Vattenfall Wind Power Ltd

Thanet Extension Offshore Wind Farm

Annex 4-4: Collision Risk Modelling Report

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Vattenfall Wind Power Ltd

Thanet Extension Offshore Wind Farm

Annex 4-4: Collision Risk Modelling Report

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Thanet Extension Environmental Statement

Volume 4, Chapter 4, Annex 4

Collision Risk Modelling Report

Vattenfall Wind Power Ltd

APEM Ref; P00001227-03

June 2018

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Revision and Amendment Register

Version Number	Date	Section(s)	Page(s)	Summary of Changes	Approved by
1.0	29/01/2018	All	All	Creation	LJ
1.1	19/03/2018	All	All	Amended to include all 24 months of bird survey data	LJ
1.2	04/04/2018	All	All	Review before client issue	SS
1.3	15/05/2018	All	All	Amends during ES Review process	SS
2.0	24/05/2018	All	All	Comments from client	JL
2.1	31/05/2018	All	All	Amends post client review FINAL VERSION	RB
2.2	05/06/2018	All	All	FINAL VERSION	SS

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1. Introduction

The main potential risks to birds from offshore wind farms are collision; disturbance or displacement; barrier to movement; and habitat change or loss. There is an increase in potential risk of collision with wind turbines if they are located in areas in which there is a high level of flight activity. That high level of flight activity can be associated with locations where food supplies are concentrated or with areas where there is a high turnover of individuals (possibly commuting daily between nesting and feeding areas or passing through the area on seasonal migrations). The potential collision risk can be estimated using collision risk modelling (CRM).

Collision risk modelling has been carried out for the proposed Thanet Extension Offshore Wind Farm (Thanet Extension) to provide information for five seabird species; gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull, using the Band (2012) collision risk Microsoft Excel spreadsheet that has been designed specifically for application to offshore wind farm developments.

Masden (2015) developed the Band (2012) model through the creation of the package 'BandModel' in the R statistical program (http://www.r-project.org). This was in response to feedback from stakeholder interviews that the Microsoft Excel version of the Band (2012) model was occasionally difficult to use and error-prone. The Masden (2015) version of the Band (2012) model required uncertainty to be accounted for in the form of Standard Deviations (SD) around input parameters, and applied a method of Monte Carlo simulation used by McAdam (2005) to allow for these. Previous advice from Statutory Nature Conservation Bodies (SNCBs) suggested that the Masden (2015) application of the Band (2012) model was the preferred method of collision risk assessment. As such, the collision risk modelling undertaken for the Thanet Extension Preliminary Environmental Information Report (PEIR) was based on this advice (APEM, 2017). However, following a review funded by Natural England of the Masden (2015) programme undertaken by MacArthur Green (Trinder, 2017), it was determined that a number of improvements were required before the 'BandModel' R package would be deemed as the agreed method for collision risk modelling for the basis of the assessment of collision mortality rates from proposed offshore wind farm developments.

Following the Trinder (2017) review, the advice from SNCBs was to revert to using the Band (2012) spreadsheet with an element of variation to coincide with the Band (2012) guidance (paragraph 14, page 7), which was previously overlooked in applications for offshore wind farm developments: "…*it is recommended that 'best estimates' are deployed, and with them an analysis of the uncertainty or variability surrounding each estimate and the range within which the collision risk can be assessed with confidence."* It was agreed that the variability in the input parameters for this report would relate to the density estimates of birds in flight and the generic SOSS-02 flight height distribution data (Johnston *et al.*, 2014).

Two Band CRM options (the technique and input parameters are explained in Section 2) were run for Thanet Extension and the outputs are presented in this report:

1. Basic Band CRM Option 2 with generic flight heights from the SOSS-02 flight height distribution data within Johnston *et al*., 2014; and
2. Basic Band CRM Option 1 with site-specific flight heights to determine the proportion of birds flying at potential collision height (PCH). The PCHs used for this modelling option were calculated from flight heights estimated from high-resolution aerial digital still imagery collected by APEM at the Thanet Offshore Wind Farm, the Thanet

Extension Offshore Wind Farm and a 4 km buffer surrounding it. These data were deemed unsuitable for impact assessment purposes. The results of these CRM outputs are presented in Appendix 7.

The outputs from Band CRM Option 2 are presented in this report with a range of avoidance rates, upper and lower confidence limits (CLs) of SOSS-02 flight height distribution data, and upper and lower CLs of density of birds in flight. The outputs from Band CRM Option 2 (with generic flight heights from the SOSS-02 flight height distribution data within Johnston *et al*., 2014) provide the mortality predictions for use in the assessment of potential collision risk for Thanet Extension that are presented in the Environmental Statement (Volume 2, Chapter 4: Offshore Ornithology (Document Ref 6.2.4)). The number of birds predicted to collide with the wind turbines per year are presented in Section 3 of this report.

A third data set was also received from the Offshore Renewables Joint Industry Programme (ORJIP) Bird Collision Avoidance Study conducted at Thanet Offshore Wind Farm. This data set was subject to review for its application in impact assessment. That review concluded that due to ongoing uncertainties in relation the most appropriate use of these data in association with other CRM parameters, such as avoidance rates, these data and use in the current Band CRM model was not considered further for impact assessment purposes.

A third Band CRM option, the Extended Band Option 3, which utilises the generic flight height distribution to calculate risk across the rotor swept area was considered in the PEIR (APEM, 2017). However, through consultation with Natural England, it was concluded that this option should not considered in the impact assessment of Thanet Extension, due to unresolved issues with the application of the data applied within it and the outcomes from it.

2. Methodology

The CRM methodology outlined by Band (2012) has been followed for the modelling and assessment of impacts predicted for the proposed Thanet Extension Offshore Wind Farm.

Basic Band CRM Option 2 (using the generic SOSS-02 flight height distribution data) CRM was carried out using the Basic Band model that applies a uniform distribution of bird flights between the lowest and the highest levels of the rotors. The proportion of birds flying between the lowest and the highest levels of the rotors (i.e. at PCH) was determined from the results of the SOSS-02 project (Cook *et al*., 2012) that analysed the flight height measurements taken from boat-based seabird surveys conducted around the UK. The model was updated following Johnston *et al.* (2014), and the revised published spreadsheet (filename: "Final_Report_SOSS02_FlightHeights2014") was used to determine the 'generic' percentage of flights at PCH and associated upper and lower CLs for each species based on the proposed project's wind turbine parameters.

The parameters used in the Band CRM are presented in Sections 2.1 to 2.6. Five species were used in the collision risk modelling: gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull. Fulmar was excluded because too few individuals were recorded in Thanet Extension to warrant further assessment (see APEM, 2018). The selection of these species for the focus of collision risk assessment for the Thanet Extension ES Chapter was agreed with Natural England and RSPB through the evidence plan process (See APEM, 2018, Section 4.3).

2.1 Avoidance Rates

The species-specific avoidance rates that were applied in the modelling are presented in Table 1. The avoidance rates that have been selected for use in the CRM follow the guidance from Cook *et al.* (2014) and the SNCBs review of avoidance rates to be applied in the Band models (JNCC *et al*., 2014 in response to Cook *et al.,* 2014).

Table 1 **Band CRM Option 2 with associated avoidance rates for Thanet Extension for five species: gannet, kittiwake, lesser black-backed gull, herring gull, and great black-backed gull**

Species	Band Option 2 Avoidance Rate (± SD)
Gannet	0.989 ± 0.002
Kittiwake	0.989 ± 0.002
Lesser black-backed gull	0.995 ± 0.001
Herring gull	0.995 ± 0.001
Great black-backed gull	0.995 ± 0.001

2.2 Species Biometrics

The species-specific biometric input parameters used in the CRM are provided in Table 2.

Table 2 Species biometrics used in the collision risk modelling of the proposed Thanet Extension for five species: gannet, kittiwake, lesser black-backed gull, herring gull, and great black-backed gull

Species	Body Length (m)	Wingspan (m)	Flight Speed (ms^{-1})	Nocturnal Activity	Flight Type
Gannet	0.94 [1]	1.72 [1]	14.9 [3]	1 [4] - 2 [5]	Gliding
Kittiwake	0.39 [1]	1.08 [1]	13.1 [2]	2 [4] - 3 [5]	Flapping
Lesser black-backed gull	0.58 [1]	1.42 [1]	13.1 [3]	2 [4] - 3 [5]	Flapping
Herring gull	0.60 [1]	1.44 [1]	12.8 [3]	2 [4] - 3 [5]	Flapping
Great black-backed gull	0.71 [1]	1.58 [1]	13.7 [3]	2 [4] - 3 [5]	Flapping

[1] Robinson (2005)
[2] Pennycuick (1997)
[3] Alerstam *et al.* (2007)
[4] MacArthur Green (2018, in prep)
[5] Garthe & Hüppop (2004)

The body length and wingspan of the five key seabirds included in the collision risk modelling were derived from Robinson (2005).

