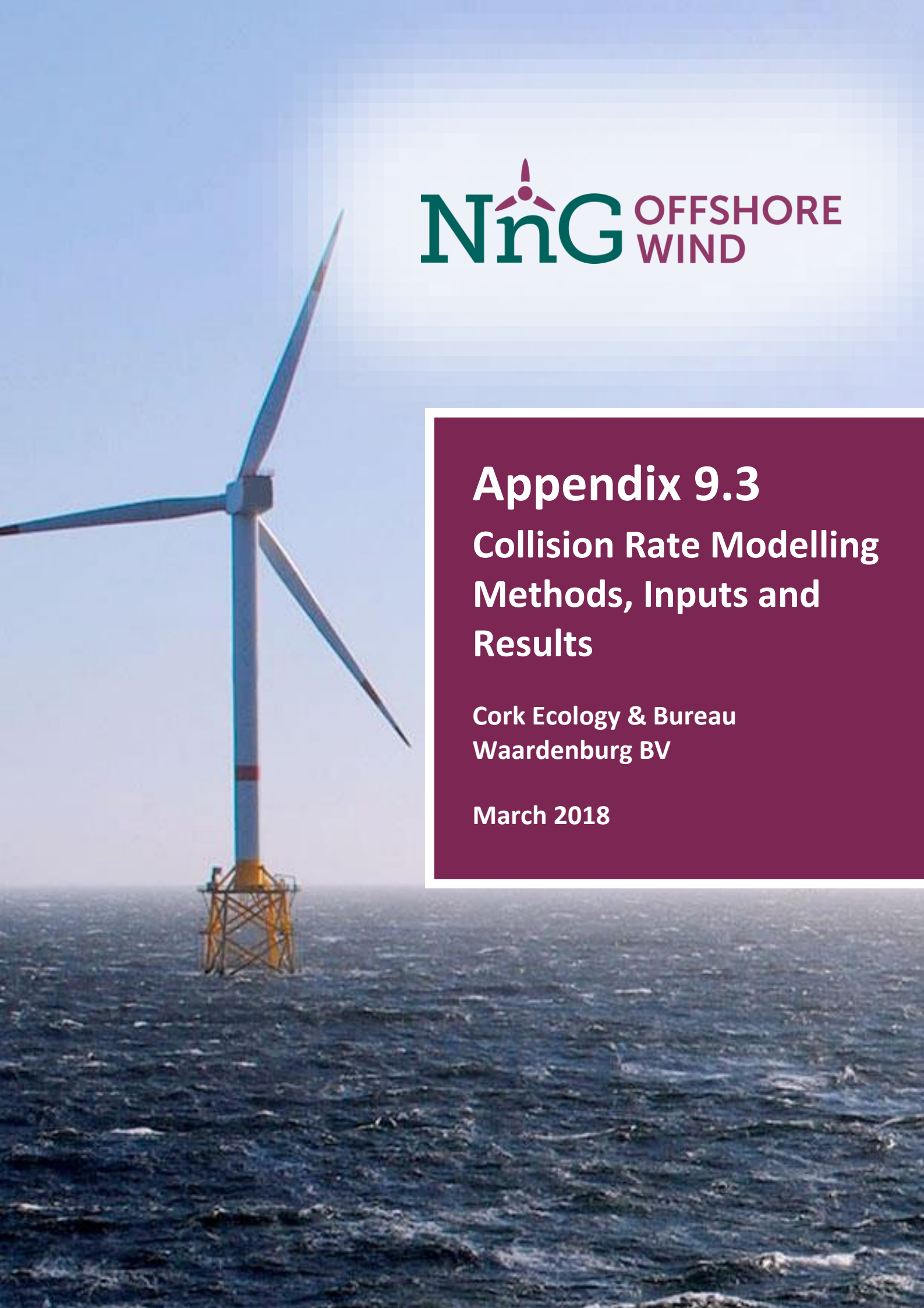

NnG OFFSHORE WIND

Appendix 9.3

Collision Rate Modelling Methods, Inputs and Results

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March 2018

Appendix 9.3 – Collision Rate Modelling methods and tables

Methods

Collision rate modelling was carried out using the methods described in Band (2012). Option 1 and 2 were carried out for gannet, kittiwake, herring gull, lesser black-backed gull and great black-backed gull, and Option 3 for herring gull, lesser black-backed gull and great black-backed gull. The 'migrant collision risk' option was applied for the passage species Arctic skua, great skua, little gull, black-headed gull and common gull using Option 2. The large array correction factor was not applied in any of the calculations as this has little effect on the results and is of potential relevance only very large wind farms of hundreds of turbines.

Input data for the worst-case design scenario (54 turbines) for the Project were modelled (Table 1). Information on rotation speed, pitch and the proportion of time in operation was available per month; as such collision rate modelling used monthly figures for these variables along with bird density.

Input data for the five main bird species are shown in Table 2. In addition, collision rate modelling was carried out for the five passage species (Table 3). For these species, modelling was based on 1,000 birds passing through the wind farm area in April and again in September.

Densities of flying birds were calculated following standardised European Seabirds at Sea protocols (Camphuysen and Garthe 2004, Webb and Durinck 1992) in which only flying birds recorded as 'in transect' (thus during the snapshot count) are included when calculating species-specific densities. Densities used in the collision rate modelling were based on mean monthly values from three years of surveys at the site.

Monthly densities were available for a maximum of three years, and in some months estimates from just two years were available. No confidence limits have been calculated due to limitations of calculating these from just three data points. Binning all the months is not advisable due to strong temporal variation in density between months. Confidence limits based on data subsampled within surveys, i.e. per transect or per snapshot count would give a poor