Awel y Môr Offshore Wind Farm

Category 6: Environmental Statement

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Awel y Môr Offshore Wind Farm

Annex 4.2 Offshore Ornithology: Collision Risk Modelling

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0.1	07/05/2021	All	All	PEIR First draft (results only)	EN
0.2	28/05/2021	All	All	PEIR First draft (complete)	TK
1.0	24/11/2021	All	All	ES First Draft	EN
1.1	29/11/2021	All	All	Amendments following Gobe Review	EN
1.2	06/01/2022	Appendix 4	23-24	Inclusion of gannet macro avoidance section	SS

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1. Introduction

1.1 Project Background

Awel y Môr Offshore Wind Farm Limited ('the Applicant') is proposing to develop the Awel y Môr Offshore Wind Farm (AyM OWF) as a proposed extension to the operational Gwynt y Môr (GyM) OWF. AyM is located approximately 10.5 km offshore from the north-east coast of Wales at its closest point, with the array covering an area of approximately 78 km^2. AyM will comprise both offshore and onshore infrastructure, including an offshore generating station (wind farm), export cables to landfall, and an onshore substation for connection to the electricity transmission network (please see **Volume 2, Chapter 1: Offshore Project Description (application ref: 6.2.1)** and **Volume 3, Chapter 1: Onshore Project Description (application ref: 6.3.1)** for full details on the Project Design).

APEM Ltd (hereafter APEM) was commissioned by the Applicant to undertake a study of offshore ornithology that characterise the area that may be influenced by AyM. A separate report (**Volume 4, Annex 4.1: Offshore Ornithology; Baseline Characterisation Report (application ref: 6.4.4.1)**) provides the findings from offshore ornithology data to determine the receptors that characterise the baseline and are of relevance to the assessment of potential impacts from AyM. This technical annex has been produced to support **Volume 2, Chapter 4: Offshore Ornithology (application ref: 6.2.4)**.

The consideration of offshore ornithology for AyM has been discussed with consultees through the Expert Technical Group (ETG) meetings; of which Natural Resources Wales, The Joint Nature Conservation Committee (JNCC), Natural England and the Royal Society for the Protection of Birds (RSPB) are members. Agreements made with consultees within the ETG process are set out in the **Evidence Plan Report (application ref: 8.2.)** and the consultation table within **Volume 2, Chapter 4: Offshore Ornithology (application ref: 6.2.4)**.

1.2 Collision Risk Modelling

There is the potential for birds flying through AyM 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 densities from baseline surveys.

Four key seabird species have been identified for which potential collision risk should be considered in relation to AyM. These have been presented for agreement with the ETG and include:

- Gannet;
- Kittiwake;
- Herring gull; and
- Great black-backed gull.

Further consideration for migratory non-seabirds and migratory seabird species is provided in a separate report (**Volume 4, Annex 4.4: Migratory Collision Risk Modelling (application ref: 6.4.4.4**)).

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 ETG. 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 AyM.

APEM conducted rigorous testing of the newly updated Donovan (2018) sCRM in consultation with SNCBs and the model's developers. 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 under 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 have been agreed as suitable for assessment with the ETG (**application ref: 8.2.**).

It is understood that SNCBs are currently reviewing the avoidance rates put forward by Cook (2021) and are due to publish an updated guidance note on avoidance rates. In the absence of the updated guidance note at the time of writing, the Cook et al. (2014) avoidance rates have been used for all four species as agreed with the ETG (**application ref: 8.2.**).

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 **Volume 2, Chapter 4: Offshore Ornithology (application ref: 6.2.4)**. 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 AyM are shown in **Table 1** and **Table 2**. These values are based on the Maximum Design Scenario (MDS), as described in **Volume 2, Chapter 4: Offshore Ornithology (application ref: 6.2.4)** and **Volume 2, Chapter 1: Offshore Project Description (application ref: 6.2.1).** The upper and lower values for rotation speed, pitch and wind speed were calculated by adding or subtracting the Standard Deviation (SD) from the mean (central estimate) value supplied by the Applicant. Footprint width was calculated as the longest distance an individual could fly across the footprint of the AyM. 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 turbine hub height above the Highest Astronomical Tide (HAT).