Flight speeds and associated standard deviations for lesser black-backed gull, herring gull, and great black-backed gull were derived from Alerstam *et al.* (2007). The flight speeds for gannet and kittiwake were derived from Pennycuick (1997).

The nocturnal activity rate was based on a 1 to 5 scoring index for each species in Garthe and Hüppop (2004) or King *et al.* (2009), with the spreadsheet converting these factors into nocturnal activity as follows; 1 = 0%, 2 = 25%, 3 = 50%, 4 = 75%, 5 = 100%. It is considered that these nocturnal activity figures are precautionary (MacArthur Green, APEM & Royal HaskoningDHV, 2015). As such, the potential mortality estimates provided in Section 3 Results are based on the reduced nocturnal activity factors (Table 2). These reduced nocturnal activity figures have been based on a review undertaken by MacArthur Green (MacArthur Green, 2015: Appendix 7) for the East Anglia THREE application of a series of seabird research studies that used activity data loggers attached to seabirds which found that the nocturnal activity recorded was much lower than the values derived from Garthe & Hüppop (2004). The potential mortality estimates based on the higher nocturnal activity factors have been provided in Appendix 6. The number of available daylight hours is calculated within the Band (2012) CRM spreadsheet based on the latitude of the wind farm development.

2.3 Proportion at Potential Collision Risk Height

The proportion of individuals at potential collision risk height (PCH) was obtained from the SOSS-02 flight height data for all five species (Table 3), which provides generic PCHs and associated lower and upper CLs.

To determine the proportion at potential collision risk height for all five species the data source used the number of individuals in flight recorded between 22 and 202 m, which are considered the worst case scenario rotor swept area for Thanet Extension.

Table 3 **Proportion (%) at potential collision risk height (PCH) used in the Band CRM Option 2 of the proposed Thanet Extension Offshore Wind Farm using data with maximum likelihood with 95% lower and upper CLs from SOSS-02**

Species	Generic SOSS-02 PCH (%)
Gannet	10.22 [4.66, 17.25]
Kittiwake	12.36 [9.33, 14.72]
Lesser black-backed gull	24.85 [17.14, 40.84]
Herring gull	28.53 [21.61, 39.91]
Great black-backed gull	29.12 [24.69, 41.75]

The method of summing the bands of the upper and lower CLs for the generic Johnston *et al.* (2014) flight height distribution data should be taken with caution, as SMart Wind (2015) noted for the Hornsea Project Two application:

"*Whilst the Applicant has, as requested by Natural England, included these CLs in revised modelling, they do not have confidence that their use within the Band (2012) CRM is appropriate. The Johnston et al. (2014) data is presented in one metre bands between 0-300 m. When considered in isolation these bands represent the proportion of birds from a population that may occur within that flight band with a 95% CL. However, it may not be considered appropriate to simply sum the bands that are presented in the Johnston et al. (2014) supplementary material, as the CLs associated with each band are independent of the CLs associated with other bands within the flight height distribution. If the CLs are summed, the proportion of birds at PCH is artificially increased or decreased by changing the total population of birds in flight within the wind farm and not by altering the proportions within the flight height distribution*."

2.4 Density of Birds in Flight

Design-based abundance and density estimates with associated 95% CLs were determined for Thanet Extension using data collected from aerial digital surveys (see APEM, 2018). For the five species of key seabirds, the CRM is based on the mean density of flying birds per month (Table 4). These data derived from the 24 months of aerial digital surveys carried out between March 2016 and February 2018 inclusive (APEM, 2018). The mean lower and upper 95% CLs for birds in flight were used as a measure of variability for the flying densities (Table 4).

Table 4 **Monthly value for the mean density, with associated lower and upper confidence limits presented in square brackets, of flying birds used in the CRM of the**

proposed Thanet Extension for five species: gannet, kittiwake, lesser black-backed gull, herring gull, and great black-backed gull

Month	Gannet	Kittiwake	LBB Gull	H Gull	GBB Gull
Jan	0.68 [0.25,1.24]	0.49 [0.19,0.91]	0 [0,0]	0 [0,0]	0.37 [0.07,0.07]
Feb	0.19 [0.02,0.57]	0.76 [0.27,1.38]	0 [0,0]	0 [0,0]	0.38 [0.07,0.07]
Mar	0.83 [0.39,1.40]	0.22 [0.03,0.49]	0.06 [0.01,0.16]	0 [0,0]	0.12 [0.01,0.36]
Apr	0 [0,0]	0.13 [0.01,0.32]	0 [0,0]	0.51 [0.08,1.02]	0 [0,0]
May	0 [0,0]	0.13 [0.01,0.32]	0.06 [0.01,0.19]	0.06 [0.01,0.19]	0.06 [0.01,0.19]
Jun	0 [0,0]	0 [0,0]	0.06 [0.01,0.16]	0.06 [0.01,0.19]	0 [0,0]
Jul	0 [0,0]	0.06 [0.01,0.19]	0.06 [0.01,0.17]	0.18 [0.02,0.47]	0.06 [0.01,0.23]
Aug	0 [0,0]	0 [0,0]	0 [0,0]	0.06 [0.01,0.17]	0 [0,0]
Sep	0 [0,0]	0.13 [0.01,0.38]	0 [0,0]	0 [0,0]	0.13 [0.01,0.37]
Oct	0 [0,0]	0 [0,0]	0 [0,0]	0 [0,0]	0.76 [0.08,2.16]
Nov	1.00 [0.32,1.92]	0.06 [0.01,0.19]	0.06 [0.01,0.24]	0 [0,0]	0.18 [0.02,0.42]
Dec	0.06 [0.01,0.19]	0.38 [0.04,0.88]	0 [0,0]	0.74 [0.13,1.72]	0.44 [0.08,0.94]

2.5 Turbine Parameters

The determination of the rotor strike probability for each species is calculated within the Band (2012) CRM spreadsheet based on each species flying in a straight line along the longest length of the wind farm. It incorporates the calculation of rotor strike probability for both upwind and downwind flights and the associated change in mortality risks. Input parameters for the wind turbine specifications used within the CRM are shown in Table 5 and Table 6.

Table 5 Wind turbine specification for the proposed Thanet Extension

Input Parameter (units in brackets)	Value	Source
Turbine Model (MW)	10	Provided by Vattenfall
Target Power (MW)	340	Provided by Vattenfall
No. of Blades	3	Provided by Vattenfall
Rotor Radius (m)	90	Provided by Vattenfall
Hub Height (m)	114.87	Value for Highest Astronomical Tide (HAT) and Mean Sea Level (MSL) provided by Vattenfall UK and the difference applied to the hub height value of 112 m (see Tidal Offset)
Max. Blade Width (m)	8	Provided by Vattenfall
Tidal Offset (m)	0	No tidal offset due to all parameters being measured against mean sea level
Wind Farm Width (km)	14.252128	Figure 1
Latitude (degrees)	51.430436	Centroid of Thanet Extension, Figure 1
Rotation speed (rpm)	9	Provided by Vattenfall
Large Array Correction	Yes	Standard procedure
Pitch (º)	15	Provided by Vattenfall

Wind farm width was calculated using the longest distance across the wind farm which is worst case as this maximises the amount of time a bird could spend in the wind farm (Figure 1). The latitude was calculated from the shapefile provided by Vattenfall Wind Power UK (Vattenfall) and represents the centroid (Figure 1).

