GREEN VOLT

Technical Appendix 12.3
Offshore Ornithology: Collision Risk Modelling

Offshore EIA Report: Volume 2

Green Volt Offshore Wind Farm

Appendix 12.3 Offshore Ornithology: Collision Risk Modelling

Green Volt Offshore Wind Ltd.

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1. Introduction

1.1 Project Background

Green Volt Offshore Wind Limited ('the Applicant') is proposing to develop the Green Volt Offshore Wind Farm (OWF) (from here on referred to as 'Green Volt') as a proposed floating offshore wind farm. The proposed site is approximately 75 km northeast of the Aberdeenshire coast in the northern North Sea, Scotland (**Figure 1**). The proposed array area covers an area of approximately 116.8 km^2, whilst the survey area included a 4 km buffer surrounding the array area providing a total study area of approximately 391 km^2. Green Volt will comprise both offshore and onshore infrastructure, including an offshore generating station (the wind farm), export cables to the Buzzard platform and landfall and an onshore transmission infrastructure for connection to the electricity network (please see **Green Volt Offshore Wind Farm Environmental Impact Assessment Report Chapter 5: Project Description** for full details on the Project Design for full details on the Project Design).

APEM Ltd (hereafter APEM) was commissioned by the Applicant to undertake a study of offshore ornithology that characterises the area that may be influenced by Green Volt. A separate report (**Appendix: 12.1 Offshore and Intertidal Ornithology Baseline Technical Report** 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 Green Volt. This technical appendix has been produced to support **Green Volt Offshore Wind Farm Environmental Impact Assessment Report Chapter 12: Offshore and Intertidal Ornithology.**

The consideration of offshore ornithology for Green Volt has been discussed with consultees through the Green Volt Ornithology Working Group meetings; of which NatureScot, Marine Scotland Science (MSS), Marine Scotland Licensing Operations Team (MS-LOT) and the Royal Society for the Protection of Birds (RSPB) are in attendance. Agreements made with consultees within the Green Volt Stakeholder Ornithology meeting process are set out in the consultation table within the **Green Volt Offshore Wind Farm Environmental Impact Assessment Report Chapter 12: Offshore and Intertidal Ornithology**.

1.2 Collision Risk Modelling

There is the potential for birds flying through Green Volt to collide with the rotating turbines and associated infrastructure, which would then be predicted to result in mortality (Drewitt & Langston, 2006). This potential collision risk can be estimated by modelling the predicted number of collisions for key seabird species using the known densities of birds in flight from baseline surveys.

Four key seabird species have been identified for which potential collision risk should be considered in relation to Green Volt. These have been presented for agreement with the Green Volt Ornithology Working Group meetings and include:

- Gannet, *Morus bassanus*;
- Kittiwake, *Rissa tridactyla*;
- Herring gull, *Larus argentatus*; and
- Great black-backed gull, *Larus marinus*.

2. Methods

2.1 Guidance and Models

Collision Risk Modelling (CRM) was undertaken using the stochastic Collision Risk Model (sCRM), developed by Marine Scotland (Donovan, 2018) as agreed through the Green Volt Ornithology Working Group meetings. 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 user interface accessible via a standard web-browser that uses an R code to estimate collision risk. The advantages of using the 'Shiny App' are that users are not required to use any R code, are not required to install or maintain 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 access (Donovan 2018). Unlike the Band 2012 CRM model the sCRM also provides a clear and transparent audit trail for all modelling run, which enables regulators to easily assess 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). The User Guide for the sCRM Shiny App provided by Marine Scotland (Donovan 2018) has been followed for the modelling and assessment of impacts predicted for Green Volt.

APEM conducted rigorous testing of the newly updated Donovan (2018) sCRM in consultation with UK Statutory Nature Conservation Bodies (SNCBs) and the Royal Society for the Protection of Birds (RSPB) and the model's developers (Orsted, 2021). This was undertaken in order to ensure the sCRM could be run deterministically to provide comparable results to the Band (2012) CRM. The results of these tests provided evidence that the Donovan (2018) sCRM could be run deterministically to reach results that were comparable to that from Band (2012) CRM outputs to within 0.01% in most instances. This testing, therefore, proved that the sCRM is suitable for assessing collision risk to seabirds deterministically for offshore wind farm assessments instead of using the older Band (2012) model.

As with the Band (2012) model, the sCRM can generate collision estimates by two different methods (basic and extended models), each of which have two different options. The basic model assumes a uniform flight height distribution across the rotor swept heights, whilst the extended model uses species-specific modelled flight height distributions to account for variation in the distribution of flights across the rotor swept heights (Band, 2012; Johnston *et al.*, 2014a, b). Seabird flight height distributions tend to be skewed towards the lower rotor swept heights, where collision risk is lower (Band, 2012), so that for most species the extended model will give lower collision estimates than the basic for a given avoidance rate and set of wind farm parameters.

Each of the basic and extended models can be run using either site-specific flight height data (i.e. as collected from the array area in question) or generic flight height data, which derive from pre-construction surveys for wind farm developments at 32 sites in the UK and elsewhere in Europe (Johnston *et al*., 2014a, b). This gives rise to Options 1 (site-specific flight height data) and 2 (generic flight height data) for the basic model and Options 3 (generic flight height data) and 4 (site-specific flight height data) for the extended model (Band, 2012).

