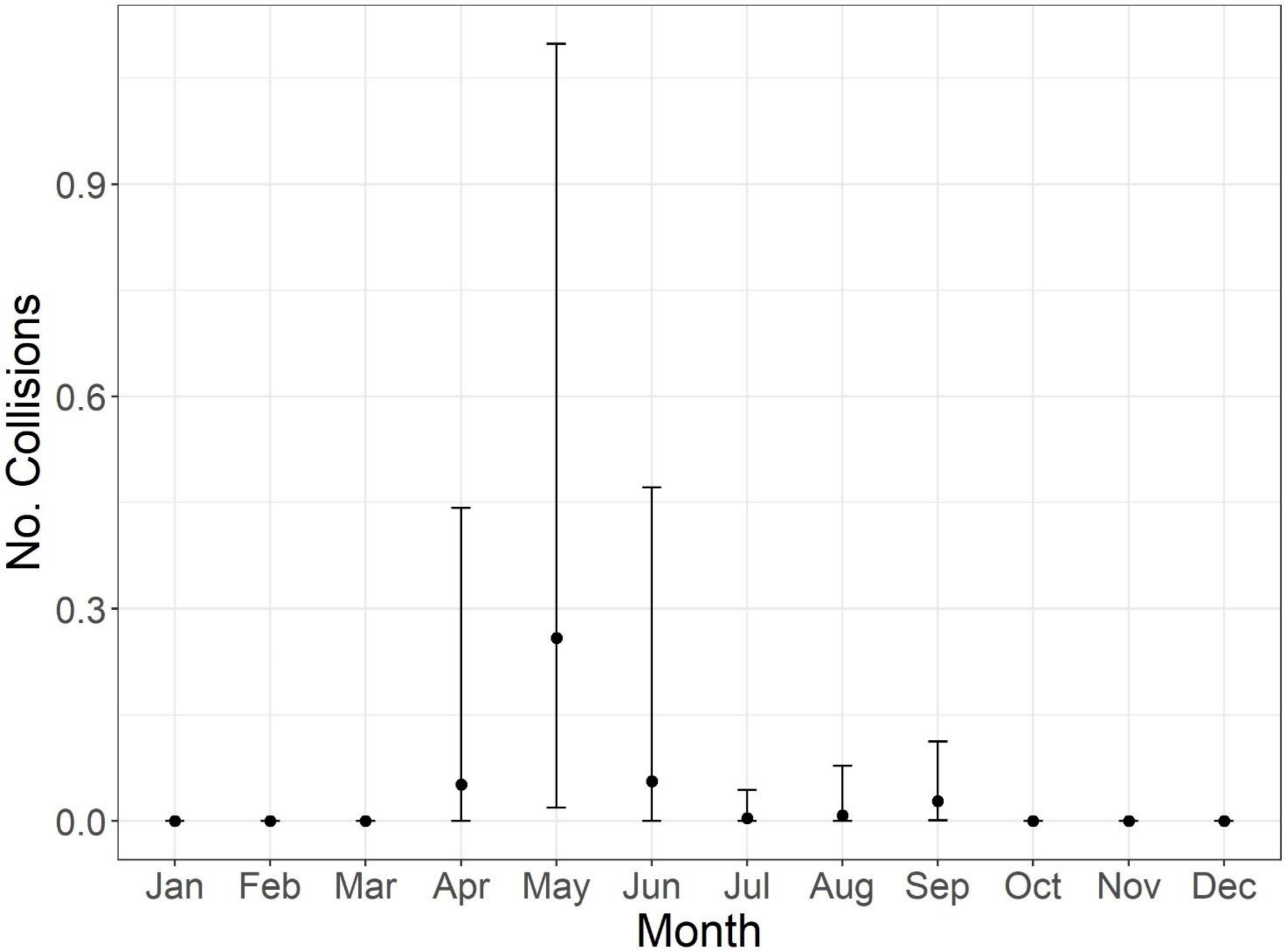

Figure 2.5: Monthly Sandwich tern collisions follow SNCB guidance for Option 2 (High scenario).

2.2.6 Gannet

51. The gannet collision rate (High scenario) for Band Option 2 estimated a mean of 1.65 annual collisions (Table 2.13). The monthly distribution of collision estimates for gannet (High scenario) are displayed in Figure 2.6, with the error bars displaying the upper and lower 95% CIs. Collisions include 70% macro-avoidance.