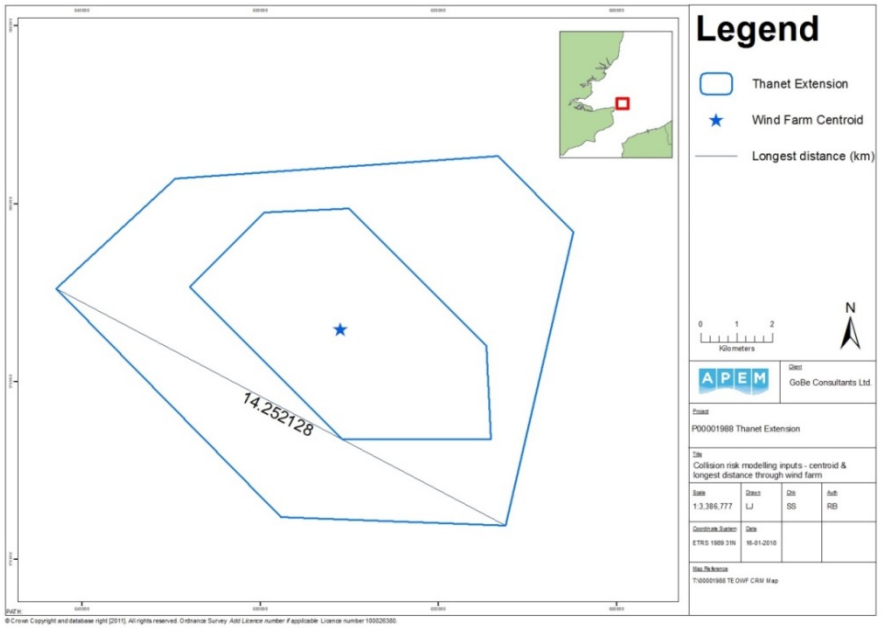

Figure 1 **Thanet Extension Offshore Wind Farm (the hexagonal centre is the operational Thanet Offshore Wind Farm). The star denotes the wind farm centroid and the line used to estimate the longest distance through the wind farm.**

The theoretical maximum operational times for the proposed Thanet Extension's wind turbines represent a worst case scenario. Wind availability, taking into account down time of the turbines due to wind speed being less than 3 ms^{-1} and greater than 25 ms^{-1} on a monthly basis from the years 2015 and 2016 was provided by Vattenfall. A mean was calculated from these values (Table 6). The worst case scenario for turbine maintenance is that the turbines are off due to the wind speed being outside of operational parameters. In reality, the down time is likely to be approximately 3-4% and approximately half when the turbines are down due to wind speed.

Table 6 **Theoretical operational time of the proposed Thanet Extension turbines**

Month	Monthly Proportion of Time Operational (%)
January	96.0
February	91.5
March	95.0
April	93.5
May	86.5
June	88.5
July	91.0
August	91.0
September	91.5
October	89.5
November	95.5
December	94.5

3. Results

This section provides a summary of the CRM outputs. For each species the following outputs are presented:

- CRM outputs for Band CRM Option 2 using best estimate and upper and lower CLs around the densities of birds in flight;
- CRM outputs for Option 2 using maximum likelihood, upper and lower CLs for the generic flight height data;
- Figure of Option 2 using CLs around the birds in flight density data; and
- Figure of Option 2 using the CLs around the generic flight height data.

3.1 Gannet

Table 7 presents the annual collision rates for gannet using Band CRM Option 2 incorporating the best estimate and 95% CLs for density data collected within Thanet Extension. Table 8 presents annual collision rates for gannet incorporating the maximum likelihood flight height distribution and associated 95% CL flight height distributions.

Monthly collision rates calculated using best estimate density data and associated 95% CLs are presented in Figure 2.

Monthly collision rates calculated using best estimate density data with associated 95% CLs for flight height distribution data (Band Model Option 2, 98.9% AR) are presented in Figure 3.

Appendix 1 details the monthly CRM outputs for gannet.

Table 7 **Annual predicted gannet collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	5
Best Estimate	14
Upper CL	26

Table 8 **Annual predicted gannet collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around generic flight height distribution data**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	6
Best Estimate	**14**
Upper CL	25

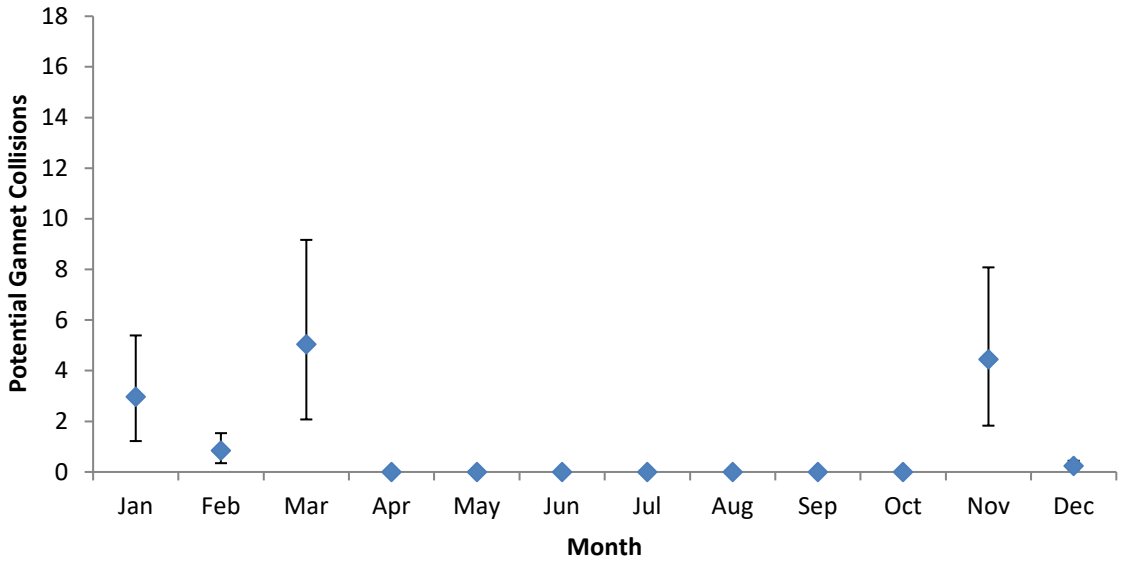

Figure 2 **Monthly predicted gannet collision rates for Band Option 2 with associated 95% CLs for density data**

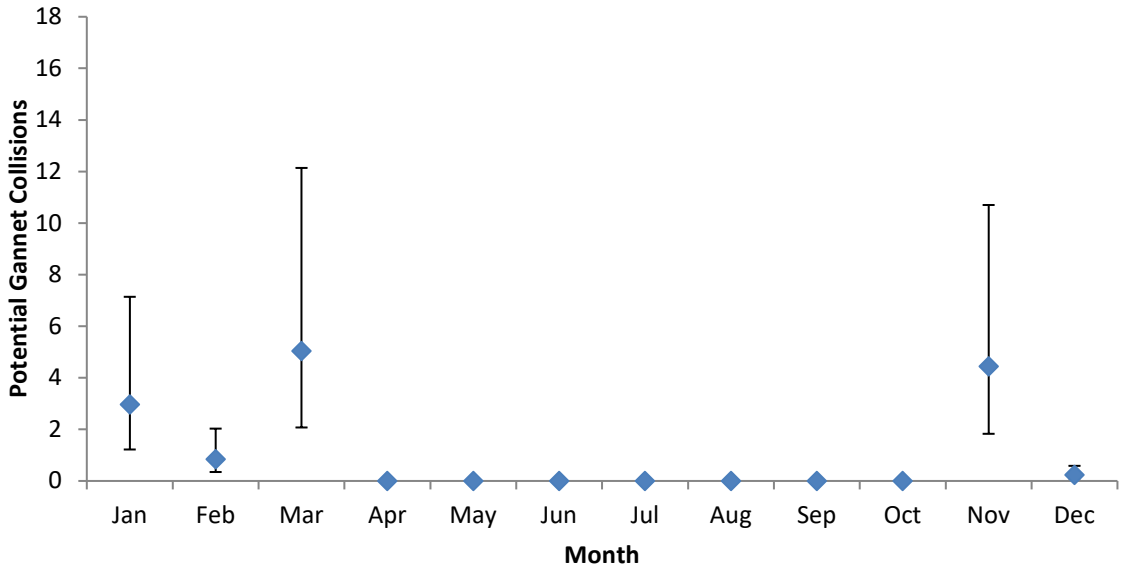

Figure 3 **Monthly predicted gannet collision rates (Band Option 2, 98.9% AR) with associated 95% CLs for flight height distribution data**

3.2 Kittiwake

Table 9 presents the annual collision rates for kittiwake using Band CRM Option 2 incorporating the best estimate and 95% CLs for density data collected within Thanet Extension. Table 10 presents annual collision rates for kittiwake incorporating the maximum likelihood flight height distribution and associated 95% CL flight height distributions.

Monthly collision rates calculated using best estimate density data and associated 95% CLs are presented in Figure 4

Monthly collision rates calculated using best estimate density data with associated 95% CLs for flight height distribution data (Band Model Option 2, 98.9% AR) are presented in Figure 5.

Appendix 2 details the monthly CRM outputs for kittiwake.

