Environmental Impact Assessment Report

NISA

North Irish Sea Array

Volume 9: Appendices (Offshore)

Appendix 15.3

Offshore and Intertidal Ornithology Collision Risk Modelling Assessment

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ARUP

North Irish Sea Array Windfarm Ltd

Offshore Ornithology Collision Risk Modelling Assessment

North Irish Sea Array Offshore Wind Farm

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Acronyms

Term	Definition
AOWFL	Aberdeen Offshore Wind Farm Limited
CI	Confidence Intervals
CRM	Collision Risk Modelling
DAS	Digital Aerial Survey
ECC	Export Cable Corridor
HAT	Highest Astronomical Tide
LCI	Lower Confidence Interval
NAF	Nocturnal Activity Factors
OSP	Offshore Substation Platform
OWF	Offshore Windfarm
RPM	Revolutions per Minute
SD	Standard Deviation
UCI	Upper Confidence Interval
WTG	Wind Turbine Generator

1 Introduction

1.1 Project Background

1.1.1 This document has been prepared by Arup and GoBe Consultants Limited (GoBe) on behalf of North Irish Sea Array Windfarm Limited (NISA Ltd) (hereafter referred to as the 'the Developer') to accompany Volume 3, Chapter 15: Offshore and Intertidal Ornithology (hereafter referred to as the 'Offshore and Intertidal Ornithology Chapter').

1.1.2 The Developer is proposing to develop the North Irish Sea Array (NISA) Offshore Windfarm (OWF) (hereafter referred to as 'the Proposed Development'). The Proposed Development will be located approximately 11.3 km to 23.5 km off the coast of counties Dublin, Meath and Louth and Louth in the western Irish Sea.

1.1.3 The proposed development will consist of offshore wind turbine generators (WTGs), an offshore substation platform (OSP), inter-array cables, and export cables (interconnector cables and on- and offshore cables taking power to an onshore converter station). The area considered in the context of offshore ornithological receptors includes the entire proposed development array area, covering 89 km^2, an asymmetric 4 km buffer surrounding the array area, and the offshore Export Cable Corridor (ECC) covering a further 67.9 km^2.

1.1.4 During the breeding season, the Irish Sea region provides foraging, loafing and preening habitat for a range of seabirds, including (but not limited to) northern gannet, *Morus bassanus*, various gull species, and several species of auks and terns. An overview of key species that are present within and in close proximity to the proposed development is presented in Volume 9, Appendix 15.1: Offshore Ornithology Baseline Characterisation (hereafter referred to as the 'Technical Baseline').

1.2 Collision Risk Modelling

1.2.1 There is potential risk to birds flying through the proposed development to collide with the wind turbine generators (WTGs) and associated infrastructure. Collision risk is higher if turbines are located in areas where bird densities are high and where there is a high level of flight activity. Areas with a high density of flying birds may be associated with locations of concentrated food availability, or where there is a high turnover of individuals (for example, seabirds commuting daily between nesting and feeding areas or passing through the area on seasonal migrations). The potential collision risk to each species can be estimated throughout the year by using collision risk modelling (CRM).

1.2.2 The CRM assessment was undertaken for 13 key seabird species[1]. These species were included for assessment due to their abundance within the array area based on digital aerial surveys (DAS) collected for the proposed development, and due to their sensitivity to collision risk (e.g. Bradbury *et al.,* 2014). These include:

- Kittiwake, *Rissa tridactyla*;

[1] Noting that commic tern is not a species but the group assigned to birds which could not be distinguished between common and Arctic tern during DAS data collection

- Black-headed gull, *Chroicocephalus ridibundus*;
- Common gull, *Larus canus*;
- Great black-backed gull, *Larus marinus*;
- Herring gull, *Larus argentatus*;
- Lesser black-backed gull, *Larus fuscus*;
- Roseate tern, *Sterna dougallii*;
- Common tern, *Sterna hirundo*;
- Arctic tern, *Sterna paradisaea*;
- Commic tern (Common and arctic tern);
- Manx shearwater, *Puffinus puffinus*;
- Fulmar, *Fulmarus glacialis*; and
- Gannet, *Morus bassanus*.

1.2.3 Species that are not prone to collision or have been recorded in negligible numbers within the array area have been screened out using expert judgement. Rationale behind these decisions can be found in Volume 3, Chapter 15: Offshore and Intertidal Ornithology.

2 Methodology

2.1 Guidance and Models

2.1.1 The methodology for assessing collision effects is based on available evidence and consultation with other East Coast Phase One Irish projects[2] (see agreed methodology in Appendix 15.7: Method Statement - Offshore Wind Ornithology Assessment for East Coast Phase 1 Projects).

2.1.2 CRM was undertaken using the Marine Science Scotland Stochastic Collision Risk Model Shiny Application ("sCRM App"; Donovan 2017). 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 that uses an R code to estimate collision risk. Using the 'Shiny App' is advantageous, since users are not required to install, maintain, or directly use R. Updates to the model are made directly to the server, so are immediately programmed to users and it is publicly available and free to use. 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 to easily access and reproduce the results of any modelling scenario.

2.1.3 As there is no specific Irish guidance for CRM at this time, the Proposed Development refers to the sCRM, recommended by both Natural England and NatureScot for use in CRM assessments. There is also a 2022 update of the shiny tool which is currently endorsed by NatureScot but not Natural England (NatureScot, 2023). Therefore, the original sCRM tool has been used in this assessment.

2.1.4 A key input parameter in the CRM assessment is determining the proportion of birds at collision risk height. This is determined from flight height distributions. These can either be based on generic data, or from site-specific data. Generic data is taken from Johnston *et al*., (2014) which uses pre-construction data across 32 potential OWFs, providing flight height distributions for 25 marine bird species. This dataset incorporates large sample sizes (predominantly >10,000 birds for species included in this assessment, and over 40,000 individuals for both gannet and kittiwake). However, there is potential for flight heights to vary across different areas (potentially due to behavioural differences, e.g., whether birds are using the area for foraging, or are passing through on migration), and therefore it is also possible to run the CRM assessment using site-specific data if it is available.

[2] Oriel Windfarm, Codling Wind Park I and II, Arklow Bank II and Dublin Array.

2.1.5 Additionally, seabird flight heights are generally not uniform across the different flight height bands, with available data (e.g. Johnston *et al*., 2014) suggesting that the majority of marine birds have a positively skewed distribution of flight heights (i.e. a higher proportion of birds at lower flight heights). To incorporate this, CRM models can be run using two main methods: a basic model, which assumes the flight height distribution of birds around the rotor swept heights is unform, or an extended model which assumes a skew towards the lower flight heights based on the species flight height distributions. Both these model options can also be run using either generic flight height data, or site-specific flight height data, resulting in four different model options:

- Option 1 (basic model, site-specific flight height data);
- Option 2 (basic model, generic flight height data);
- Option 3 (Extended model, generic flight height data); and
- Option 4 (Extended model, site-specific data)

2.1.6 The sCRM models for the proposed development were run using the Band Option 2, using generic flight height data derived from Johnston *et al.,* (2014) and assuming the flight height distribution across the rotor swept heights is uniform. Further information on the proposed development's approach to flight heights can be found in Section 2.

2.2 CRM Input Parameters

2.2.1 Models were run stochastically for each species, as agreed between Phase One Irish projects and advised by both Natural England and NatureScot. This method is advantageous over the alternative deterministic method, as it provides robust confidence intervals of collision mortality estimates based on measured variation in input parameters.

2.2.2 Models use seabird data and turbine data to estimate the predicted number of collisions for each species per month. An evidence-led approach was used to determine model input parameters for each species taking into account the latest guidance and common practice within CRM assessments. Key input parameters were reviewed to provide mean estimates of collision mortality where possible, along with standard deviations. Since the worst-case scenario varied across species, two turbine scenarios were modelled as presented in the Section below. To represent a precautionary approach, only the worst-case scenario for each species is presented graphically in the results (Section 3).

2.2.3 In addition, commic tern (a term used to represent both common or arctic tern that could not be identified to species level) were included as a separate species within this report. The impacts on these species have then been apportioned to each species, as deemed appropriate, within the Offshore and Intertidal Ornithology Chapter. The majority of parameters used in the assessment are identical for these two species (with the exception of body length and wingspan). Parameters used within the CRM for commic tern were based on those for common tern, since this species was recorded far more frequently than Arctic tern (11 common terns recorded in the array area, versus 2 Arctic terns) as outlined below.

Turbine parameters

2.2.4 The WTG specifications used within the CRM are shown in Table 2-1 and Table 2-2. These values are based on the project options with the greatest magnitude of impact, as described in Volume 2, Chapter 6: Project Description. For rotation speed and pitch, mean values and standard deviation were included in the model. The parameters used in calculating the mean estimates of collision rates are also presented in Table 2-1.

2.2.5 For Project Option 2, parameters are split into 2a and 2b. This is due to a reduction in tip height for 13 turbines in because of an aviation restricted zone overlapping the array area. Impacts for 2a and 2b were modelled separately and added together to give a total impact for Project Option 2.

Table 2-1: Turbine parameters used for the two project options in all CRM scenarios.

