Morven North Offshore Wind Array Project

Environmental Impact Assessment Report

Volume 3, Annex 10.3: Marine Mammals Shared Digital Aerial Survey Report

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1 Introduction

1.1.1.1 Morven Offshore Wind Limited (MvOWL), a joint venture between JERA Nex bp Limited (JNBP), and EnBW Energie Baden-Württemberg AG (EnBW) (hereafter "the Applicant"), are developing the Morven North Offshore Wind Array Project (hereafter referred to as "Morven North") and the Morven South Offshore Wind Array Project (hereafter referred to as "Morven South").

1.1.1.2 Morven North and Morven South will each be comprised of wind turbines, offshore substation platforms, associated foundations, inter-array and interconnector cables, and associated infrastructure. The Applicant will seek to consent the export cables for Morven North and Morven South separately. Morven North is located approximately 61.2km from the Aberdeenshire coast (at its closest point), within Scottish offshore waters. Morven South is located approximately 86.1km from the Aberdeenshire coast (at its closest point), within Scottish offshore waters.

1.1.1.3 To inform the baseline for marine mammals and offshore ornithology, the Applicant commissioned Digital Aerial Surveys (DAS), which were undertaken by APEM Ltd (hereafter "APEM") across the Morven Option Lease Agreement Site Marine Mammal Study Area (as defined in Section 2.1, hereafter "Morven Site Marine Mammal Study Area"). DAS flights commenced in January 2021 and were undertaken monthly, with a total of 33 months of data collected up until September 2023. This Marine Mammal DAS Data Analysis Report presents the results of analysis for marine mammal data collected during these DAS flights. Although the Morven Site Marine Mammal Study Area now encompasses Morven North and Morven South as independent projects, their respective locations adjacent to each other, and the fact that marine mammals are highly mobile, supports the approach to present the results of DAS data analysis in a single report.

2 Methodology

2.1 Study Area

2.1.1.1 The Morven Site Marine Mammal Study Area comprises the entire area over which DAS flights were undertaken between January 2021 and September 2023 and incorporates the Morven North Boundary and the Morven South Boundary, plus an approximate 4km buffer, covering an area of approximately 1,477km^2 (Figure 2.1).

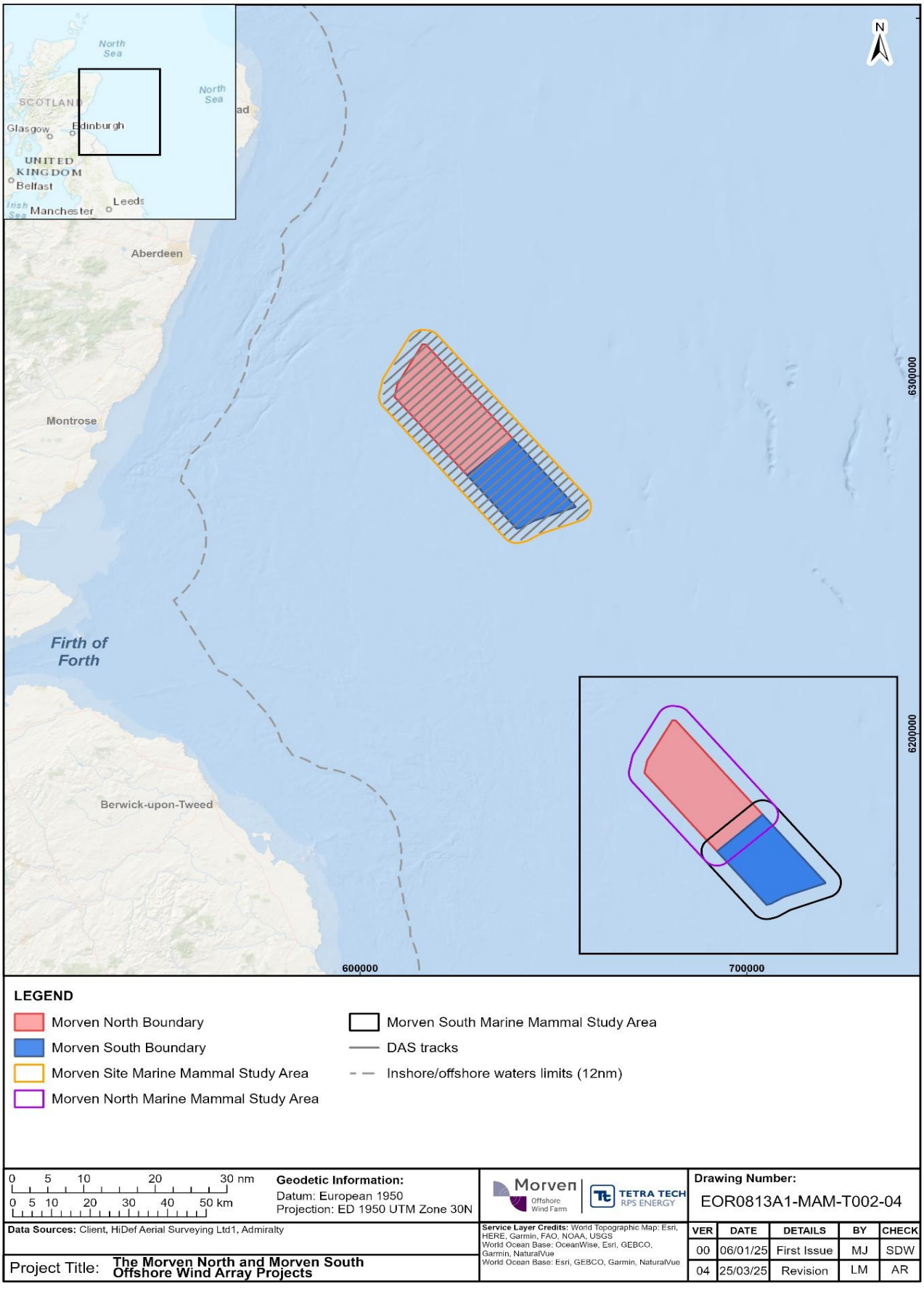

Figure 2.1: Morven North and Morven South, within Morven Site Marine Mammal Study Area

2.1.1.2 Since the project was split the following study areas have also been defined, as illustrated in Figure 2.2:

- The Morven North Marine Mammal Study Area comprises the Morven North Boundary plus a 4km buffer and covers an area of approximately 958km^2.
- The Morven South Marine Mammal Study Area comprises the Morven South Boundary plus a 4km buffer and covers an area of approximately 716km^2.

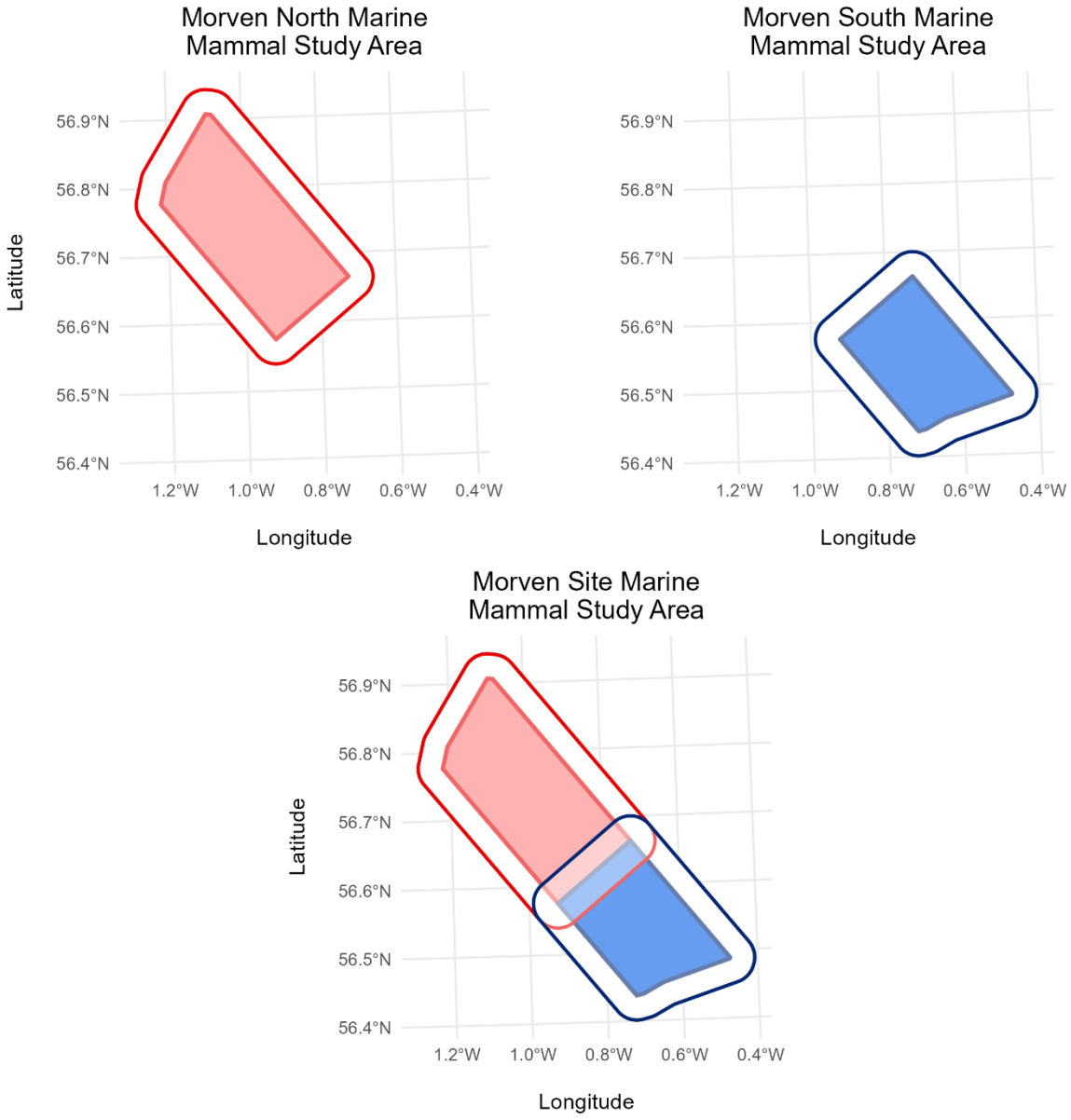

Figure 2.2: Morven North Marine Mammal Study Area, Morven South Marine Mammal Study Area and Morven Site Marine Mammal Study Area

2.1.1.3 As Morven North and Morven South are adjacent their respective 4km buffers overlap, thus any data recorded in the area of overlap has been analysed on the basis of the Morven Site Marine Mammal Study Area to avoid double counting.

2.1.1.4 The extent of the Morven Site Marine Mammal Study Area provides an indication of the spatial and temporal distribution of marine mammal activity within Morven North and Morven South array areas and beyond. This information will be useful to determine where Zones of Influence (ZoI) for some

impacts extend further than the Morven North and Morven South Boundaries. However, the Morven Site Marine Mammal Study Area may not incorporate the full extent of the ZoI for all impacts with the potential to affect marine mammals (e.g. piling noise).

2.2 Survey Approach

2.2.1.1 The DAS campaign was undertaken between January 2021 and September 2023 (33 months) by APEM using a grid-based collection method in which imagery of 30% of the sea surface was collected, and data from approximately 12% of the Morven Site Marine Mammal Study Area were analysed. A summary of coverage for each monthly survey is presented in Table 3.1. APEM utilised a bespoke camera system fitted into a twin-engine aircraft and custom flight planning software allowed each flight line to be accurately mapped for use before and during the flight.

2.2.1.2 The camera system captured abutting still imagery along 34 parallel survey lines (transects) spaced approximately 2km apart (Figure 2.3). The Morven North Marine Mammal Study Area was covered by 21 transects and the Morven South Marine Mammal Study Area was covered by 17 transects, with four transects overlapping with both the Morven North Marine Mammal Study Area and the Morven South Marine Mammal Study Area. The aircraft collected the data at an altitude of approximately 1,300ft (~400m), and a speed of approximately 120kn. The data collected were 1.5cm Ground Sampling Distance digital still images.

2.2.1.3 Sea states are categorical values used to give an approximate but concise description of sea condition, as this will affect the probability of a sighting. Sea state conditions used in the aerial survey were 0 = Calm (Glassy), 1 = Calm (Rippled), 2 = Smooth, 3 = Slightly Moderate and 4 = Moderate.

2.2.1.4 All surveys were undertaken in weather conditions that did not compromise the ability to provide data on the identification, distribution and abundance of marine megafauna and were also safe to fly in. Favourable conditions for surveying are defined as a cloud base of >396m, visibility of >5km, wind speed of <30kn and a sea state of no more than four (moderate).

2.2.1.5 Measures were taken to minimise glint and glare (strong reflected light off the sea), that makes finding and identifying marine megafauna more difficult. On days with minimal cloud, surveys were avoided for two hours around midday to reduce the risk of collecting images that are difficult to analyse. Due to weather constraints, some surveys were undertaken over more than one day, and where this was the case, the survey was undertaken at the very next opportunity.

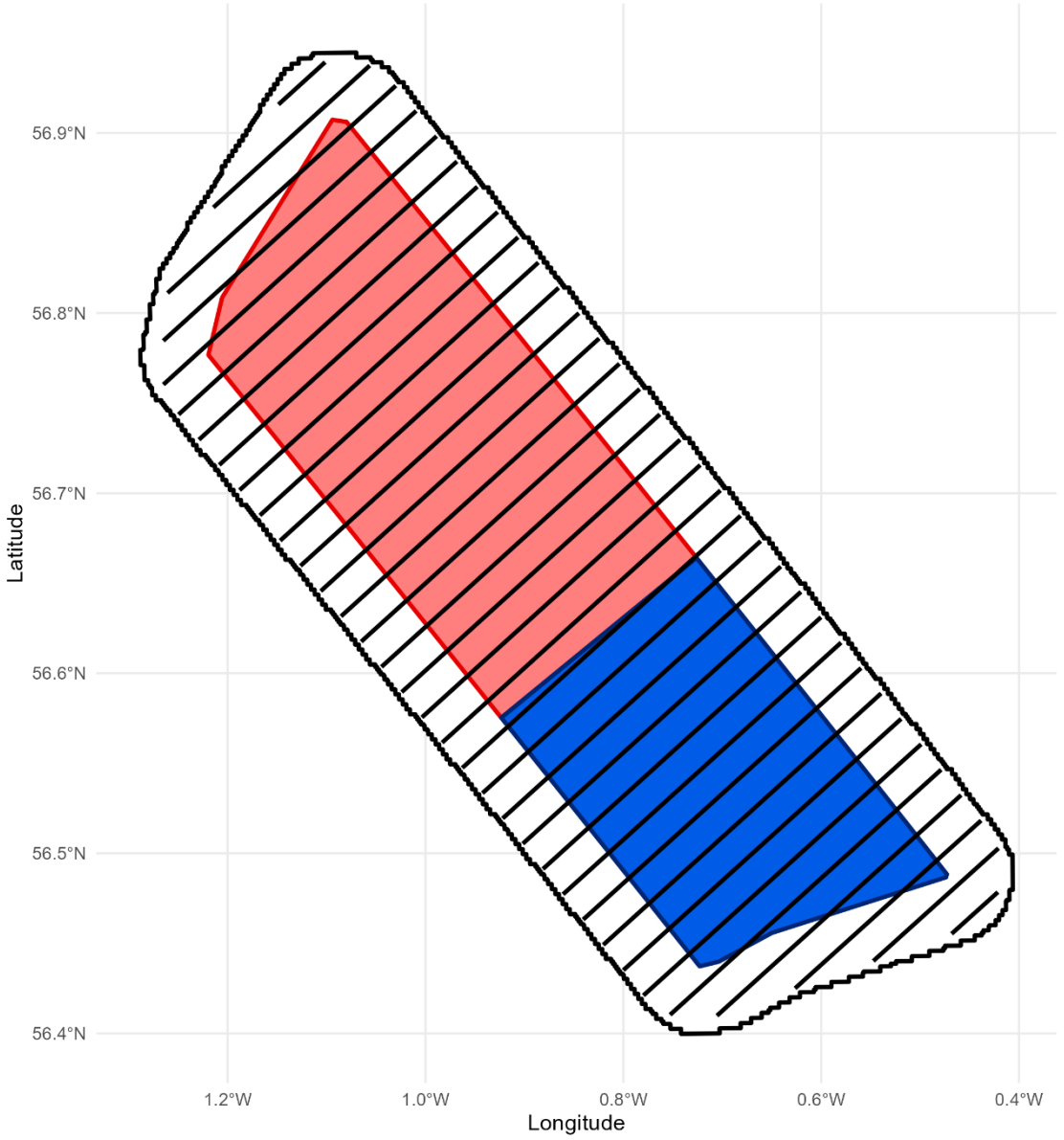

Figure 2.3: Overview of digital aerial survey flight transects (black diagonal lines) over Morven North (red shaded area) and Morven South (blue shaded area) with 4km buffer comprising the Morven Site Marine Mammal Study Area (black outline)

2.3 Processing of digital aerial survey data

2.3.1.1 The images were analysed to enumerate marine mammals. Internal quality assurance (QA) was undertaken to check for missed targets and to ensure that species were correctly identified. Marine mammals identified from the images were located within the images and categorised to the lowest taxonomic level possible.

2.3.1.2 The analysis was undertaken by senior image analysts with at least two years of full-time experience. Image analysts receive ongoing identification training from APEM's QA Manager and have access to a regularly updated in-house image archive reference library to aid in the identification of marine mammals. As part of the image analysis process the size of individuals can also be measured, which can aid in species level identification. Images were always reviewed by a minimum of two staff members as part of a comprehensive internal QA process. APEM have included their senior marine mammal consultant and principal marine mammal consultant in the QA process of all images,

holding a minimum of five years' experience at identifying marine mammals to species level nationally and internationally.

2.3.1.3 APEM uses the precautionary principle and only identify species to a level they are 100% confident with. Accurate identification is based upon species level ID; and if a target cannot be identified to species level it is assigned to the next taxonomic level possible.

2.3.1.4 Summary statistics (monthly sightings, monthly mean density, group size) were produced to describe the data for each of the key species or species groups within the aerial survey dataset.

2.4 Density estimates with bootstrapping

2.4.1.1 Statistically robust, design-based baseline population estimates for marine mammals identified in the Morven North and Morven South Marine Mammal Study Areas, and the Morven Site Marine Mammal Study Area were calculated. For each DAS, species-specific abundances and density estimates were produced, with upper and lower 95% confidence limits (CLs) and precision estimates in the form of a Coefficient of Variation (CV). The input data comprised of geo-referenced locations of marine mammals contained within each individual digital still image, which were used to generate the raw counts for the analysis.

2.4.1.2 For species with sufficient sightings, seasonal relative densities were estimated from the count data. First, raw counts were adjusted to take account of the area covered in each DAS flight (Table 3.1) to give estimates of abundance. These relative abundances were then corrected for availability bias (see paragraphs 2.6.2.1 to 2.6.2.3) to give estimates of absolute abundance. Densities were then calculated by dividing abundance estimates by the size of the relevant study areas. Average densities were then calculated for each month, season, bio-season (see Section 2.4.1.7) and across the whole survey period.

2.4.1.3 It is important to note that, given the overlap between the Morven North Marine Mammal Study Area and the Morven South Marine Mammal Study Area, summing the respective abundance estimates would result in double counting for the Morven Site Marine Mammal Study Area. Abundance estimates for the Morven Site Marine Mammal Study Area were therefore calculated separately.

2.4.1.4 Density estimates with bootstrapping were undertaken for harbour porpoise (*Phocoena phocoena*), white-beaked dolphin (*Lagenorhynchus albirostris*) grey seal (*Halichoerus grypus*) and minke whale (*Balaenoptera acutorostrata*). Monthly densities were resampled with replacement (n = 1,000) to generate an estimated value for overall uncorrected density and 95% confidence intervals (CI).