Table 9 **Annual predicted kittiwake collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	4
Best Estimate	**15**
Upper CL	32

Table 10 **Annual predicted kittiwake collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around generic flight height distribution data**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	11
Best Estimate	**15**
Upper CL	18

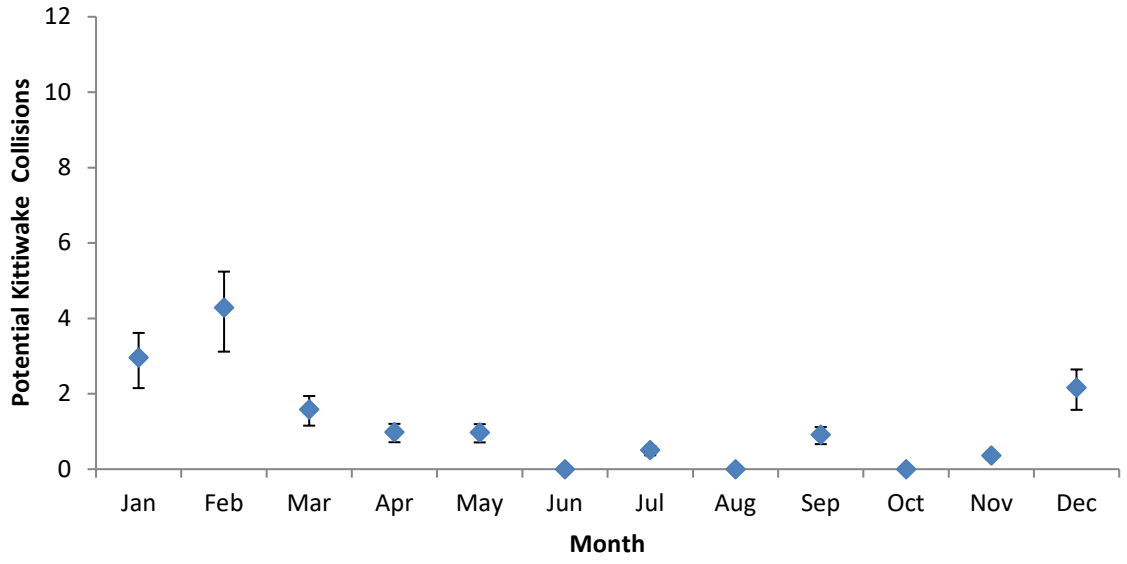

Figure 4 **Monthly predicted kittiwake collision rates for Band Option 2 with associated 95% CLs for density data**

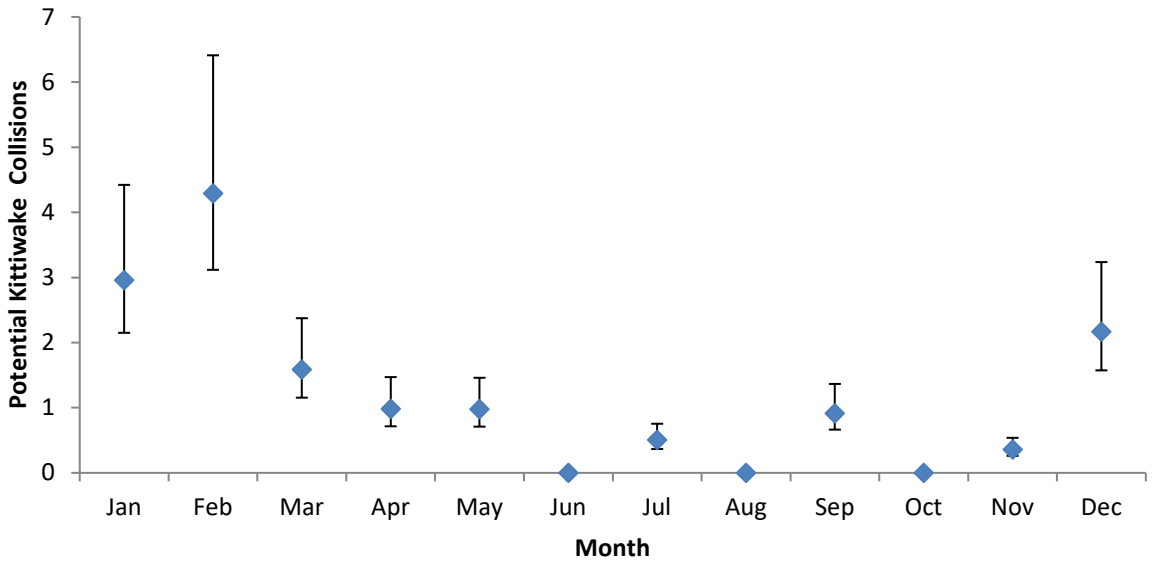

Figure 5 **Monthly predicted kittiwake collision rates (Band Option 2, 98.9% AR) with associated 95% CLs for flight height distribution data**

3.3 Lesser black-backed gull

Table 11 presents the annual collision rates for lesser black-backed gull using Band CRM Option 2 incorporating the best estimate and 95% CLs for density data collected within Thanet Extension. Table 12 presents annual collision rates for lesser black-backed gull incorporating the maximum likelihood flight height distribution and associated 95% CL flight height distributions.

Monthly collision rates calculated using best estimate density data and associated 95% CLs are presented in Figure 6.

Monthly collision rates calculated using best estimate density data with associated 95% CLs for flight height distribution data (Band Model Option 2, 99.5% AR) are presented in Figure 7.

Appendix 3 details the monthly CRM outputs for lesser black-backed gull.

Table 11 **Annual predicted lesser black-backed gull collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	0
Best Estimate	**2**
Upper CL	8

Table 12 **Annual predicted lesser black-backed gull collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around generic flight height distribution data**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	2
Best Estimate	**2**
Upper CL	4

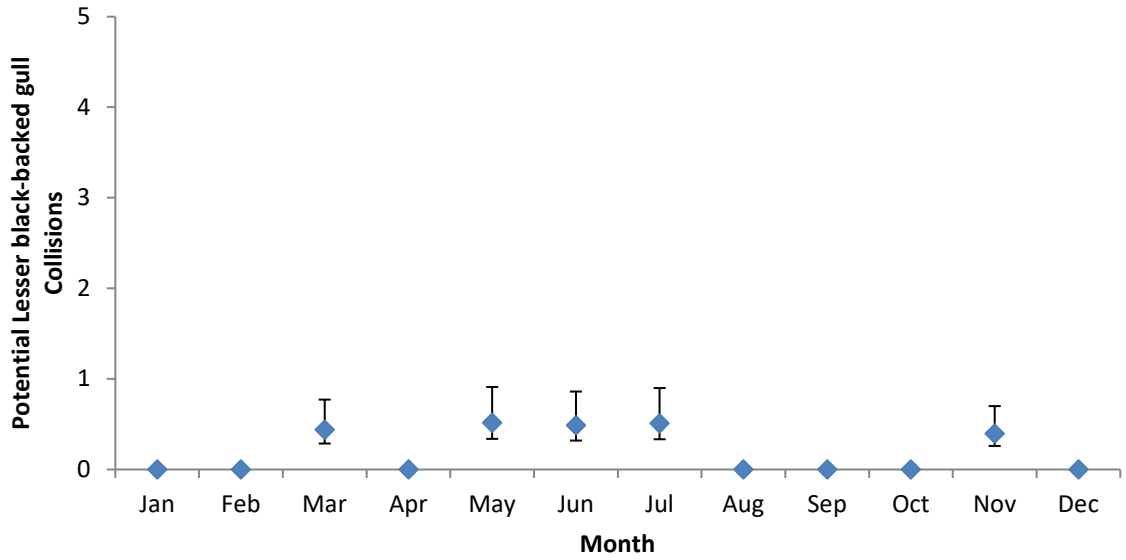

Figure 6 **Monthly predicted lesser black-backed gull collision rates for Band Option 2 with associated 95% CLs for density data**