Parameter	Project Option 1	Project Option 2a	Project Option 2b
No. WTGs	49	22	13
Latitude (ºN)	53.7		
Width of array (km)	17.8		
Tidal offset (m)	2.71		
No. Blades	3		
Rotor radius (m)	125	138	
Max Chord (m)	7	7.5	
Average RPM (+/- SD)	8.3 (±1.45)	7.5 (±1.45)	
Average Pitch (º) (SD)	5.6 (0.5)		
Tip Clearance Highest Astronomical Tide (HAT) (m)	34.44	34.44	29.44

Table 2-2: Predicted mean wind availability and downtime for all CRM scenarios.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind availability (%)	95.7	95.7	95.7	95.7	95.7	93.0	93.0	93.0	95.7	95.7	95.7	95.7
Mean downtime (%)	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
Mean downtime SD (%)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Avoidance rates

2.2.6 Avoidance rates are a key parameter in the CRM, they take into consideration that birds will undertake avoidance behaviour in response to the presence of a windfarm to prevent collision. This can occur at three scales (Cook *et al.,* 2014); micro-avoidance (avoiding individual turbine blades); meso-avoidance (avoiding whole wind turbines, not just the rotor-swept area) and macro-avoidance (avoiding the whole wind farm array area and buffer). This adjustment is required since baseline survey data are collected before turbines are present. The avoidance rates used in CRM for each species, presented in Table 2-3, were agreed on through consultation with other Phase 1 Irish projects (see Appendix 15.7: Method Statement - Offshore Wind Ornithology Assessment for East Coast Phase 1 Projects and in line with the latest interim guidance from Natural England (Natural England, 2022)). The avoidance rates recommended by Natural England (used in CRM here) are based upon the most recent evidence (Cook, 2021) and a re-analysis of avoidance rates (Ozsanlev-Harris *et al.,* 2022). Furthermore, the avoidance rates are precautionary with the findings reported in the AOWFL (2023) study, during which collision risk was very low and no collisions or narrow escapes were observed.

2.2.7 There is strong evidence of macro-avoidance with gannets and offshore windfarms (Garthe *et al.,* 2017a; Garthe *et al.,* 2017b; Skov *et al.,* 2018; Pavat *et al.,* 2023) with avoidance rates used in CRM likely to be highly precautionary which can result in overestimation of collision mortality (Garthe *et al.,* 2017b). The CRM results are presented with a macro-avoidance rate of 70% applied to the gannet collision mortalities (Table 3.1).

Table 2-3: Species- specific mean avoidance rates and associated standard deviation (SD) used in the CRM.

Species	Avoidance rates Mean (SD)
Kittiwake	0.993 (0.0003)
Black-headed gull	0.995 (0.0002)
Common gull	0.995 (0.0002)
Great black-backed gull	0.994 (0.0004)
Herring gull	0.994 (0.004)
Lesser black-backed gull	0.994 (0.004)
Roseate tern	0.991 (0.0004)
Common tern	0.991 (0.0004)
Arctic tern	0.991 (0.0004)
Commic tern	0.991 (0.0004)
Manx shearwater	0.98 (0)
Fulmar	0.98 (0)
Gannet	0.993 (0.0003)

Density of birds in flight

2.2.8 The monthly density estimates were extracted from site specific digital aerial survey (DAS) data. A summary of estimates is presented in Table 2-4. A single monthly density estimate was absent for January 2021, therefore the density estimates for that species during the same month in 2022 was used in the assessment. Months during which no birds of a particular species were present were recorded as 0. The standard deviation (SD) was calculated for each month using the "rule of thumb" that one SD is approximately one quarter of the range, where the range was estimated as the difference between the highest upper confidence limit and the smallest lower confidence limit.

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Table 2-4: Mean density of birds in flight within the array area across 29-months of DAS data.

Species	Estimate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kittiwake	Mean	3.56	0.59	0.57	0.19	0.21	0.11	0.54	0.38	0.63	0.57	0.67	1.42
	SD	2.29	0.36	0.45	0.10	0.20	0.08	0.79	0.20	0.77	0.40	0.44	0.70
Black-headed gull	Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.12	0.00
	SD	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.14	0.00
Common gull	Mean	0.38	0.24	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.02	0.65	0.08
	SD	0.26	0.20	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.68	0.08
Great black-backed gull	Mean	0.17	0.35	0.19	0.00	0.00	0.04	0.23	0.04	0.11	0.07	0.16	0.69
	SD	0.09	0.25	0.13	0.00	0.00	0.04	0.53	0.05	0.08	0.06	0.10	0.61
Herring gull	Mean	1.67	0.32	0.64	0.08	0.02	0.12	0.52	0.05	0.40	0.05	0.50	1.89
	SD	0.09	0.06	0.05	0.08	0.11	0.09	0.14	0.96	0.40	0.03	0.00	1.33
Lesser black-backed gull	Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.02	0.02	0.00
	SD	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.04	0.04	0.00
Roseate tern	Mean	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00
	SD	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Common tern	Mean	0.00	0.00	0.00	0.00	0.00	0.05	0.15	0.00	0.00	0.00	0.00	0.00
	SD	0.00	0.00	0.00	0.00	0.00	0.12	0.28	0.00	0.00	0.00	0.00	0.00
Arctic tern	Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
	SD	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
Commic tern	Mean	0.00	0.00	0.00	0.00	0.02	0.47	0.30	0.05	0.02	0.00	0.00	0.00
	SD	0.00	0.00	0.00	0.00	0.00	0.36	0.29	0.10	0.04	0.00	0.00	0.00
Manx shearwater	Mean	0.00	0.00	0.00	0.00	0.66	0.52	0.53	2.89	1.15	0.00	0.00	0.00
	SD	0.00	0.00	0.00	0.00	1.10	0.87	0.64	2.16	1.00	0.00	0.00	0.00
Fulmar	Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00
	SD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00
Gannet	Mean	0.00	0.03	0.06	0.05	0.08	0.11	0.09	0.14	0.96	0.40	0.03	0.00
	SD	0.00	0.04	0.07	0.08	0.08	0.08	0.11	0.16	0.58	0.48	0.04	0.00

Species biometrics

2.2.9 The species-specific biometric input parameters used in the CRM are provided in Table 2-5. The biometrics for all species (body length and wingspan) were taken as presented in Natural England's most recent guidance (Natural England, 2022), on the basis of the biometric data from Snow and Perrins (1987). These rates were agreed through consultation with other Phase 1 Irish projects (see agreed methodology in Phase 1 Irish Projects Methodology Note).

Table 2-5: Seabird species biometrics and associated Standard Deviations (SD) for the eight species included in the CRM.

Species	Body length (SD) (m)	Wingspan (SD) (m)
Kittiwake	0.39 (0.005)	1.08 (0.0625)
Black-headed gull	0.36 (0)	1.05(0)
Common gull	0.41 (0)	1.2 (0)
Great black-backed gull	0.71 (0.035)	1.58 (0.0375)
Herring gull	0.60 (0.0225)	1.44 (0.03)
Lesser black-backed gull	0.58 (0.03)	1.42 (0.0375)
Roseate tern	0.36 (0)	0.76 (0)
Common tern	0.33 (0)	0.88 (0)
Arctic tern	0.33 (0)	0.88 (0)
Commic tern	0.33 (0)	0.88 (0)
Manx shearwater	0.34 (0)	0.83 (0)
Fulmar	0.45 (0)	1.07 (0)
Gannet	0.94 (0.0325)	1.72 (0.0375)

Nocturnal activity

2.2.10 To enable collision risk during the night to be included within the CRM model, Nocturnal Activity Factors (NAF) are applied in the CRM. NAF allows for daytime activity derived from survey data, to be extrapolated to include activity at night. The nighttime activity of seabird species has been estimated based on existing evidence from tracking data. The rates used are based on the most recent guidance provided by Natural England (2022), which are evidenced from the most robust scientific research and expert judgement (Garthe and Hüppop, 2004; Furness *et al.*, 2018).

2.2.11 The species-specific NAF used in the CRM assessment are presented in Table 2-6 and are based on available evidence and as agreed on through consultation with other Phase 1 Irish projects (see agreed methodology in the East Coast Phase 1 Irish Projects Methodology Note). The mean NAF value were all derived from Garthe and Hüppop (2004) except for gannet NAF which was taken from Furness *et al.,* (2018), as per the most recent Natural England guidance (Natural England, 2022).

Table 2-6: Species-specific mean nocturnal activity levels used in the CRM.

Species	Mean (SD)
Kittiwake	0.375 (0.0637)
Black-headed gull	0.375 (0.0637)

Common gull	0.25 (0)
Great black-backed gull	0.375 (0.0637)
Herring gull	0.375 (0.0637)
Lesser black-backed gull	0.375 (0.0637)
Roseate tern	0 (0)
Common tern	0 (0)
Arctic tern	0 (0)
Commic tern	0 (0)
Manx shearwater	0.5 (0)
Fulmar	0.75 (0)
Gannet	0.08 (0.1000)

Seabird flight speeds

2.2.12 Species-specific flight speeds used in the CRM assessment are presented in Table 2-7. Flight speeds were taken from Pennycuick (1987) for gannet and Alerstam *et al*. (1997) for all other species, as per the latest interim guidance from Natural England (Natural England, 2022) and NatureScot (NatureScot, 2023) and were agreed on through consultation with other Phase 1 Irish projects (see agreed methodology in the East Coast Phase 1 Irish Projects Methodology Note).

Table 2-7: Mean flight speeds and associated standard deviation (SD) for the seven species included in CRM assessment.

