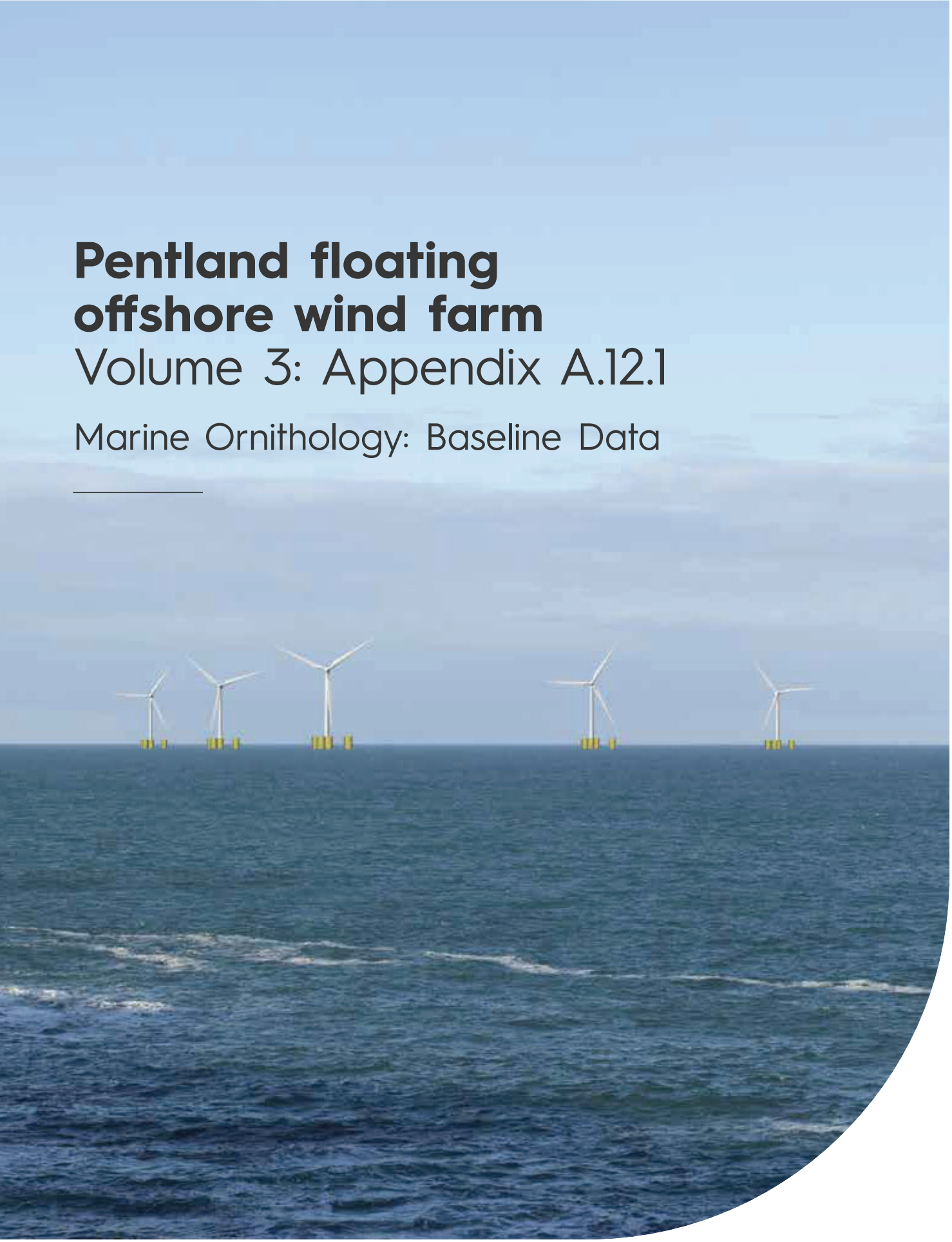
Pentland floating offshore wind farm

Volume 3: Appendix A.12.1

Marine Ornithology: Baseline Data



PENTLAND FLOATING OFFSHORE WIND FARM

OFFSHORE EIAR (VOLUME 3): TECHNICAL APPENDICES

APPENDIX 12.1: MARINE ORNITHOLOGY - BASELINE DATA

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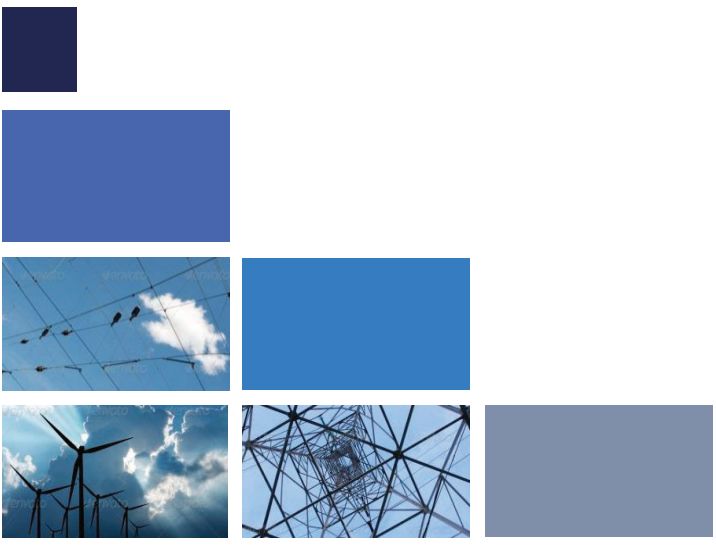

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Pentland Floating Offshore Wind Farm: Marine Ornithology 12.1 Technical Appendix - Baseline Data

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6	27/06/2022	Sixth draft, addressing final third-party review comments
7	14/07/2022	Seventh draft, final formatting
8	27/07/2022	Final report

Contents

Figures

Tables

Acronyms and abbreviations

Acronyms / abbreviation	Full name
ASL	Above Sea Level
BBRC	British Birds Rarities Committee
BDMPS	Biologically Defined Minimum Population Scales
COP	Copenhagen Offshore Partners
CRM	Collision Risk Modelling
CL	Confidence Limit
CV	Coefficient of Variance
DDC	Dounreay Demonstration Centre
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
ESAS	European Seabird at Sea Partnership
GIS	Geographical Information System
GPS	Global Positioning System
GSD	Ground Sample Distance
HiDef	HiDef Aerial Surveying Limited
HRA	Habitats Regulations Appraisal
HWL	Highland Wind Limited
MSP	Mean Seasonal Peak
MS-LOT	Marine Scotland Licensing Operations Team
MSS	Marine Scotland Science
NS	NatureScot
PFOWF	Pentland Floating Offshore Wind Farm
QA	Quality Assurance
RSPB	Royal Society for the Protection of Birds

1 Introduction

1 The proposed Pentland Floating Offshore Wind Farm (PFOWF) Array Area and Offshore Export Cable(s) (the 'Offshore Development') is located ~7.5 km off the Dounreay coast, Caithness. The seabed shelves from the coast in a north-westerly direction, reaching 50 m between 2 and 4 km from the shore. The seabed substrate is a mixture of sand and gravel. Situated to the west of Scapa Flow and to the north of Caithness, the site is relatively sheltered from high tidal speed, wave heights and main shipping routes.

2 In January 2015 and September 2020, Hexicon and Highland Wind Limited (HWL) respectively commissioned HiDef Aerial Surveying Limited (HiDef) to undertake a programme of high-resolution digital video aerial surveys of marine megafauna and ornithological -activity to support the previously consented Dounreay Tri Floating Wind demonstration Project ('Dounreay Tri') and the current proposal for the Offshore Development. In total 25 monthly surveys have been carried out. This report only considers ornithological activity; marine megafauna are addressed in the Offshore Environmental Impact Assessment Report (EIAR) (Volume 2) Chapter 11 Marine Mammals and Other Megafauna.

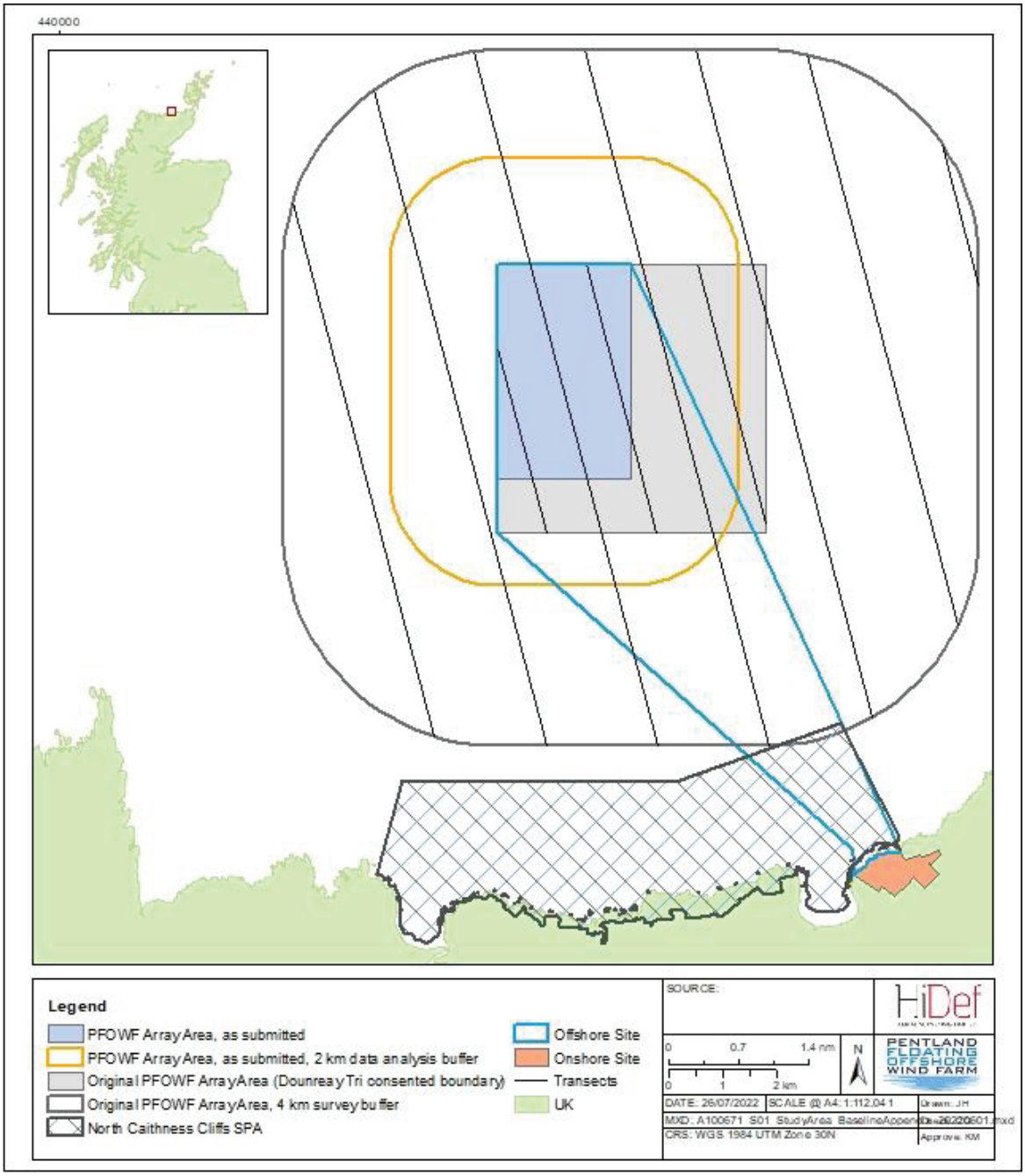
3 Thirteen surveys were undertaken between January and December 2015 for Dounreay Tri (twelve monthly surveys plus one extra survey in June), and a further twelve months between September 2020 and August 2021 for the PFOWF Array Area. Following receipt of the Scoping Opinion a pre-application meeting was held on 4 November 2021 to discuss whether it would be acceptable to use the older 2015 survey data together with the 2020/21 survey data to support the baseline characterisation for the PFOWF Array Area. Advice was received from Marine Scotland Science (MSS) and NatureScot (NS), and the approach was agreed in writing by Marine Scotland Licensing Operations Team (MS-LOT), in their email dated 24 November 2021. The full record of pre-application advice and liaison is provided in Technical Appendix 12.6 Marine Ornithology: Consultation Advice.

4 The survey data for each year have previously been analysed separately to each other and the results of these analyses are provided in each annual survey report. A summary of the survey findings for each year are presented in Annex A. The survey design remained the same between each year (2015 and 2020/21); 1 km transect spacing in the intended array areas for each proposal and 2 km transect spacing in the buffer. While a 2 km buffer area was agreed for Dounreay Tri and originally agreed for the Offshore Development, NS and the Royal Society for the Protection of Birds (RSPB) Scotland provided updated advice on the applicant's scoping report and requested a 4 km buffer be used. This was implemented in the surveys from April 2021 to August 2021, the results from which are presented in Annex A.

5 To inform the current assessment for the Offshore Development the 2015 survey data have been pooled with the 2020/21 survey data and reanalysed. In this regard, it is important to note that the submitted application is for a revised and reduced PFOWF Array Area as shown in Figure 1. This now measures 10 km^2 compared to the original project areas surveyed (25 km^2 for each of Dounreay Tri and the Offshore Development). This figure is for illustrative purposes only, to demonstrate changes to the original survey area and buffer. Original survey transects are shown, which are not those taken forward for final analysis after changes to the survey design.

6 In this regard, HiDef undertook preliminary analysis to confirm that there was still sufficient sampling effort and survey coverage for the revised and reduced PFOWF Array Area, as the number and length of transects had been reduced. This was confirmed with ~50% coverage achieved for the new PFOWF Array Area, and approximately 20% in the revised buffer. The survey design taken forward for analysis is shown in Figure 2 and data reanalysis further discussed in Section 2.1.

Figure 1 PFOWF Array Area, as submitted, with 2 km buffer; including original ornithology survey design and transects (North Caithness Cliffs SPA presented for reference).



7 Along with each annual survey report (2015 and 2020/21), data provided in this Technical Appendix supports baseline characterisation of the Offshore Development as presented in

Section 12.4 of the Offshore EIAR (Volume 2) Chapter 12, Marine Ornithology. These data also inform the impact modelling for ornithological interests as reported in Technical Appendix 12.3 Marine Ornithology: Collision Risk Modelling and Technical Appendix 12.4 Marine Ornithology: Displacement Analysis. Table 3 sets out how those data are analysed to provide the required inputs for each modelling method.

8 In this regard, data from the buffer zone between 2-4 km have not been further processed as they are not used in the quantitative assessment of impacts, either collision risk or displacement. These data are fully presented in the annual survey report for 2020/21 and a summary of what they show is presented in Annex A to this Technical Appendix.

9 The full range of bird species recorded during survey work are presented in Tables 5 – 8. As discussed at the meeting with MS-LOT, MSS, NS and RSPB Scotland held on 16 December 2021, species are scoped in for assessment where they have been recorded in reasonable numbers on-site, although these decisions were made from the original data analysis rather than that for the revised PFOWF Array Area. Due to changes in survey design, some species have been taken forward for assessment even though the estimated numbers present in the revised PFOWF Array Area are very low (for example, herring gull and great skua; Table 1).

10 The Baseline Description, Section 12.4.4 in the Offshore EIAR (Volume 2) Chapter 12, Marine Ornithology, sets out in more detail risks to species from various wind farm impacts. This Technical Appendix provides the required information to model collision risk and displacement for the species presented in Table 1.

Table 1 Species scoped in for impact modelling

Species	Latin name	Collision risk	Displacement
Black-legged kittiwake (hereafter 'kittiwake')	*Rissa tridactyla*	✓	✓
Common guillemot (hereafter 'guillemot')	*Uria aalge*	✗	✓
Razorbill	*Alca torda*	✗	✓
Atlantic puffin (hereafter 'puffin')	*Fratercula arctica*	✗	✓
Northern fulmar (hereafter 'fulmar')	*Fulmarus glacialis*	✓	✓
Northern gannet (hereafter 'gannet')	*Morus bassanus*	✓	✓
Arctic tern	*Sterna paradisaea*	✓	✓
Great black-backed gull	*Larus marinus*	✓	✗
Great skua	*Stercorarius skua*	✓	✓
Herring gull	*Larus argentatus*	✓	✗

11 To calculate the Mean Seasonal Peaks (MSP) needed for displacement assessment, seasons have to be defined. Following available guidance, and as presented at the meeting with MS-LOT, MSS, NS and RSPB held on 16 December 2021, these definitions are based on NatureScot (2020) guidance for the breeding season and Furness' Biologically Defined Minimum Population Scales (BDMPS) (2015) for the non-breeding season as set out in Table 2.

