



Bowdun Offshore Wind Farm, Offshore EIA Report

Volume 3, Technical Appendix 10.2: Marine
Mammal Digital Aerial Survey Report

TWP-BOW-RPS-OFE-RPT-00071 | April 2026



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Glossary

Defined Term	Definition
Applicant (the)	Bowdun Offshore Wind Farm Limited (BOWFL).
Array Area	The Array Area is the area in which the Offshore Generation Assets will be located.
Bowdun Offshore Wind Farm Limited (BOWFL)	A Special-Purpose Vehicle (SPV) (legal entity) for the purpose of developing the Project. BOWFL are the Applicant for the Offshore Application.
Digital Aerial Survey (DAS)	A method for undertaking baseline ornithological and marine mammal data collection surveys. Usually undertaken over a period of 24 months.
Environmental Impact Assessment (EIA)	Process for the assessment of the potential likely significant environmental effects of a project on the physical, biological, and human environment during construction, Operations and Maintenance (O&M) and decommissioning.
Offshore Environmental Impact Assessment (EIA) Report (hereafter, ‘Offshore EIA Report’)	Document prepared to report the findings of the EIA for the Proposed Development and produced in accordance with the EIA Regulations. The Offshore EIA Report is submitted to support the Offshore Application for the Proposed Development, and to comply with EIA Regulations.
Offshore Export Cables	Subsea cables used to transmit electricity generated offshore by the Wind Turbines from the OSPs to shore. The Transition Joint Bay (TJB) is the location where the Offshore Export Cables terminate, and the onshore cabling begins.
Offshore Substation Platform(s) (OSP(s))	OSP(s) comprise the support structure, topside and electrical components used for collecting and/or converting electricity generated by the Wind Turbines for transmission by the Offshore Export Cables.
Piling	The action of installing piles: installation can use various methodologies, the most common of which are impact piling (in which the piles are struck by a “hammer”) and drilling (during which a hole is drilled into the seafloor, the drilling tool is removed, and the pile is slotted into that hole).
Project (the)	An overarching term for the Bowdun Offshore Wind Farm (Bowdun OWF) comprising the offshore and onshore infrastructure required to generate and transmit electricity from the Array Area to the onshore Grid Connection Point. The Project includes the Offshore Generation Assets, the Offshore Transmission Assets and the Onshore Transmission Assets.
Study Area	For each environmental topic, the baseline environment will be characterised, and the potential environmental impacts will be described within a topic-specific study area. Specific study areas are defined for each topic and are based on the maximum spatial extent across which potential impacts of the Project may be experienced by the relevant receptors (i.e. Zone of Influence).
Thistle Wind Partners (TWP)	Company established for the development of the Project.
Wind Turbines	Structures comprising of a tubular tower, rotor blades, and a nacelle which houses the Wind Turbine generator.

Acronyms

Acronym	Definition
CI	Confidence Interval
CL	Confidence Limit
CV	Coefficient of Variation
DAS	Digital aerial survey
EIA	Environmental Impact Assessment
GPS	Global Positioning System
MRSea	Marine Renewables Strategic Environmental Assessment
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
POA	Plan Option Area
QA	Quality Assurance
SCOS	Special Committee on Seals
ZoI	Zone of Influence

Table of Units

Units	Definition
cm	Centimetre
ft	Feet
km	Kilometre
km ²	Square kilometre
kts	knots
m	Metre
nm	Nautical mile
s	Second

1 Introduction

1.1 Project Overview

- 1.1.1 Bowdun Offshore Wind Farm Limited (hereafter referred to as the 'Applicant'), is developing the Bowdun Offshore Wind Farm (OWF) Project, the offshore elements of the Project are hereafter referred to as the Proposed Development.
- 1.1.2 The Proposed Development Array will be located within the Array Area, approximately 38 km east of the coast of Aberdeenshire (at its closest point) (see Figure 1.1), and includes the offshore infrastructure required to produce electricity including Wind Turbines (including their fixed substructures), fixed bottom Offshore Substation Platforms (OSPs) and inter-array and interconnector cables. The Array is the subject of this Technical Appendix of the Offshore Environmental Impact Assessment (EIA) Report.
- 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 Limited (hereafter 'APEM') across the E3 Plan Option Area (POA), as defined in the Sectoral Marine Plan for Offshore Wind Energy (Scottish Government, 2020) plus a 12 km buffer (defined in Section 2.1 as the 'DAS Area'). Between April and August the coverage of DAS flights extended west to the Aberdeenshire coast (defined in Section 2.1 as the 'Extended DAS Area'). DAS flights commenced in March 2022 and were undertaken monthly, with a total of 24 months of data collected up until February 2024.

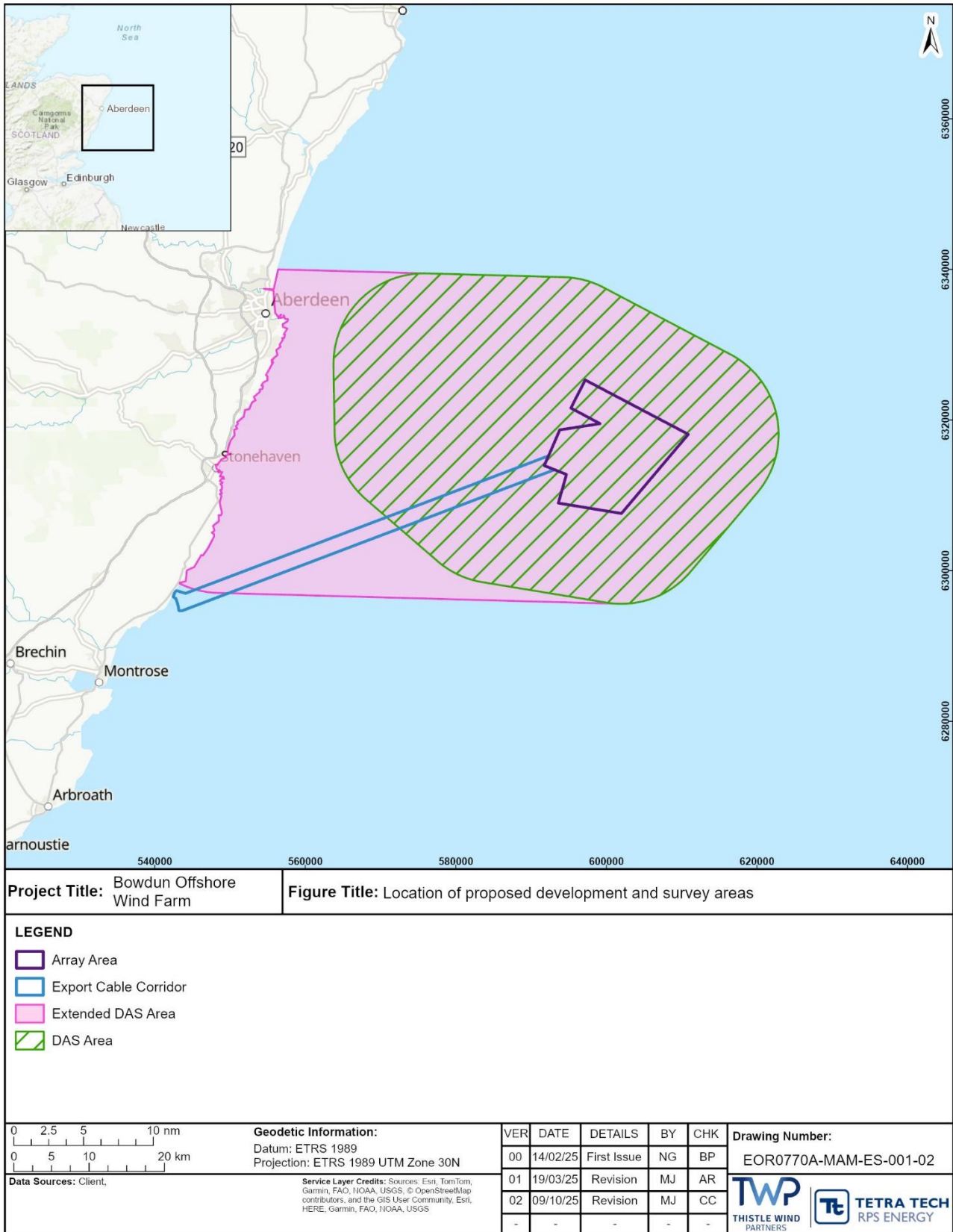


Figure 1.1: Location of the Proposed Development, DAS Area and Extended DAS Area

2 Methodology

2.1 Survey Area

- 2.1.1 The survey area for the Proposed Development marine mammal DAS data collection used slightly different areas dependant on the season. During the winter (September – March, inclusive) the area comprised of a 12 km buffer around the E3 POA (Figure 2.1) and covered an area¹ of approximately 1,991.59 km² (hereafter referred to as the ‘DAS Area’). During the summer months (April – August, inclusive) the area of survey was extended to the Aberdeenshire coastline (hereafter referred to as the ‘Extended DAS Area’) and covered an area of approximately 2,770.91 km². DAS flights were extended to the coast during the summer months to capture additional observations from breeding seabirds, and marine mammal observations have been included here to provide additional context of coastal distribution. It is important to recognise, however, that comparisons should not be made between estimates calculated from the DAS Area and the Extended DAS Area, given the different areas covered.
- 2.1.2 Although the Array Area was refined at Scoping stage, the DAS data collected remain appropriate for use, because the spatial extent and survey design was based on the ScotWind E3 POA, which still fully incorporates the Array Area (see Figure 2.1). Note that the E3 POA has since been refined as the Array Area (Paragraph 11.2), but the DAS Area, derived on the basis of the E3 POA, has been retained since this informed the spatial extent and survey design for the site-specific DAS campaign (i.e. all DAS flights across all survey months and both the DAS Area and the Extended DAS Area).
- 2.1.3 The extent of both the DAS Area and Extended DAS Area provides an indication of the spatial and temporal distribution of marine mammal activity within the Array Area and buffer. This information provides useful site characterisation; however, Zones of Influence (Zols) may extend further than the Array Area for some impacts associated with the Proposed Development. Therefore, both the DAS Area and Extended DAS Area may not incorporate the full extent of the Zol for all impacts with the potential to affect marine mammals (e.g. piling noise).

¹ Due to the nature of applying different geographical projections in calculating area, the numerical value used in estimating abundance and density (1,991.59 km²) differed from the value reported in the survey reports (1,977 km²). However, both values are considered to be accurate and relevant.

² Due to the nature of applying different geographical projections in calculating area, the numerical value used in estimating abundance and density (2770.91 km²) differed from the value reported in the survey reports (2,775 km²). However, both values are considered to be accurate and appropriate.

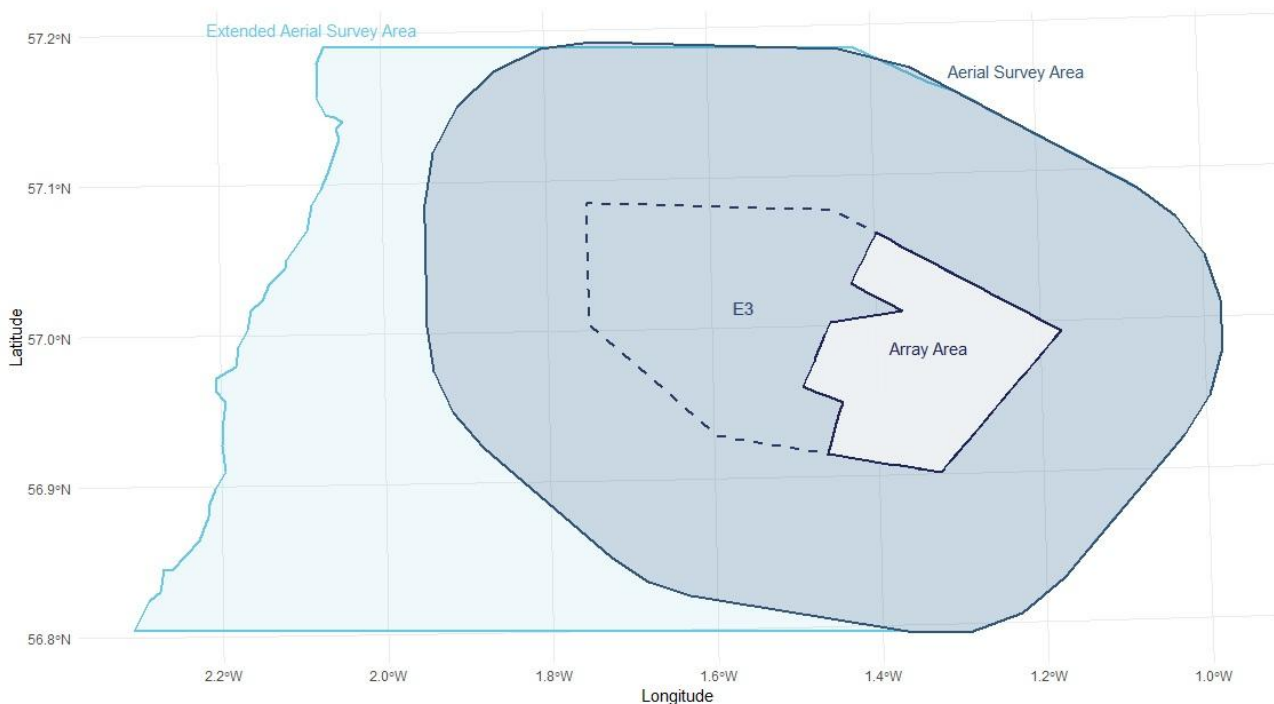


Figure 2.1: DAS Area (Dark Blue), Extended DAS Area (Light Blue) and Array Area (Pale Grey). The Dashed Line Indicates the Spatial Extent of the E3 POA, on Which the DAS Area was Defined

2.2 Survey Approach

- 2.2.1 The Proposed Development DAS campaign was undertaken between March 2022 and February 2024 (24 months) by APEM using a transect-based collection method in which imagery of 25% of the sea surface was collected, and data covering a minimum of 12.5% of the DAS Area and Extended DAS Area were analysed. A summary of coverage for each monthly survey is presented in Table 3.1.
- 2.2.2 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. The camera system captured abutting still imagery along 17 parallel survey lines spaced approximately 2.6 km apart, running east to west (Figure 2.2). Image data were collected at an altitude of approximately 1,300 ft (~400 m), and a speed of approximately 120 kts, with a Ground Sampling Distance of 1.5 cm.
- 2.2.3 The Douglas Sea Scale assigns categorical values to sea states to give an approximate but concise description of sea conditions, as this will affect the probability of a sighting. Sea state conditions used in the DAS campaign were 0 = Calm (Glassy), 1 = Calm (Rippled), 2 = Smooth, 3 = Slight and 4 = Moderate.

2.2.4 All surveys were undertaken in weather conditions that did not compromise the ability to provide data on the identification, distribution and abundance of marine megafauna³ and were also safe to fly in. Favourable conditions for surveying are defined as a cloud base of >396 m, visibility of >5 km, wind speed of <30 kts and a sea state of 3 (slight) or less on the Douglas Sea Scale.

2.2.5 Measures were taken to minimise glint and glare (strong reflected light off the sea), which could make finding and identifying marine megafauna more difficult. On days with minimal cloud, surveys were avoided for two hours around midday, when sun angle has the greatest potential to impact image quality. 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.

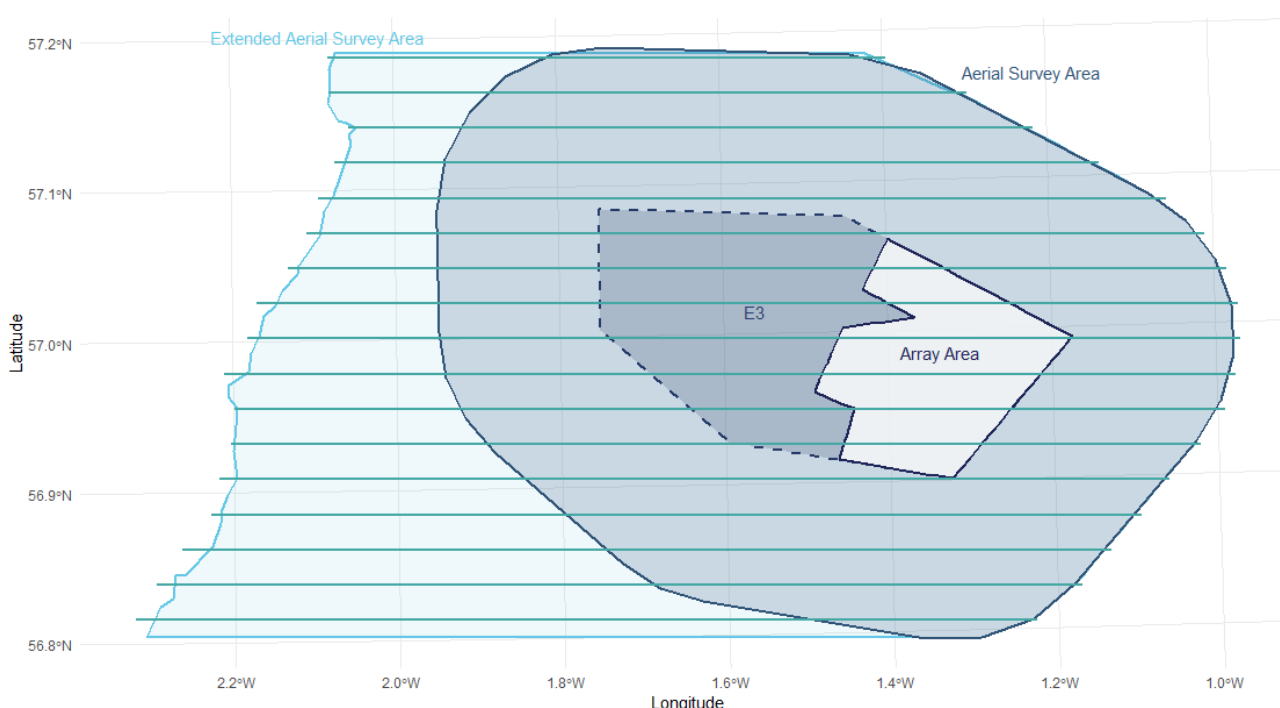


Figure 2.2: Overview of DAS Transects (Horizontal Teal Lines) Over the Array Area (Pale Grey Shaded Polygon), DAS Area (Dark Blue Shaded Polygon) and Extended DAS Area (Light Blue Shaded Polygon). The Dashed Line Indicates the Spatial Extent of the E3 ScotWind Site, on Which the DAS Area was Defined

2.3 Processing of DAS Data

2.3.1 Survey images were analysed to enumerate marine mammals. Internal Quality Assurance (QA) was undertaken to check for missed targets (i.e. uncounted marine mammals) 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.

³ Marine megafauna covers ornithology and marine mammals, however the focus of this report is marine mammals only

- 2.3.2 The analysis was undertaken by a senior image analyst 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 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 of experience in identifying marine mammals to species level nationally and internationally.
- 2.3.3 APEM uses the precautionary principle and only identifies species to a level they are 100% confident with. If a target cannot be identified to species level it is assigned to the next taxonomic level possible.

2.4 Summary Statistics

- 2.4.1 Unless otherwise stated (for example in Section 2.3), all analyses of DAS data presented in this annex were undertaken by Tetra Tech RPS Energy Limited.
- 2.4.2 Summary statistics (e.g. monthly sightings, confidence assessment, group size) were produced to describe the data for each of the key species or species groups within the aerial survey dataset (Section 3.1).