representation of the range in estimates due to the relative few number of transects and high variability between snapshot counts. Therefore, monthly densities of flying birds from the baseline surveys for five species (gannet, kittiwake, herring gull, lesser black-backed gull and great black-backed gull) are presented in Tables 6 to 10 in this appendix to give a clearer overview of the month densities across the three years.

For passage species, aerial densities were calculated following Annex 2 of the guidance published by the Crown Estate Strategic Ornithological Support Services group (Band 2012). These were based on a total of 1,000 individuals of each species assessed passing through the development area during April and then again in September.

In Band Option 1, the proportion of birds at rotor height (PCH in Table 2 and Table 3) was calculated from data recorded during the ship-based surveys and following standardised protocols in which only flying birds recorded as 'in transect' (thus during the snapshot count) are included. The heights of flying birds recorded as 'in transect' were recorded in categories. To account for observers rounding off, particularly at heights above 30 m, flying birds were pooled into 10 m categories and divided equally across the 1 m bands within these categories. This assumes a precautionary approach as it over-estimates the numbers of birds in the upper limits of each category. The proportion of birds at rotor height was then calculated based on the birds at 32 m and above (for a minimum rotor height of 32m above mean sea level, MSL).

For Band Options 2 and 3, flight height data accompanying Johnston *et al*. (2014) were used. In Band Option 2, the proportions of birds at rotor height were taken as those at 32 m and above. In Band Option 3,

the collision model calculation uses these flight height data as input data to calculate the proportions of birds throughout the rotor height.

Biometric data were obtained from Snow and Perrins (1997) and flight speeds from Alerstam *et al.* (2007), Pennycuick (1987) and Pennycuick (1997). As a precautionary approach, flapping was used for all species to account for the unknown behaviour as birds pass the rotor-swept area. Figures for nocturnal activity factor and avoidance rates followed SNH advice, as detailed in the Scoping Opinion (Marine Scotland 2017).