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

Input Parameter	Mean	Minimum	Maximum
Number of turbines	50	50	50
Number of blades	3	3	3
Rotor radius (m)	125	125	125
Rotation speed (rpm)	5.46	4.50	7.81
Pitch (degrees)	2.27	0.00	3.59
Maximum blade width (m)	7	7	7
Minimum air gap (m)	21.19	21.19	21.19
Tidal offset (m)	4.46	4.46	4.46
Maximum footprint width (km)	17.3	17.3	17.3
Latitude (degrees)	53.46	53.46	53.46
Large array correction	Yes	Yes	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 **Table 2**.

Table 2 Theoretical turbine operational time per month.

Month	Operational Time (%)
January	89.2
February	88.4
March	87.1
April	83.5
May	84.2
June	80.5
July	81.1
August	84.4
September	86.5
October	89.6
November	91.2
December	89.9

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 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 Statutory Nature Conservation Bodies (SNCB) review of avoidance rates to be applied in the Band models (SNCBs, 2014) in response to Cook *et al*., 2014). The upper and lower values were derived from +/- 2SD from the central estimate. It is understood that SNCBs are currently reviewing the avoidance rates put forward by Cook (2021). In the absence of updated guidance from SNCBs at the time of writing, the Cook et al. (2014) avoidance rates have been used for all four species as agreed with the ETG.

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	14.9	0	0 – 25	25
Kittiwake	0.39	1.08	13.10	25	25 – 50	50
Herring gull	0.60	1.44	12.80	25	25 – 50	50
Great black-backed gull	0.71	1.58	13.70	25	25 – 50	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	0.988	0.990	0.992
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 AyM using data collected across 24 months of baseline aerial digital surveys, carried out between March 2019 and February 2021, inclusive. The data used are presented in **Volume 4, Annex 4.1: Baseline Characterisation Report (application ref: 6.4.4.1)**. The density data used for CRM are inclusive of apportionment of unidentified birds and corrections for availability bias, where appropriate. 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
July 2019	1.62	0.76	2.59
July 2020	0.10	0.01	0.31

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

$$1\ SD \approx (2.59 - 0.01) / 4 = 0.64$$

$$Mean = 0.86\ birds/km^2$$

$$Mean + 1\ SD = 1.50\ birds/km^2$$

$$Mean - 1\ SD = 0.22\ birds/km^2.$$

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.

Band Option	Predicted annual collisions		
	Mean (Scenario 1)	Minimum (Scenario 3)	Maximum (Scenario 4)
Option 2	20.49	3.13	60.04

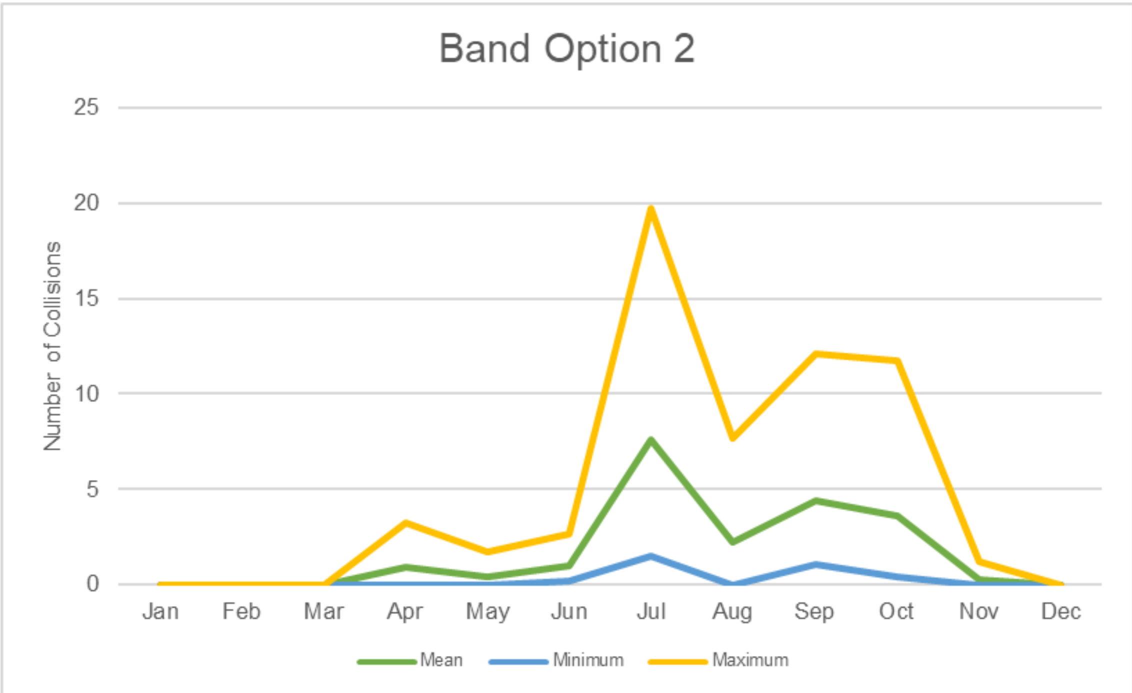

Figure 1 Predicted monthly collision mortality for gannet (Band Option 2).