Robustly estimating site-specific flight heights from aerial digital imagery requires a sufficient sample size of birds of each species from which flight height can be determined. Not all individuals are suitable for flight height estimation, as the method requires clear imagery of individuals in straight and level flight, with wings fully extended. Following completion of the full 24 months of site-specific baseline surveys, sample sizes were insufficient to accurately calculate site-specific flight heights for the four species selected for CRM. Therefore, Band Options 2 and 3 only are presented within this report.

In their review to derive species-specific avoidance rates for use with CRM, Cook *et al*. (2014) failed to identify suitable values for gannet and kittiwake in relation to the extended model. Therefore, the CRM are undertaken using Band Option 2 for gannet and kittiwake, and Band Options 2 and 3 for herring gull and great black-backed gull. The avoidance rates applied to the CRMs for each species and model option follow the latest Statutory Nature Conservation Bodies (SNCBs) advice (SNCBs, 2014) and follow recommendations in the Scoping Report Consultation Responses (Green Volt Offshore Wind Farm, Appendix 1: Consultation Responses and advice) and the Green Volt Ornithology Working Group meetings.

It is understood that SNCBs are currently reviewing the latest avoidance rates put forward by Cook (2021), which was withdrawn due to some errors identified in the data, and are due to publish an updated guidance note on avoidance rates in 2022. In the absence of the updated guidance note at the time of writing, all species follow the guidance from Cook et al. (2014) and the Joint Nature Conservation Committee (JNCC) led UK SNCBs review of avoidance rates to be applied in the Band models (JNCC et al., 2014) in response to Cook et al., (2014) as agreed within the Green Volt Ornithology Working Group.

However, it is noted that the latest guidance paper on avoidance rates for collision risk modelling (Cook, 2021) included acknowledgement of the double counting of collision risk and displacement for gannet and proposed that assessments of gannet should take into account observed high levels of macro avoidance within collision risk modelling to reduce the over-inflation of impacts when combining the two together (APEM, 2014; Dierschke et al., 2016; Orsted, 2022). The issue of over-inflating displacement and collision when combining the two for assessing the potential impacts on gannet from offshore wind farms is also noted in the joint SNCBs interim advice note on displacement (SNCBs, updated 2022). Despite updated guidance not being issued for gannet collision risk modelling to account for a greater degree of macro avoidance account has been provided in this report of such potential additional macro avoidance in an alternate set of CRM outputs. These revised CRM outputs altered the monthly mean density estimates for gannet to account for macro avoidance of 70% (the mid-point of the displacement range of 60 to 80% advocated by SNCBs) and are presented in **Appendix 4.**

2.2 CRM Input Parameters

Models were run deterministically for each species, rather than stochastically, given a lack of data regarding variability around input values. Therefore, an evidence-led approach was used to determine appropriate model input parameters for each species. Key input values were reviewed in order to provide mean, 'minimum' and 'maximum' estimates of collision mortality where possible, with mean estimates forming the basis of the assessments described in **Green Volt Offshore Wind Farm Environmental Impact Assessment Report Chapter 12: Offshore and Intertidal Ornithology**. A summary of all CRM scenarios and corresponding input parameters is provided in **Appendix 1** and the results for all modelling scenarios are presented monthly in **Appendix 3**.

2.2.1.1 Turbine parameters

Input parameters relating to Green Volt are shown in **Table 1** and Error! Reference source not found.. These values are based on the Maximum Design Scenario (MDS), as described in **Green Volt Offshore Wind Farm Environmental Impact Assessment Report Chapter 12: Offshore and Intertidal Ornithology** and **Green Volt Offshore Wind Farm Environmental Impact Assessment Report Chapter 5: Project Description**. Footprint width was calculated as the longest distance an individual could fly across the footprint of the Green Volt. Latitude, used to estimate the number of hours of daylight per month across the year, was calculated from the centroid of the array area. Minimum air gap reflects lowest blade tip height above the Highest Astronomical Tide (HAT).

Table 1. Turbine and array parameters used to inform Collision Risk Models.

Input Parameter	Scenario 1
Number of turbines	35
Number of blades	3
Rotor radius (m)	121N
Rotation speed (rpm)	8
Average Pitch at Site Mean Speed (degrees)	6°
Maximum blade width (m)	8
Minimum air gap (m) against HAT	22m
Maximum footprint width (km)	16.93
Latitude (degrees)	57.88177
Large array correction	Yes

In addition to the parameters presented in **Table 1**, the estimated percentage of time that the turbines are predicted to be operational per month (average across all turbines) is presented in Error! Reference source not found.. The operational time is based on a cut-in speed of >3.5 m/s and cut out speed of ≤28m/s.

Table 2. Predicted turbine operational time per month.

Month	Operational Time (%)
January	98.79
February	98.66
March	97.58
April	86.53
May	92.07
June	79.58
July	87.90
August	94.89
September	94.17
October	93.01
November	83.89
December	88.98

2.2.1.2 Species Biometrics

For each species, a number of physical and behavioural characteristics were used to inform CRM (**Table 3**). These characteristics may increase or decrease collision risk and are as follows:

- Bird length;
- Wingspan;
- Flight speed; and
- Nocturnal activity.

Bird length and wingspan for all species were derived from Robinson (2005). Standard deviation was not included around these two parameters since these are not provided in Robinson (2005). Whilst standard deviation around these values is built-in to the sCRM Shiny App, these were not utilised due to uncertainties surrounding the source of these data.