Table 1: Input data for Project worst-case design scenario (54 turbines) used in collision rate modelling

Parameter	Details.
Latitude (o)	56.27
Number of turbines	54
Number of blades	3
Rotor radius (m)	83.5
Minimum rotor height (m)	32
Maximum blade width (m)	5
Tidal offset (m)	3
Width of wind farm (km)	8.22
Rotation speed (rpm) - Jan	9.07
Rotation speed (rpm) - Feb	8.58
Rotation speed (rpm) - Mar	8.48
Rotation speed (rpm) - Apr	8.02
Rotation speed (rpm) - May	7.94
Rotation speed (rpm) - Jun	7.33
Rotation speed (rpm) - Jul	7.31
Rotation speed (rpm) - Aug	7.44
Rotation speed (rpm) - Sep	8.05
Rotation speed (rpm) - Oct	8.65
Rotation speed (rpm) - Nov	8.84
Rotation speed (rpm) - Dec	8.70
Pitch (o) - Jan	3.41
Pitch (o) - Feb	2.31
Pitch (o) - Mar	1.86
Pitch (o) - Apr	0.56
Pitch (o) - May	0.24
Pitch (o) - Jun	-0.44

Parameter	Details.
Pitch (o) - Jul	-0.70
Pitch (o) - Aug	-0.16
Pitch (o) - Sep	0.66
Pitch (o) - Oct	1.37
Pitch (o) - Nov	2.73
Pitch (o) - Dec	2.49
P time operational - Jan	0.92
P time operational - Feb	0.89
P time operational - Mar	0.90
P time operational - Apr	0.88
P time operational - May	0.85
P time operational - Jun	0.82
P time operational - Jul	0.81
P time operational - Aug	0.82
P time operational - Sep	0.87
P time operational - Oct	0.90
P time operational - Nov	0.91
P time operational - Dec	0.90

Table 2: Input data for the five bird species used in collision rate modelling for the Project

Species	Gannet	Kittiwake	Herring Gull	Lesser Black-backed Gull	Great Black-backed Gull
Length (m)	0.935	0.390	0.595	0.580	0.710
Wingspan (m)	1.725	1.075	1.440	1.425	1.575
Flight speed (m/s)	14.9	13.1	12.8	13.1	13.7
Flapping(0)/gliding(1)	0	0	0	0	0
Nocturnal activity factor	1	2	2	3	3
PCH option 1	0.018	0.019	0.120	0.041	0.119
PCH option 1 smoothed	0.029	0.030	N/A	N/A	N/A
PCH option 2	0.036	0.047	0.160	0.131	0.167
Density Jan (birds/km^2)	0.084	0.147	0.231	0.000	0.127
Density Feb (birds/km^2)	1.328	0.044	0.065	0.000	0.000
Density Mar (birds/km^2)	2.358	0.189	0.118	0.000	0.000
Density Apr (birds/km^2)	1.240	0.214	0.043	0.021	0.000
Density May (birds/km^2)	4.412	0.616	0.085	0.064	0.000
Density Jun (birds/km^2)	3.419	0.234	0.086	0.000	0.022
Density Jul (birds/km^2)	5.120	0.943	0.042	0.021	0.000
Density Aug (birds/km^2)	4.175	0.171	0.000	0.000	0.000
Density Sep (birds/km^2)	4.742	0.653	0.000	0.000	0.043
Density Oct (birds/km^2)	2.272	0.803	0.000	0.000	0.000
Density Nov (birds/km^2)	0.287	0.764	0.096	0.000	0.064
Density Dec (birds/km^2)	0.031	3.364	0.159	0.000	0.127
Avoidance rate (%)	98.9	98.9	99.5	99.5	99.5

Table 3: Input data for the five passage bird species used in collision rate modelling for the Project

Species	Great Skua	Arctic Skua	Little Gull	Black-headed Gull	Common Gull
Length (m)	0.56	0.44	0.26	0.36	0.41
Wingspan (m)	1.36	1.18	0.78	1.05	1.20
Flight speed (m/s)	14.9	13.8	11.5	11.9	13.4
Flapping(0)/gliding(1)	0	0	0	0	0
Nocturnal activity factor	1	1	2	2	3
PCH option 2	0.011	0.003	0.047	0.433	0.884
Avoidance rate (%)	98.0	98.0	98.0	98.0	98.0

Inch Cape & Seagreen A & B collision estimates, based on 2014 turbine parameters and Band Model Option 2, are shown in Table 4 and Table 5.