2.4.1.5 Uncertainty in the data was estimated with upper and lower 95% CLs and CVs. CLs were calculated from the survey densities via non-parametric bootstrapping (Buckland *et al.,* 2001). Bootstrapping is a commonly applied method to produce an approximate distribution of the empirical data, particularly where the sample size is insufficient for straightforward statistical inference. The resampling generates a probability distribution which is subsequently used to produce estimates of accuracy (e.g. standard errors, CI). Non-parametric bootstrapping makes no assumptions about the data, in contrast to parametric bootstrapping which assumes that data follow a specific distribution. CVs were calculated as the standard deviation divided by the mean of the data (e.g. standard deviation of January densities, divided by the mean of January densities).

2.4.1.6 For marine mammals, it is unlikely that low CVs would be obtainable as the sample size sufficient for cryptic species, in particular species that spend the majority of their life underwater such as cetaceans, would require a high level of survey effort. CVs will be higher for marine mammals, due to very low sighting numbers given their life history, so the difference between raw counts during different sampling months would be proportionally greater. Literature has highlighted CVs for marine mammal abundances can be large (Taylor *et al.,* 2007), and detecting population trends is difficult due to small sample size and relatively large uncertainty in abundance or density estimates (Authier *et al.,* 2020). Expert groups (ICES, 2008, 2014, 2016) have discussed this at length, but statistical power to detect change remained low (ICES, 2016, OSPAR, 2017). Furthermore, there will be big

differences between species and months due to abundance and distribution within the Morven Site Marine Mammal Study Area.

2.4.1.7 Research into temporal patterns of harbour porpoise density identified two broad divisions in distribution, termed by Heinänen and Skov (2015) as “summer” (April to September) and “winter” (October to March), and hereafter referred to as the ”summer” and ‘winter’ bio-seasons. The division of the year into two equal halves is based upon bimodal patterns of spatial distribution and is intended to address the difficulties in implementing criteria for designating Special Areas of Conservation (Heinänen and Skov, 2015). This approach has been applied here to assist in estimating harbour porpoise density at a broader temporal scale that is relevant to this species, to complement the estimates calculated across human-defined months and meteorological seasons.

2.4.1.8 Similarly for grey seal, broad-scale seasonal patterns of density have been determined based upon potential changes in distribution between the breeding season (defined as September to December for this region (SCOS, 2020, Marine Scotland, 2020)) and the non-breeding season (January to August). This is because most females would be expected to be hauled out with pups during the breeding season, rather than being at sea. As for harbour porpoise, these divisions are hereafter referred to as the ”breeding” and “non-breeding” bio-seasons.

2.4.1.9 Pooling data into two bio-seasons allows the robustness of analyses to be improved where sample sizes in seasonal or monthly divisions may be small, whilst retaining greater resolution than pooling data by year. However, no bimodal temporal patterns in occurrence, similar to those for harbour porpoise and grey seal, have been identified in the literature for either white-beaked dolphin or minke whale.

2.4.1.10 White-beaked dolphin has been observed to peak in occurrence off the Aberdeenshire coast during the months of June, July and August, with no animals sighted outside this season (Canning *et al.,* 2008, Weir *et al.,* 2007). As this pattern aligns with meteorological summer (June, July and August), additional temporal divisions for white-beaked dolphin were not considered to provide additional information. Minke whale has also been observed to peak in occurrence in this region between May and November (Baumgartner, 2008, Risch *et al.,* 2019), but this pattern was not reflected consistently across the DAS campaign.

2.4.1.11 Both white-beaked dolphin and minke whale were identified during multiple months of DAS, but only white-beaked dolphin occurred at sufficient regularity for temporal patterns to be ascertained. Even so, these patterns aligned with meteorological summer and were therefore not analysed separately. Minke whale was identified in only five months (May 2021, June 2021, July 2021, May 2022 and September 2022), so pooling data into two bio-seasons was not possible.

2.4.1.12 All analysis and data manipulation were conducted in the R programming language (R Core Team, 2023) and non-parametric 95% CIs were generated using the ‘boot’ library of functions (Canty and Ripley, 2022).

2.5 Model-based density estimates

2.5.1.1 DAS data were imported into R statistical software v4.3.0 (R Core Team, 2023), and the MRSea package v1.3.1 (Scott-Hayward *et al.,* 2013) was used in the analysis to best predict the density of marine mammals within the Morven Site Marine Mammal Study Area. Only harbour porpoise and white-beaked dolphin were identified in sufficient numbers for model-based analysis to be conducted. Sample sizes for all species were too low to facilitate separate model-based analysis for the Morven North Marine Mammal Study Area and the Morven South Marine Mammal Study Area.

2.5.1.2 Months were initially modelled separately; however, this approach was not found to be robust due to data being too sparse to fit MRSea models. Next, data were explored by pooling across months within the meteorological seasons (winter: December, January, February; spring: March, April, May; summer: June, July, August; and autumn: September, October, November) to overcome this issue, incorporating the biological assumption that species behave similarly within each season. Again,

data pooled by meteorological season also proved too sparse for robust analysis. Finally, for harbour porpoise, data were pooled into the two bio-seasons described in Section 2.4.1.7, and this proved to be the most statistically robust approach. For completeness, the results of all three modelled approaches have been presented for harbour porpoise (Section 3.2.2), and seasonal and overall estimates presented for white-beaked dolphin (Section 3.2.3).

2.5.1.3 The following covariates were used within all modelling to predict species distribution:

- bathymetry (depth and ruggedness);
- distance to coast;
- latitude and longitude.

2.5.1.4 The degree of smoothing for each species and season was determined within the MRSea software using tenfold cross validation and a range of different models were explored to determine the best model to predict species distribution. Within each of the exploratory models, separate maps with associated 95% lower and upper CIs were also produced for each species and season.

2.5.1.5 Before any analyses could take place, the data had to be pre-processed to ensure no survey date/time data were missing from image identifiers, which would prevent accurate assignment and cross-referencing of observations. There were no occurrences of missing information and no data required removing from subsequent analysis.

2.5.1.6 In total, for the Morven Site Marine Mammal Study Area, 1,122 survey transects were used in the analysis (34 flight lines, for 33 months) covering a total survey area of 5,756.12km^2 and incorporating 162,379 images (mean 0.035km2 (SD = 0.004) coverage per image). For the Morven North Marine Mammal Study Area, 693 survey transects were analysed (21 flight lines for 33 months) covering a total area of 3,662.37km^2, incorporating 103,352 images (mean 0.035km^2 (SD = 0.004) coverage per image). For the Morven South Marine Mammal Study Area, 561 survey transects were analysed (17 flight lines for 33 months) covering a total area of 2,797.16km^2, incorporating 78,927 images (mean 0.035km^2 (SD = 0.004) coverage per image).

2.6 Data limitations

2.6.1 Snapshot data collection

2.6.1.1 Aerial survey data represent a snapshot of marine mammal distribution and densities within a given survey month and may not fully capture the natural variability of marine mammal distribution or densities over time. Changes in sightings rates may be influenced by environmental conditions; however, due to the short time frames (single day) of data collection, this has not been possible to analyse. Therefore, whilst differences in sightings rates between months may be due to seasonal changes, environmental conditions also have the potential to influence these results.

2.6.2 Bias

2.6.2.1 Availability bias - an estimator of the probability that an animal is available at any randomly chosen time – is used as multiplier to account for the period of time that each species may be available for detection. In the case of aerial digital surveys, the time when an animal is available for detection is during the period that an animal is on the sea surface or just below the surface.

2.6.2.2 Availability bias is likely to be influenced by extrinsic factors that combine to produce a situation that is unique to each survey: factors such as light conditions, water clarity (turbidity), and animal behaviour can influence whether an animal will be detected, particularly those beneath the water surface. In most cases (Section 3.1.4), animals were noted and identified from digital images where the animal is under the sea surface. The depth at which reliable interpretation of images is assured will therefore rely considerably on the factors mentioned and for this reason availability bias may differ from month to month.

2.6.2.3 Estimates of availability bias during aerial surveys are often based on studies looking at diving behaviour of a species, which provide a correction factor for the proportion of time that animals are under the sea surface and therefore not available for detection. For the purpose of this assessment, correction factors were derived from studies in the Baltic and North Seas. The caveat here is that species correction factors are unlikely to be a true representation of availability bias from one region to another, or from one month to the next, due to the potential spatial and temporal differences in environmental conditions. However, a precautionary approach was taken by reviewing the literature to compare correction factors from different studies and different months and then applying a conservative estimate (see Sections 3.2.2, 3.2.3 and 3.2.4 for species-specific correction factors).

2.6.2.4 Perception bias – where an animal is available for detection, but the detection is missed – is less of a limiting factor during DAS compared to visual boat-based surveys since the high-definition video utilised during DAS captures all animals on the sea surface, or just under the sea surface, and the detection is not influenced by the ability of an observer to detect an animal. In addition, during data processing, a 20% subsample of the data were quality assured to ensure that images were not overlooked and therefore the potential for perception bias is negligible.

2.6.2.5 Similarly, response bias, where an animal may respond to the presence of the platform (either moving towards or away from the platform), is considered to be less of a limiting factor for aerial surveys compared to boat-based surveys. Therefore, the potential for response bias is negligible.

2.6.3 Species identification

2.6.3.1 Animals were identified first to a species group (e.g. seals) and then to species level where possible (for example grey seal or harbour seal). For seals, the identification to species level is more difficult as it is not always possible to distinguish between species where an individual is submerged. A subsample of data was subject to an external QA process by a third-party marine mammal expert to ensure agreement in identification. Where a full species identification could not be made, to avoid introducing unquantifiable biases, these data were not included in quantitative analysis but have been discussed qualitatively.

3 Results

3.1 Summary data

3.1.1 Survey descriptions

3.1.1.1 A summary of survey coverage for each month of the DAS campaign (33 months) is presented in Table 3.1 and a summary of the survey dates and conditions during DAS flights over the Morven Site Marine Mammal Study Area is given in Table 3.2.

Table 3.1: Monthly survey effort across the Morven North Marine Mammal Study Area, Morven South Marine Mammal Study Area and the Morven Site Marine Mammal Study Area

Survey Number	Survey Month	Morven North Marine Mammal Study Area (947.10km^2)		Morven South Marine Mammal Study Area (705.54km^2)		Morven Site Marine Mammal Study Area (1,477.27km^2)	
		Survey Coverage (km^2)	Percentage of Study Area	Survey Coverage (km^2)	Percentage of Study Area	Survey Coverage (km^2)	Percentage of Study Area
1	January 2021	111.46	11.63	84.68	12.00	174.74	11.83
2	February 2021	111.14	11.60	84.54	11.98	174.40	11.81
3	March 2021	108.91	11.37	84.05	11.91	172.07	11.65
4	April 2021	112.24	11.71	85.41	12.11	176.03	11.92
5	May 2021	110.67	11.55	85.08	12.06	174.31	11.80
6	June 2021	109.81	11.46	83.89	11.89	172.81	11.70
7	July 2021	110.46	11.53	84.41	11.96	173.61	11.75
8	August 2021	109.76	11.45	84.99	12.05	173.78	11.76
9	September 2021	110.70	11.55	83.94	11.90	173.51	11.75
10	October 2021	113.18	11.81	85.64	12.14	177.40	12.01
11	November 2021	108.54	11.33	84.07	11.92	171.67	11.62
12	December 2021	110.43	11.52	84.53	11.98	173.63	11.75
13	January 2022	111.72	11.66	85.63	12.14	175.76	11.90
14	February 2022	111.82	11.67	85.02	12.05	175.54	11.88
15	March 2022	111.94	11.68	85.07	12.06	175.75	11.90
16	April 2022	110.13	11.49	86.05	12.20	174.68	11.82

Survey Number	Survey Month	Morven North Marine Mammal Study Area (947.10km^2)		Morven South Marine Mammal Study Area (705.54km^2)		Morven Site Marine Mammal Study Area (1,477.27km^2)	
		Survey Coverage (km^2)	Percentage of Study Area	Survey Coverage (km^2)	Percentage of Study Area	Survey Coverage (km^2)	Percentage of Study Area
17	May 2022	109.94	11.47	84.23	11.94	172.64	11.69
18	June 2022	110.62	11.54	84.32	11.95	173.69	11.76
19	July 2022	111.27	11.61	84.93	12.04	174.90	11.84
20	August 2022	112.65	11.76	85.23	12.08	176.11	11.92
21	September 2022	110.02	11.48	83.13	11.78	172.23	11.66
22	October 2022	109.72	11.45	83.38	11.82	172.14	11.65
23	November 2022	111.79	11.67	85.11	12.06	175.56	11.88
24	December 2022	110.74	11.56	83.95	11.90	173.31	11.73
25	January 2023	111.17	11.60	86.83	12.31	176.49	11.95
26	February 2023	111.22	11.61	84.08	11.92	174.15	11.79
27	March 2023	111.34	11.62	85.89	12.17	175.88	11.91
28	April 2023	112.11	11.70	84.89	12.03	175.44	11.88
29	May 2023	111.28	11.61	84.74	12.01	174.56	11.82
30	June 2023	111.25	11.61	84.95	12.04	174.77	11.83
31	July 2023	111.30	11.61	84.66	12.00	174.65	11.82
32	August 2023	112.13	11.70	85.01	12.05	175.83	11.90
33	September 2023	110.89	11.57	84.80	12.02	174.10	11.78
Overall total		3,662.36	n/a	2,797.16	n/a	5,756.12	n/a
Overall mean		110.98	11.58	84.76	12.01	174.43	11.81

3.1.1.2 The DAS campaign was designed to cover the Morven Site Marine Mammal Study Area, so although percentage survey coverage over the Morven North and Morven South Marine Mammal Study Areas appears to be lower than for the Morven Site Marine Mammal Study Area, this is simply a result of the way in which survey coverage was subsequently divided across the Morven North and Morven South Marine Mammal Study Areas (Figure 2.2). The sum of the Morven North and Morven South Marine Mammal Study Areas is greater than the Morven Site Marine Mammal Study Area, so divided over the "larger" area, survey coverage appears to be lower. However, the minimum coverage required for robust analysis of DAS data is considered to be 10%, and in all survey months, for all study areas, this target was comfortably exceeded.

Table 3.2: survey dates and conditions during surveys for the Morven Site Marine Mammal Study Area

Survey No.	Month	Date	Visibility (km)	Sea State[1]	Glint/Glare (%)	Turbidity[2]	Cloud Cover (%)[3]	Air Temp (°C)	Wind Speed (kn)	Wind Direction
1	January 2021	18/01/2021	10+	1 – 2	–	1	20 – 70	4	25	W
2	February 2021	16/02/2021	7 – 10+	1	–	1	20 – 40	6 – 8	30 – 35	SSW
		17/02/2021	10+	1 – 3	–	1	50 – 60	7	30 – 40	S/SSW
3	March 2021	13/03/2021	10+	1	–	1	30 – 70	1 – 2	12	NNE
4	April 2021	01/04/2021	10+	0	–	1	50 – 70	2	6 – 13	NNE/NE
5	May 2021	09/05/2021	10+	1 – 2	10 – 50	0 – 1	10 – 30	9 – 10	13 – 26	W/SW
6	June 2021	11/06/2021	10+	4	0 – 30	0	0 – 100	12 – 13	28 – 39	W/SW
7	July 2021	17/07/2021	20+	3	30 – 40	1 – 2	0 – 20	18 – 21	20 – 31	W/WNW
8	August 2021	02/08/2021	20+	2	0 – 5	1	90	9 – 10	1 – 11	SW/NNW
9	September 2021	14/09/2021	10+	2	0 – 10	0	50 – 100	12	8 – 20	S
10	October 2021	16/10/2021	10+	2 – 3	0	3	5	5 – 7	12 – 20	W/WNW
11	November 2021	09/11/2021	10+	2	0 – 5	2	50 – 100	10	20	W
12	December 2021	07/12/2021	10+	2 – 3	0	2	5 – 100	3	22 – 25	S/SE
13	January 2022	11/01/2022	15+	0.5 – 1.5	0 – <10	1	0 – 20	4 – 5	20 – 30	W
14	February 2022	19/02/2022	30+	2 – 3	0 – <15	0.5	0	0 – 1	12 – 20	WNW/NW

Survey No.	Month	Date	Visibility (km)	Sea State[1]	Glint/Glare (%)	Turbidity[2]	Cloud Cover (%)[3]	Air Temp (°C)	Wind Speed (kn)	Wind Direction
15	March 2022	06/03/2022	10+	1	0	0	1 – 50	3	5	N
		07/03/2022	10+	3	0	2	0 – 100	2 – 3	21 – 25	SW
16	April 2022	11/04/2022	10+	2	0 – 40	2	5 – 50	4	17	SE/SSE
17	May 2022	07/05/2022	7 – 10+	0 – 1	0 – 40	1	30 – 50	6 – 7	3 – 7	NNE/E, S
18	June 2022	06/06/2022	10+	2	0 – 10	2	25 – 100	7 – 8	22	NNE
19	July 2022	04/07/2022	15 – 20	3	0	3	80 – 95	10 – 13	10 – 28	W/WNW
20	August 2022	02/08/2022	10+	3 – 4	0 – 40	1	0 – 30	17 – 19	29 – 40	WSW
21	September 2022	01/09/2022	10+	0	0 – 20	0	0	12 – 13	10 – 14	SSE
22	October 2022	13/10/2022	10+	2	0 – 20	2	25	8 – 9	12 – 16	WSW/W
23	November 2022	03/11/2022	10+	2 – 3	0	0	0 – 5	7	14	W
24	December 2022	20/12/2022	10	3	10 – 20	2	15 – 20	6 – 8	25 – 36	SWS/WSW
25	January 2023	15/01/2023	10+	4+	–	1 – 2	50 – 70	2	30 – 50	NW
26	February 2023	15/02/2023	10+	2	–	1 – 2	40 – 100	7 – 10	33 – 40	SW/WSW
27	March 2023	15/03/2023	10+	1	0 – 20	1	55	5	15	SSW
		15/03/2023	10+	3	5 – 15	3	50 – 80	1	9 – 10	W/WSW
28	April 2023	14/04/2023	5 – 10+	2	30 – 50	1	0	4 – 6	10 – 15	SSW
29	May 2023	22/05/2023	10+	2	0 – 10	2	5 – 10	6 – 7	12 – 20	SSW/S

Survey No.	Month	Date	Visibility (km)	Sea State[1]	Glint/Glare (%)	Turbidity[2]	Cloud Cover (%)[3]	Air Temp (°C)	Wind Speed (kn)	Wind Direction
30	June 2023	14/06/2023	25+	1	0 – 50	1	5 – 10	17	16 – 21	SSE
		14/06/2023	25	1	0	1	5	17	6 – 11	SSW/NW
31	July 2023	10/07/2023	25	1 – 2	0 – 60	2	25 – 60	13 –14	11 – 15	SSW
		10/07/2023	25	1	0 – 40	2	40 – 60	14	14 – 24	S/SSW
32	August 2023	09/08/2023	10+	1	5	1	40	10 – 11	19	NW
		09/08/2023	10+	1	0	1	60 – 95	12	15	W
33	September 2023	17/09/2023	10+	2 – 3	5 – 25	0	0 – 50	9 – 11	12	E

[1] 0 = Calm (Glassy); 1 = Calm (Rippled); 2 = Smooth; 3 = Slight; 4 = Moderate
[2] 0 = Clear; 1 = Slightly Turbid; 2 = Moderately Turbid; 3 = Highly Turbid
[3] 0 = Clear; 1-10 = Few; 11-50 = Scattered; 51-95 = Broken; 96-100 = Overcast

3.1.2 Species counts

3.1.2.1 Harbour porpoise accounted for the highest number of sightings identified to species level (based on raw count data) across the Morven Site Marine Mammal Study Area (n = 593) and was recorded in all but four survey months (Table 3.3). White-beaked dolphin accounted for the second highest number of sightings identified to species level (n = 85) and was recorded in 14 months over the 33-month DAS campaign. For other sightings identified to species level – grey seal, minke whale (*Balaenoptera acutorostrata*) and common dolphin (*Delphinus delphis*) – both the number and frequency of sightings was small (Table 3.3). Grey seal and minke whale did occur in sufficient numbers for design-based density estimates to be made, although it was not possible to identify clear temporal patterns, and the number of observations for these species was too low for model-based density estimates to be calculated. One humpback whale (*Megaptera novaeangliae*) was also identified during the May 2022 survey. No bottlenose dolphin (*Tursiops truncatus*) or harbour seal (*Phoca vitulina*) were observed during any surveys.