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.

Band Option	Predicted annual collisions		
	Mean (Scenario 1)	Minimum (Scenario 3)	Maximum (Scenario 4)
Option 2	53.86	13.66	137.94

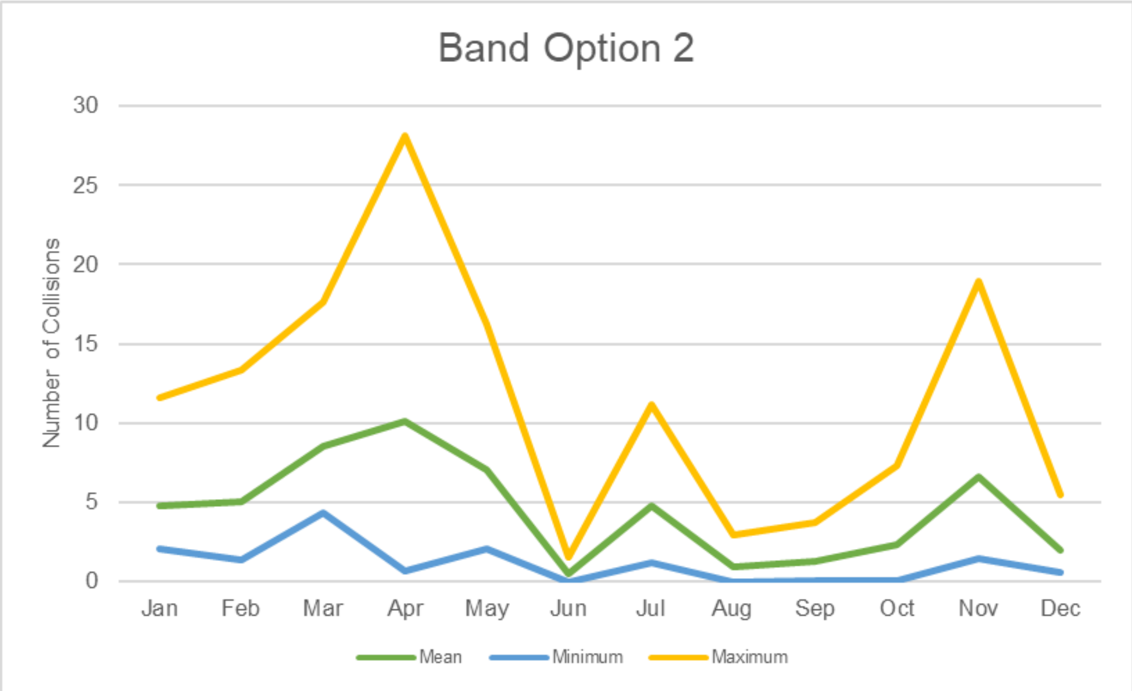

Figure 2 Predicted monthly collision mortality for kittiwake (Band Option 2).

3.3 Herring gull

The annual predicted herring gull collision values for Band Option 2 and 3 are presented in **Table 8**. The corresponding monthly predicted collision rates are presented in **Figure 3**, **Figure 4** 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.

Band Option	Predicted annual collisions		
	Mean (Scenario 1)	Minimum (Scenario 3)	Maximum (Scenario 4)
Option 2	2.96	0.00	11.91
Option 3	1.49	0.00	6.74