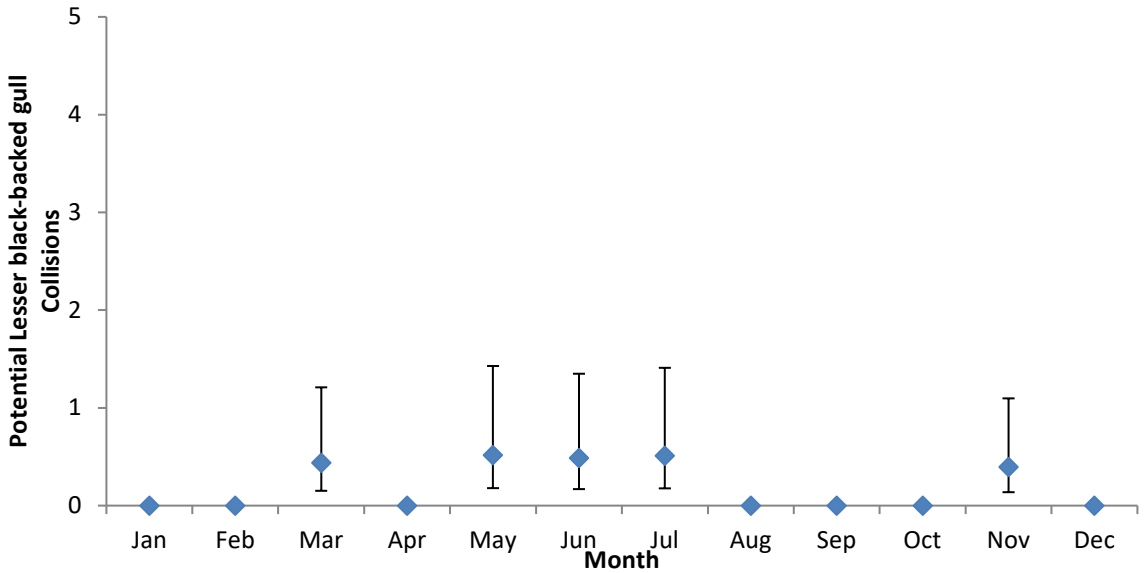

Figure 7 **Monthly predicted lesser black-backed gull collision rates (Band Option 2, 98.9% AR) with associated 95% CLs for flight height distribution data**

3.4 Herring gull

Table 13 presents the annual collision rates for herring gull using Band CRM Option 2 incorporating the best estimate and 95% CLs for density data collected within Thanet Extension. Table 14 presents annual collision rates for herring gull incorporating the maximum likelihood flight height distribution and associated 95% CL flight height distributions.

Monthly collision rates calculated using best estimate density data and associated 95% CLs are presented in Figure 8 .

Monthly collision rates calculated using best estimate density data with associated 95% CLs for flight height distribution data (Band Model Option 2, 99.5% AR) are presented in Figure 9.

Appendix 4 details the monthly CRM outputs for herring gull.

Table 13 **Annual predicted herring gull collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	2
Best Estimate	**14**
Upper CL	33

Table 14 **Annual predicted herring gull collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around generic flight height distribution data**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	10
Best Estimate	**14**
Upper CL	21

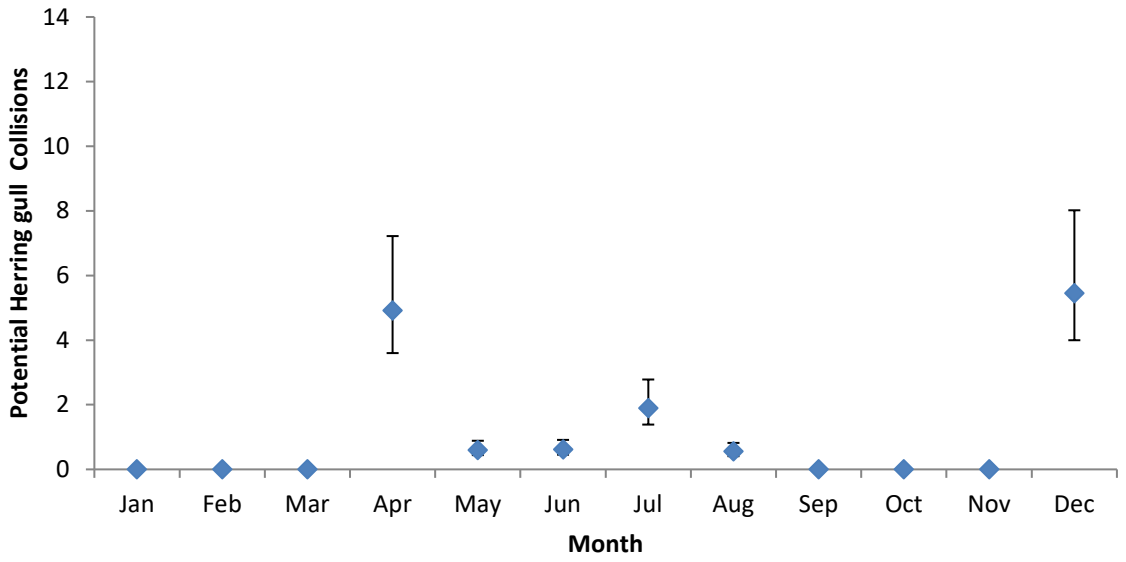

Figure 8 **Monthly predicted herring gull collision rates for Band Option 2 with associated 95% CLs for density data**

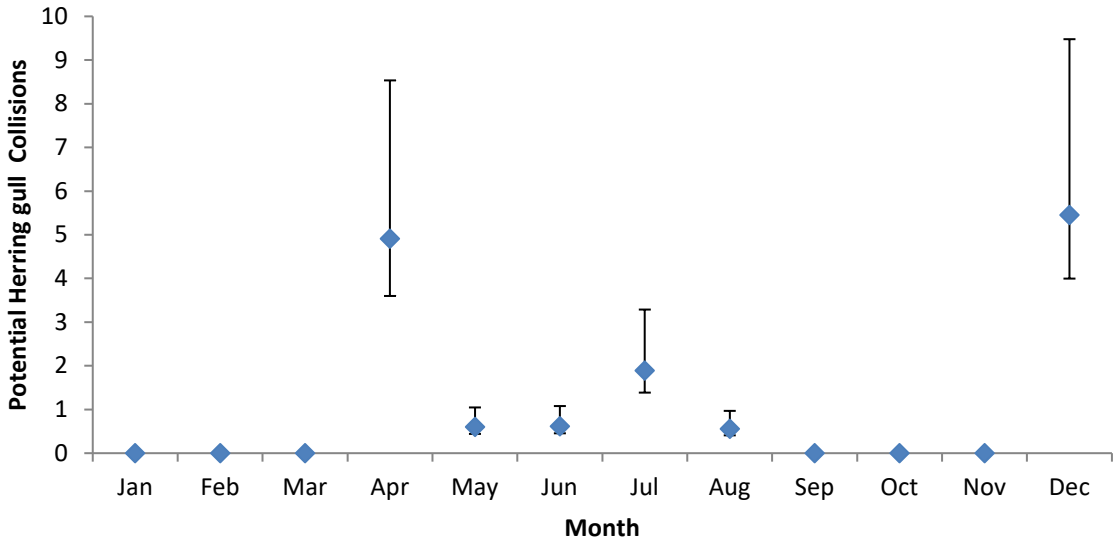

Figure 9 **Monthly predicted herring gull collision rates (Band Option 2, 98.9% AR) with associated 95% CLs for flight height distribution data**

3.5 Great black-backed gull

Table 15 presents the annual collision rates for great black-backed gull using Band CRM Option 2 incorporating the best estimate and 95% CLs for density data collected within Thanet Extension. Table 16 presents annual collision rates for great black-backed gull incorporating the maximum likelihood flight height distribution and associated 95% CL flight height distributions.

Monthly collision rates calculated using best estimate density data and associated 95% CLs are presented in Figure 10.

Monthly collision rates calculated using best estimate density data with associated 95% CLs for flight height distribution data (Band Model Option 2, 99.5% AR) are presented in Figure 11.

Appendix 5 details the monthly CRM outputs for great black-backed gull.

Table 15 **Annual predicted great black-backed gull collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	3
Best Estimate	**22**
Upper CL	57

Table 16 **Annual predicted great black-backed gull collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around generic flight height distribution data**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	18
Best Estimate	**22**
Upper CL	33

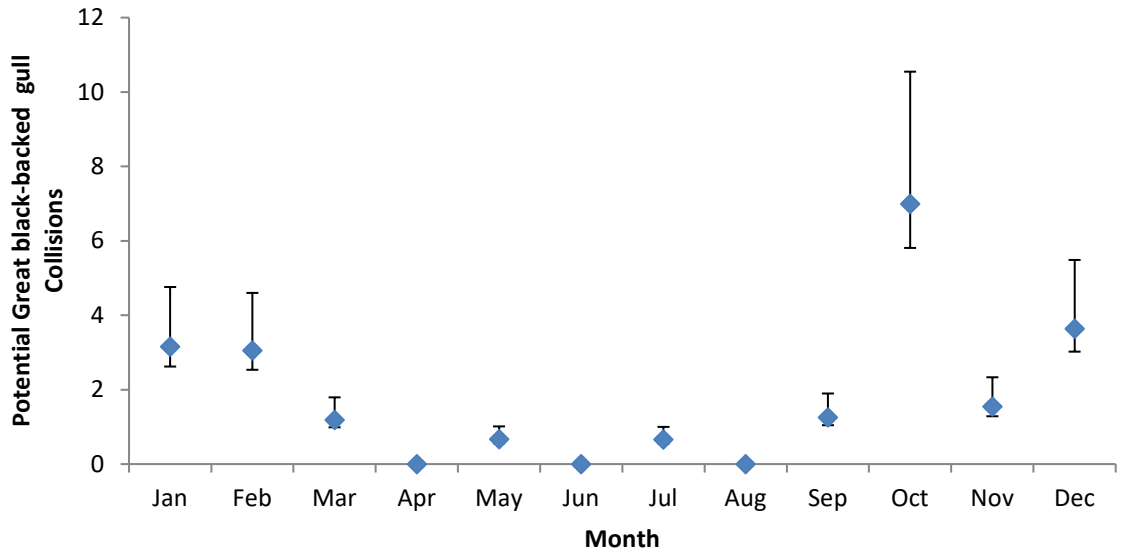

Figure 10 **Monthly predicted great black-backed gull collision rates for Band Option 2 with associated 95% CLs for density data**