12 Dealing with overlap in the guidance between breeding and non-breeding seasons is discussed in Section 3.2 where it relates to the determination of mean seasonal peaks for displacement assessment.

Table 2 Seasons used in analysis

Species	NatureScot, 2020 Breeding season	Furness, 2015		
		Autumn migration	Non-breeding	Spring migration
Kittiwake	mid Apr - Aug	Aug - Dec	n/a	Jan - Apr
Guillemot	Apr - mid Aug	n/a	Aug - Feb	n/a
Razorbill	Apr - mid Aug	Aug - Oct	Nov - Dec	Jan - Mar
Puffin	Apr - mid Aug	n/a	Aug - Mar	n/a
Fulmar	Apr - mid Sep	Sep - Oct	Nov	Dec - Mar
Gannet	mid Mar - Sep	Sep - Nov	n/a	Dec - Mar
Arctic tern	May - Aug	Jul - mid Sep	n/a	Apr - May
Great black-backed gull	Apr - Aug	n/a	Sep - Mar	n/a
Great skua	mid Apr - mid Sep	Aug - Oct	Nov - Feb	Mar - Apr
Herring gull	Apr - Aug	n/a	Sep - Feb	n/a

2 Methods

2.1 Survey flights

13 A series of strip transects were flown monthly between January and December 2015 and between September 2020 and August 2021. Two surveys were flown in June 2015; survey one (S01) on 08 June 2015, and survey two (S02) on 30 June 2015.

14 HiDef designed the survey methodology to provide information suitable to support an Environmental Impact Assessment (EIA) and Habitats Regulations Appraisal (HRA) of the potential effects of a floating wind demonstration project, for which an accurate assessment of abundance and distribution of seabirds and marine mammals is required. Surveys commenced in 2020 were flown using a 1 km transect spacing and a 2 km transect spacing for the surrounding buffer as per the original Dounreay Tri Project area (Figure 1).

15 Transects extended roughly north-west to south-east, perpendicular to the depth contours along the coast. This helped to ensure that each transect sampled a range of habitats (primarily relating to water depth), to reduce variation in bird and marine mammal abundance estimates between transects. Transects used in data analysis are shown on Figure 2.

16 During the 2015 surveys, a 2 km buffer was surveyed, however, in 2020/21 the buffer size was altered during the survey period. A 2 km buffer was flown between September 2020 and March 2021, and a 4 km buffer flown between April and August 2021 (as explained in the Introduction). As also discussed in the Introduction, the 2-4 km buffer data have not been analysed for this Technical Appendix but a summary of what they show is presented in Annex A for context.

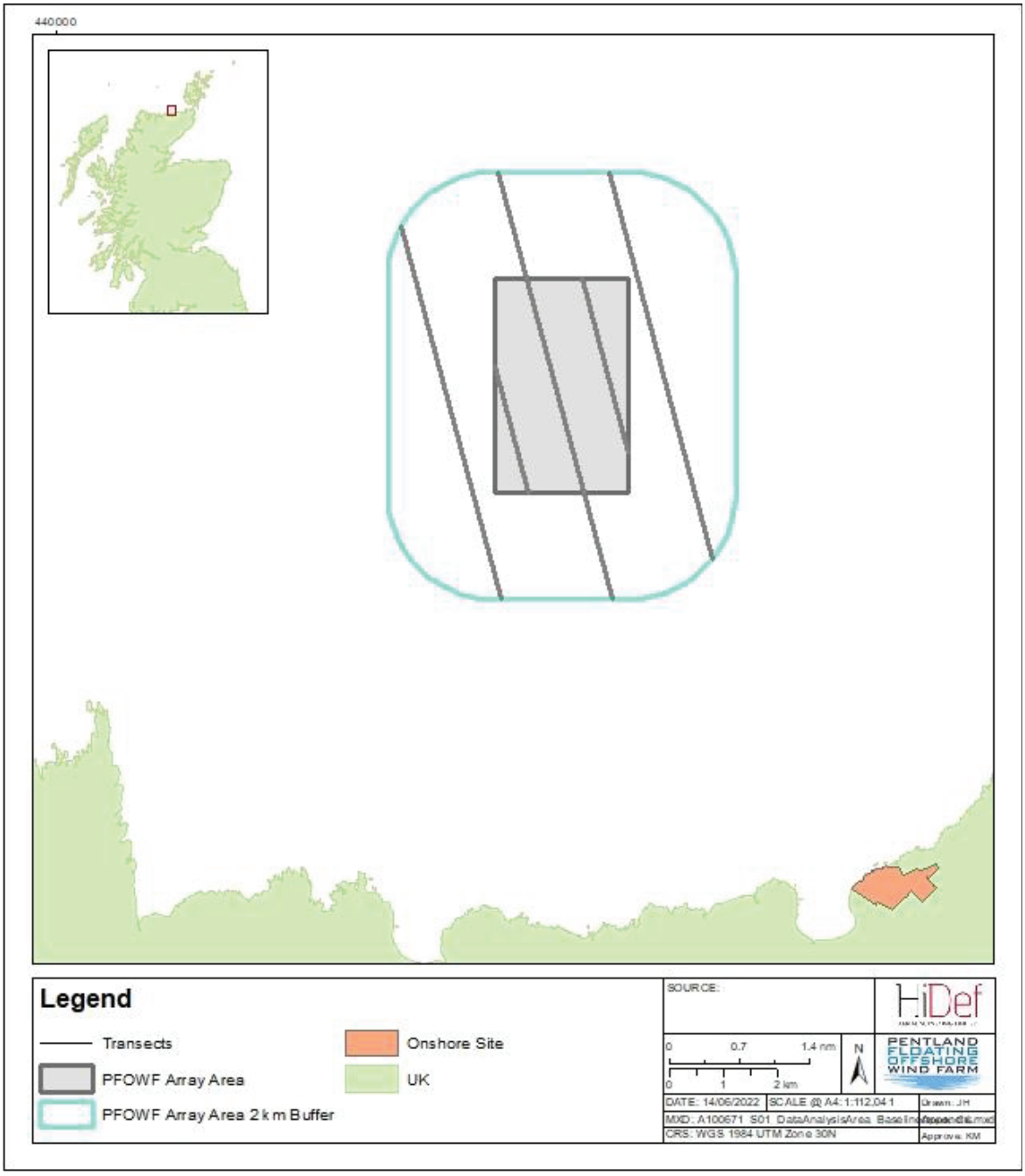
17 For the PFOWF Array Area an average of 50% coverage has been achieved for each year of survey, with approximately 20% coverage across the 2 km buffer. Only these data have been analysed for this Technical Appendix, a total area of ~49km^2.

18 Surveys were flown using an aircraft equipped with four HiDef Gen II digital video cameras with sensors set to a resolution of 2 cm Ground Sample Distance (GSD). Each camera sampled a strip of 125 m width, separated from the next camera by ~25 m, providing a combined sampled width of 500 m within a 575 m overall strip. Data captured from all four cameras were reviewed and used in data analysis.

19 Surveys were flown at a height of approximately 550m Above Sea Level (ASL) (~1800'). Flying at this height ensures there is no risk of flushing those species easily disturbed by aircraft noise. Thaxter *et al.* (2016) recommends a minimum flight altitude of 460 – 500 m ASL.

20 Position data for the aircraft were captured from a Garmin Global Positioning System (GPS) Map 296 receiver with differential GPS enabled to give 1 m accuracy for the positions and recording updates in location at one second intervals for later matching to bird and marine mammal observations.

Figure 2 PFOWF Array Area and 2 km buffer, showing 1 km and 2 km spaced transects used in data analysis



2.2 Data analysis

21 HiDef's process to review the digital aerial video survey footage is described in Annex B. Survey identification rates to species from original surveys performed in 2015 and 2020/2021 are presented with data summaries in Annex A.

2.2.1 Data treatment

22 All data within the PFOWF Array Area plus 2 km buffer were collated across the two years of survey work and compiled for analysis. Data from all surveys were trimmed to the relevant boundaries during analysis to ensure consistency across surveys, these being (i) PFOWF Array Area and (ii) PFOWF Array Area plus 2 km buffer.

23 Records identified to species level were separated out from records of individuals identified to group level, and the following analyses undertaken on both datasets. All confidence levels of species identifications were used in analysis.

24 Apportioning of 'unidentified' birds to species level was included for calculating density and population estimates. The number of unidentified birds in each species group were assigned to species where appropriate, based on their respective abundance ratios. For example, if identified guillemots and razorbills occurred in a 4:1 ratio, then 80% of unidentified birds would be assigned to guillemot and 20% assigned to razorbill.

25 Monthly population estimates are provided to help inform Baseline Characterisation for the Offshore Development, as set out for each species in the Results Section of this Technical Appendix. This information also informs the species summaries provided in Section 12.4.4 of the Offshore EIAR (Volume 2) Chapter 12, Marine Ornithology. The required information for impact modelling is set out in Table 3.

Table 3 Overview of analytical approaches

Output	Buffer size	Seabird subset	Requirement
Displacement	PFOWF Array Area + 2 km buffer	All birds (sitting and flying)	• MSP population estimates
Collision risk	PFOWF Array Area (no buffer)	Flying birds only	• Monthly densities of flying birds
Age-class analysis	PFOWF Array Area + 2 km buffer	Flying birds only	• Proportion of birds in each age class

2.2.2 Population estimates

26 Population estimates were calculated for the PFOWF Array Area alone, and for the PFOWF Array Area plus 2 km buffer.

27 Digital aerial survey data were collected along 1 km spaced transects in the PFOWF Array Area and a 2 km transect spacing for the surrounding buffer. The four cameras sample a survey "strip" transcending the transect line of 500m width. Each strip transect was treated as a statistically independent random sample from the site. The length and breadth (i.e., the width of the field of view of the camera) of each transect were multiplied to give the transect area; dividing the number of observations for each species on each transect by the transect area gives a point estimate of the density of that species for the transect.

28 The density of animals at the site (and hence the population size by multiplying by the area of the site), the standard deviation, the 95% Confidence Limits (CLs) and Coefficient of Variance (CV) were then estimated using a non-parametric block bootstrap method with replacement (Buckland *et al.*, 2001), to ensure equal transect effort was sampled across each bootstrap iteration. This was achieved using transect ID as the sampling unit with replacement. A group of transects were randomly sampled until their total length equalled approximately the same length as the total survey length.

29 A total of 1,000 bootstrap iterations were performed from which the mean and standard deviation of the sampled means were calculated, as well as the relative standard error (or CV), as defined by the standard deviation divided by the mean. Data were processed in the R programming language (version 4.1.1) and code can be provided on request.

30 Since transect spacing, and thus survey effort, within the PFOWF Array Area and buffer differed, abundance estimates were first calculated for each area separately then combined to give abundance and density estimates for the entire Ornithology Survey Area.

31 Lower CLs of population estimates were calculated by summing the respective estimates for the PFOWF Array Area and the buffer which were initially calculated separately. The same was done for upper CLs of population estimates. For density estimates, limits were calculated by dividing abundance by the total area in km^2 (PFOWF plus 2 km buffer). Standard Deviation (SD) of population estimates for the PFOWF Array Area plus 2 km buffer were derived by calculating the square root of the sum of the SD of the population estimate for the PFOWF Array Area to the power of two and the SD of the population estimate for the 2 km buffer to the power of two (rounded up to the nearest integer). The CV of the PFOWF Array Area plus 2 km buffer was calculated by dividing the new SD for the Ornithology Survey Area by the population estimate and multiplying by 100, rounded to two decimal places.

32 The density estimate is expressed as the average number of animals per square km in the whole area (Figure 2). The population estimate is expressed as the estimated number of animals within the whole area (i.e., the PFOWF Array Area plus 2 km buffer). The upper and lower CLs define the range that the population estimate falls within with 95% certainty. The CV is a measure of the precision of the population and density estimates.

33 Throughout this appendix, CVs are presented alongside CLs, since this metric is comparable across surveys and provides a quick and easy way to interpret variance around presented values. Following changes to the survey design post data collection, sample sizes for many species were small, increasing variation around mean values, leading to large CVs presented for some species/surveys.

34 For most species these abundance estimates relate to absolute abundance, but for diving species such as auks, the abundance relates to relative abundance, due to a proportion of animals being submerged at the time of survey. Section 2.2.3, describes the method for taking account of species availability to generate estimates of absolute abundance for auks.

2.2.3 Availability bias

35 In wildlife surveys, a proportion of seabirds or marine mammals that spend any time underwater, especially while feeding, will not be detectable at the surface. This 'availability bias' leads to an under-estimate of their abundance during surveys. For species, such as gannet, that make long dives underwater, this bias might be significant.

36 Within the Ornithology Survey Area, availability bias relates to the observations of the auk species (guillemot, razorbill and puffin). The method for applying a correction factor to account for availability bias is set out in Annex C and the 'absolute' population estimates (adjusted to correct for availability bias) are presented for each species in Table C1.1 to Table C1.12 It is these 'absolute' population estimates that are presented in Section 3.4 Guillemot, Section 3.5 Razorbill and Section 3.6 Puffin. They are used to calculate the Mean Seasonal Peaks (MSP) required for displacement analysis (Table 3) and discussed below in Section 2.2.4.

2.2.4 Mean seasonal peaks

37 MSP population estimates, calculated for each species in each appropriate season (see Table 2), were taken as an average over the two years of surveying.

38 For example, the MSP population estimate for kittiwake in the breeding season was calculated as the average of the peak count of kittiwake in the breeding season in year one (2015) and the peak count in the breeding season in year two (2020/21). Confidence intervals were calculated as an average of the lower and upper confidence limits of both peak counts and are presented for reference only.

39 For seasons starting or ending halfway through the month, the 15/16 was used as a mid-month cut off. Surveys were assigned to a season (Table 2) based on the date that the survey was flown.

40 For the three auk species (guillemot, razorbill and puffin), the MSPs that are presented have been adjusted for availability bias to account for birds likely to be diving at the time of survey (as discussed in Section 2.2.3 and Annex C).

2.2.5 Age proportions

41 To assess the proportion of birds in each age class (adult, immature, juvenile), the average number of birds recorded in each class was calculated across all surveys that occurred in each season. For example, if there were four surveys in the breeding season in Year one (2015) and four surveys in the breeding season in Year two (2020/21), then the average number of adult birds was calculated across eight surveys in total. This was conducted using all data within the PFWOF Array Area and 2 km boundary. Surveys were assigned to a season (Table 2) based on the date that the survey was flown. For seasons starting or ending halfway through the month, the 15/16 was used as a mid-month cut off.

42 The resulting percentage in each class was calculated as a proportion of the sum of the average number in each age class. This is presented for species where aging was possible; namely flying gulls and gannet. It is particularly relevant to assessment for kittiwake where NS advise that age-class apportioning for the breeding season be based on the survey data collected.

3 Results

3.1 Survey results

43 Following data analysis each identified object was assigned to at least a species group, and where possible these were also assigned a species identification, with confidence levels of 'Possible', 'Probable' or 'Definite'. Any animals that could not be identified to species level were assigned to a category 'No ID' in the species column. The analysis of data to species level uses all levels of identification confidence. The overall identification rate of birds and non-avian animals to species level for the 25 surveys flown to the original survey design are presented in Annex A: Table A4.1

44 The total numbers of species detected in each survey flight are presented in Table 4 to Table 7 for the PFOWF Array Area and for the PFOWF Array Area plus 2 km buffer.

45 Compared to other surveys, relatively high numbers of puffin were recorded in June 2015 and June 2021. In June 2015, a secondary survey was performed to determine if elevated abundance was likely to be typical of the area or could possibly be attributed to local, temporary feeding conditions. The second June 2015 survey revealed numbers comparable to other surveys performed between January and December 2015.