Species	Flight speeds (SD) (ms^{-1})
Kittiwake	13.1 (0.40)
Black-headed gull	11.9 (0)
Common gull	13.4 (0)
Great black-backed gull	13.7 (1.20)
Herring gull	12.8 (1.80)
Lesser black-backed gull	13.1 (1.90)
Roseate tern	10.5 (0)
Common tern	10.5 (0)
Arctic tern	10.5 (0)
Commic tern	10.5 (0)
Manx shearwater	9.4 (0)
Fulmar	13.0 (0)
Gannet	14.9 (0)

2.2.13 Site-specific seabird flight height was collected both during vessel-based surveys and DAS data, as outlined in Volume 9, Appendix 15.1: Ornithology Technical Baseline. However, the flight height data from the two collection methods was inconsistent. The DAS data indicated that birds were predominantly at higher flight heights, whereas the vessel data recorded birds at considerably lower heights. Owing to these discrepancies, only generic flight height data from Johnston *et al.* (2014) was used in the assessment (i.e., Option 2). This data was considered most appropriate for the assessment given its large sample size (data from over 10,000 birds for most included species) and is recommended for use in CRM assessments by both Natural England and NatureScot. This is therefore considered a robust approach for the proposed development.

3 Results

3.1.1 This section presents the outputs from the CRM analysis for each seabird species. A summary of the results for each species is presented in Table 3-1, presenting the annual mean for each species and the lower (2.5%) and upper (97.5%) confidence intervals (CI).

Table 3-1: Summary of annual collision estimates following the project approach for Band Option 2 based on both Project Options.

Option 2	Annual collision estimate		
Species	Mean	LCI	UCI
Project Option 1			
Kittiwake	19.32	1.74	45.74
Black-headed gull	0.26	0.01	1.10
Common gull	5.51	0.40	14.45
Great black-backed gull	26.29	1.71	69.97
Herring gull	57.16	9.77	140.05
Lesser black-backed gull	1.79	0.07	5.80
Roseate tern	0.12	0.01	0.35
Common tern	0.22	0.01	0.62
Arctic tern	0.02	0.00	0.16
Commic tern	0.56	0.04	1.45
Manx shearwater	0.00	0.00	0.00
Fulmar	0.02	0.00	0.16
Gannet	1.42	0.08	4.74
Project Option 2			
Kittiwake	17.95	1.79	42.09
Black-headed gull	0.24	0.01	0.91
Common gull	4.67	0.29	11.98
Great black-backed gull	21.48	1.71	54.46
Herring gull	47.91	8.36	116.23
Lesser black-backed gull	1.54	0.07	4.81
Roseate tern	0.11	0.01	0.33
Common tern	0.22	0.01	0.67
Arctic tern	0.02	0.00	0.15
Commic tern	0.57	0.04	1.47
Manx shearwater	0.00	0.00	0.00
Fulmar	0.02	0.00	0.14
Gannet	1.34	0.07	4.26

3.1 Kittiwake

3.1.1 The worst-case scenario for Kittiwake is Project Option 1. Results for each scenario are presented below.

Project Option 1

3.1.2 The kittiwake collision rate for Band Option 2 estimated a mean of 19.32 annual collisions (based on the Project Option 1), with the LCI and UCI ranging from 1.74 to 45.74 annual collisions. The monthly distribution of collision estimates for kittiwake are displayed in Figure 3.1.

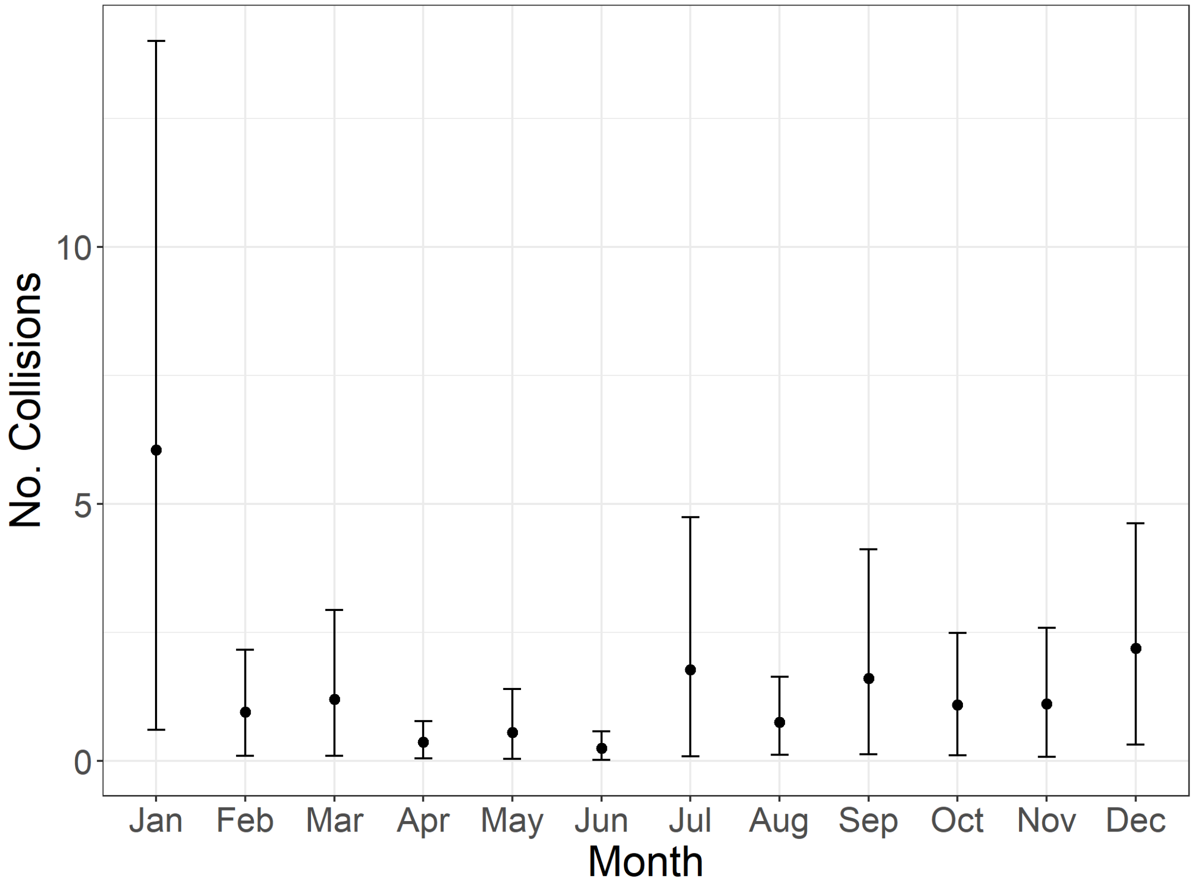

Figure 3.1. Mean monthly collisions predicted for kittiwake for Project Option 1 Band Option 2. Error bars display the upper and lower confidence intervals of monthly collision.

Project Option 2

3.1.3 The kittiwake collision rate for Band Option 2 estimates a mean of 17.95 annual collisions (based on Project Option 2), with the LCI and UCI ranging from 1.79 to 42.09 annual collisions.

3.2 Black-headed gull

3.2.1 The worst-case scenario for black-headed gull is Project Option 1 (Figure XX). Results for each scenario are presented below.

Project Option 1

3.2.2 The black-headed gull collision rate for Band Option 2 estimated a mean of 0.26 annual collisions (based on Project Option 1), with the LCI and UCI ranging from 0.01 to 1.10 annual collisions. The monthly distribution of collision estimates for black-headed gull are displayed in Figure 3.2.

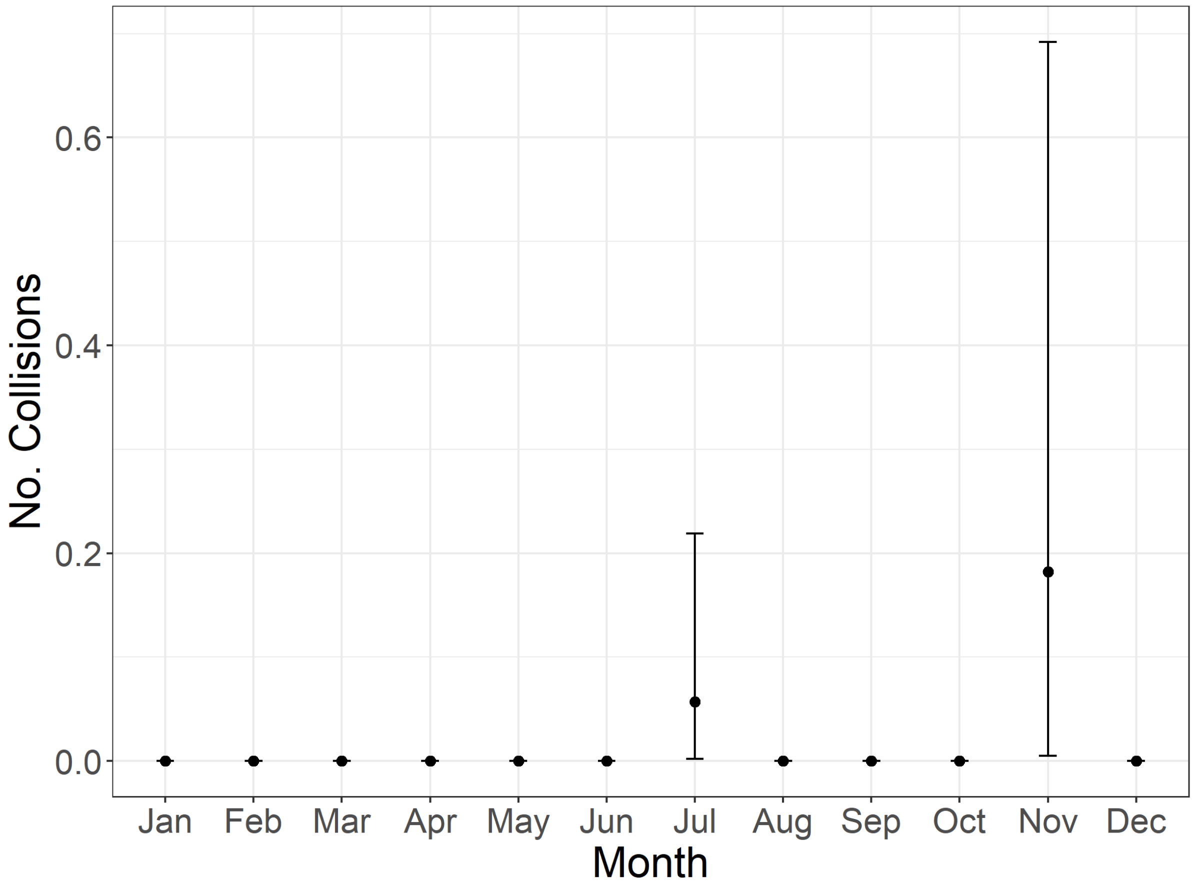

Figure 3.2 Mean monthly collisions predicted for black-headed gull for Project Option 1 Band Option 2. Error bars display the upper and lower confidence intervals of monthly collision.