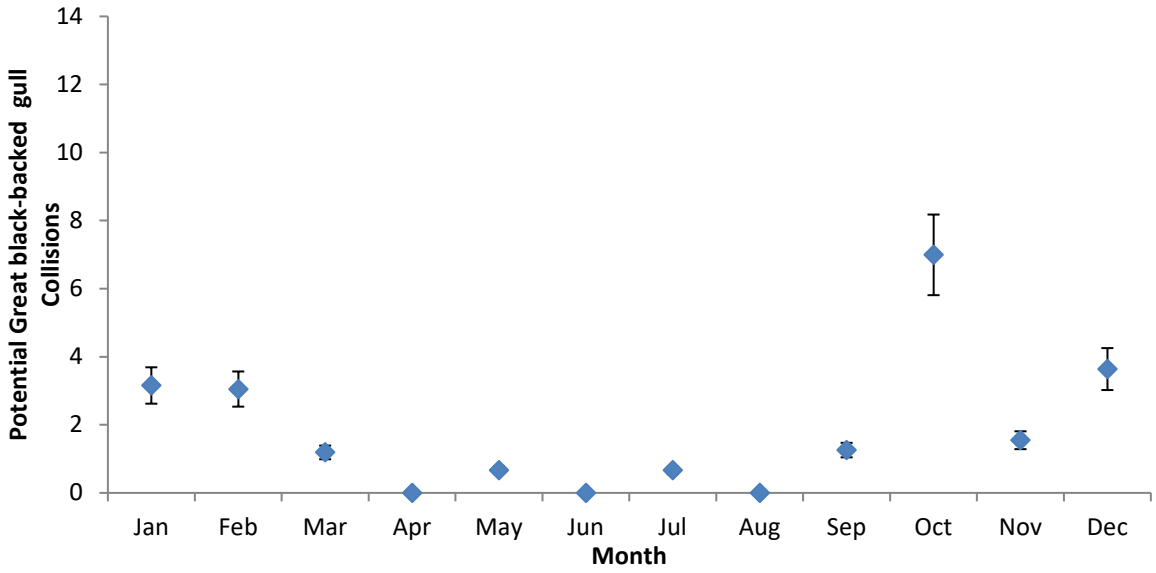

Figure 11 **Monthly predicted great black-backed gull collision rates (Band Option 2, 98.9% AR) with associated 95% CLs for flight height distribution data**

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Appendix 1 – Gannet monthly collision rates

Table 17 **Monthly and annual gannet collision risk estimates using mean lower CL density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Lower CL Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	1	0	1	0	0	0	0	0	0	0	1	0	2
98.9	0	0	1	0	0	0	0	0	0	0	1	0	2
99.1	0	0	1	0	0	0	0	0	0	0	0	0	2
BO2 - Mean Lower CL Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	1	0	3	0	0	0	0	0	0	0	2	0	6
98.9	1	0	2	0	0	0	0	0	0	0	1	0	5
99.1	1	0	2	0	0	0	0	0	0	0	1	0	4
BO2 - Mean Lower CL Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	2	0	5	0	0	0	0	0	0	0	3	0	11
98.9	2	0	4	0	0	0	0	0	0	0	3	0	9
99.1	2	0	4	0	0	0	0	0	0	0	2	0	7

Table 18 **Monthly and annual gannet collision risk estimates using mean density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	1	0	2	0	0	0	0	0	0	0	2	0	7
98.9	1	0	2	0	0	0	0	0	0	0	2	0	6
99.1	1	0	2	0	0	0	0	0	0	0	1	0	5
BO2 - Mean Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	4	1	6	0	0	0	0	0	0	0	5	0	16
98.9	3	1	5	0	0	0	0	0	0	0	4	0	14
99.1	2	1	4	0	0	0	0	0	0	0	4	0	11
BO2 - Mean Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	6	2	11	0	0	0	0	0	0	0	10	1	29
98.9	5	2	9	0	0	0	0	0	0	0	8	0	25
99.1	4	1	7	0	0	0	0	0	0	0	7	0	20

Table 19 **Monthly and annual gannet collision risk estimates using mean upper CL density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Upper CL Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	3	1	4	0	0	0	0	0	0	0	4	0	13
98.9	2	1	3	0	0	0	0	0	0	0	4	0	11
99.1	2	1	3	0	0	0	0	0	0	0	3	0	9
BO2 - Mean Upper CL Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	6	3	10	0	0	0	0	0	0	0	10	1	30
98.9	5	3	9	0	0	0	0	0	0	0	9	1	26
99.1	4	2	7	0	0	0	0	0	0	0	7	1	21
BO2 - Mean Upper CL Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	12	5	18	0	0	0	0	0	0	0	18	2	55
98.9	10	5	15	0	0	0	0	0	0	0	16	1	47
99.1	8	4	13	0	0	0	0	0	0	0	13	1	38

Appendix 2 – Kittiwake monthly collision rates

Table 20 **Monthly and annual kittiwake collision risk estimates using mean lower CL density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Lower CL Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	1	1	0	0	0	0	0	0	0	0	0	0	3
98.9	1	1	0	0	0	0	0	0	0	0	0	0	3
99.1	1	1	0	0	0	0	0	0	0	0	0	0	2
BO2 - Mean Lower CL Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	1	2	0	0	0	0	0	0	0	0	0	0	4
98.9	1	2	0	0	0	0	0	0	0	0	0	0	4
99.1	1	1	0	0	0	0	0	0	0	0	0	0	3
BO2 - Mean Lower CL Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	2	2	0	0	0	0	0	0	0	0	0	0	5
98.9	1	2	0	0	0	0	0	0	0	0	0	0	4
99.1	1	2	0	0	0	0	0	0	0	0	0	0	4

Table 21 **Monthly and annual kittiwake collision risk estimates using mean density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	3	4	1	1	1	0	0	0	1	0	0	2	13
98.9	2	3	1	1	1	0	0	0	1	0	0	2	11
99.1	2	3	1	1	1	0	0	0	1	0	0	1	9
BO2 - Mean Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	3	5	2	1	1	0	1	0	1	0	0	3	17
98.9	3	4	2	1	1	0	1	0	1	0	0	2	15
99.1	2	4	1	1	1	0	0	0	1	0	0	2	12
BO2 - Mean Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	4	6	2	1	1	0	1	0	1	0	1	3	21
98.9	4	5	2	1	1	0	1	0	1	0	0	3	18
99.1	3	4	2	1	1	0	1	0	1	0	0	2	15

Table 22 **Monthly and annual kittiwake collision risk estimates using mean upper CL density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Upper CL Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	5	7	3	2	2	0	1	0	2	0	1	4	28
98.9	4	6	3	2	2	0	1	0	2	0	1	4	23
99.1	3	5	2	1	1	0	1	0	2	0	1	3	19
BO2 - Mean Upper CL Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	7	9	4	3	3	0	2	0	3	0	1	6	38
98.9	6	8	4	2	2	0	2	0	3	0	1	5	32
99.1	5	6	3	2	2	0	1	0	2	0	1	4	26
BO2 - Mean Upper CL Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	8	11	5	3	4	0	2	0	4	0	2	7	47
98.9	7	10	4	3	3	0	2	0	3	0	1	6	39
99.1	6	8	4	2	2	0	2	0	3	0	1	5	32