3.1.2.2 There were also a number of sightings of cetaceans (n = 94) that could not be assigned to species level. Similarly, sightings classified as “phocid” or “seal species” (n = 33) occurred in 15 months, due to the difficulty of identifying phocids to species level from aerial survey data.

Table 3.3: Monthly raw sightings* data (number of animals, uncorrected for effort) across the Morven Site Marine Mammal Study Area

Survey month	Harbour Porpoise	White-beaked Dolphin	Common Dolphin	Grey Seal	Minke Whale	Humpback Whale	Dolphin/ Porpoise	Dolphin species	Seal species	Whale species	Marine Mammal species	Total
January 2021	-	-	-	-	-	-	-	-	1	-	-	1
February 2021	-	-	-	-	-	-	2	-	2	-	-	4
March 2021	-	-	-	-	-	-	2	-	1	-	-	3
April 2021	3	-	-	-	-	-	2	-	7	-	-	12
May 2021	116	-	-	-	1	-	32	9	2	-	-	160
June 2021	3	10	-	1	1	-	2	1	-	-	1	19
July 2021	47	4	-	-	2	-	2	-	1	1	3	60
August 2021	7	2	-	-	-	-	-	-	-	-	1	10
September 2021	9	8	-	-	-	-	-	-	-	-	2	19
October 2021	5	-	-	-	-	-	4	-	-	-	-	9
November 2021	2	-	-	-	-	-	-	-	1	-	-	3
December 2021	7	-	-	1	-	-	-	-	-	-	2	10
January 2022	-	5	-	-	-	-	-	-	-	-	-	5
February 2022	7	8	-	1	-	-	6	-	3	-	1	26
March 2022	6	-	-	-	-	-	-	-	5	-	2	13
April 2022	1	-	-	-	-	-	1	-	1	-	-	3

Survey month	Harbour Porpoise	White-beaked Dolphin	Common Dolphin	Grey Seal	Minke Whale	Humpback Whale	Dolphin/ Porpoise	Dolphin species	Seal species	Whale species	Marine Mammal species	Total
May 2022	158	-	-	-	1	1	9	-	4	-	2	175
June 2022	3	-	8	-	-	-	1	-	-	-	-	12
July 2022	10	6	-	-	-	-	-	-	-	-	-	16
August 2022	3	6	-	-	-	-	-	-	-	-	-	9
September 2022	23	8	-	1	1	-	1	1	-	-	-	35
October 2022	22	-	-	-	-	-	9	-	-	-	-	31
November 2022	9	-	-	-	-	-	-	-	-	-	-	9
December 2022	2	-	-	-	-	-	1	-	-	-	-	3
January 2023	1	-	-	-	-	-	-	-	-	-	-	1
February 2023	2	-	-	-	-	-	-	-	-	-	-	2
March 2023	3	-	-	2	-	-	-	-	-	-	-	5
April 2023	21	5	-	1	-	-	3	-	2	-	-	32
May 2023	17	-	-	1	-	-	3	-	1	-	-	22
June 2023	57	9	-	-	-	-	-	-	1	-	1	68
July 2023	34	8	-	1	-	-	-	-	1	-	-	44
August 2023	8	5	-	1	-	-	1	-	-	-	-	15
September 2023	7	1	-	1	-	-	-	2	-	-	-	11

Survey month	Harbour Porpoise	White-beaked Dolphin	Common Dolphin	Grey Seal	Minke Whale	Humpback Whale	Dolphin/ Porpoise	Dolphin species	Seal species	Whale species	Marine Mammal species	Total
Total	593	85	8	11	6	1	81	13	33	1	15	847

* Note that four deceased marine mammals were observed in the Morven Site Marine Mammal Study Area, indicated in the table by red text. These animals have been described in summary statistics but have not been included in the calculation of density estimates.

3.1.2.3 Seasonal marine mammal sightings across the three Marine Mammal Study Areas are summarised in Table 3.4. In most cases in which there is a difference in the number of observations between Morven North and Morven South, a greater number of animals occur in the Morven North Marine Mammal Study Area. This is not simply a result of this being larger than the Morven South Marine Mammal Study Area but is related to the spatial distribution of species (see Figure 3.4, Figure 3.5, Figure 3.6 and Figure 3.7).

3.1.2.4 It is also important to note here that due to the spatial overlap between the Morven North and Morven South Marine Mammal Study Areas the number of animals does not necessarily sum to the number of animals recorded in the Morven Site Marine Mammal Study Area.

Table 3.4: Seasonal raw sightings data (number of animals, uncorrected for effort) across the Morven North Marine Mammal Study Area (N), Morven South Marine Mammal Study Area (S) and the Morven Site Marine Mammal Study Area (P)*

Taxon	Winter			Spring			Summer			Autumn		
	N	S	P	N	S	P	N	S	P	N	S	P
Harbour porpoise	16	3	19	296	41	325	113	86	172	41	41	77
White-beaked dolphin	13	-	13	5	5	5	46	19	50	9	16	17
Common dolphin	-	-	-	-	-	-	8	8	8	-	-	-
Grey seal	2	1	2	3	1	4	2	1	3	1	1	2
Minke whale	-	-	-	2	-	2	3	-	3	1	-	1
Humpback whale	-	-	-	1	-	1	-	-	-	-	-	-
Dolphin/porpoise	7	4	9	45	11	52	4	2	6	14	-	14
Dolphin species	-	-	-	9	-	9	1	-	1	3	1	3
Seal species	5	1	6	13	16	23	2	1	3	1	-	1
Whale species	-	-	-	-	-	-	-	1	1	-	-	-
Marine mammal species	3	1	3	4	-	4	5	2	6	2	2	2
Total	46	10	52	378	74	425	181	120	253	72	61	117

3.1.2.5 Seasonal distribution did not show substantial differences between the Morven North and Morven South Marine Mammal Study Areas, so in the interest of clarity, Figure 3.1 illustrates seasonal percentages only for the Morven Site Marine Mammal Study Area.

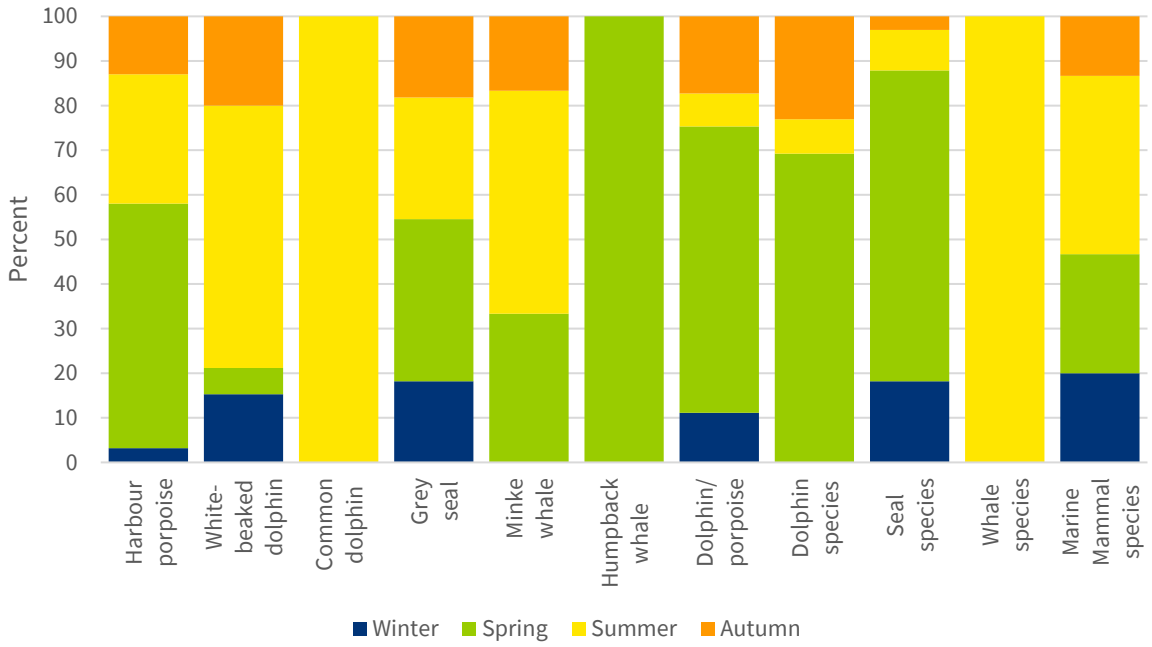

Figure 3.1: Seasonal percentage of marine mammal sightings in the Morven Site Marine Mammal Study Area (P)

3.1.3 Group size

3.1.3.1 Group size was calculated using source image files. For cases in which more than one animal of a given species was identified in the same image, these were considered to occur within a close enough vicinity of each other to be considered a group. Mean group size was calculated per month, alongside minimum and maximum group sizes and 95% CI for all animals identified to species level (Table 3.5). Note that 95% CIs could not be calculated in cases where only one group, or no groups, of a species were observed, and species that were not observed in groups across all surveys have been omitted from these tables for clarity.

3.1.3.2 Group size varied by species and across the months. The largest group sizes were recorded for harbour porpoise (max = 12) and white-beaked dolphin (max = 8) with an overall average group size of 2.99 animals (95% CI ±0.34) across all harbour porpoise sightings and 3.86 animals (95% CI±0.79) for white-beaked dolphin, over the 33-month DAS campaign. Other species observed during the DAS campaign have been omitted here as these species were observed only as single animals.

3.1.3.3 Mean, maximum and minimum group sizes were similar in the Morven North and Morven South Marine Mammal Study Areas to those observed in the Morven Site Marine Mammal Study Area, however, for clarity, only groups observed in the latter are presented in Table 3.5.

Table 3.5: Monthly mean and maximum group sizes for species sightings across the Morven Site Marine Mammal Study Area. Note that minke whale and grey seal have been omitted as these species were observed only as single animals

Month	Harbour porpoise			White-beaked dolphin			Common dolphin		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Jan	-	-	-	5.00	5	5	-	-	-
Feb	-	-	-	8.00	8	8	-	-	-

Month	Harbour porpoise			White-beaked dolphin			Common dolphin		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Mar	-	-	-	-	-	-	-	-	-
Apr	2.00	2	2	5.00	5	5	-	-	-
May	3.41	2	12	-	-	-	-	-	-
Jun	2.14	2	3	3.80	2	7	8.00	8	8
Jul	2.13	2	3	2.83	2	4	-	-	-
Aug	2.25	2	3	2.60	2	4	-		-
Sep	3.11	2	7	5.33	4	8	-	-	-
Oct	4.25	2	8	-	-	-	-	-	-
Nov	3.50	2	5	-	-	-	-	-	-
Dec	2.00	2	2	-	-	-	-	-	-
Overall mean	**2.99**	**2.00**	**5.00**	**3.86**	**4.00**	**5.86**	**8.00**	**n/a**	**n/a**
95% CI [±]	**0.34**	**0.00**	**2.22**	**0.79**	**1.66**	**1.31**	**n/a**	**n/a**	**n/a**

3.1.4 Surfacing categories

3.1.4.1 There were no clear temporal patterns in surfacing behaviour across the 33 months of DAS data (Figure 3.2), although in two survey months (January 2023 and February 2023) all sighted marine mammals were observed to be surfacing. However, observations in these months numbered one and two individuals, respectively, so these observations may not be representative of broader patterns. In six of the survey months, all observations were of submerged individuals, and in 25 of the survey months a clear majority of observations were of submerged or deeply submerged individuals. The only month in which observations of surfacing individuals outnumbered observations of submerged individuals was November 2021, when three marine mammals were observed, of which two were surfacing and one was submerged. Figure 3.3 presents a summary of surfacing categories for all marine mammals, combined across months.

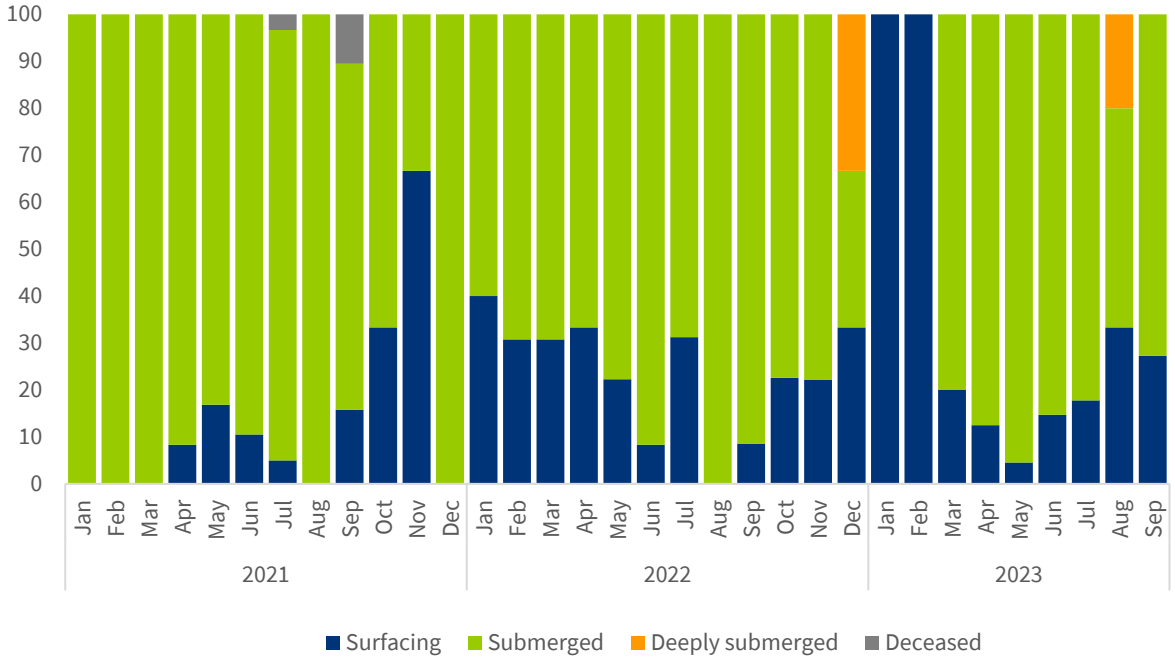

Figure 3.2: Summary of surfacing categories by month, combined across all species, for the Morven Site Marine Mammal Study Area

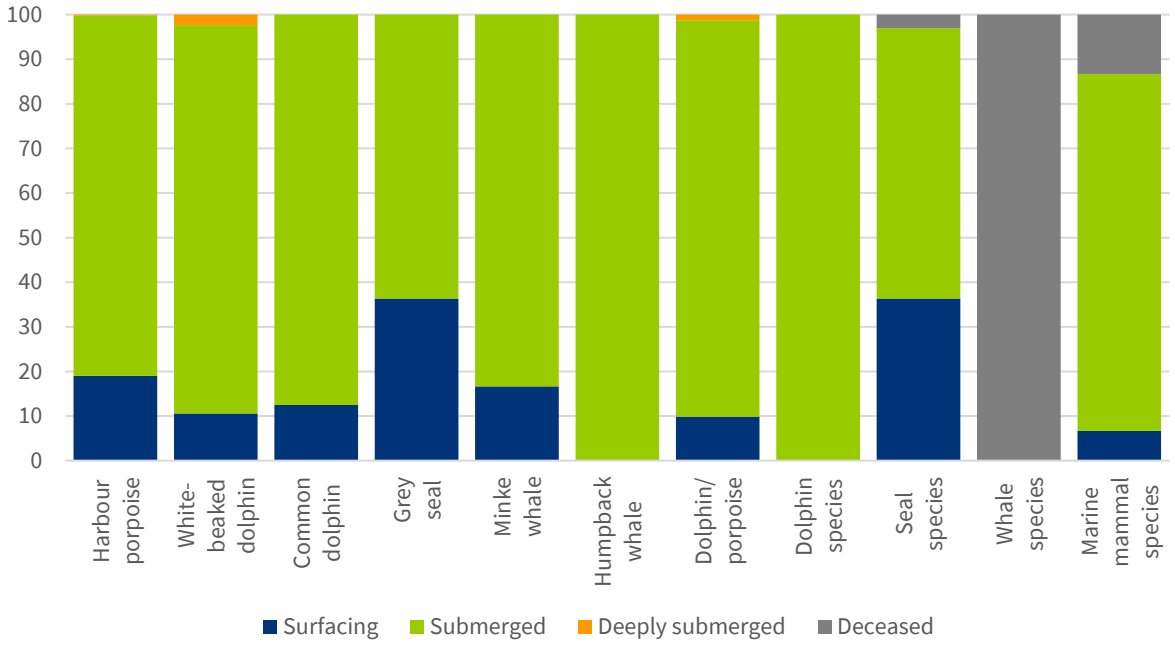

Figure 3.3: Summary of surfacing categories by species, combined across All Survey Months, for the Morven Site Marine Mammal Study Area

3.1.5 Confidence assessment

3.1.5.1 Confidence in identification varied by species/species group for the Morven aerial surveys. Where possible, high-confidence sightings were identified to species level, but where not possible they were assigned to other descriptive categories (Table 3.3). A total of 11 animals were identified as grey

seal, whilst a further 33 animals could not be assigned to either grey seal or harbour seal and were instead labelled “seal species”.

3.1.5.2 For cetaceans, a total of 594 harbour porpoise, 85 white-beaked dolphin and eight common dolphin were identified to species level, whilst a further 13 were labelled as “dolphin species” and 81 identified as ”dolphin/porpoise” (i.e. could not be assigned to a species). Six minke whale and one humpback whale were identified to species level, whilst one individual was identified as ”whale species”. The unidentified whale was, however, deceased, which may have made identification difficult if it was in a state of decay. Finally, a total of 15 animals could not be assigned as either cetacean or seal and were instead assigned the label “marine mammal species”.

3.1.6 Distribution of sightings

3.1.6.1 Sightings of marine mammals were spatially distributed throughout the Morven Site Marine Mammal Study Area. Figure 3.4 illustrates the monthly distribution of harbour porpoise sightings, Figure 3.5 illustrates the distribution of all cetacean sightings, excluding harbour porpoise, Figure 3.6 illustrates the distribution of seal species, and Figure 3.7 illustrates the distribution of unidentified marine mammal species. The Morven Site Marine Mammal Study Area is indicated by the solid outline and the Morven North and Morven South Boundaries are indicated by the dashed line.

3.1.6.2 Harbour porpoise sightings were clearly distributed at the north of the Morven Site Marine Mammal Study Area (i.e. within Morven North Marine Mammal Study Area) in May 2021 and May 2022, although this concentration of sightings was not repeated in May 2023 as sightings were distributed relatively evenly across the Morven Site Marine Mammal Study Area. Similarly, sightings in the July 2021, September 2022, October 2022 and April 2023 surveys were distributed relatively evenly across the Morven Site Marine Mammal Study Area.