46 Drifting of birds on the water surface was suggested as a possible reason for elevated puffin abundance in June 2021. The time of these surveys were compared to state of the tide (Table 8).

47 The two surveys with relatively high puffin abundance (8 June 2015 and 15 June 2021) were flown at different states of the tide (ebb and slack, respectively). When considering the June 2021 survey especially, the state of the tide (slack tide; within a 1-hour window of high tide where tidal flow is likely to be at its lowest) was unlikely to cause congregation of birds on the water surface. Coupled with the small size of the survey area and the speed of the plane (~210 km/hr), the risk of double counting is deemed to be low.

48 Differing survey coverage across the PFOWF Array Area and the 2 km buffer was also considered as a potential explanation for relatively high puffin abundance in this survey, however, analysis indicates for the updated survey design coverage for the buffer and PFOWF Array Area were calculated at 20% and 50% respectively (also see paragraph 15). This high level of survey coverage should be more than effective at capturing baseline site characteristics.

49 If applicable, issues associated with tidal state and survey coverage should be consistent across species and surveys, further indicating any relatively high abundance may be attributed to temporary, local foraging conditions.

3.2 Determining mean seasonal peaks

50 For many of the species being assessed, there is an overlap between breeding and non-breeding seasons as defined by the relevant guidance (NatureScot, 2020 and Furness, 2015), Table 2. Where this could affect assessment, i.e., for any peak count in an overlap month, it is preferentially assigned to the breeding season (as defined in NatureScot, 2020). This avoids double-counting in the estimation of the MSPs. Where this has been necessary for a species, it is noted in the discussion of the results.

Table 4 Number of objects detected per survey, assigned to species level in the PFOWF Array Area only between January and December 2015

Species	Scientific name	Month													Total
		Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15-S01	Jun-15-S02	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	
Golden plover	*Pluvialis apricaria*	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Kittiwake	*Rissa tridactyla*	1	3	1	1	0	17	24	5	1	1	5	19	0	**78**
Common gull	*Larus canus*	0	0	0	0	0	0	0	0	0	0	1	0	0	**1**
Great black-backed gull	*Larus marinus*	1	1	2	0	0	0	0	0	0	0	4	1	3	**12**
Herring gull	*Larus argentatus*	0	0	0	0	0	0	0	0	0	0	2	0	0	**2**
Lesser black-backed gull	*Larus fuscus*	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Arctic tern	*Sterna paradisaea*	0	0	0	0	0	0	5	2	0	0	0	0	0	**7**
Great skua	*Stercorarius skua*	0	0	0	0	1	0	1	0	0	0	0	0	0	**2**
Arctic skua	*Stercorarius parasiticus*	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Guillemot	*Uria aalge*	10	10	14	4	9	44	61	48	3	6	23	49	12	**293**
Razorbill	*Alca torda*	1	0	0	0	0	1	2	0	0	2	0	1	0	**7**
Puffin	*Fratercula arctica*	0	0	0	0	3	179	22	3	1	0	0	0	0	**208**
Red-throated diver	*Gavia stellata*	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Fulmar	*Fulmarus glacialis*	8	8	3	17	0	1	3	1	15	1	0	4	0	**61**
Manx shearwater	*Puffinus puffinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Gannet	*Morus bassanus*	0	0	1	0	0	0	1	0	5	4	0	0	0	**11**

Table 5 Number of objects detected per survey assigned to species level in the PFOWF Array Area plus 2 km buffer between January and December 2015

Species	Scientific name	Month													Total
		Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15-S01	Jun-15-S02	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	
Golden plover	*Pluvialis apricaria*	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Kittiwake	*Rissa tridactyla*	2	7	5	3	2	61	82	54	3	4	5	62	35	**325**
Common gull	*Larus canus*	0	1	0	0	0	0	0	0	0	0	1	0	0	**2**
Great black-backed gull	*Larus marinus*	3	2	3	0	0	0	0	0	38	0	6	1	4	**57**
Herring gull	*Larus argentatus*	0	0	0	0	0	0	0	0	0	0	2	0	0	**2**
Lesser black-backed gull	*Larus fuscus*	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Arctic tern	*Sterna paradisaea*	0	0	0	0	0	1	19	19	0	0	0	0	0	**39**
Great skua	*Stercorarius skua*	0	0	0	0	1	0	1	0	1	0	0	0	0	**3**
Arctic skua	*Stercorarius parasiticus*	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Guillemot	*Uria aalge*	32	63	75	21	39	128	167	98	5	24	60	92	69	**873**
Razorbill	*Alca torda*	5	0	0	0	0	3	15	0	0	3	1	1	6	**34**
Puffin	*Fratercula arctica*	0	0	0	1	14	667	76	4	6	1	2	0	0	**771**
Red-throated diver	*Gavia stellata*	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**
Fulmar	*Fulmarus glacialis*	15	36	13	31	2	3	4	3	491	6	0	15	0	**619**
Manx shearwater	*Puffinus puffinus*	0	0	0	0	0	0	0	5	0	0	0	0	0	**5**
Gannet	*Morus bassanus*	0	0	3	0	0	1	34	0	27	19	0	2	0	**86**

Table 6 Number of objects detected per survey assigned to species level in the PFOWF Array Area only between September 2020 and August 2021

Species	Scientific name	Month												Total
		Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	
Golden plover	*Pluvialis apricaria*	1	0	0	0	0	0	0	0	0	0	0	0	**1**
Kittiwake	*Rissa tridactyla*	1	0	3	0	0	0	7	0	5	65	26	4	**111**
Common gull	*Larus canus*	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Great black-backed gull	*Larus marinus*	0	4	3	1	3	0	0	0	0	0	0	0	**11**
Herring gull	*Larus argentatus*	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Lesser black-backed gull	*Larus fuscus*	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Arctic tern	*Sterna paradisaea*	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Great skua	*Stercorarius skua*	0	0	0	0	0	0	0	0	0	1	0	0	**1**
Arctic skua	*Stercorarius parasiticus*	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Guillemot	*Uria aalge*	73	10	4	0	11	4	12	31	4	59	25	81	**314**
Razorbill	*Alca torda*	1	0	0	0	1	0	0	1	11	15	0	0	**29**
Puffin	*Fratercula arctica*	1	0	0	0	0	0	0	30	30	828	50	3	**942**
Red-throated diver	*Gavia stellata*	0	0	0	0	1	0	0	0	0	1	0	0	**2**
Fulmar	*Fulmarus glacialis*	6	0	0	0	13	3	31	0	9	0	0	2	**64**
Manx shearwater	*Puffinus puffinus*	0	0	0	0	0	0	0	0	0	1	0	0	**1**
Gannet	*Morus bassanus*	21	4	0	0	0	0	0	0	0	4	0	10	**39**

Table 7 Number of objects detected per survey assigned to species level in the PFOWF Array Area plus 2 km buffer between September 2020 and August 2021

Species	Scientific name	Month												Total
		Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	
Golden plover	*Pluvialis apricaria*	1	0	0	0	0	0	0	0	0	0	0	0	**1**
Kittiwake	*Rissa tridactyla*	2	5	4	1	0	0	18	1	82	230	101	20	**464**
Common gull	*Larus canus*	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Great black-backed gull	*Larus marinus*	0	10	5	4	6	1	0	0	0	0	0	0	**26**
Herring gull	*Larus argentatus*	0	0	2	0	0	0	0	0	0	2	0	0	**4**
Lesser black-backed gull	*Larus fuscus*	0	0	0	0	0	1	0	0	0	0	0	0	**1**
Arctic tern	*Sterna paradisaea*	0	0	0	0	0	0	0	0	0	2	4	4	**10**
Great skua	*Stercorarius skua*	0	0	0	0	0	0	0	0	2	2	0	0	**4**
Arctic skua	*Stercorarius parasiticus*	0	0	0	0	0	0	0	0	0	0	1	0	**1**
Guillemot	*Uria aalge*	206	33	17	0	56	6	33	51	33	200	105	320	**1,060**
Razorbill	*Alca torda*	3	0	0	0	1	0	0	8	15	44	1	8	**80**
Puffin	*Fratercula arctica*	1	0	0	0	0	0	0	146	81	2,542	96	11	**2,877**
Red-throated diver	*Gavia stellata*	0	0	0	0	1	0	0	0	0	3	0	0	**4**
Fulmar	*Fulmarus glacialis*	12	1	1	0	70	7	60	1	22	5	1	7	**187**
Manx shearwater	*Puffinus puffinus*	0	0	0	0	0	0	0	0	0	3	0	0	**3**
Gannet	*Morus bassanus*	56	11	0	0	0	0	1	1	0	17	3	22	**111**

Table 8 State of the tide and transect start times for surveys flown in June 2015 and June 2021

Survey Date	Transect number (east to west)					High tide (UTC)	Low tide (UTC)	State of the tide during survey
	1	2	3	4	5			
08/06/2015	14:41	14:46	14:49	14:54	14:58	12:46	18:50	Ebb
30/06/2015	11:54	11:50	11:46	11:40	11:36	07:07	13:21	Ebb
15/06/2021	11:32	11:27	11:20	11:16	11:10	11:40	05:32	Slack

3.3 Kittiwake

51 This survey data analysis helps inform the baseline description for kittiwake set out in Section 12.4.4.1 of the Offshore EIAR (Volume 2) Chapter 12, Marine Ornithology. Kittiwake sensitivity to wind farm impacts is discussed in Chapter 12 and summarised in Table 1 in the Introduction to this Technical Appendix.

52 In this regard, kittiwake are deemed sensitive to both collision risk and displacement impacts, so density estimates are provided for input into Collision Risk Modelling (CRM), Technical Appendix 12.3 Marine Ornithology: Collision Risk Modelling, and MSP estimates are provided for input into the displacement assessment, Technical Appendix 12.4 Marine Ornithology: Displacement Analysis. Please see Table 3 for a summary of the data requirements in this regard.

53 Maximum population estimates within the PFOWF Array Area ranged between 14 birds (95% CI 6 – 25) and 134 birds (95% CI 105 – 170) for the spring migration and breeding season, respectively (Table 9). Generally, population estimates were higher over the summer period, peaking in June S01 2015 in Year one and June 2021 in Year two (Table 10).

54 Across all seasons, most birds were aged as adults, with few immature and juvenile birds recorded during the survey programme (Table 11). The highest proportion of adults were recorded during the spring migration period, while more immature and juvenile birds were recorded during the breeding season and autumn migration period.

55 Within the PFOWF Array Area, flying kittiwake were recorded in varying densities (Table 12), ranging between 0.00 birds/km^2 (e.g., September 2015) and 9.05 birds/km^2 (95% CI 5.72 – 12.10; June 2021). Peak densities of flying kittiwake were calculated for November 2015 in Year one and June 2021 in Year two.

56 Generally, densities of flying kittiwake within the PFOWF Array Area were low during the autumn migration period, with the exception of November 2015, where elevated densities of flying kittiwake were observed.

57 Population estimates for all kittiwake in the PFOWF Array Area plus the 2 km buffer varied between months, ranging between 0 birds (e.g., January 2021) to 808 birds (95% CI 517 – 975) in June 2021 (Table 13). The MSP calculated for the breeding season was considerable higher than that for the migratory periods (Table 14).

Table 9 Maximum population estimates for kittiwake in each season within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Kittiwake	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Breeding	134	105	170	18	12.87	Jun	2021
Autumn migration	39	12	60	12	29.26	Nov	2015
Spring migration	14	6	25	5	37.16	Mar	2021

Table 10 Monthly population estimates for kittiwake within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Kittiwake	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	3	0	6	2	69.90
25 February 2015	7	0	12	4	49.15
13 March 2015	3	0	5	2	66.01
09 April 2015	2	0	5	2	66.56
09 May 2015	0	0	0	0	0.00
08 June 2015	34	19	46	8	22.50
30 June 2015	50	6	101	27	52.63
14 July 2015	10	5	18	4	39.39
05 August 2015	2	0	5	2	70.41
28 September 2015	2	0	6	2	79.69
13 October 2015	10	2	20	5	43.79
25 November 2015	39	12	60	12	29.26
03 December 2015	0	0	0	0	0.00
24 September 2020	3	0	5	2	67.21
14 October 2020	0	0	0	0	0.00
12 November 2020	7	2	11	3	35.86
10 December 2020	0	0	0	0	0.00
08 January 2021	0	0	0	0	0.00
02 February 2021	0	0	0	0	0.00
01 March 2021	14	6	25	5	37.16
22 April 2021	0	0	0	0	0.00
20 May 2021	11	5	19	4	31.77
15 June 2021	134	105	170	18	12.87
02 July 2021	54	35	82	14	25.34
13 August 2021	9	4	12	3	30.46

Table 11 Percentage of aged kittiwake (n = 516) in each age class averaged across all surveys in each season

Season	Adult	Immature	Juvenile
Breeding	95.90%	3.86%	0.24%
Autumn migration	87.91%	3.30%	8.79%
Spring migration	100.00%	0.00%	0.00%

3.3.1 Input densities for Collision Risk Modelling (CRM)

Table 12 Monthly density estimates of flying kittiwake within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Kittiwake	Density estimate (n/km²)	Lower 95% confidence limit (n/km²)	Upper 95% confidence limit (n/km²)	Standard deviation (n/km²)	CV (%)
19 January 2015	0.21	0.00	0.57	0.20	72.03
25 February 2015	0.61	0.00	1.13	0.40	49.69
13 March 2015	0.20	0.00	0.48	0.20	65.82
09 April 2015	0.19	0.00	0.49	0.20	67.06
09 May 2015	0.00	0.00	0.00	0.00	0.00
08 June 2015	2.99	1.72	3.98	0.60	19.32
30 June 2015	3.46	0.00	8.22	2.60	73.95
14 July 2015	0.99	0.48	1.75	0.40	38.86
05 August 2015	0.20	0.00	0.48	0.20	70.89
28 September 2015	0.00	0.00	0.00	0.00	0.00
13 October 2015	0.79	0.00	1.93	0.60	66.16
25 November 2015	3.60	1.17	5.42	1.10	28.40
03 December 2015	0.00	0.00	0.00	0.00	0.00
24 September 2020	0.21	0.00	0.48	0.20	64.20
14 October 2020	0.00	0.00	0.00	0.00	0.00
12 November 2020	0.42	0.18	0.61	0.20	24.76
10 December 2020	0.00	0.00	0.00	0.00	0.00
08 January 2021	0.00	0.00	0.00	0.00	0.00
02 February 2021	0.00	0.00	0.00	0.00	0.00
01 March 2021	0.93	0.56	1.47	0.30	24.63
22 April 2021	0.00	0.00	0.00	0.00	0.00
20 May 2021	0.60	0.48	0.72	0.10	10.16
15 June 2021	9.05	5.72	12.10	1.70	17.80
02 July 2021	5.30	3.21	8.14	1.50	26.55
13 August 2021	0.79	0.33	1.17	0.30	30.10

3.3.2 Input densities and abundances for displacement modelling

Table 13 Monthly population estimates of all kittiwake (flying and sitting) within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Kittiwake	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	8	0	16	4	50.00
25 February 2015	24	0	45	10	41.67
13 March 2015	20	9	29	5	25.00
09 April 2015	11	4	16	3	27.27
09 May 2015	9	0	19	6	66.67
08 June 2015	217	168	259	18	8.29
30 June 2015	285	71	569	117	41.05
14 July 2015	213	133	305	44	20.66
05 August 2015	11	0	37	10	90.91
28 September 2015	15	0	35	10	66.67
13 October 2015	10	2	20	5	50.00
25 November 2015	214	94	357	59	27.57
03 December 2015	146	56	235	50	34.25
24 September 2020	8	0	15	4	50.00
14 October 2020	21	0	43	12	57.14
12 November 2020	12	2	21	5	41.67
10 December 2020	4	0	10	3	75.00
08 January 2021	0	0	0	0	0.00
02 February 2021	0	0	0	0	0.00
01 March 2021	58	31	88	12	20.69
22 April 2021	5	0	10	3	60.00
20 May 2021	334	57	627	147	44.01
15 June 2021	808	517	975	100	12.38
02 July 2021	368	81	995	243	66.03
13 August 2021	76	27	168	39	51.32

Table 14 Mean seasonal peak population estimates of all kittiwake (flying and sitting) in each season within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Kittiwake	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit
Breeding	547	294	772
Autumn migration	118	47	200
Spring migration	41	16	67

3.4 Guillemot

58 This survey data analysis helps inform the baseline description for guillemot set out in Section 12.4.4.2 of the Offshore EIAR (Volume 2) Chapter 12, Marine Ornithology. Guillemot sensitivity to wind farm impacts is discussed in Chapter 12 and summarised in Table 1 in the Introduction to this Technical Appendix. In this regard, guillemot are deemed sensitive to displacement impacts, so MSP estimates are provided for displacement assessment, Technical Appendix 12.4 Marine Ornithology: Displacement Analysis. Please see Table 3 for a summary of the data requirements.

