DOCUMENT NUMBER: HP00113-703-01
DATE: 23 November 2021
ISSUE: Draft 2

Erebus: Offshore Ornithology 11.1 Technical Appendix - Baseline Data

Authorisations

Responsibility	Name	Signature	Date
Prepared by	Ruth Peters-Grundy		19/10/2021
	Jaz Harker		
Checked by	Kelly Macleod		19/10/2021
Approved by	Andy Webb		19/10/2021

Distribution List

Name	Organisation	Email Address
Jonny Lewis	Marine Space	Jonny.Lewis@marinespace.co.uk
Katie Cross	Marine Space	Katie.Cross@marinespace.co.uk

Document History

Issue	Date	Status / Changes
Draft 1	20/10/2021	First draft for client review
Draft 2	23/11/2021	Second draft for client review

Contents

Figures

Tables

1 Introduction

1 Erebus (hereafter the Project) is a proposed floating offshore wind farm, located 35 km off the Pembrokeshire coast in the Welsh waters of the Celtic Sea. The Project is being developed by Blue Gem Wind, a joint venture between Simply Blue Group and TotalEnergies.

2 This Technical Appendix on baseline data follows on from the two-year digital aerial survey report provided as Volume 3, Technical Appendix 11.6: 2 Year Bird Survey Report in support of the Environmental Statement (ES) Chapter 11: Offshore Ornithology. It summarises the input parameters required for ornithological impact modelling, collision risk and displacement, as addressed in Volume 3, Technical Appendix 11.3: Collision Risk Modelling and Volume 3, Technical Appendix 11.4: Displacement Analysis.

3 Digital aerial survey work was undertaken between October 2019 and September 2021 providing 24 months, or two years of survey data. Surveys covered the Project array area, the area where wind turbines are proposed, and a 4km buffer. Full survey results are presented in Volume 3, Technical Appendix 11.6: 2 Year Bird Survey Report.

1.1 Collision Risk Modelling

4 Based on Furness et al. (2013), and as set out in Chapter 11: Offshore Ornithology, the key species to address in collision risk modelling for the Project are:

- Northern gannet *Morus bassanus*;
- Black legged kittiwake *Rissa tridactyla;*
- Great black-backed gull *Larus marinus*;
- Lesser black-backed gull *Larus fuscus*; and
- Herring gull *Larus argentatus*.

5 During pre-application discussion with Natural Resources Wales (NRW), Joint Nature Conservation Committee (JNCC), Royal Society for the Protection of Birds (RSPB) and Wildlife Trust of South and West Wales (WTSWW), it was agreed that Manx shearwater (*Puffinus puffinus*) and common guillemot (*Uria aalge*), would also be assessed for collision risk and these species have also been taken forward in the modelling (Chapter 11: Offshore Ornithology, Table 11.4).

6 The approach to collision risk modelling follows current good practice guidance (McGregor et al. 2018), and is set out in Volume 3, Technical Appendix 11.3: Collision Risk Modelling. It requires the following information:

- monthly densities of flying birds in the Project array area;
- estimated proportions of birds flying at potential collision height (PCH) within the Project array area.

7 This information is presented for each species in this Technical Appendix. To inform the analysis of the proportions of birds flying at PCH, the following turbine scenarios have been used, supplied by the Applicant, Table 1-1.

Table 1-1 Turbine scenarios for collision risk modelling

Parameter	Turbine scenario		
	9.5 MW	14 MW	16-18 MW
Latitude (degrees)	51.4	51.4	51.4
Windfarm width (km)	7	7	7
Tidal offset (m)	0	0	0
No. turbines	10	7	6
No. blades	3	3	3
Rotor radius (m)	87	111	121
Air gap (m)	22	22	22
Max. blade width (m)	5.8	5.8	5.8
Upper blade height (m)	196	244	270
Rotation speed (rpm)	9.9	9.9	9.9
Pitch (degrees)	2	2	2

1.2 Displacement Analysis

8 Based on Furness et al. (2013), and as set out in Chapter 11: Offshore Ornithology, the key species to address in displacement analysis for the Project are:

- Northern gannet;
- Manx shearwater;
- Black legged kittiwake;
- Common guillemot;
- Razorbill (*Alca torda*); and
- Atlantic puffin (*Fratercula arctica*).

9 The approach to displacement assessment follows current good practice guidance (SNCB 2017), and is set out in Volume 3, Technical Appendix 11.4: Displacement Analysis. It requires the following information:

- mean seasonal peak population estimates of all birds within the 2 km buffer per season.

10 Seasonal definitions were agreed during pre-application consultation with NRW and JNCC (Chapter 11: Offshore Ornithology, Table 11.4), and are based on Furness (2015) as set out in Table 1-2.

Table 1-2 Seasons used in analysis, Furness (2015)

Species	Migration free breeding	BDMPS		
		Autumn migration	Non-breeding	Spring migration
Northern gannet	Apr - Aug	Sep - Nov	n/a	Dec - Mar
Manx shearwater	Jun - Jul	Aug - Oct	n/a	Mar - May
Black legged Kittiwake	May - Jul	Aug - Dec	n/a	Jan - Apr
Common guillemot	Mar - Jun	n/a	Aug - Feb	n/a
Razorbill	Apr - Jun	Aug - Oct	Nov - Dec	Jan - Mar
Atlantic puffin	May - Jun	n/a	mid Aug - Mar	n/a
Great black-backed gull	May - Jul	n/a	Sep - Mar	n/a
Lesser black-backed gull	May - Jul	Aug - Oct	Nov - Feb	Mar - Apr
Herring gull	May - Jul	n/a	Sep - Feb	n/a

2 Methods

2.1 Survey flight methodology

11 Detailed explanation of survey flight methodology is presented in the two-year digital aerial survey report, Volume 3, Technical Appendix 11.6: 2 Year Bird Survey Report. Strip transects placed at 1km intervals were flown roughly monthly across the survey area plus a 4km buffer, to achieve a site coverage of approximately 25%.

12 Further information regarding data review, object identification, and final processing is also presented in Volume 3, Technical Appendix 11.6: 2 Year Bird Survey Report.

2.2 Data analysis

2.2.1 Data treatment

13 The two-year survey report outlines the data processing to prepare data for abundance and density estimation and further analysis for the species of interest. 'Partially identified' birds (those not identified to species level) were excluded from analysis for the purposes of this report.

2.2.2 Abundance Estimates

14 Abundance estimates were calculated for the Project array area alone, and for the Project array area plus a 2 km buffer (as used in displacement assessment). Analysis used the same methodology as is set out in Volume 3, Technical Appendix 11.6: 2 Year Bird Survey Report.

15 In summary, the abundance of each species observed was estimated individually using a design-based strip transect analysis with variance and confidence intervals (CI) derived using a blocked bootstrapping technique. This technique uses total length of transect to limit selection rather than total number of transects and is particularly advantageous when transects are of unequal length to provide precise estimates. Mean and standard deviation of the sampled means, as well as the relative standard error, i.e. coefficient of variation (CV), as defined by the standard deviation divided by the mean were calculated. Results were expressed as density (±95 CI) and population estimates (±95 CI) and their standard deviations.

16 For guillemot, razorbill and puffin, absolute abundances are presented, accounting for animals underwater at the time of the surveys. This was achieved by estimating availability bias from known time spent underwater by each species, following information presented by Barlow et al. (1998), Thaxter et al. (2010) and Spencer (2012). Detailed methodology outlining availability bias calculations is presented in Volume 3, Technical Appendix 11.6: 2 Year Bird Survey Report.

17 Abundance and density estimates were calculated as set out in Table 1-3. Density of flying birds in the Project array area is needed for collision risk modelling (Volume 3, Technical Appendix 11.3: Collision Risk). Mean seasonal peak estimates for the Project array area and 2 km buffer is needed for the displacement assessment (Volume 3, Technical Appendix 11.4: Displacement Assessment). For determining age classes of birds, the Project array area plus a 4 km buffer was assessed.

18 The number of bootstrap iterations performed varied depending on whether data were to be used in displacement analysis or for use in the stochastic collision risk model (sCRM, McGregor et al. 2018) due to restrictions on the amount of data that can be fed into the sCRM. As standard, HiDef perform 5,000 bootstrap iterations when calculating abundance estimates, however the sCRM can only take a maximum of 1,000. This is unlikely to affect final abundance estimates, but rather affects variation around outputs, with increased bootstrap iterations decreasing variation. It was agreed that differences in calculated estimates would be negligible, so for displacement the threshold was left at 5,000 instead of lowering to 1,000 to match those used in the sCRM.