3.1.6.3 No clear temporal patterns were observed in the spatial distribution of any other marine mammal species.

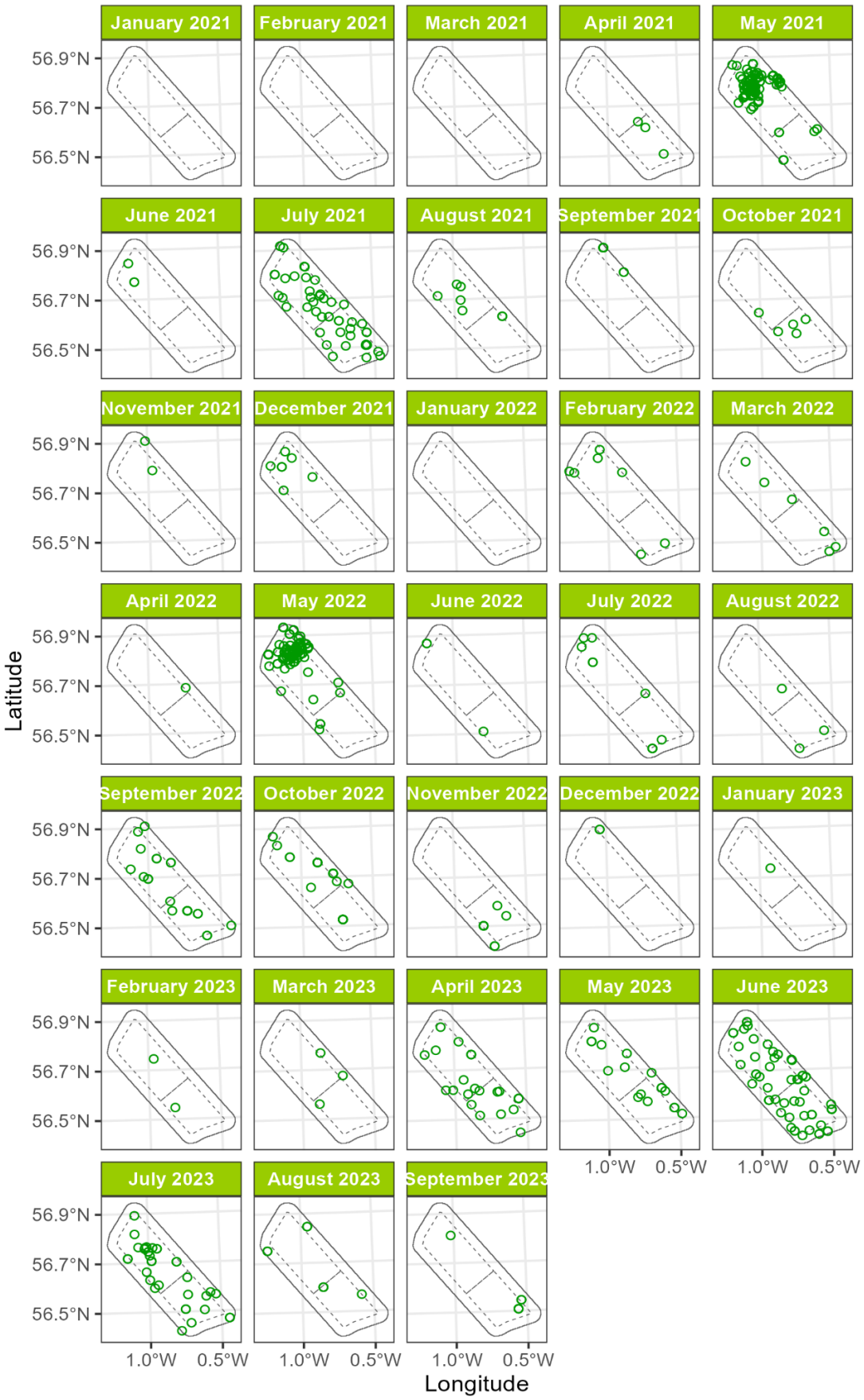

Figure 3.4: Monthly distribution of harbour porpoise sightings across the Morven Site Marine Mammal Study Area. dashed lines indicate the Morven North and Morven South Boundaries

Figure 3.5: Monthly distribution of cetacean sightings (excluding harbour porpoise) Across the Morven Site Marine Mammal Study Area. Dashed lines indicate the Morven North and Morven South Boundaries

Figure 3.6: Monthly distribution of seal sightings across the Morven Site Marine Mammal Study Area. Dashed Lines Indicate the Morven North and Morven South Boundaries

Figure 3.7: Monthly distribution of unidentified marine mammal sightings across the Morven Site Marine Mammal Study Area. Dashed Lines Indicate the Morven North and Morven South Boundaries

3.2 Density estimates

3.2.1.1 Mean densities of marine mammals were produced from the DAS count data, averaged at the monthly, seasonal and (where relevant) bio-season scale, and an overall mean was also estimated across the survey period. CV has also been calculated to present the variability in the raw data. Density estimates were calculated only for species that occurred at sufficient frequency to allow patterns of occurrence to be inferred: harbour porpoise, white-beaked dolphin, grey seal and minke whale.

3.2.2 Harbour porpoise

Design-based analysis

3.2.2.1 Raw counts of harbour porpoise (Table 3.1) were adjusted for survey effort to provide estimates of mean relative abundance and density across monthly, seasonal, bio-season and annual scales for the Morven Site Marine Mammal Study Area. Relative estimates were then corrected for availability bias to provide estimates of absolute abundance and density, with 95% CLs obtained via bootstrapping (1,000 simulations) (Wessa, 2019). Figure 3.8 illustrates the simulated mean absolute densities resulting from the bootstrapping process.

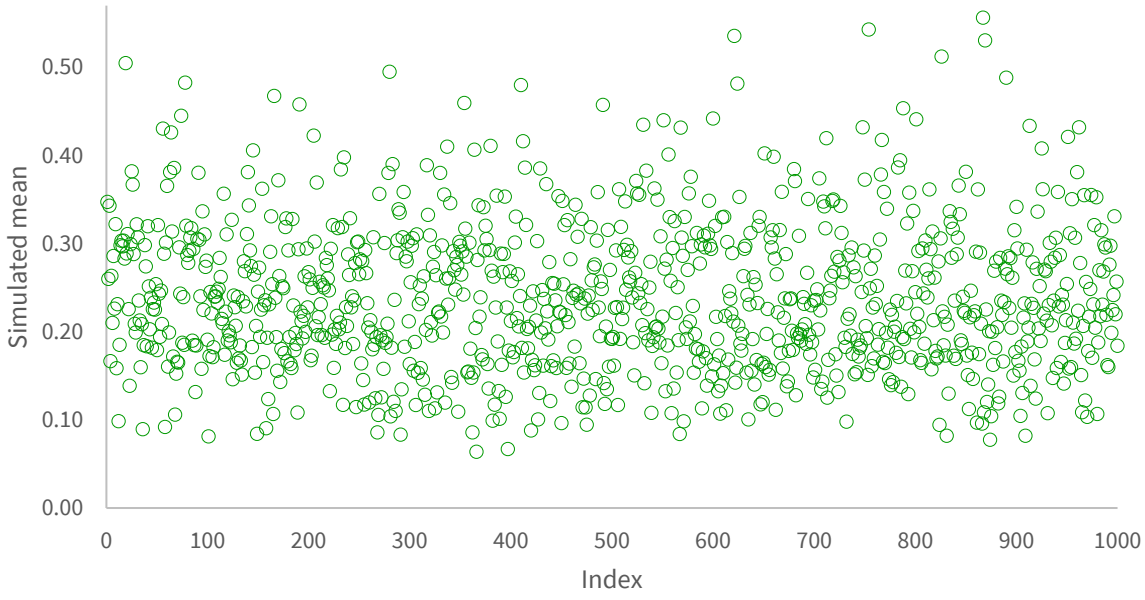

Figure 3.8: Bootstrapped simulation (n = 1,000) of mean monthly absolute density for harbour porpoise across the Morven Site Marine Mammal Study Area

3.2.2.2 Relative density estimates for harbour porpoise can be corrected for availability bias (Section 2.6.2.1) using published correction factors based on the proportion of time individuals are likely to be at or near the surface and available for detection. For example, availability bias was estimated based on a tagging study in the Baltic/North Sea which looked at the proportion of time that harbour porpoise spent surfacing or in the top 0m to 2m (Teilmann *et al.,* 2013). Notably, in this study no significant difference in diving behaviour between geographic areas or in relation to the size of the animals was found, although there was a significant seasonal difference in diving behaviour. The correction factor which gave the lowest estimate of availability (i.e. most conservative) was 42.5%, based on winter months, when surfacing time was found to be lower than in other seasons (Teilmann *et al.,* 2013).

3.2.2.3 Similarly, fine scale movements of harbour porpoise in the Danish North Sea were investigated using global positioning system (GPS) and dive recorder (V-tags) to record the diving behaviour of tagged individuals (van Beest *et al.,* 2018). This study estimated a mean dive duration of 53s (min = 10.1s, max = 250.0s) and a mean surfacing time of 39s (min = 2s, max = 309s). Using the mean values, the availability bias was calculated as 42.4% (mean surfacing time as a proportion of the mean surfacing time plus mean dive time) which corroborates the value estimated by Teilmann *et al*. (2013).

3.2.2.4 Overall, observations of harbour porpoise density were greatest in the Morven North Marine Mammal Study Area. Peaks in estimated absolute density observed for the months of May 2021 and May 2022, with a smaller peak in July 2021 and June 2023, and a maximal absolute density of 3.317 in May 2022 (95% CLs = 1.222, 6.351). Due to the large variability in the number of observations of harbour porpoise across surveys, with very low densities in some months and higher densities in others (range of absolute density = 0.000, 3.317; CV = 2.299), monthly trends are not easy to interpret visually on a linear scale (Figure 3.9).

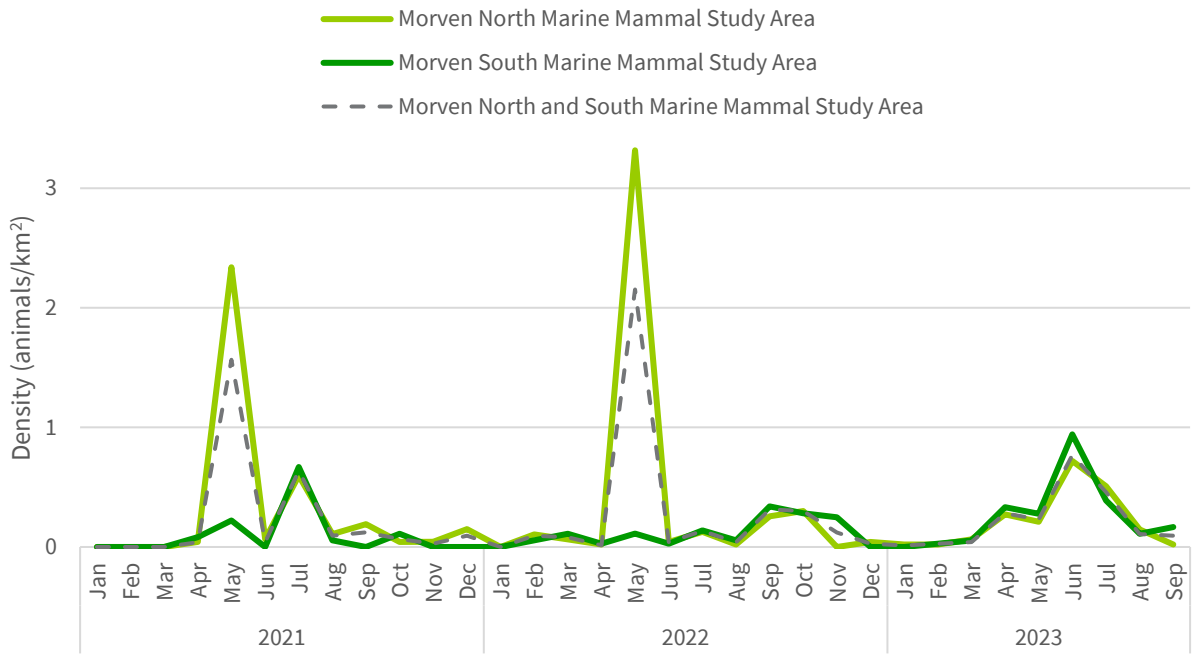

Figure 3.9: Estimated absolute density of harbour porpoise (corrected for availability bias) for each survey over the Morven North, Morven South and Morven Site Marine Mammal Study Areas.

3.2.2.5 Data were therefore also plotted on a log10 scale (Figure 3.10), where monthly variation is more apparent. Here, densities fluctuate across the DAS campaign period, with the peaks in May 2021, July 2021, May 2022 and June 2023, (as seen on the linear scale in Figure 3.9), and a broad elevation in the summer months, in line with patterns described by Teilmann *et al.* (2013). Note that gaps in time series represent occasions when no animals were observed (zero counts cannot be plotted on a log scale).

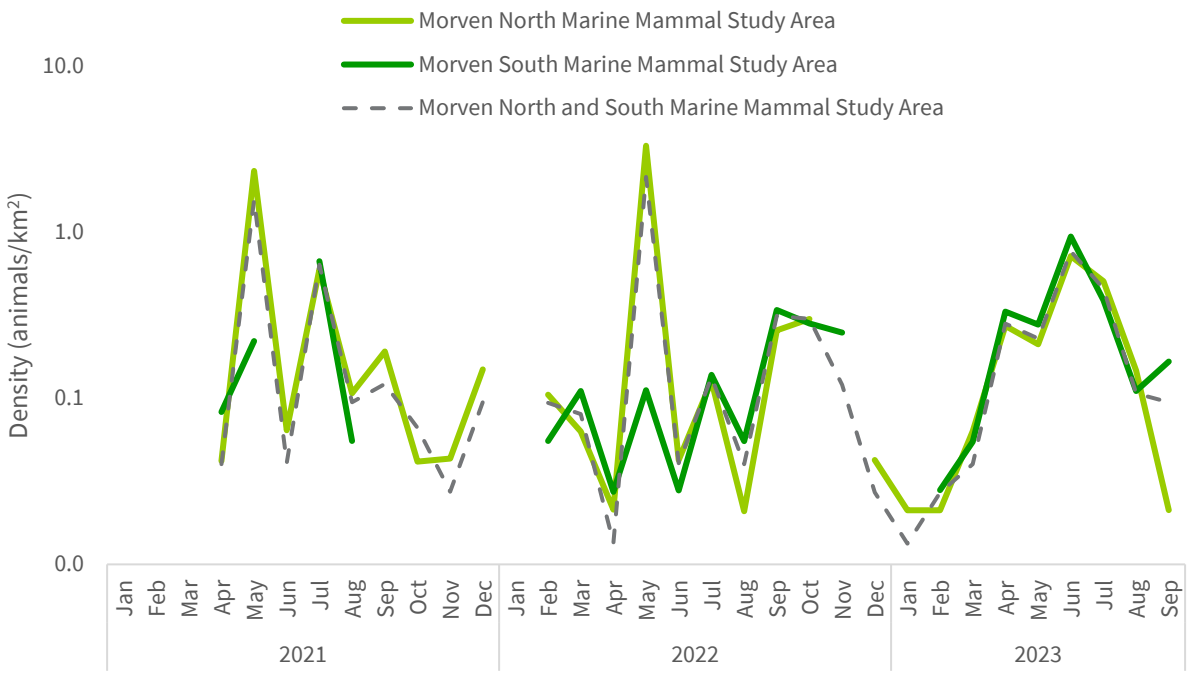

Figure 3.10: estimated absolute density of harbour porpoise (corrected for availability bias) for each survey over the Morven North and Morven South and Morven Site Marine Mammal Study Areas, presented on a log_{10} scale

3.2.2.6 The mean absolute density of harbour porpoise, estimated from data pooled across all transects in the Morven Site Marine Mammal Study Area, and all months for the 33 month DAS campaign (Table 3.6), was 0.243 animals/km2 (95% CLs = 0.111, 0.423; CV = 1.892).

3.2.2.7 The maximal absolute density estimates for respective temporal divisions in the Morven Site Marine Mammal Study Area were:

- monthly: 1.316 animals/km2 (95% CLs = 0.581, 2.160; CV = 0.749) (May);
- seasonal: 0.489 animals/km2 (95% CLs = 0.223, 0.850; CV = 1.628) (spring);
- bio-season: 0.396 animals/km2 (95% CLs = 0.175, 0.689; CV = 1.469) ('summer').

3.2.2.8 A summary of density and abundance estimates for harbour porpoise across all study areas is presented in Table 3.6.

Table 3.6: Design-based estimates for mean absolute abundance and density of harbour porpoise in the Morven North, Morven South and Morven Site Marine Mammal Study Areas, across monthly, seasonal, bio-season, and annual scales, including lower and upper 95% CLs, and CVs

Temporal Division	Morven North Marine Mammal Study Area					Morven South Marine Mammal Study Area					Morven Site Marine Mammal Study Area				
	Abundance[1]	Density[2]	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV
Month															
Jan	7	0.007	0.003	0.012	1.732	0	0.000	0.000	0.000	-	7	0.004	0.002	0.007	1.732
Feb	40	0.041	0.015	0.073	1.321	20	0.027	0.015	0.041	0.997	60	0.040	0.021	0.062	1.199
Mar	40	0.041	0.015	0.073	0.866	39	0.054	0.030	0.082	1.004	60	0.040	0.021	0.061	1.000
Apr	107	0.109	0.040	0.194	1.247	105	0.145	0.081	0.218	1.104	166	0.110	0.058	0.171	1.323
May	1,853	1.906	0.697	3.384	0.812	144	0.200	0.111	0.301	0.414	1,945	1.296	0.684	2.014	0.749
Jun	261	0.268	0.098	0.476	1.397	229	0.317	0.177	0.479	1.658	419	0.279	0.147	0.433	1.483
Jul	389	0.399	0.146	0.709	0.608	282	0.391	0.218	0.590	0.664	606	0.408	0.215	0.633	0.617
Aug	87	0.089	0.033	0.158	0.703	53	0.072	0.040	0.109	0.436	120	0.079	0.042	0.123	0.442
Sep	149	0.152	0.056	0.270	0.777	120	0.166	0.092	0.250	1.006	262	0.174	0.092	0.271	0.676
Oct	162	0.167	0.061	0.296	1.070	139	0.192	0.107	0.290	0.624	272	0.181	0.095	0.281	0.904
Nov	21	0.021	0.008	0.037	1.414	88	0.122	0.068	0.184	1.414	110	0.073	0.038	0.113	0.892
Dec	91	0.093	0.034	0.166	0.787	0	0.000	0.000	0.000	-	91	0.060	0.032	0.093	0.784
Meteorological season															
Winter	41	0.041	0.015	0.073	1.311	8	0.010	0.006	0.015	1.981	48	0.032	0.017	0.049	1.251
Spring	667	0.685	0.251	1.217	1.753	96	0.133	0.074	0.201	0.854	723	0.482	0.254	0.749	1.628
Summer	246	0.252	0.092	0.448	1.041	188	0.260	0.145	0.393	1.258	381	0.255	0.135	0.397	1.103

Temporal Division	Morven North Marine Mammal Study Area					Morven South Marine Mammal Study Area					Morven Site Marine Mammal Study Area				
	Abundance[1]	Density[2]	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV
Autumn	116	0.119	0.043	0.211	1.017	116	0.161	0.090	0.243	0.822	221	0.147	0.078	0.229	0.756
Bio-season															
Winter	54	0.055	0.020	0.098	1.410	42	0.058	0.032	0.088	1.561	88	0.059	0.031	0.091	1.308
Summer	474	0.487	0.178	0.865	1.774	155	0.215	0.120	0.325	1.138	586	0.391	0.206	0.607	1.467
Annual															
Year 1	283	0.290	0.108	0.529	2.228	67	0.093	0.054	0.139	2.037	332	0.220	0.116	0.343	2.040
Year 2	340	0.349	0.130	0.637	2.617	83	0.114	0.067	0.171	0.988	409	0.272	0.144	0.423	2.169
Year 3 (partial)	192	0.215	0.080	0.392	1.114	163	0.251	0.146	0.376	1.141	332	0.222	0.117	0.345	1.115
Overall	283	0.291	0.106	0.517	2.299	104	0.144	0.080	0.217	1.420	360	0.240	0.127	0.373	1.890

[1] Mean absolute abundance calculated as mean density across the respective study area, corrected for availability bias.
[2] Mean absolute density calculated as the number of animals per km^2 across the respective study area, corrected for availability bias.