59 Maximum absolute population estimates within the PFOWF Array Area were calculated at 217 birds (95% CI 75 – 417) for the breeding season and 201 birds (95% CI 166 – 223) in the non-breeding season (Table 15). This accounted for the overlap in seasons between NatureScot (2020) and Furness (2015) guidance, where the peak population estimate recorded on 13 August 2021 was assigned to the breeding season, and the estimate for 24 September 2020 was taken as the peak for the non-breeding season.

60 Absolute population estimates of guillemot within the PFOWF Array Area varied between season, with greatest numbers observed during summer breeding season months and lowest during the winter non-breeding season (Table 16).

61 When analysing the PFOWF Array Area plus 2 km buffer, lower absolute abundance of guillemot were recorded during the non-breeding season (Table 17). Across the 25 months of survey, absolute population estimates for the region peaked in August 2021, equating to 1,546 birds (95% CI 1,003 – 2,220).

62 Absolute MSP for all guillemot within the PFOWF Array Area plus 2 km buffer were estimated at 1,146 birds (95% CI 712 – 1,692) in the breeding season and 651 birds (95% CI 530 – 817) in the non-breeding season (Table 18).

Table 15 Maximum absolute population estimates for guillemot in each season within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Guillemot	Maximum absolute population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Breeding	217	75	417	89	41.01	Aug	2021
Non-breeding	201	166	223	16	7.96	Sep	2020

Table 16 Monthly absolute population estimates for guillemot within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Guillemot	Absolute population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	29	16	59	13	44.83
25 February 2015	28	16	46	8	28.57
13 March 2015	34	16	49	10	29.41
09 April 2015	11	0	18	6	54.55
09 May 2015	23	15	25	3	13.04
08 June 2015	117	83	163	23	19.66
30 June 2015	162	54	327	85	52.47
14 July 2015	126	20	255	65	51.59
05 August 2015	8	0	19	5	62.50
28 September 2015	17	13	20	3	17.65
13 October 2015	63	57	71	3	4.76
25 November 2015	138	70	245	57	41.30
03 December 2015	33	16	51	7	21.21
24 September 2020	201	166	223	16	7.96
14 October 2020	29	14	46	10	34.48
12 November 2020	12	5	17	4	33.33
10 December 2020	0	0	0	0	0.00
08 January 2021	30	20	38	7	23.33
02 February 2021	17	3	33	8	47.06
01 March 2021	34	26	46	7	20.59
22 April 2021	76	13	145	31	40.79
20 May 2021	16	0	34	11	68.75
15 June 2021	165	80	289	42	25.45
02 July 2021	72	46	99	12	16.67
13 August 2021	217	75	417	89	41.01

3.4.1 Input densities and abundances for displacement modelling

Table 17 Monthly absolute population estimates of all guillemot (flying and sitting) within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Guillemot	Absolute population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	152	38	315	73	48.03
25 February 2015	313	101	595	139	44.41
13 March 2015	316	213	423	46	14.56
09 April 2015	96	48	144	18	18.75
09 May 2015	172	115	233	19	11.05
08 June 2015	577	399	779	82	14.21
30 June 2015	745	421	1,163	163	21.88
14 July 2015	404	92	799	145	35.89
05 August 2015	19	0	46	11	57.89
28 September 2015	119	47	185	41	34.45
13 October 2015	275	248	300	13	4.73
25 November 2015	374	250	607	74	19.79
03 December 2015	366	213	562	98	26.78
24 September 2020	927	810	1,026	48	5.18
14 October 2020	153	59	266	54	35.29
12 November 2020	78	37	132	13	16.67
10 December 2020	0	0	0	0	0.00
08 January 2021	279	196	357	42	15.05
02 February 2021	34	3	68	13	38.24
01 March 2021	150	62	254	47	31.33
22 April 2021	176	53	311	40	22.73
20 May 2021	189	39	404	94	49.74
15 June 2021	942	589	1,286	124	13.16
02 July 2021	494	178	876	148	29.96
13 August 2021	1,546	1,003	2,220	272	17.59

Table 18 Absolute mean seasonal peak population estimates of all guillemot (flying and sitting) in each season within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Guillemot	Absolute population estimate	Lower 95% confidence limit	Upper 95% confidence limit
Breeding	1,146	712	1,692
Non-breeding	651	530	817

3.5 Razorbill

63 This survey data analysis helps inform the baseline description for razorbill set out in Section 12.4.4.3 of the Offshore EIAR (Volume 2) Chapter 12, Marine Ornithology. Razorbill sensitivity to wind farm impacts is discussed in Chapter 12 and summarised in Table 1 in the Introduction to this Technical Appendix. In this regard, razorbill are deemed sensitive to displacement impacts, so MSP estimates are provided for displacement assessment, Technical Appendix 12.4 Marine Ornithology: Displacement Analysis. Please see Table 3 for a summary of the data requirements.

64 Maximum absolute population estimates within the PFOWF Array Area ranged between four birds (95% CI 0 – 6) during the spring migration period and 40 birds (95% CI 13 – 73) in the breeding season (Table 19). Across all surveys, absolute population estimates of razorbill varied but were generally quite low with zero birds recorded in many surveys (Table 20).

65 When analysing the PFOWF Array Area plus 2 km buffer, a similar seasonal pattern is apparent (Table 21). Absolute population estimates for the region ranged between 0 birds (e.g. February 2015) and 76 birds (95% CI 24 – 125; in June S02 2015) in Year one and between 0 birds (e.g. October 2020) and 191 birds (95% CI 109 – 276; in June 2021) in Year two.

66 Absolute MSP for all razorbill within the PFOWF Array Area plus 2 km buffer were estimated at 134 birds (95% CI 67 - 201) in the breeding season and 14 birds (95% CI 0 – 32) in the spring migration period (Table 22).

Table 19 Maximum absolute population estimates for razorbill in each season within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Razorbill	Maximum absolute population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Breeding	40	13	73	20	50.00	Jun	2021
Autumn migration	10	5	15	4	40.00	Aug	2021
Non-breeding	4	0	7	3	75.00	Nov	2015
Spring migration	4	0	6	3	75.00	Jan	2015 and 2020

Table 20 Monthly absolute population estimates for razorbill within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Razorbill	Absolute population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	4	0	7	3	75.00
25 February 2015	0	0	0	0	0.00
13 March 2015	0	0	0	0	0.00
09 April 2015	0	0	0	0	0.00
09 May 2015	0	0	0	0	0.00
08 June 2015	4	1	7	3	75.00
30 June 2015	6	2	7	3	50.00
14 July 2015	0	0	0	0	0.00
05 August 2015	0	0	0	0	0.00
28 September 2015	10	5	15	4	40.00
13 October 2015	0	0	0	0	0.00
25 November 2015	4	0	7	3	75.00
03 December 2015	0	0	0	0	0.00
24 September 2020	4	0	7	3	75.00
14 October 2020	0	0	0	0	0.00
12 November 2020	0	0	0	0	0.00
10 December 2020	0	0	0	0	0.00
08 January 2021	4	0	6	3	75.00
02 February 2021	0	0	0	0	0.00
01 March 2021	0	0	0	0	0.00
22 April 2021	4	0	7	3	75.00
20 May 2021	39	26	52	6	15.38
15 June 2021	40	13	73	20	50.00
02 July 2021	0	0	0	0	0.00
13 August 2021	0	0	0	0	0.00

3.5.1 Input densities and abundances for displacement modelling

Table 21 Monthly absolute population estimates of all razorbill (flying and sitting) within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Razorbill	Absolute population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	24	0	57	18	75.00
25 February 2015	0	0	0	0	0.00
13 March 2015	0	0	0	0	0.00
09 April 2015	0	0	0	0	0.00
09 May 2015	0	0	0	0	0.00
08 June 2015	15	1	32	10	66.67
30 June 2015	76	24	125	29	38.16
14 July 2015	0	0	0	0	0.00
05 August 2015	0	0	0	0	0.00
28 September 2015	16	5	27	7	43.75
13 October 2015	6	1	13	4	66.67
25 November 2015	4	0	7	3	75.00
03 December 2015	34	15	49	10	29.41
24 September 2020	15	1	32	10	66.67
14 October 2020	0	0	0	0	0.00
12 November 2020	0	0	0	0	0.00
10 December 2020	0	0	0	0	0.00
08 January 2021	4	0	6	3	75.00
02 February 2021	0	0	0	0	0.00
01 March 2021	0	0	0	0	0.00
22 April 2021	40	1	77	24	60.00
20 May 2021	62	26	96	16	25.81
15 June 2021	191	109	276	38	19.90
02 July 2021	6	1	13	5	83.33
13 August 2021	42	1	87	27	64.29

Table 22 Absolute mean seasonal peak population estimates of all razorbill (flying and sitting) in each season within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Razorbill	Absolute population estimate	Lower 95% confidence limit	Upper 95% confidence limit
Breeding	134	67	201
Autumn migration	16	3	30
Non-breeding	17	8	25
Spring migration	14	0	32

3.6 Puffin

67 This survey data analysis helps inform the baseline description for puffin set out in Section 12.4.4.4 of the Offshore EIAR (Volume 2) Chapter 12, Marine Ornithology. Puffin sensitivity to wind farm impacts is discussed in Chapter 12 and summarised in Table 1 in the Introduction to this Technical Appendix. In this regard, puffin are deemed sensitive to displacement impacts, so MSP estimates are provided for displacement assessment, Technical Appendix 12.4 Marine Ornithology: Displacement Analysis. Please see Table 3 for a summary of the data requirements.

68 Absolute maximum population estimates for puffin show seasonality, with most individuals present in the PFOWF Array Area during the breeding season. There is an overlap in seasons between NatureScot (2020) and Furness (2015) guidance therefore, August counts (5 August 2015 and 13 August 2021) were assigned to the breeding season. Peak population estimate for the breeding season were calculated at 2,003 birds (95% CI 1,454 – 2,401; June 2021), compared to 3 birds (95% CI 0 – 8; September 2020) in the non-breeding season (Table 23; Table 24).

69 In year one, absolute population estimates for all puffin within the PFOWF Array Area plus 2 km buffer ranged from 0 birds (e.g. January 2015), to 2,848 birds (95% CI 2,326 – 3,422) in June S01 2015, while in Year two estimates ranged between 0 birds, (e.g. October 2020), and 10,194 birds (95% CI 7,226 – 12,208) in June 2021 (Table 25).

70 Mean absolute seasonal peaks were highest during the breeding season, calculated at 6,521 birds (95% CI 4,776 – 7,815; Table 26).

Table 23 Maximum absolute population estimates for puffin in each season within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Puffin	Maximum absolute population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Breeding	2,003	1,454	2,401	283	14.13	Jun	2021
Non-breeding	3	0	8	3	100.00	Sep	2015

Table 24 Monthly absolute population estimates for puffin within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Puffin	Absolute population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	0	0	0	0	0.00
25 February 2015	0	0	0	0	0.00
13 March 2015	0	0	0	0	0.00
09 April 2015	0	0	0	0	0.00
09 May 2015	8	0	19	7	87.50
08 June 2015	419	325	542	69	16.47
30 June 2015	52	34	83	16	30.77
14 July 2015	7	0	14	4	57.14
05 August 2015	2	0	7	3	150.00
28 September 2015	0	0	0	0	0.00
13 October 2015	0	0	0	0	0.00
25 November 2015	0	0	0	0	0.00
03 December 2015	0	0	0	0	0.00
24 September 2020	3	0	8	3	100
14 October 2020	0	0	0	0	0.00
12 November 2020	0	0	0	0	0.00
10 December 2020	0	0	0	0	0.00
08 January 2021	0	0	0	0	0.00
02 February 2021	0	0	0	0	0.00
01 March 2021	0	0	0	0	0.00
22 April 2021	79	29	107	25	31.65
20 May 2021	78	33	113	30	38.46
15 June 2021	2,003	1,454	2,401	283	14.13
02 July 2021	131	38	249	57	43.51
13 August 2021	40	17	55	15	37.50

3.6.1 Input densities and abundances for displacement modelling

Table 25 Monthly absolute population estimates of all puffin (flying and sitting) within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Puffin	Absolute population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	0	0	0	0	0.00
25 February 2015	0	0	0	0	0.00
13 March 2015	0	0	0	0	0.00
09 April 2015	20	4	39	9	45.00
09 May 2015	62	12	148	45	72.58
08 June 2015	2,848	2,326	3,422	303	10.64
30 June 2015	317	192	415	58	18.30
14 July 2015	13	0	26	7	53.85
05 August 2015	27	5	51	15	55.56
28 September 2015	6	0	12	4	66.67
13 October 2015	10	5	13	3	30.00
25 November 2015	0	0	0	0	0.00
03 December 2015	0	0	0	0	0.00
24 September 2020	3	0	8	3	100.00
14 October 2020	0	0	0	0	0.00
12 November 2020	0	0	0	0	0.00
10 December 2020	0	0	0	0	0.00
08 January 2021	0	0	0	0	0.00
02 February 2021	0	0	0	0	0.00
01 March 2021	0	0	0	0	0.00
22 April 2021	680	404	913	132	19.41
20 May 2021	343	204	557	98	28.57
15 June 2021	10,194	7,226	12,208	1,232	12.09
02 July 2021	379	71	729	134	35.36
13 August 2021	133	80	179	25	18.80

Table 26 Absolute mean seasonal peak population estimates of all puffin (flying and sitting) within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Puffin	Absolute population estimate	Lower 95% confidence limit	Upper 95% confidence limit
Breeding	6,521	4,776	7,815
Non-breeding	7	3	11

3.7 Fulmar

71 This survey data analysis helps inform the baseline description for fulmar set out in Section 12.4.4.5 of the Offshore EIAR (Volume 2) Chapter 12, Marine Ornithology. Fulmar sensitivity to wind farm impacts is discussed in Chapter 12 and summarised in Table 1 in the Introduction to this Technical Appendix.

72 In this regard, collision and displacement impacts are quantified for fulmar on a precautionary basis even though the species is not considered particularly sensitive to either. Fulmar densities are provided for input into CRM, Technical Appendix 12.3 Marine Ornithology: Collision Risk Modelling, and fulmar MSP estimates are provided for input into displacement assessment, Technical Appendix 12.4 Marine Ornithology: Displacement Analysis. Please see Table 3 for a summary of the data requirements in this regard.

73 Maximum population estimates within the PFOWF Array Area ranged between 9 birds (95% CI 0 – 16) and 59 birds (95% CI 38 – 78) for the non-breeding and breeding seasons, respectively (Table 27). Across all surveys, population estimates peaked at 33 birds (95% CI 25 – 44; April 2021) in Year one and 59 birds (95% CI 38 – 78) in Year two (Table 28).

74 Within the PFOWF Array Area, flying fulmars were recorded in varying densities (Table 29), ranging between 0.00 birds/km^2 (e.g. October 2015), and 5.77 birds/km^2 (95% CI 3.74 – 7.78; such as in January 2021). Peak densities of flying fulmar were calculated in January 2015 in Year one and March 2021 in Year two.

75 Population estimates for all fulmar in the PFOWF Array Area plus 2 km buffer varied between months, ranging between 0 birds in December 2015 and 2,058 birds (95% CI 162 – 5,049) in August 2015 (Table 30). The mean seasonal peak calculated for the breeding season was considerably higher than for other seasons (Table 31).