Table 2.13: Summary of annual gannet collisions following SNCB guidance for Option 2.

Scenario	Mean estimate	2.5% CI	97.5% CI
High	1.65	0.07	6.74
Low	1.04	0.05	4.13

41.

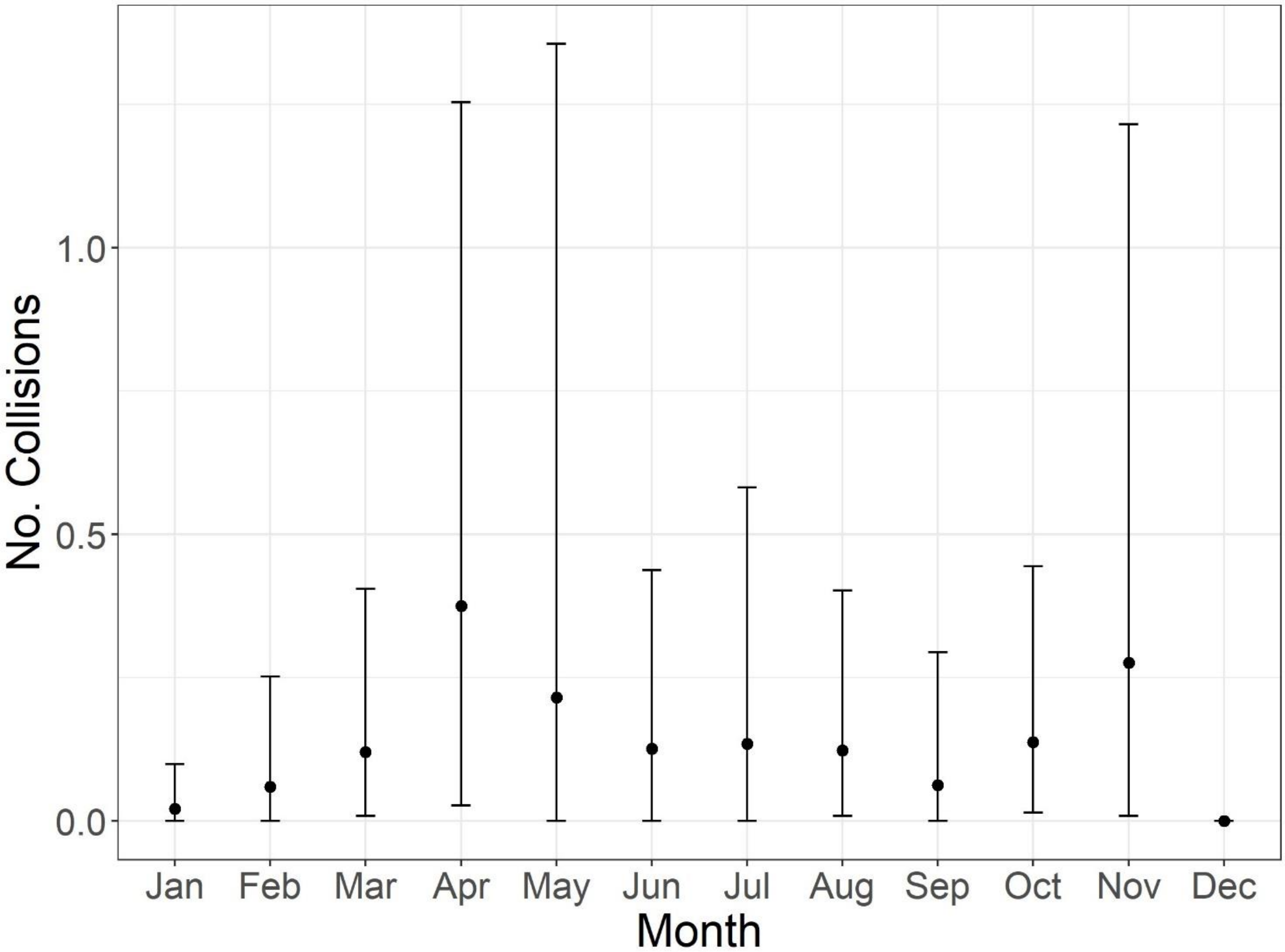

Figure 2.6: Monthly gannet collisions following SNCB guidance for Option 2 (High scenario).