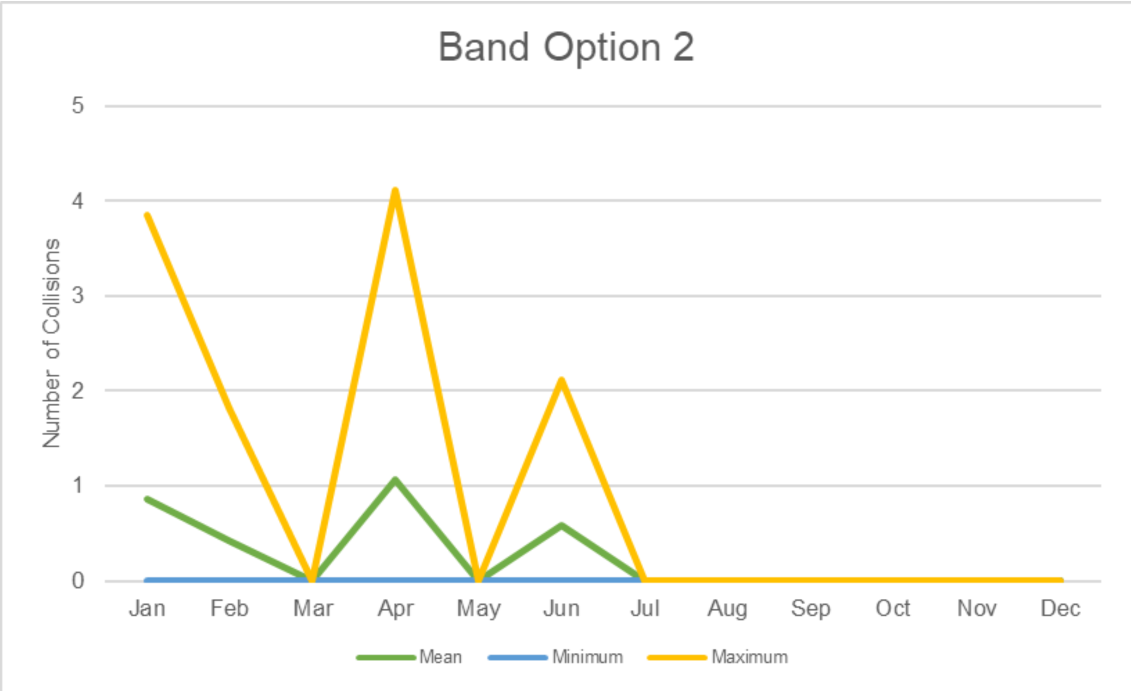

Figure 3 Predicted monthly collision mortality for herring gull (Band Option 2).

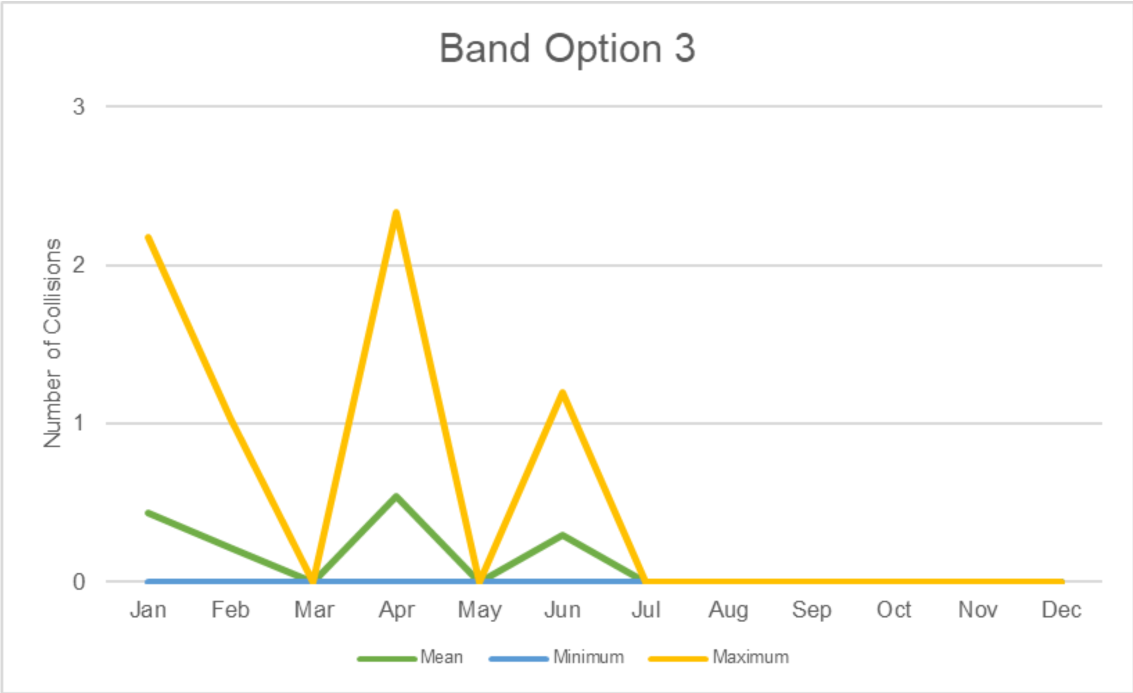

Figure 4 **Predicted monthly collision mortality for herring gull (Band Option 3).**

3.4 Great black-backed gull

The annual predicted great black-backed gull collision values for Band Option 2 and 3 are presented in **Table 9**. The corresponding monthly predicted collision rates are presented in **Figure 5**, **Figure 6** 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.