Project Option 2

3.2.3 The black-headed gull collision rate for Band Option 2 estimated a mean of 0.24 annual collisions (based on Project Option 2), with the LCI and UCI ranging from 0.01 to 0.91 annual collisions.

3.3 Common gull

3.3.1 The worst-case scenario for common gull is Project Option 1 (Figure 3.3). Results for each scenario are presented below.

Project Option 1

3.3.2 The common gull collision rate for Band Option 2 estimated a mean of 5.51 annual collisions (based on Project Option 1), with the LCI and UCI ranging from 0.40 to 14.45 annual collisions. The monthly distribution of collision estimates for common gull are displayed in Figure 3.3.

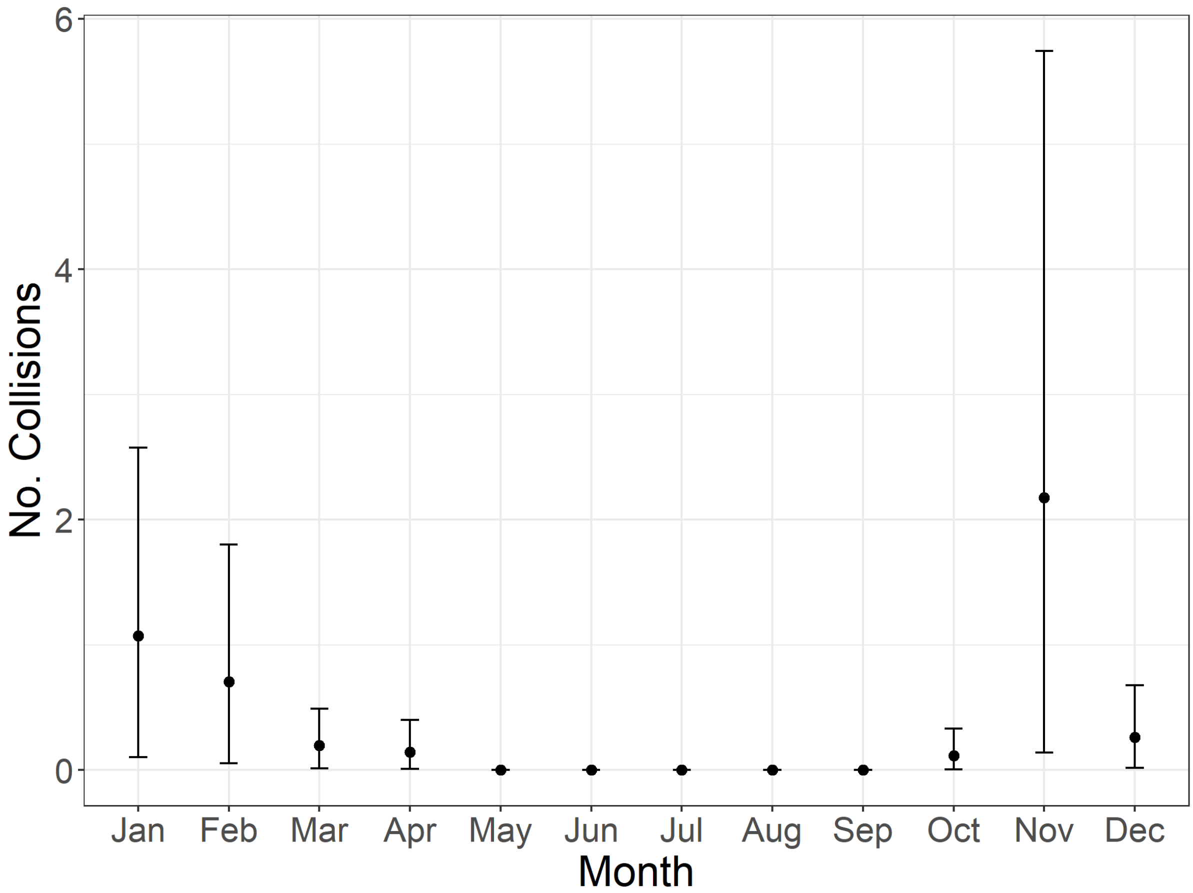

Figure 3.3: Mean monthly collisions predicted for common gull for Project Option 1 Band Option 2. Error bars display the upper and lower confidence intervals of monthly collisions.

Project Option 2

3.3.3 The common gull collision rate for Band Option 2 estimated a mean of 4.67 annual collisions (based on Project Option 2), with the LCI and UCI ranging from 0.29 to 11.98 annual collisions.

3.4 Great black-backed gull

3.4.1 The worst-case scenario for great black-backed gull is Project Option 1. Results for each scenario are presented below.

Project Option 1

3.4.2 The great black-backed gull collision rate for Band Option 2 estimates a mean of 26.29 annual collisions (based on Project Option 1), with the LCI and UCI ranging from 1.71 to 69.97 annual collisions. The monthly distribution of collision estimates for great black-backed gull are displayed in Figure 3.4.

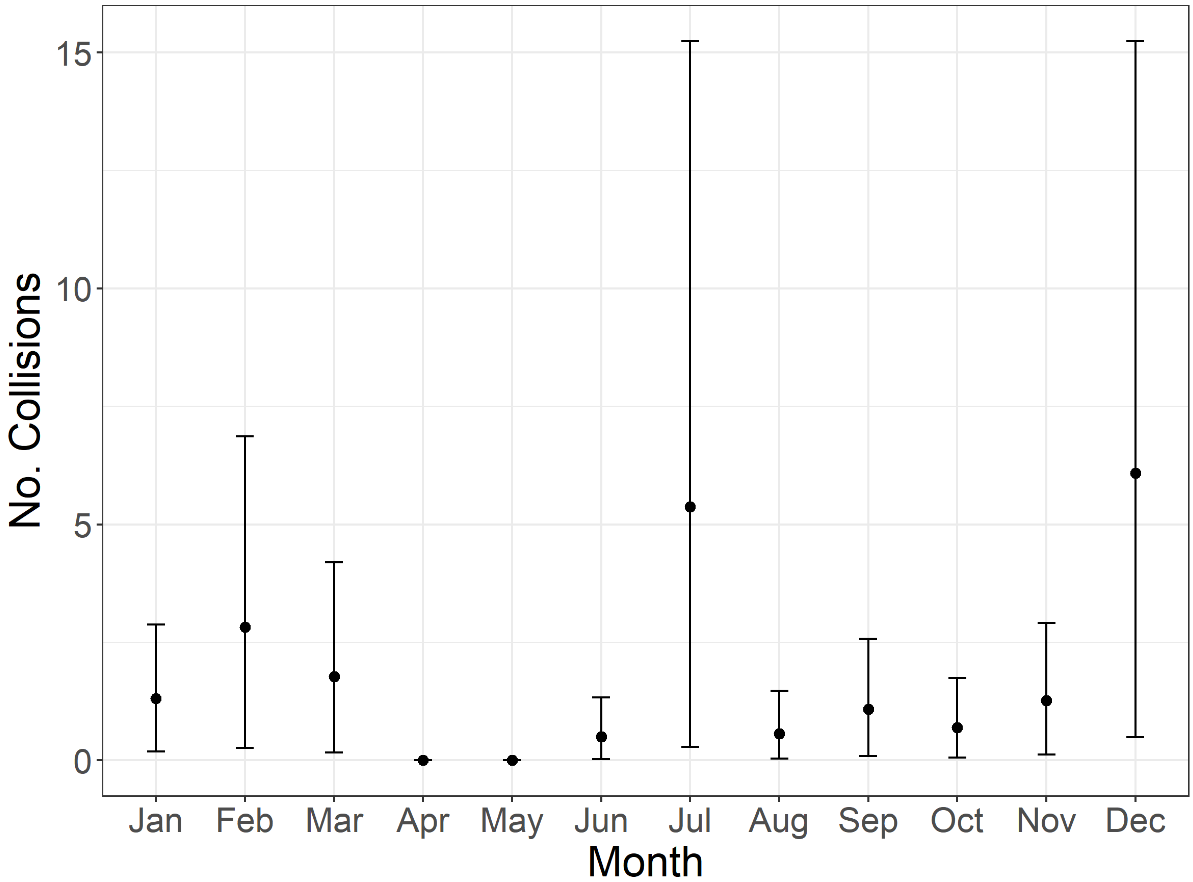

Figure 3.4 Mean monthly collisions predicted for great black-backed gull for Project Option 1 Band Option 2. Error bars display the upper and lower confidence intervals of monthly collision.

Project Option 2

3.4.3 The great black-backed gull collision rate for Band Option 2 estimates a mean of 21.48 annual collisions (based on Project Option 2), with the LCI and UCI ranging from 1.71 to 54.46 annual collisions.