Central estimates of flight speeds for gannet, kittiwake, herring gull and great black-backed gull were derived from Cook *et al*. (2014), which presents flight speed values taken from Pennycuick (1997) and Alerstam *et al*. (2007).

Nocturnal activity rates for all species are represented as an upper and lower values. A range of values were selected to account for uncertainty in currently available data sources on seabird nocturnal activity levels. The upper values for nocturnal activity are based on the 1 to 5 scoring index for each species presented in Garthe & Hüppop (2004) and King *et al*. (2009), with these factors converted into nocturnal activity as follows: 1 = 0%, 2 = 25%, 3 = 50%, 4 = 75%, 5 = 100%. However, there is evidence to suggest that this scoring index is likely to be overly precautionary for some species (MacArthur Green *et al.,* 2015; Skov *et al.,* 2018; Masden, 2015), and as such, the Applicant considers the lower nocturnal activity rates in **Table 3** the most appropriate values based on these recent studies.

2.2.1.3 Avoidance Rates

Since most birds will exhibit avoidance behaviour when faced with wind turbine generators (WTGs), a key element of collision risk modelling is the inclusion of a parameter to describe this behaviour. Different species are expected to avoid wind farms to differing degrees (Cook *et al*. 2012; Johnston *et al*. 2014a).

The species-specific avoidance rates that were applied in the CRM are presented in **Table 4**. The avoidance rates for all species follows the guidance from Cook et al. (2014) and the JNCC led UK SNCBs review of avoidance rates to be applied in the Band models (JNCC et al., 2014) in response to Cook et al., (2014). The upper and lower values were derived from +/- 2 SD from the central estimate.

Table 3. Species biometric data used to inform Collision Risk Models.

Species	Body Length (m)	Wingspan (m)	Flight Speed (m/s)	Nocturnal Activity (%)		
				Min	Mean	Max
Gannet	0.94	1.72	13.33	0	0	25
Kittiwake	0.39	1.08	13.10	25	25	50
Herring gull	0.60	1.44	12.80	25	25	50
Great black-backed gull	0.71	1.58	13.70	25	25	50

Table 4. Avoidance rates used to inform Collision Risk Models (Cook et al. 2014).

Species	Avoidance Rate (Basic Model Option 2)			Avoidance Rate (Extended Model Option 3)		
	Min	Mean	Max	Min	Mean	Max
Gannet	0.991	0.989	0.987	NA	NA	NA
Kittiwake	0.991	0.989	0.987	NA	NA	NA
Herring gull	0.996	0.995	0.994	0.992	0.990	0.988
Great black-backed gull	0.996	0.995	0.994	0.991	0.989	0.987

2.2.1.4 *Density of Birds in Flight*

Density estimates +/- 1 SD were determined for Green Volt using data collected across 24 months of baseline aerial digital surveys, carried out between May 2020 and April 2022, inclusive. The data used are presented in **Appendix: 12.1 Offshore and Intertidal Ornithology Baseline Technical Report**. The density data used for CRM are inclusive of apportionment of unidentified birds. The minimum CRM scenario used mean – 1 SD density estimates while the maximum CRM scenario used mean + 1 SD density estimates for all species.

One SD was estimated using the following equation:

$$1\ SD \approx (Maximum - Minimum) / 4$$

Where "Maximum" is the higher of the two upper 95% confidence limit (CL) estimates for a given calendar month, and "Minimum" is the lower of the two lower CL estimates for the same calendar month. An example is given below for the calendar month of July (**Table 5**).

Table 5. Example values used to calculate one SD.

Survey	Density (birds/km^2)		
	Mean	Lower CL	Upper CL
May 2020	0.27	0.09	0.70
May 2021	0.08	0.00	0.23

An example of how the data in **Table 5** is used to calculate mean ± one SD is provided below:

$$1\ SD \approx (0.70 – 0.00) / 4 = 0.18$$

$$Mean = (0.27 + 0.08) / 2 = 0.17\ birds/km^2$$

$$Mean + 1\ SD = 0.35\ birds/km^2$$

$$Mean – 1\ SD = 0.00\ birds/km^2.$$

The mean, minimum and maximum monthly densities of each species used for CRM are presented in **Appendix 2**.

3. Results

This section provides a summary of the Applicant's evidence-led annual CRM results only for each of the four seabird species modelled. A summary of all CRM scenarios and corresponding input parameters is provided in **Appendix 1** and the results for all modelling scenarios are presented monthly in **Appendix 3**.

3.1 Gannet

The annual predicted gannet collision values for Band Option 2 are presented in **Table 6**. The corresponding monthly predicted collision rates are presented in **Figure 1** and **Appendix 3**. Collision risk input parameters used to determine the mean, minimum and maximum number of collisions is presented in **Appendix 1**.

Table 6. Predicted annual collision mortality for gannet.