Band Option	Predicted annual collisions		
	Mean (Scenario 1)	Minimum (Scenario 3)	Maximum (Scenario 4)
Option 2	4.87	0.00	18.49
Option 3	2.89	0.00	12.10

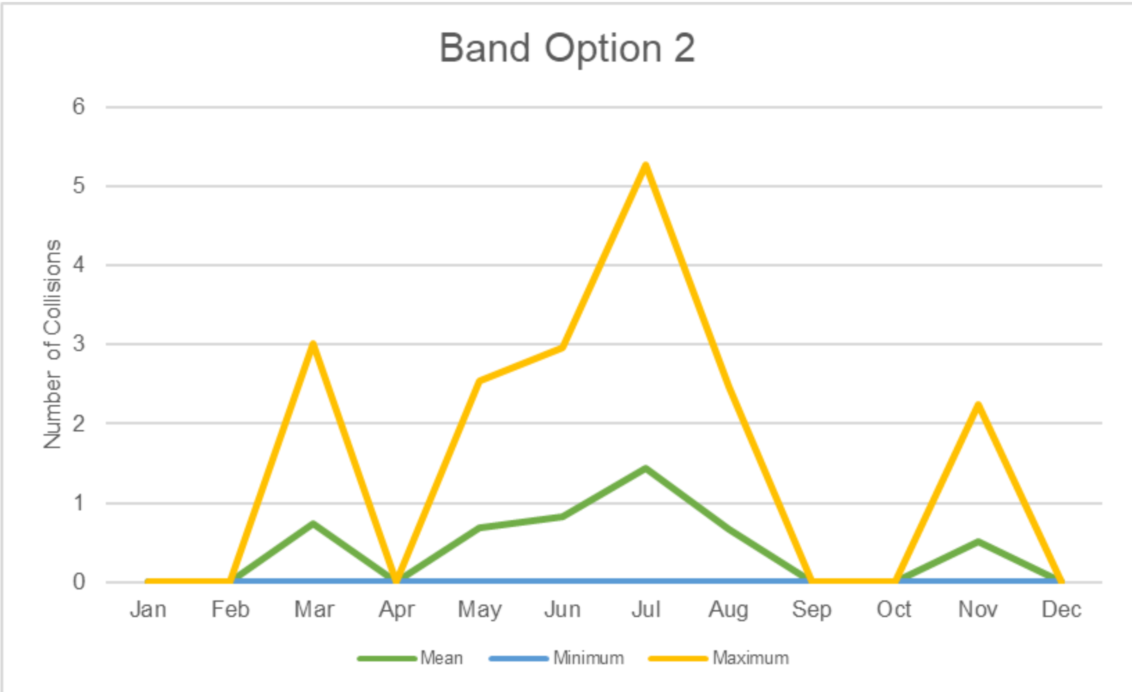

Figure 5 Predicted monthly collision mortality for great black-backed gull (Band Option 2).