Table 1-3 Overview of analytical approaches

Output	Buffer size	Seabird subset	Bootstrap iterations
Peak population estimates	Project array (no buffer)	All birds	n/a
Displacement	Project array + 2 km buffer	All birds	5,000
Collision risk	Project array (no buffer)	Flying birds only	1,000
Age	Project array + 4km buffer	All birds	n/a
Flight height estimates	Project array	Flying birds only	n/a

2.2.3 Flight height analysis

19 Flight heights of birds were calculated for the development area only, using a size-based estimation method.

20 The body lengths of flying birds at sea level (a *known* height) were measured using a bespoke tool and compared to the body lengths of birds flying within the development area at *unknown* height. A full description of the methodology is available in Humphries et al. (in prep). The proportional size of these birds at height and birds at sea surface were multiplied against the altitude of the aircraft to determine the distance of the bird from the sea surface along the camera angle.

21 The result is a bootstrapped mean height per flying bird. The proportion of birds at potential collision risk height were calculated as the number of birds whose mean estimated flight height fell within the rotor swept area of the proposed turbines, as a proportion of the total number of flying birds present in the development area.

22 For the purpose of collision risk modelling, three turbine scenarios were analysed, supplied by the applicant (Table 1-1). Since the Project proposes to use floating turbines, minimum blade height, and therefore air gap between the sea and rotor swept area, can be viewed as constant.

3 Results

3.1 Norther gannet

23 The density and mean seasonal peak population estimates are provided for gannets for input into collision risk modelling (Volume 3, Technical Appendix 11.3: Collision Risk Modelling) and displacement assessment (Volume 3, Technical Appendix 11.4: Displacement Analysis).

24 The maximum population estimate in the development area was recorded in the migration free breeding season at 160 birds (±95CI 47 – 333; August 2020), with lower peak results in the autumn and spring migration periods (Table 3-1).

25 This month also produced the highest densities of flying birds within the development boundary at 3.54 birds/km^2 (±95CI 0.99 - 7.63), with relatively high densities also recorded in the spring and summer (Figure 1; Table 3-2).

26 Turbine dimensions did not alter the results of flight height analysis, with 59% of birds flying at potential collision risk height in all turbine scenarios.

27 In contrast, the highest seasonal mean peak population estimates of all birds within the development site plus 2 km buffer (required for displacement modelling) occurred in the autumn migration period at 334 birds (±95CI 138 – 555) (Table 3-5). High numbers were also recorded in the migration free breeding season, followed by the spring migration.

28 Very few young birds were observed, with adults making up 99-100% of all aged birds during the breeding season and spring and autumn migration periods (Table 3-6).

Table 3-1 Maximum population estimates for gannets in each season within the Project array area between October 2019 and September 2021

Gannet	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Migration free breeding season	160	47	333	80	50.24	Aug	2020
Autumn migration	79	12	185	50	62.84	Sep	2021
Spring migration	53	12	106	25	46.98	Feb	2021

3.1.1 Input densities for CRM

Figure 1 Monthly densities of flying gannets within the Project array area between October 2019 and April 2021

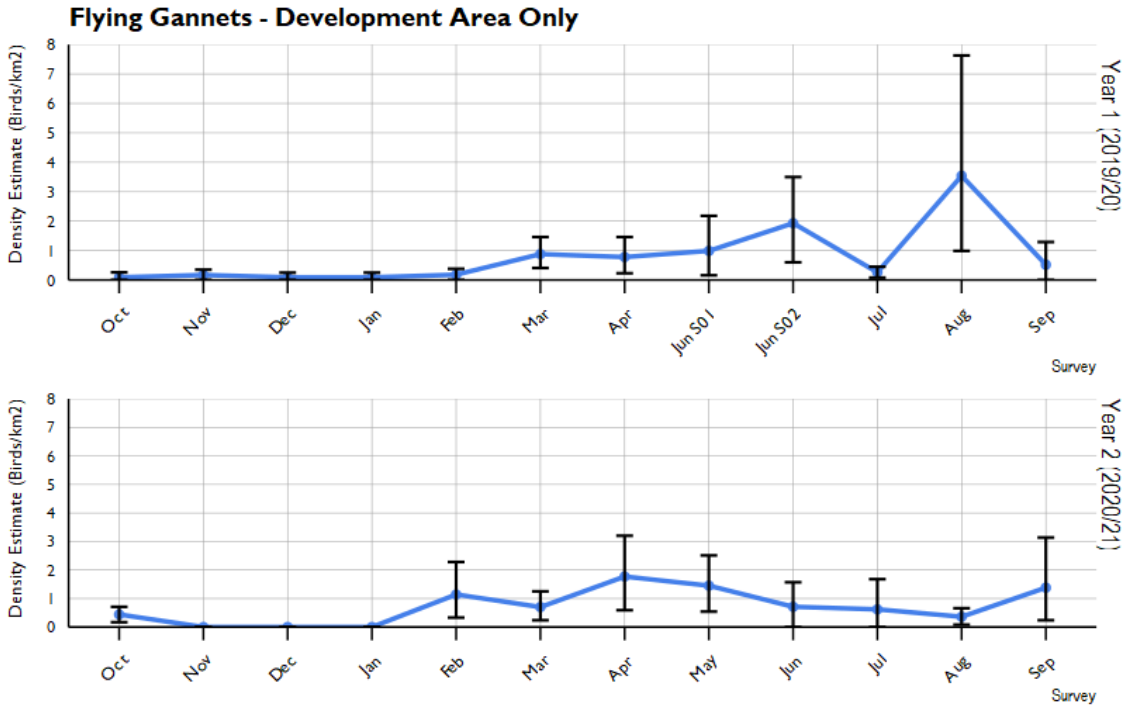

Table 3-2 Density estimates of flying gannets within the Project array area between October 2019 and September 2021

Gannet	Density estimate (n/km²)	Lower 95% confidence limit of density (n/km²)	Upper 95% confidence limit of density (n/km²)	Standard deviation of density (n/km²)	CV (%)
22-Oct-19	0.09	0.00	0.26	0.09	87.05
08-Nov-19	0.17	0.00	0.35	0.11	54.89
04-Dec-19	0.09	0.00	0.25	0.09	89.16
18-Jan-20	0.09	0.00	0.25	0.09	85.33
04-Feb-20	0.18	0.00	0.38	0.11	55.78
03-Mar-20	0.88	0.41	1.46	0.30	32.62
04-Apr-20	0.78	0.23	1.46	0.34	42.02
08-Jun-20	0.99	0.16	2.18	0.57	55.46
24-Jun-20	1.93	0.6	3.5	0.76	38.46
23-Jul-20	0.26	0.08	0.45	0.11	37.89
31-Aug-20	3.54	0.99	7.63	1.84	51.42
12-Sep-20	0.52	0.00	1.29	0.37	69.41
15-Oct-20	0.44	0.17	0.71	0.14	31.38
22-Nov-20	0.00	0.00	0.00	0.00	0.00
31-Dec-20	0.00	0.00	0.00	0.00	0.00
16-Jan-21	0.00	0.00	0.00	0.00	0.00
22-Feb-21	1.14	0.33	2.28	0.50	44.35
05-Mar-21	0.7	0.24	1.25	0.30	39.70
10-Apr-21	1.77	0.59	3.2	0.69	38.55
14-May-21	1.45	0.54	2.51	0.53	35.85
15-Jun-21	0.71	0.00	1.57	0.41	56.20
14-Jul-21	0.62	0.00	1.68	0.50	77.97
16-Aug-21	0.36	0.08	0.66	0.16	43.13
01-Sep-21	1.38	0.24	3.14	0.85	60.87

Table 3-3 Proportion of flying gannets at potential collision risk height for three turbine scenarios in the Project array area

Scenario	Rotor swept area (m)	Number of birds in development area	Proportion at PCH
9.5 MW	22 – 196	162	0.59
14 MW	22 - 244	162	0.59
16-18 MW	22 – 270	162	0.59

3.1.2 Input densities and abundances for displacement modelling

Table 3-4 Monthly population estimates of all gannets (flying and sitting) within the Project array area plus 2 km buffer between October 2019 and September 2021

Gannet	Population estimate	Lower 95% confidence	Upper 95% confidence	Standard deviation	CV (%)
22-Oct-19	499	168	865	176	35.26
08-Nov-19	55	22	98	20	36.34
04-Dec-19	24	4	54	15	60.30
18-Jan-20	4	0	12	4	92.54
04-Feb-20	12	4	23	6	47.02
03-Mar-20	67	40	97	15	22.55
04-Apr-20	55	15	105	24	42.84
08-Jun-20	95	36	163	33	34.97
24-Jun-20	137	72	211	36	26.00
23-Jul-20	309	33	770	216	69.78
31-Aug-20	184	88	307	88	47.82
12-Sep-20	55	15	104	23	41.97
15-Oct-20	168	107	245	36	21.42
22-Nov-20	4	0	12	4	93.46
31-Dec-20	28	11	46	9	32.67
16-Jan-21	0	0	0	0	0.00
22-Feb-21	110	53	172	31	28.00
05-Mar-21	134	95	177	22	15.89
10-Apr-21	140	72	223	40	28.10
14-May-21	94	38	174	36	37.46
15-Jun-21	134	12	291	72	53.77
14-Jul-21	55	15	109	25	45.18
16-Aug-21	35	16	54	10	27.84
01-Sep-21	286	139	478	90	31.38

Table 3-5 Mean seasonal peak population estimate of all gannets in each season within the Project array area plus 2 km buffer between October 2019 and September 2021

Gannet	Population estimate	Lower 95% confidence	Upper 95% confidence	Density estimate	Lower 95% confidence	Upper 95% confidence
Migration free breeding season	224	52	496	2.05	0.48	4.54
Autumn migration	334	138	555	3.04	1.25	5.07
Spring migration	100	68	137	0.91	0.61	1.25

Table 3-6 Percentage of aged gannets in each age class averaged across all surveys in each season

Season	Adult	Immature	Juvenile
Migration free breeding season	99%	1%	0%
Autumn migration	99%	1%	0%
Spring migration	100%	0%	0%

3.2 Manx shearwater

29 The density and mean seasonal peak population estimates are provided for Manx shearwaters for input into collision risk modelling (Volume 3, Technical Appendix 11.3: Collision Risk Modelling) and displacement assessment (Volume 3, Technical Appendix 11.4: Displacement Analysis).