2.5 Marine Mammal Density Estimates

Pooling of Data

- 2.5.1 Pooling data across defined time periods allows the robustness of analyses to be improved where sample sizes in a single survey may be small. By considering observations over longer time periods, it is also possible to capture patterns that may be associated with environmental or biological processes, rather than simply those which align with the logistics of surveying.
- 2.5.2 As well as the individual survey months, where possible, observations have been pooled by month (e.g. March 2022 and March 2023), by meteorological season (e.g. spring), by species-specific "bio-season" (see Paragraphs 2.5.3 and 2.5.4), by individual year (e.g. March 2022 to February 2023, inclusive) and across the whole DAS campaign. A summary of the temporal divisions in which data have been pooled is presented in Table 2.1.
- 2.5.3 Research into temporal patterns of harbour porpoise *Phocoena phocoena* 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.

- 2.5.4 Similarly for grey seal *Halichoerus grypus*, 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, 2025; Special Committee on Seals (SCOS), 2024) 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.
- 2.5.5 White-beaked dolphin *Lagenorhynchus albirostris* have been observed to peak in occurrence off the Aberdeenshire coast during June, July and August, with no animals sighted outside this season (Canning *et al.*, 2008; Weir *et al.*, 2007). However, this pattern aligns with meteorological summer (June, July and August), so additional temporal divisions for white-beaked dolphin would not provide additional information. Minke whale *Balaenoptera acutorostrata* have 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. No bimodal temporal patterns in occurrence have been identified in the literature for Risso’s dolphin *Grampus griseus*, which was subsequently pooled across the whole year, and across meteorological seasons and months.

Table 2.1: Summary of Temporal Divisions in Which Observations Have Been Pooled For Analysis

Temporal scale		Duration (months)	Survey months included
Month		2	Corresponding months (e.g. March 2022 and March 2023)
Meteorological season			
Winter		3	December, January, February
Spring		3	March, April, May
Summer		3	June, July, August
Autumn		3	September, October, November
Bio-season			
Harbour porpoise	‘Summer’	6	April, May, June, July, August, September
	‘Winter’	6	October, November, December, January, February, March
Grey seal	‘Breeding’	4	September, October, November, December
	‘Non-breeding’	8	January, February, March, April, May, June, July, August
Annual			
Year 1		12	March 2022 to February 2023, inclusive
Year 2		12	March 2023 to February 2024, inclusive
Overall		24	All surveys across DAS campaign (March 2022 to February 2024)

Design-Based Density Estimates

- 2.5.6 Statistically robust, design-based baseline population estimates for marine mammals identified in both the DAS Area and Extended DAS 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).
- 2.5.7 The input data comprised geo-referenced locations of marine mammals contained within each individual digital still image, which were used to generate the raw counts for the analysis. Only individuals located within the relevant DAS Area/Extended DAS Area were used to calculate the population estimates, and deceased individuals were excluded from all analyses.
- 2.5.8 For species observed in a sufficient number of surveys to allow temporal patterns to be investigated, relative densities were estimated from the count data. First, raw counts during each DAS were divided by the area covered in the respective DAS flight (Table 3.1) to give estimates of relative density across the whole DAS Area/Extended DAS Area. These relative densities were then corrected for availability bias (see Paragraphs 2.6.7 to 2.6.8) to give estimates of absolute density.
- 2.5.9 From here, absolute abundances were then calculated by multiplying absolute density estimates by the size of the relevant study area; the DAS Area (1,977 km) and the Extended DAS Area (2,775 km). Average densities and abundances were then calculated for:
- each month (for both DAS Area and Extended DAS Area);
 - season (DAS Area only);
 - bio-season (For relevant species only, DAS Area only);
 - survey year (i.e. March to February: survey months 1-12 (Year 1) and 13-24 (Year 2)) (for both DAS Area and Extended DAS Area); and
 - across the whole survey period (for both DAS Area and Extended DAS Area).
- 2.5.10 The survey programme of the Extended DAS Area ran from April 2022 to August 2022, and April 2023 to August 2023 and therefore does not span complete seasons or bio-seasons (see Table 2.1) to enable calculation of these temporal divisions. As such, results are presented separately per DAS Area and Extended DAS Area.
- 2.5.11 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 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, CLs). Non-parametric bootstrapping makes no assumptions about the data, in contrast to parametric

bootstrapping which assumes beforehand that the data follow a specific distribution.

- 2.5.12 Density estimates with bootstrapping were undertaken for harbour porpoise, minke whale, white-beaked dolphin and grey seal. Monthly density estimates were resampled with replacement ($n = 1,000$) to generate an estimated mean density and 95% confidence intervals (CI), for each species, across the DAS campaign.
- 2.5.13 CVs were calculated as the standard deviation divided by the mean of the data. 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 sizes 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 is low (ICES, 2016; OSPAR, 2017). Furthermore, there will be large differences between species and months due to abundance and distribution within the DAS campaign.
- 2.5.14 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).

Model-Based Density Estimates

- 2.5.15 The model-based density estimates used the DAS Area only, for consistency across the 24 months of surveys, to allow for the most robust models.
- 2.5.16 DAS data were imported into R statistical software v4.3.3 (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 DAS Area. Only harbour porpoise, grey seal and white-beaked dolphin were identified in sufficient numbers for model-based analysis to be conducted.
- 2.5.17 For the DAS Area modelling was undertaken at multiple temporal scales, beginning with models incorporating all observations for each species across the 24-month DAS campaign. Following this, models for bio-season (see Paragraphs 2.5.3 to 2.5.4) and meteorological season were parameterised where sample sizes within respective temporal scales were sufficient for modelling ($n > 30$).
- 2.5.18 The following covariates were used within all modelling to predict species distribution:
- bathymetry (depth and ruggedness);
 - distance to coast; and
 - latitude and longitude.
- 2.5.19 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 CLs were also produced for each species and season.

- 2.5.20 Before any analyses could take place, the data were pre-processed to ensure no survey date/time data were missing from image identifiers, to prevent accurate assignment and cross-referencing of observations. There were no occurrences of missing information, and no data required removing from subsequent analysis.
- 2.5.21 In total, for the DAS Area, 408 survey transects were used in the analysis (17 flight lines, for 24 months) covering a total survey area of 8,282.04 km² and incorporating 258,484 images (mean 0.035 km² (SD = 0.005) coverage per image). For the Extended DAS Area, 170 survey transects were used in the analysis (17 flight lines, for 10 months) covering a total survey area of 4851.44 km² and incorporating 150,749 images (mean 0.035 km² (SD = 0.004) coverage per image).

2.6 Data Limitations

Snapshot Data Collection

- 2.6.1 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.

Bias

- 2.6.2 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 imaging 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 50% subsample of observations were quality assured, as well as 10% of ‘blank’ images (i.e. those images in which no animals were observed) to ensure that animals were not overlooked and therefore the potential for perception bias is minimal.
- 2.6.3 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.
- 2.6.4 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.
- 2.6.5 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 (Paragraphs 3.1.13 to 3.1.15), 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.

- 2.6.6 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. 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. Similarly, the platform type from which surveys are undertaken (e.g. land, vessel, aircraft) will influence both the detection of animals, as well as the estimation of availability bias. However, a precautionary approach was taken by reviewing the literature to compare correction factors from different studies and different months and regions, and then applying a conservative estimate (see Paragraphs 2.6.7 to 2.6.13 for species-specific correction factors).

Correction Factors

Harbour Porpoise

- 2.6.7 Raw counts of harbour porpoise can be corrected for availability bias (Paragraph 2.6.4) 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 0 m to 2 m (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).
- 2.6.8 Similarly, fine scale movements of harbour porpoise in the Danish North Sea were investigated using 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 53 s (min = 10.1 s, max = 250.0 s) and a mean surfacing time of 39 s (min = 2 s, max = 309 s). 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). As the more conservative value, a correction of 0.425 was applied for harbour porpoise.

Grey Seal

- 2.6.9 Raw counts of grey seals do not account for availability bias during aerial surveys (see Paragraph 2.6.4). A tracking study of three male grey seals in the Farne Islands (North-East 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%.
- 2.6.10 Similarly, telemetry data from tags deployed by the Sea Mammal Research Unit 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 15 s and 45 s, with a median of 40 s (Ørsted, 2018). Recorded grey seal dive durations observed varied between 20 s and 496 s with an average of 216 s (Ørsted, 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% (Ørsted, 2018) and was therefore similar to the figures cited by Thompson *et al.* (1991).
- 2.6.11 As with harbour porpoise, 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: Paragraph 2.6.2). The correction factor for availability bias, based on the telemetry studies described in Paragraph 2.6.10, was 0.156 as the most conservative estimate.

White-beaked Dolphin

- 2.6.12 Relative density estimates for white-beaked dolphin can be corrected for availability bias (Paragraph 2.6.4) 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 (0 m to 2 m depth) and 82% of the time diving (Rasmussen *et al.*, 2013). The correction factor to account for availability bias in white-beaked dolphin would therefore be 0.180.

Minke Whale

- 2.6.13 Relative density estimates for minke whale can be corrected for availability bias (Paragraph 2.6.4) 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 58 s whilst dive duration was a mean of 73 s. Therefore, based on these data, the correction factor applied to adjust relative estimates for availability bias would be approximately 0.440.

Species Identification

- 2.6.14 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.
- 2.6.15 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 Statistics

Survey Descriptions

3.1.1 A summary of survey coverage for each month of the DAS campaign (24 months) is presented in Table 3.1 and a summary of the survey dates and conditions during DAS flights, as reported by APEM, is given in Table 3.2.

Table 3.1: Monthly Survey Effort Across the DAS Area. Blue Shaded Rows are Surveys of the Extended DAS Area and therefore have Additional Survey Coverage with a Larger Survey Area Compared to the DAS Area

Survey No.	Survey month	Survey coverage ¹ (km ²)	Percentage of relevant DAS area ²
1	March 2022	345.94	17.37
2	April 2022	486.15	17.54
3	May 2022	484.40	17.48
4	June 2022	490.16	17.69
5	July 2022	482.03	17.40
6	August 2022	485.67	17.53
7	September 2022	345.22	17.33
8	October 2022	348.18	17.48
9	November 2022	339.99	17.07
10	December 2022	345.77	17.36
11	January 2023	335.86	16.86
12	February 2023	345.19	17.33
13	March 2023	346.58	17.40
14	April 2023	485.87	17.53
15	May 2023	484.54	17.49
16	June 2023	485.62	17.53
17	July 2023	481.27	17.37
18	August 2023	485.73	17.53
19	September 2023	351.91	17.67
20	October 2023	341.87	17.17
21	November 2023	327.39	16.44
22	December 2023	348.22	17.48
23	January 2024	343.21	17.23
24	February 2024	345.35	17.34
Overall total (All surveys)		9,662.11	n/a
Overall mean (DAS Area)		345.08	17.32
Overall mean (Extended DAS Area)		485.14	17.51

¹ Survey coverage is calculated from the area covered by all survey images within each survey flight, dissolved to remove overlap, and clipped to the DAS Area.

² Percentage coverage is calculated from the corresponding survey value used in estimating abundance and density (1,991.59 km² for the DAS Area and 2,770.91 km² for the Extended DAS Area) as discussed in Section 2.1.

Table 3.2: Survey Dates and Conditions during Surveys. Blue Shaded Rows are Surveys of the Extended DAS Area

Survey no.	Month	Date	No. survey flights	Cloud cover (%) ¹	Visibility (km)	Wind speed (kts)	Wind direction	Sea state ²	Turbidity ³
1	March 2022	02/04/2022	1	35	10+	6	N	1	1
2	April 2022	28/04/2022	2	0-100	30+	0-20	S, N	0	1
		29/04/2022	1	0	0	0	0	0	0
3	May 2022	02/06/2022	1	0	10+	1-8	All directions	1	0-1
4	June 2022	25/06/2022	1	15-35	10+	24-30	S	2	1
5	July 2022	07/07/2022	1	10-70	10+	7-28	SW, W	1-2	2
6	August 2022	01/08/2022	1	0-80	10+	14-26	SW	2-4	1
7	September 2022	21/09/2022	1	1-10	10	17-21	W	0-1	0
8	October 2022	25/10/2022	1	10-40	20+	10-22	W	3	2
9	November 2022	24/11/2022	2	40-80	10+	20-31	N	3-4	1
10	December 2022	22/12/2022	1	0-50, increasing	10+	14-22	S, W	1-2	0-1
11	January 2023	08/01/2023	1	20	10+	30	SSE	2	1
12	February 2023	23/02/2023	1	0-100, increasing	10+	19-23	NW, W	2	2
13	March 2023	10/03/2023	1	10	10	12-25	NW, N	2-3	2-3
14	April 2023	18/05/2023	1	70	10+	10	W	1	1
		19/05/2023	3	0-90	10+	3-8	W, variable	1-2	0-1
15	May 2023	27/05/2023	4	40-95	20	5-15	WNW	1-2	1-2
16	June 2023	12/06/2023	1	50-70	10+	1-17	SE, SW, N	0-1	0
17	July 2023	23/07/2023	1	10	10+	16-22	NE	1	1
18	August 2023	10/08/2023	2	80-90	10+	2-8	NW, E	0-1	0-1

Survey no.	Month	Date	No. survey flights	Cloud cover (%) ¹	Visibility (km)	Wind speed (kts)	Wind direction	Sea state ²	Turbidity ³
19	September 2023	13/09/2023	2	100	10+	2	SW	2	0
20	October 2023	01/10/2023	1	30-50	10+	26-36	WSW	1	0-1
21	November 2023	06/11/2023	1	50-75	10+	14	SW	3	1
22	December 2023	13/12/2023	1	40-50	10+	14	NE	1	1
23	January 2024	09/01/2024	1	70-100	10+	3-10	NE, ESE	0	0-1
24	February 2024	12/02/2024	1	10-70	8, 10+	24-26	WSW, W	2-3	3

¹ 0 = Clear; 1-10 = Few; 11-50 = Scattered; 51-95 = Broken; 96-100 = Overcast

² 0 = Calm (Glassy); 1 = Calm (Rippled); 2 = Smooth; 3 = Slight; 4 = Moderate

³ 0 = Clear; 1 = Slightly Turbid; 2 = Moderately Turbid; 3 = Highly Turbid

⁴ Three survey flights were postponed until the following month: the March 2022 survey was conducted on 2 April 2022, the May 2022 survey was conducted on 02 June 2022, and the April 2023 survey was conducted on 18 and 19 May 2023.

Confidence Assessment

- 3.1.2 Confidence in identification varied by species/species group across the Proposed Development DAS campaign (over both DAS Area and Extended DAS Area). Where possible, high-confidence sightings were identified to species level, and where this was not possible, they were assigned to higher-level taxonomic categories such as ‘seal species’ or ‘dolphin/porpoise’. In cases where animals could not be assigned to a higher taxonomic level, but were clearly marine mammals, they were assigned simply as ‘marine mammal species’.
- 3.1.3 Figure 3.1 illustrates the proportion of animals identified to species level, non-species level, and ‘marine mammal species’, and Figure 3.2 illustrates the proportion of cetaceans and pinnipeds identified to species and non-species level. Overall, 3,103 animals were able to be identified to species level, 367 animals were identified to a higher taxonomic category (e.g. ‘seal species’), and 41 animals could only be confidently categorised as ‘marine mammal’.

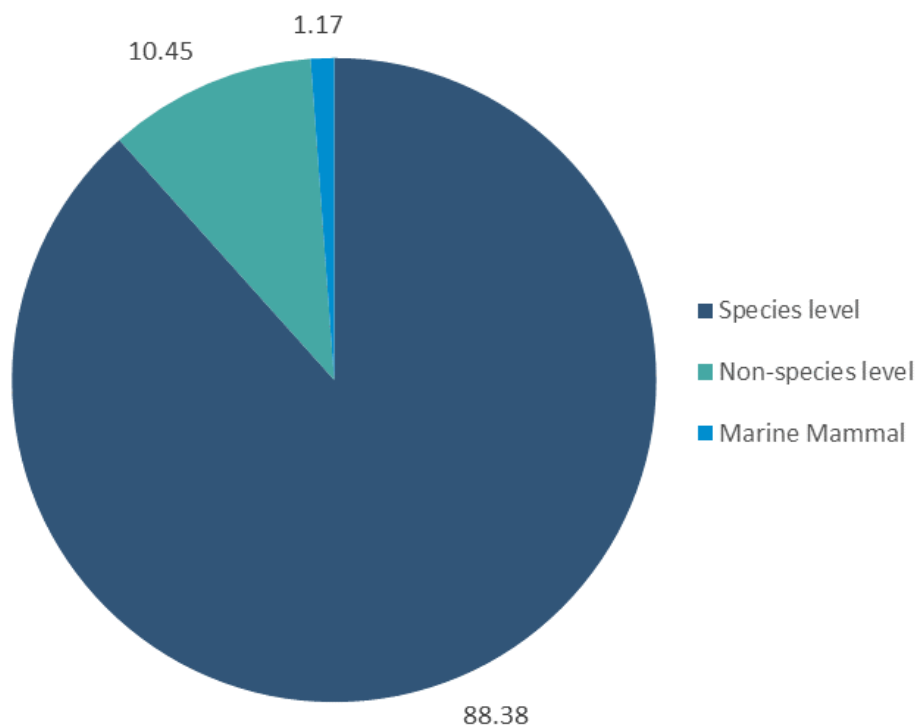


Figure 3.1: Proportion of Animals Observed During the Proposed Development DAS Campaign and Identified at Species and Higher Taxonomic Levels. Numbers Indicate Percentage

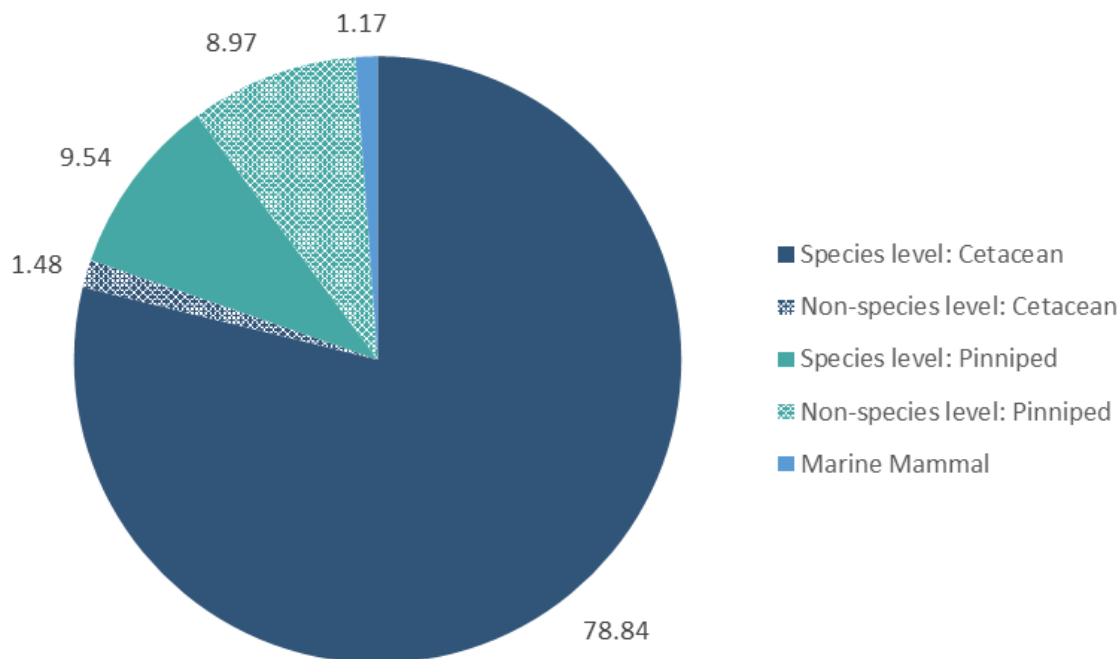


Figure 3.2: Proportion of Animals Observed During the Proposed Development DAS Campaign and Identified at Species and Higher Taxonomic Levels, Split Between Cetaceans and Pinnipeds. Numbers Indicate Percentage

3.1.4 For cetaceans, a total of 2,768 animals were identified to species level, whilst a further 52 were labelled as either ‘dolphin/porpoise’ or ‘whale species’ (i.e. could not be assigned to a Family). A total of 332 animals were identified as grey seal and three animals identified as harbour seal, whilst a further 315 animals could not be assigned to either grey seal or harbour seal and were instead identified as ‘seal species’. One animal which was identified as ‘seal species’ was deceased, which may have made identification difficult if it was in a state of decay. Finally, a total of 41 animals could not be assigned as either cetacean or seal and were instead assigned the label ‘marine mammal species’.