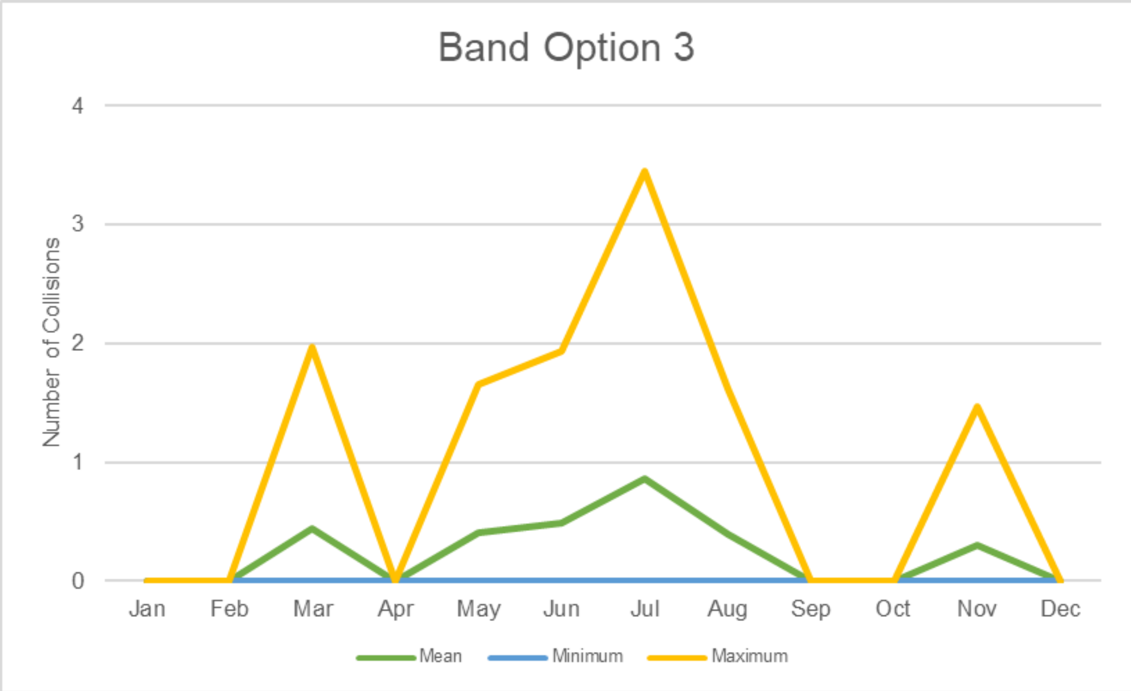

Figure 6 **Predicted monthly collision mortality for great black-backed gull (Band Option 3).**

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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	50	0.989	N/A	Johnston et al. (2014) Max Likelihood	Mean density
	Scenario 3	25	0.991	N/A	Johnston et al. (2014) Max Likelihood	Minimum density (mean - SD)
	Scenario 4	50	0.987	N/A	Johnston et al. (2014) Max Likelihood	Maximum density (mean + SD)
Gannet	Scenario 1	0	0.989	N/A	Johnston et al. (2014) Max Likelihood	Mean density
	Scenario 2	25	0.989	N/A	Johnston et al. (2014) Max Likelihood	Mean density
	Scenario 3	0	0.991	N/A	Johnston et al. (2014) Max Likelihood	Minimum density (mean - SD)
	Scenario 4	25	0.987	N/A	Johnston et al. (2014) Max Likelihood	Maximum density (mean + SD)

Herring gull	Scenario 1	25	0.995	0.990	Johnston et al. (2014) Max Likelihood	Mean density
	Scenario 2	50	0.995	0.990	Johnston et al. (2014) Max Likelihood	Mean density
	Scenario 3	25	0.996	0.992	Johnston et al. (2014) Max Likelihood	Minimum density (mean - SD)
	Scenario 4	50	0.994	0.988	Johnston et al. (2014) Max Likelihood	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	50	0.995	0.989	Johnston et al. (2014) Max Likelihood	Mean density
	Scenario 3	25	0.996	0.991	Johnston et al. (2014) Max Likelihood	Minimum density (mean - SD)
	Scenario 4	50	0.994	0.987	Johnston et al. (2014) Max Likelihood	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 km²)

Month	Mean density (Birds/ km²)	Minimum density (mean – SD; Birds/ km²)	Maximum density (mean + SD; Birds/ km²)
Jan	0.00	0.00	0.00
Feb	0.00	0.00	0.00
Mar	0.00	0.00	0.00
Apr	0.12	0.00	0.27
May	0.05	0.00	0.13
Jun	0.12	0.03	0.20
Jul	0.86	0.22	1.50
Aug	0.27	0.00	0.60
Sep	0.63	0.20	1.05
Oct	0.57	0.08	1.06
Nov	0.05	0.00	0.13
Dec	0.00	0.00	0.00

Table 12 Kittiwake densities (birds per km²)

Month	Mean density (Birds/ km²)	Minimum density (mean – SD; Birds/ km²)	Maximum density (mean + SD; Birds/ km²)
Jan	0.73	0.39	1.07
Feb	0.79	0.27	1.31
Mar	1.10	0.70	1.49
Apr	1.26	0.10	2.43
May	0.78	0.29	1.28
Jun	0.05	0.00	0.13
Jul	0.53	0.16	0.90
Aug	0.10	0.00	0.23
Sep	0.16	0.00	0.32
Oct	0.31	0.00	0.62
Nov	1.00	0.27	1.73
Dec	0.31	0.11	0.51