30 The maximum population estimate in the Project array area was recorded in the migration free breeding season at 918 birds (±95CI 105 - 1866; July 2020), with lower peak results in the autumn followed by spring migration periods (Table 3-7).

31 Densities of flying Manx shearwaters within the Project array area were low for the majority of the year, peaking in the breeding season in Year 1 and the autumn migration in Year 2, at 3.20 birds/km^2 (±95% CI 0.00 – 8.83; June 2020) and 1.62 birds/km^2 (±95% CI 0.24 – 3.17; September 2021) respectively (Figure 2; Table 3-8).

32 The highest mean peak population estimates of all birds within the Project array area plus 2 km buffer (required for displacement modelling) occurred in the migration free breeding season at 1540 birds (±95CI 472 - 2920) (Table 3-10). Considerably fewer birds were recorded in the autumn migration period, with very few birds recorded in the spring migration period.

Table 3-7 Maximum population estimates for Manx shearwaters in each season within the Project array area between October 2019 and September 2021

Manx shearwater	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Migration free breeding season	918	105	1866	444	48.38	Jul	2020
Autumn migration	201	61	349	74	36.80	Sep	2021
Spring migration	4	0	11	4	89.88 87.70 88.68	Apr Apr May	2020 2021 2021

3.2.1 Input densities for CRM

Figure 2 Monthly densities of flying Manx shearwater within the Project Array Area between October 2019 and September 2021

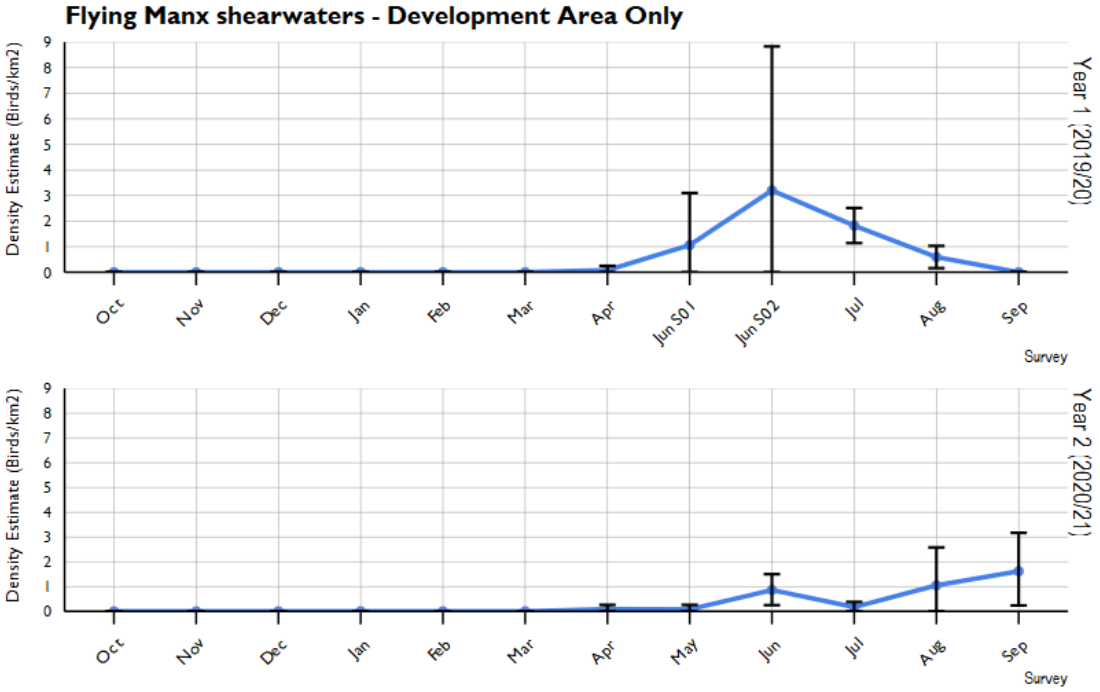

Table 3-8 Density estimates of flying Manx shearwaters within the Project array area between October 2019 and September 2021

Manx shearwater	Density estimate (n/km²)	Lower 95% confidence limit of density (n/km²)	Upper 95% confidence limit of density (n/km²)	Standard deviation of density (n/km²)	CV (%)
22-Oct-19	0.00	0.00	0.00	0.00	0.00
08-Nov-19	0.00	0.00	0.00	0.00	0.00
04-Dec-19	0.00	0.00	0.00	0.00	0.00
18-Jan-20	0.00	0.00	0.00	0.00	0.00
04-Feb-20	0.00	0.00	0.00	0.00	0.00
03-Mar-20	0.00	0.00	0.00	0.00	0.00
04-Apr-20	0.08	0.00	0.25	0.09	90.37
08-Jun-20	1.06	0.00	3.10	0.96	89.83
24-Jun-20	3.20	0.00	8.83	2.68	83.36
23-Jul-20	1.82	1.14	2.51	0.37	19.77
31-Aug-20	0.59	0.16	1.03	0.25	40.70
12-Sep-20	0.00	0.00	0.00	0.00	0.00
15-Oct-20	0.00	0.00	0.00	0.00	0.00
22-Nov-20	0.00	0.00	0.00	0.00	0.00
31-Dec-20	0.00	0.00	0.00	0.00	0.00
16-Jan-21	0.00	0.00	0.00	0.00	0.00
22-Feb-21	0.00	0.00	0.00	0.00	0.00
05-Mar-21	0.00	0.00	0.00	0.00	0.00
10-Apr-21	0.09	0.00	0.26	0.09	87.07
14-May-21	0.08	0.00	0.26	0.09	91.91
15-Jun-21	0.86	0.25	1.50	0.32	36.72
14-Jul-21	0.17	0.00	0.38	0.11	55.14
16-Aug-21	1.05	0.00	2.58	0.76	69.73
01-Sep-21	1.62	0.24	3.17	0.76	46.42

3.2.2 Input densities and abundances for displacement modelling

Table 3-9 Monthly population estimates of all Manx shearwater (flying and sitting) within the Project array area plus 2 km buffer between October 2019 and September 2021

Manx shearwater	Population estimate	Lower 95% confidence	Upper 95% confidence	Standard deviation	CV (%)
22-Oct-19	0	0	0	0	0.00
08-Nov-19	0	0	0	0	0.00
04-Dec-19	0	0	0	0	0.00
18-Jan-20	0	0	0	0	0.00
04-Feb-20	0	0	0	0	0.00
03-Mar-20	0	0	0	0	0.00
04-Apr-20	4	0	12	4	91.43
08-Jun-20	518	97	1150	285	55.00
24-Jun-20	1135	343	1989	423	37.21
23-Jul-20	1615	473	3077	664	41.09
31-Aug-20	252	107	397	96	37.77
12-Sep-20	12	4	23	6	45.91
15-Oct-20	0	0	0	0	0.00
22-Nov-20	0	0	0	0	0.00
31-Dec-20	0	0	0	0	0.00
16-Jan-21	0	0	0	0	0.00
22-Feb-21	0	0	0	0	0.00
05-Mar-21	0	0	0	0	0.00
10-Apr-21	8	0	19	5	61.44
14-May-21	32	8	65	15	46.75
15-Jun-21	1464	472	2762	598	40.84
14-Jul-21	24	8	47	11	45.88
16-Aug-21	134	4	366	110	82.09
01-Sep-21	862	324	1532	310	35.88

Table 3-10 Mean seasonal peak population estimate of all Manx shearwater (flying and sitting) in each season within the Project array area plus 2 km buffer between October 2019 and September 2021

Manx shearwater	Population estimate	Lower 95% confidence	Upper 95% confidence	Density estimate	Lower 95% confidence	Upper 95% confidence
Migration free breeding season	1540	472	2920	14.08	4.32	26.71
Autumn migration	557	216	964	5.09	1.97	8.82
Spring migration	18	4	38	0.16	0.04	0.34

3.3 Black legged Kittiwake

33 The density and mean seasonal peak population estimates are provided for kittiwake for input into collision risk modelling (Volume 3, Technical Appendix 11.3: Collision Risk Modelling) and displacement assessment (Volume 3, Technical Appendix 11.4: Displacement Analysis).