3.5 Herring gull

3.5.1 The worst-case scenario for herring gull is Project Option 1. Results for each scenario are presented below.

Project Option 1

3.5.2 The herring gull collision rate for Band Option 2 estimated a mean of 57.16 annual collisions (based on Project Option 1), with the LCI and UCI ranging from 9.77 to 140.05 annual collisions. The monthly distribution of collision estimates for herring gull are displayed in Figure 3.5.

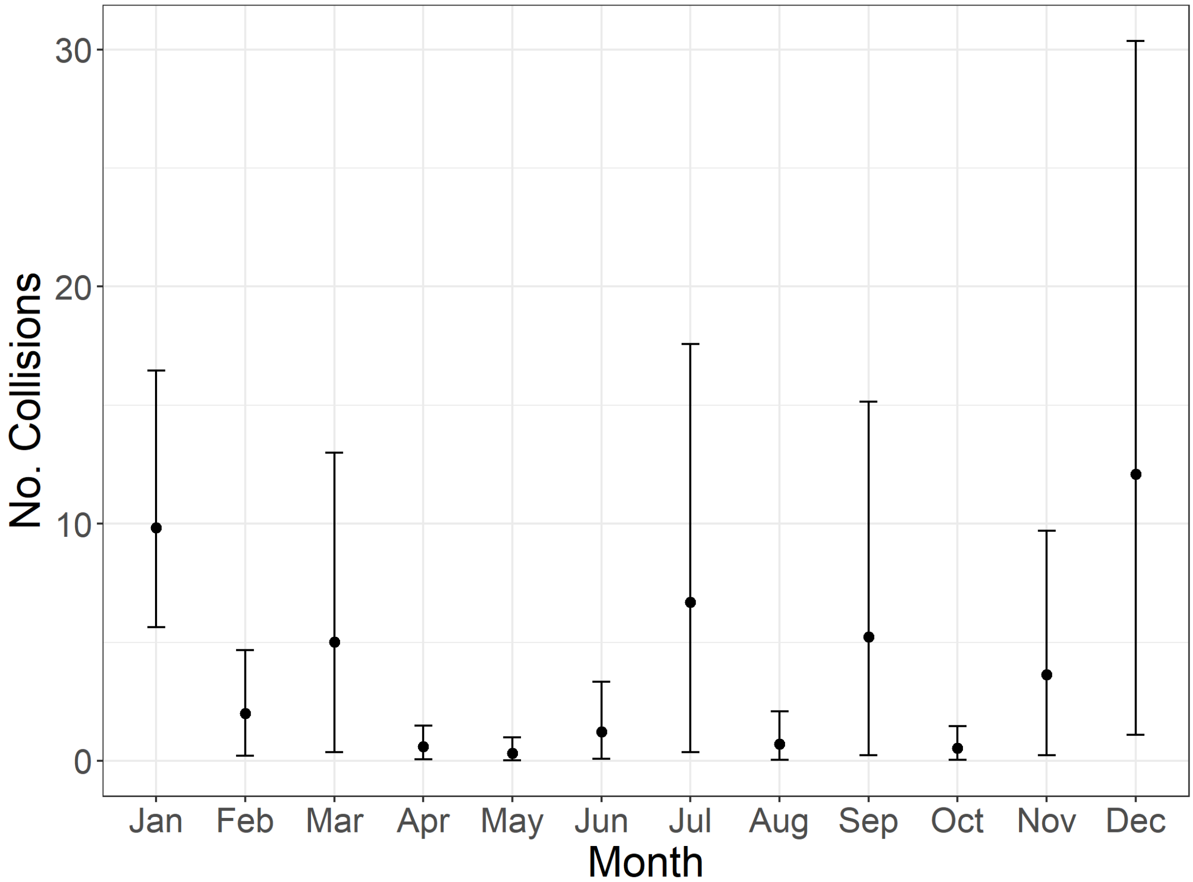

Figure 3.5: Mean monthly collisions predicted for herring gull for Project Option 1 Band Option 2. Error bars display the upper and lower confidence intervals of monthly collision.

Project Option 2

3.5.3 The herring gull collision rate for Band Option 2 estimated a mean of 47.91 annual collisions (based on Project Option 2), with the LCI and UCI ranging from 8.36 to 116.23 annual collisions.

3.6 Lesser black-backed gull

3.6.1 The worst-case scenario for lesser black-backed gull is Project Option 1. Results for each scenario are presented below.

Project Option 1

3.6.2 The lesser black-backed gull collision rate for Band Option 2 estimated a mean of 1.79 annual collisions (based on Project Option 1), with the LCI and UCI ranging from 0.07 to 5.80 annual collisions. The monthly distribution of collision estimates for lesser black-backed gull are displayed in Figure 3.6.

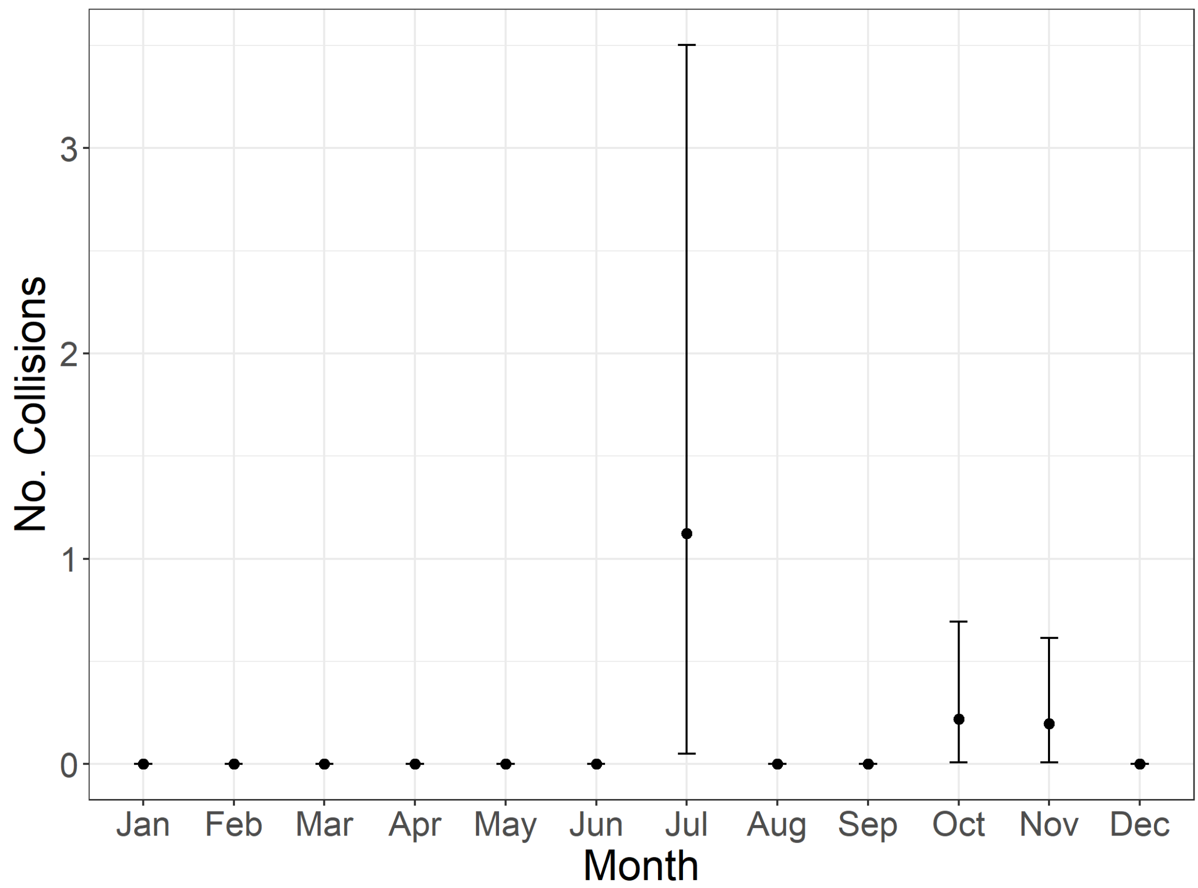

Figure 3.6: Mean monthly collisions predicted for lesser black-backed gull for Project Option 1 Band Option 2. Error bars display the upper and lower confidence intervals of monthly collisions.

Project Option 2

3.6.3 The lesser black-backed gull collision rate for Band Option 2 estimated a mean of 1.54 annual collisions (based on Project Option 2), with the LCI and UCI ranging from 0.07 to 4.81 annual collisions.

3.7 Roseate tern

3.7.1 The worst-case scenario for roseate tern is Project Option 2. Results for each scenario are presented below.

Project Option 1

3.7.2 The roseate tern collision rate for Band Option 2 estimated a mean of 0.12 annual collisions (based on Project Option 1), with the LCI and UCI ranging from 0.01 to 0.35 annual collisions.

Project Option 2

3.7.3 The roseate collision rate for Band Option 2 estimated a mean of 0.11 annual collisions (based on Project Option 2), with the LCI and UCI ranging from 0.01 to 0.33 annual collisions. The monthly distribution of collision estimates for roseate tern are displayed in Figure 3.7.