Appendix 3 – Lesser black-backed gull monthly collision rates

Table 23 **Monthly and annual lesser black-backed gull collision risk estimates using mean lower CL density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Lower CL Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	0	0	0	0	0	0	0	0	0	0
99.5	0	0	0	0	0	0	0	0	0	0	0	0	0
99.6	0	0	0	0	0	0	0	0	0	0	0	0	0
BO2 - Mean Lower CL Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	0	0	0	0	0	0	0	0	0	0
99.5	0	0	0	0	0	0	0	0	0	0	0	0	0
99.6	0	0	0	0	0	0	0	0	0	0	0	0	0
BO2 - Mean Lower CL Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	0	0	0	0	0	0	0	0	0	1
99.5	0	0	0	0	0	0	0	0	0	0	0	0	1
99.6	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 24 **Monthly and annual lesser black-backed gull collision risk estimates using mean density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	0	0	0	0	0	0	0	0	0	2
99.5	0	0	0	0	0	0	0	0	0	0	0	0	2
99.6	0	0	0	0	0	0	0	0	0	0	0	0	1
BO2 - Mean Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	1	0	1	1	1	0	0	0	0	0	3
99.5	0	0	0	0	1	0	1	0	0	0	0	0	2
99.6	0	0	0	0	0	0	0	0	0	0	0	0	2
BO2 - Mean Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	1	0	1	1	1	0	0	0	1	0	5
99.5	0	0	1	0	1	1	1	0	0	0	1	0	4
99.6	0	0	1	0	1	1	1	0	0	0	1	0	3

Table 25 **Monthly and annual lesser black-backed gull collision risk estimates using mean upper CL density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Upper CL Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	1	0	1	1	1	0	0	0	1	0	6
99.5	0	0	1	0	1	1	1	0	0	0	1	0	5
99.6	0	0	1	0	1	1	1	0	0	0	1	0	4
BO2 - Mean Upper CL Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	2	0	2	2	2	0	0	0	2	0	9
99.5	0	0	1	0	2	1	2	0	0	0	2	0	8
99.6	0	0	1	0	1	1	1	0	0	0	1	0	6
BO2 - Mean Upper CL Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	3	0	4	3	3	0	0	0	3	0	16
99.5	0	0	2	0	3	3	3	0	0	0	3	0	13
99.6	0	0	2	0	2	2	2	0	0	0	2	0	11

Appendix 4 – Herring gull monthly collision rates

Table 26 **Monthly and annual herring gull collision risk estimates using mean lower CL density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Lower CL Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	1	0	0	0	0	0	0	0	1	2
99.5	0	0	0	1	0	0	0	0	0	0	0	1	2
99.6	0	0	0	0	0	0	0	0	0	0	0	1	1
BO2 - Mean Lower CL Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	1	0	0	0	0	0	0	0	1	3
99.5	0	0	0	1	0	0	0	0	0	0	0	1	2
99.6	0	0	0	1	0	0	0	0	0	0	0	1	2
BO2 - Mean Lower CL Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	1	0	0	0	0	0	0	0	2	4
99.5	0	0	0	1	0	0	0	0	0	0	0	1	3
99.6	0	0	0	1	0	0	0	0	0	0	0	1	3

Table 27 **Monthly and annual herring gull collision risk estimates using mean density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	4	1	1	2	0	0	0	0	5	12
99.5	0	0	0	4	0	0	1	0	0	0	0	4	10
99.6	0	0	0	3	0	0	1	0	0	0	0	3	8
BO2 - Mean Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	6	1	1	2	1	0	0	0	7	17
99.5	0	0	0	5	1	1	2	1	0	0	0	5	14
99.6	0	0	0	4	0	0	2	0	0	0	0	4	11
BO2 - Mean Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	9	1	1	3	1	0	0	0	10	25
99.5	0	0	0	7	1	1	3	1	0	0	0	8	21
99.6	0	0	0	6	1	1	2	1	0	0	0	6	17

Table 28 **Monthly and annual herring gull collision risk estimates using mean upper CL density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Upper CL Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	7	3	2	2	0	1	0	2	0	1	4	28
99.5	0	6	3	2	2	0	1	0	2	0	1	4	23
99.6	0	5	2	1	1	0	1	0	2	0	1	3	19
BO2 - Mean Upper CL Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	12	2	2	6	2	0	0	0	15	40
99.5	0	0	0	10	2	2	5	2	0	0	0	13	33
99.6	0	0	0	8	2	2	4	1	0	0	0	10	27
BO2 - Mean Upper CL Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	17	3	4	9	3	0	0	0	23	59
99.5	0	0	0	15	3	3	8	3	0	0	0	19	49
99.6	0	0	0	12	2	2	6	2	0	0	0	15	39

Appendix 5 – Great black-backed gull monthly collision rates

Table 29 **Monthly and annual great black-backed gull collision risk estimates using mean lower CL density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Lower CL Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	1	1	0	0	0	0	0	0	0	1	0	1	3
99.5	0	0	0	0	0	0	0	0	0	1	0	1	3
99.6	0	0	0	0	0	0	0	0	0	1	0	0	2
BO2 - Mean Lower CL Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	1	1	0	0	0	0	0	0	0	1	0	1	4
99.5	1	1	0	0	0	0	0	0	0	1	0	1	3
99.6	0	0	0	0	0	0	0	0	0	1	0	0	3
BO2 - Mean Lower CL Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	1	1	0	0	0	0	0	0	0	1	0	1	6
99.5	1	1	0	0	0	0	0	0	0	1	0	1	5
99.6	1	1	0	0	0	0	0	0	0	1	0	1	4

Table 30 **Monthly and annual great black-backed gull collision risk estimates using mean density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	3	3	1	0	1	0	1	0	1	7	2	4	22
99.5	3	3	1	0	1	0	1	0	1	6	1	3	18
99.6	2	2	1	0	0	0	0	0	1	5	1	2	15
BO2 - Mean Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	4	4	1	0	1	0	1	0	2	8	2	4	27
99.5	3	3	1	0	1	0	1	0	1	7	2	4	22
99.6	3	2	1	0	1	0	1	0	1	6	1	3	18
BO2 - Mean Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	6	6	2	0	1	0	1	0	2	13	3	7	40
99.5	5	5	2	0	1	0	1	0	2	11	2	5	33
99.6	4	4	1	0	1	0	1	0	2	8	2	4	27

Table 31 **Monthly and annual great black-backed gull collision risk estimates using mean upper CL density with generic flight height distribution and associated upper and lower CLs**

BO2 - Mean Upper CL Density - Lower SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	7	6	4	0	2	0	3	0	4	20	4	8	57
99.5	6	5	3	0	2	0	2	0	3	17	3	6	47
99.6	5	4	2	0	1	0	2	0	2	13	2	5	38
BO2 - Mean Upper CL Density - Maximum Likelihood SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	9	7	4	0	3	0	3	0	4	24	4	9	69
99.5	7	6	4	0	2	0	3	0	4	20	4	8	57
99.6	6	5	3	0	2	0	2	0	3	16	3	6	46
BO2 - Mean Upper CL Density - Upper SOSS-02 CL													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	13	11	7	0	4	0	5	0	7	36	7	14	103
99.5	11	9	6	0	3	0	4	0	6	30	5	12	86
99.6	9	7	4	0	3	0	3	0	5	24	4	9	69

Appendix 6 – Nocturnal Sensitivity

Appendix 6 presents information on the predicted mortalities using Band CRM Option 2 for gannet, kittiwake, lesser black-backed gull, herring gull, and great black-backed gull in relation to a reduction of 1 nocturnal activity factor in comparison to Garthe & Huppop (2004).

Table 32 ES and PEIR nocturnal activity factors as used for the collision risk assessment

Species	ES Nocturnal Activity	PEIR Nocturnal Activity
Gannet	1	2
Kittiwake	2	3
LBB Gull	2	3
H Gull	2	3
GBB Gull	2	3

The reduction in mortalities ranged from -0.37 to -4 for lesser black-backed gull and kittiwake respectively.

Table 33 Annual predicted gannet collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density with a reduction in nocturnal activity

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	5
Best Estimate	**14**
Upper CL	26
Reduction	**-5**

Table 34 Annual predicted kittiwake collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density with a reduction in nocturnal activity

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	4
Best Estimate	**15**
Upper CL	32
Reduction	**-4**

Table 35 **Annual predicted lesser black-backed gull collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density with a reduction in nocturnal activity**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	0
Best Estimate	**2**
Upper CL	8
Reduction	**-0.37**

Table 36 **Annual predicted herring gull collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density with a reduction in nocturnal activity**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	2
Best Estimate	**14**
Upper CL	33
Reduction	**-3**

Table 37 **Annual predicted great black-backed gull collision rates for Band Option 2 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density with a reduction in nocturnal activity**

Band Model (Avoidance Rate)	Option 2 - SOSS-02 (98.9%)
Lower CL	3
Best Estimate	**22**
Upper CL	57
Reduction	**-6**

Appendix 7 – Band Option 1 Results

Appendix 7 provides a summary of the CRM outputs based on Band Option 1 using APEM site-specific flight height information. The avoidance rate applicable to Band Option 1 for each species is presented in Table 38. The PCH calculated based on APEM site-specific flight height information is presented in Table 39. Tables 40-44 summarise the CRM outputs for Band CRM Option 1 using best estimate and upper and lower CLs around the densities of birds in flight for each species. The potential monthly mortality estimates are presented in Tables 45-49. The potential mortality estimates based on a reduction in the nocturnal activity for each species are presented in Tables 50-54.