34 Within the Project array area, flying kittiwakes were recorded in varying densities (Table 3-12; Figure 3), ranging between 0.00 birds/km^2 (±95% CI 0 – 0; April 2020), and 4.99 birds/km^2 (±95% CI 2.72 – 7.19; January 2021). Generally, densities were highest over the autumn and spring migration periods, peaking in November 2019 in Year 1 and December 2020 and January 2021 in Year 2. Between February and September, over the migration-free breeding season, densities of flying kittiwake within the development site remained low, this was observed in both years.

35 Proportion of birds at collision risk height was the same for the three turbine scenarios (Table 3-13).

36 Population estimates for all kittiwakes in the Project array area plus the 2 km buffer varied between months, ranging between 0 birds (±95% CI 0 - 0) in June 2020 and 3,428 birds (±95% CI 1,226 – 6,037) in October 2019 (Table 3-14). A substantially higher mean seasonal peak was recorded in the autumn migration period compared to other seasons.

37 Across all seasons, the majority of birds were aged as adults, with very few immature birds recorded during the survey programme (Table 3-16). The highest proportion of adults were recorded during the breeding season, in contrast to the spring migration period when more immature birds were present, which equated to 17% of all aged birds.

Table 3-11 Maximum population estimates for kittiwakes in each season within the Project array area between October 2019 and September 2021

Kittiwake	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Migration free breeding season	4	0	11	4	88.96/ 87.75	Jun Jul	2020
Autumn migration	304	35	614	147	48.38	Nov	2019
Spring migration	486	234	744	130	26.57	Jan	2021

3.3.1 Input densities for CRM

Figure 3 Monthly densities of flying kittiwakes within the Project array area between October 2019 and September 2021

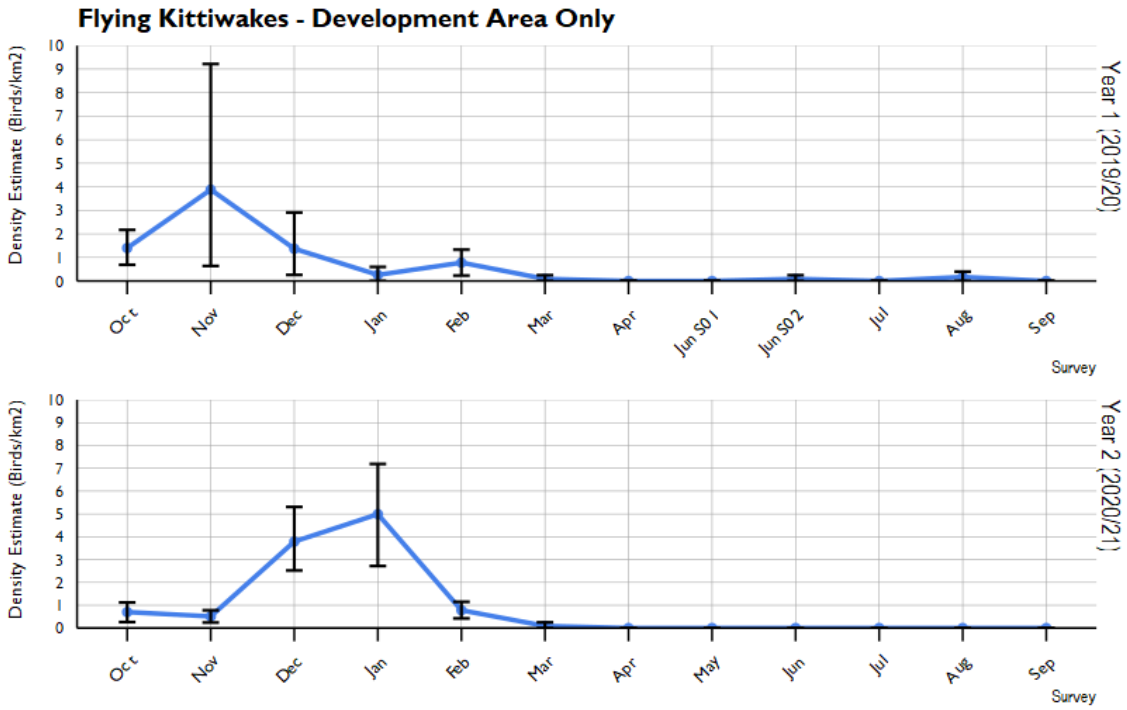

Table 3-12 Density estimates of flying kittiwakes within the Project array area between October 2019 and September 2021

Kittiwake	Density estimate (n/km²)	Lower 95% confidence limit of density (n/km²)	Upper 95% confidence limit of density (n/km²)	Standard deviation of density (n/km²)	CV (%)
22-Oct-19	1.40	0.69	2.17	0.39	27.26
08-Nov-19	3.88	0.64	9.22	2.52	64.68
04-Dec-19	1.37	0.26	2.91	0.71	51.91
18-Jan-20	0.26	0.00	0.60	0.16	59.15
04-Feb-20	0.78	0.23	1.33	0.30	37.64
03-Mar-20	0.09	0.00	0.25	0.09	85.86
04-Apr-20	0.00	0.00	0.00	0.00	0.00
08-Jun-20	0.00	0.00	0.00	0.00	0.00
24-Jun-20	0.09	0.00	0.25	0.09	86.88
23-Jul-20	0.00	0.00	0.00	0.00	0.00
31-Aug-20	0.17	0.00	0.40	0.11	59.25
12-Sep-20	0.00	0.00	0.00	0.00	0.00
15-Oct-20	0.70	0.26	1.12	0.23	31.15
22-Nov-20	0.51	0.24	0.78	0.16	28.42
31-Dec-20	3.79	2.52	5.31	0.73	18.9
16-Jan-21	4.99	2.72	7.19	1.17	23.32
22-Feb-21	0.78	0.42	1.15	0.21	24.72
05-Mar-21	0.09	0.00	0.25	0.09	80.82
10-Apr-21	0.00	0.00	0.00	0.00	0.00
14-May-21	0.00	0.00	0.00	0.00	0.00
15-Jun-21	0.00	0.00	0.00	0.00	0.00
14-Jul-21	0.00	0.00	0.00	0.00	0.00
16-Aug-21	0.00	0.00	0.00	0.00	0.00
01-Sep-21	0.00	0.00	0.00	0.00	0.00

Table 3-13 Proportion of flying kittiwake at potential collision risk height for three turbine scenarios in the Project array area

Scenario	Rotor swept area (m)	Number of birds in development area	Proportion at PCH
9.5 MW	22 – 196	125	0.49
14 MW	22 - 244	125	0.49
16-18 MW	22 – 270	125	0.49

3.3.2 Input densities and abundances for displacement modelling

Table 3-14 Monthly population estimates of all kittiwakes (flying and sitting) within the Project array area plus 2 km buffer between October 2019 and September 2021

Kittiwake	Population estimate	Lower 95% confidence	Upper 95% confidence	Standard deviation	CV (%)
22-Oct-19	3428	1226	6037	1241	36.18
08-Nov-19	591	195	1130	244	41.22
04-Dec-19	144	50	281	63	43.81
18-Jan-20	36	19	57	10	28.44
04-Feb-20	51	23	78	15	27.69
03-Mar-20	36	8	77	19	51.97
04-Apr-20	4	0	12	4	93.29
08-Jun-20	0	0	0	0	0.00
24-Jun-20	4	0	12	4	92.96
23-Jul-20	4	0	12	4	93.35
31-Aug-20	36	21	48	10	27.89
12-Sep-20	20	4	39	9	46.38
15-Oct-20	324	73	706	169	52.16
22-Nov-20	82	59	106	13	14.90
31-Dec-20	616	432	804	97	15.61
16-Jan-21	966	587	1383	202	20.91
22-Feb-21	67	35	97	16	23.70
05-Mar-21	32	11	58	12	38.54
10-Apr-21	0	0	0	0	0.00
14-May-21	0	0	0	0	0.00
15-Jun-21	0	0	0	0	0.00
14-Jul-21	0	0	0	0	0.00
16-Aug-21	0	0	0	0	0.00
01-Sep-21	4	0	12	4	91.34

Table 3-15 Mean seasonal peak population estimate of all kittiwakes (flying and sitting) in each season within the Project array area plus 2 km buffer between October 2019 and September 2021

Kittiwake	Population estimate	Lower 95% confidence	Upper 95% confidence	Density estimate	Lower 95% confidence	Upper 95% confidence
Migration free breeding season	2	0	6	0.02	0	0.06
Autumn migration	2022	829	3420	18.5	7.59	31.3
Spring migration	508	305	730	4.65	2.79	6.68

Table 3-16 Percentage of aged kittiwakes in each age class averaged across all surveys in each season

Season	Adult	Immature	Juvenile
Migration free breeding season	100%	0%	0%
Autumn migration	86%	0%	14%
Spring migration	83%	17%	0%

3.4 Common guillemot

38 The density and mean seasonal peak population estimates are provided for guillemot for input into collision risk modelling (Volume 3, Technical Appendix 11.3: Collision Risk Modelling) and displacement assessment (Volume 3, Technical Appendix 11.4: Displacement Analysis).