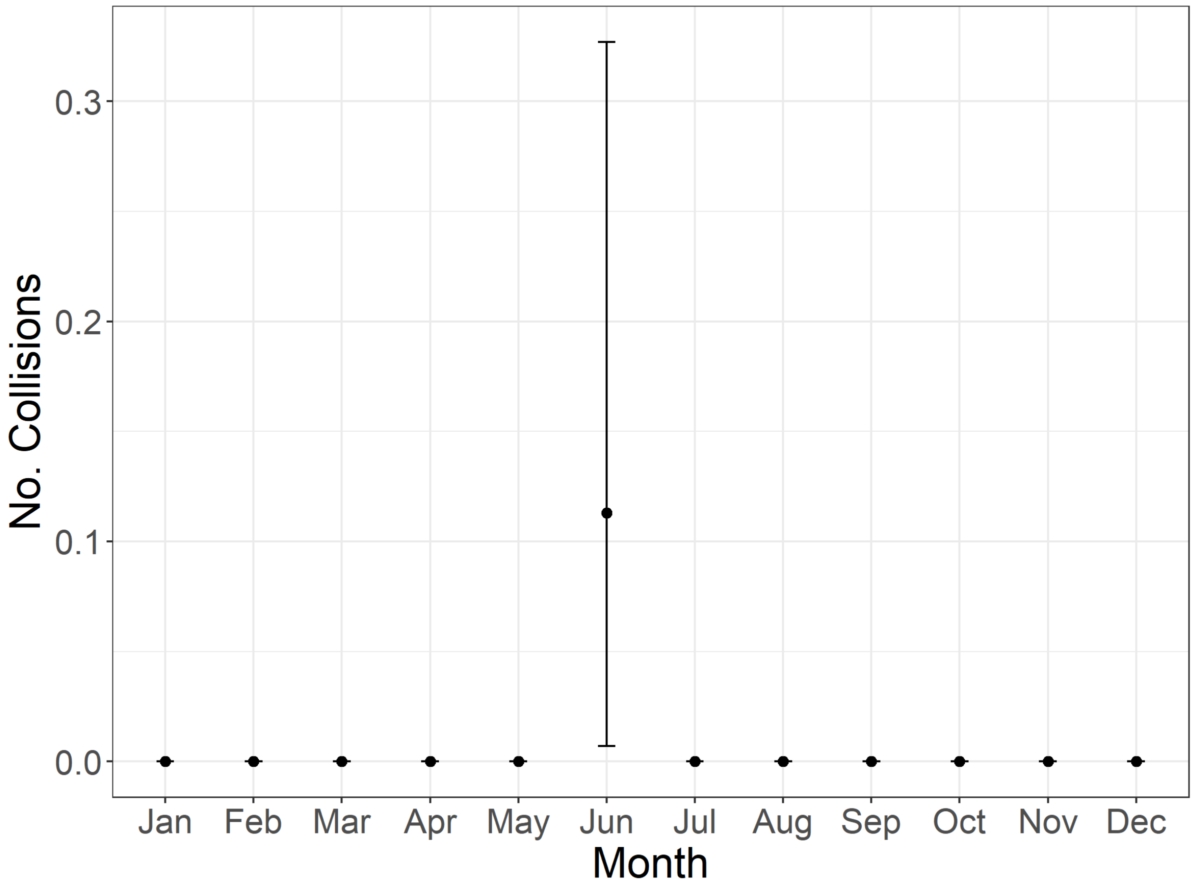

Figure 3.7. Mean monthly collisions predicted for roseate tern for Project Option 2 Band Option 2. Error bars display the upper and lower confidence intervals of monthly collisions.

3.8 Common tern

3.8.1 The worst-case scenario for common tern is Project Option 2. Results for each scenario are presented below.

Project Option 1

3.8.2 The common tern collision rate for Band Option 2 estimated a mean of 0.22 annual collisions (based on Project Option 1), with the LCI and UCI ranging from 0.01 to 0.62 annual collisions.

Project Option 2

3.8.3 The common tern collision rate for Band Option 2 estimated a mean of 0.22 annual collisions (based on Project Option 2), with the LCI and UCI ranging from 0.01 to 0.67 annual collisions. The monthly distribution of collision estimates for common tern are displayed in Figure 3.8.

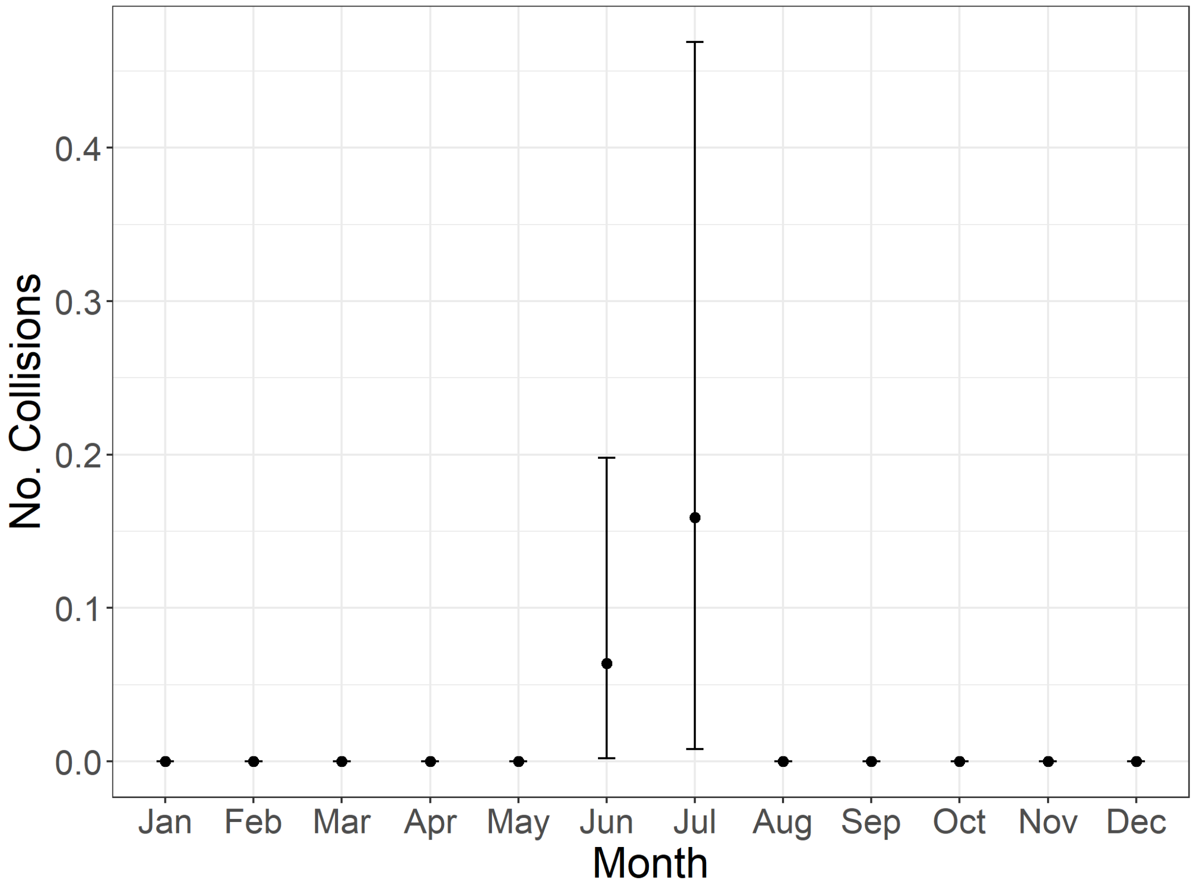

Figure 3.8. Mean monthly collisions predicted for common tern for Project Option 2 Band Option 2. Error bars display the upper and lower confidence intervals of monthly collisions.

3.9 Arctic tern

3.9.1 The worst-case scenario for Arctic tern is Project Option 1. Results for each scenario are presented below.

Project Option 1

3.9.2 The Arctic tern collision rate for Band Option 2 estimated a mean of 0.02 annual collisions (based on Project Option 1), with the LCI and UCI ranging from 0.00 to 0.16 annual collisions. The monthly distribution of collision estimates for Arctic tern are displayed in Figure 3.9.