Table 27 Maximum population estimates for fulmar in each season within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Fulmar	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Breeding	59	38	78	11	18.9	Apr	2015
Autumn migration	13	3	25	6	46.57	Sep	2020
Non-breeding	9	0	16	4	47.64	Nov	2015
Spring migration	27	10	49	11	39.1	Jan	2021

Table 28 Monthly population estimates for fulmar for the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Fulmar	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	18	0	34	10	52.69
25 February 2015	17	10	23	4	21.08
13 March 2015	7	0	13	4	51.30
09 April 2015	33	25	44	6	16.97
09 May 2015	0	0	0	0	0.00
08 June 2015	2	0	6	2	76.44
30 June 2015	7	2	12	3	38.26
14 July 2015	3	0	5	2	78.48
05 August 2015	32	25	39	4	12.15
28 September 2015	2	0	6	2	81.39
13 October 2015	0	0	0	0	0.00
25 November 2015	9	0	16	4	47.64
03 December 2015	0	0	0	0	0.00
24 September 2020	13	3	25	6	46.57
14 October 2020	0	0	0	0	0.00
12 November 2020	0	0	0	0	0.00
10 December 2020	0	0	0	0	0.00
08 January 2021	27	10	49	11	39.10
02 February 2021	7	0	13	4	53.51
01 March 2021	59	38	78	11	18.90
22 April 2021	0	0	0	0	0.00
20 May 2021	19	6	36	9	47.74
15 June 2021	0	0	0	0	0.00
02 July 2021	0	0	0	0	0.00
13 August 2021	5	2	6	2	28.83

3.7.1 Input densities for CRM

Table 29 Monthly density estimates of flying fulmar within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Fulmar	Density estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	1.77	0.00	3.36	1.00	51.26
25 February 2015	1.62	0.97	2.27	0.40	20.04
13 March 2015	0.61	0.00	1.26	0.40	53.25
09 April 2015	1.15	0.49	1.84	0.40	31.10
09 May 2015	0.00	0.00	0.00	0.00	0.00
08 June 2015	0.19	0.00	0.57	0.20	75.67
30 June 2015	0.39	0.00	1.17	0.40	77.59
14 July 2015	0.20	0.00	0.49	0.20	75.62
05 August 2015	1.37	0.49	2.31	0.50	33.55
28 September 2015	0.00	0.00	0.00	0.00	0.00
13 October 2015	0.00	0.00	0.00	0.00	0.00
25 November 2015	0.82	0.00	1.54	0.40	46.55
03 December 2015	0.00	0.00	0.00	0.00	0.00
24 September 2020	1.25	0.21	2.42	0.60	45.25
14 October 2020	0.00	0.00	0.00	0.00	0.00
12 November 2020	0.00	0.00	0.00	0.00	0.00
10 December 2020	0.00	0.00	0.00	0.00	0.00
08 January 2021	2.27	0.98	3.88	0.80	34.73
02 February 2021	0.61	0.00	1.27	0.40	52.79
01 March 2021	5.77	3.74	7.78	1.10	18.11
22 April 2021	0.00	0.00	0.00	0.00	0.00
20 May 2021	1.80	0.43	3.52	0.90	49.35
15 June 2021	0.00	0.00	0.00	0.00	0.00
02 July 2021	0.00	0.00	0.00	0.00	0.00
13 August 2021	0.40	0.17	0.59	0.20	30.75

3.7.2 Input densities and abundances for displacement modelling

Table 30 Monthly population estimates of all fulmar (flying and sitting) within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Fulmar	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	47	9	91	16	34.04
25 February 2015	134	84	209	30	22.39
13 March 2015	49	25	75	11	22.45
09 April 2015	90	71	121	10	11.11
09 May 2015	9	0	19	6	66.67
08 June 2015	11	0	25	6	54.55
30 June 2015	11	2	22	5	45.45
14 July 2015	12	4	16	3	25.00
05 August 2015	2,058	162	5,049	1,342	65.21
28 September 2015	23	0	54	15	65.22
13 October 2015	0	0	0	0	0.00
25 November 2015	63	34	95	13	20.63
03 December 2015	0	0	0	0	0.00
24 September 2020	38	11	63	10	26.32
14 October 2020	5	0	14	4	80.00
12 November 2020	5	0	10	3	60.00
10 December 2020	0	0	0	0	0.00
08 January 2021	264	85	482	105	39.77
02 February 2021	24	10	38	6	25.00
01 March 2021	181	86	273	37	20.44
22 April 2021	5	0	16	5	100.00
20 May 2021	76	16	147	28	36.84
15 June 2021	21	10	32	6	28.57
02 July 2021	9	0	19	6	66.67
13 August 2021	26	10	35	6	23.08

Table 31 Mean seasonal peak population estimates of all fulmar (flying and sitting) in each season within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Fulmar	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit
Breeding	1,067	89	2,598
Autumn migration	31	6	59
Non-breeding	34	17	53
Spring migration	199	85	346

3.8 Gannet

76 This survey data analysis helps inform the baseline description for gannet set out in Section 12.4.4.6 of the Offshore EIAR (Volume 2) Chapter 12, Marine Ornithology. Gannet sensitivity to wind farm impacts is discussed in Chapter 12 and summarised in Table 1 in the Introduction to this Technical Appendix.

77 In this regard, gannet are deemed sensitive to both collision risk and displacement impacts, so gannet densities are provided for input into collision risk modelling, Technical Appendix 12.3 Marine Ornithology: Collision Risk Modelling, and gannet MSP estimates are provided for input into displacement assessment, Technical Appendix 12.4 Marine Ornithology: Displacement Analysis. Please see Table 3 for a summary of the data requirements in this regard.

78 Population estimates for gannet in the PFOWF Array Area were generally low, peaking late in each breeding season, calculated at 10 birds (95% CI 2 – 24; August 2015) in Year 1 and 44 birds (95% CI 0 – 71; September 2020) in Year 2 (Table 32; Table 33). Again, there is overlap between the breeding seasons advised in NatureScot (2020) and in Furness (2015); in this regard the September counts were assigned to the breeding season, leaving a peak count of 9 birds (95% CI 7 – 10) during the autumn migration, recorded in October 2020.

79 Across all seasons, most birds were aged as adults, with few juvenile birds (Table 34). The highest proportion of adults were recorded during the spring migration season with 100% of birds aged as adults, in contrast to the breeding period when the highest proportion of immature birds were present, equating to 15% of all aged birds.

80 The highest densities of flying birds within the PFOWF Array Area were estimated at 0.78 birds/km^2 (95% CI 0.00 – 2.31; August 2015) in Year one and 4.07 birds/km^2 (95% CI 0.00 – 6.30; September 2020) in Year two (Table 35).

81 Population estimates for all gannets in the PFOWF Array Area plus 2 km buffer varied between months, ranging between 0 birds (e.g. January 2021), and 190 birds (95% CI 92 – 306; such as in September 2020; Table 36). A higher MSP was recorded during the breeding season, with 166.5 birds (95% CI 46 – 313.5) compared to spring migration, with on average, 8 birds estimated within the area (95% CI 0 – 18) (Table 37).

Table 32 Maximum population estimates for gannet in each season within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Gannet	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Breeding	44	0	71	18	40.31	Sep	2020
Autumn migration	9	7	10	1	11.46	Oct	2020
Spring migration	2	0	6	2	90.27	Mar	2015

Table 33 Monthly population estimates for gannet for the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Gannet	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	0	0	0	0	0.00
25 February 2015	0	0	0	0	0.00
13 March 2015	2	0	6	2	90.27
09 April 2015	0	0	0	0	0.00
09 May 2015	0	0	0	0	0.00
08 June 2015	0	0	0	0	0.00
30 June 2015	3	0	6	2	87.70
14 July 2015	0	0	0	0	0.00
05 August 2015	10	2	24	6	54.16
28 September 2015	9	0	19	6	63.63
13 October 2015	0	0	0	0	0.00
25 November 2015	0	0	0	0	0.00
03 December 2015	0	0	0	0	0.00
24 September 2020	44	0	71	18	40.31
14 October 2020	9	7	10	1	11.46
12 November 2020	0	0	0	0	0.00
10 December 2020	0	0	0	0	0.00
08 January 2021	0	0	0	0	0.00
02 February 2021	0	0	0	0	0.00
01 March 2021	0	0	0	0	0.00
22 April 2021	0	0	0	0	0.00
20 May 2021	0	0	0	0	0.00
15 June 2021	9	2	19	4	47.20
02 July 2021	0	0	0	0	0.00
13 August 2021	20	5	36	8	38.57

Table 34 Percentage of aged gannet (n = 126) in each age class averaged across all surveys in each season

Season	Adult	Immature	Juvenile
Breeding	82.46%	14.91%	2.63%
Autumn migration	86.67%	9.33%	4.00%
Spring migration	100.00%	0.00%	0.00%

3.8.1 Input densities for CRM

Table 35 Monthly density estimates of flying gannet within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Gannet	Density estimate (n/km²)	Lower 95% confidence limit (n/km²)	Upper 95% confidence limit (n/km²)	Standard deviation (n/km²)	CV (%)
19 January 2015	0.00	0.00	0.00	0.00	0.00
25 February 2015	0.00	0.00	0.00	0.00	0.00
13 March 2015	0.20	0.00	0.59	0.20	87.40
09 April 2015	0.00	0.00	0.00	0.00	0.00
09 May 2015	0.00	0.00	0.00	0.00	0.00
08 June 2015	0.00	0.00	0.00	0.00	0.00
30 June 2015	0.00	0.00	0.00	0.00	0.00
14 July 2015	0.00	0.00	0.00	0.00	0.00
05 August 2015	0.78	0.00	2.31	0.60	76.78
28 September 2015	0.40	0.00	0.75	0.20	48.05
13 October 2015	0.00	0.00	0.00	0.00	0.00
25 November 2015	0.00	0.00	0.00	0.00	0.00
03 December 2015	0.00	0.00	0.00	0.00	0.00
24 September 2020	4.07	0.00	6.30	1.60	38.96
14 October 2020	0.21	0.00	0.49	0.20	63.84
12 November 2020	0.00	0.00	0.00	0.00	0.00
10 December 2020	0.00	0.00	0.00	0.00	0.00
08 January 2021	0.00	0.00	0.00	0.00	0.00
02 February 2021	0.00	0.00	0.00	0.00	0.00
01 March 2021	0.00	0.00	0.00	0.00	0.00
22 April 2021	0.00	0.00	0.00	0.00	0.00
20 May 2021	0.00	0.00	0.00	0.00	0.00
15 June 2021	0.22	0.00	0.61	0.20	74.11
02 July 2021	0.00	0.00	0.00	0.00	0.00
13 August 2021	1.39	0.00	2.34	0.70	46.17

3.8.2 Input densities and abundances for displacement modelling

Table 36 Monthly population estimates of all gannet (flying and sitting) within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Gannet	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	0	0	0	0	0.00
25 February 2015	0	0	0	0	0.00
13 March 2015	11	0	26	7	63.64
09 April 2015	0	0	0	0	0.00
09 May 2015	0	0	0	0	0.00
08 June 2015	5	0	10	3	60.00
30 June 2015	143	0	321	90	62.94
14 July 2015	0	0	0	0	0.00
05 August 2015	102	22	249	59	57.84
28 September 2015	71	32	127	22	30.99
13 October 2015	0	0	0	0	0.00
25 November 2015	9	0	20	6	66.67
03 December 2015	0	0	0	0	0.00
24 September 2020	190	92	306	42	22.11
14 October 2020	38	24	51	8	21.05
12 November 2020	0	0	0	0	0.00
10 December 2020	0	0	0	0	0.00
08 January 2021	0	0	0	0	0.00
02 February 2021	0	0	0	0	0.00
01 March 2021	5	0	10	3	60.00
22 April 2021	5	0	10	3	60.00
20 May 2021	0	0	0	0	0.00
15 June 2021	62	11	118	25	40.32
02 July 2021	13	0	31	9	69.23
13 August 2021	69	21	112	17	24.64

Table 37 Mean seasonal peak population estimates of all gannet (flying and sitting) in each season within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Gannet	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit
Breeding	167	46	314
Autumn migration	24	12	36
Spring migration	8	0	18

3.9 Arctic tern

82 This survey data analysis helps inform the baseline description for Arctic tern set out in Section 12.4.4.7 of the Offshore EIAR (Volume 2) Chapter 12, Marine Ornithology. Arctic tern sensitivity to wind farm impacts is discussed in Chapter 12 and summarised in Table 1 in the Introduction to this Technical Appendix.

83 Arctic tern are deemed sensitive to both collision risk and displacement impacts, so densities for this species are provided for input into collision risk modelling, Technical Appendix 12.3 Marine Ornithology: Collision Risk Modelling, and MSP estimates are provided for input into displacement assessment, Technical Appendix 12.4 Marine Ornithology: Displacement Analysis. Please see Table 3 for a summary of the data requirements in this regard.

84 Few Arctic tern were recorded during the two years of digital aerial survey work, with birds only present during the breeding season. Maximum population estimate in the PFOWF Array Area was calculated at 11 birds (9% CI 5 – 16) in June 2015 (Table 38; Table 39). As there is overlap between NatureScot (2020) and Furness (2015) guidance, this peak was assigned to the breeding season and not to autumn migration.

85 Within the PFOWF Array Area, flying Arctic tern were recorded in varying densities (Table 40), ranging between 0.00 birds/km^2 (e.g. January 2015) and 1.02 birds/km^2 (95% CI 0.48 – 1.57; in June 2015).

86 Population estimates for all Arctic tern in the PFOWF Array Area plus 2 km buffer varied between months, ranging between 0 birds (e.g. January 2015) to 75 birds (95% CI 4 – 148) in July 2015 (Table 41).

87 For displacement assessment, a MSP of 46 birds was estimated for the PFOWF Array Area plus 2 km buffer during the breeding season. No birds were recorded during the autumn and spring migration periods (Table 42).