Species Counts

3.1.5 Across the entire 24-month DAS campaign a total of 3,511 marine mammals were observed, with animals identified into seven species (Table 3.3).

3.1.6 Harbour porpoise accounted for the highest number of sightings identified to species level (based on raw count data) (n = 2,412) and was recorded in all survey months (Table 3.3). Sightings of harbour porpoise peaked significantly in April 2023 when 540 were identified (noting this was during surveys of the Extended DAS Area).

3.1.7 Grey seal accounted for the second highest number of sightings identified to species level (n = 332) and was identified in 23 surveys, with a total raw count of 332 animals recorded. In comparison, harbour seal was only recorded in two surveys (March and June 2022), with a total of three harbour seal sighted.

- 3.1.8 White-beaked dolphin accounted for the third highest number of sightings identified to species level (n = 291) and was recorded in ten months over the 24-month DAS campaign, with a peak of 112 animals in August 2022 (noting this was during surveys of the Extended DAS Area).
- 3.1.9 Other sightings identified to species level included Risso's dolphin, bottlenose dolphin and minke whale. Risso's dolphin was sighted in five survey months, with a total of 11 Risso's dolphin recorded. Bottlenose dolphin was sighted in two survey months, with a total of 12 individuals. Minke whale was sighted in 12 survey months, with a total of 42 sightings (18 in August 2022) (Table 3.3). 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. The number of observations for Risso's dolphin, bottlenose dolphin and minke whale was too low for model-based density estimates to be calculated.
- 3.1.10 No humpback whale *Megaptera novaeangliae* or orca (killer whale) *Orcinus orca* were observed during any surveys.
- 3.1.11 In addition, there were a number of sightings of cetaceans (n = 52) that could not be assigned to species level. Similarly, sightings classified as 'Seal species' (n = 316) occurred in 20 months, due to the difficulty of identifying phocids to species level from aerial survey data, and 41 animals were identified in 15 months simply as 'Marine Mammal species'.

Table 3.3: Monthly Raw Sightings Data (Number of Animals) (Uncorrected for Effort). Blue Shaded Rows are Surveys of the Extended DAS Area

Month	Harbour porpoise	White-beaked dolphin	Common minke whale	Bottlenose dolphin	Risso's dolphin	Grey seal	Harbour seal	Dolphin/porpoise	Whale species	Seal species	Marine Mammal species	Total
March 2022	269		1			18	2	1		8	2	301
April 2022	117		4	6		13		3		20	5	168
May 2022	290		1			140		12	1	101	6	551
June 2022	64	1	2			11	1	2		10	3	94
July 2022	61	10	1			17		2		68		159
August 2022	37	112	18			2		6		29		204
September 2022	50	6	1			2				4	4	67
October 2022	103				4	6		2		3		118
November 2022	43					1		7		3	1	55
December 2022	8				3	7					2	20
January 2023	4				1							5
February 2023	41					10				2	1	54
March 2023	50	5				4		8		4	4	75
April 2023	540		5			31				10	4	590
May 2023	104		2			10				24		140
June 2023	49	29	3			9				3	1	94

Month	Harbour porpoise	White-beaked dolphin	Common minke whale	Bottlenose dolphin	Risso's dolphin	Grey seal	Harbour seal	Dolphin/porpoise	Whale species	Seal species	Marine Mammal species	Total
July 2023	20	12		6		4				3	2	47
August 2023	157	48	2		1	16						224
September 2023	253	63	2			8		6		6	2	340
October 2023	64					9				2		75
November 2023	32				2	5				5		44
December 2023	6	5				1					2	14
January 2024	27					5		2		4		38
February 2024	23					3				6	2	34
Total	2,412	291	42	12	11	332	3	51	1	315	41	3,511

3.1.12 Seasonal marine mammal sightings across the DAS Area are summarised in Table 3.4, and seasonal percentages are illustrated in Figure 3.3. There is no equivalent for the Extended DAS Area as seasonal coverage is not complete, and it would therefore not represent seasons correctly.

Table 3.4: Seasonal Raw Sightings Data (Number of Animals, Not Corrected for Effort) Across the Proposed Development DAS Campaign

Species	Autumn	Spring	Summer	Winter	Total
Harbour porpoise	545	1,370	388	109	2,412
Minke whale	3	13	26	-	42
White-beaked dolphin	69	5	212	5	291
Risso's dolphin	6	-	1	4	11
Bottlenose dolphin	-	6	6	-	12
Grey seal	31	216	59	26	332
Harbour Seal	-	2	1	-	3
Seal species	23	167	113	12	315
Whale species	-	1	-	-	1
Dolphin/Porpoise	15	24	10	2	51
Marine Mammal species	7	21	6	7	41
Total	699	1,825	822	165	3,511

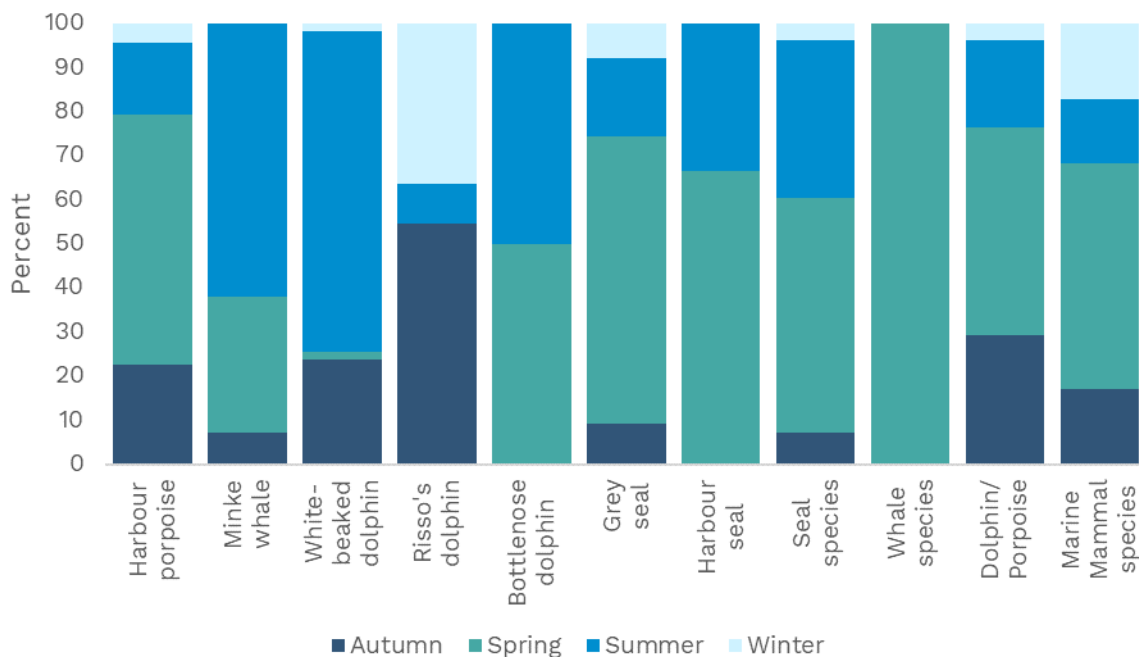


Figure 3.3: Seasonal Percentage of Marine Mammal Sightings in the DAS Area

Surfacing Categories

- 3.1.13 There were no clear temporal patterns in surfacing behaviour across the 24 months of DAS data (Figure 3.4). December 2022 showed the highest percentage of surfacing behaviour and was the only month in which observations of surfacing individuals outnumbered observations of submerged individuals, when 20 marine mammals were observed, of which 12 were surfacing and eight were submerged.
- 3.1.14 May 2022, July 2022, August 2022 and May 2023 were the only surveys during which animals were observed to be hauled out, all of which coincided with DAS flights incorporating the Extended DAS Area. One deceased ‘seal species’ was observed, in-water, in September 2023.

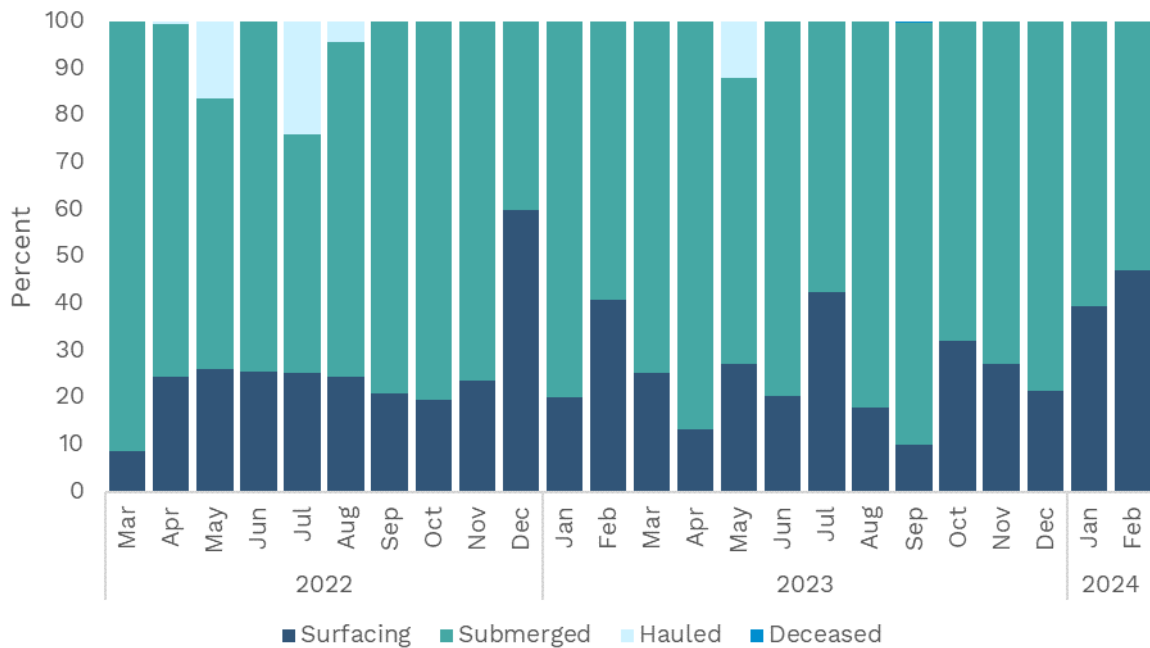


Figure 3.4: Summary of Surfacing Categories by Month, Combined Across All Species

- 3.1.15 Figure 3.5 presents a summary of surfacing categories for all marine mammals, combined across months. At a species level, 84% of harbour porpoise were submerged and 16% surfacing. This was similar for minke whale (submerged 85%, surfacing 14%) and white-beaked dolphin (submerged 88%, surfacing 12%). Risso’s dolphin and bottlenose dolphin were similar, with 64% and 67% submerged respectively. Grey seal was recorded as 35% surfacing, 36% submerged and 29% hauled out, whilst harbour seal was 100% submerged.

3.1.16 'Seal species' represents the greatest proportion of surfacing animals, with 54% of individuals (n = 170) identified at the surface. This pattern supports the observation discussed in Paragraph 3.1.11 that phocids may have been more difficult to identify to species level from DAS images, since submerged animals appear to have been less frequently identified to species level. Animals observed out of the water were not always identifiable to species level and were categorised as 'Seal species' (n = 59). The one deceased marine mammal observed was also identified as 'Seal species'.

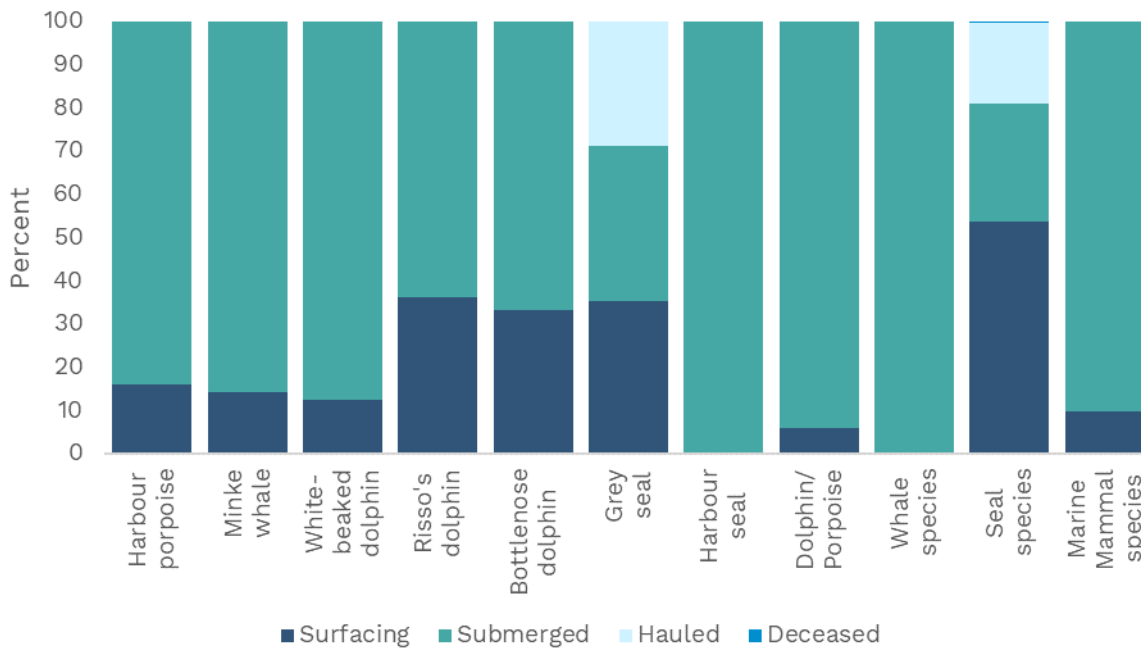


Figure 3.5: Summary of Surfacing Categories by Species, Combined Across All Survey Months

Distribution of Sightings

3.1.17 Sightings of marine mammals were distributed throughout the DAS Area and the Extended DAS Area, with no clear spatial or temporal patterns. Figure 3.6 illustrates the monthly distribution of harbour porpoise sightings, Figure 3.7 illustrates the monthly distribution of grey seal sightings, Figure 3.8 illustrates the distribution of small cetacean sightings (odontocetes), excluding harbour porpoise, Figure 3.9 illustrates the distribution of large cetacean sightings (minke whale), and Figure 3.10 illustrates the distribution of unidentified marine mammal species within the DAS Area and Extended DAS Area.

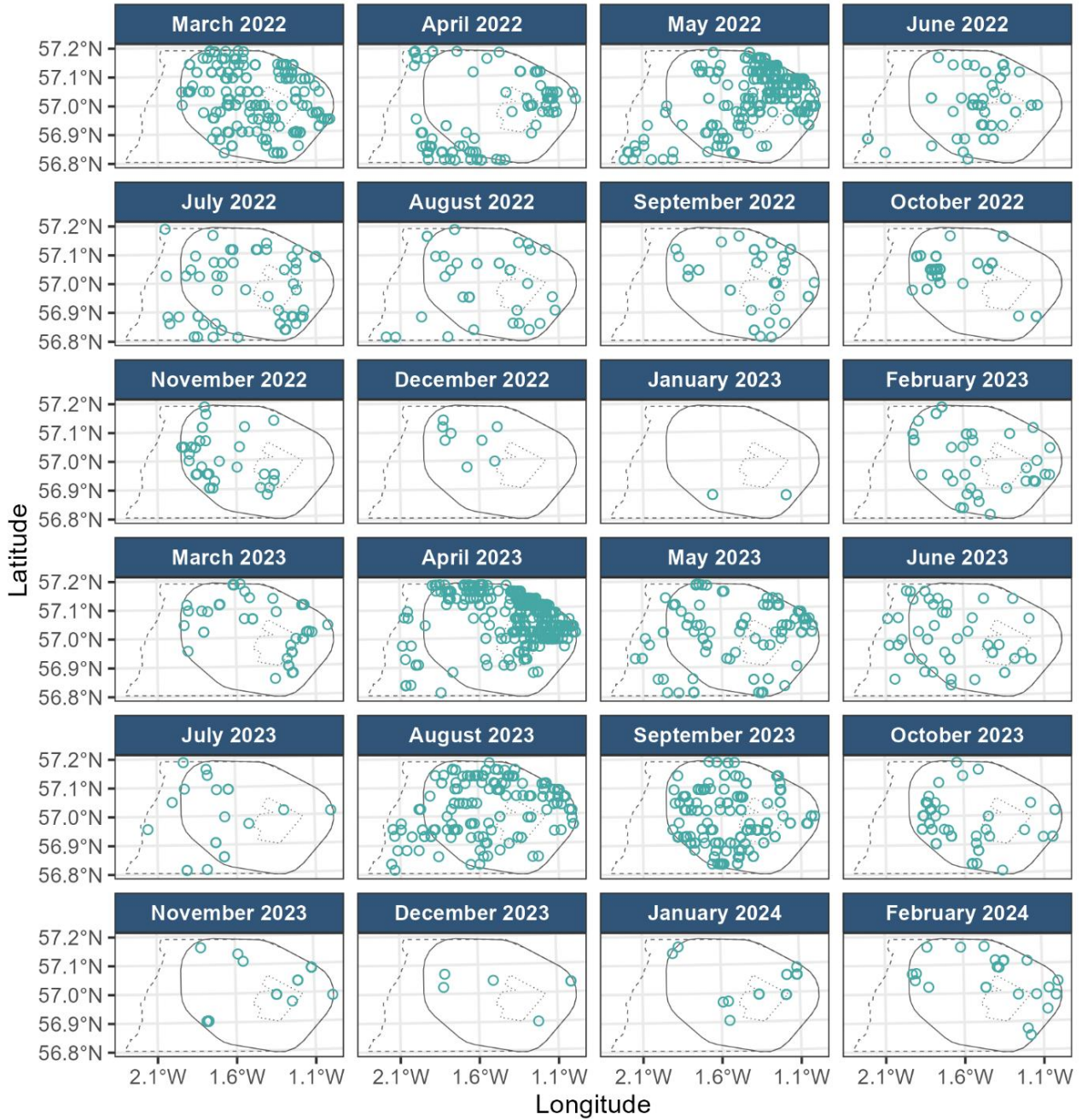


Figure 3.6: Monthly Distribution of Harbour Porpoise Sightings Across the DAS Area (solid outline). Dotted Line Indicates Array Area, Dashed Line Indicates Extended DAS Area