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 windfarms', The Crown Estate Strategic Ornithological Support Services (SOSS) report SOSS-02. http://www.bto.org/science/wetland-and-marine/soss/projects. Original published Sept 2011, extended to deal with flight height distribution data March 2012.

Bowgen, K., Cook, A. (2018), 'Bird Collision Avoidance: Empirical evidence and impact assessments', JNCC Report No. 614, JNCC, Peterborough, ISSN 0963-8091.

Cook, A. S. C. P., Humphries, E. M., Masden, E. A. Burton, N. H. K. (2014), 'The avoidance rates of collision between birds and offshore turbines', BTO Research Report No 656 to Marine Scotland Science.

Cook, A.S.C.P. (2021), 'Additional analysis to inform SNCB recommendations regarding collision risk modelling', BTO Research Report 739.

Cook, A.; Thaxter, C.; Davies, J.; Green, R.; Wischnewski, S.; Boersch-Supan, P. (2023). Understanding seabird behaviour at sea part 2: improved estimates of collision risk model parameters. Report by Scottish Government.

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

Furness, R. W., Garthe, S., Trinder, M., Matthiopoulos, J., Wanless, S. and Jeglinski, J. (2018), 'Nocturnal flight activity of northern gannets Morus bassanus and implications for modelling collision risk at offshore wind farms', Environmental Impact Assessment Review, 73: 1-6.

Fijn, R. C. and Gyimesi, A. (2018), 'Behaviour related flight speeds of Sandwich Terns and their implications for wind farm collision rate modelling and impact assessment', Environmental Impact Assessment Review, 71: 12-16.

Garthe, S. and Hüppop, O. (2004), 'Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index', Journal of Applied Ecology, 41: 724734.

JNCC, NE, SNH, NRW, NIEA. (2014), 'Joint Response from the Statutory Nature Conservation Bodies to the Marine Scotland Science Avoidance Rate Review', [Downloaded from: http://www.snh.gov.uk/docs/A1464185.pdf]

JNCC, Natural England, Natural Resources Wales, NatureScot. (2024). Joint advice note from the Statutory Nature Conservation Bodies (SNCBs) regarding bird collision risk modelling for offshore wind developments. JNCC, Peterborough. https://hub.jncc.gov.uk/f7892820-0f84-4e96-9eff-168f93bd343d

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

MacArthur Green, APEM & Royal Haskoning DHV. (2015), ‘East Anglia THREE: Appendix 13.1 Offshore Ornithology Evidence Plan Volume 3’ – Document Reference: 6.3.13(1).

Masden, E. (2015), ‘Developing an avian collision risk model to incorporate variability and uncertainty’, Scottish Marine and Freshwater Science Vol 6 No 14. Edinburgh: Scottish Government, 43. DOI: 10.7489/1659-1.

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

Natural England. (2022). ‘Natural England interim advice on updated Collision Risk Modelling parameters’ (November, 2022).

Natural England. (2024). Relevant Representations of Natural England. Five Estuaries Offshore Wind Farm. Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010115/EN010115-000510-Natural%20England%20Combined.pdf

Ozsanlav-Harris, L, Inger, R and Sherley R. (2023). Review of data used to calculate avoidance rates for collision risk modelling of seabirds. JNCC Report No. X (Research & review report), JNCC, Peterborough, ISSN 0963-8091.

Parker, J., Fawcett, A., Banks, A., Rowson, T., Allen, S., Rowell, H., Harwood, A., Ludgate, C., Humphrey, O., Axelsson, M., Baker, A. & Copley, V. (2022c), ‘Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase III: Expectations for data analysis and presentation at examination for offshore wind applications’, Natural England, 1.2: 140.

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

R Core Team. (2021), ‘R: A language and environment for statistical computing’, R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

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

Scott-Hayward, L.A.S., Mackenzie, M.L., Donovan, C.R., Walker, C.G., and Ashe, E., (2014) Complex Region Spatial Smoother (CReSS). Journal of Computational and Graphical Statistics, 23(2), pp. 340-360.

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.

Snow and Perrins. (1987), ‘The Birds of the Western Palearctic’.

Vattenfall. (2023), ‘Resolving Key Uncertainties of Seabird Flight and Avoidance Behaviours at Offshore Wind Farms’, AOWFL, February 2023.