39 Population estimates of guillemots within the Project array area varied considerably by season, with maximum population estimates indicating over three times as many birds may be present in the non-breeding season compared to the breeding season (Table 3-17). Maximum population estimates were calculated at 11,002 birds (±95% CI 8,415 – 13,571) and 3,468 birds (±95% CI 2,701 – 4,464) for the non-breeding and breeding season respectively.

40 For flying birds within the Project array area, densities were low over the breeding season in Year 1, with peak densities estimated in December 2020 in the non-breeding season at 2.56 birds/km^2 (±95% CI 1.06 – 4.47; Figure 4; Table 3-18). In Year 2, the highest densities were estimated in March 2021 in the breeding season at 1.92 birds/km^2 (±95% CI 0.08 – 5.09).

41 When analysing the Project array area plus 2 km buffer, very low numbers of guillemots were recorded during the migration free breeding season (Table 3-19). Across the full 24-month period, population estimates for the region peaked in August 2020, equating to 22,963 birds (±95% CI 18,572 – 27,301).

42 Mean seasonal peaks for all guillemots within the Project array area plus 2 km buffer were estimated at 3,558 birds (±95% CI 2,697 – 4,740) in the migration free breeding season and 15,324 birds (±95% CI 11,731 – 19,168) in the non-breeding season, equating to densities of 32.55 birds//km2 (±95% CI 24.67 - 43.37) and 140.21 birds/km2 (±95% CI 107.33 - 175.40) respectively (Table 3-20).

Table 3-17 Maximum absolute population estimates for guillemots in each season within the Project array area between October 2019 and September 2021, adjusted for availability bias

Guillemot	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Migration free breeding season	3468	2701	4464	282	8.13	Mar	2021
Non-breeding	11002	8415	13571	1415	12.86	Aug	2020

3.4.1 Input densities for CRM

Figure 4 Monthly densities of flying guillemots within the Project array area between October 2019 and September 2021

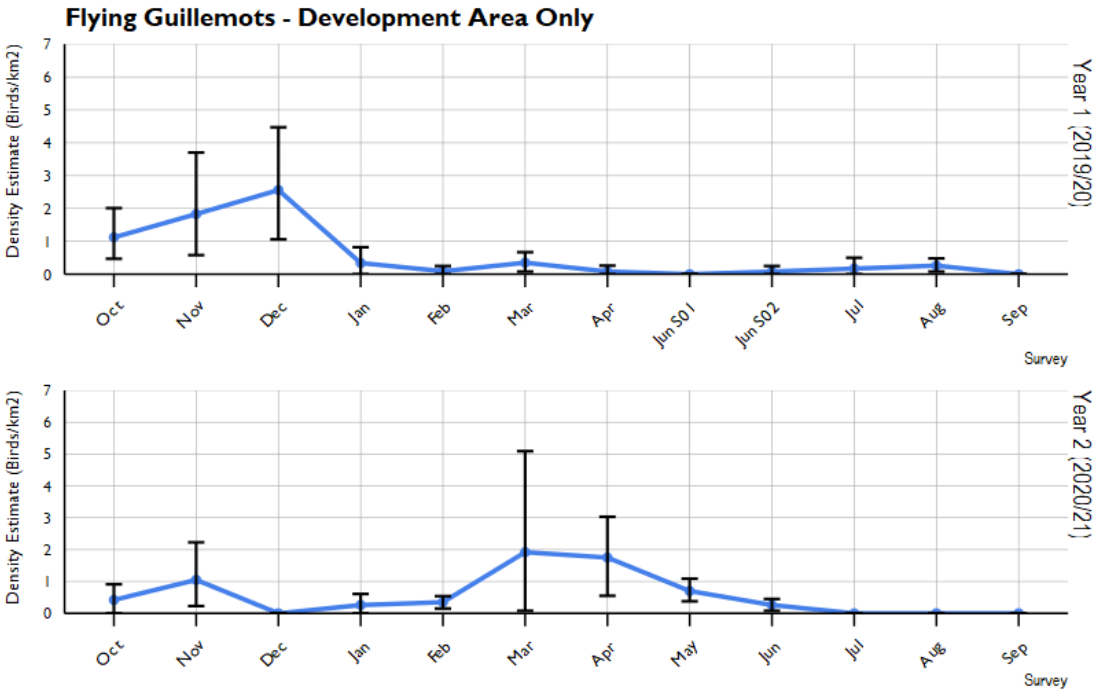

Table 3-18 Density estimates of flying guillemots within the Project array area between October 2019 and September 2021

Guillemot	Density estimate (n/km²)	Lower 95% confidence limit of density (n/km²)	Upper 95% confidence limit of density (n/km²)	Standard deviation of density (n/km²)	CV (%)
22-Oct-19	1.12	0.47	2.01	0.41	35.19
08-Nov-19	1.83	0.58	3.70	0.87	46.81
04-Dec-19	2.56	1.06	4.47	0.94	35.93
18-Jan-20	0.34	0.00	0.82	0.23	65.56
04-Feb-20	0.09	0.00	0.25	0.09	86.41
03-Mar-20	0.35	0.08	0.67	0.16	43.03
04-Apr-20	0.08	0.00	0.26	0.09	93.57
08-Jun-20	0.00	0.00	0.00	0.00	0.00
24-Jun-20	0.08	0.00	0.25	0.09	89.48
23-Jul-20	0.17	0.00	0.50	0.16	89.54
31-Aug-20	0.26	0.08	0.48	0.11	42.44
12-Sep-20	0.00	0.00	0.00	0.00	0.00
15-Oct-20	0.42	0.00	0.91	0.25	57.70
22-Nov-20	1.05	0.23	2.23	0.60	54.62
31-Dec-20	0.00	0.00	0.00	0.00	0.00
16-Jan-21	0.26	0.00	0.61	0.16	60.75
22-Feb-21	0.35	0.15	0.54	0.11	30.17
05-Mar-21	1.92	0.08	5.09	1.47	76.35
10-Apr-21	1.75	0.55	3.03	0.67	37.44
14-May-21	0.70	0.38	1.09	0.21	27.15
15-Jun-21	0.26	0.08	0.45	0.11	36.89
14-Jul-21	0.00	0.00	0.00	0.00	0.00
16-Aug-21	0.00	0.00	0.00	0.00	0.00
01-Sep-21	0.00	0.00	0.00	0.00	0.00

3.4.2 Input densities and abundances for displacement modelling

Table 3-19 Monthly absolute population estimates of all guillemots (flying and sitting) within the Project array area plus 2 km buffer between October 2019 and September 2021, corrected for availability bias

Guillemot	Absolute population estimate	Lower 95% confidence	Upper 95% confidence	Standard deviation	CV (%)
22-Oct-19	7685	4890	11036	1679	21.85
08-Nov-19	1259	839	1747	210	16.68
04-Dec-19	1606	1263	1938	159	9.90
18-Jan-20	666	492	850	86	12.91
04-Feb-20	182	103	268	42	23.08
03-Mar-20	426	235	653	102	23.94
04-Apr-20	199	133	270	36	18.09
08-Jun-20	80	36	133	23	28.75
24-Jun-20	539	400	702	80	14.84
23-Jul-20	597	420	803	96	16.08
31-Aug-20	22963	18572	27301	2582	11.24
12-Sep-20	5876	5077	6774	462	7.86
15-Oct-20	6824	5755	7853	541	7.93
22-Nov-20	5552	4906	6214	325	5.85
31-Dec-20	1780	1365	2238	238	13.37
16-Jan-21	2282	1916	2615	188	8.24
22-Feb-21	685	523	894	92	13.43
05-Mar-21	6577	4993	8778	994	15.11
10-Apr-21	746	473	1040	113	15.15
14-May-21	1113	945	1293	80	7.19
15-Jun-21	655	476	855	94	14.35
14-Jul-21	200	108	299	53	26.50
16-Aug-21	51	0	153	52	101.96
01-Sep-21	62	14	120	30	48.39

Table 3-20 Absolute mean seasonal peak population estimate of all guillemots (flying and sitting) in each season within the Project array area plus 2 km buffer between October 2019 and September 2021, corrected for availability bias

Guillemot	Population estimate	Lower 95% confidence	Upper 95% confidence	Density estimate	Lower 95% confidence	Upper 95% confidence
Migration free breeding season	3558	2697	4740	32.55	24.67	43.37
Non-breeding	15324	11731	19168	140.21	107.33	175.4

3.5 Razorbill

43 Mean seasonal peak population estimates are provided for razorbill for input into displacement assessment (Volume 3, Technical Appendix 11.4: Displacement Analysis).