Model-based analysis

3.2.2.9 Harbour porpoise was present in sufficient numbers for modelling only when considered across the whole 33 month DAS period within the Morven Site Marine Mammal Study Area and when divided by bio-season and meteorological season. The MRSea models included water depth, terrain ruggedness and distance from coast as explanatory environmental variables. However, the meteorological season model, the bio-season model and the model fitted across all 33 months of DAS data fitted the data poorly, as indicated by the low values for concordance correlation and marginal r^2, summarised in Table 3.7. Given the low statistical power of these models, the relative contribution of environmental variables to harbour porpoise distribution has not been presented, as these estimates would not be an accurate reflection of their respective influence.

Table 3.7: Metrics of model fit for MRSea models fitted to harbour porpoise observation data across bio-season and across the 33 months of digital aerial survey data

Model	Concordance correlation	Marginal R-squared
Meteorological season	0.0766	0.0500
Bio-season	0.0412	0.0267
Overall DAS campaign	0.0178	0.0116
Model	Concordance Correlation	Marginal R-squared

3.2.2.10 Given the poor fit of the models, their predictions (Table 3.8) do not correspond well with absolute densities estimated from the design-based analysis for the Morven Site Marine Mammal Study Area (Table 3.6), and are largely not useful in illustrating likely patterns of spatial distribution across the year, and between bio-seasons (Figure 3.11 to Figure 3.13).

3.2.2.11 Abundance varied across meteorological seasons and bio-seasons, with higher densities in the aerial survey area predicted during the meteorological summer (June to August, inclusive) and the 'winter' bio-season (October to March, inclusive). These modelled predictions do not correspond with temporal patterns estimated from design-based analysis. Estimates of absolute density (plus 95% CLs) for the four meteorological seasons, 'winter' and 'summer' bio-seasons, and for the 33 month period of DAS data, are presented in Table 3.8.

Table 3.8: Modelled absolute abundance and density of harbour porpoise, with lower and upper 95% CIs and CV for meteorological seasons, bio-seasons and across the digital aerial survey data collection period (33 months)

Temporal Division	Mean Abundance	Mean Density (Animals/km2)	Lower 95% CL	Upper 95% CL	CV
Meteorological season					
Winter	48	0.032	0.014	0.066	0.417
Spring	215	0.145	0.079	0.242	0.417
Summer	321	0.216	0.119	0.361	0.417
Autumn	223	0.150	0.083	0.252	0.417
Bio-season					
"Winter" bio-season	91	0.062	0.011	0.532	2.08

Temporal Division	Mean Abundance	Mean Density (Animals/km2)	Lower 95% CL	Upper 95% CL	CV
"Summer" bio-season	14	0.009	0.001	0.082	2.08
Year					
Overall DAS campaign	219	0.148	0.073	0.317	1.721

3.2.2.12 No clear distinction in predicted spatial distribution and absolute density is visible between the meteorological seasons (Figure 3.11). During meteorological summer absolute density was predicted to be greater than during other times of the year, contrasting with the results of the design-based analysis which concluded that density would be expected to peak in spring. Likewise for bio-seasons, the model-based analysis predicted higher density during the 'winter' bio-season compared to the 'summer' bio-season. This contradicts the results of the design-based analysis, and the conclusions of Heinänen and Skov (2015), both of which observed higher density during the 'summer' bio-season. These contrasts highlight the particularly low predictive power of the models described in Table 3.7.

3.2.2.13 Spatial distribution of harbour porpoise density was predicted to be slightly elevated in the north of the Morven Site Marine Mammal Study Area during the summer, with markedly lower density during the winter (Figure 3.11).

3.2.2.14 During the 'winter' bio-season density is predicted to be low across the Morven Site Marine Mammal Study Area, with slightly higher density in the east (Figure 3.12). Spatial distribution during the 'summer' bio-season is also predicted to be concentrated in the east, where much higher absolute density is predicted (Figure 3.12).

3.2.2.15 When considered across the 33 months of DAS data, overall mean absolute density was predicted to be greater towards the northwest of the Morven Site Marine Mammal Study Area (Figure 3.13) These patterns mirror the higher raw counts of harbour porpoise during the May 2021 (n = 116) and May 2022 (n = 158) surveys.

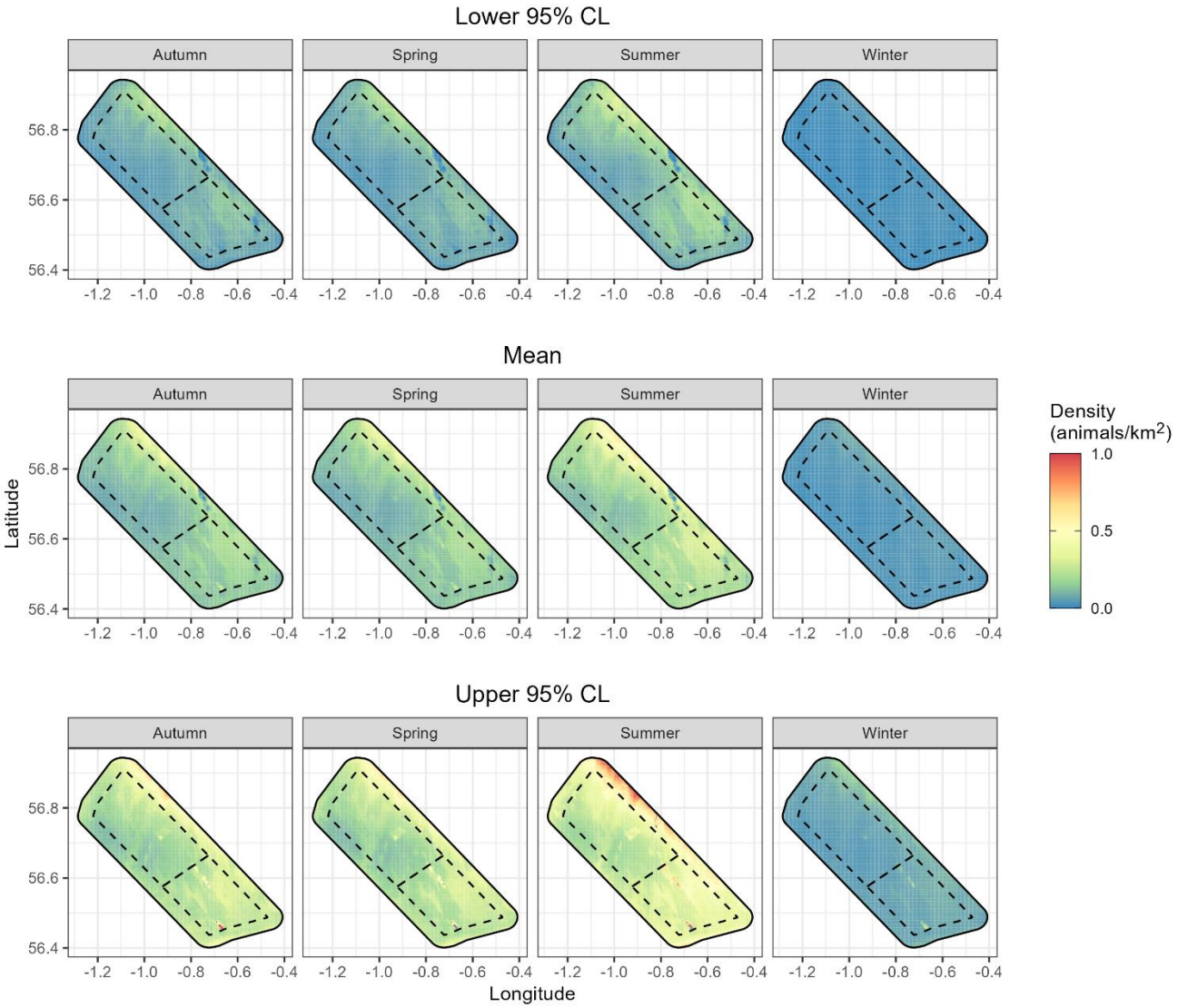

Figure 3.11: Predicted mean absolute density of harbour porpoise, with 95% CIs, across the Morven Site Marine Mammal Study Area split across meteorological seasons. Dashed line indicates the Morven North and Morven South Boundaries

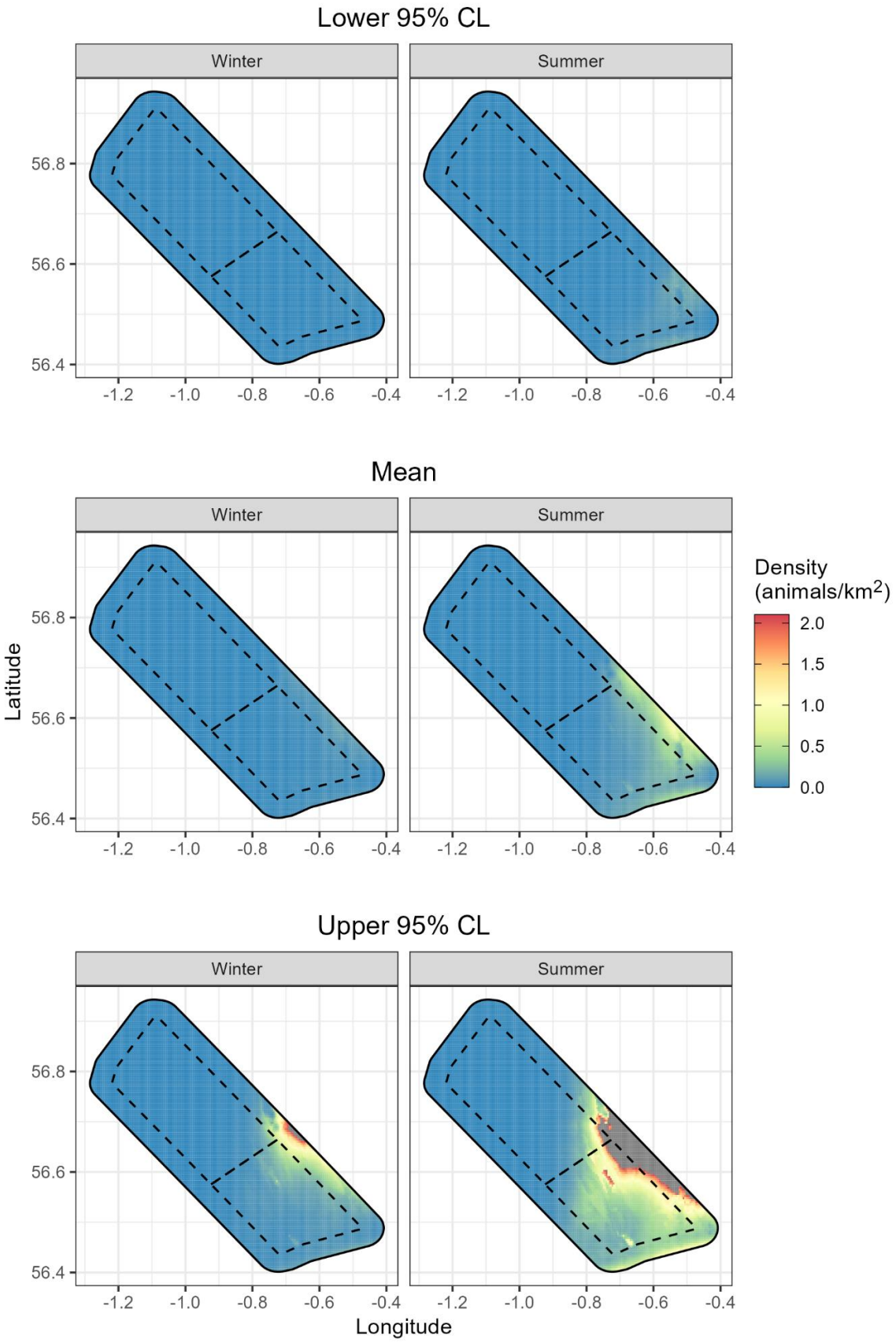

Figure 3.12: Predicted mean absolute density of harbour porpoise, with 95% CIs, across the Morven Site Marine Mammal Study Area split between 'winter' and 'summer' bio-seasons. Dashed line indicates the Morven North and Morven South Boundaries

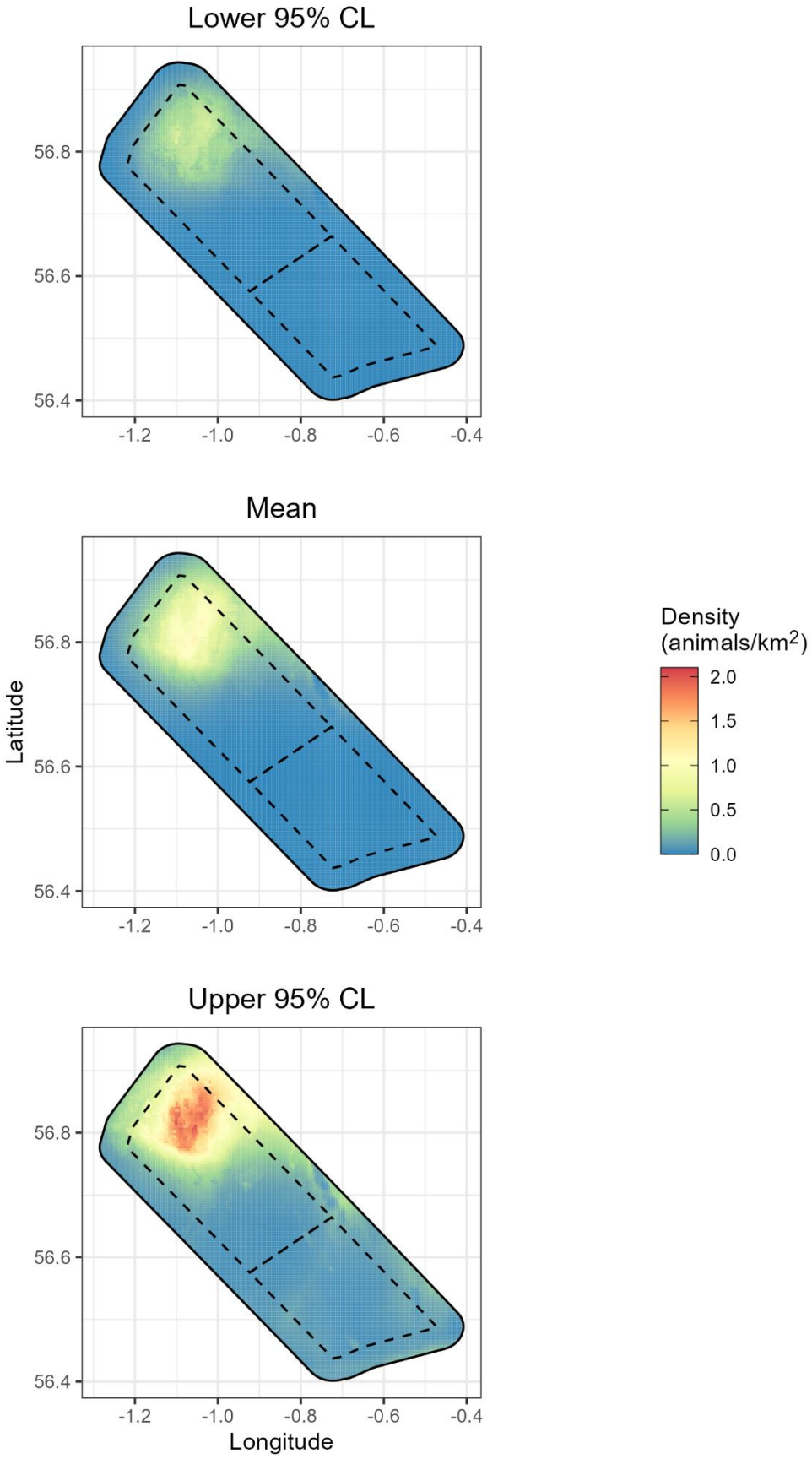

Figure 3.13: Overall predicted mean absolute density of harbour porpoise, with 95% CIs, across the Morven Site Marine Mammal Study Area for the whole 33 month period of digital aerial survey data. Dashed line indicates the Morven North and Morven South Boundaries

3.2.3 White-beaked dolphin

Design-based analysis

3.2.3.1 Raw counts of white-beaked dolphin (Table 3.3) were adjusted for survey effort to provide estimates of mean relative abundance and density across monthly, seasonal and annual scales for the Morven Site Marine Mammal Study Area. Temporal distribution of white-beaked dolphin has not been investigated in the literature to the same extent as for harbour porpoise (Section 2.4.1.7), although some seasonality has been identified (Canning *et al.,* 2008, Weir *et al.,* 2007). However, this aligns with meteorological summer and as such, no separate bio-seasons have been defined for white-beaked dolphin.

3.2.3.2 Relative estimates were corrected for availability bias to provide estimates of absolute abundance and density, with 95% CLs obtained via bootstrapping (1,000 simulations) (Wessa, 2019). Figure 3.14 illustrates the simulated mean absolute densities resulting from the bootstrapping process.

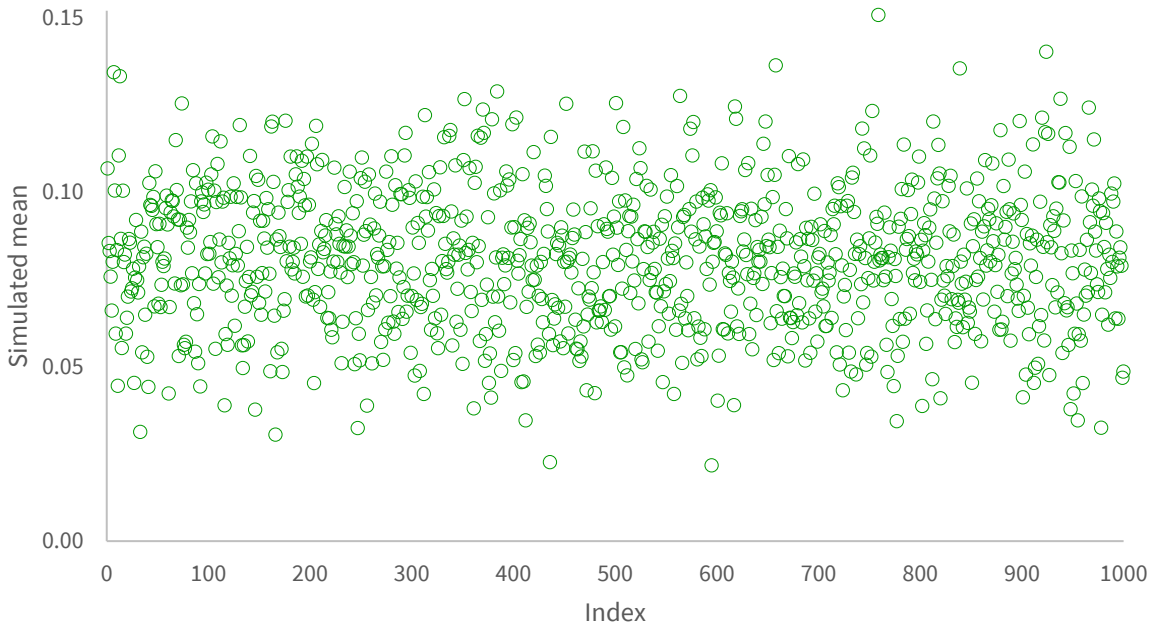

Figure 3.14: Bootstrapped simulation (N = 1,000) of mean monthly absolute density for white-beaked dolphin across the Morven Site Marine Mammal Study Area

3.2.3.3 Relative density estimates for white-beaked dolphin, as for other species, can be corrected for availability bias (Section 2.6.2.1) using published correction factors based on the proportion of time individuals are likely to be at or near the surface and available for detection. There is limited information on diving and surfacing times of white-beaked dolphin and consequently many studies report relative density estimates only (Paxton *et al.,* 2016). A bio-logging study of two individual free-ranging white-beaked dolphins in Iceland found that, on average, animals spent 18% of time close to the surface (0m to 2m depth) and 82% of the time diving (Rasmussen *et al.,* 2013). Therefore, the correction factor to account for availability bias in white-beaked dolphin would be 0.18.