Table 4: Estimated number of gannets predicted to be at risk of mortality due to collision impacts from Inch Cape Wind and Seagreen A and B, based on 2014 turbine parameters and Band Option Model 2. (Source: Inch Cape collison estimates from ICOL; Seagreen A & B collision estimates from Marine Scotland)

Project	AR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Inch Cape	0	125	523	745	3212	7545	6910	6560	8254	2031	1186	170	0	**37,261**
Seagreen A	0	202	330	2,143	1,424	11,267	13,503	2,094	6,406	2,700	1,154	329	53	**41,605**
Seagreen B	0	221	621	1,890	1,348	4,537	5,810	4,151	5,301	2,070	1,362	440	52	**27,804**
Avoidance rate of 98.9%														
Inch Cape	98.9%	1	6	8	35	83	76	72	91	22	13	2	0	**410**
Seagreen A	98.9%	2	4	24	16	124	149	23	70	30	13	4	1	**458**
Seagreen B	98.9%	2	7	21	15	50	64	46	58	23	15	5	1	**306**
Breeding season only														
Inch Cape	98.9%			4	35	83	76	72	91	22				**383**
Seagreen A	98.9%			12	16	124	149	23	70	30				**423**
Seagreen B	98.9%			10	15	50	64	46	58	23				**266**

Table 5: Estimated number of kittiwakes predicted to be at risk of mortality due to collision impacts from Inch Cape Wind and Seagreen A and B, based on 2014 turbine parameters and Band Option Model 2. (Source: Inch Cape collision estimates from ICOL; Seagreen A & B collision estimates from Marine Scotland)

Project	AR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Inch Cape	0	242	59	870	998	1539	3758	6909	845	3844	2272	769	404	**22,509**
Seagreen A	0	1,577	639	3,447	2,829	1,691	4,684	2,866	757	4,587	3,038	11,414	683	**38,213**
Seagreen B	0	2,806	2,354	3,342	1,866	4,068	4,736	2,045	512	523	1,915	7,932	809	**32,908**
Avoidance rate of 98.9%														
Inch Cape	98.9%	3	1	10	11	17	41	76	9	42	25	8	4	**248**
Seagreen A	98.9%	17	7	38	31	19	52	32	8	50	33	126	8	**420**
Seagreen B	98.9%	31	26	37	21	45	52	22	6	6	21	87	9	**362**
Breeding season only														
Inch Cape	98.9%				6	17	41	76	9					**149**
Seagreen A	98.9%				16	19	52	32	8					**126**
Seagreen B	98.9%				10	45	52	22	6					**135**

Table 6 to Table 10 show monthly aerial densities recorded on baseline surveys between 2009 and 2012 for five species (gannet, kittiwake, herring gull, lesser black-backed gull and great black-backed gull).

Table 6: Monthly aerial densities of gannets recorded on baseline surveys between 2009 and 2012

Survey year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009/20010	0.064	0.188	4.079	1.216	1.451	2.208	0.838	1.667	3.415	1.506	0.192	0.000
2010/2011	0.125	3.607	0.710	1.676	7.463	5.760	11.913	6.910	5.920	2.895	-	0.063
2011/2012	0.063	0.191	2.283	0.828	4.322	2.290	2.610	3.946	4.893	2.417	0.381	-
Mean	0.084	1.328	2.358	1.240	4.412	3.419	5.120	4.175	4.742	2.272	0.287	0.031
Maximum	0.125	3.607	4.079	1.676	7.463	5.760	11.913	6.910	5.920	2.895	0.381	0.063
Sample size	3	3	3	3	3	3	3	3	3	3	2	2
Used in CRM (mean across all years)	0.084	1.328	2.358	1.240	4.412	3.419	5.120	4.175	4.742	2.272	0.287	0.031