Seal species ● Grey Seal ○ Harbour Seal

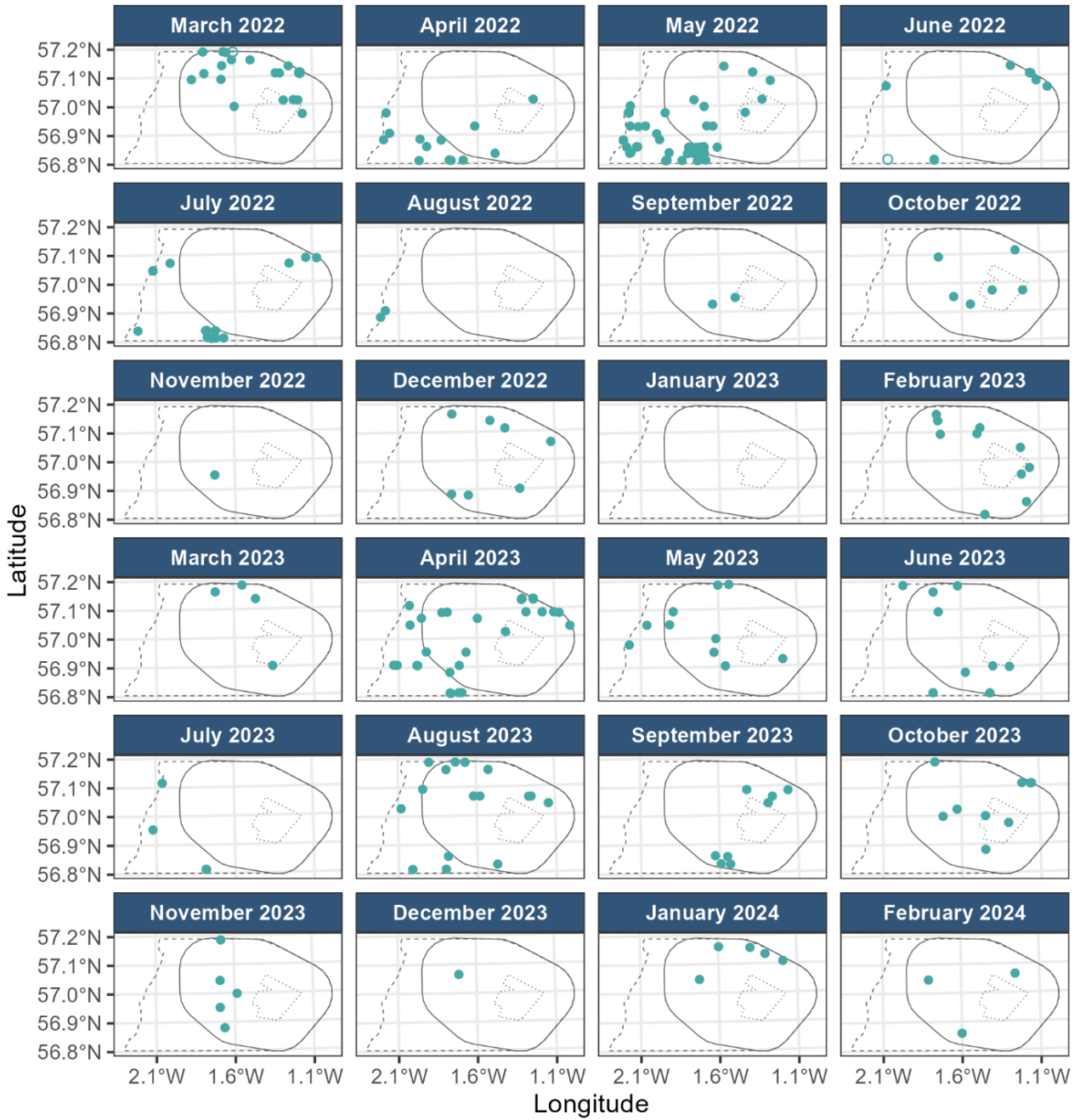


Figure 3.7: Monthly Distribution of Grey Seal and Harbour Seal Sightings Across the DAS Area (solid outline). Dotted Line Indicates Array Area, Dashed Line Indicates Extended DAS Area

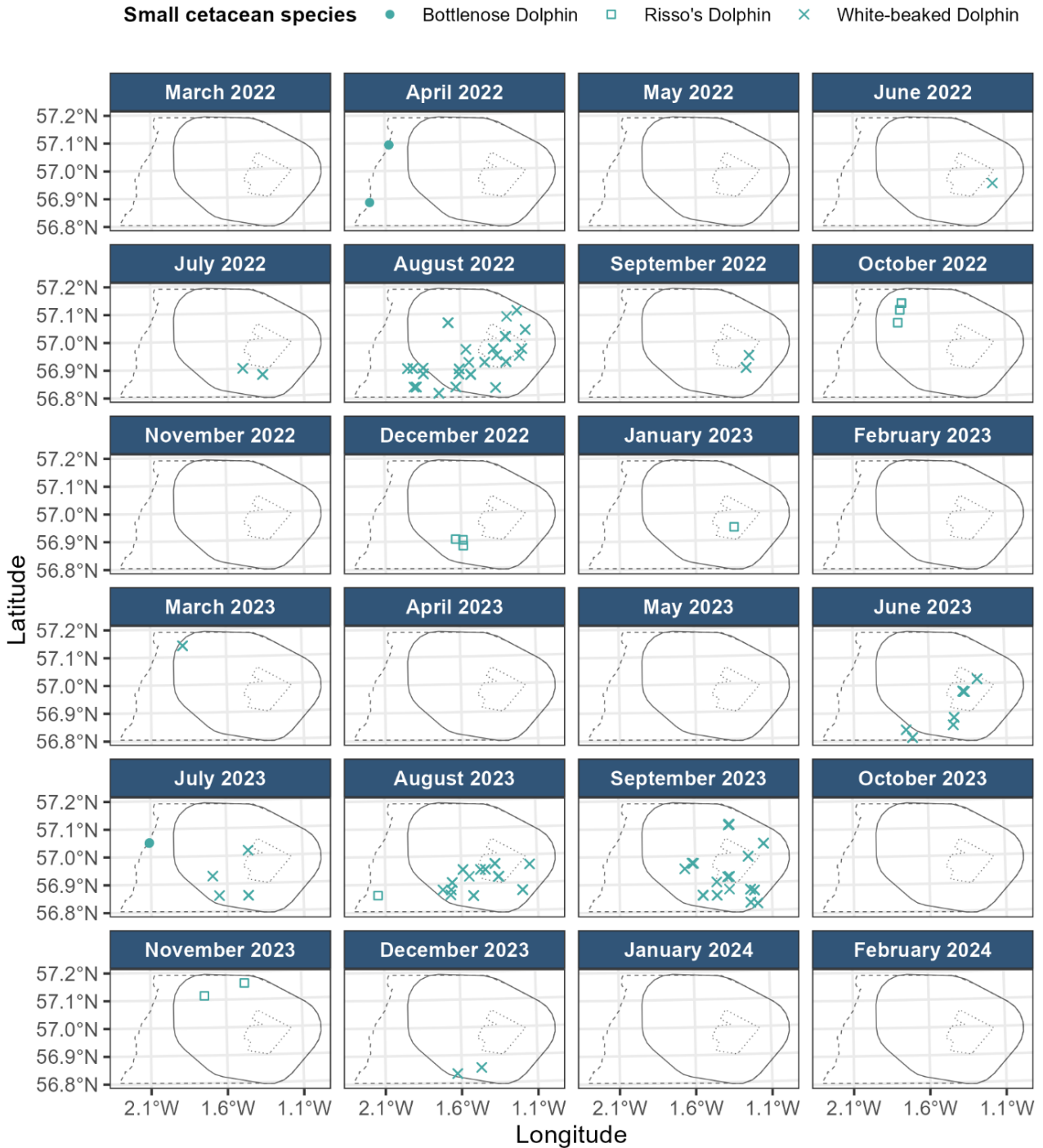


Figure 3.8: Monthly distribution of Small Cetacean Species (Excluding Harbour Porpoise) Sightings Across the DAS Area (solid outline). Dotted Line Indicates Array Area, Dashed Line Indicates Extended DAS Area

Large cetacean species ● Common Minke Whale

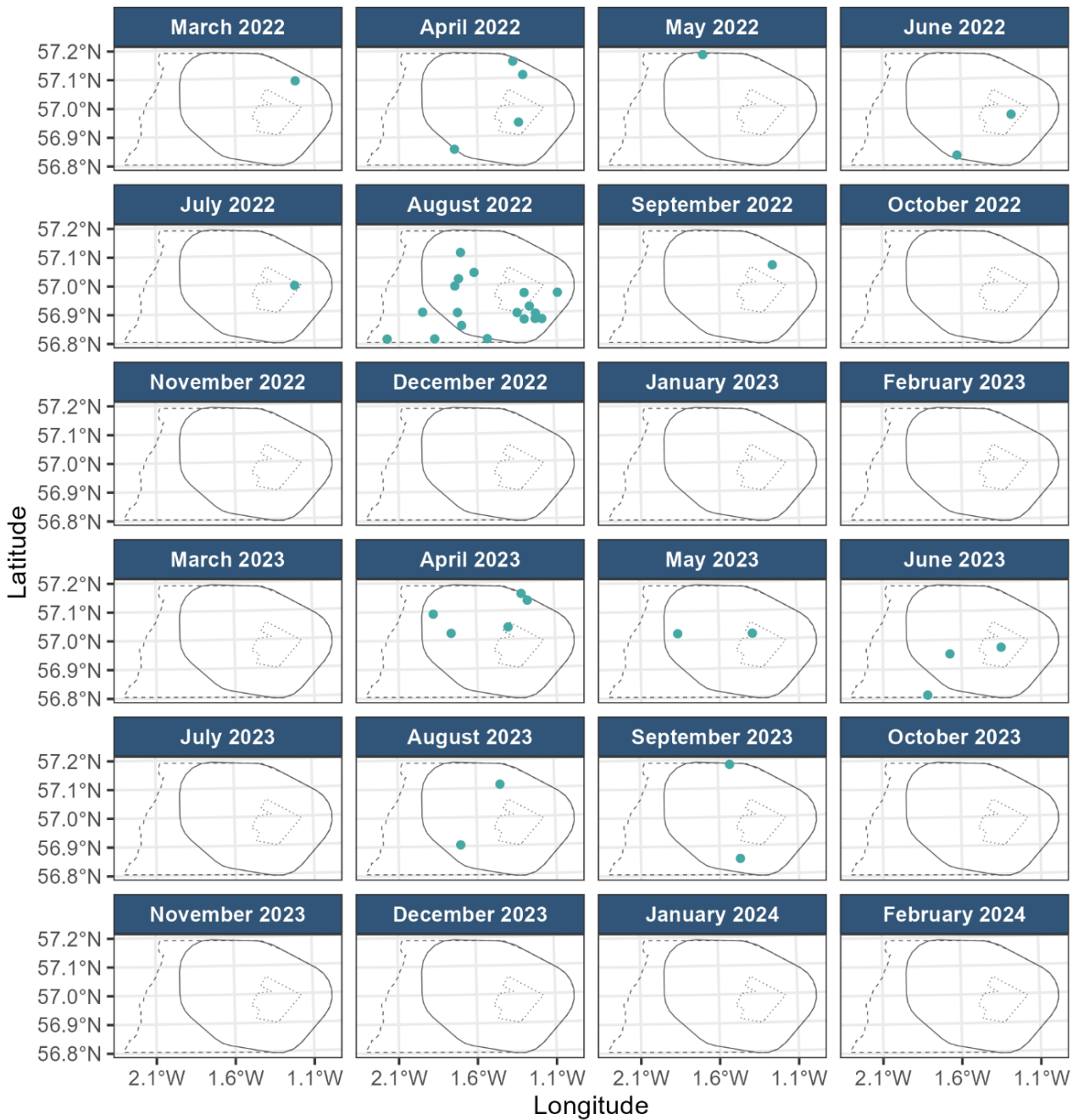


Figure 3.9: Monthly Distribution of Large Cetacean Species Sightings Across the DAS Area (solid outline). Dotted Line Indicates Array Area, Dashed Line Indicates Extended DAS Area

**Unidentified
 marine mammals**

- Dolphin/Porpoise
- Marine mammal species
- × Seal species
- △ Whale species

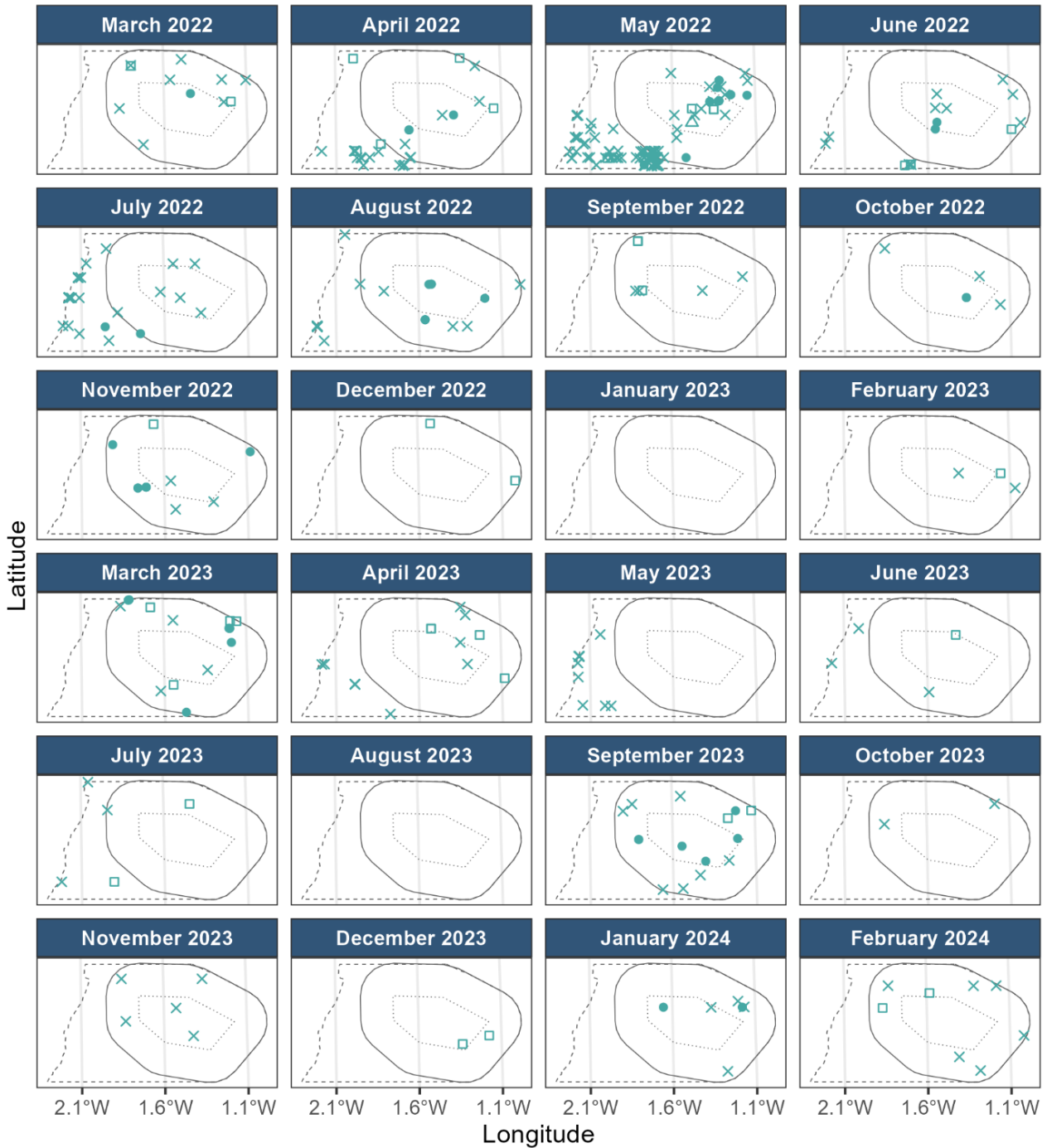


Figure 3.10: Monthly Distribution of Unidentified Marine Mammal Species Sightings Across the DAS Area (solid outline). Dotted Line Indicates Array Area, Dashed Line Indicates Extended DAS Area

Group Size

- 3.1.18 Group size was calculated using survey 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), and no distinction between groups observed within the DAS Area and Extended DAS Area has been made. Note that 95% CIs could not be calculated in cases where only one group, or no groups, of a species were observed. Species that were not observed in groups across all surveys have been omitted from these tables for clarity (Risso's dolphin, minke whale and harbour seal).
- 3.1.19 Group size varied by species and across the months. The largest group sizes were recorded for grey seal (max = 80) with an overall average group size of 12 animals (95% CI ± 16.75) across all grey seal sightings over the 24-month DAS campaign. For harbour porpoise and white-beaked dolphin, the maximum group size was ten animals with an overall average group size of 2.74 animals for harbour porpoise (95% CI ± 0.13) and 3.6 animals for white-beaked dolphin (95% CI ± 0.42).

Table 3.5: Monthly Mean and Maximum Group Sizes for Species Sightings Across the DAS Area and Extended DAS Area. Species Observed Only as Single Animals Have Been Omitted

Month	Harbour porpoise			White-beaked dolphin			Bottlenose dolphin			Grey seal		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
January	2.50	2.00	4.00	-	-	-	-	-	-	-	-	-
February	2.40	2.00	4.00	-	-	-	-	-	-	-	-	-
March	3.16	2.00	8.00	5.00	5.00	5.00	-	-	-	-	-	-
April	2.46	2.00	6.00	-	-	-	3.00	2.00	4.00	2.00	2.00	2.00
May	2.36	2.00	5.00	-	-	-	-	-	-	16.50	2.00	80.00
June	2.24	2.00	4.00	3.63	2.00	6.00	-	-	-	2.00	2.00	2.00
July	2.08	2.00	3.00	3.67	2.00	7.00	3.00	2.00	4.00	5.00	5.00	5.00
August	2.06	2.00	3.00	3.83	2.00	9.00	-	-	-	-	-	-
September	3.41	2.00	8.00	3.21	2.00	10.00	-	-	-	-	-	-
October	4.04	2.00	10.00	-	-	-	-	-	-	-	-	-
November	3.75	2.00	10.00	-	-	-	-	-	-	-	-	-
December	2.00	2.00	2.00	2.50	2.00	3.00	-	-	-	-	-	-
Overall mean	2.74	2.00	5.58	3.61	2.50	6.67	3.00	2.00	4.00	12.00	2.75	22.25
95% CI [±]	0.13	0.00	0.26	0.42	0.36	0.91	1.13	0.76	1.53	16.75	1.02	14.97

3.2 Density Estimates

Harbour Porpoise

Design-Based Analysis

- 3.2.1 Raw counts of harbour porpoise (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 DAS campaign.
- 3.2.2 Relative estimates were then adjusted for availability bias with a correction factor of 0.425 (see Paragraph 2.6.7) to provide estimates of absolute abundance and density, with 95% CLs obtained via bootstrapping (1,000 simulations) (Wessa, 2019). The simulated mean absolute densities resulting from the bootstrapping process for the DAS Area is presented in Figure 3.11 and for the Extended DAS Area in Figure 3.12.