44 Population estimates of razorbills within the Project array area varied, with maximum absolute population estimates remaining low during the breeding season and autumn migration period, peaking in the spring migration period (Table 3-21). Maximum estimates in the spring migration period were calculated as over four times higher as during autumn migration, with 363 birds (±95% CI 119 - 627) and 82 birds (±95% CI 28 – 137) estimated respectively.

45 Although maximum absolute population estimates for the development area suggest the spring migration period hosts the largest population of razorbills, mean seasonal peaks for the 2 km buffer area indicate this may occur during the autumn migration period, with a population of 1,228 birds (±95% CI 683 – 1,971) estimated at this time, equating to densities of 11.23 birds/km^2 (±95% CI 6.24 – 18.04; Table 3-23). In Year 1, absolute population estimates ranged from 0 birds (±95% CI 0 – 0), such as in June 2020, to 2,189 birds (±95% CI 1,264 – 3,411) in October 2019, while in Year 2 estimates ranged between 0 birds (±95% CI 0 – 0), such as in July 2021, and 848 birds (±95% CI 343 – 1,408) in January 2021 (Table 3-22).

Table 3-21 Maximum absolute population estimates for razorbills in each season within the Project array area between October 2019 and September 2021, adjusted for availability bias

Razorbill	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Migration free breeding season	84	28	136	33	39.29	Apr	2020
Autumn migration	82	28	137	24	29.27	Oct	2019
Non-breeding	250	104	417	71	28.40	Nov	2019
Spring migration	363	119	627	152	41.87	Jan	2021

3.5.1 Input densities and abundances for displacement modelling

Table 3-22 Monthly absolute population estimates of all razorbills (flying and sitting) within the Project array area plus 2 km buffer between October 2019 and September 2021, corrected for availability bias

Razorbill	Absolute population estimate	Lower 95% confidence	Upper 95% confidence	Standard deviation	CV (%)
22-Oct-19	2189	1264	3411	627	28.64
08-Nov-19	510	320	739	106	20.78
04-Dec-19	104	57	161	30	28.85
18-Jan-20	72	13	148	41	56.94
04-Feb-20	9	0	27	6	66.67
03-Mar-20	44	4	101	20	45.45
04-Apr-20	166	77	260	54	32.53
08-Jun-20	0	0	0	0	0.00
24-Jun-20	5	0	15	6	120.00
23-Jul-20	15	0	43	16	106.67
31-Aug-20	81	37	143	35	43.21
12-Sep-20	120	59	188	40	33.33
15-Oct-20	268	101	532	102	38.06
22-Nov-20	107	40	175	35	32.71
31-Dec-20	622	218	1105	262	42.12
16-Jan-21	848	343	1408	316	37.26
22-Feb-21	77	22	138	28	36.36
05-Mar-21	133	48	263	68	51.13
10-Apr-21	29	5	62	18	62.07
14-May-21	39	10	73	20	51.28
15-Jun-21	9	0	27	6	66.67
14-Jul-21	0	0	0	0	0.00
16-Aug-21	0	0	0	0	0.00
01-Sep-21	0	0	0	0	0.00

Table 3-23 Absolute mean seasonal peak population estimate of all razorbills (flying and sitting) in each season within the Project array area plus 2 km buffer between October 2019 and September 2021, corrected for availability bias

Razorbill	Population estimate	Lower 95% confidence	Upper 95% confidence	Density estimate	Lower 95% confidence	Upper 95% confidence
Migration free breeding season	103	43	167	0.93	0.39	1.53
Autumn migration	1228	683	1971	11.23	6.24	18.04
Non-breeding	566	269	922	5.17	2.46	8.42
Spring migration	460	178	778	4.2	1.63	7.11

3.6 Atlantic puffin

46 Mean seasonal peak population estimates are provided for puffin for input into displacement assessment (Volume 3, Technical Appendix 11.4: Displacement Analysis).

47 Maximum population estimates for puffin indicate most individuals are present in the Project array area during the breeding season, with 242 birds (±95% CI 141 – 358) estimated to be present, compared to 19 birds (±95% CI 0 – 51) in the non-breeding season (Table 3-24).

48 In Year 1, absolute population estimates for birds within the Project array area plus a 2 km buffer ranged from 0 birds (±95% CI 0 – 0), such as in January 2020, to 904 birds (±95% CI 683 – 1,161) in April 2020, while in Year 2 estimates ranged between 0 birds (±95% CI 0 – 0), such as in December 2021, and 497 birds (±95% CI 348 – 653) in June 2021 (Table 3-25).

49 Mean seasonal peaks for the additional 2 km buffer also indicate the breeding season is most important for the species at the Project, with 449 birds (±95% CI 297 – 616) estimated during the breeding season, equating to densities for the region of 4.11 birds/km2 (±95% CI 2.71– 5.62; Table 3-26).

Table 3-24 Maximum absolute population estimates for puffins in each season within the Project array area between October 2019 and September 2021, adjusted for availability bias

Puffin	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Migration free breeding season	242	141	358	66	27.27%	Jun	2021
Non-breeding	19	0	51	20	105.26%	Mar	2021

3.6.1 Input densities and abundances for displacement modelling

Table 3-25 Monthly absolute population estimates of all puffins (flying and sitting) within the Project array area plus 2 km buffer between October 2019 and September 2021, corrected for availability bias

Puffin	Absolute population estimate	Lower 95% confidence	Upper 95% confidence	Standard deviation	CV (%)
22-Oct-19	41	0	120	42	102.44
08-Nov-19	0	0	0	0	0.00
04-Dec-19	9	0	22	8	88.89
18-Jan-20	0	0	0	0	0.00
04-Feb-20	0	0	0	0	0.00
03-Mar-20	8	0	23	8	100.00
04-Apr-20	904	683	1161	139	15.38
08-Jun-20	0	0	0	0	0.00
24-Jun-20	402	246	578	93	23.13
23-Jul-20	5	0	14	6	120.00
31-Aug-20	19	5	38	11	57.89
12-Sep-20	5	0	14	6	120.00
15-Oct-20	0	0	0	0	0.00
22-Nov-20	0	0	0	0	0.00
31-Dec-20	0	0	0	0	0.00
16-Jan-21	0	0	0	0	0.00
22-Feb-21	0	0	0	0	0.00
05-Mar-21	23	0	66	21	91.30
10-Apr-21	85	38	140	24	28.24
14-May-21	190	72	344	81	42.63
15-Jun-21	497	348	653	88	17.71
14-Jul-21	23	5	48	14	60.87
16-Aug-21	9	0	27	11	122.22
01-Sep-21	9	0	22	7	77.78

Table 3-26 Absolute mean seasonal peak population estimate of all puffins (flying and sitting) in each season within the Project array area plus 2 km buffer between October 2019 and September 2021, corrected for availability bias

Puffin	Population estimate	Lower 95% confidence	Upper 95% confidence	Density estimate	Lower 95% confidence	Upper 95% confidence
Migration free breeding season	449	297	616	4.11	2.71	5.62
Non-breeding	32	0	93	0.29	0	0.85

3.7 Great black-backed gull

50 The density estimates are provided for great black-backed gull for input into collision risk modelling (Volume 3, Technical Appendix 11.3: Collision Risk Modelling).

51 Flying great black-backed gulls reached peak densities in the Project array area during the non-breeding period, peaking in December in both Year 1 and Year 2, reaching densities of 0.09 birds/km^2 (±95% CI 0.00 – 0.25) and 0.18 birds/km^2 (±95% CI 0.00 – 0.38) in 2019 and 2020 respectively (Table 3-28; Figure 5).

52 The proportion of birds at collision risk height was the same across all turbine scenarios, with approximately one bird out of three likely to be flying at collision risk height (Table 3-29).

53 Although the species were sporadically recorded during the breeding season between May and July, observations were so few that densities within development site were negligible, giving population estimates for the region of 0 birds (±95% CI 0 – 0) at this time.

54 Across the Project array area and 4km buffer, most great black-backed gulls were aged as adults, which made up 80% and 69% of aged birds in the breeding season and non-breeding season respectively (Table 3-30).