Table 7: Monthly aerial densities of kittiwakes recorded on baseline surveys between 2009 and 2012

Survey year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009/20010	0.000	0.000	0.000	0.064	0.396	0.189	0.387	0.064	1.576	1.255	0.192	0.127
2010/2011	0.063	0.131	0.059	0.451	0.753	0.259	2.125	0.258	0.191	0.836	-	6.602
2011/2012	0.378	0.000	0.507	0.127	0.699	0.254	0.318	0.191	0.191	0.318	1.335	-
Mean	0.147	0.044	0.189	0.214	0.616	0.234	0.943	0.171	0.653	0.803	0.764	3.364
Maximum	0.378	0.131	0.507	0.451	0.753	0.259	2.125	0.258	1.576	1.255	1.335	6.602
Sample size	3	3	3	3	3	3	3	3	3	3	2	2
Used in CRM (mean across all years)	0.147	0.044	0.189	0.214	0.616	0.234	0.943	0.171	0.653	0.803	0.764	3.364

Table 8: Monthly aerial densities of herring gulls recorded on baseline surveys between 2009 and 2012

Survey year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009/20010	0.192	0.063	0.236	0.064	0.000	0.063	0.000	0.000	0.000	0.000	0.192	0.255
2010/2011	0.376	0.131	0.118	0.000	0.000	0.194	0.000	0.000	0.000	0.000	-	0.063
2011/2012	0.126	0.000	0.000	0.064	0.254	0.000	0.127	0.000	0.000	0.000	0.000	-
Mean	0.231	0.065	0.118	0.043	0.085	0.086	0.042	0.000	0.000	0.000	0.096	0.159
Maximum	0.376	0.131	0.236	0.064	0.254	0.194	0.127	0.000	0.000	0.000	0.192	0.255
Sample size	3	3	3	3	3	3	3	3	3	3	2	2
Used in CRM (mean across all years)	0.231	0.065	0.118	0.043	0.085	0.086	0.042	0.000	0.000	0.000	0.096	0.159

Table 9: Monthly aerial densities of lesser black-backed gulls recorded on baseline surveys between 2009 and 2012

Survey year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009/20010	0.000	0.000	0.000	0.064	0.066	0.000	0.064	0.000	0.000	0.000	0.000	0.000
2010/2011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	0.000
2011/2012	0.000	0.000	0.000	0.000	0.127	0.000	0.000	0.000	0.000	0.000	0.000	-
Mean	0.000	0.000	0.000	0.021	0.064	0.000	0.021	0.000	0.000	0.000	0.000	0.000
Maximum	0.000	0.000	0.000	0.064	0.127	0.000	0.064	0.000	0.000	0.000	0.000	0.000
Sample size	3	3	3	3	3	3	3	3	3	3	2	2
Used in CRM (mean across all years)	0.000	0.000	0.000	0.021	0.064	0.000	0.021	0.000	0.000	0.000	0.000	0.000

Table 10: Monthly aerial densities of great black-backed gulls recorded on baseline surveys between 2009 and 2012

Survey year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009/20010	0.128	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.066	0.000	0.064	0.191
2010/2011	0.063	0.000	0.000	0.000	0.000	0.065	0.000	0.000	0.064	0.000	-	0.063
2011/2012	0.189	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.064	-
Mean	0.127	0.000	0.000	0.000	0.000	0.022	0.000	0.000	0.043	0.000	0.064	0.127
Maximum	0.189	0.000	0.000	0.000	0.000	0.065	0.000	0.000	0.066	0.000	0.064	0.191
Sample size	3	3	3	3	3	3	3	3	3	3	2	2
Used in CRM (mean across all years)	0.127	0.000	0.000	0.000	0.000	0.022	0.000	0.000	0.043	0.000	0.064	0.127