3.2.3.4 White-beaked dolphin was identified during 17 of the 33 surveys over the Morven Site Marine Mammal Study Area, with peaks in recorded presence during June 2021, September 2021, February 2022, September 2022, June 2023 and July 2023 (Figure 3.15) and a maximal absolute density of 0.321 animals/km^2 during the June 2021 DAS (95% CLs = 0.185, 0.474), located in the Morven North Marine Mammal Study Area. No clear spatial trends were visible from the DAS data, with animals

showing no preference for either the Morven North or Morven South Marine Mammal Study Areas. No animals were identified between the months of March to May during the first two years of DAS (2021 and 2022) or between October and December.

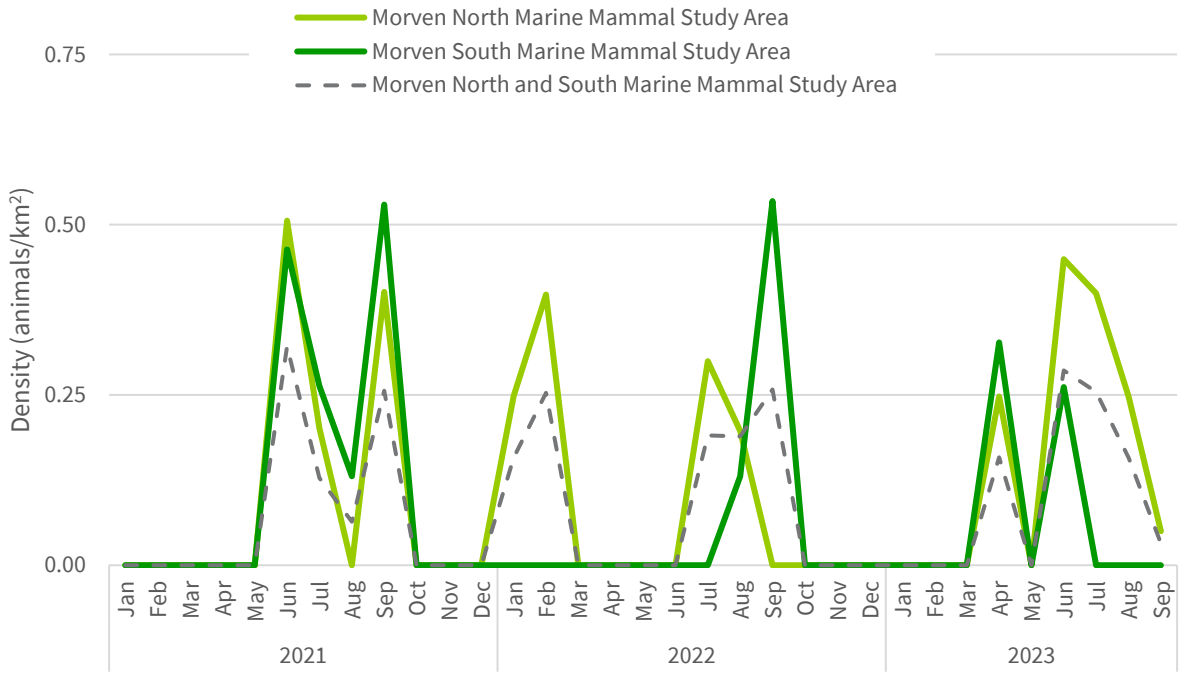

Figure 3.15: Estimated absolute density of white-beaked dolphin (corrected for availability bias) for each survey over the Morven North, Morven South and Morven Site Marine Mammal Study Areas

3.2.3.5 The overall estimated mean absolute density of white-beaked dolphin, estimated from data pooled across all transects across the Morven Site Marine Mammal Study Area and all 33 months of DAS data (Table 3.9) was 0.082 animals/km2 (95% CLs = 0.047, 0.121; CV = 1.350). The maximal mean absolute density estimates for respective temporal divisions were:

- monthly: 0.203 animals/km^2 (95% CLs = 0.114, 0.299; CV = 0.870) (June);
- seasonal: 0.177 animals/km^2 (95% CLs = 0.100, 0.261; CV = 0.586) (summer).

3.2.3.6 A summary of density and abundance estimates for white-beaked dolphin across all study areas is presented in Table 3.9.

Table 3.9: Design-based estimates for mean absolute abundance and density of white-beaked dolphin in the Morven North, Morven South and Morven Site Marine Mammal Study Areas, across monthly, seasonal, and annual scales, including lower and upper 95% CLs, and CV

Temporal Division	Morven North Marine Mammal Study Area					Morven South Marine Mammal Study Area					Morven Site Marine Mammal Study Area				
	Abundance[1]	Density[2]	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV
Month															
Jan	79	0.083	0.042	0.124	1.732	0	0.000	0.000	0.000	-	78	0.053	0.030	0.078	1.732
Feb	126	0.132	0.071	0.198	1.732	0	0.000	0.000	0.000	-	125	0.084	0.048	0.125	1.732
Mar	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Apr	79	0.083	0.044	0.124	1.732	77	0.109	0.038	0.180	1.732	78	0.053	0.030	0.078	1.732
May	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Jun	302	0.318	0.170	0.476	0.871	171	0.242	0.084	0.399	0.962	300	0.203	0.114	0.299	0.870
Jul	285	0.300	0.160	0.449	0.330	62	0.088	0.030	0.145	1.732	283	0.191	0.108	0.282	0.331
Aug	141	0.148	0.079	0.222	0.883	62	0.087	0.030	0.144	0.866	203	0.137	0.077	0.202	0.476
Sep	143	0.151	0.080	0.225	1.453	251	0.355	0.123	0.586	0.866	269	0.182	0.103	0.269	0.714
Oct	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Nov	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Dec	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Meteorological season															
Winter	77	0.081	0.043	0.121	1.916	0	0.000	0.000	0.000	-	76	0.051	0.029	0.076	1.917
Spring	27	0.028	0.015	0.041	3.000	26	0.036	0.013	0.060	3.000	26	0.018	0.010	0.026	3.000
Summer	243	0.256	0.136	0.382	0.705	98	0.139	0.048	0.229	1.176	262	0.177	0.100	0.261	0.586

Temporal Division	Morven North Marine Mammal Study Area					Morven South Marine Mammal Study Area					Morven Site Marine Mammal Study Area				
	Abundance[1]	Density[2]	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV
Autumn	62	0.065	0.034	0.096	2.321	108	0.152	0.053	0.251	1.708	116	0.078	0.044	0.115	1.575
Annual															
Year 1	88	0.092	0.047	0.141	1.945	82	0.116	0.043	0.202	1.693	95	0.064	0.037	0.094	1.760
Year 2	91	0.095	0.048	0.146	1.550	40	0.055	0.021	0.097	2.806	130	0.087	0.050	0.129	1.272
Year 3 (partial)	133	0.155	0.078	0.237	1.187	42	0.065	0.024	0.114	2.000	146	0.099	0.057	0.145	1.187
Overall	105	0.110	0.059	0.165	1.509	57	0.080	0.028	0.132	2.035	122	0.082	0.047	0.121	1.350

[1] Mean absolute abundance calculated as mean density across the respective study area, corrected for availability bias.
[2] Mean absolute density calculated as the number of animals per km^2 across the respective study area, corrected for availability bias.

Model-based analysis

3.2.3.7 Modelling of white-beaked dolphin was only possible when pooled across the whole 33 months of DAS data within the Morven Site Marine Mammal Study Area, due to the relatively low frequency of occurrence and identification of this species during the DAS campaign. The MRSea model included only distance to coast as an explanatory environmental variable. However, the model fitted to 33 months of DAS data fitted the data poorly, as indicated by the extremely low values for concordance correlation and marginal r^2 in Table 3.10. Given the low statistical power of this model, the contribution of distance from coast to white-beaked dolphin distribution has not been presented, as this estimate would not be an accurate reflection of its influence.

3.2.3.8 Although estimates of absolute density and abundance (Table 3.10) correspond well with those calculated from the design-based analysis (Table 3.9), visual inspection of model outputs (Figure 3.16) indicates that the sample size may not have been sufficient to facilitate robust prediction of spatial distribution.

Table 3.10: Metrics of MRSea model fit and modelled absolute abundance and density of white-beaked dolphin with lower and upper 95% CIs and CV across the digital aerial survey data collection period (33 Months)

Temporal division	Concordance correlation	Marginal r-squared	Mean abundance	Mean density (animals/km^2)	Lower 95% CL	Upper 95% CL	CV
Overall DAS campaign	0.0059	0.0030	131	0.088	0.004	1.488	4.972

3.2.3.9 Figure 3.16 illustrates the predictions from modelling of white-beaked dolphin spatial distribution across the 33 months of DAS data. The large, uniform areas of blue (corresponding to predicted densities of 0 animals/km^2) suggest that the model was unable to make accurate predictions from environmental covariates. Where higher density has been predicted (up to approximately 5 animals/km^2), these areas are represented in Figure 3.16 by ostensibly discrete regions of the Morven Site Marine Mammal Study Area. However, since sightings of white-beaked dolphin were also made outside of these predictions, and some predictions are higher in locations where white-beaked dolphin was not observed (Figure 3.16) it is likely that the model has both over- and under-predicted the spatial distribution of this species. Moreover, the areas of grey indicate predicted densities above the range that allows useful illustration of spatial variability, with some predictions substantially above the upper 95% CL.

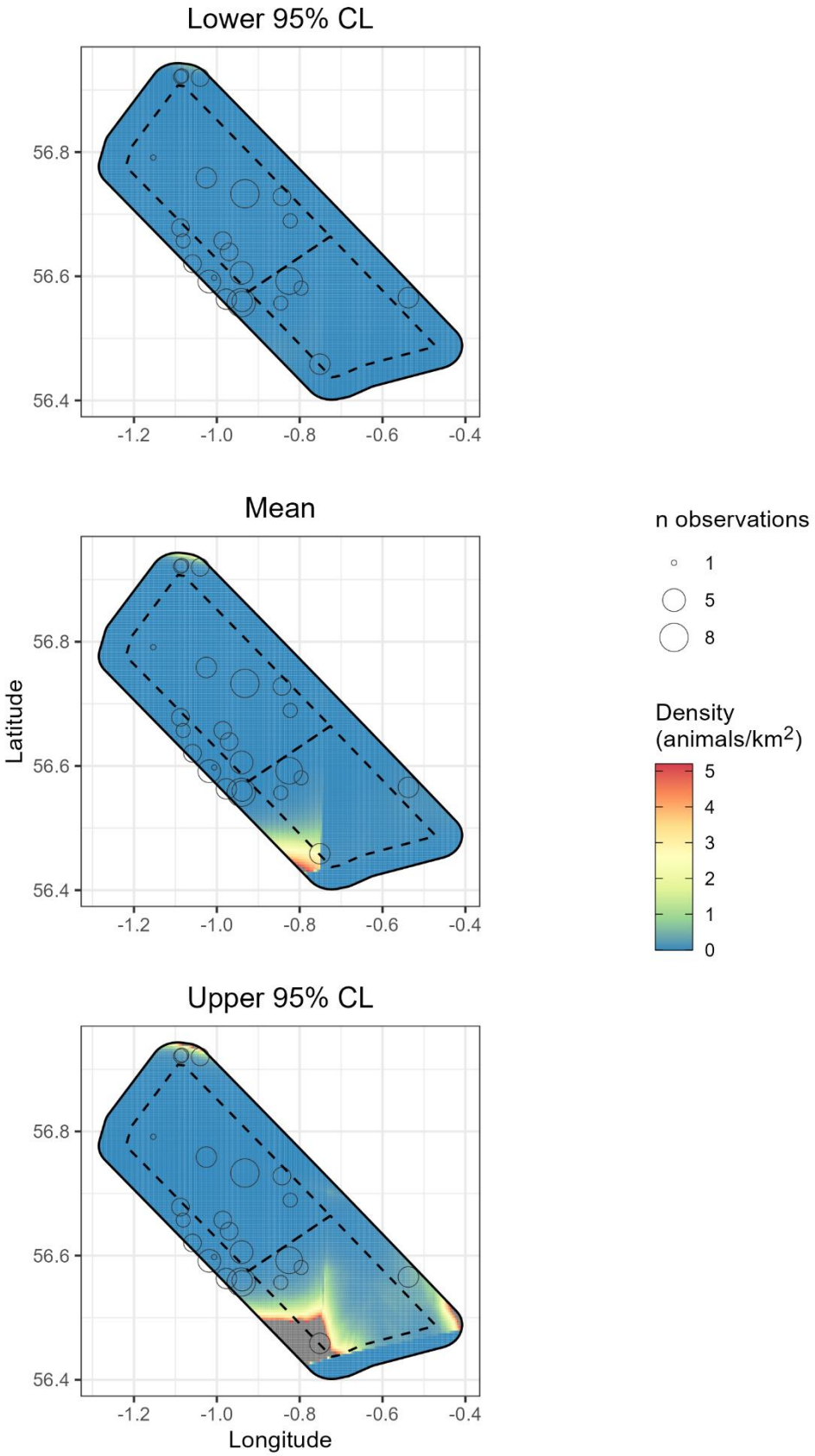

Figure 3.16: Overall predicted mean absolute density of white-beaked dolphin with 95% CIs Across the Morven Site Marine Mammal Study Area for the Whole 33 month period of digital aerial survey data. black circles indicate observations of white-beaked dolphin and dashed line indicate the Morven North and Morven South Boundaries

3.2.4 Grey Seal

Design-based analysis

3.2.4.1 Raw counts of grey seal (Table 3.3) were adjusted for survey effort to provide estimates of mean relative abundance and density across monthly, seasonal, bio-season and annual scales for the Morven Site Marine Mammal Study Area. Relative estimates were then corrected for availability bias to provide estimates of absolute abundance and density, with 95% CLs obtained via bootstrapping (1,000 simulations) (Wessa, 2019). Figure 3.17 illustrates the simulated mean absolute densities resulting from the bootstrapping process.

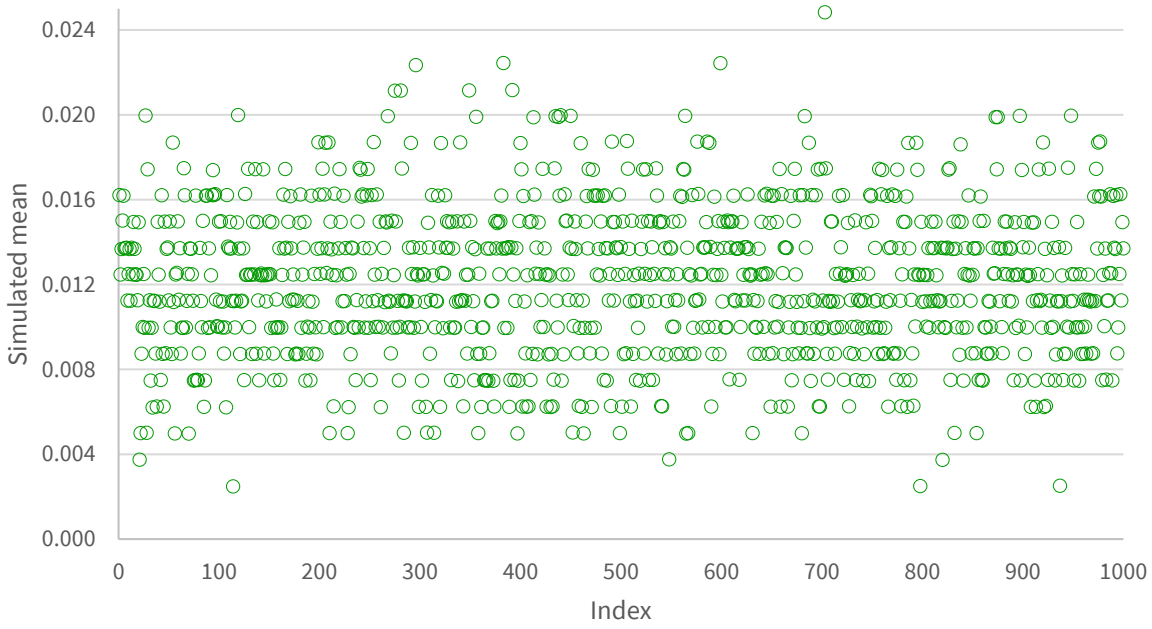

Figure 3.17: Bootstrapped simulation (n = 1,000) of mean monthly absolute density for grey seal across the Morven Site Marine Mammal Study Area

3.2.4.2 Relative estimates of density and abundance do not account for availability bias during aerial surveys (see 2.6.2.1). A tracking study of three male grey seals in the Farne Islands (northeast England) found that the average proportion of time animals were submerged as they travelled was 84.3%, which was slightly lower during short duration trips (83.4%) (Thompson *et al.*, 1991). It was therefore surmised that the average proportion of time a travelling grey seal would be available for detection ranges between 15.7% and 16.6%.

3.2.4.3 Similarly, telemetry data from tags deployed by the Sea Mammal Research Unit (SMRU) on grey seals in the North Sea recorded 1,551 grey seal dives. These data were analysed for the Hornsea Three Offshore Wind Farm (to estimate detection probability) and showed that 60% of surfacing periods were between 15s and 45s, with an average of 40s (Orsted, 2018). Recorded grey seal dive durations observed varied between 20s and 496s with an average of 216s (Orsted, 2018). The average values reported from the telemetry data were used to estimate the proportion of time that grey seals were surfacing, compared to diving, to give an indication of the availability bias for the site specific aerial surveys. The estimated availability was calculated as 15.6% (Orsted, 2018) and was therefore similar to the figures cited by Thompson et al. (1991).

3.2.4.4 As with harbour porpoise and white-beaked dolphin, it was assumed that all animals on (or near) the surface of the water were available for detection during the aerial surveys (i.e. no perception bias: Section 2.6.2.4). The correction factor for availability bias, based on the telemetry studies described in paragraph 3.2.4.3, was 15.6% as the most conservative estimate.

3.2.4.5 Thus, estimates for absolute density for grey seal across the Morven Site Marine Mammal Study Area ranged between 0.000 and 0.077 animals/km^2 (Figure 3.18) and mean absolute density across all transects and all surveys was 0.012 animals/km^2 (95% CLs = 0.007, 0.019; CV = 1.618).