Table 38 **Band collision risk model Option 1 with associated avoidance rates for Thanet Extension for five species: gannet, kittiwake, lesser black-backed gull, herring gull, and great black-backed gull**

Species	Band Option 1 Avoidance Rate (± SD)
Gannet	0.989 ± 0.002
Kittiwake	0.989 ± 0.002
Lesser black-backed gull	0.995 ± 0.001
Herring gull	0.995 ± 0.001
Great black-backed gull	0.995 ± 0.001

Table 39 **Proportion (%) at potential collision risk height (PCH) used in the Band Option 1 collision risk model of the proposed Thanet Extension Offshore Wind Farm using site-specific data derived from aerial digital surveys (APEM)**

Species	Site-specific APEM PCH (%)
Gannet	20.51
Kittiwake	48.43
Lesser black-backed gull	48.00
Herring gull	38.46
Great black-backed gull	35.82

Table 40 **Annual predicted gannet collision rates for Band Option 1 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density**

Band Model (Avoidance Rate)	Option 1 - APEM (98.9%)
Lower CL	14
Best Estimate	38
Upper CL	72

Table 41 **Annual predicted kittiwake collision rates for Band Option 1 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density**

Band Model (Avoidance Rate)	Option 1 - APEM (98.9%)
Lower CL	19
Best Estimate	**78**
Upper CL	172

Table 42 **Annual predicted lesser black-backed gull collision rates for Band Option 1 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density**

Band Model (Avoidance Rate)	Option 1 - APEM (98.9%)
Lower CL	1
Best Estimate	**6**
Upper CL	18

Table 43 **Annual predicted herring gull collision rates for Band Option 1 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density**

Band Model (Avoidance Rate)	Option 1 - APEM (98.9%)
Lower CL	4
Best Estimate	**23**
Upper CL	54

Table 44 **Annual predicted great black-backed gull collision rates for Band Option 1 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density**

Band Model (Avoidance Rate)	Option 1 - APEM (98.9%)
Lower CL	5
Best Estimate	**33**
Upper CL	84

Table 45 **Monthly and annual gannet collision risk estimates for Band Option 1 using mean density, upper and lower CLs with APEM derived site-specific flight heights for proportion at PCH**

BO1 - Mean Lower CL Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	4	0	8	0	0	0	0	0	0	0	5	0	16
98.9	3	0	7	0	0	0	0	0	0	0	4	0	14
99.1	2	0	5	0	0	0	0	0	0	0	3	0	11
BO1 - Mean Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	10	3	17	0	0	0	0	0	0	0	15	1	45
98.9	8	2	14	0	0	0	0	0	0	0	12	1	38
99.1	7	2	12	0	0	0	0	0	0	0	10	1	31
BO1 - Mean Upper CL Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	18	8	28	0	0	0	0	0	0	0	28	2	85
98.9	15	7	24	0	0	0	0	0	0	0	24	2	72
99.1	12	6	19	0	0	0	0	0	0	0	20	2	59

Table 46 **Monthly and annual kittiwake collision risk estimates for Band Option 1 using mean density, upper and lower CLs with APEM derived site-specific flight heights for proportion at PCH**

BO1 - Mean Lower CL Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	7	10	1	1	1	0	0	0	1	0	0	1	22
98.9	6	8	1	1	1	0	0	0	1	0	0	1	19
99.1	5	7	1	0	0	0	0	0	0	0	0	1	15
BO1 - Mean Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	19	27	10	6	6	0	3	0	6	0	2	14	93
98.9	16	23	8	5	5	0	2.68	0	5	0	2	12	78
99.1	13	19	7	4	4	0	2	0	4	0	2	9	64
BO1 - Mean Upper CL Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
98.7	35	49	22	15	16	0	10	0	17	0	7	32	203
98.9	29	42	19	13	13	0	8.29	0	14	0	6	27	172
99.1	24	34	16	10	11	0	7	0	12	0	5	22	140

Table 47 **Monthly and annual lesser black-backed gull collision risk estimates for Band Option 1 using mean density, upper and lower CLs with APEM derived site-specific flight heights for proportion at PCH**

BO1 - Mean Lower CL Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	0	0	0	0	0	0	0	0	0	1
99.5	0	0	0	0	0	0	0	0	0	0	0	0	1
99.6	0	0	0	0	0	0	0	0	0	0	0	0	1
BO1 - Mean Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	1	0	1	1	1	0	0	0	1	0	7
99.5	0	0	1	0	1	1	1	0	0	0	1	0	6
99.6	0	0	1	0	1	1	1	0	0	0	1	0	4
BO1 - Mean Upper CL Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	4	0	5	4	5	0	0	0	5	0	22
99.5	0	0	3	0	4	3	4	0	0	0	4	0	18
99.6	0	0	2	0	3	3	3	0	0	0	3	0	14

Table 48 **Monthly and annual herring gull collision risk estimates for Band Option 1 using mean density, upper and lower CLs with APEM derived site-specific flight heights for proportion at PCH**

BO1 - Mean Lower CL Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	2	0	0	0	0	0	0	0	2	4
99.5	0	0	0	1	0	0	0	0	0	0	0	2	4
99.6	0	0	0	1	0	0	0	0	0	0	0	1	3
BO1 - Mean Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	10	1	1	4	1	0	0	0	11	27
99.5	0	0	0	8	1	1	3	1	0	0	0	9	23
99.6	0	0	0	6	1	1	2	1	0	0	0	7	18
BO1 - Mean Upper CL Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	0	0	0	19	4	4	10	3	0	0	0	25	65
99.5	0	0	0	16	3	3	8	3	0	0	0	21	54
99.6	0	0	0	13	3	3	7	2	0	0	0	17	44

Table 49 **Monthly and annual great black-backed gull collision risk estimates for Band Option 1 using mean density, upper and lower CLs with APEM derived site-specific flight heights for proportion at PCH**

BO1 - Mean Lower CL Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	1	1	0	0	0	0	0	0	0	1	0	1	6
99.5	1	1	0	0	0	0	0	0	0	1	0	1	5
99.6	1	1	0	0	0	0	0	0	0	1	0	1	4
BO1 - Mean Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	6	5	2	0	1	0	1	0	2	12	3	6	39
99.5	5	5	2	0	1	0	1	0	2	10	2	5	33
99.6	4	4	1	0	1	0	1	0	1	8	2	4	26
BO1 - Mean Upper CL Density - APEM Site-Specific													
AR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
99.4	13	11	7	0	4	0	5	0	7	35	6	14	101
99.5	11	9	5	0	3	0	4	0	6	29	5	11	84
99.6	9	7	4	0	3	0	3	0	4	24	4	9	68

Table 50 **Annual predicted gannet collision rates for Band Option 1 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density with a reduction in nocturnal activity**

Band Model (Avoidance Rate)	Option 1 - APEM (98.9%)
Lower CL	14
Best Estimate	**38**
Upper CL	72
Reduction	**-14**

Table 51 **Annual predicted kittiwake collision rates for Band Option 1 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density with a reduction in nocturnal activity**

Band Model (Avoidance Rate)	Option 1 - APEM (98.9%)
Lower CL	19
Best Estimate	**78**
Upper CL	172
Reduction	**-20**

Table 52 **Annual predicted lesser black-backed gull collision rates for Band Option 1 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density with a reduction in nocturnal activity**

Band Model (Avoidance Rate)	Option 1 - APEM (98.9%)
Lower CL	1
Best Estimate	**6**
Upper CL	18
Reduction	**-1**

Table 53 **Annual predicted herring gull collision rates for Band Option 1 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density with a reduction in nocturnal activity**

Band Model (Avoidance Rate)	Option 1 - APEM (98.9%)
Lower CL	4
Best Estimate	**23**
Upper CL	54
Reduction	**-5**

Table 54 **Annual predicted great black-backed gull collision rates for Band Option 1 using best estimate, lower and upper 95% confidence limits (CL) around Thanet Extension flying density with a reduction in nocturnal activity**

Band Model (Avoidance Rate)	Option 1 - APEM (98.9%)
Lower CL	5
Best Estimate	**33**
Upper CL	84
Reduction	**-8**