	Predicted annual collisions		
	Mean (Scenario 1)	Minimum	Max
Band Option 2	21.7	5.6	51.5

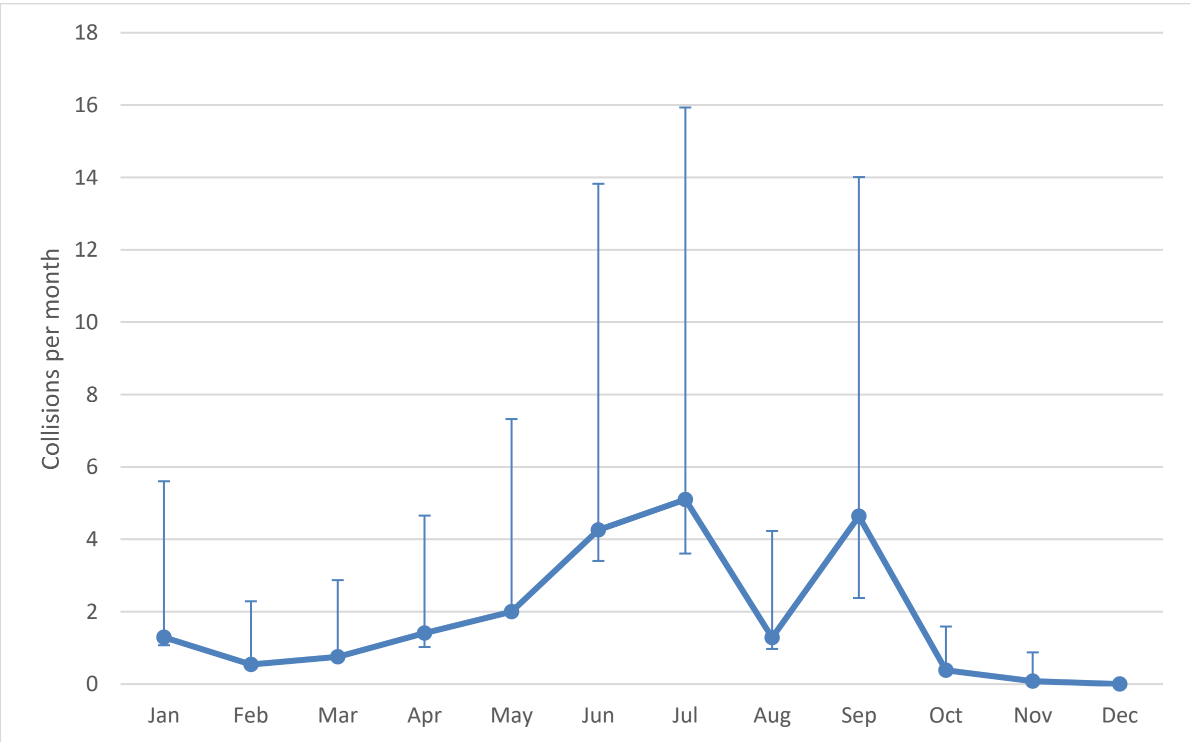

Figure 1. Predicted monthly collision mortality for gannet (error bars show minimum and maximum scenario) using Band Option 2.

3.2 Kittiwake

The annual predicted kittiwake collision values for Band Option 2 are presented in **Table 7.** The corresponding monthly predicted collision rates are presented in **Figure 2** and **Appendix 3**. Collision risk input parameters used to determine the mean, minimum and maximum number of collisions is presented in **Appendix 1**.

Table 7. Predicted annual collision mortality for kittiwake.

	Predicted annual collisions		
	Mean (Scenario 1)	Minimum	Max
Band Option 2	18.9	8.9	38.2

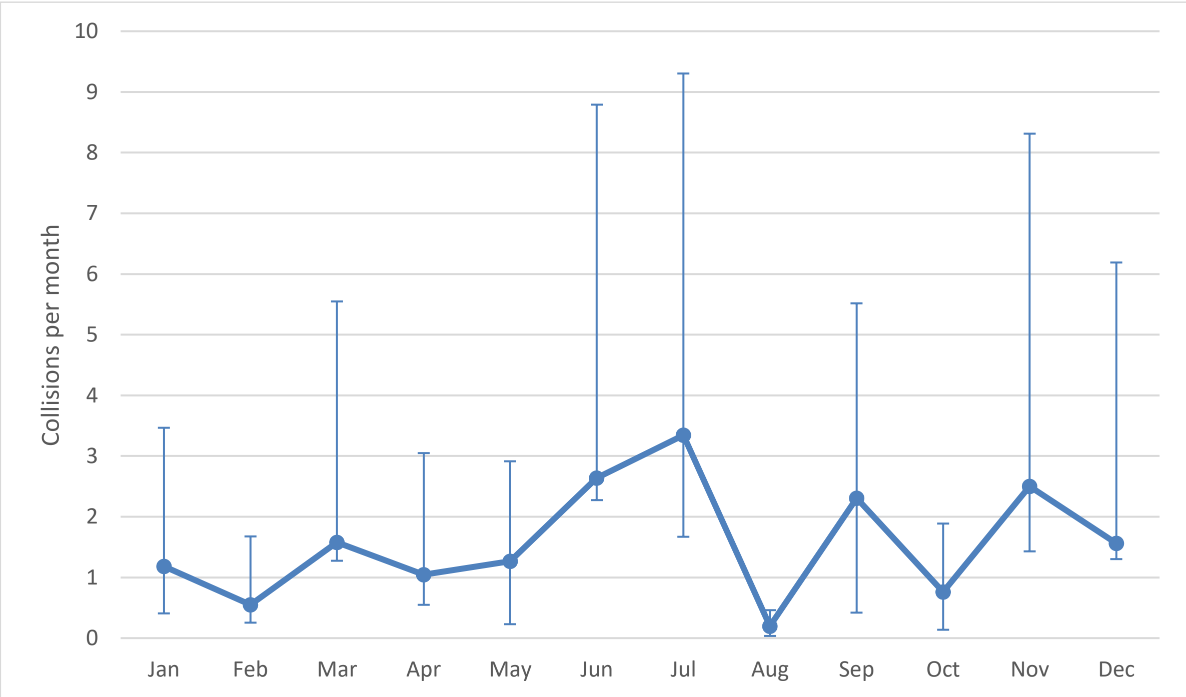

Figure 2. Predicted monthly collision mortality for kittiwake (error bars show minimum and maximum scenario) using Band Option 2.