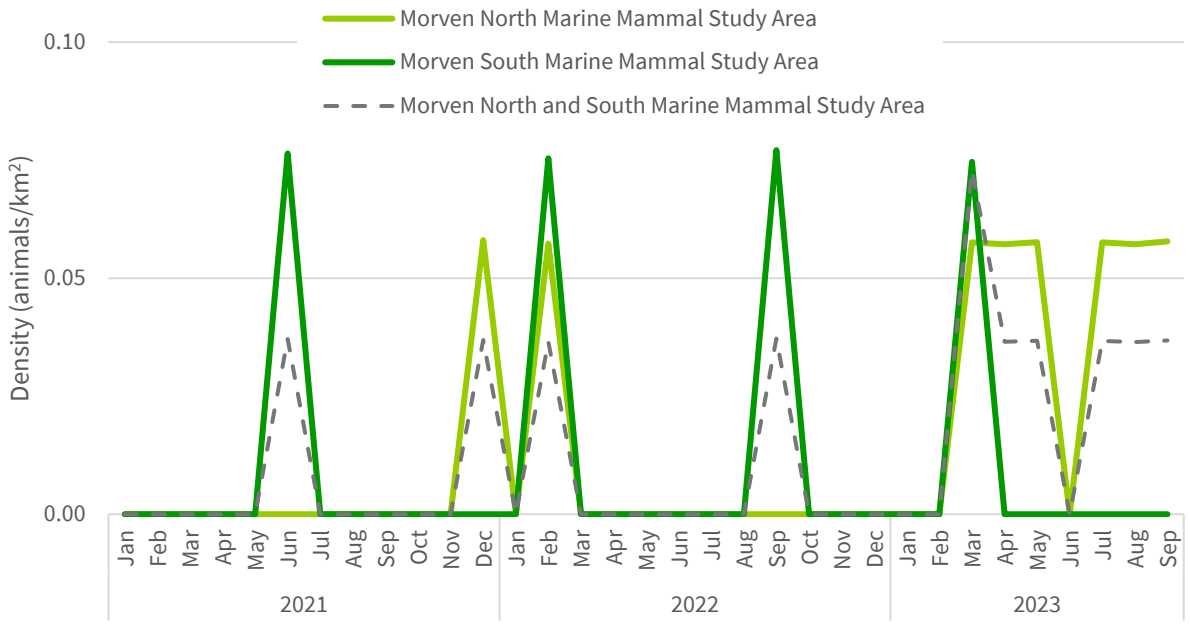

Figure 3.18: Estimated absolute density of grey seal (corrected for availability bias) for each survey over the Morven North, Morven South and Morven Site Marine Mammal Study Areas

3.2.4.6 No clear temporal trends were visible in monthly DAS sightings of grey seal, and due to the preponderance of zero counts, presenting density estimates on a $\log_{10}$ scale (as for harbour porpoise in Figure 3.10) was not possible. Therefore, the non-zero values in Figure 3.18 represent the only surveys (n = 10) during which grey seal was identified during the 33 months of DAS data, corresponding to raw counts of lone individuals. The low numbers of grey seal identified during DAS of the Morven Site Marine Mammal Study Area is likely due to the distance offshore.

3.2.4.7 Table 3.11 summarises the mean absolute abundance and density of grey seal, across monthly, seasonal, bio-season, and annual scales, wherein the maximal mean absolute density estimates for respective temporal divisions were calculated as:

- monthly: 0.025 animals/km^2 (95% CLs = 0.011, 0.038; CV = 0.866) (September);
- seasonal: 0.016 animals/km^2 (95% CLs = 0.007, 0.025; CV = 1.633) (spring);
- bio-season: 0.012 animals/km^2 (95% CLs = 0.006, 0.019; CV = 1.765) (breeding bio-season).

3.2.4.8 A summary of density and abundance estimates for grey seal across all study areas is presented in Table 3.11.

Table 3.11: Design-based estimates for mean absolute abundance and density of grey seal in the Morven North, Morven South and Morven Site Marine Mammal Study Areas, across monthly, seasonal, bio-season, and annual scales, including lower and upper 95% CLs, and CV

Temporal Division	Morven North Marine Mammal Study Area					Morven South Marine Mammal Study Area					Morven Site Marine Mammal Study Area				
	Abundance[1]	Density[2]	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV
Month															
Jan	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Feb	19	0.019	0.009	0.028	1.732	18	0.025	0.006	0.044	1.732	18	0.012	0.006	0.019	1.732
Mar	19	0.019	0.009	0.028	1.732	18	0.025	0.006	0.044	1.732	36	0.024	0.011	0.038	1.732
Apr	19	0.019	0.009	0.028	1.732	0	0.000	0.000	0.000	-	18	0.012	0.006	0.019	1.732
May	19	0.019	0.009	0.028	1.732	0	0.000	0.000	0.000	-	19	0.012	0.006	0.019	1.732
Jun	0	0.000	0.000	0.000	-	18	0.025	0.006	0.045	1.732	19	0.012	0.006	0.019	1.732
Jul	19	0.019	0.009	0.028	1.732	0	0.000	0.000	0.000	-	19	0.012	0.006	0.019	1.732
Aug	19	0.019	0.009	0.028	1.732	0	0.000	0.000	0.000	-	18	0.012	0.006	0.019	1.732
Sep	19	0.019	0.010	0.029	1.732	19	0.026	0.006	0.045	1.732	37	0.025	0.011	0.038	0.866
Oct	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Nov	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Dec	28	0.029	0.014	0.043	1.414	0	0.000	0.000	0.000	-	28	0.018	0.009	0.029	1.414
Meteorological season															
Winter	14	0.014	0.007	0.021	1.852	7	0.009	0.002	0.017	2.828	14	0.009	0.004	0.014	1.852
Spring	19	0.019	0.009	0.028	1.500	6	0.008	0.002	0.015	3.000	24	0.016	0.007	0.025	1.633

Temporal Division	Morven North Marine Mammal Study Area					Morven South Marine Mammal Study Area					Morven Site Marine Mammal Study Area				
	Abundance[1]	Density[2]	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV
Summer	13	0.013	0.006	0.019	1.984	6	0.008	0.002	0.015	3.000	19	0.012	0.006	0.019	1.500
Autumn	8	0.008	0.004	0.012	2.646	8	0.011	0.003	0.019	2.646	16	0.011	0.005	0.016	1.708
Bio-Season															
Breeding	14	0.012	0.006	0.017	2.070	5	0.010	0.003	0.018	2.639	19	0.012	0.006	0.019	1.765
Non-breeding	13	0.016	0.008	0.024	1.659	8	0.009	0.002	0.015	2.910	19	0.012	0.006	0.019	1.511
Annual															
Year 1	5	0.005	0.002	0.008	3.464	5	0.006	0.002	0.011	3.464	10	0.006	0.003	0.010	2.336
Year 2	5	0.005	0.002	0.008	3.464	9	0.013	0.003	0.022	2.336	10	0.006	0.003	0.009	2.336
Year 3 (partial)	33	0.038	0.014	0.062	0.750	6	0.008	0.002	0.015	3.000	43	0.028	0.015	0.044	0.855
Overall	14	0.014	0.007	0.021	1.795	7	0.009	0.002	0.016	2.735	19	0.012	0.007	0.019	1.618

[1] Mean absolute abundance calculated as mean density across the respective study area, corrected for availability bias.
[2] Mean absolute density calculated as the number of animals per km2 across the respective study area, corrected for availability bias.

Model-based analysis

3.2.4.9 Grey seal was not identified during the 33 months of DAS data in sufficient numbers for robust modelling to be undertaken, and as such their density and abundance in the Morven Site Marine Mammal Study Area can only be estimated via design-based methods.

3.2.5 Minke Whale

Design-based analysis

3.2.5.1 Raw counts of minke whale (Table 3.1) were adjusted for survey effort to provide estimates of mean relative abundance and density across monthly, seasonal and annual scales for the Morven Site Marine Mammal Study Area. Temporal distribution of minke whale has not been investigated to the same extent as for harbour porpoise and grey seal (2.4.1.7) as such, no bio-seasons have been defined for minke whale.

3.2.5.2 Relative estimates were corrected for availability bias to provide estimates of absolute abundance and density, with 95% CLs obtained via bootstrapping (1,000 simulations) (Wessa, 2019). Figure 3.19 illustrates the simulated mean absolute densities resulting from the bootstrapping process.

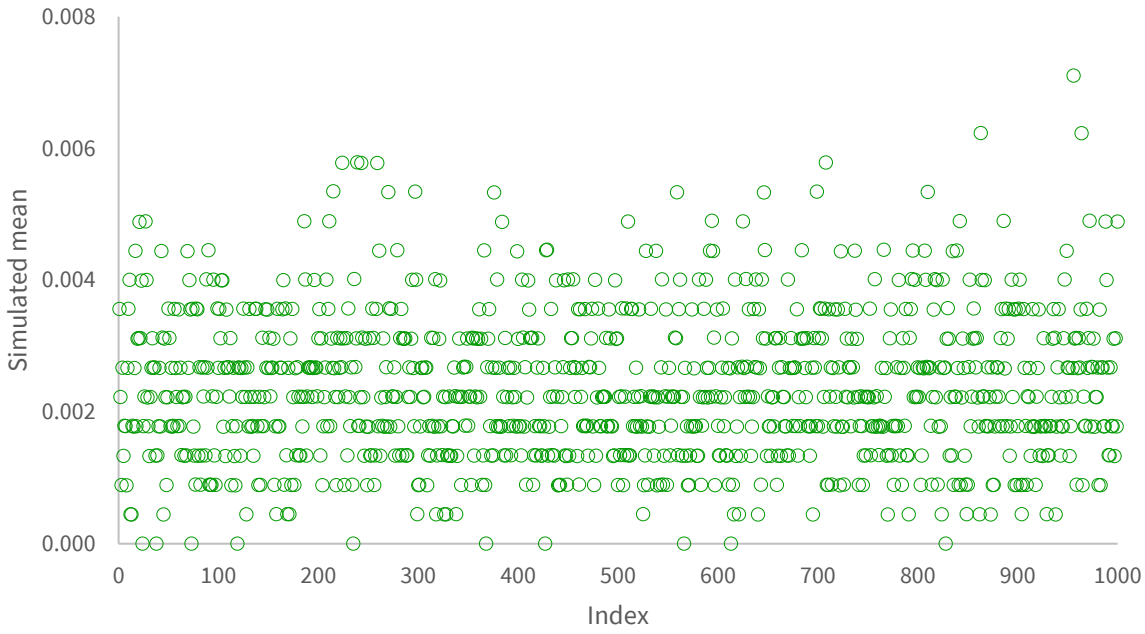

Figure 3.19: Bootstrapped simulation (n = 1,000) of mean monthly absolute density for minke whale across the Morven Site Marine Mammal Study Area

3.2.5.3 As for harbour porpoise, white-beaked dolphin and grey seal, relative density estimates for minke whale can be corrected for availability bias (Section 2.6.2.1) using published correction factors based on the proportion of time individuals are likely to be at or near the surface and available for detection. A visual tracking study of minke whale in Iceland recorded the time sequence of individual minke whales in terms of the duration when they were on the surface in between both short and long dive sequences (McGarry *et al.,* 2017). Surfacing time was estimated as 58s whilst dive duration was a mean of 73s. Therefore, based on these data, the

correction factor applied to adjust relative estimates for availability bias would be approximately 0.440.

3.2.5.4 Minke whale was identified during five of the 33 months of DAS data, with single animals recorded in May 2021, June 2021, May 2022 and September 2022, and two animals identified in July 2021 (Figure 3.20). Note that no minke whale was observed within the Morven South Marine Mammal Study Area.

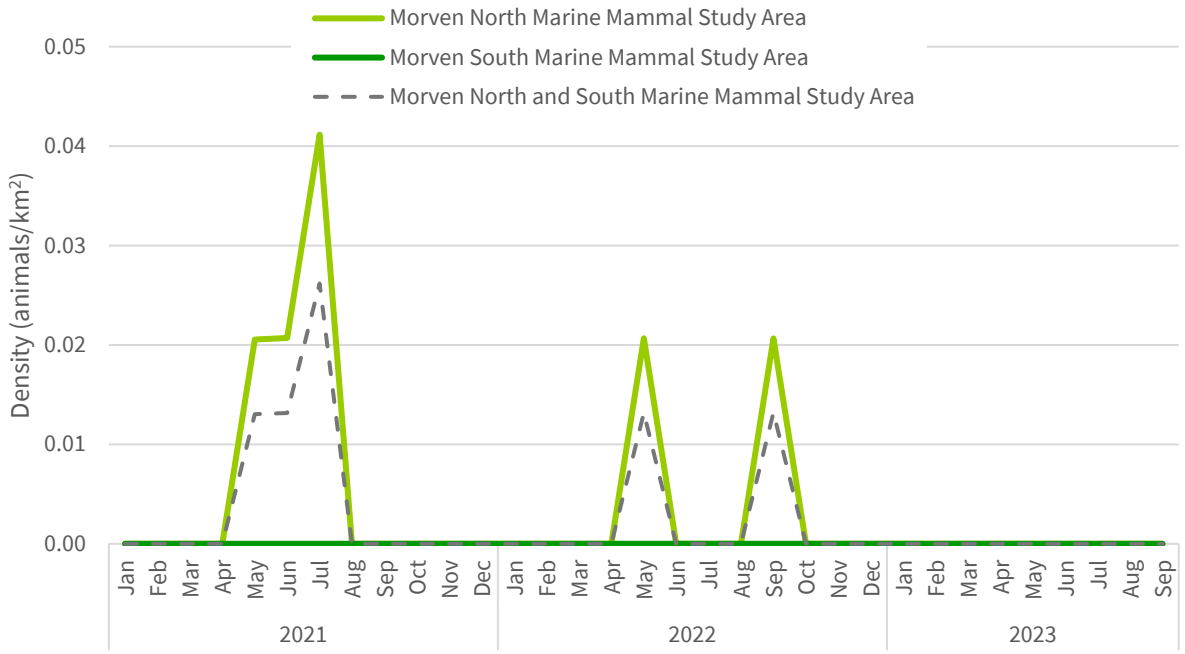

Figure 3.20: Estimated Absolute density (corrected for availability bias) of minke whale for each survey over the Morven North, Morven South and Morven Site Marine Mammal Study Areas

3.2.5.5 Mean absolute density across the 33 months of DAS data can be estimated within the Morven North and South Marine Mammal Study Area as 0.002 animals/km^2 (95% CLs = 0.001, 0.004; CV = 2.554) (Table 3.12) with a maximum estimated absolute density of 0.026 animals/km2 in July 2021, corresponding to an absolute abundance of 39 animals. The maximal mean absolute density estimates for respective temporal divisions were:

- monthly: 0.009 animals/km^2 (95% CLs = 0.003, 0.015; CV = 1.732) (July);
- seasonal: 0.004 animals/km^2 (95% CLs = 0.001, 0.007; CV = 2.120) (summer).

3.2.5.6 A summary of density and abundance estimates for minke whale across all study areas is presented in Table 3.12.

Table 3.12: Design-based estimates for mean absolute abundance and density of white-beaked dolphin in the Morven North, Morven South and Morven Site Marine Mammal Study Areas, across monthly, seasonal, and annual scales, including lower and upper 95% CLs, and CV

Temporal Division	Morven North Marine Mammal Study Area					Morven South Marine Mammal Study Area					Morven Site Marine Mammal Study Area				
	Abundance[1]	Density[2]	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV
Month															
Jan	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Feb	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Mar	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Apr	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
May	14	0.014	0.005	0.023	0.866	0	0.000	0.000	0.000	-	13	0.009	0.003	0.015	0.866
Jun	7	0.007	0.002	0.012	1.732	0	0.000	0.000	0.000	-	7	0.004	0.001	0.007	1.732
Jul	13	0.013	0.004	0.024	1.732	0	0.000	0.000	0.000	-	13	0.009	0.003	0.015	1.732
Aug	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Sep	7	0.007	0.002	0.012	1.732	0	0.000	0.000	0.000	-	7	0.004	0.001	0.007	1.732
Oct	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Nov	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Dec	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Meteorological season															
Winter	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Spring	5	0.005	0.002	0.008	1.984	0	0.000	0.000	0.000	-	5	0.003	0.001	0.005	1.984

Temporal Division	Morven North Marine Mammal Study Area					Morven South Marine Mammal Study Area					Morven Site Marine Mammal Study Area				
	Abundance[1]	Density[2]	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV	Abundance	Density	Lower 95%	Upper 95%	CV
Summer	7	0.007	0.002	0.012	2.119	0	0.000	0.000	0.000	-	7	0.004	0.001	0.007	2.120
Autumn	3	0.003	0.001	0.005	2.646	0	0.000	0.000	0.000	-	3	0.002	0.001	0.003	2.646
Annual															
Year 1	7	0.007	0.002	0.012	1.953	0	0.000	0.000	0.000	-	7	0.004	0.001	0.008	1.954
Year 2	4	0.003	0.001	0.006	2.335	0	0.000	0.000	0.000	-	4	0.002	0.001	0.004	2.335
Year 3 (partial)	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-	0	0.000	0.000	0.000	-
Overall	4	0.004	0.001	0.007	2.554	0	0.000	0.000	0.000	-	4	0.002	0.001	0.004	2.554

[1] Mean absolute abundance calculated as mean density across the respective study area, corrected for availability bias.
[2] Mean absolute density calculated as the number of animals per km^2 across the respective study area, corrected for availability bias.

Model-based analysis

3.2.5.7 Minke whale was not identified during the 33 months of DAS data in sufficient numbers for robust modelling to be undertaken, and as such their density and abundance in the Morven Site Marine Mammal Study Area can only be estimated via design-based methods.

4 Summary

4.1.1.1 This appendix provides a summary of estimated marine mammal distribution recorded during the 33 months of DAS data collection, between January 2021 and September 2023 across the Morven Site Marine Mammal Study Area, encompassing the Morven North Boundary and the Morven South Boundary, plus a 4km buffer.

4.1.1.2 A mean coverage of 11.81% of the Morven Site Marine Mammal Study Area was processed by APEM across the 33 months of the DAS campaign, with a minimum coverage of 11.62% in November 2021 and a maximum coverage of 12.01% in October 2021 (Table 3.1). Across the Morven North Marine Mammal Study Area mean DAS coverage was equivalent to 11.58%, and across the Morven South Marine Mammal Study Area mean DAS coverage was equivalent 12.01%.

4.1.1.3 Harbour porpoise accounted for the highest number of individuals identified to species level (n = 593, based on raw count data) across the Morven Site Marine Mammal Study Area, and individuals were recorded in all survey months except for January 2021, February 2021, March 2021 and January 2022. When considered across the Morven North and Morven South Marine Mammal Study Areas, an apparent trend towards the north was observed, with 463 and 174 harbour porpoise recorded, respectively. It is important to note though, that this pattern was not consistent throughout the survey campaign and is largely a result of two peaks in occurrence within the Morven North Marine Mammal Study Area during May 2021 and May 2022.

4.1.1.4 White-beaked dolphin was the second most abundant species (n = 85), and individuals were sighted in only 14 months across the 33 month DAS period. No clear spatial patterns were observed between the Morven North and Morven South Marine Mammal Study Areas.

4.1.1.5 Eight individuals of common dolphin were identified in one month (June 2022), located in the area of overlap between the Morven North and Morven South Marine Mammal Study Areas, with no further sightings. Six minke whales were identified across five months, all within the Morven North Marine Mammal Study Area.

4.1.1.6 Eleven grey seals were identified across 10 months (approximately two-thirds of these were in the Morven North Marine Mammal Study Area), and 33 individuals classified as 'unidentified seal species' were observed across 15 survey months, spatially distributed relatively evenly.

4.1.1.7 One humpback whale was recorded in May 2022, and no bottlenose dolphin or harbour seal were identified across the 33-month DAS campaign.

4.1.1.8 For harbour porpoise, white-beaked dolphin, grey seal and minke whale, relative density estimates were calculated from the raw DAS data and subsequently corrected for availability bias to give absolute densities. These were calculated with correction factors derived from studies of these species' diving behaviour, which give an indication of the average proportion of time that individuals of a species may be on, or near, the surface and available for detection.

4.1.1.9 The limitations of using availability bias estimates from published studies are recognised (e.g. potentially subject to geographic, seasonal, diurnal, and individual animal variation) and therefore absolute densities are considered to be approximations only but have been employed in an effort to obtain more precautionary estimates of marine mammal abundance.