Table 38 Maximum population estimates for Arctic tern in each season within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Arctic tern	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Breeding	11	5	16	3	26.69	Jun	2015
Autumn migration	0	0	0	0	0.00	-	-
Spring migration	0	0	0	0	0.00	-	-

Table 39 Monthly population estimates for Arctic tern for the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Arctic tern	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	0	0	0	0	0.00
25 February 2015	0	0	0	0	0.00
13 March 2015	0	0	0	0	0.00
09 April 2015	0	0	0	0	0.00
09 May 2015	0	0	0	0	0.00
08 June 2015	0	0	0	0	0.00
30 June 2015	11	5	16	3	26.69
14 July 2015	4	0	10	3	64.20
05 August 2015	0	0	0	0	0.00
28 September 2015	0	0	0	0	0.00
13 October 2015	0	0	0	0	0.00
25 November 2015	0	0	0	0	0.00
03 December 2015	0	0	0	0	0.00
24 September 2020	0	0	0	0	0.00
14 October 2020	0	0	0	0	0.00
12 November 2020	0	0	0	0	0.00
10 December 2020	0	0	0	0	0.00
08 January 2021	0	0	0	0	0.00
02 February 2021	0	0	0	0	0.00
01 March 2021	0	0	0	0	0.00
22 April 2021	0	0	0	0	0.00
20 May 2021	0	0	0	0	0.00
15 June 2021	0	0	0	0	0.00
02 July 2021	0	0	0	0	0.00
13 August 2021	0	0	0	0	0.00

3.9.1 Input densities for CRM

Table 40 Monthly density estimates of flying Arctic tern within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Arctic tern	Density estimate (n/km²)	Lower 95% confidence limit (n/km²)	Upper 95% confidence limit (n/km²)	Standard deviation (n/km²)	CV (%)
19 January 2015	0.00	0.00	0.00	0.00	0.00
25 February 2015	0.00	0.00	0.00	0.00	0.00
13 March 2015	0.00	0.00	0.00	0.00	0.00
09 April 2015	0.00	0.00	0.00	0.00	0.00
09 May 2015	0.00	0.00	0.00	0.00	0.00
08 June 2015	0.00	0.00	0.00	0.00	0.00
30 June 2015	1.02	0.48	1.57	0.30	26.15
14 July 2015	0.41	0.00	0.97	0.30	64.18
05 August 2015	0.00	0.00	0.00	0.00	0.00
28 September 2015	0.00	0.00	0.00	0.00	0.00
13 October 2015	0.00	0.00	0.00	0.00	0.00
25 November 2015	0.00	0.00	0.00	0.00	0.00
03 December 2015	0.00	0.00	0.00	0.00	0.00
24 September 2020	0.00	0.00	0.00	0.00	0.00
14 October 2020	0.00	0.00	0.00	0.00	0.00
12 November 2020	0.00	0.00	0.00	0.00	0.00
10 December 2020	0.00	0.00	0.00	0.00	0.00
08 January 2021	0.00	0.00	0.00	0.00	0.00
02 February 2021	0.00	0.00	0.00	0.00	0.00
01 March 2021	0.00	0.00	0.00	0.00	0.00
22 April 2021	0.00	0.00	0.00	0.00	0.00
20 May 2021	0.00	0.00	0.00	0.00	0.00
15 June 2021	0.00	0.00	0.00	0.00	0.00
02 July 2021	0.00	0.00	0.00	0.00	0.00
13 August 2021	0.00	0.00	0.00	0.00	0.00

3.9.2 Input densities and abundances for displacement modelling

Table 41 Monthly population estimates of all Arctic tern (flying and sitting) within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Arctic tern	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	0	0	0	0	0.00
25 February 2015	0	0	0	0	0.00
13 March 2015	0	0	0	0	0.00
09 April 2015	0	0	0	0	0.00
09 May 2015	0	0	0	0	0.00
08 June 2015	5	0	10	3	60.00
30 June 2015	72	37	104	17	23.61
14 July 2015	75	4	148	38	50.67
05 August 2015	0	0	0	0	0.00
28 September 2015	0	0	0	0	0.00
13 October 2015	0	0	0	0	0.00
25 November 2015	0	0	0	0	0.00
03 December 2015	0	0	0	0	0.00
24 September 2020	0	0	0	0	0.00
14 October 2020	0	0	0	0	0.00
12 November 2020	0	0	0	0	0.00
10 December 2020	0	0	0	0	0.00
08 January 2021	0	0	0	0	0.00
02 February 2021	0	0	0	0	0.00
01 March 2021	0	0	0	0	0.00
22 April 2021	0	0	0	0	0.00
20 May 2021	0	0	0	0	0.00
15 June 2021	9	0	19	6	66.67
02 July 2021	17	0	41	12	70.59
13 August 2021	17	0	39	12	70.59

Table 42 Mean seasonal peak population estimates of all Arctic tern (flying and sitting) in each season within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Arctic tern	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit
Breeding	46	2	94
Autumn migration	0	0	0
Spring migration	0	0	0

3.10 Great black-backed gull

88 This survey data analysis helps inform the baseline description for great black-backed gull set out in Section 12.4.4.8 of the Offshore EIAR (Volume 2) Chapter 12, Marine Ornithology. Great black-backed gull sensitivity to wind farm impacts is discussed in Chapter 12 and summarised in Table 1 in the Introduction to this Technical Appendix. In this regard, great back-backed gull are deemed sensitive to collision risk, so density estimates are provided for CRM, Technical Appendix 12.3 Marine Ornithology: Collision Risk Modelling. Please see Table 3 for a summary of the data requirements.

89 Maximum population estimates within the PFOWF Array Area equated to 10 birds (95% CI 9 – 10) during the non-breeding season, with the species absent during the breeding season (Table 43). In both Year one and Year two, population estimates peaked in October (Table 44).

90 Across all seasons, most birds were aged as adults, with few immature and juvenile birds recorded during the survey programme (Table 45). For the non-breeding season, 70% of birds were aged as adults.

91 Flying great black-backed gulls reached peak densities in the PFOWF Array Area during the non-breeding season, peaking in December 2015 at 0.41 birds/km^2 (95% CI 0.18 – 0.57; Table 46).

Table 43 Maximum population estimates for great black-backed gull in each season within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Great black-backed gull	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Breeding	0	0	0	0	0.00	-	-
Non-breeding	10	9	10	1	3.69	Oct	2020

Table 44 Monthly population estimates for great black-backed gull for the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Great black-backed gull	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	3	0	6	2	70.85
25 February 2015	3	0	5	2	67.89
13 March 2015	5	0	13	4	75.81
09 April 2015	0	0	0	0	0.00
09 May 2015	0	0	0	0	0.00
08 June 2015	0	0	0	0	0.00
30 June 2015	0	0	0	0	0.00
14 July 2015	0	0	0	0	0.00
05 August 2015	0	0	0	0	0.00
28 September 2015	0	0	0	0	0.00
13 October 2015	10	9	10	1	3.69
25 November 2015	3	0	6	2	76.84
03 December 2015	7	2	10	2	31.64
24 September 2020	0	0	0	0	0.00
14 October 2020	9	0	25	8	92.16
12 November 2020	7	0	10	3	39.91
10 December 2020	3	0	5	2	62.77
08 January 2021	7	2	10	3	35.63
02 February 2021	0	0	0	0	0.00
01 March 2021	0	0	0	0	0.00
22 April 2021	0	0	0	0	0.00
20 May 2021	0	0	0	0	0.00
15 June 2021	0	0	0	0	0.00
02 July 2021	0	0	0	0	0.00
13 August 2021	0	0	0	0	0.00

Table 45 Percentage of aged great black-backed gull (n = 21) in each age class averaged across all surveys in each season

Season	Adult	Immature	Juvenile
Breeding	Zero birds recorded		
Non-breeding	70.00%	25.00%	5.00%

3.10.1 Input densities for CRM

Table 46 Monthly density estimates of flying great black-backed gull within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Great black-backed gull	Density estimate (n/km²)	Lower 95% confidence limit (n/km²)	Upper 95% confidence limit (n/km²)	Standard deviation (n/km²)	CV (%)
19 January 2015	0.00	0.00	0.57	0.20	74.18
25 February 2015	0.00	0.00	0.49	0.20	68.08
13 March 2015	0.00	0.00	1.22	0.40	74.35
09 April 2015	0.00	0.00	0.00	0.00	0.00
09 May 2015	0.00	0.00	0.00	0.00	0.00
08 June 2015	0.00	0.00	0.00	0.00	0.00
30 June 2015	0.00	0.00	0.00	0.00	0.00
14 July 2015	0.00	0.00	0.00	0.00	0.00
05 August 2015	0.00	0.00	0.00	0.00	0.00
28 September 2015	0.00	0.00	0.00	0.00	0.00
13 October 2015	0.00	0.00	0.00	0.00	0.00
25 November 2015	0.00	0.00	0.00	0.00	0.00
03 December 2015	0.41	0.18	0.57	0.20	26.82
24 September 2020	0.00	0.00	0.00	0.00	0.00
14 October 2020	0.00	0.00	0.00	0.00	0.00
12 November 2020	0.22	0.00	0.71	0.20	89.02
10 December 2020	0.21	0.00	0.47	0.20	62.23
08 January 2021	0.64	0.17	0.97	0.30	35.74
02 February 2021	0.00	0.00	0.00	0.00	0.00
01 March 2021	0.00	0.00	0.00	0.00	0.00
22 April 2021	0.00	0.00	0.00	0.00	0.00
20 May 2021	0.00	0.00	0.00	0.00	0.00
15 June 2021	0.00	0.00	0.00	0.00	0.00
02 July 2021	0.00	0.00	0.00	0.00	0.00
13 August 2021	0.00	0.00	0.00	0.00	0.00

3.11 Great skua

92 This survey data analysis helps inform the baseline description for great skua as set out in Section 12.4.4.9 of the Offshore EIAR (Volume 2) Chapter 12 of the EIAR, Marine Ornithology. Great skua sensitivity to wind farm impacts is discussed in Chapter 12 and summarised in Table 1 in the Introduction to this Technical Appendix.

93 In this regard, great skua are deemed sensitive to collision risk and less so to displacement, however, they have been scoped into displacement assessment on a precautionary basis. Great skua densities are provided for input into CRM Technical Appendix 12.3 Marine Ornithology: Collision Risk Modelling, and MSP estimates are provided for input into displacement assessment, Technical Appendix 12.4 Marine Ornithology: Displacement Analysis. Please see Table 3 for a summary of the data requirements in this regard.

94 Few great skua were recorded during the two-year period. Maximum population estimates within the PFOWF Array Area were calculated at 3 birds (95% CI 0 – 5) for the breeding season (Table 47).

95 Within the PFOWF Array Area, flying great skua were recorded in extremely low densities, peaking at 0.00 birds/km^2 (95% CI 0.00 – 0.48) in Mary 2015 and June 2021 (Table 49).

96 Population estimates for great skua in the PFOWF Array Area plus 2 km buffer varied between months, ranging between 0 birds, (e.g. January 2015) to 9 birds (95% CI 0 – 18) in June 2021 (Table 50). The MSP in the breeding season was estimated at 7 birds (95% CI 0 – 15.5; Table 51).

Table 47 Maximum population estimates for great skua in each season within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Great skua	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Breeding	3	0	5	2	65.31	Jun	2015
Autumn migration	0	0	0	0	0.00	-	-
Non-breeding	0	0	0	0	0.00	-	-
Spring migration	0	0	0	0	0.00	-	-

Table 48 Monthly population estimates for great skua for the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Great skua	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	0	0	0	0	0.00
25 February 2015	0	0	0	0	0.00
13 March 2015	0	0	0	0	0.00
09 April 2015	0	0	0	0	0.00
09 May 2015	3	0	5	2	65.31
08 June 2015	0	0	0	0	0.00
30 June 2015	2	0	6	2	92.4
14 July 2015	0	0	0	0	0.00
05 August 2015	0	0	0	0	0.00
28 September 2015	0	0	0	0	0.00
13 October 2015	0	0	0	0	0.00
25 November 2015	0	0	0	0	0.00
03 December 2015	0	0	0	0	0.00
24 September 2020	0	0	0	0	0.00
14 October 2020	0	0	0	0	0.00
12 November 2020	0	0	0	0	0.00
10 December 2020	0	0	0	0	0.00
08 January 2021	0	0	0	0	0.00
02 February 2021	0	0	0	0	0.00
01 March 2021	0	0	0	0	0.00
22 April 2021	0	0	0	0	0.00
20 May 2021	0	0	0	0	0.00
15 June 2021	3	0	5	2	65.49
02 July 2021	0	0	0	0	0.00
13 August 2021	0	0	0	0	0.00

3.11.1 Input densities for CRM

Table 49 Monthly density estimates of flying great skua within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Great skua	Density estimate (n/km²)	Lower 95% confidence limit (n/km²)	Upper 95% confidence limit (n/km²)	Standard deviation (n/km²)	CV (%)
19 January 2015	0.00	0.00	0.00	0.00	0.00
25 February 2015	0.00	0.00	0.00	0.00	0.00
13 March 2015	0.00	0.00	0.00	0.00	0.00
09 April 2015	0.00	0.00	0.00	0.00	0.00
09 May 2015	0.00	0.00	0.48	0.20	65.50
08 June 2015	0.00	0.00	0.00	0.00	0.00
30 June 2015	0.00	0.00	0.00	0.00	0.00
14 July 2015	0.00	0.00	0.00	0.00	0.00
05 August 2015	0.00	0.00	0.00	0.00	0.00
28 September 2015	0.00	0.00	0.00	0.00	0.00
13 October 2015	0.00	0.00	0.00	0.00	0.00
25 November 2015	0.00	0.00	0.00	0.00	0.00
03 December 2015	0.00	0.00	0.00	0.00	0.00
24 September 2020	0.00	0.00	0.00	0.00	0.00
14 October 2020	0.00	0.00	0.00	0.00	0.00
12 November 2020	0.00	0.00	0.00	0.00	0.00
10 December 2020	0.00	0.00	0.00	0.00	0.00
08 January 2021	0.00	0.00	0.00	0.00	0.00
02 February 2021	0.00	0.00	0.00	0.00	0.00
01 March 2021	0.00	0.00	0.00	0.00	0.00
22 April 2021	0.00	0.00	0.00	0.00	0.00
20 May 2021	0.00	0.00	0.00	0.00	0.00
15 June 2021	0.00	0.00	0.48	0.20	68.22
02 July 2021	0.00	0.00	0.00	0.00	0.00
13 August 2021	0.00	0.00	0.00	0.00	0.00

3.11.2 Input densities and abundances for displacement modelling

Table 50 Monthly population estimates of all great skua (flying and sitting) within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Great skua	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	0	0	0	0	0.00
25 February 2015	0	0	0	0	0.00
13 March 2015	0	0	0	0	0.00
09 April 2015	0	0	0	0	0.00
09 May 2015	3	0	5	2	66.67
08 June 2015	0	0	0	0	0.00
30 June 2015	2	0	6	2	100.00
14 July 2015	0	0	0	0	0.00
05 August 2015	5	0	13	4	80.00
28 September 2015	0	0	0	0	0.00
13 October 2015	0	0	0	0	0.00
25 November 2015	0	0	0	0	0.00
03 December 2015	0	0	0	0	0.00
24 September 2020	0	0	0	0	0.00
14 October 2020	0	0	0	0	0.00
12 November 2020	0	0	0	0	0.00
10 December 2020	0	0	0	0	0.00
08 January 2021	0	0	0	0	0.00
02 February 2021	0	0	0	0	0.00
01 March 2021	0	0	0	0	0.00
22 April 2021	0	0	0	0	0.00
20 May 2021	9	0	18	5	55.56
15 June 2021	8	0	15	4	50.00
02 July 2021	0	0	0	0	0.00
13 August 2021	0	0	0	0	0.00

Table 51 Mean seasonal peak population estimates of all great skua (flying and sitting) in each season within the PFOWF Array Area plus 2 km buffer between January to December 2015 and September 2020 to August 2021

Great skua	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit
Breeding	7	0	16
Autumn migration	0	0	0
Non-breeding	0	0	0
Spring migration	0	0	0

3.12 Herring gull

97 This survey data analysis helps inform the baseline description for herring gull set out in Section 12.4.4.10 of the Offshore EIAR (Volume 2) Chapter 12, Marine Ornithology. Herring gull sensitivity to wind farm impacts is discussed in Chapter 12 and summarised in Table 1 in the Introduction to this Technical Appendix. In this regard, herring gull are deemed sensitive to collision risk, so density estimates are provided for CRM, Technical Appendix 12.3 Marine Ornithology: Collision Risk Modelling. Please see Table 3 for a summary of the data requirements.

98 Maximum population estimates within the PFOWF Array Area equated to 5 birds (95% CI 0 – 7) during the non-breeding season, with the species absent during the breeding season (Table 52). Herring gull were only recorded within the PFOWF Array Area in October 2015 (Table 53).