3.3 Herring gull

The annual predicted herring gull collision values for Band Option 2 and Band Option 3 are presented in **Table 8**. The corresponding monthly predicted collision rates are presented in **Figure 3** and **Appendix 3**. Collision risk input parameters used to determine the mean, minimum and maximum number of collisions is presented in **Appendix 1**.

Table 8. Predicted annual collision mortality for herring gull.

	Predicted annual collisions		
	Mean (Scenario 1)	Minimum	Max
Band Option 2	3.79	2.70	7.07
Band Option 3	2.14	1.52	3.99

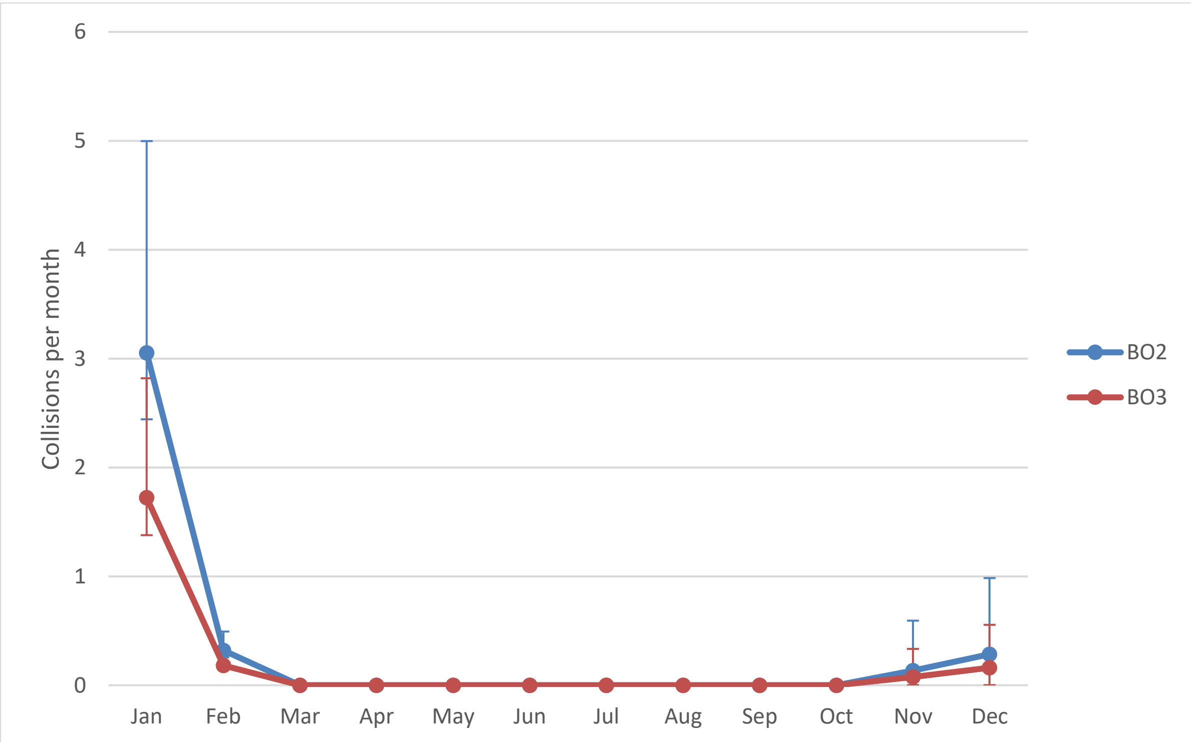

Figure 3. Predicted monthly collision mortality for herring gull (error bars show minimum and maximum scenario) using Band Option 2 and Band Option 3.

3.4 Great black-backed gull

The annual predicted great black-backed gull collision values for Band Option 2 and Band Option 3 are presented in **Table 9**. The corresponding monthly predicted collision rates are presented in

and **Appendix 3**. Collision risk input parameters used to determine the mean, minimum and maximum number of collisions is presented in **Appendix 1**.

Table 9. Predicted annual collision mortality for great black-backed gull.