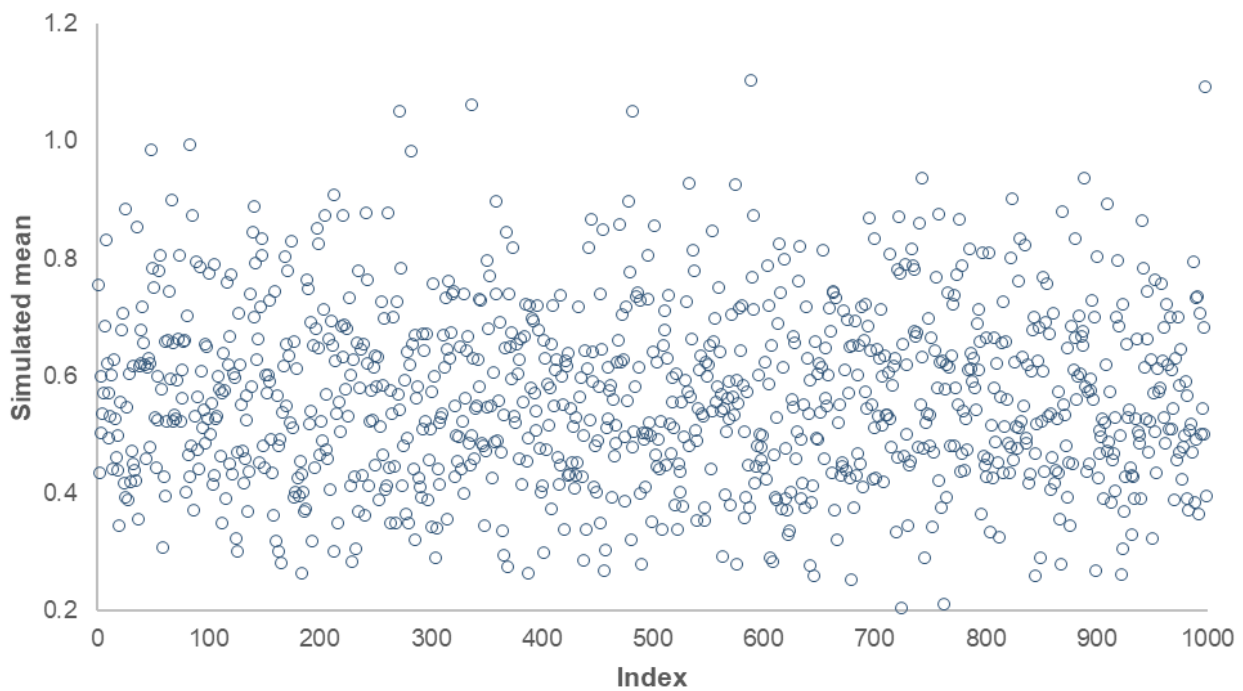


Figure 3.11: Bootstrapped Simulation (n = 1,000) of Mean Monthly Absolute Density for Harbour Porpoise Across the DAS Area

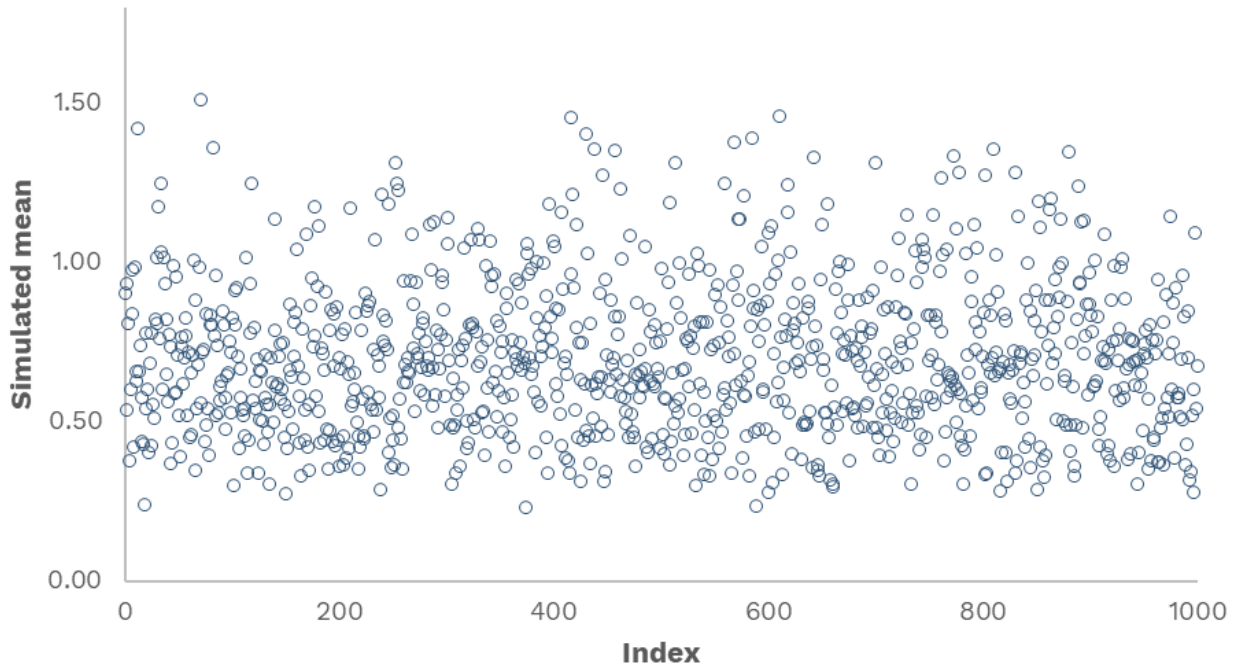


Figure 3.12: Bootstrapped Simulation (n = 1,000) of Mean Monthly Absolute Density for Harbour Porpoise Across the Extended DAS Area

DAS Area

- 3.2.3 Estimated absolute density of harbour porpoise (corrected for availability bias, see Paragraph 2.6.7) for each survey over the DAS Area only (24-month survey campaign) are presented in Figure 3.13 with bootstrapped 95% CI. A peak in estimated absolute density was observed in April 2023, with a maximal absolute density of 3.544 animals/km² (95% CLs = 1.906, 5.550). 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 = 0.028, 3.544; CV = 1.290), monthly trends are not always easy to interpret visually on a linear scale due to the large variation in values (Figure 3.13).
- 3.2.4 Data were therefore also plotted on a log₁₀ scale (Figure 3.14), where monthly variation is more apparent. Here, densities are variable across the DAS campaign period, displaying no clear seasonal pattern, with a peak in April 2023 and smaller peaks in March 2022, May 2022 and September 2023 (as seen on the linear scale in Figure 3.13), and a minimal density of 0.028 animals/km² (95% CLs = 0.015, 0.044) during January 2023.

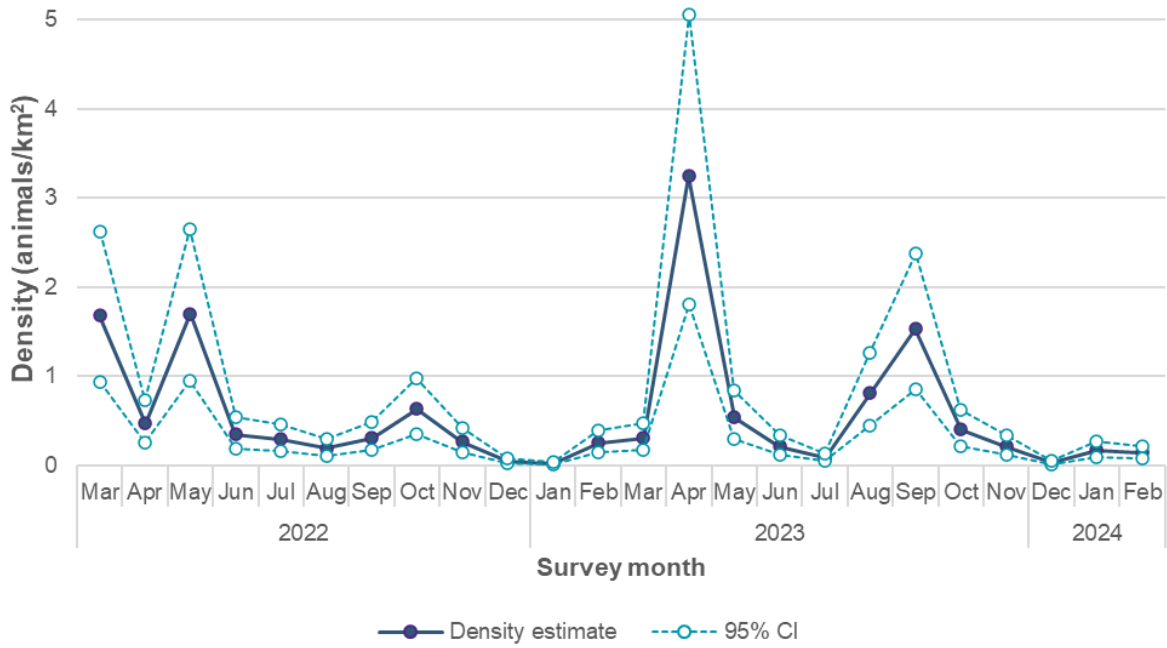


Figure 3.13: Estimated Absolute Density of Harbour Porpoise (Corrected For Availability Bias) for Each Survey over the DAS Area, with Bootstrapped 95% CI

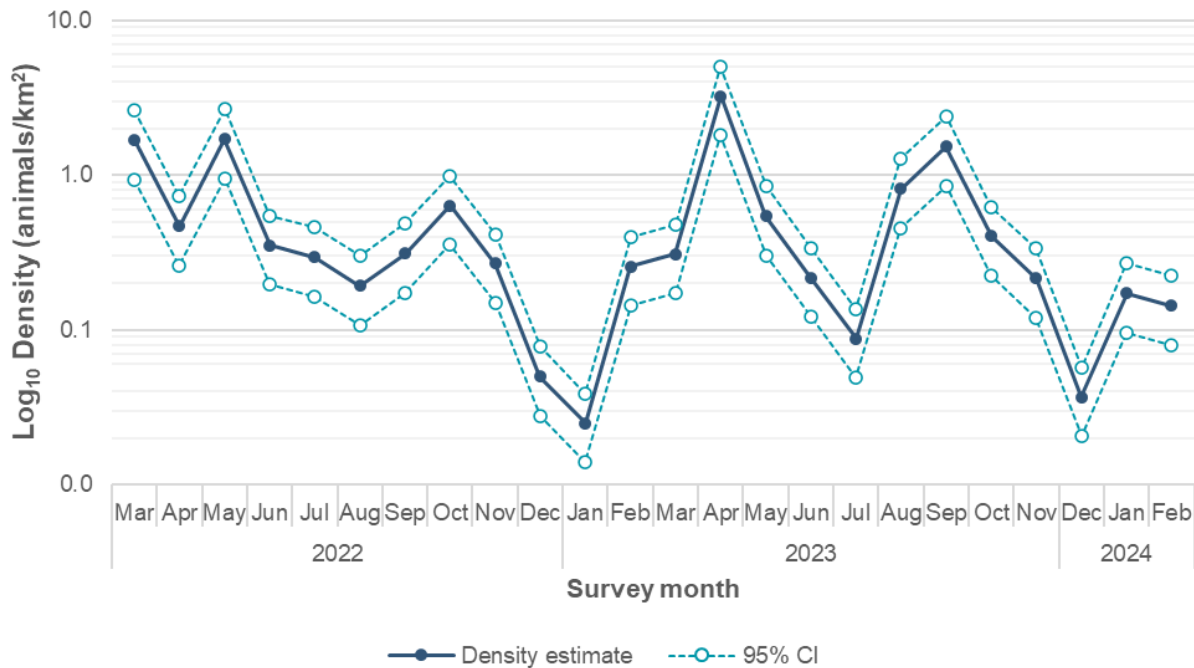


Figure 3.14: Estimated Absolute Density of Harbour Porpoise (Corrected For Availability Bias) for Each Survey Over the DAS Area, With Bootstrapped 95% CI, Presented on a log₁₀ Scale

- 3.2.5 The overall mean absolute density of harbour porpoise for the DAS Area, estimated from data pooled across all transects and all months for the 24-month DAS campaign (Table 3.6), was 0.635 animals/km² (95% CLs = 0.361, 1.039, CV = 1.290).
- 3.2.6 The maximal mean absolute density estimates for respective temporal divisions were:
- monthly: 2.029 animals/km² (95% CLs = 1.151, 3.317; CV = 1.056) (April);
 - seasonal: 1.444 animals/km² (95% CLs = 0.820, 2.361 CV = 0.850) (Spring);
and
 - bio-season: 0.889 animals/km² (95% CLs = 0.505, 1.454, CV = 1.118) ('summer').

Table 3.6: Design-Based Estimates for Mean Relative and Absolute Abundance and Density of Harbour Porpoise for the DAS Area (24 months of survey), Across Monthly, Seasonal, Bio-Season, and Annual Scales

Temporal scale	Relative estimates		Absolute estimates				
	Mean abundance	Mean density (animals/km ²)	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Month							
January	91	0.045	213	0.107	0.057	0.174	1.042
February	185	0.093	435	0.218	0.124	0.356	0.398
March	918	0.461	2,160	1.085	0.615	1.773	0.972
April	1,718	0.862	4,041	2.029	1.151	3.317	1.056
May	1,033	0.518	2,429	1.219	0.692	1.993	0.729
June	265	0.133	623	0.312	0.177	0.511	0.340
July	177	0.089	416	0.209	0.118	0.341	0.764
August	467	0.234	1,097	0.551	0.312	0.900	0.877
September	861	0.432	2,024	1.016	0.577	1.661	0.940
October	481	0.242	1,132	0.568	0.322	0.929	0.318
November	224	0.112	526	0.264	0.150	0.431	0.181
December	41	0.020	95	0.047	0.027	0.078	0.207
Meteorological season							
Winter	105	0.053	248	0.124	0.070	0.203	0.806
Spring	1,223	0.614	2,877	1.444	0.820	2.361	0.850
Summer	303	0.152	712	0.357	0.203	0.584	0.785
Autumn	522	0.262	1,227	0.616	0.350	1.007	0.895
Bio-season							
Winter	323	0.162	760	0.381	0.216	0.624	1.310
Summer	753	0.378	1,772	0.889	0.505	1.454	1.118

Temporal scale	Relative estimates		Absolute estimates				
	Mean abundance	Mean density (animals/km ²)	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Annual							
Year 1	481	0.241	1,130	0.567	0.305	0.888	0.589
Year 2	596	0.299	1,402	0.704	0.379	1.102	0.768
Overall	538	0.270	1,266	0.635	0.361	1.039	1.290

Extended DAS Area

- 3.2.7 Estimated absolute density of harbour porpoise (corrected for availability bias, see Paragraph 2.6.7) for each survey over the Extended DAS Area (i.e. April to August in 2022/2023) are presented in Figure 3.15 with bootstrapped 95% CI. The Extended DAS Area was surveyed only in April to August each year and therefore does not demonstrate seasonality.
- 3.2.8 A peak in estimated absolute density for the Extended DAS Area was observed in April 2023, with a maximal absolute density of 2.615 animals/km² (95% CLs = 1.239, 4.488). 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 = 0.098, 2.615 ; CV = 1.110), monthly trends are not always easy to interpret visually on a linear scale due to the large variation in values (Figure 3.15).
- 3.2.9 Data were therefore also plotted on a log₁₀ scale (Figure 3.16), where monthly variation is more apparent, however noting the Extended DAS Area was surveyed only in April to August each year and therefore does not demonstrate seasonality.

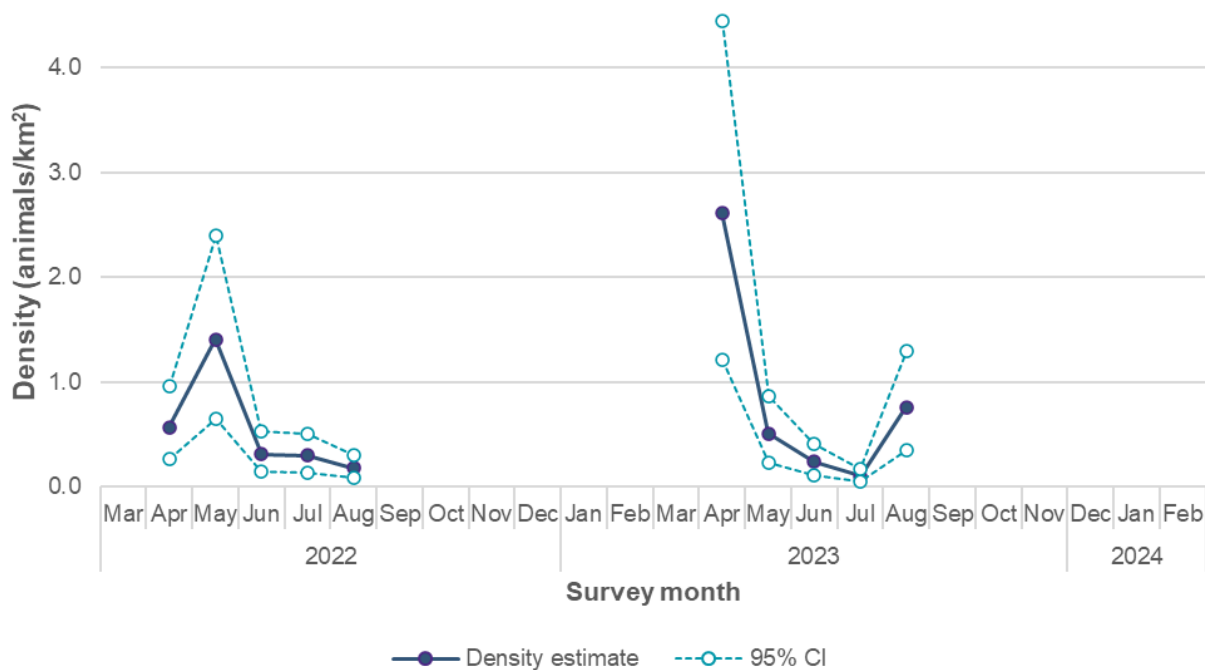


Figure 3.15: Estimated Absolute Density of Harbour Porpoise (Corrected for Availability Bias) for Each Survey Over the Extended DAS Area, with Bootstrapped 95% CI

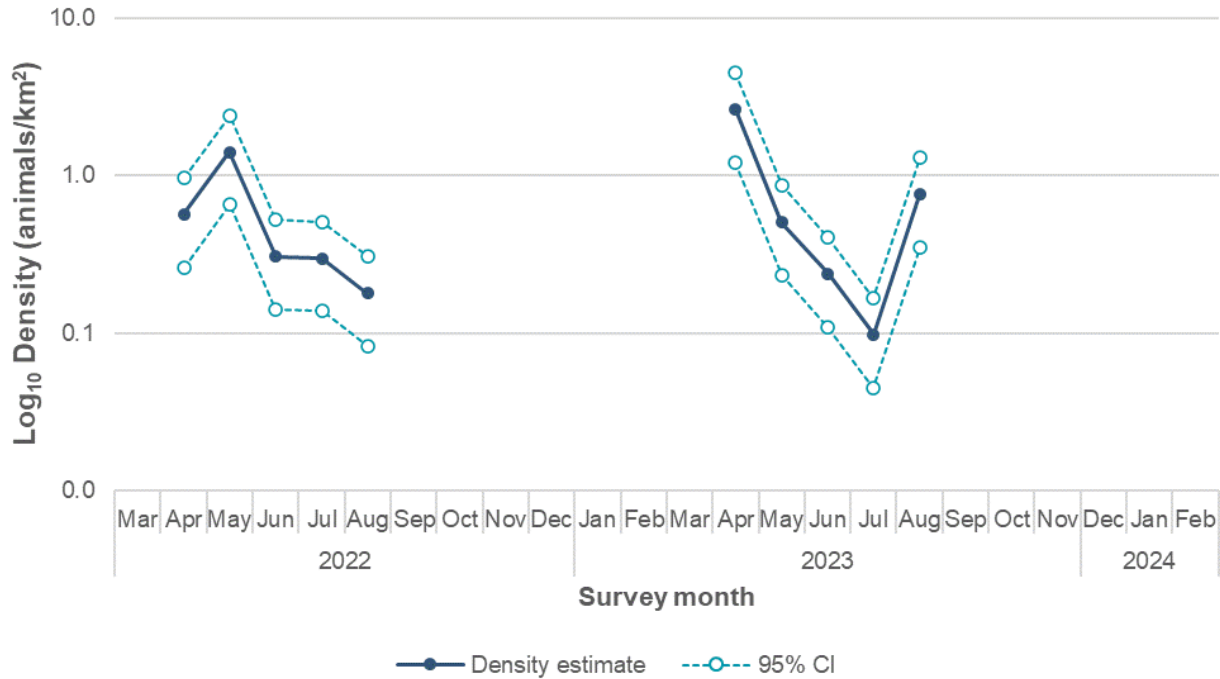


Figure 3.16: Estimated Absolute Density of Harbour Porpoise (Corrected for Availability Bias) for Each Survey Over the Extended DAS Area, With Bootstrapped 95% CI, Presented on a log₁₀ Scale

3.2.10 The overall mean absolute density of harbour porpoise for the Extended DAS Area, estimated from data pooled across all transects and all months for the Extended DAS Area (Table 3.7), was 0.698 animals/km² (95% CLs = 0.336, 1.182, CV = 1.110).