Table 3-27 Maximum population estimates for great black-backed gulls in each season in the Project array area between October 2019 and September 2021

Great black-backed gull	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Migration free breeding season	0	0	0	0	0.00	n/a	n/a
Non-breeding	12	4	20	5	38.70	Dec	2020

3.7.1 Input densities for CRM

Figure 5 Monthly densities of flying great black-backed gulls within the Project array area between October 2019 and September 2021

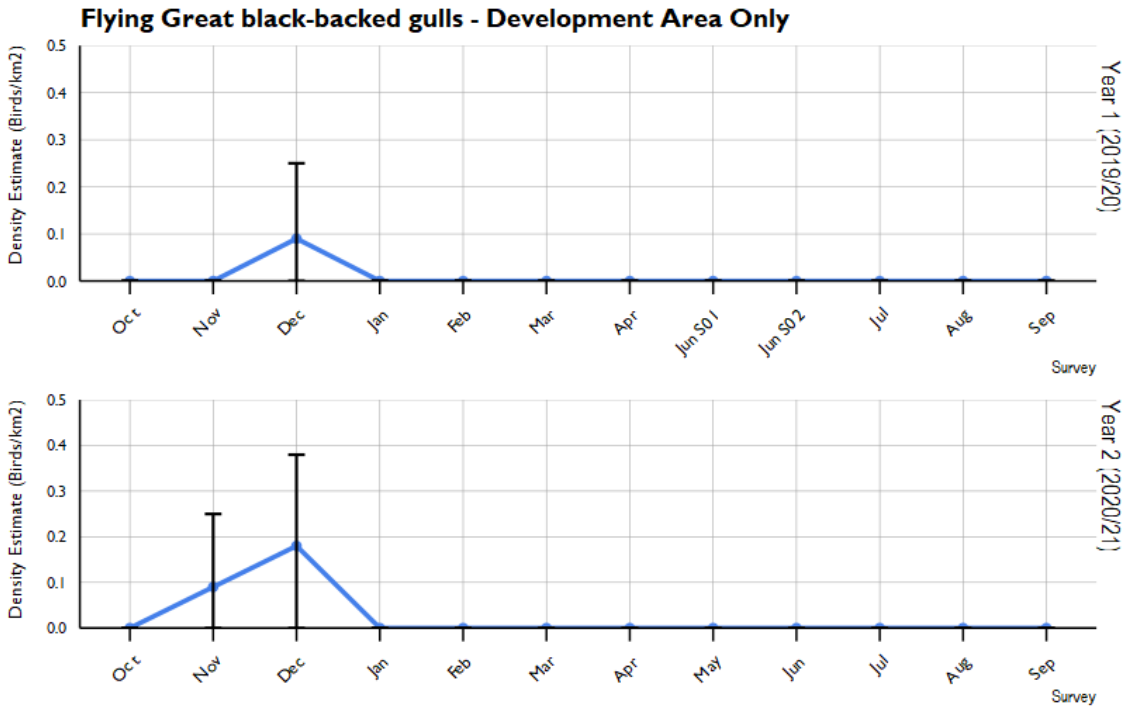

Table 3-28 Density estimates of flying great black-backed gulls within the Project array area between October 2019 and September 2021

Great black-backed gull	Density estimate (n/km²)	Lower 95% confidence limit of density (n/km²)	Upper 95% confidence limit of density (n/km²)	Standard deviation of density (n/km²)	CV (%)
22-Oct-19	0.00	0.00	0.00	0.00	0.00
08-Nov-19	0.00	0.00	0.00	0.00	0.00
04-Dec-19	0.09	0.00	0.25	0.09	83.08
18-Jan-20	0.00	0.00	0.00	0.00	0.00
04-Feb-20	0.00	0.00	0.00	0.00	0.00
03-Mar-20	0.00	0.00	0.00	0.00	0.00
04-Apr-20	0.00	0.00	0.00	0.00	0.00
08-Jun-20	0.00	0.00	0.00	0.00	0.00
24-Jun-20	0.00	0.00	0.00	0.00	0.00
23-Jul-20	0.00	0.00	0.00	0.00	0.00
31-Aug-20	0.00	0.00	0.00	0.00	0.00
12-Sep-20	0.00	0.00	0.00	0.00	0.00
15-Oct-20	0.00	0.00	0.00	0.00	0.00
22-Nov-20	0.09	0.00	0.25	0.09	88.56
31-Dec-20	0.18	0.00	0.38	0.11	55.03
16-Jan-21	0.00	0.00	0.00	0.00	0.00
22-Feb-21	0.00	0.00	0.00	0.00	0.00
05-Mar-21	0.00	0.00	0.00	0.00	0.00
10-Apr-21	0.00	0.00	0.00	0.00	0.00
14-May-21	0.00	0.00	0.00	0.00	0.00
15-Jun-21	0.00	0.00	0.00	0.00	0.00
14-Jul-21	0.00	0.00	0.00	0.00	0.00
16-Aug-21	0.00	0.00	0.00	0.00	0.00
01-Sep-21	0.00	0.00	0.00	0.00	0.00

Table 3-29 Proportion of flying great black-backed gulls at potential collision risk height for three turbine scenarios in the Project array area

Scenario	Rotor swept area (m)	Number of birds in development area	Proportion at PCH
9.5 MW	22 – 196	3	0.33
14 MW	22 - 244	3	0.33
16-18 MW	22 – 270	3	0.33

Table 3-30 Percentage of aged great black-backed gulls in each age class averaged across all surveys in each season

Season	Adult	Immature	Juvenile
Migration free breeding season	80%	20%	0%
Non-breeding	69%	30%	1%

3.8 Lesser black-backed gull

55 The density estimates are provided for lesser black-backed gull for input into collision risk modelling (Volume 3, Technical Appendix 11.3: Collision Risk Modelling).

56 In both survey years, peaks of lesser black-backed gulls occurred during the migration free breeding season, with population estimates for the Project array area during this season estimated at 38 birds (±95% CI 11 – 69; Table 3-31). Densities of flying lesser black-backed gulls within the Project array area varied between months, peaking in July in Year 1 and June in Year 2, reaching densities of 0.61 birds/km^2 (±95% CI 0.23 – 1.07) and 0.86 birds/km^2 (±95% CI 0.17 – 1.60) in 2019 and 2020 respectively (Table 3-32; Figure 6).

57 Proportions of flying birds at collision risk height varied per scenario: 72% under the 14 MW and 16-18 MW turbine scenarios (Table 3-33). Proportions are marginally lower for the 9 MW turbine scenario, decreasing to 67%.

58 Across all seasons, adults were the predominant life history stage recorded, with over 75% adults present in all seasons. The highest proportion of immature birds was recorded in the autumn migration period, making up 25% of birds (Table 3-34).

Table 3-31 Maximum population estimates for lesser black-backed gulls in each season within the Project array area between October 2019 and September 2021

Lesser black-backed gull	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Migration free breeding season	38	11	69	16	39.95	June	2021
Autumn migration	8	0	17	5	57.80	Aug	2021
Non-breeding	0	0	0	0	0	n/a	n/a
Spring migration	0	0	0	0	0	n/a	n/a

3.8.1 Input densities for CRM

Figure 6 Monthly densities of flying lesser black-backed gulls within the Project array area between October 2019 and September 2021

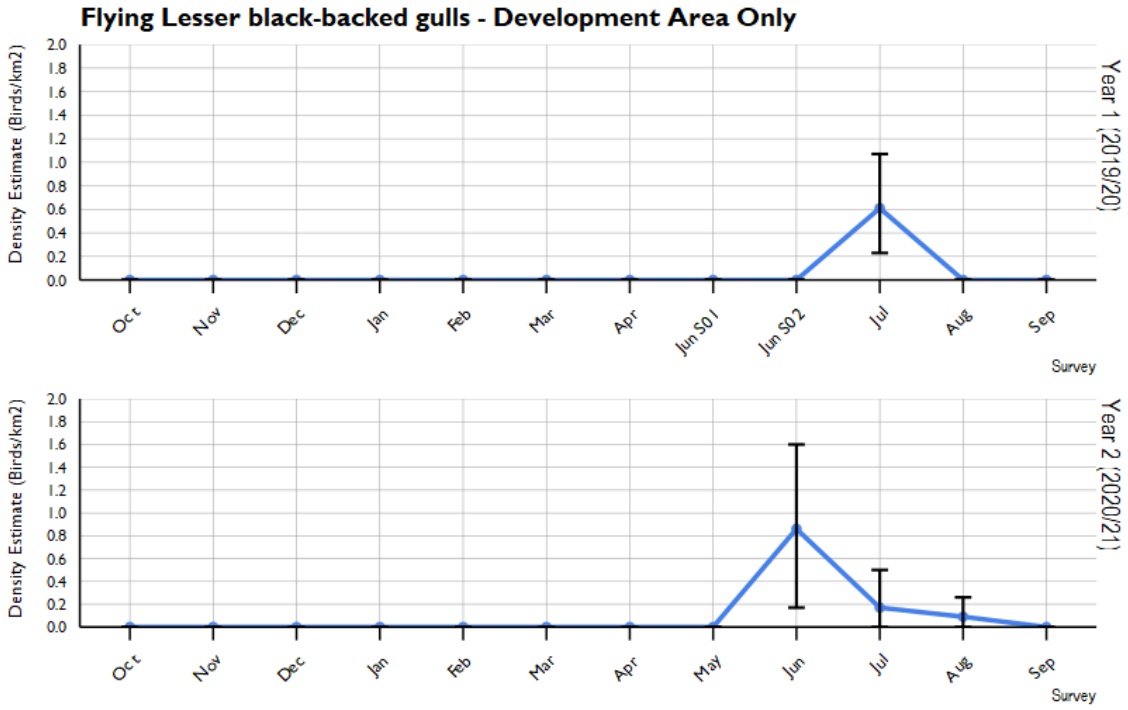

Table 3-32 Density estimates of flying lesser black-backed gulls within the Project array area between October 2019 and September 2021