	Predicted annual collisions		
	Mean (Scenario 1)	Minimum	Max
Band Option 2	4.30	2.65	8.49
Band Option 3	2.84	1.79	5.53

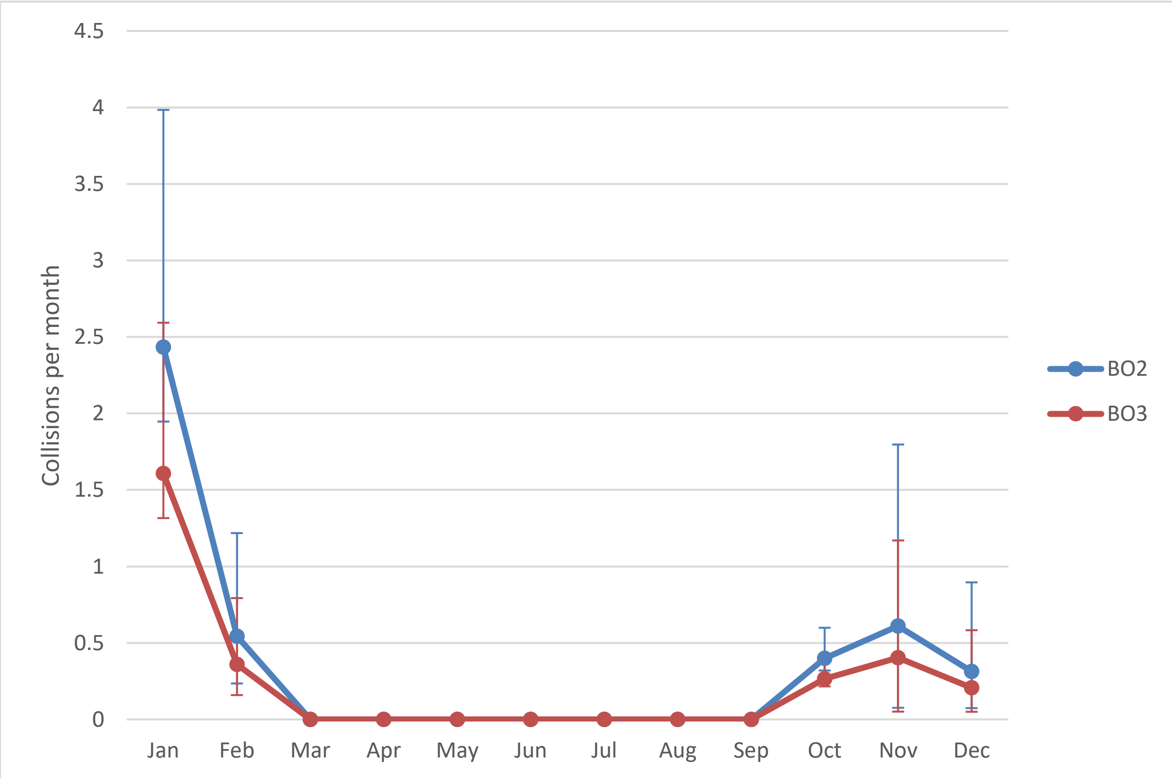

Figure 4. Predicted monthly collision mortality for great black-backed gull (error bars show minimum and maximum scenario) using Band Option 2 and Band Option 3.

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Appendix 1 Collision Risk Modelling Parameters Summary

Table 10. Input parameters for the four collision risk scenarios modelled using Band Options 2 and 3 (BO 2 and BO 3).

Species	Scenario	Nocturnal Activity	Basic Avoidance Rates (BO2)	Extended Avoidance rate (BO3)	Flight Height Data	Density Data
Kittiwake	Scenario 1	25	0.989	N/A	Johnston *et al.* (2014) Max Likelihood	Mean density
	Scenario 2	25	0.991	N/A		Minimum density (mean - SD)
	Scenario 3	50	0.987	N/A		Maximum density (mean + SD)
Gannet	Scenario 1	0	0.989	N/A	Johnston *et al.* (2014) Max Likelihood	Mean density
	Scenario 2	0	0.991	N/A		Minimum density (mean - SD)
	Scenario 3	25	0.987	N/A		Maximum density (mean + SD)
Herring gull	Scenario 1	25	0.995	0.990	Johnston *et al.* (2014) Max Likelihood	Mean density
	Scenario 2	25	0.996	0.992		Minimum density (mean - SD)
	Scenario 3	50	0.994	0.988		Maximum density (mean + SD)
Great black-backed gull	Scenario 1	25	0.995	0.989	Johnston *et al.* (2014) Max Likelihood	Mean density
	Scenario 2	25	0.996	0.991		Minimum density (mean - SD)
	Scenario 3	50	0.994	0.987		Maximum density (mean + SD)

Appendix 2 Monthly Densities of Birds in Flight

Mean, minimum and maximum monthly densities of each species used for CRM are presented in **Table 11** to **Table 14**.

Table 11. Gannet densities (birds per km^2).

Month	Mean density (Birds/ km^2)	Minimum density (mean – SD; Birds/ km^2)	Maximum density (mean + SD; Birds/ km^2)
Jan	0.235	0.049	0.422
Feb	0.086	0.004	0.167
Mar	0.086	0.009	0.163
Apr	0.154	0.051	0.257
May	0.171	0.000	0.347
Jun	0.402	0.098	0.706
Jul	0.437	0.156	0.717
Aug	0.116	0.034	0.197
Sep	0.518	0.308	0.728
Oct	0.051	0.000	0.105
Nov	0.017	0.000	0.090
Dec	0.000	0.000	0.000

Table 12. Kittiwake densities (birds per km^2).