Table 13 Herring gull 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	0.10	0.00	0.26
Feb	0.05	0.00	0.13
Mar	0.00	0.00	0.00
Apr	0.10	0.00	0.26
May	0.00	0.00	0.00
Jun	0.05	0.00	0.13
Jul	0.00	0.00	0.00
Aug	0.00	0.00	0.00
Sep	0.00	0.00	0.00
Oct	0.00	0.00	0.00
Nov	0.00	0.00	0.00
Dec	0.00	0.00	0.00

Table 14 Great black-backed gull 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	0.00	0.00	0.00
Feb	0.00	0.00	0.00
Mar	0.06	0.00	0.16
Apr	0.00	0.00	0.00
May	0.05	0.00	0.13
Jun	0.06	0.00	0.16
Jul	0.11	0.00	0.27
Aug	0.05	0.00	0.13
Sep	0.00	0.00	0.00
Oct	0.00	0.00	0.00
Nov	0.05	0.00	0.13
Dec	0.00	0.00	0.00

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	Scenario 4
Jan	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00
Apr	0.90	1.06	0.00	3.21
May	0.44	0.50	0.00	1.69
Jun	1.01	1.11	0.17	2.63
Jul	7.63	8.51	1.50	19.75
Aug	2.20	2.54	0.00	7.66
Sep	4.44	5.41	1.08	12.12
Oct	3.61	4.74	0.38	11.74
Nov	0.26	0.37	0.00	1.24
Dec	0.00	0.00	0.00	0.00
Annual	**20.49**	**24.25**	**3.13**	**60.04**

Table 16 Monthly predicted collision rates for kittiwake.

Band Option 2				
Month	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Jan	4.74	6.30	2.03	11.59
Feb	5.05	6.40	1.38	13.34
Mar	8.54	10.29	4.36	17.62
Apr	10.11	11.66	0.64	28.15
May	7.09	7.90	2.07	16.23
Jun	0.45	0.49	0.00	1.55
Jul	4.77	5.25	1.17	11.18
Aug	0.89	1.01	0.00	2.90
Sep	1.26	1.48	0.02	3.69
Oct	2.37	2.93	0.02	7.34
Nov	6.65	8.68	1.42	18.92
Dec	1.95	2.63	0.55	5.44
Annual	**53.86**	**65.02**	**13.66**	**137.94**

Table 17 Monthly predicted collision rates for herring gull.

Band Option 2				
Month	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Jan	0.87	0.00	0.00	3.85
Feb	0.43	0.00	0.00	1.83
Mar	0.00	0.00	0.00	0.00
Apr	1.07	0.00	0.00	4.12
May	0.00	0.00	0.00	0.00
Jun	0.59	0.00	0.00	2.11
Jul	0.00	0.00	0.00	0.00
Aug	0.00	0.00	0.00	0.00
Sep	0.00	0.00	0.00	0.00
Oct	0.00	0.00	0.00	0.00
Nov	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00
Annual	**2.96**	**3.58**	**0.00**	**11.91**
Band Option 3				
Month	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Jan	0.44	0.00	0.00	2.18
Feb	0.22	0.00	0.00	1.04
Mar	0.00	0.00	0.00	0.00
Apr	0.54	0.00	0.00	2.33
May	0.00	0.00	0.00	0.00
Jun	0.30	0.00	0.00	1.20
Jul	0.00	0.00	0.00	0.00
Aug	0.00	0.00	0.00	0.00
Sep	0.00	0.00	0.00	0.00
Oct	0.00	0.00	0.00	0.00
Nov	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00
Annual	**1.49**	**1.80**	**0.00**	**6.74**

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

Band Option 2				
Month	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Jan	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00
Mar	0.74	0.00	0.00	3.01
Apr	0.00	0.00	0.00	0.00
May	0.69	0.00	0.00	2.54
Jun	0.83	0.00	0.00	2.95
Jul	1.45	0.00	0.00	5.27
Aug	0.66	0.00	0.00	2.48
Sep	0.00	0.00	0.00	0.00
Oct	0.00	0.00	0.00	0.00
Nov	0.51	0.00	0.00	2.24
Dec	0.00	0.00	0.00	0.00
Annual	**4.87**	**5.57**	**0.00**	**18.49**
Band Option 3				
Month	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Jan	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00
Mar	0.44	0.00	0.00	1.97
Apr	0.00	0.00	0.00	0.00
May	0.41	0.00	0.00	1.66
Jun	0.49	0.00	0.00	1.93
Jul	0.86	0.00	0.00	3.45
Aug	0.39	0.00	0.00	1.62
Sep	0.00	0.00	0.00	0.00
Oct	0.00	0.00	0.00	0.00
Nov	0.30	0.00	0.00	1.46
Dec	0.00	0.00	0.00	0.00
Annual	**2.89**	**3.30**	**0.00**	**12.10**