3.2.11 The maximal mean absolute density estimates for respective temporal divisions were:

- monthly: 1.591 animals/km² (95% CLs = 0.767, 2.695, CV = 0.911) (April); and
- yearly: 0.843 animals/km² (95% CLs = 0.399, 1.447, CV = 0.575) ('Year 2').

Table 3.7: Design-Based Estimates for Mean Relative and Absolute Abundance and Density of Harbour Porpoise for the Extended DAS Area, Across Monthly and Annual Scales

Temporal scale	Relative estimates		Absolute estimates				
	Mean abundance	Mean density (animals/km ²)	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Month							
January	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-
April	1,874	0.676	4,408	1.591	0.767	2.695	0.911
May	1,127	0.407	2,652	0.957	0.461	1.621	0.668
June	321	0.116	755	0.272	0.131	0.461	0.181
July	233	0.084	549	0.198	0.095	0.335	0.715
August	554	0.200	1,303	0.470	0.227	0.796	0.875
September	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-
Annual							
Year 1	650	0.235	1,530	0.552	0.261	0.947	0.429
Year 2	993	0.358	2,337	0.843	0.399	1.447	0.575
Overall	822	0.296	1,933	0.698	0.336	1.182	1.110

Model-Based Analysis

- 3.2.12 Harbour porpoises were present in sufficient numbers for modelling when considered across the whole 24-month DAS period (using the DAS Area only) and when pooled by bio-season and meteorological season. Model-based analysis was not carried out for the Extended DAS Area. When considered at a monthly scale (i.e. the period between surveys), harbour porpoise did not occur in sufficiently consistent numbers for modelling to be possible.
- 3.2.13 The MRSea models included only distance from coast as an explanatory environmental variable. However, all models fitted the data poorly, as indicated by the low values for concordance correlation and marginal r^2 , summarised in Table 3.8.
- 3.2.14 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 3.8: Metrics of Model Fit for MRSea Models Fitted to Harbour Porpoise Observation Data Across Meteorological Season, Bio-Season and Across the 24 Months of DAS Data

Model	Concordance correlation	Marginal r-squared
Meteorological season	0.0814	0.0489
Bio-season	0.0284	0.0184
Overall DAS campaign	0.0291	0.0176

- 3.2.15 Despite the poor fit of all models, the predictions (Table 3.9) from the model which included all observations across the 24-month DAS campaign corresponded well with absolute densities estimated from the design-based analysis (Table 3.6) (e.g. 0.580 animals per km² from the model-based density compared to 0.582 animals per km² from the absolute design-based density). The results of models pooled across bio-season and meteorological season did not correspond well with the estimates derived from design-based methods.
- 3.2.16 Modelled abundance varied across meteorological seasons and bio-seasons, with higher densities in the DAS Area predicted during the meteorological autumn (September to November, inclusive) and the ‘summer’ bio-season (April to September, inclusive) (Table 3.9). Whilst this aligns with temporal trends observed in the design-based analysis for bio-seasons, the predicted autumn peak from the model-based analysis does not align with the peak during meteorological spring from the design-based analysis (Table 3.6).

Table 3.9: Modelled Absolute Abundance and Density Of Harbour Porpoise for Meteorological Seasons, Bio-Seasons and Across the 24-Month DAS Data Collection Period for the DAS Area

Temporal scale	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Meteorological season					
Winter	533	0.268	0.130	0.491	0.538
Spring	3,457	1.740	1.160	2.510	
Summer	569	0.285	0.200	0.392	
Autumn	4,405	2.210	1.360	3.400	
Bio-season					
‘Winter’ bio-season	1,121	0.562	0.415	0.737	0.801
‘Summer’ bio-season	2,639	1.320	1.000	1.740	
Year					
Overall DAS campaign	1,156	0.580	0.365	0.856	0.724

3.2.17 The results of the models incorporating data pooled by meteorological season and bio-season, and across the whole DAS Area, are visualised in Figure 3.17, Figure 3.18 and Figure 3.19, respectively. The distribution of observations (represented by black circles) corresponds poorly with the distribution of harbour porpoise density (represented by the heatmap). In particular, areas and times of the year in which more animals were observed (represented by clustering of black circles) do not correspond with predictions of higher density, highlighting the low predictive power of these models.

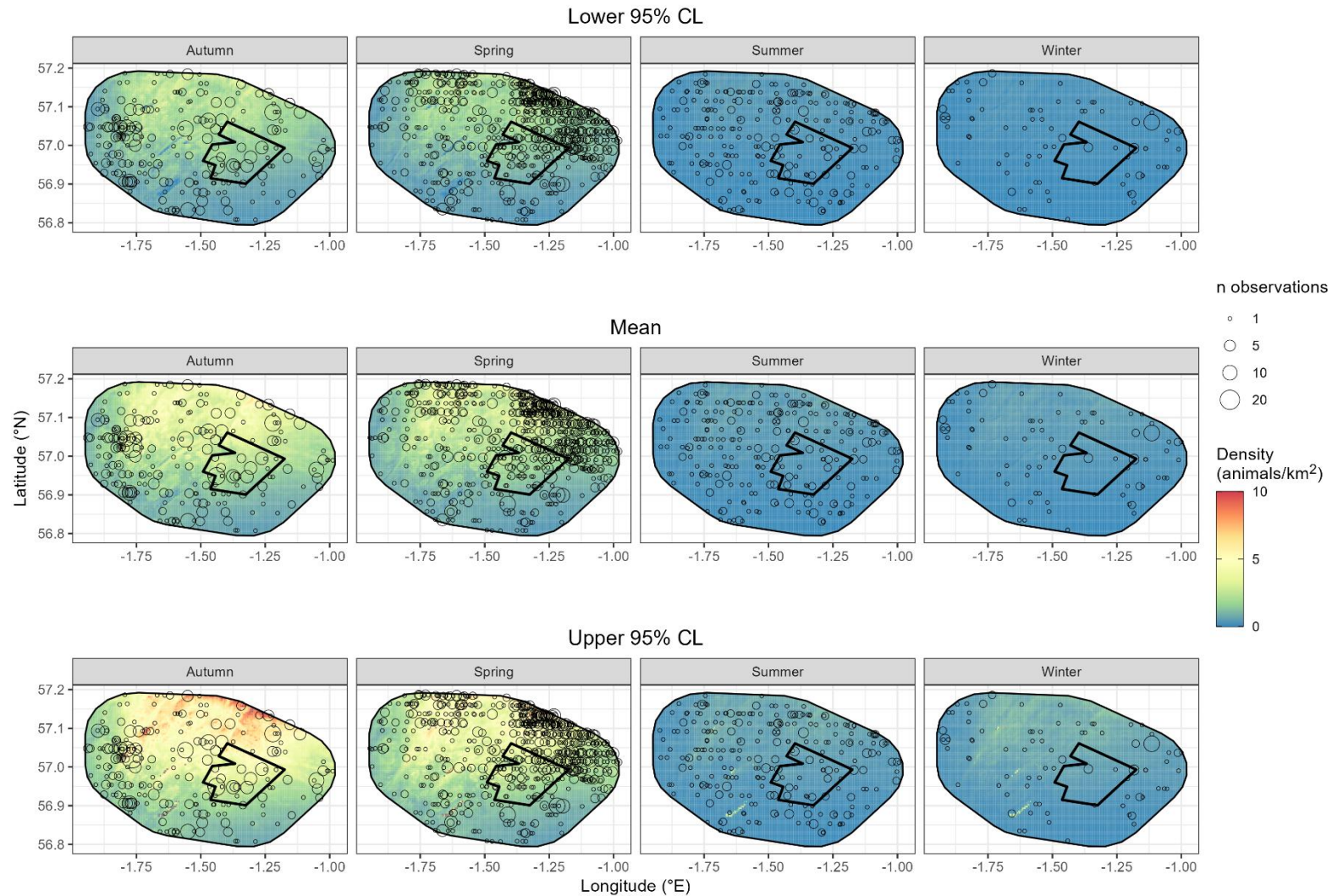


Figure 3.17: Predicted Mean Absolute Density of Harbour Porpoise, with 95% CLs, Across the DAS Area Split Across Meteorological Seasons. Bold Line Indicates the Array Site Boundary, Points Indicate DAS Observations

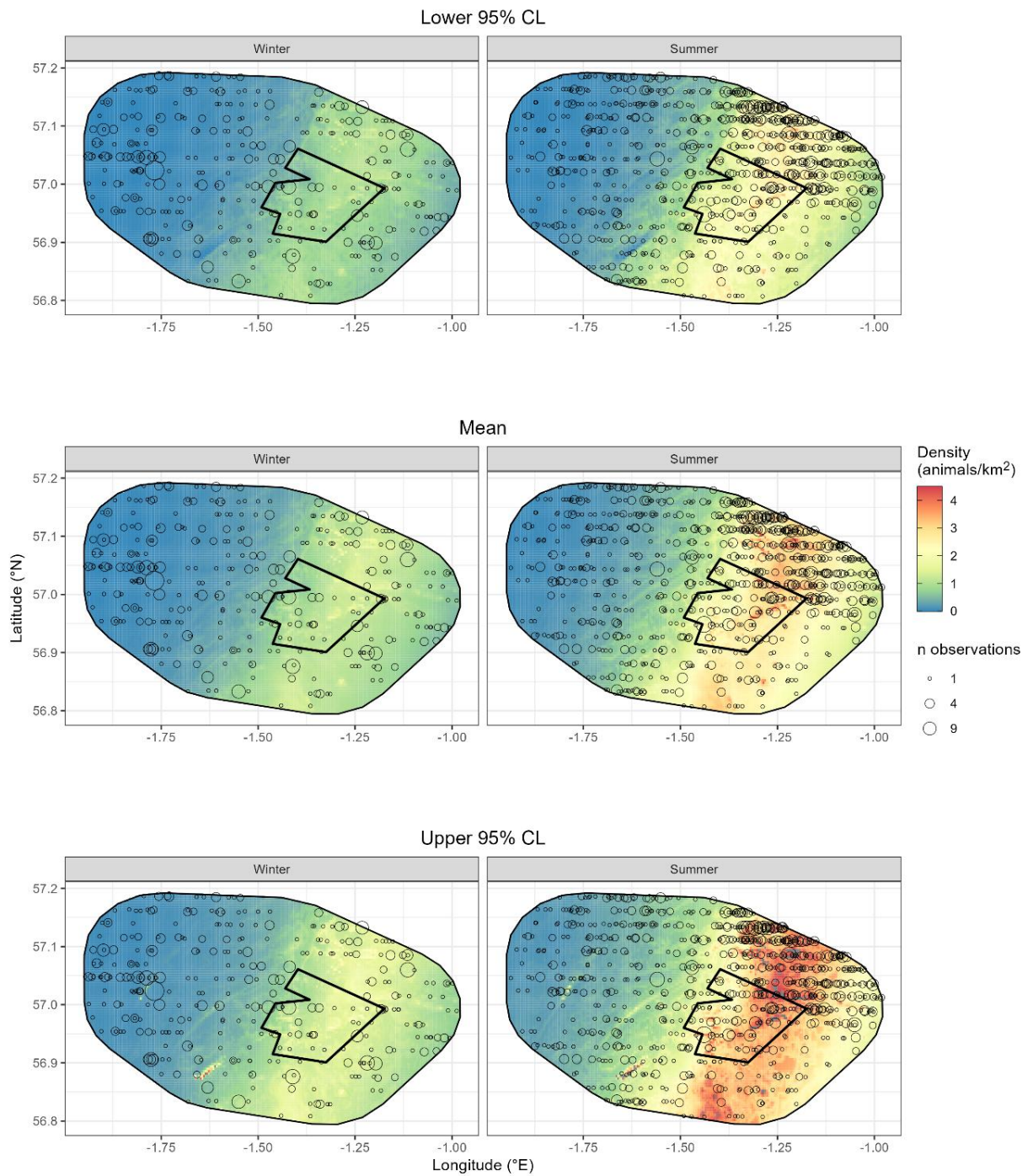


Figure 3.18: Predicted Mean Absolute Density of Harbour Porpoise, with 95% CLs, Across the DAS Area Split Between Bio-Seasons. Bold Line Indicates the Array Site Boundary, Points Represent DAS Observations

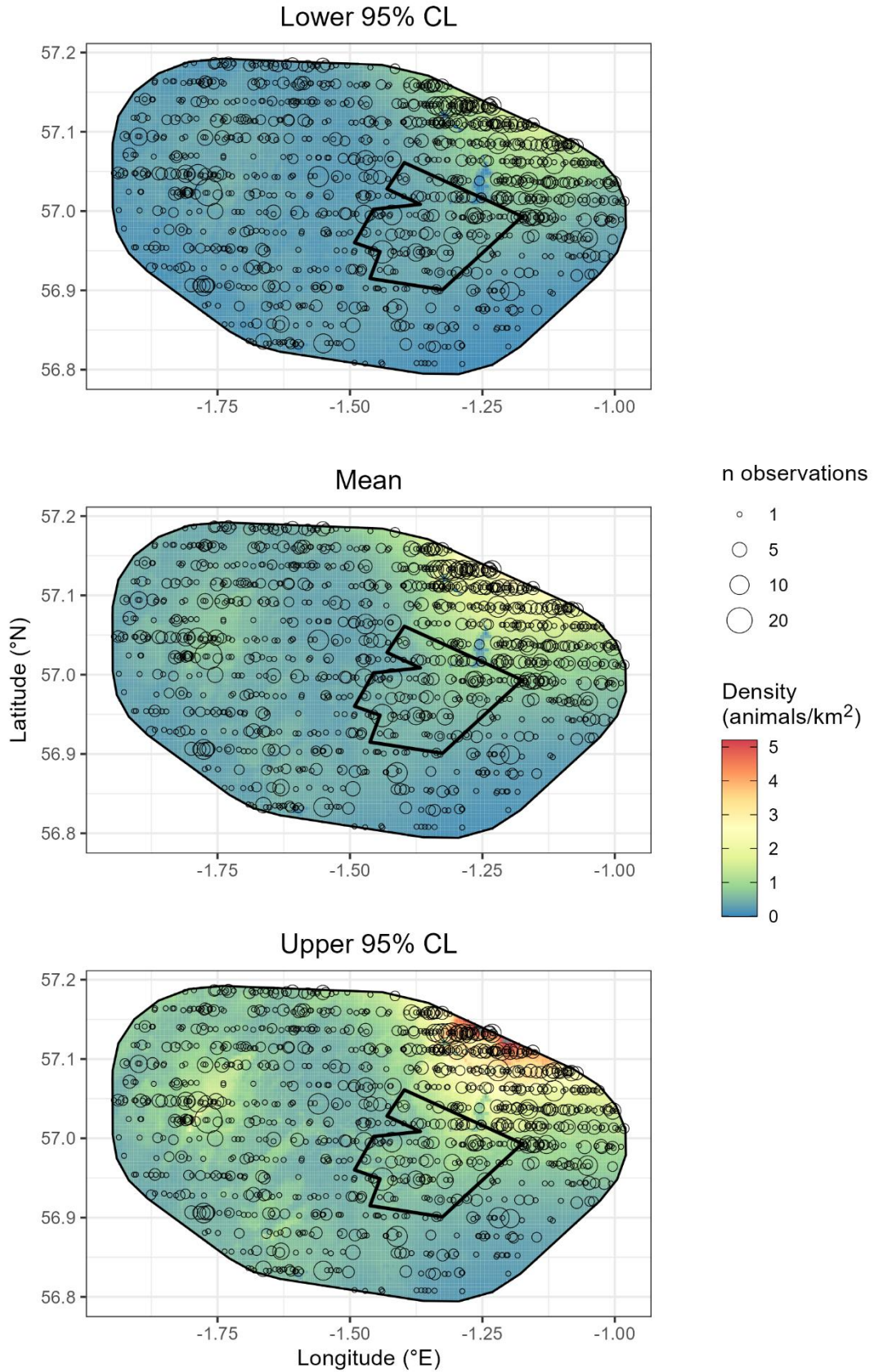


Figure 3.19: Predicted Mean Absolute Density of Harbour Porpoise, with 95% CLs, Across The DAS Area for the Whole 24-Month Period of DAS data. Bold Line Indicates the Array Site Boundary, Points Indicate DAS Observations

Grey Seal

Design-Based Analysis

3.2.18 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 24-months of DAS campaign. Relative estimates were then adjusted for availability bias using a correction factor of 0.156 (see Paragraph 2.6.9) to provide estimates of absolute abundance and density, with 95% CLs obtained via bootstrapping (1,000 simulations) (Wessa, 2019). Figure 3.20 illustrates the simulated mean absolute densities resulting from the bootstrapping process for the DAS Area and Figure 3.21 illustrates the Extended DAS Area, and the arrangement of points is indicative of the variability of the raw counts.