99 Densities of flying herring gull in October 2015 equated to 0.19 birds/km^2 (95% CI 0.00 – 0.48; Table 54).

Table 52 Maximum population estimates for herring gull in each season within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Herring gull	Maximum population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)	Month	Year
Breeding	0	0	0	0	0	-	-
Non-breeding	5	2	7	2	29.43	Oct	2015

Table 53 Monthly population estimates for all herring gull (flying and sitting) for the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Herring gull	Population estimate	Lower 95% confidence limit	Upper 95% confidence limit	Standard deviation	CV (%)
19 January 2015	0	0	0	0	0.00
25 February 2015	0	0	0	0	0.00
13 March 2015	0	0	0	0	0.00
09 April 2015	0	0	0	0	0.00
09 May 2015	0	0	0	0	0.00
08 June 2015	0	0	0	0	0.00
30 June 2015	0	0	0	0	0.00
14 July 2015	0	0	0	0	0.00
05 August 2015	0	0	0	0	0.00
28 September 2015	0	0	0	0	0.00
13 October 2015	5	2	7	2	29.43
25 November 2015	0	0	0	0	0.00
03 December 2015	0	0	0	0	0.00
24 September 2020	0	0	0	0	0.00
14 October 2020	0	0	0	0	0.00
12 November 2020	0	0	0	0	0.00
10 December 2020	0	0	0	0	0.00
08 January 2021	0	0	0	0	0.00
02 February 2021	0	0	0	0	0.00
01 March 2021	0	0	0	0	0.00
22 April 2021	0	0	0	0	0.00
20 May 2021	0	0	0	0	0.00
15 June 2021	0	0	0	0	0.00
02 July 2021	0	0	0	0	0.00
13 August 2021	0	0	0	0	0.00

3.12.1 Input densities for CRM

Table 54 Monthly density estimates of flying herring gull within the PFOWF Array Area between January to December 2015 and September 2020 to August 2021

Herring gull	Density estimate (n/km²)	Lower 95% confidence limit (n/km²)	Upper 95% confidence limit (n/km²)	Standard deviation (n/km²)	CV (%)
19 January 2015	0.00	0.00	0.00	0.00	0.00
25 February 2015	0.00	0.00	0.00	0.00	0.00
13 March 2015	0.00	0.00	0.00	0.00	0.00
09 April 2015	0.00	0.00	0.00	0.00	0.00
09 May 2015	0.00	0.00	0.00	0.00	0.00
08 June 2015	0.00	0.00	0.00	0.00	0.00
30 June 2015	0.00	0.00	0.00	0.00	0.00
14 July 2015	0.00	0.00	0.00	0.00	0.00
05 August 2015	0.00	0.00	0.00	0.00	0.00
28 September 2015	0.00	0.00	0.00	0.00	0.00
13 October 2015	0.19	0.00	0.48	0.20	70.19
25 November 2015	0.00	0.00	0.00	0.00	0.00
03 December 2015	0.00	0.00	0.00	0.00	0.00
24 September 2020	0.00	0.00	0.00	0.00	0.00
14 October 2020	0.00	0.00	0.00	0.00	0.00
12 November 2020	0.00	0.00	0.00	0.00	0.00
10 December 2020	0.00	0.00	0.00	0.00	0.00
08 January 2021	0.00	0.00	0.00	0.00	0.00
02 February 2021	0.00	0.00	0.00	0.00	0.00
01 March 2021	0.00	0.00	0.00	0.00	0.00
22 April 2021	0.00	0.00	0.00	0.00	0.00
20 May 2021	0.00	0.00	0.00	0.00	0.00
15 June 2021	0.00	0.00	0.00	0.00	0.00
02 July 2021	0.00	0.00	0.00	0.00	0.00
13 August 2021	0.00	0.00	0.00	0.00	0.00

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Annex A Summary of Baseline Characterisation Surveys

A1: 2015 Survey Summary (Year One)

1 In January 2015, HiDef were commissioned to undertake a programme of high-resolution digital video aerial ornithological, marine megafauna, and human activity surveys in support of the Dounreay Tri Floating Wind demonstration project. Thirteen surveys were undertaken between January and December 2015 (with two surveys in June 2015).

2 A total of 4,960 birds of 14 species and 24 marine mammals of four species were recorded. A further 172 animals were recorded which were not assigned to a species. An identification rate to species level of 97% was achieved across the survey programme.

3 The primary observation from the surveys were:

- Low to moderate density of fulmar were recorded, mainly during the winter months, with a peak in August 2015 possibly attributed to young birds leaving nest sites.
- Low density of gannet were present, and these increased in numbers in late June and August 2015, although most of these were in the buffer area around the project site.
- Kittiwake were one of the most abundant species recorded during these surveys and reached moderate density in June 2015.
- Low densities of great black-backed gull were recorded with peak abundance in August 2015. Few other large gulls present in these surveys.
- Arctic tern were found to be present at moderate density during the June and July surveys.
- Guillemot were the most common species recorded and high density was found to occur in the two June 2015 surveys, then again at the end of the survey period in November and December 2015.
- Razorbill were only present at low density in the survey area and were also found to be most abundant in the summer months.
- The density of puffin was generally found to be low to moderate, but the survey on 8 June 2015 identified very high densities across the survey area which were not present during the follow-up survey less than three weeks later (30 June 2015), suggesting that this concentration was ephemeral; highly likely to be an exploitation of a temporary food source.

4 Distribution maps for all species show no regular patterns between surveys to give any suggestion that one part of the survey area might be more important than any other which is typical given the highly mobile nature of the bird and mammal species present in the area. Flight direction of seabirds were difficult to interpret and for most species no patterns could be determined.

A2: 2020/21 Survey Summary (Year Two)

5 In May 2020, HiDef were commissioned to undertake a programme of high-resolution digital video aerial surveys for ornithological marine megafauna and human activity in support of the Pentland Floating Offshore Wind Farm (the Offshore Development).

6 Twelve monthly surveys were flown between September 2020 and August 2021. HiDef designed a methodology to replicate surveys undertaken in 2015; placing 1 km spaced transects within the original PFOWF Array Area (the high-intensity area) and 2 km spaced transects within the surrounding buffer. A 2 km buffer was used between September 2020 and March 2021, and a 4 km buffer between April and August 2021. Combined with the high-intensity area, this created total survey areas of approximately 80 km^2 and 150 km^2 for the 2 km and 4 km buffer options, respectively.

7 The surveys were successful in recording a total of 12,539 birds of 17 species and 27 marine mammals of two species, in addition to one jellyfish species. A further 458 birds and five marine mammals were recorded which were not assigned to a species. An identification rate to species level of 93.85% was achieved throughout the 12-month period.

8 The primary observations from the surveys were:

- Several species, such as kittiwake, guillemot and razorbill were present in relatively high densities during the breeding season, suggesting linkage between the site and nearby breeding colonies.
- Relative to other months, very high numbers of puffin were recorded during the June 2021 survey, with seven times as many birds recorded compared to the next highest, possibly attributed to temporary favourable foraging conditions within the site.
- Fulmar were predominantly recorded during the non-breeding winter period, peaking in March 2021, possibly linked to the return of birds back to coastal areas after spending the winter offshore.
- Gannet density peaked in September 2020, suggesting the addition of juvenile birds to the population post-fledging. The lack of birds sitting on the water suggests the area is primarily used during passage to other areas, and not during foraging.

9 Distribution maps for all bird species appeared to show generally higher densities in the south of the survey area, with high densities also observed in the north during some surveys. Generally, distribution was species and month specific, with species such as kittiwakes and guillemots selecting the south of the survey area in many months, compared to gannets which were generally widespread throughout the survey area, distributed within the buffer and the high-intensity area.

A3: Data for the 4 km buffer between March-August 2021

10 Following preliminary scoping advice from NS and RSPB Scotland, a 4 km buffer was flown around the original PFOWF Array Area between March and August 2021. Within this extended area, 2 km-spaced transects were flown, following the same NW-SE orientation as used in previous surveys with 1 km-spaced transects flown within the original PFOWF Array Area.

11 ID rate to species for surveys including the 4 km buffer ranged between 85.60% and 98.69% in May 2021 and June 2021 respectively. Peaks in non-identification in May could be attributed to difficulties separating razorbill and guillemot and reflect the large number of birds present at that time. These are especially hard to distinguish when they are accompanied by juveniles. Many of these unidentified auk species were located within the 4 km buffer, with varied and widespread distribution between surveys.

12 Compared to other surveys, numbers of birds recorded in June 2021 were four times as high as the next highest peak (July 2021). No part of the survey area appeared to be selected more than others, with many birds occurring in relatively higher densities in the south (e.g., April 2021), west (e.g., May and July 2021) and east of the 4 km buffer (e.g., August 2021).

13 In June 2021, over seven times as many puffin were recorded compared to the next most numerous survey (April 2021), possibly attributed to temporary local feeding conditions. Guillemot abundance peaked in June and August 2021, possibly attributed to the presence of juveniles accompanying adults post-breeding. High guillemot densities were typically within the 4 km buffer, located in the east in May and July 2021, and the south in June 2021.

14 High densities of razorbill in the east and south of the 4 km buffer were recorded in May and June 2021. In July 2021, a relatively high number of great skua were recorded, with many of these located within the 2-4 km buffer region. Red-throated diver were observed within the 4 km buffer in June 2021, while in May and July 2021, high densities of kittiwake were recorded in the east of the 4 km buffer.

15 The number of birds recorded to species and species group level within the 2-4 km buffer are presented in Table A3.1.

Table A3.1 Number of objects detected per survey assigned to species level within the 2-4 km buffer zone between April and August 2021 (following original survey design)

Species	Scientific name	Month					Total
		Apr-21	May-21	Jun-21	Jul-21	Aug-21	
Golden plover	*Pluvialis apricaria*	0	0	0	0	0	**1**
Kittiwake	*Rissa tridactyla*	0	5	65	26	4	**111**
Common gull	*Larus canus*	0	0	0	0	0	**0**
Great black-backed gull	*Larus marinus*	0	0	0	0	0	**11**
Herring gull	*Larus argentatus*	0	0	0	0	0	**0**
Lesser black-backed gull	*Larus fuscus*	0	0	0	0	0	**0**
Arctic tern	*Sterna paradisaea*	0	0	0	0	0	**0**
Great skua	*Stercorarius skua*	0	0	1	0	0	**1**
Arctic skua	*Stercorarius parasiticus*	0	0	0	0	0	**0**
Guillemot	*Uria aalge*	31	4	59	25	81	**314**
Razorbill	*Alca torda*	1	11	15	0	0	**29**
Puffin	*Fratercula arctica*	30	30	828	50	3	**942**
Red-throated diver	*Gavia stellata*	0	0	1	0	0	**2**
Fulmar	*Fulmarus glacialis*	0	9	0	0	2	**64**
Manx shearwater	*Puffinus puffinus*	0	0	1	0	0	**1**
Gannet	*Morus bassanus*	0	0	4	0	10	**39**
Shag	*Gulosus aristotelis*	1	0	0	2	0	**3**

A4: Survey identification rates from original survey design

Table A4.1 Survey identification rates to species for all recorded birds between January and December 2015 and between September 2020 and August 2021 within the original PFOWF and buffer (2 km between January 2015 and March 2021; 4 km between April and August 2021) *4 km buffer assigned following advice from NatureScot

Survey date	ID rate (%)
19 January 2015	96.99
25 February 2015	99.33
13 March 2015	96.04
09 April 2015	91.80
09 May 2015	100.00
08 June 2015	97.49
30 June 2015	96.71
14 July 2015	95.60
05 August 2015	98.71
28 September 2015	93.43
13 October 2015	91.76
25 November 2015	97.59
03 December 2015	92.19
24 September 2020	96.88
14 October 2020	93.22
12 November 2020	97.39
10 December 2020	96.43
08 January 2021	97.04
02 February 2021	83.33
01 March 2021	96.28
22 April 2021*	95.34
20 May 2021*	85.60
15 June 2021*	98.69
02 July 2021*	97.08
13 August 20 21*	88.93
Average	**94.95**

A5: Dounreay Demonstration Centre Survey Summary

16 HiDef were commissioned to undertake a programme of high-resolution digital video aerial surveys across the Dounreay Demonstration Centre ('DDC') between May 2015 and April 2016. The DDC is located roughly 2 km off the north Caithness coast, lying south-east to the PFOWF Array Area. Proximity of the site to the PFOWF Array Area meant that it was flown in conjunction with surveys for Dounreay Tri, between May and December 2015.

17 Twelve surveys were commissioned, one per month, between May 2015 and April 2016. The survey design consisted of transects spaced at 1.7 km intervals within the DDC array area and 3.5 km intervals within the 3 km surrounding buffer.

18 A total of 3,779 birds of 13 species and 45 marine mammals of three species were recorded during the surveys. An identification rate to species level of 96.21% was achieved across the survey programme.

19 The primary observations from the surveys were:

- Fulmar were one of the most abundant species, peaking in August 2015; likely attributed to young birds leaving nest sites.
- Relatively low densities of gannet were present, with higher densities observed from July to October. Lower densities were recorded across winter months.
- Kittiwakes were also relatively abundant, recorded during all surveys, peaking in June 2015.
- Great black-backed gull were mostly recorded during winter months and at relatively low densities.
- Arctic tern were only present in July 2015.
- The most abundant species recorded over the survey period was guillemot, with relatively high density estimates in all surveys except August 2015. Density gradually increased over the winter months, peaking in January 2015.
- Relatively low densities of razorbill were recorded, peaking in March.
- Puffin density was generally relatively low, however high densities were observed in the June 2015 survey. As this high density was not reflected in the other surveys and historical data, it is likely that high densities were ephemeral and likely to be an exploitation of a temporary food source.
- Distribution and density maps for all species indicated no regular patterns between surveys to suggest that one part of the study area might be more important than any other, which is typical given the highly mobile nature of the studied species.

20 As for data collected for Dounreay Tri in 2015, relatively high numbers of puffin were recorded in the DDC survey area in June 2015. A secondary survey was not attempted for this site, but in July 2015 considerably fewer puffin were recorded, similar to other surveys.

Annex B HiDef Data Review Process

B1: Data Review and Object Detection

1 The digital video aerial survey data were reviewed by trained reviewers who marked any objects in the footage as requiring further analysis, as well as determining which objects were birds, marine megafauna (cetaceans, pinnipeds or other large, non-avian marine fauna), or anthropogenic objects such as ships or buoys.

2 As part of HiDef's Quality Assurance (QA) process, an additional 'blind' review of 20% of the raw data was carried out and the results compared with those of the original review. If 90% agreement is not attained during the QA process, then corrective action is initiated: the remaining data set is reviewed and where appropriate, the failed reviewer's data discarded and all the data re-reviewed. In addition, additional training is then given to the reviewer to improve performance.

3 Objects are only recorded where it reaches a reference line (known as 'the red line') which defines the true transect width of 125 m for each camera. By excluding objects that do not cross the red line, biases to abundance estimates caused by flux (movement of objects in the video footage relative to the aircraft, such as 'wing wobble') are eliminated.

B2: Object Identification

4 After review, images marked as requiring further analysis were passed to the identification stage for the ID Team; specialist ornithologists[1] and marine mammal specialists[2] to identify objects to the lowest taxonomic level possible and for assessment of the approximate age and the sex of each animal, as well as any behaviour traits visible from the imagery.

5 At least 20% of all objects were selected at random and subjected to a separate 'blind' QA process. If less than 90% agreement was attained for any individual camera then corrective action was initiated: if appropriate, the failed identifier's data were discarded, and the data re-identified. Any disputed identifications were passed to a third-party expert ornithologist for a final decision[1]. The level of agreement within the QA process is calculated as the final number of agreements as a percentage of all identifications subjected for QA for the entire survey.

6 All objects were assigned to a species group and where possible, each of these then further identified to species level. The species identifications were given a confidence rating of 'possible', 'probable' or 'definite'[3].

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1 HiDef currently employs four of the ten current members of the British Birds Rarities Committee ('BBRC') as expert ornithologists.

2 HiDef staff have long-standing experience in marine mammal identification, regularly undertaking boat surveys as part of the European Seabirds at Sea Partnership (ESAS). They process thousands of cetacean images, hold regular internal training sessions and have access to marine specialists within our wider company BioConsult SH.

3 Definite: as certain as reasonably possible. Probable: very likely to be this species or species group. Possible: more likely to be this species or species group than anything else.

7 All objects were assigned to a species group and where possible, each of these then further identified to species level. The species identifications were given a confidence rating of 'possible', 'probable' or 'definite'[4].

8 It is important to note that these confidence ratings are not a standardised assessment. The likelihood of achieving a definite or probable identification was not consistent for all component members of a species group. For example, someone undertaking identification of a large auk species would find it easier to be confident of guillemot identification than razorbill. Confidence scores should not be used to filter or weight the probability of 'large auk' being one species or another in any analysis, as this will lead to biased results, particularly if the identification rate is low.

9 Additional information was recorded on basic behaviour (i.e., whether the bird was sitting, loafing on land or other objects or flying). More detail was recorded where possible on foraging behaviour, approximate age, sex and any other details of interest. Aging of birds was based on moults and was mostly conducted on flying individuals and species which show seasonal variation in plumage.

B3: Final Processing

10 All data were geo-referenced, taking into account the offset from the transect line of the cameras, and compiled into a single output; Geographical Information System (GIS) files for the Observation and Track data are issued in ArcGIS shapefile format, using UTM30N projection, WGS84 datum.