Lesser black-backed gull	Density estimate (n/km²)	Lower 95% confidence limit of density (n/km²)	Upper 95% confidence limit of density (n/km²)	Standard deviation of density (n/km²)	CV (%)
22-Oct-19	0.00	0.00	0.00	0.00	0.00
08-Nov-19	0.00	0.00	0.00	0.00	0.00
04-Dec-19	0.00	0.00	0.00	0.00	0.00
18-Jan-20	0.00	0.00	0.00	0.00	0.00
04-Feb-20	0.00	0.00	0.00	0.00	0.00
03-Mar-20	0.00	0.00	0.00	0.00	0.00
04-Apr-20	0.00	0.00	0.00	0.00	0.00
08-Jun-20	0.00	0.00	0.00	0.00	0.00
24-Jun-20	0.00	0.00	0.00	0.00	0.00
23-Jul-20	0.61	0.23	1.07	0.23	34.46
31-Aug-20	0.00	0.00	0.00	0.00	0.00
12-Sep-20	0.00	0.00	0.00	0.00	0.00
15-Oct-20	0.00	0.00	0.00	0.00	0.00
22-Nov-20	0.00	0.00	0.00	0.00	0.00
31-Dec-20	0.00	0.00	0.00	0.00	0.00
16-Jan-21	0.00	0.00	0.00	0.00	0.00
22-Feb-21	0.00	0.00	0.00	0.00	0.00
05-Mar-21	0.00	0.00	0.00	0.00	0.00
10-Apr-21	0.00	0.00	0.00	0.00	0.00
14-May-21	0.00	0.00	0.00	0.00	0.00
15-Jun-21	0.86	0.17	1.60	0.37	41.75
14-Jul-21	0.17	0.00	0.50	0.16	89.06
16-Aug-21	0.09	0.00	0.26	0.09	89.80
01-Sep-21	0.00	0.00	0.00	0.00	0.00

Table 3-33 Proportion of flying lesser black-backed gulls at potential collision risk height for three turbine scenarios in the Project array area

Scenario	Rotor swept area (m)	Number of birds in development area	Proportion at PCH
9.5 MW	22 – 196	18	0.67
14 MW	22 - 244	18	0.72
16-18 MW	22 – 270	18	0.72

Table 3-34 Percentage of aged lesser black-backed gulls in each age class averaged across all surveys in each season

Season	Adult	Immature	Juvenile
Migration free breeding season	78%	22%	0%
Autumn migration	75%	25%	0%
Non-breeding	100%	0%	0%
Spring migration	100%	0%	0%

3.9 Herring gull

59 The density estimates are provided for herring gull for input into collision risk modelling (Volume 3, Technical Appendix 11.3: Collision Risk Modelling).

60 Flying herring gulls within the Project array area reached peak densities during the non-breeding period, peaking in March 2020 in Year 1 at 0.25 birds/km^2 (±95% CI 0.00 – 0.74) and February 2021 in Year 2 at 0.34 birds/km^2 (±95% CI 0.15 – 0.57; Table 3-36; Figure 7). In Year 1, multiple peaks in density were observed, occurring in December, March and July; however, in Year 2 only one peak was recorded, occurring in February 2021.

61 The proportion of herring gull at collision risk height was relatively high, 60%, for each of the three different turbine scenarios (Table 3-37).

62 During the migration-free breeding season, 100% of birds were recorded as adults, while during the non-breeding season the proportion of younger birds in the population was more equal, with 58% and 42% of birds recorded as adults and immatures respectively (Table 3-38).

Table 3-35 Maximum population estimates for herring gulls in each season within the Project array area between October 2019 and September 2021

Herring gull	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Migration free breeding season	8	0	22	7	87.99%	Jul	2020
Non-breeding	186	17	476	135	72.84	Feb	2021

3.9.1 Input densities for CRM

Figure 7 Monthly densities of flying herring gulls within the Project array area between October 2019 and September 2021

Table 3-36 Density estimates of flying herring gulls within the Project array area between October 2019 and September 2021

Herring gull	Density estimate (n/km²)	Lower 95% confidence limit of density (n/km²)	Upper 95% confidence limit of density (n/km²)	Standard deviation of density (n/km²)	CV (%)
22-Oct-19	0.00	0.00	0.00	0.00	0.00
08-Nov-19	0.00	0.00	0.00	0.00	0.00
04-Dec-19	0.08	0.00	0.25	0.09	90.06
18-Jan-20	0.00	0.00	0.00	0.00	0.00
04-Feb-20	0.09	0.00	0.25	0.09	88.11
03-Mar-20	0.25	0.00	0.74	0.25	92.65
04-Apr-20	0.00	0.00	0.00	0.00	0.00
08-Jun-20	0.00	0.00	0.00	0.00	0.00
24-Jun-20	0.00	0.00	0.00	0.00	0.00
23-Jul-20	0.17	0.00	0.50	0.16	88.93
31-Aug-20	0.00	0.00	0.00	0.00	0.00
12-Sep-20	0.00	0.00	0.00	0.00	0.00
15-Oct-20	0.00	0.00	0.00	0.00	0.00
22-Nov-20	0.00	0.00	0.00	0.00	0.00
31-Dec-20	0.00	0.00	0.00	0.00	0.00
16-Jan-21	0.00	0.00	0.00	0.00	0.00
22-Feb-21	0.34	0.15	0.57	0.14	33.86
05-Mar-21	0.00	0.00	0.00	0.00	0.00
10-Apr-21	0.00	0.00	0.00	0.00	0.00
14-May-21	0.00	0.00	0.00	0.00	0.00
15-Jun-21	0.00	0.00	0.00	0.00	0.00
14-Jul-21	0.00	0.00	0.00	0.00	0.00
16-Aug-21	0.00	0.00	0.00	0.00	0.00
01-Sep-21	0.00	0.00	0.00	0.00	0.00

Table 3-37 Proportion of flying herring gulls at potential collision risk height for the three turbine scenarios in the Project array area

Scenario	Rotor swept area (m)	Number of birds in development area	Proportion at PCH
9.5 MW	22 – 196	10	0.6
14 MW	22 - 244	10	0.6
16-18 MW	22 – 270	10	0.6

Table 3-38 Percentage of aged herring gulls in each age class averaged across all surveys in each season

Season	Adult	Immature	Juvenile
Migration free breeding season	100%	0%	0%
Non-breeding	58%	42%	0%

4 References

Barlow, J, Oliver, C.W., Jackson, T.D. and Taylor, B.L. (1988). Harbour porpoise *Phocoena phocoena*, abundance estimation for California, Oregon and Washington: II. *Fishery Bulletin* 86, 433-444.

Furness, R. W., Wade, H. M. and Masden, E.A. (2013). Assessing vulnerability of marine bird populations to offshore wind farms. *Journal of Environmental Management,* 119 pp.56-66.

Furness, R.W. (2015). *Non-breeding season populations of seabirds in UK waters: Population sizes for Biologically Defined Minimum Population Scales (BDMPS).* Natural England Commissioned Reports, Number 164.

McGregor, R.M., King, S., Donovan, C.R., Caneco, B. and Webb, A. (2018). *A Stochastic Collision Risk Model for Seabirds in Flight.* Report for Marine Scotland.

SNCB. (2017). *Joint SNCB Interim Displacement Advice Note.*

Spencer, S.M. (2012). *Diving behaviour and identification of sex of breeding Atlantic puffins (Fratercula arctica) and nest site characteristics of Alcids on Petit Manan Island, Maine.* MSc Thesis submitted to University of Massachusetts Amherst May 2012.

Thaxter, C.B., Wanless, S., Daunt, F., Harris, M.P., Benvenuti, S., Watanuki, Y., Grémillet, D. and Hamer, K.C. 2010. Influence of wing loading on the trade-off between pursuit-diving and flight in common guillemots and razorbills. *Journal of Experimental Biology,* 213, 1018-1025.