Appendix 4 Gannet Macro Avoidance Collision Risk Assessment

The latest guidance paper on avoidance rates of seabirds for collision risk modelling (Cook, 2021) proposed that assessment of gannet should take into account observed high levels of macro avoidance (APEM, 2014; Dierschke et al., 2016). The inclusion of gannet macro avoidance was discussed with the ETG and SNCBs provided written response suggesting that gannet macro avoidance, could be accounted for by reducing the density of birds inputted into collision risk modelling by 70% which is consistent with the mid-point displacement level which is currently advised (Table 3 of **Volume 2, Chapter 4: Offshore Ornithology (application ref: 6.2.4**). Revised monthly mean density estimates accounting for a reduction of 70% as advised 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)	0.00	0.00	0.00	0.04	0.02	0.03	0.26	0.08	0.19	0.17	0.02	0.00

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
0.00	0.00	0.00	0.27	0.13	0.30	2.29	0.66	1.33	1.08	0.08	0.00	**6.14**

When considering the inclusion of macro avoidance in the assessment of collision risk to gannet, the mean (Scenario 1) annual predicted collisions is six (6.14) gannets per annum. A monthly comparison between the monthly predicted collisions for Scenario 1 including and excluding consideration of macro avoidance is presented in **Figure 7**. The significant difference between the two scenarios in **Figure 7** highlights the current over precaution in assessment of gannet collision risk, due to macro avoidance not being accounted for.

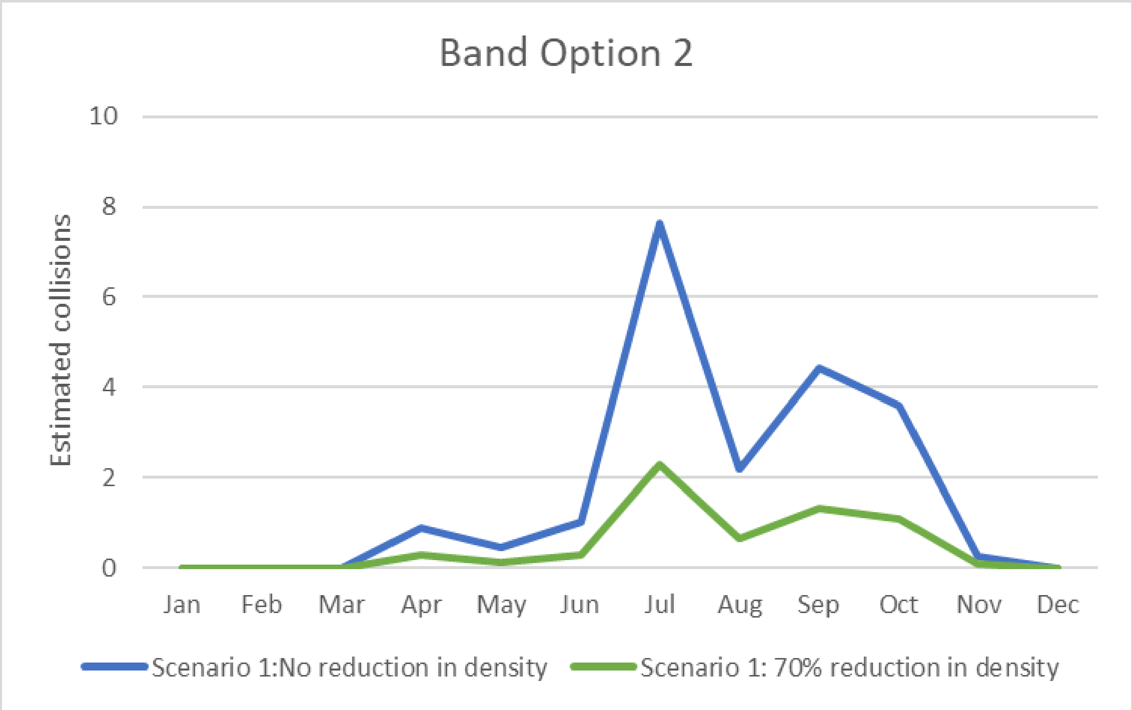

Figure 7 **Predicted monthly collision mortality for gannet (Band Option 2) including and excluding macro avoidance.**

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