4.1.1.10 The division of the year into two bio-seasons for harbour porpoise, based upon bimodal patterns of spatial distribution ("winter" and "summer") is an approach intended to address the difficulties in implementing criteria for designating Special Areas of Conservation (Heinänen and Skov, 2015). Similarly for grey seal, broad-scale seasonal patterns of density have been determined based upon potential changes in distribution between the breeding season (defined as September to December for this region (Marine Scotland, 2020; SCOS,

2020) and the non-breeding season (January to August). For white-beaked dolphin and minke whale, meteorological season was used as a means to determine broader-scale temporal patterns in density. This approach has also been taken forward to the EIA.

4.1.1.11 Peaks in absolute abundance for harbour porpoise were estimated to occur in the month of May, with a mean monthly estimate in the Morven Site Marine Mammal Study Area of 1,945 animals, equating to 1.316 animals/km^2. When considered across broader temporal scales, the 'summer' bio-season appeared to have comparatively lower estimates of occurrence from both design-based (0.396 animals/km^2: Table 3.6) and model-based (0.009 animals/km^2:Table 3.8) analyses.

4.1.1.12 Plotting of model predictions suggested a temporal pattern of spatial distribution for harbour porpoise. Greater density was expected in the Morven North Marine Mammal Study Area during the 'summer' bio-season, with 'winter' bio-season density concentrated in the Morven South Marine Mammal Study Area, albeit at low levels (Table 3.12)

4.1.1.13 White-beaked dolphin was identified during 14 surveys, with a peak density estimated from the design-based analysis of 0.321 animals/km^2 during the June 2021 DAS, a seasonal maximum of 0.177 animals/km^2 during meteorological summer (June to August), and an overall estimate of 0.082 animals/km^2 across the whole 33-month DAS campaign. No white-beaked dolphin was identified during any surveys between the months of October to December, and in the first two survey years (2021 and 2022) no individuals were identified during the months of March to May.

Table 4.1: Summary of estimated absolute (corrected for availability bias) abundance and density, per species, calculated from the design-based analysis.

Temporal Division	Mean Abundance	Mean Density (Animals/km2)	Lower 95% CL	Upper 95% CL	CV
Harbour porpoise					
Overall	360	0.240	0.127	0.373	1.890
"Winter" bio-season	88	0.059	0.031	0.091	1.308
"Summer" bio-season	586	0.391	0.206	0.607	1.467
White-beaked dolphin					
Overall	122	0.082	0.047	0.121	1.350
Winter	76	0.051	0.029	0.076	1.917
Spring	26	0.018	0.010	0.026	3.000
Summer	262	0.177	0.100	0.261	0.586
Autumn	116	0.078	0.044	0.115	1.575
Grey seal					
Overall	19	0.012	0.007	0.019	1.618
Breeding bio-season	19	0.012	0.006	0.019	1.765
Non-breeding bio-season	19	0.012	0.006	0.019	1.511
Minke whale					
Overall	4	0.002	0.001	0.004	2.554

Temporal Division	Mean Abundance	Mean Density (Animals/km2)	Lower 95% CL	Upper 95% CL	CV
Winter	0	0.000	0.000	0.000	-
Spring	5	0.003	0.001	0.005	1.984
Summer	7	0.004	0.001	0.007	2.120
Autumn	3	0.002	0.001	0.003	2.646

Table 4.2: Summary of mean estimated absolute (corrected for availability bias) abundance and density for harbour porpoise and white-beaked dolphin, calculated from the model-based analysis

Temporal Division	Mean Abundance	Mean Density (Animals/km2)	Lower 95% CL	Upper 95% CL	CV
Harbour porpoise					
Overall	219	0.148	0.073	0.317	1.721
”Winter” bio-season	91	0.062	0.011	0.532	2.08
“Summer” bio-season	14	0.009	0.001	0.082	2.08
White-beaked dolphin					
Overall	131	0.088	0.004	1.488	4.972

4.1.1.14 Grey seal was consistently low in numbers across the 33 months of DAS data, with a total of 11 animals identified to species level, which was too few for robust modelling. A seasonal maximum was estimated at 0.012 animals/km^2 during both the breeding bio-season (September to December) and the non-breeding bio-season (January to August, see Section 2.4.1.8), with an overall density estimate of 0.012 animals/km^2.

4.1.1.15 Minke whale was also identified in very low numbers, with just six individuals recorded across the 33 months of DAS data, all within the Morven North Marine Mammal Study Area. The estimated absolute density across the DAS campaign was 0.002 animals/km^2 with a seasonal peak of 0.004 animals/km^2 during the summer.

4.1.1.16 The model-based approach provided estimates of spatial distribution across meteorological seasons and bio-seasons (for harbour porpoise) and across the 33 months of DAS data (harbour porpoise and white-beaked dolphin). However, the models did not fit sufficiently well to produce robust predictions of density suitable to inform assessments (Table 3.7, Table 3.8 and Table 3.10). In the case of white-beaked dolphin, density and abundance estimates were similar to those obtained via design-based analysis, but this similarity was not observed between design-based and model-based analyses for harbour porpoise (Table 4.2). As a result of the poor fit of the models, interpretation of the suggested seasonality and spatial distribution of marine mammals should therefore be undertaken with caution. Preference should instead be given to estimates obtained via the design-based analyses, since these offer a more precautionary and more consistent estimate of marine mammal density.

5 References

Authier, M., Galatius, A., Gilles, A. and Spitz, J. (2020). Of power and despair in cetacean conservation: estimation and detection of trend in abundance with noisy and short time-series. PeerJ, 8, pp.e9436. DOI:10.7717/peerj.9436.

Baumgartner, N. (2008). Distribution, diving behaviour and identification of the north Atlantic minke whale in northeast Scotland. Aberdeen University.

Buckland, S. T., Anderson, D. R., Burnham, K. P., Laake, J. L., Borchers, D. L. and Thomas, L. (2001). Introduction to Distance Sampling. Oxford, Oxford University Press.

Canning, S., Santos, M., Reid, R., Evans, P., Sabin, R., Bailey, N. and Pierce, G. (2008). Seasonal distribution of white-beaked dolphins (Lagenorhynchus albirostris) in UK waters with new information on diet and habitat use. Journal of the Marine Biological Association of the UK, 88, pp.1159-1166. DOI:10.1017/S0025315408000076.

Canty, A. and Ripley, B. (2022). boot: Bootstrap R (S-Plus) Functions. 1.3-28.1 ed.

Heinänen, S. and Skov, H. (2015). The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area. JNCC Report No: 544. Peterborough, UK

ICES. (2008). Report of the Working Group on Marine Mammal Ecology (WGMME). St. Andrews, UK pp.86.

ICES. (2014). Report of the Working Group on Marine Mammal Ecology (WGMME). Woods Hole, Massachusetts, USA pp.234.

ICES. (2016). Report of the Working Group on Marine Mammal Ecology (WGMME). Madrid, Spain pp.117.

Marine Scotland. (2020). Scotland's Marine Assessment 2020 – Seals [Online]. Marine Scotland. Available at: https://marine.gov.scot/sma/assessment/seals. Accessed on: September 2023.

McGarry, T., Boisseau, O., Stephenson, S. and Compton, R. (2017). Understanding the Effectiveness of Acoustic Deterrent Devices (ADDs) on Minke Whale (Balaenoptera acutorostrata), a Low Frequency Cetacean. ORJIP Project 4, Phase 2. Prepared on behalf of The Carbon Trust. Document Number RPS Report EOR0692.

Orsted, H. P. T. L. (2018). Hornsea Project Three Offshore Wind Farm Environmental Statement: Volume 5, Annex 4.1 – Marine Mammal Technical Report. pp.143pp.

OSPAR. (2017). Intermediate assessment 2017 – Abundance and distribution of cetaceans.

Paxton, C. G. M., Scott-Hayward, L. A. S., MacKenzie, M. L., Rexstad, E. and Thomas, L. J. (2016). Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resources with Advisory Note. Joint Nature Conservation Committee.

R Core Team. (2023). R: A Language and Environment for Statistical Computing. Vienna: R Foundation for Statistical Computing.

Rasmussen, M., Akamatsu, T., Teilmann, J., Víkingsson, G. and Miller, L. (2013). Biosonar, diving and movements of two tagged white-beaked dolphin in Icelandic waters. Deep Sea Research Part II: Topical Studies in Oceanography, 88–89, pp.97–105. DOI:10.1016/j.dsr2.2012.07.011.

Risch, D., Wilson, S. C., Hoogerwerf, M., van Geel, N. C. F., Edwards, E. W. J. and Brookes, K. L. (2019). Seasonal and diel acoustic presence of North Atlantic minke whales in the North Sea. Sci Rep, 9 (1), pp.3571. DOI:10.1038/s41598-019-39752-8.

SCOS. (2020). Scientific Advice on Matters Related to the Management of Seal Populations: 2019. Natural Environment Research Council, Special Committee on Seals pp.154.

Scott-Hayward, L., Oedekoven, C., Mackenzie, M. and Rexstad, E. (2013). MRSea Package (version 0.0.1): Statistical Modelling of Bird and Cetacean Distributions in Offshore Renewables Development Areas. Report by University of St Andrews. Report for Marine Scotland Science. Document Number CR/2012/05.

Taylor, B. L., Martinez, M., Gerrodette, T., Barlow, J. and Hrovat, Y. N. (2007). Lessons from monitoring trends in abundance of marine mammals. Marine Mammal Science, 23 (1), pp.157-175.

Teilmann, J., Christiansen, C. T., Kjellerup, S., Dietz, R. and Nachman, G. (2013). Geographic, seasonal, and diurnal surface behavior of harbor porpoises. Marine Mammal Science, 29 (2), pp.E60-E76. DOI:10.1111/j.1748-7692.2012.00597.x.

Thompson, D., Hammond, P. S., Nicholas, K. S. and Fedak, M. A. (1991). Movements, diving and foraging behaviour of grey seals (Halichoerus grypus). Journal of Zoology, 224 (2), pp.223-232.

van Beest, F. M., Teilmann, J., Hermannsen, L., Galatius, A., Mikkelsen, L., Sveegaard, S., Balle, J. D., Dietz, R. and Nabe-Nielsen, J. (2018). Fine-scale movement responses of free-ranging harbour porpoises to capture, tagging and short-term noise pulses from a single airgun. R Soc Open Sci, 5 (1), pp.170110. DOI:10.1098/rsos.170110.

Weir, C., Stockin, K. and Pierce, G. (2007). Spatial and temporal trends in the distribution of harbour porpoises, white-beaked dolphins and minke whales off Aberdeenshire (UK), north-western North Sea. Journal of the Marine Biological Association of the United Kingdom, 87, pp.327-338. DOI:10.1017/S0025315407052721.

Wessa, P. (2019). Bootstrap Plot for Central Tendency (v1.0.16) in Free Statistics Software (v1.2.1) [Online]. Office for Research Development and Education. Available at: https://www.wessa.net/rwasp_bootstrapplot1.wasp/. Accessed on: September 2023.

Appendix A Species count tables for Morven North and Morven South

A.1: Monthly raw sightings* data (number of animals, uncorrected for effort) across the Morven North Marine Mammal Study Area

Survey month	Harbour Porpoise	White-beaked Dolphin	Common Dolphin	Grey Seal	Minke Whale	Humpback Whale	Dolphin/ Porpoise	Dolphin species	Seal species	Marine Mammal species	Total
January 2021	-	-	-	-	-	-	-	-	1	-	**1**
February 2021	-	-	-	-	-	-	2	-	2	-	**4**
March 2021	-	-	-	-	-	-	2	-	1	-	**3**
April 2021	1	-	-	-	-	-	1	-	3	-	**5**
May 2021	110	-	-	-	1	-	30	9	1	-	**151**
June 2021	3	10	-	-	1	-	2	1	-	-	**17**
July 2021	31	4	-	-	2	-	-	-	-	3	**40**
August 2021	5	-	-	-	-	-	-	-	-	1	**6**
September 2021	9	8	-	-	-	-	-	-	-	2	**19**
October 2021	2	-	-	-	-	-	4	-	-	-	**6**
November 2021	2	-	-	-	-	-	-	-	1	-	**3**
December 2021	7	-	-	1	-	-	-	-	-	2	**10**
January 2022	-	5	-	-	-	-	-	-	-	-	**5**

Survey month	Harbour Porpoise	White-beaked Dolphin	Common Dolphin	Grey Seal	Minke Whale	Humpback Whale	Dolphin/ Porpoise	Dolphin species	Seal species	Marine Mammal species	Total
February 2022	5	8	-	1	-	-	4	-	2	1	**21**
March 2022	3	-	-	-	-	-	-	-	2	2	**7**
April 2022	1	-	-	-	-	-	1	-	-	-	**2**
May 2022	156	-	-	-	1	1	7	-	4	2	**171**
June 2022	2	-	8	-	-	-	1	-	-	-	**11**
July 2022	6	6	-	-	-	-	-	-	-	-	**12**
August 2022	1	4	-	-	-	-	-	-	-	-	**5**
September 2022	12	-	-	-	1	-	1	1	-	-	**15**
October 2022	14	-	-	-	-	-	9	-	-	-	**23**
November 2022	-	-	-	-	-	-	-	-	-	-	**-**
December 2022	2	-	-	-	-	-	1	-	-	-	**3**
January 2023	1	-	-	-	-	-	-	-	-	-	**1**
February 2023	1	-	-	-	-	-	-	-	-	-	**1**
March 2023	3	-	-	1	-	-	-	-	-	-	**4**
April 2023	13	5	-	1	-	-	1	-	1	-	**21**
May 2023	9	-	-	1	-	-	3	-	1	-	**14**

Survey month	Harbour Porpoise	White-beaked Dolphin	Common Dolphin	Grey Seal	Minke Whale	Humpback Whale	Dolphin/ Porpoise	Dolphin species	Seal species	Marine Mammal species	Total
June 2023	34	9	-	-	-	-	-	-	1	1	**45**
July 2023	24	8	-	1	-	-	-	-	1	-	**34**
August 2023	7	5	-	1	-	-	1	-	-	-	**14**
September 2023	2	1	-	1	-	-	-	2	-	-	**6**
Total	**466**	**73**	**8**	**8**	**6**	**1**	**70**	**13**	**21**	**14**	**680**

* Note that two deceased marine mammals were observed in the Morven North Marine Mammal Study Area, both of which occurred during the September 2021 survey. Neither animal was identifiable to species level, and were instead recorded as 'Marine Mammal Species'. These observations are indicated in the table by red text.

A. 2: Monthly raw sightings* data (number of animals, uncorrected for effort) across the Morven South Marine Mammal Study Area

Survey month	Harbour Porpoise	White-beaked Dolphin	Common Dolphin	Grey Seal	Dolphin/ Porpoise	Dolphin species	Seal species	Whale species	Marine Mammal species	Total
January 2021	-	-	-	-	-	-	-	-	-	-
February 2021	-	-	-	-	2	-	-	-	-	**2**
March 2021	-	-	-	-	-	-	-	-	-	-
April 2021	3	-	-	-	1	-	7	-	-	**11**
May 2021	5	-	-	-	4	-	1	-	-	**10**
June 2021	-	7	-	1	-	-	-	-	1	**9**
July 2021	25	4	-	-	2	-	1	1	1	**34**
August 2021	2	2	-	-	-	-	-	-	-	**4**

Survey month	Harbour Porpoise	White-beaked Dolphin	Common Dolphin	Grey Seal	Dolphin/ Porpoise	Dolphin species	Seal species	Whale species	Marine Mammal species	Total
September 2021	-	8	-	-	-	-	-	-	2	**10**
October 2021	4	-	-	-	-	-	-	-	-	**4**
November 2021	-	-	-	-	-	-	-	-	-	-
December 2021	-	-	-	-	-	-	-	-	1	**1**
January 2022	-	-	-	-	-	-	-	-	-	-
February 2022	2	-	-	1	2	-	1	-	-	**6**
March 2022	4	-	-	-	-	-	3	-	-	**7**
April 2022	1	-	-	-	-	-	1	-	-	**2**
May 2022	4	-	-	-	2	-	1	-	-	**7**
June 2022	1	-	8	-	-	-	-	-	-	**9**
July 2022	5	-	-	-	-	-	-	-	-	**5**
August 2022	2	2	-	-	-	-	-	-	-	**4**
September 2022	12	8	-	1	-	1	-	-	-	**22**
October 2022	10	-	-	-	-	-	-	-	-	**10**
November 2022	9	-	-	-	-	-	-	-	-	**9**
December 2022	-	-	-	-	-	-	-	-	-	-
January 2023	-	-	-	-	-	-	-	-	-	-

Survey month	Harbour Porpoise	White-beaked Dolphin	Common Dolphin	Grey Seal	Dolphin/ Porpoise	Dolphin species	Seal species	Whale species	Marine Mammal species	Total
February 2023	1	-	-	-	-	-	-	-	-	**1**
March 2023	2	-	-	1	-	-	-	-	-	**3**
April 2023	12	5	-	-	3	-	2	-	-	**22**
May 2023	10	-	-	-	1	-	1	-	-	**12**
June 2023	34	4	-	-	-	-	-	-	-	**38**
July 2023	13	-	-	-	-	-	-	-	-	**13**
August 2023	4	-	-	-	-	-	-	-	-	**4**
September 2023	6	-	-	-	-	-	-	-	-	**6**
Total	**171**	**40**	**8**	**4**	**17**	**1**	**18**	**1**	**5**	**265**

* Note that four deceased marine mammals were observed in the Morven South Marine Mammal Study Area. Two of these occurred during the September 2021 survey, and are the same animals described in Appendix A. The other two animals were observed during the July 2021 survey and comprised one 'Seal Species' and one 'Whale Species'. These observations are indicated in the table by red text.

Table A. 3: Monthly mean and maximum group sizes for species sightings across the Morven North Marine Mammal Study Area.

Month	Harbour porpoise			White-beaked dolphin			Common dolphin		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Jan	-	-	-	5.00	5	5	-	-	-
Feb	-	-	-	8.00	8	8	-	-	-
Mar	-	-	-	-	-	-	-	-	-
Apr	2.00	2	2	5.00	5	5	-	-	-
May	3.41	2	12	-	-	-	-	-	-
Jun	2.14	2	3	3.80	2	7	8.00	8.00	8
Jul	2.13	2	3	2.83	2	4	-	-	-
Aug	2.25	2	3	2.60	2	4	-	-	-
Sep	3.11	2	7	5.33	4	8	-	-	-
Oct	4.25	2	8	-	-	-	-	-	-
Nov	3.50	2	5	-	-	-	-	-	-
Dec	2.00	2	2	-	-	-	-	-	-
Overall mean	2.99	2.00	5.00	3.86	4.00	5.86	8.00	8.00	8.00
95% CI [±]	0.34	0.00	2.22	0.79	1.66	1.31	n/a	n/a	n/a

A. 4: Monthly mean and maximum group sizes for species sightings across the Morven South Marine Mammal Study Area.

Month	Harbour porpoise			White-beaked dolphin			Common dolphin		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Jan	-	-	-	5.00	5	5	-	-	-
Feb	-	-	-	8.00	8	8	-	-	-
Mar	-	-	-	-	-	-	-	-	-
Apr	2.00	2	2	5.00	5	5	-	-	-
May	3.44	2	12	-	-	-	-	-	-
Jun	2.14	2	3	3.80	2	7	8.00	8.00	8
Jul	2.13	2	3	2.83	2	4	-	-	-
Aug	2.25	2	3	2.60	2	4	-	-	-
Sep	3.11	2	7	5.33	4	8	-	-	-

Month	Harbour porpoise			White-beaked dolphin			Common dolphin		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Oct	4.25	2	8	-	-	-	-	-	-
Nov	3.50	2	5	-	-	-	-	-	-
Dec	2.00	2	2	-	-	-	-	-	-
Overall mean	2.99	2.00	5.00	3.86	4.00	5.86	8.00	8.00	8.00
95% CI [±]	0.34	0.00	2.22	0.79	1.66	1.31	n/a	n/a	n/a