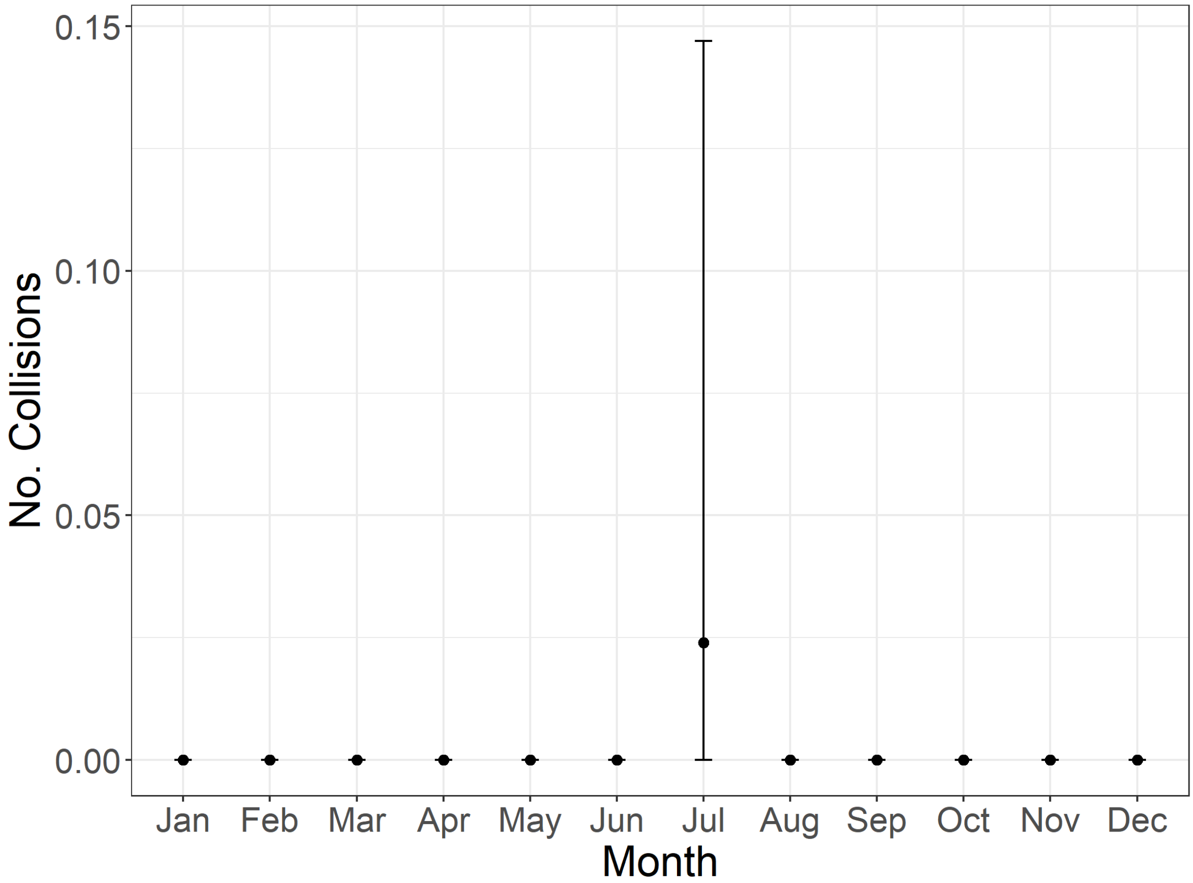

Figure 3.9 Mean monthly collisions predicted for arctic tern for Project Option 1 Band Option 2. Error bars display the upper and lower confidence intervals of monthly collision.

Project Option 2

3.9.3 The Arctic tern collision rate for Band Option 2 estimated a mean of 0.02 annual collisions (based on Project Option 2), with the LCI and UCI ranging from 0.00 to 0.15 annual collisions.

3.10 Commic tern

3.10.1 The worst-case scenario for Commic tern is Project Option 2. Results for each scenario are presented below.

Project Option 1

3.10.2 The commic tern collision rate for Band Option 2 estimated a mean of 0.56 annual collisions (based on Project Option 1), with the LCI and UCI ranging from 0.04 to 1.45 annual collisions.

Project Option 2

3.10.3 The commic tern collision rate for Band Option 2 estimated a mean of 0.57 annual collisions (based on Project Option 2), with the LCI and UCI ranging from 0.04 to 1.47 annual collisions. The monthly distribution of collision estimates for commic tern are displayed in Figure 3.10.

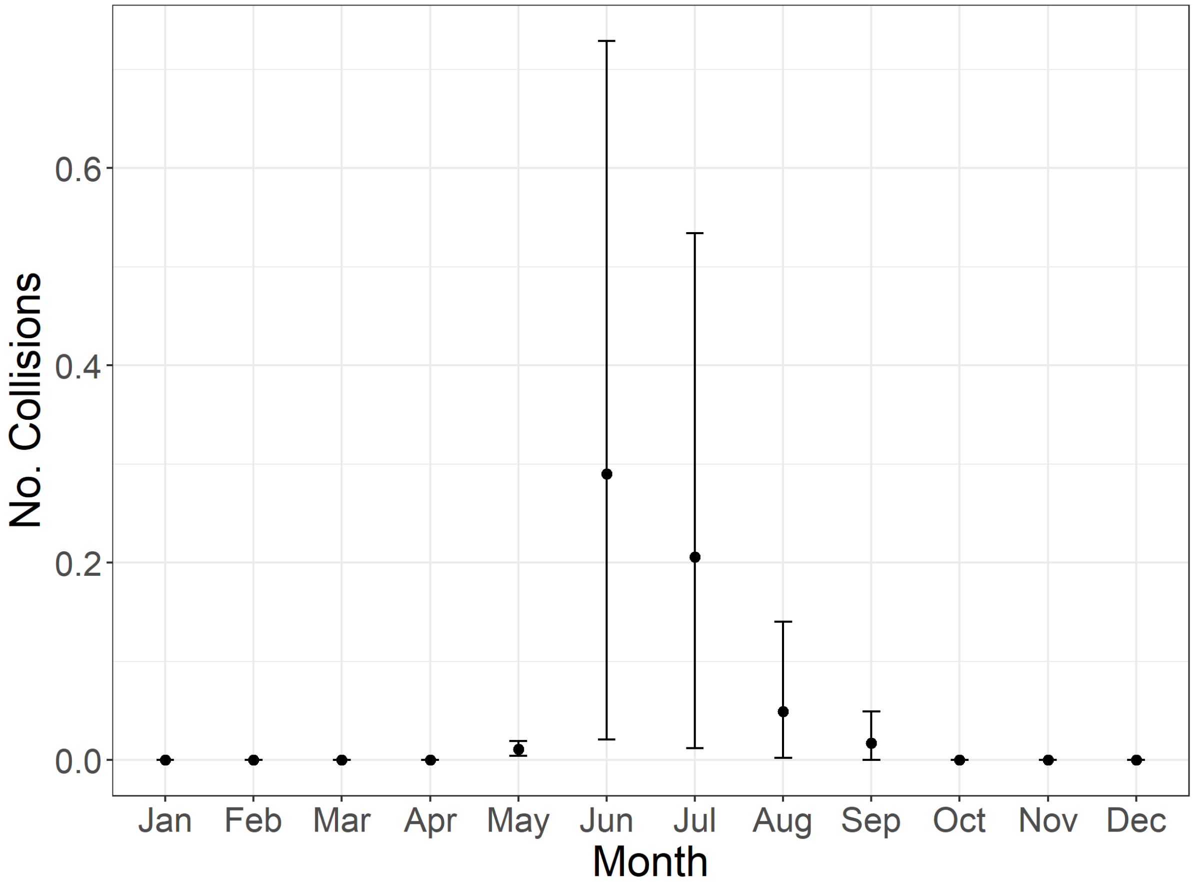

Figure 3.10. Mean monthly collisions predicted for commic tern for Project Option 3 Band Option 2. Error bars display the upper and lower confidence intervals of monthly collisions.

3.11 Manx shearwater

3.11.1 No collision mortalities were predicted for Manx shearwater and therefore no worst-case scenario is evident.

3.12 Fulmar

3.12.1 The worst-case scenario for fulmar is Project Option 1. Results for each scenario are presented below.

Project Option 1

3.12.2 The fulmar collision rate for Band Option 2 estimated a mean of 0.02 annual collisions (based on Project Option 1), with the LCI and UCI ranging from 0.00 to 0.16 annual collisions. The monthly distribution of collision estimates for fulmar are displayed in Figure 3.11.

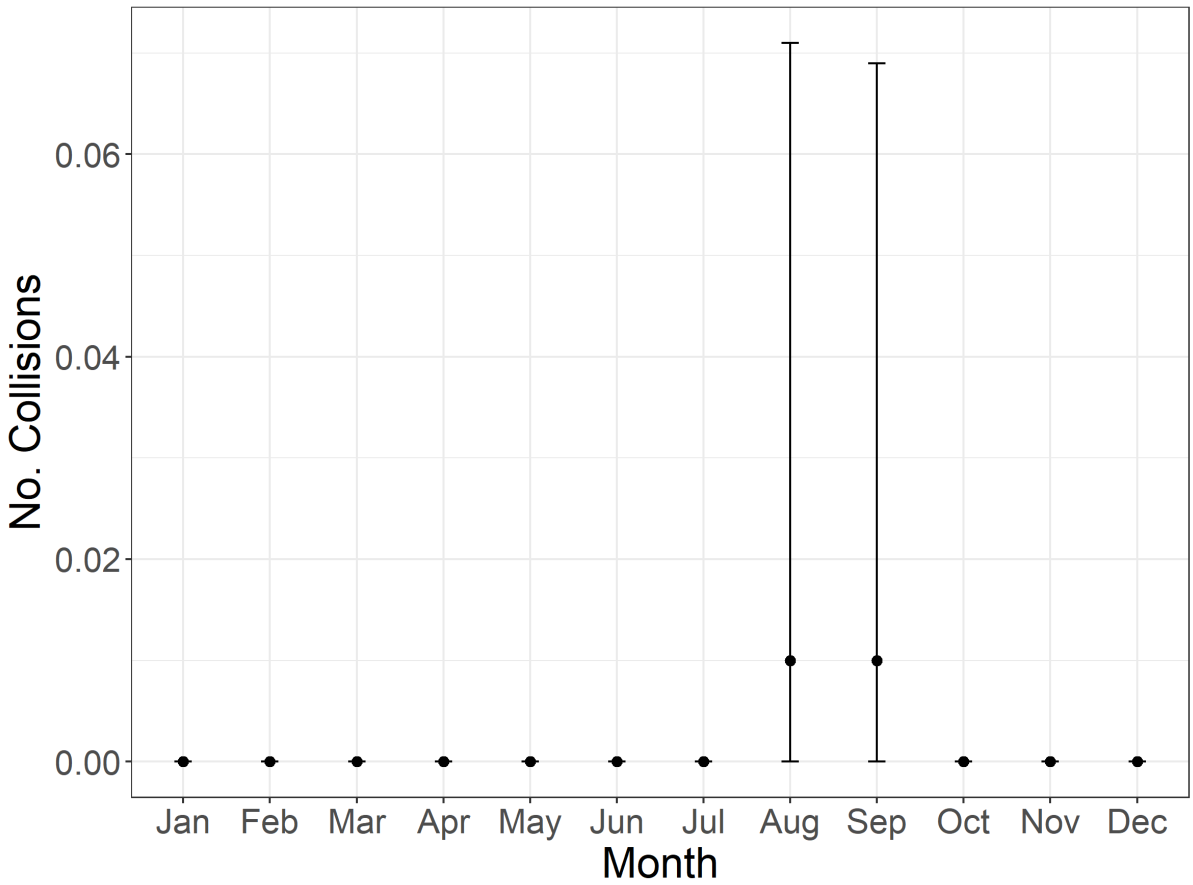

Figure 3.11. Mean monthly collisions predicted for fulmar for Project Option 1 Band Option 2. Error bars display the upper and lower confidence intervals of monthly collision.