Month	Mean density (Birds/ km^2)	Minimum density (mean – SD; Birds/ km^2)	Maximum density (mean + SD; Birds/ km^2)
Jan	0.150	0.120	0.180
Feb	0.068	0.045	0.092
Mar	0.157	0.037	0.276
Apr	0.107	0.062	0.152
May	0.107	0.107	0.107
Jun	0.252	0.043	0.462
Jul	0.287	0.175	0.398
Aug	0.017	0.017	0.017
Sep	0.232	0.232	0.232
Oct	0.086	0.086	0.086
Nov	0.368	0.193	0.544
Dec	0.230	0.047	0.413

Table 13. Herring gull densities (birds per km²).

Month	Mean density (Birds/ km²)	Minimum density (mean – SD; Birds/ km²)	Maximum density (mean + SD; Birds/ km²)
Jan	0.334	0.334	0.334
Feb	0.034	0.034	0.034
Mar	0.000	0.000	0.000
Apr	0.000	0.000	0.000
May	0.000	0.000	0.000
Jun	0.000	0.000	0.000
Jul	0.000	0.000	0.000
Aug	0.000	0.000	0.000
Sep	0.000	0.000	0.000
Oct	0.000	0.000	0.000
Nov	0.017	0.000	0.047
Dec	0.036	0.000	0.075

Table 14. Great black-backed gull densities (birds per km²).

Month	Mean density (Birds/ km²)	Minimum density (mean – SD; Birds/ km²)	Maximum density (mean + SD; Birds/ km²)
Jan	0.235	0.235	0.235
Feb	0.051	0.028	0.075
Mar	0.000	0.000	0.000
Apr	0.000	0.000	0.000
May	0.000	0.000	0.000
Jun	0.000	0.000	0.000
Jul	0.000	0.000	0.000
Aug	0.000	0.000	0.000
Sep	0.000	0.000	0.000
Oct	0.034	0.034	0.034
Nov	0.068	0.011	0.126
Dec	0.035	0.010	0.060

Appendix 3 Predicted Monthly Collision Risk Modelling Results

Table 15. Monthly predicted collision rates for gannet.

Band Option 2			
Month	**Scenario 1**	**Scenario 2**	**Scenario 3**
Jan	1.294	0.221	4.308
Feb	0.543	0.022	1.744
Mar	0.751	0.061	2.123
Apr	1.41	0.384	3.246
May	2.002	0.000	5.321
Jun	4.259	0.853	9.569
Jul	5.101	1.494	10.835
Aug	1.284	0.311	2.951
Sep	4.641	2.259	9.368
Oct	0.378	0.000	1.212
Nov	0.085	0.000	0.791
Dec	0.000	0.000	0.000
Annual	**21.7**	**5.6**	**51.5**

Table 16. Monthly predicted collision rates for kittiwake.

Band Option 2			
Month	**Scenario 1**	**Scenario 2**	**Scenario 3**
Jan	1.181	0.773	2.285
Feb	0.552	0.297	1.124
Mar	1.578	0.303	3.970
Apr	1.044	0.495	2.005
May	1.267	1.037	1.647
Jun	2.640	0.366	6.150
Jul	3.344	1.674	5.960
Aug	0.198	0.162	0.263
Sep	2.307	1.887	3.210
Oct	0.763	0.625	1.125
Nov	2.500	1.070	5.812
Dec	1.561	0.259	4.629
Annual	**18.9**	**8.9**	**38.2**

Table 17. Monthly predicted collision rates for herring gull.

Band Option 2			
Month	**Scenario 1**	**Scenario 2**	**Scenario 3**
Jan	3.052	2.442	4.997
Feb	0.32	0.256	0.493
Mar	0.000	0.000	0.000
Apr	0.000	0.000	0.000
May	0.000	0.000	0.000
Jun	0.000	0.000	0.000
Jul	0.000	0.000	0.000
Aug	0.000	0.000	0.000
Sep	0.000	0.000	0.000
Oct	0.000	0.000	0.000
Nov	0.135	0.000	0.593
Dec	0.285	0.000	0.984
Annual	**3.79**	**2.70**	**7.07**
Band Option 3			
Month	**Scenario 1**	**Scenario 2**	**Scenario 3**
Jan	1.722	1.378	2.819
Feb	0.181	0.144	0.278
Mar	0.000	0.000	0.000
Apr	0.000	0.000	0.000
May	0.000	0.000	0.000
Jun	0.000	0.000	0.000
Jul	0.000	0.000	0.000
Aug	0.000	0.000	0.000
Sep	0.000	0.000	0.000
Oct	0.000	0.000	0.000
Nov	0.076	0.000	0.334
Dec	0.161	0.000	0.555
Annual	**2.14**	**1.52**	**3.99**

Table 18. Monthly predicted collision rates for great black-backed gull.

Band Option 2			
Month	**Scenario 1**	**Scenario 2**	**Scenario 3**
Jan	2.433	1.947	3.984
Feb	0.543	0.235	1.218
Mar	0.000	0.000	0.000
Apr	0.000	0.000	0.000
May	0.000	0.000	0.000
Jun	0.000	0.000	0.000
Jul	0.000	0.000	0.000
Aug	0.000	0.000	0.000
Sep	0.000	0.000	0.000
Oct	0.4	0.32	0.599
Nov	0.61	0.076	1.797
Dec	0.314	0.074	0.896
Annual	**4.30**	**2.65**	**8.49**
Band Option 3			
Month	**Scenario 1**	**Scenario 2**	**Scenario 3**
Jan	1.608	1.316	2.593
Feb	0.359	0.159	0.793
Mar	0.000	0.000	0.000
Apr	0.000	0.000	0.000
May	0.000	0.000	0.000
Jun	0.000	0.000	0.000
Jul	0.000	0.000	0.000
Aug	0.000	0.000	0.000
Sep	0.000	0.000	0.000
Oct	0.265	0.216	0.39
Nov	0.403	0.051	1.17
Dec	0.207	0.05	0.583
Annual	**2.84**	**1.79**	**5.53**