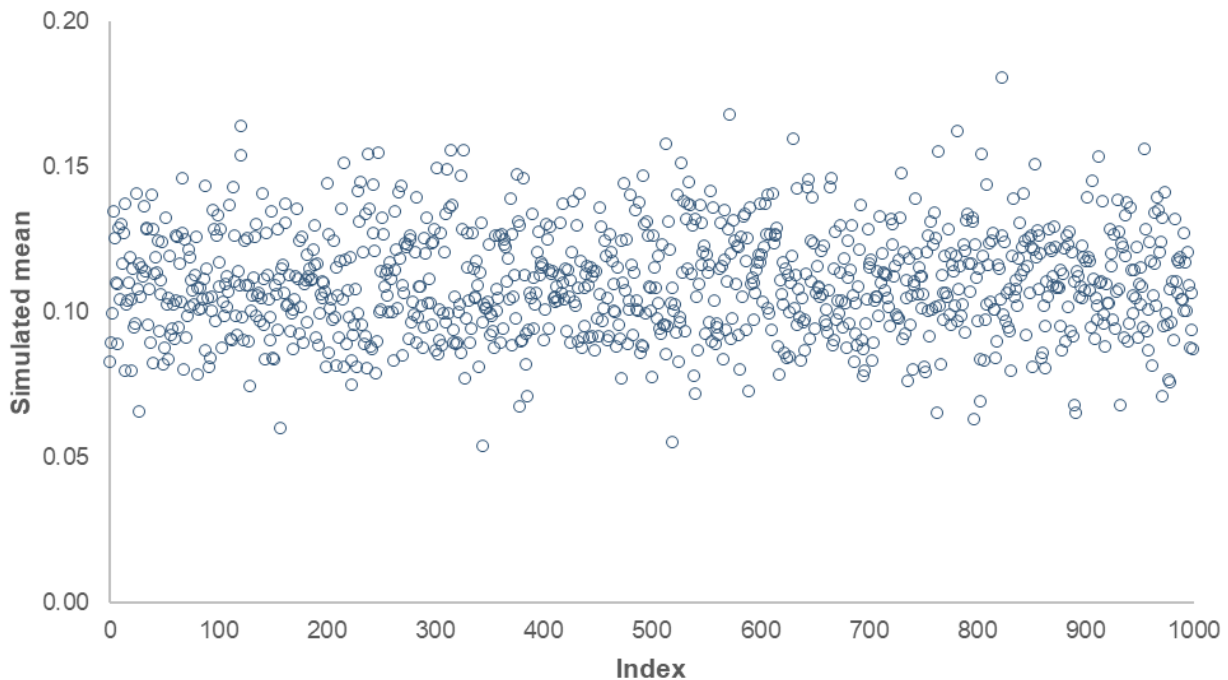


Figure 3.20: Bootstrapped Simulation (n = 1,000) of Mean Monthly Absolute Density for Grey Seal Across the DAS Area

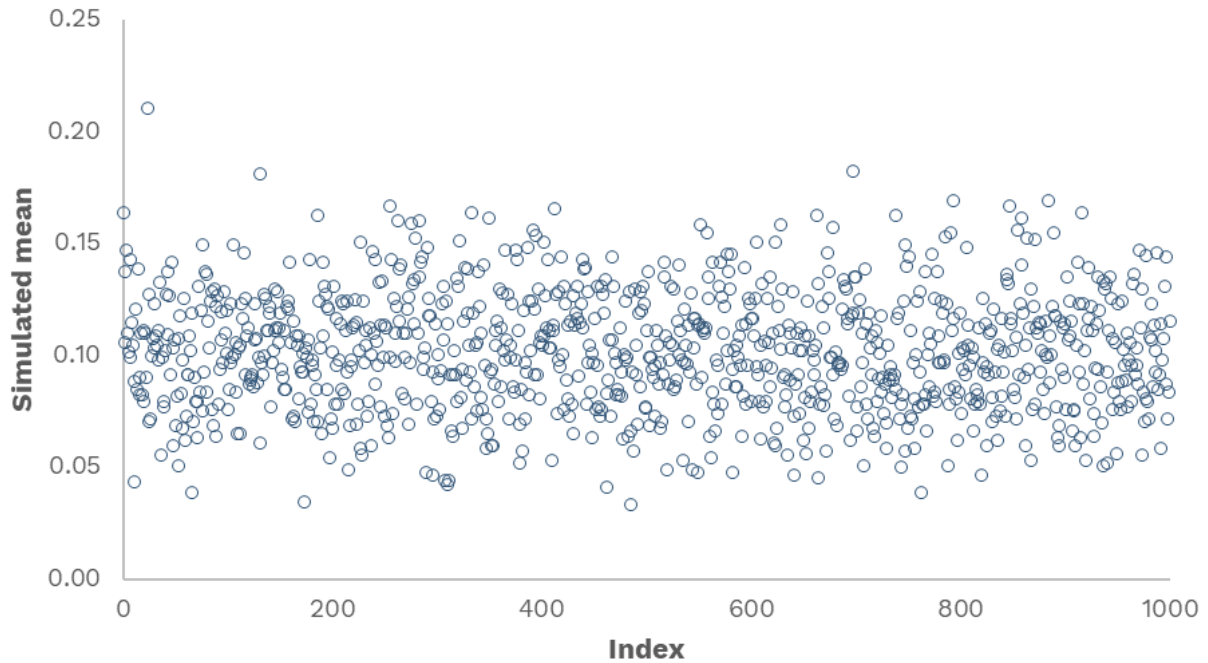


Figure 3.21: Bootstrapped Simulation (n = 1,000) of Mean Monthly Absolute Density for Grey Seal Across the Extended DAS Area

DAS Area

3.2.19 Estimates for absolute density for grey seal across the DAS Area ranged between 0.000 and 0.351 animals/km² (Figure 3.22) and mean absolute density across all transects and all surveys was 0.120 animals/km² (95% CLs = 0.081, 0.161; CV = 0.852).

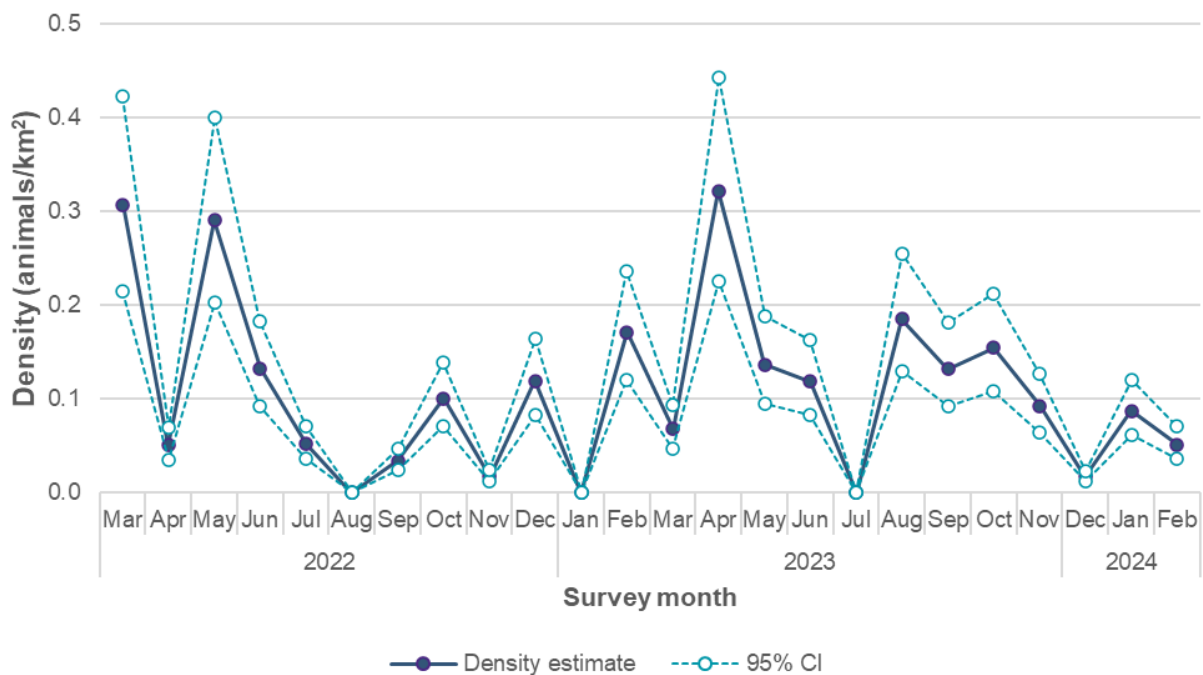


Figure 3.22: Estimated Absolute Density of Grey Seal (Corrected For Availability Bias) for Each Survey Over the DAS Area, With Bootstrapped 95% CI

3.2.20 No clear temporal trends were visible in monthly DAS sightings of grey seal. Density estimates are also presented on a \log_{10} scale, despite the gaps resulting from zero-counts in some survey months, which cannot be displayed on a log scale (Figure 3.23).

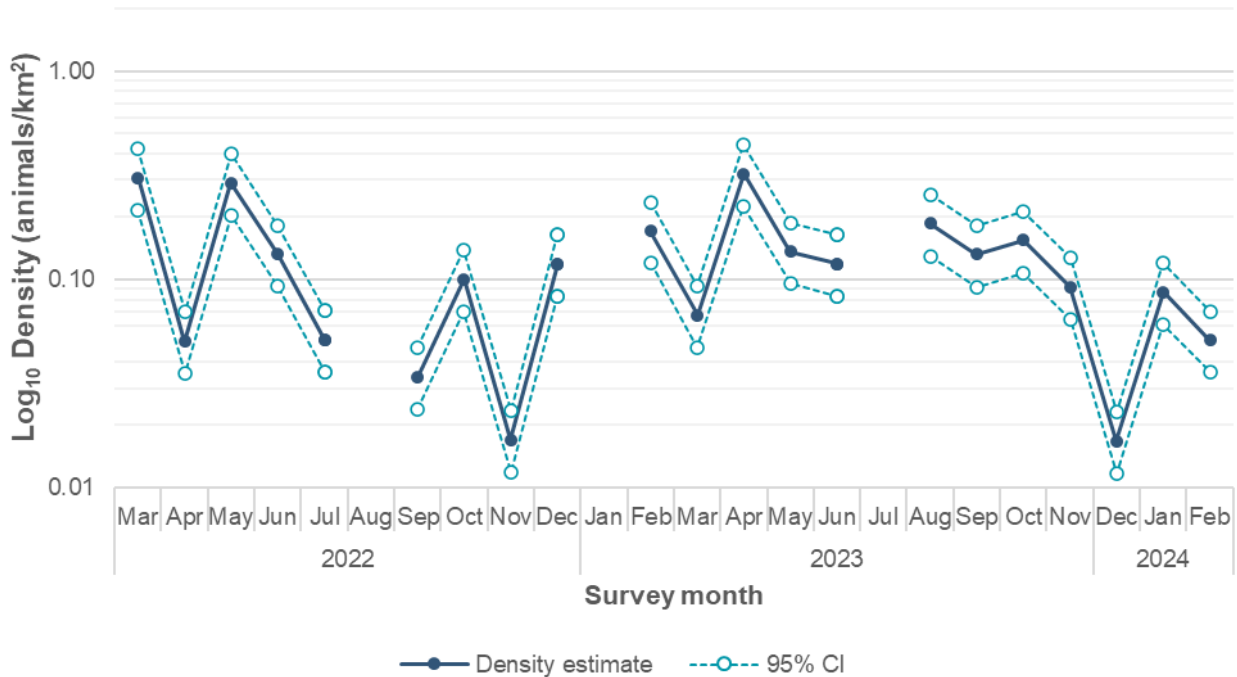


Figure 3.23: Estimated Absolute Density of Grey Seal for Each Survey Over the DAS Area, with Bootstrapped 95% CI, Presented on a \log_{10} scale

3.2.21 Table 3.10 summarises the mean relative and 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: 0.231 animals/km² (95% CLs = 0.157, 0.312; CV = 0.510) (May);
- seasonal: 0.213 animals/km² (95% CLs = 0.144, 0.287; CV = 0.639) (Spring); and
- bio-season: 0.134 animals/km² (95% CLs = 0.091, 0.181; CV = 0.882) (non-breeding).

Table 3.10: Design-Based Estimates for Mean Relative and Absolute Abundance and Density of Grey Seal for the DAS Area (24 months of survey), Across Monthly, Seasonal, Bio-Season, and Annual Scales

Temporal scale	Relative estimates		Absolute estimates				
	Mean abundance	Mean density (animals /km ²)	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Month							
January	15	0.007	93	0.047	0.032	0.063	1.414
February	38	0.019	241	0.121	0.082	0.163	0.762
March	64	0.032	406	0.204	0.138	0.275	0.901
April	64	0.032	405	0.203	0.138	0.274	1.029
May	72	0.036	461	0.231	0.157	0.312	0.510
June	43	0.021	274	0.137	0.093	0.185	0.084
July	9	0.004	56	0.028	0.019	0.038	1.414
August	32	0.016	202	0.101	0.069	0.137	1.414
September	29	0.014	183	0.091	0.062	0.123	0.840
October	44	0.022	279	0.140	0.095	0.188	0.295
November	19	0.009	117	0.058	0.040	0.079	0.957
December	24	0.012	148	0.074	0.050	0.100	1.063
Meteorological season							
Winter	26	0.013	161	0.080	0.055	0.109	0.872
Spring	67	0.033	424	0.213	0.144	0.287	0.639
Summer	28	0.014	178	0.089	0.060	0.120	0.937
Autumn	30	0.015	193	0.096	0.065	0.130	0.611
Bio-season							
Breeding	29	0.014	181	0.091	0.062	0.123	0.778
Non-breeding	42	0.021	267	0.134	0.091	0.181	0.882

Temporal scale	Relative estimates		Absolute estimates				
	Mean abundance	Mean density (animals /km ²)	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Annual							
Year 1	36	0.018	231	0.116	0.080	0.159	0.683
Year 2	39	0.019	247	0.124	0.086	0.170	0.524
Overall	38	0.019	239	0.120	0.081	0.161	0.852

Extended DAS Area

3.2.22 Estimates for absolute density for grey seal across the Extended DAS Area ranged between 0.026 and 1.853 animals/km² (Figure 3.24) and mean absolute density across all transects and all surveys was 0.334 animals/km² (95% CLs = 0.107, 0.712; CV = 1.626).

3.2.23 A peak in estimated absolute density for the Extended DAS Area was observed in April 2023, with a maximal absolute density of 0.409 animals/km² (95% CLs = 0.152, 0.830). Due to the large variability in the number of observations of grey seal across surveys, with very low densities in some months and higher densities in others (range of absolute density = 0.026, 1.853 ; CV = 1.626), monthly trends are not always easy to interpret visually on a linear scale due to the large variation in values (Figure 3.24). Data were therefore also plotted on a log₁₀ scale (Figure 3.25), where monthly variation is more apparent, however noting the Extended DAS Area was surveyed only in April to August each year and therefore cannot illustrate seasonality, if present.

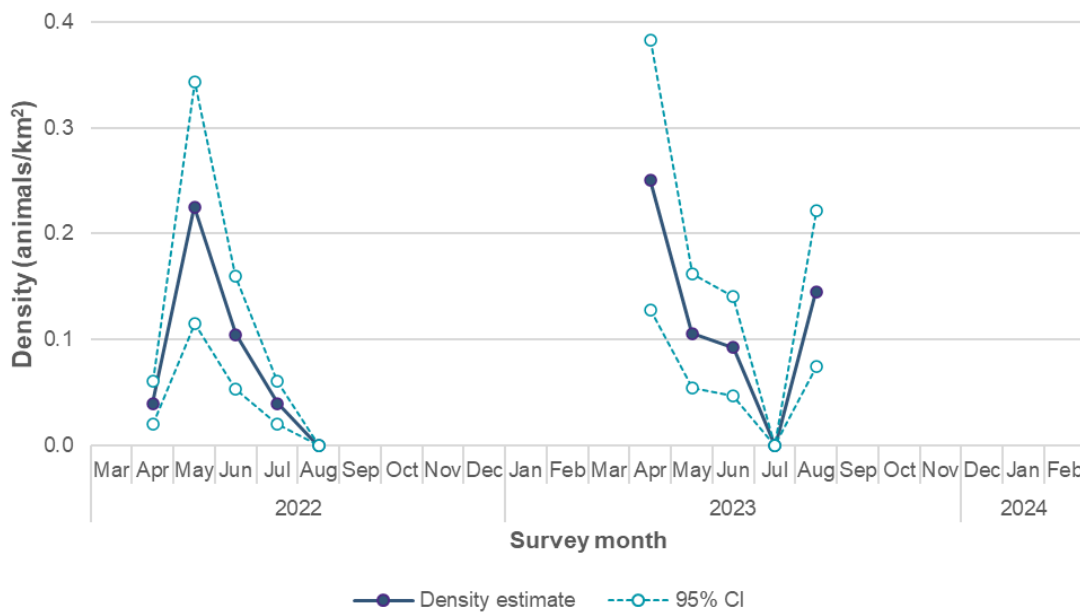


Figure 3.24: Estimated Absolute ‘Summer’ Density of Grey Seal (Corrected for Availability Bias) for Each Survey Over the Extended DAS Area, with Bootstrapped 95% CI

3.2.24 No clear temporal trends were visible in the summer sightings of grey seal. Density estimates are also presented on a log₁₀ scale, despite the gaps resulting from zero-counts in some survey months, which cannot be displayed on a log scale (Figure 3.23).

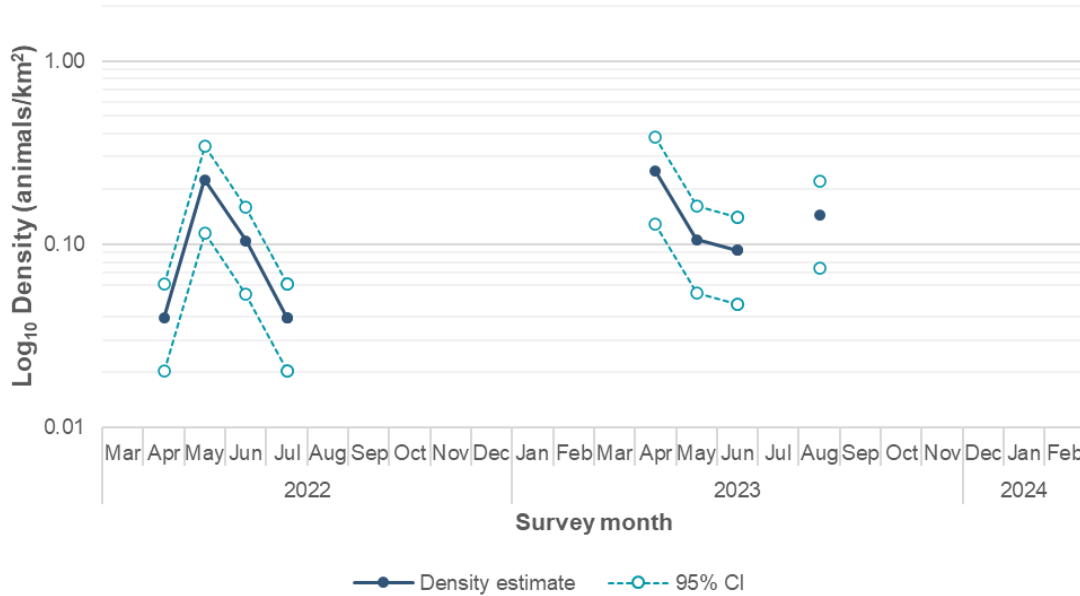


Figure 3.25: Estimated Absolute ‘Summer’ Density of Grey Seal for Each Survey Over the Extended DAS Area, With Bootstrapped 95% CI, Presented on a log₁₀ Scale

3.2.25 Table 3.11 summarises the mean relative and absolute abundance and density of grey seal, across monthly, seasonal and annual scales for the Extended DAS Area. The overall mean absolute density of grey seal for the Extended DAS Area, estimated from data pooled across all transects and all months for the Extended DAS Area was 0.332 animals/km² (95% CLs = 0.106, 0.706, CV = 1.644).