Project Option 2

3.12.3 The fulmar collision rate for Band Option 2 estimated a mean of 0.02 annual collisions (based on Project Option 2), with the LCI and UCI ranging from 0.00 to 0.14 annual collisions.

3.13 Gannet

3.13.1 The worst-case scenario for gannet is Project Option 1. Results for each scenario are presented below.

Project Option 1

3.13.2 The gannet collision rate for Band Option 2 estimated a mean of 1.42 annual collisions (based on Project Option 1), with the LCI and UCI ranging from 0.08 to 4.74 annual collisions. The monthly distribution of collision estimates for gannet with macro-avoidance are displayed in Figure 3.12.

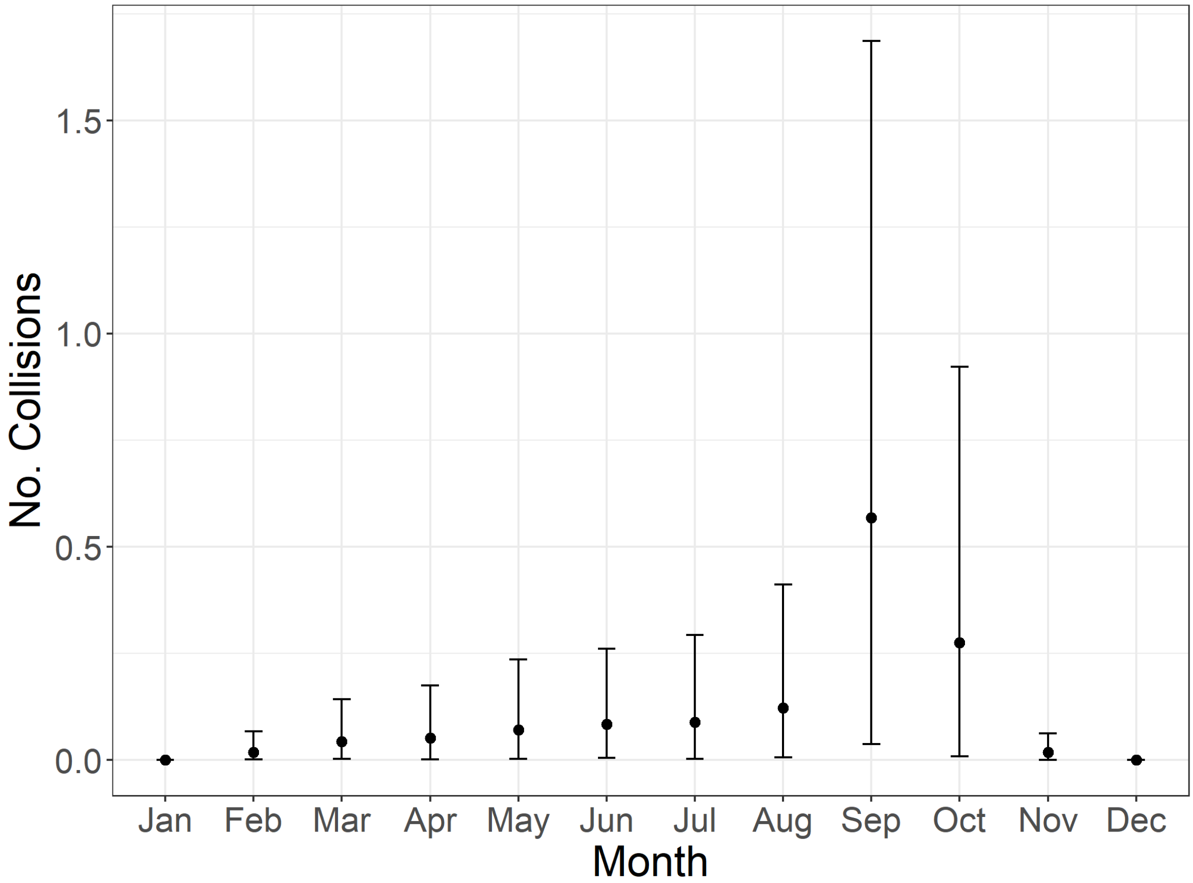

Figure 3.12. Mean monthly collisions predicted for gannet with macro-avoidance applied for Project Option 1 Band Option 2. Error bars display the upper and lower confidence intervals of monthly collision.

Project Option 2

3.13.3 The gannet collision rate for Band Option 2 estimated a mean of 1.34 annual collisions (based on Project Option 2), with the LCI and UCI ranging from 0.07 to 4.26 annual collisions.

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APPENDIX A - Monthly collisions estimates by species

North Irish Sea Array Windfarm Ltd
North Irish Sea Array Offshore Wind Farm

Date: September 2022

Revision: Final

A Monthly collisions estimates by species

Table 4-1: Kittiwake monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	6.4	1	1.3	0.4	0.6	0.3	2.0	0.8	1.8	1.2	1.2	2.4
LCI	0.6	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
UCI	14.3	2.3	3.1	0.9	1.5	0.6	5.5	1.8	5.0	2.7	2.9	5.1
Project Option 2												
Mean	6.0	1.0	1.2	0.4	0.6	0.3	1.8	0.8	1.6	1.1	1.1	2.2
LCI	0.6	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.3
UCI	14.0	2.2	2.9	0.8	1.4	0.6	4.7	1.6	4.1	2.5	2.6	4.6

Table 4-2 Black-headed gull monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.8	0.0
Project Option 2												
Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.7	0.0

Table 4-3: Common gull monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	1.2	0.8	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.1	2.6	0.3
LCI	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
UCI	3.1	2.0	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.4	6.4	0.8
Project Option 2												
Mean	1.1	0.7	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.1	2.2	0.3
LCI	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
UCI	2.6	1.8	0.5	0.4	0.0	0.0	0.0	0.0	0.0	0.3	5.7	0.7

Table 4-4: Great black-backed gull monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	1.6	3.4	2.2	0.0	0.0	0.6	6.5	0.7	1.3	0.8	1.6	7.5
LCI	0.2	0.3	0.2	0.0	0.0	0.0	0.2	0.0	0.1	0.1	0.2	0.4
UCI	3.6	8.6	5.6	0.0	0.0	1.6	18.6	1.8	3.2	2.1	3.8	21.0
Project Option 2												
Mean	1.3	2.8	1.8	0.0	0.0	0.5	5.4	0.6	1.1	0.7	1.3	6.1
LCI	0.2	0.3	0.2	0.0	0.0	0.0	0.3	0.0	0.1	0.1	0.1	0.5
UCI	2.9	6.9	4.2	0.0	0.0	1.3	15.2	1.5	2.6	1.7	2.9	15.2

Table 4-5: Herring gull monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	11.8	2.3	6.0	0.8	0.4	1.5	8.0	0.8	6.2	0.7	4.2	14.5
LCI	6.6	0.3	0.4	0.1	0.0	0.1	0.4	0.0	0.3	0.0	0.3	1.2
UCI	20.1	5.4	15.2	1.9	1.1	4.1	23.4	2.2	17.2	2.0	11.2	36.2
Project Option 2												
Mean	9.8	2.0	5.0	0.6	0.3	1.2	6.7	0.7	5.2	0.5	3.6	12.1
LCI	5.6	0.2	0.4	0.1	0.0	0.1	0.4	0.0	0.2	0.0	0.2	1.1
UCI	16.5	4.7	13.0	1.5	1.0	3.3	17.6	2.1	15.1	1.5	9.7	30.4

Table 4-6: Lesser black-backed gull monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.3	0.2	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.9	0.8	0.0
Project Option 2												
Mean	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.2	0.2	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.7	0.6	0.0

Table 4-7: Roseate tern monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Project Option 2												
Mean	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0

Table 4-8: Common tern monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0	0.0
Project Option 2												
Mean	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0	0.0

Table 4-9: Arctic tern monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Project Option 2												
Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0

Table 4-10: Commic tern monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.7	0.5	0.1	0.0	0.0	0.0	0.0
Project Option 2												
Mean	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.7	0.5	0.1	0.0	0.0	0.0	0.0

Table 4-11: Manx shearwater monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Project Option 2												
Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4-12: Fulmar monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Project Option 2												
Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0

Table 4-13: Gannet monthly collision estimates.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Option 1												
Mean	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.4	2.0	1.0	0.1	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
UCI	0.0	0.2	0.5	0.6	0.9	0.9	1.1	1.4	6.4	3.4	0.2	0.0
Project Option 2												
Mean	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	1.9	0.9	0.1	0.0
LCI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
UCI	0.0	0.2	0.5	0.6	0.8	0.9	1.0	1.4	5.6	3.1	0.2	0.0

GoBe Consultants Ltd
Suites B2 & C2, Higher Mill
Higher Mill Lane
Buckfastleigh
Devon
TQ11 0EN

GoBe Consultants Ltd
5/2 Merchant's House
7 West George Street
Glasgow
Scotland
G2 1BA

www.gobeconsultants.com