Appendix 4 Gannet Macro Avoidance Collision Risk Assessment

It is noted that the latest guidance paper on avoidance rates for collision risk modelling (Cook, 2021) included acknowledgement of the double counting of collision risk and displacement for gannet and proposed that assessments of gannet should take into account observed high levels of macro avoidance within collision risk modelling to reduce the over-inflation of impacts when combining the two together (APEM, 2014; Dierschke et al., 2016; Orsted, 2022).

The issue of over-inflating displacement and collision when combining the two for assessing the potential impacts on gannet from offshore wind farms is also noted in the joint SNCBs interim advice note on displacement (SNCBs, updated 2022). Despite updated guidance not being issued for gannet collision risk modelling to account for a greater degree of macro avoidance account has been provided in this report of such potential additional macro avoidance in an alternate set of CRM outputs. These revised CRM outputs altered the monthly mean density estimates for gannet to account for macro avoidance of 70% (the mid-point of the displacement range of 60 to 80% advocated by SNCBs) and are provided in **Table 19**.

Table 19. Gannet density estimates accounting for a 70% reduction due to macro avoidance.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Density (Birds/ km^2)	0.071	0.026	0.026	0.046	0.051	0.121	0.131	0.035	0.155	0.015	0.005	0.000

Gannet collision risk has been modelled accounting for macro avoidance using the mean parameters as presented in **Section 2.2** and summarised in **Table 10** (Scenario 1), the mean and the reduced density estimates in **Table 19**. The monthly CRM results accounting for macro avoidance for Scenario 1 are presented in **Table 20** for Band Option 2.

Table 20. Gannet Scenario 1 monthly predicted collisions for Band Option 2 when considering macro avoidance

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.388	0.163	0.225	0.423	0.601	1.278	1.530	0.385	1.392	0.113	0.026	0.000	**6.5**

When considering the inclusion of macro avoidance in the assessment of collision risk to gannet, the mean (Scenario 1) annual predicted collisions is 6.5 gannets per annum compared to 21.7 when macro avoidance is unaccounted. A monthly comparison between the monthly predicted collisions for Scenario 1 including and excluding consideration of macro avoidance is presented in

Figure 5. The significant difference between the two scenarios in

Figure 5 highlights the current over precaution in assessment of gannet collision risk, due to macro avoidance not being accounted for.

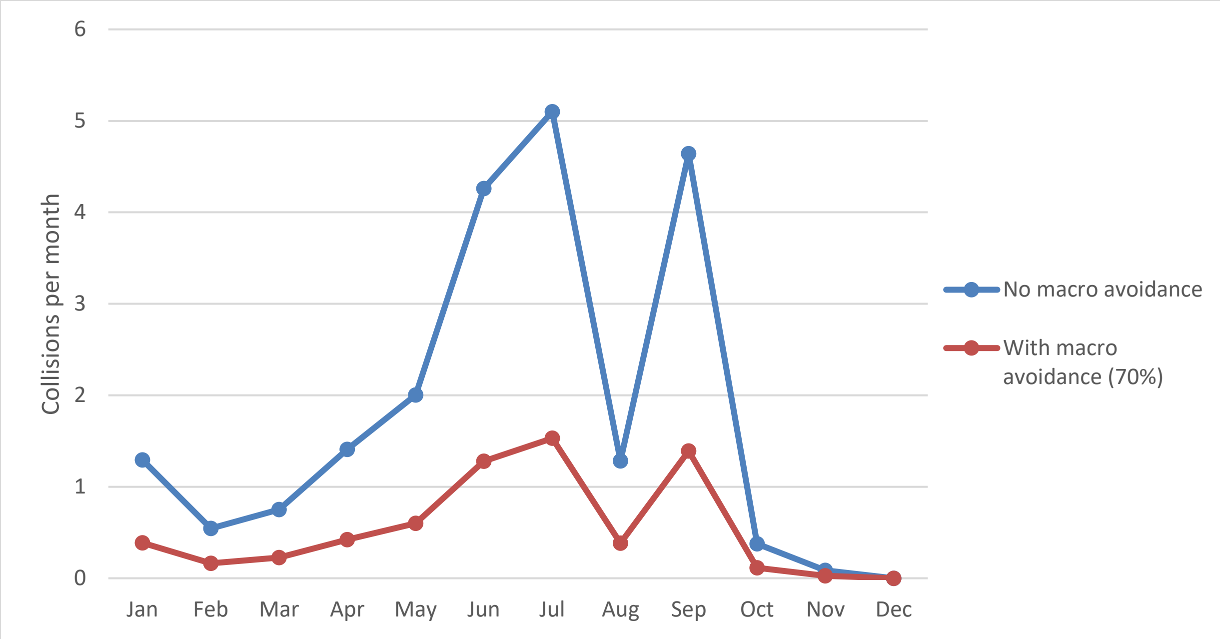

Figure 5. Predicted monthly collision mortality for gannet (Band Option 2) including and excluding macro avoidance.

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