4 Definite: as certain as reasonably possible. Probable: very likely to be this species or species group. Possible: more likely to be this species or species group than anything else.

Annex C Availability bias and absolute population estimates for auk species

1 In wildlife surveys, a proportion of seabirds or marine mammals that spend any time underwater, especially while feeding, will not be detectable at the surface. This 'availability bias' leads to an under-estimate of their abundance during surveys.

2 There are two main approaches to account for availability bias: by using double platform surveys (for example Borchers *et al.*, 2002) which can be logistically difficult to achieve; and by using known data on time spent underwater to apply correction factors to abundance estimates (for example Barlow *et al.*, 1988).

3 Following Barlow *et al.* (1988) the probability that an animal is available at the surface is calculated as:

$$\Pr(being\ visible) = \frac{(s+t)}{(s+d)}$$

4 Where s is the average time spent at the surface, t is the window of time that the animal is within view and d is the average time below the surface. In the case of digital video surveys, the value of t is negligibly small and is treated as zero.

5 At the Offshore Development, availability bias relates to the observations of the auks; guillemot, razorbill and puffin, and has been corrected for using Barlow's method.

6 The proportion of time that an animal is available at the surface was calculated (Pr (visible)) for guillemot and razorbill. Absolute density, corrected for availability, is then obtained by dividing the density of birds observed by the Pr(visible).

7 For guillemot and razorbill, data obtained during the breeding season using data loggers were used to estimate availability bias. Thaxter *et al.* (2010) gives mean times for these species engaged in flying, feeding and underwater per trip during the chick-rearing period.

8 Thus, the proportion of time that guillemot and razorbill are available at the surface (Pr(visible)) was estimated at 0.7595 and 0.8182, respectively.

9 For puffin, the results from a study using data loggers reported in Spencer (2012) were used. The results show that puffin spend 14.16% of daylight time underwater. This infers that the proportion of time that puffin were available at the surface (Pr(visible)) was 0.8584.

10 The estimates of Pr(visible) for guillemot, razorbill and puffin were used to correct relative abundance estimates of birds sitting on the sea. These corrected abundance estimates for sitting birds are then added to the abundance estimate of flying birds to give an overall absolute abundance for the species.

11 For each of the auk species (guillemot, razorbill and puffin), Table C1.1 to Table C1.12 give the absolute estimates adjusted for availability bias, presented alongside the relative estimates. It is these adjusted (absolute) population estimates that are presented in Section 3, Results, and that are carried forward into the impact assessments, especially displacement analysis

Table C1.1 Adjusted monthly density and population estimates for guillemot in the PFOWF Array Area between January and December 2015, accounting for the potential number of birds estimated as being unavailable for detection

Guillemot	Non-adjusted (relative) population estimates						Adjusted (absolute) population estimates					
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
19 January 2015	2.19	22	12	46	9	38.08	2.82	29	16	59	13	44.83
25 February 2015	2.03	21	12	35	6	27.05	2.67	28	16	46	8	28.57
13 March 2015	2.89	29	12	49	10	32.53	3.34	34	16	49	10	29.41
9 April 2015	0.77	8	0	14	4	43.82	1.01	11	0	18	6	54.55
9 May 2015	1.83	19	15	21	2	6.65	2.09	23	15	25	3	13.04
8 June 2015	8.90	90	69	121	16	17.78	11.55	117	83	163	23	19.66
30 June 2015	12.61	127	41	249	62	48.36	16.07	162	54	327	85	52.47
14 July 2015	9.64	97	15	194	46	47.60	12.52	126	20	255	65	51.59
5 August 2015	0.57	6	0	12	3	52.35	0.71	8	0	19	5	62.50
28 September 2015	1.20	13	10	15	2	11.44	1.58	17	13	20	3	17.65
13 October 2015	4.70	48	45	49	2	2.40	6.14	63	57	71	3	4.76
25 November 2015	10.35	104	53	186	41	38.79	13.76	138	70	245	57	41.30
3 December 2015	2.47	25	21	31	3	10.81	3.14	33	16	51	7	21.21

Table C1.2 Adjusted monthly density and population estimates for guillemot in the PFOWF Array Area between September 2020 and August 2021, accounting for the potential number of birds estimated as being unavailable for detection

Guillemot	Non-adjusted (relative) population estimates						Adjusted (absolute) population estimates					
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
24 September 2020	15.25	153	126	169	11	6.87	20.11	201	166	223	16	7.96
14 October 2020	2.08	21	11	35	7	30.22	2.78	29	14	46	10	34.48
21 November 2020	0.85	9	4	13	3	24.53	1.12	12	5	17	4	33.33
10 December 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
08 January 2021	2.26	23	15	29	5	18.64	3.02	30	20	38	7	23.33
02 February 2021	1.23	13	2	25	6	46.23	1.61	17	3	33	8	47.06
01 March 2021	2.59	26	20	35	5	16.55	3.41	34	26	46	7	20.59
22 April 2021	6.79	68	31	130	30	42.99	7.48	76	13	145	31	40.79
20 May 2021	1.07	11	0	28	9	79.66	1.39	16	0	34	11	68.75
15 June 2021	12.69	128	74	193	29	22.13	16.43	165	80	289	42	25.45
02 July 2021	5.41	55	35	69	10	16.78	6.96	72	46	99	12	16.67
13 August 2021	16.89	170	57	323	65	38.17	21.63	217	75	417	89	41.01

Table C1.3 Adjusted monthly density and population estimates for guillemot in the PFOWF Array Area plus 2 km buffer between January and December 2015, accounting for the potential number of birds estimated as being unavailable for detection

Guillemot	Non-adjusted (relative) population estimates						Adjusted (absolute) population estimates					
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
19 January 2015	2.37	115	29	239	53	46.09	3.14	152	38	315	73	48.03
25 February 2015	4.78	232	77	441	98	42.24	6.45	313	101	595	139	44.41
13 March 2015	5.75	279	208	365	34	12.19	6.52	316	213	423	46	14.56
9 April 2015	1.57	76	47	104	12	15.79	1.98	96	48	144	18	18.75
9 May 2015	2.94	143	123	164	11	7.69	3.54	172	115	233	19	11.05
8 June 2015	8.94	434	309	589	58	13.36	11.89	577	399	779	82	14.21
30 June 2015	11.88	577	323	903	115	19.93	15.34	745	421	1,163	163	21.88
14 July 2015	6.22	302	65	608	103	34.11	8.32	404	92	799	145	35.89
5 August 2015	0.29	14	0	32	7	50.00	0.39	19	0	46	11	57.89
28 September 2015	1.87	91	36	144	31	34.07	2.44	119	47	185	41	34.45
13 October 2015	4.30	209	190	221	9	4.31	5.65	275	248	300	13	4.73
25 November 2015	5.77	280	190	436	52	18.57	7.7	374	250	607	74	19.79
3 December 2015	5.87	285	175	450	70	24.56	7.54	366	213	562	98	26.78

Table C1.4 Adjusted monthly density and population estimates for guillemot in the PFOWF Array Area plus 2 km buffer between September 2020 and August 2021, accounting for the potential number of birds estimated as being unavailable for detection

Guillemot	Non-adjusted (relative) population estimates						Adjusted (absolute) population estimates					
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
24 September 2020	14.5	704	615	779	34	4.83	19.09	927	810	1,026	48	5.18
14 October 2020	2.39	116	42	205	39	33.62	3.15	153	59	266	54	35.29
21 November 2020	1.30	63	45	84	9	14.29	1.60	78	37	132	13	16.67
10 December 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
08 January 2021	4.39	213	152	271	30	14.08	5.75	279	196	357	42	15.05
02 February 2021	0.54	26	2	49	10	38.46	0.69	34	3	68	13	38.24
01 March 2021	2.37	115	49	191	36	31.30	3.09	150	62	254	47	31.33
22 April 2021	3.27	159	77	267	39	24.53	3.63	176	53	311	40	22.73
20 May 2021	2.88	140	30	309	66	47.14	3.89	189	39	404	94	49.74
15 June 2021	14.89	723	481	920	86	11.89	19.40	942	589	1,286	124	13.16
02 July 2021	8.18	397	205	622	106	26.70	10.17	494	178	876	148	29.96
13 August 2021	24.65	1,197	767	1,692	193	16.12	31.84	1,546	1,003	2,220	272	17.59

Table C1.5 Adjusted monthly density and population estimates for razorbill in the PFOWF Array Area between January and December 2015, accounting for the potential number of birds estimated as being unavailable for detection

Razorbill	Non-adjusted (relative) population estimates						Adjusted (absolute) population estimates					
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
19 January 2015	0.22	3	0	6	2	70.06	0.26	4	0	7	3	75.00
25 February 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
13 March 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
9 April 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
9 May 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
8 June 2015	0.20	3	1	6	2	72.28	0.26	4	1	7	3	75.00
30 June 2015	0.40	5	2	6	2	27.96	0.49	6	2	7	3	50.00
14 July 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
5 August 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
28 September 2015	0.80	8	4	12	3	29.60	0.97	10	5	15	4	40.00
13 October 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
25 November 2015	0.21	3	0	6	2	67.96	0.26	4	0	7	3	75.00
3 December 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00

Table C1.6 Adjusted monthly density and population estimates for razorbill in the PFOWF Array Area between September 2020 and August 2021, accounting for the potential number of birds estimated as being unavailable for detection

Razorbill	Non-adjusted (relative) population estimates						Adjusted (absolute) population estimates					
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
24 September 2020	0.21	3	0	6	2	76.94	0.26	4	0	7	3	75.00
14 October 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
21 November 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
10 December 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
08 January 2021	0.21	3	0	5	2	63.90	0.26	4	0	6	3	75.00
02 February 2021	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
01 March 2021	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
22 April 2021	0.23	3	0	6	2	64.60	0.27	4	0	7	3	75.00
20 May 2021	3.13	32	24	38	5	12.88	3.77	39	26	52	6	15.38
15 June 2021	3.33	34	11	60	14	39.15	3.95	40	13	73	20	50.00
02 July 2021	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
13 August 2021	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00

Table C1.7 Adjusted monthly density and population estimates for razorbill in the PFOWF Array Area plus 2 km buffer between January and December 2015, accounting for the potential number of birds estimated as being unavailable for detection

Razorbill	Non-adjusted (relative) population estimates						Adjusted (absolute) population estimates					
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
19 January 2015	0.41	20	0	47	13	65.00	0.50	24	0	57	18	75.00
25 February 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
13 March 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
9 April 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
9 May 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
8 June 2015	0.25	12	1	26	7	58.33	0.31	15	1	32	10	66.67
30 June 2015	1.28	62	20	98	20	32.26	1.56	76	24	125	29	38.16
14 July 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
5 August 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
28 September 2015	0.27	13	4	22	5	38.46	0.33	16	5	27	7	43.75
13 October 2015	0.10	5	1	11	3	60.00	0.12	6	1	13	4	66.67
25 November 2015	0.06	3	0	6	2	66.67	0.07	4	0	7	3	75.00
3 December 2015	0.56	27	12	40	7	25.93	0.71	34	15	49	10	29.41

Table C1.8 Adjusted monthly density and population estimates for razorbill in the PFOWF Array Area plus 2 km buffer between September 2020 and August 2021, accounting for the potential number of birds estimated as being unavailable for detection

Razorbill	Non-adjusted (relative) population estimates						Adjusted (absolute) population estimates					
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
24 September 2020	0.25	12	1	26	7	58.33	0.31	15	1	32	10	66.67
14 October 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
21 November 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
10 December 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
08 January 2021	0.06	3	0	5	2	66.67	0.07	4	0	6	3	75.00
02 February 2021	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
01 March 2021	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
22 April 2021	0.68	33	1	63	17	51.52	0.83	40	1	77	24	60.00
20 May 2021	1.05	51	24	74	12	23.53	1.29	62	26	96	16	25.81
15 June 2021	3.21	156	82	226	27	17.31	3.92	191	109	276	38	19.90
02 July 2021	0.10	5	1	11	4	80.00	0.12	6	1	13	5	83.33
13 August 2021	0.70	34	1	71	19	55.88	0.86	42	1	87	27	64.29

Table C1.9 Adjusted monthly density and population estimates for Puffin in the PFOWF Array Area between January and December 2015, accounting for the potential number of birds estimated as being unavailable for detection

Puffin	Non-adjusted (relative) population estimates						Adjusted (absolute) population estimates					
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
19 January 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
25 February 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
13 March 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
9 April 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
9 May 2015	0.61	7	0	16	5	67.41	0.71	8	0	19	7	87.50
8 June 2015	36.02	361	279	465	49	13.46	41.83	419	325	542	69	16.47
30 June 2015	4.44	45	29	71	11	23.30	5.16	52	34	83	16	30.77
14 July 2015	0.58	6	0	12	3	50.41	0.69	7	0	14	4	57.14
5 August 2015	0.19	2	0	6	2	88.89	0.23	2	0	7	3	150.00
28 September 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
13 October 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
25 November 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
3 December 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00

Table C1.10 Adjusted monthly density and population estimates for Puffin in the PFOWF Array Area between September 2020 and August 2021, accounting for the potential number of birds estimated as being unavailable for detection

Puffin	Non-adjusted (relative) population estimates						Adjusted (absolute) population estimates					
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
24 September 2020	0.21	3	0	7	2	90.09	0.26	3	0	8	3	100.00
14 October 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
21 November 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
10 December 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
08 January 2021	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
02 February 2021	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
01 March 2021	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
22 April 2021	6.73	68	25	92	18	25.37	7.86	79	29	107	25	31.65
20 May 2021	6.77	68	28	97	21	30.52	7.79	78	33	113	30	38.46
15 June 2021	172.85	1,730	1,304	2,063	200	11.53	200.03	2,003	1,454	2,401	283	14.13
02 July 2021	11.50	116	33	198	42	35.98	12.96	131	38	249	57	43.51
13 August 2021	3.39	34	15	47	10	29.10	3.91	40	17	55	15	37.50

Table C1.11 Adjusted monthly density and population estimates for Puffin in the PFOWF Array Area plus 2 km buffer between January and December 2015, accounting for the potential number of birds estimated as being unavailable for detection

Puffin	Non-adjusted (relative) population estimates						Adjusted (absolute) population estimates					
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
19 January 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
25 February 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
13 March 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
9 April 2015	0.41	20	4	39	9	45.00	0.41	20	4	39	9	45.00
9 May 2015	1.09	53	10	137	33	62.26	1.27	62	12	148	45	72.58
8 June 2015	50.35	2,445	2,015	2,944	213	8.71	58.66	2,848	2,326	3,422	303	10.64
30 June 2015	5.60	272	159	357	43	15.81	6.52	317	192	415	58	18.30
14 July 2015	0.23	11	0	22	5	45.45	0.27	13	0	26	7	53.85
5 August 2015	0.47	23	4	44	11	47.83	0.55	27	5	51	15	55.56
28 September 2015	0.10	5	0	10	3	60.00	0.12	6	0	12	4	66.67
13 October 2015	0.19	9	4	11	2	22.22	0.22	10	5	13	3	30.00
25 November 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
3 December 2015	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00

Table C1.12 Adjusted monthly density and population estimates for Puffin in the PFOWF Array Area plus 2 km buffer between September 2020 and August 2021, accounting for the potential number of birds estimated as being unavailable for detection

Puffin	Non-adjusted (relative) population estimates						Adjusted (absolute) population estimates					
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
24 September 2020	0.06	3	0	7	2	66.67	0.07	3	0	8	3	100.00
14 October 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
21 November 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
10 December 2020	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
08 January 2021	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
02 February 2021	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
01 March 2021	0.00	0	0	0	0	0.00	0.00	0	0	0	0	0.00
22 April 2021	11.92	579	342	785	95	16.41	14.01	680	404	913	132	19.41
20 May 2021	6.12	297	182	468	68	22.9	7.07	343	204	557	98	28.57
15 June 2021	180.58	8,769	6,265	10,318	875	9.98	209.93	10,194	7,226	12,208	1,232	12.09
02 July 2021	6.80	330	97	579	96	29.09	7.81	379	71	729	134	35.36
13 August 2021	2.35	114	68	154	18	15.79	2.74	133	80	179	25	18.80