3.2.26 The maximal mean absolute density estimates for respective temporal divisions were calculated as:

- monthly: 0.992 animals/km² (95% CLs = 0.317, 2.111; CV = 1.226) (May); and
- yearly: 0.479 animals/km² (95% CLs = 0.178, 0.972, CV = 0.599) (‘Year 1’).

Table 3.11: Design-Based Estimates for Mean Relative and Absolute Abundance and Density of Grey Seal for the Extended DAS Area, Across Monthly, Seasonal, and Annual Scales

Temporal scale	Relative estimates		Absolute estimates				
	Mean abundance	Mean density (animals/km ²)	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Month							
January	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-
April	126	0.045	805	0.290	0.093	0.617	0.579
May	430	0.155	2,751	0.992	0.317	2.111	1.226
June	57	0.020	364	0.131	0.042	0.279	0.135
July	61	0.022	388	0.140	0.045	0.297	0.875
August	52	0.019	330	0.119	0.038	0.253	1.100
September	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-
Annual							
Year 1	207	0.075	1,327	0.479	0.178	0.972	0.599
Year 2	80	0.029	513	0.185	0.069	0.375	0.276
Overall	144	0.052	920	0.332	0.106	0.706	1.644

Model-Based Analysis

- 3.2.27 As for harbour porpoise, grey seals were present in sufficient numbers for modelling only when considered across the whole 24-month DAS period for the DAS Area only and when pooled by bio-season.
- 3.2.28 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 24 months of DAS Area data fitted the data poorly, as indicated by the low values for concordance correlation and marginal r^2 , summarised in Table 3.12.
- 3.2.29 Given the low statistical power of these models, and the need to remove outliers to allow modelling to proceed, the relative contribution of environmental variables to grey seal distribution has not been presented, as these estimates would not be an accurate reflection of their respective influence.
- 3.2.30 Similarly, the density and abundance estimates obtained from model-based analysis of grey seal distribution should therefore be interpreted with extreme caution and should not be considered to be a true representation of grey seal occurrence in the DAS Area.

Table 3.12: Metrics of Model Fit for MRSea Models Fitted to Grey Seal Observation Data Across Meteorological Season, Bio-Season and Across the 24 Months of DAS Data for the DAS Area

Model	Concordance correlation	Marginal r-squared
Meteorological season	-	-
Bio-season	0.0065	0.0036
Overall DAS campaign	0.0102	0.0054

- 3.2.31 Estimates of abundance varied spatially and across bio-seasons, and due to the poor fit of the models, their predictions are not useful in illustrating likely patterns of spatial distribution across the year, or between bio-seasons. Figure 3.26 and Figure 3.27 further illustrate a poor fit of the models since observations (indicated by black circles) do not coincide well with spatial patterns of density across the plot. Estimates of absolute density (plus 95% CLs) for the ‘breeding’ and ‘non-breeding’ bio-seasons, and for the 24-month period of DAS Area data, are presented in Table 3.13 (modelling was not possible at a meteorological seasonal scale).

Table 3.13: Modelled Absolute Abundance and Density of Grey Seal for Bio-Seasons and Across the 24-Month DAS Data Collection Period for the DAS Area

Temporal scale	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Bio-season					
'Breeding' bio-season	424	0.213	0.121	0.343	0.775
'Non-breeding' bio-season	622	0.312	0.196	0.478	
Year					
Overall DAS campaign	219	0.056	0.11	0.201	1.117

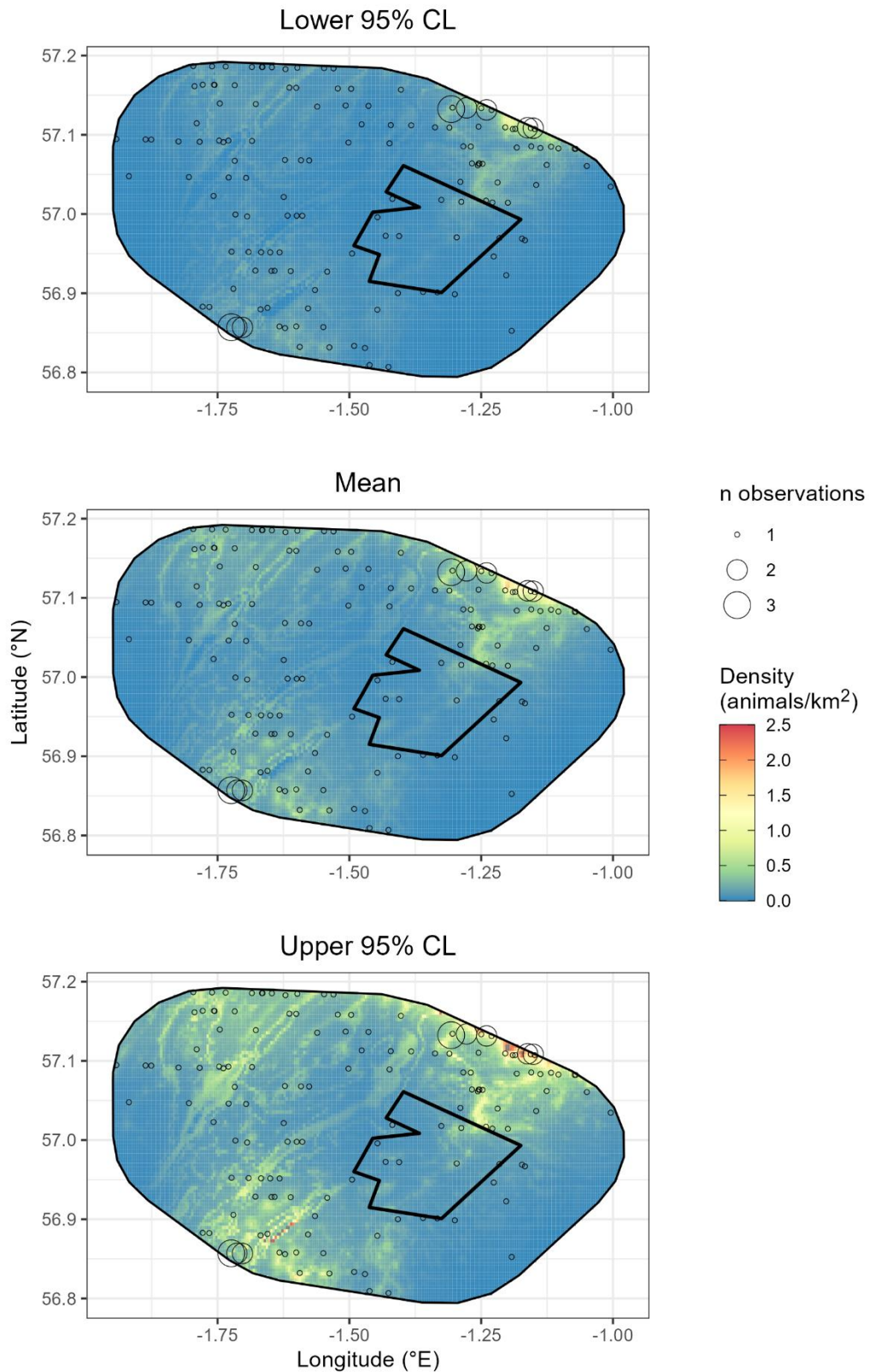


Figure 3.26: Predicted Mean Absolute Density of Grey Seal, with 95% CLs, Across the DAS Area for the Whole 24-Month Period of DAS Data. Dashed Line Indicates the Array Site Boundary

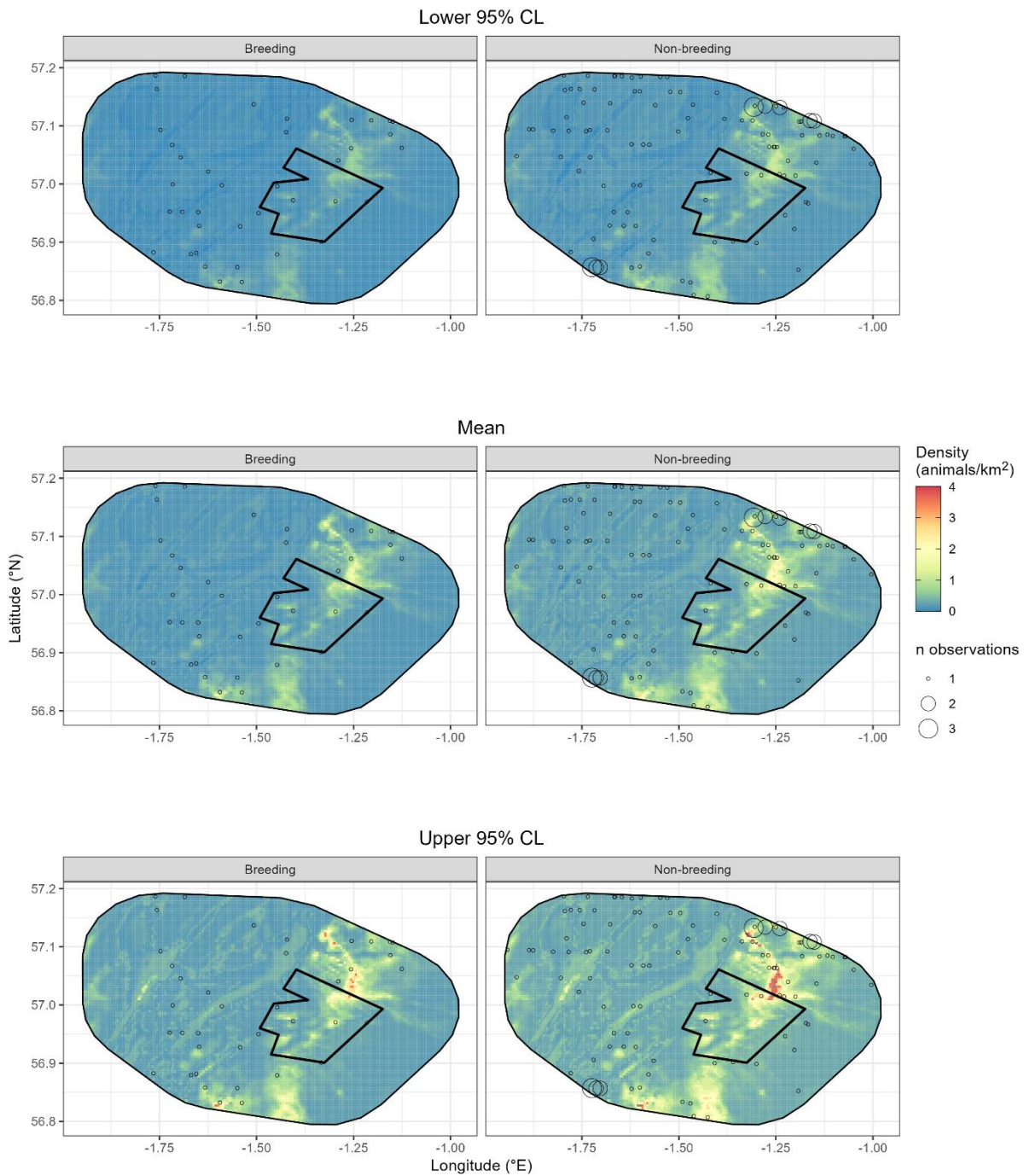


Figure 3.27: Predicted Mean Absolute Density of Grey Seal, with 95% CLs, Across the DAS Area Split Between Bio-Seasons. Dashed line Indicates the Array Site Boundary

White-Beaked Dolphin

Design-Based Analysis

- 3.2.32 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 DAS Area. Although some seasonality has been identified in white-beaked dolphin distribution (Canning *et al.*, 2008, Weir *et al.*, 2007), this largely aligns with meteorological summer (see Paragraph 2.5.2) so bio-seasons have not been defined for white-beaked dolphin.
- 3.2.33 Relative estimates were adjusted for availability bias using a correction factor of 0.180 (see Paragraph 2.6.12) to provide estimates of absolute abundance and density, with 95% CLs obtained via bootstrapping (1,000 simulations) (Wessa, 2019). Figure 3.28 illustrates the simulated mean absolute densities resulting from the bootstrapping process for the DAS Area and Figure 3.29 for the Extended DAS Area.

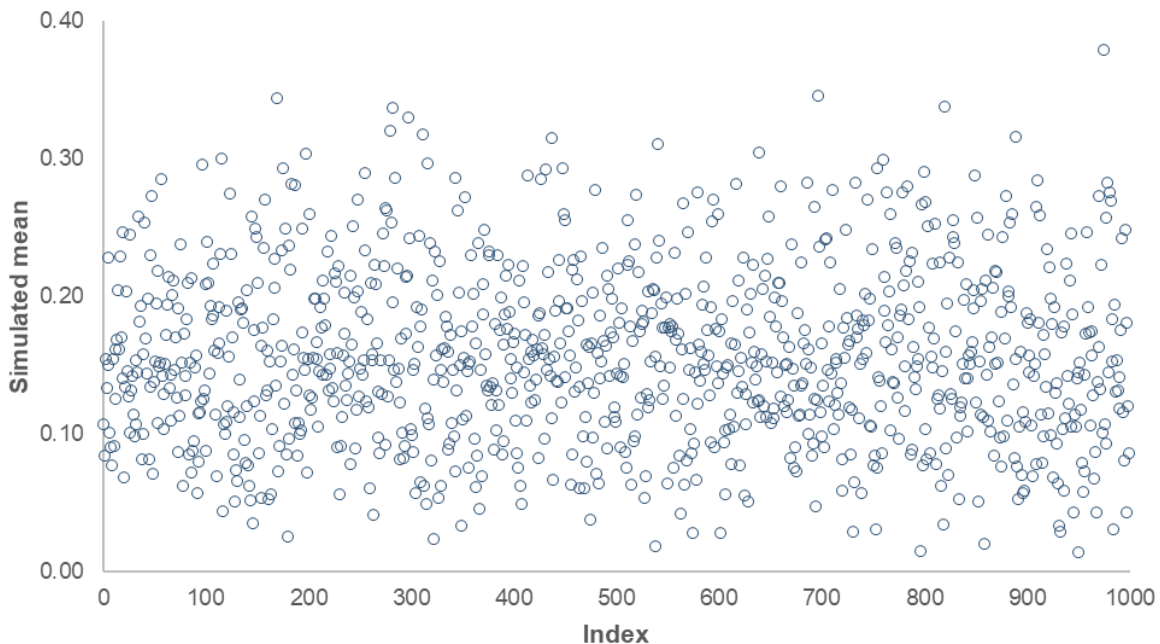


Figure 3.28: Bootstrapped Simulation (n = 1,000) of Mean Monthly Absolute Density for White-Beaked Dolphin Across the DAS Area

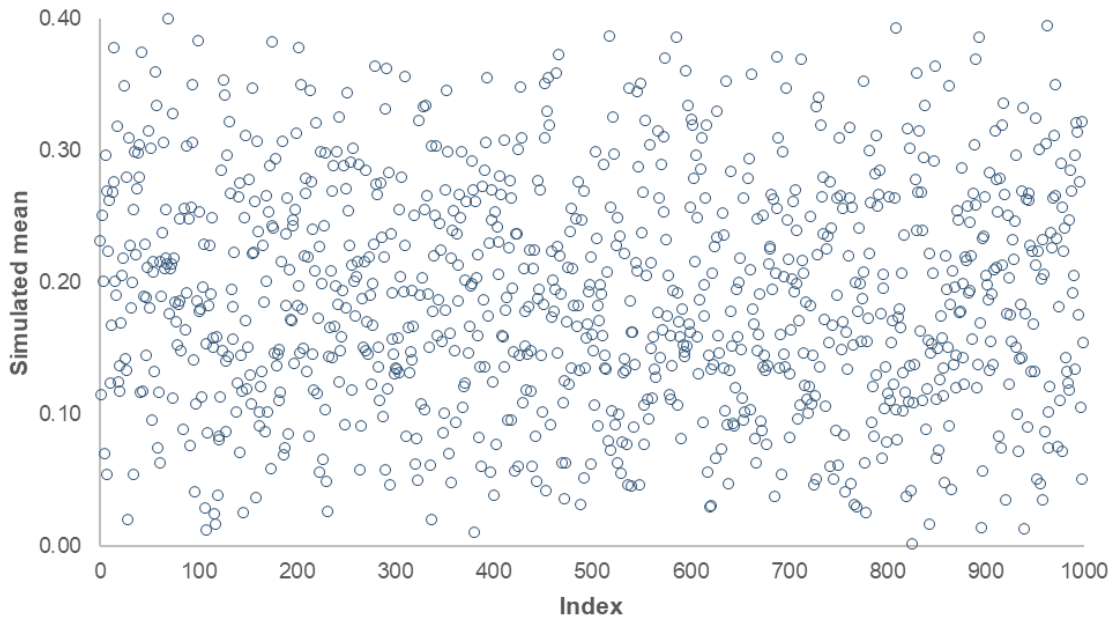


Figure 3.29: Bootstrapped Simulation (n = 1,000) of Mean Monthly Absolute Density for White-Beaked Dolphin Across the Extended DAS Area

DAS Area

3.2.34 White-beaked dolphin was identified during ten of the 24 surveys, with peaks in recorded presence during August 2022 and September 2023 (Figure 3.30) and a maximal absolute density of 1.291 animals/km² during August 2023 (95% CLs = 0.381, 2.451).

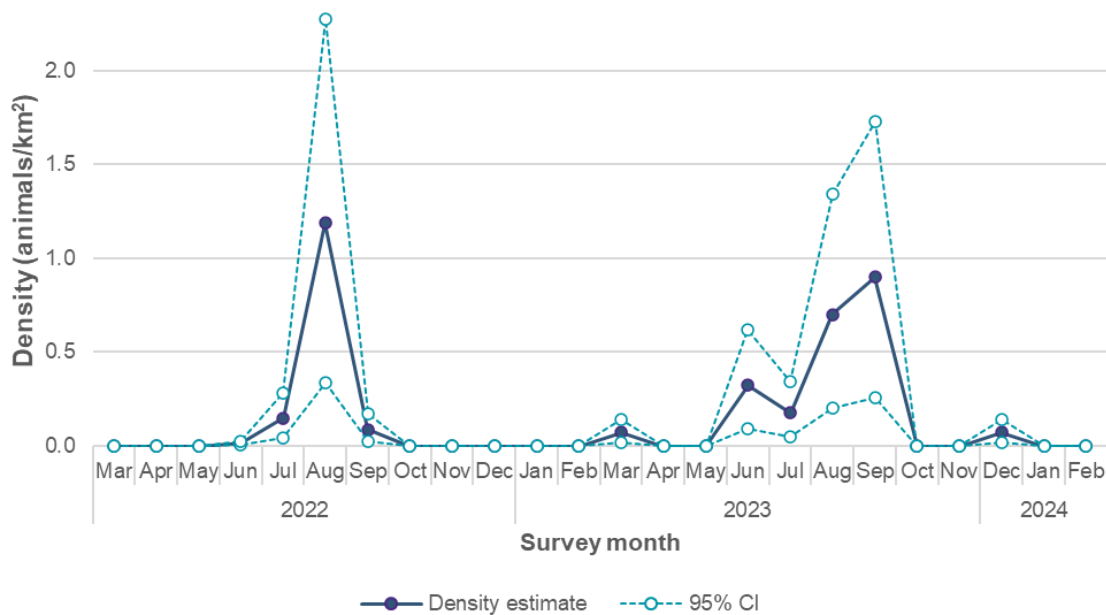


Figure 3.30: Estimated Absolute Density of White-Beaked Dolphin for Each Survey Over the DAS Area, With Bootstrapped 95% CI

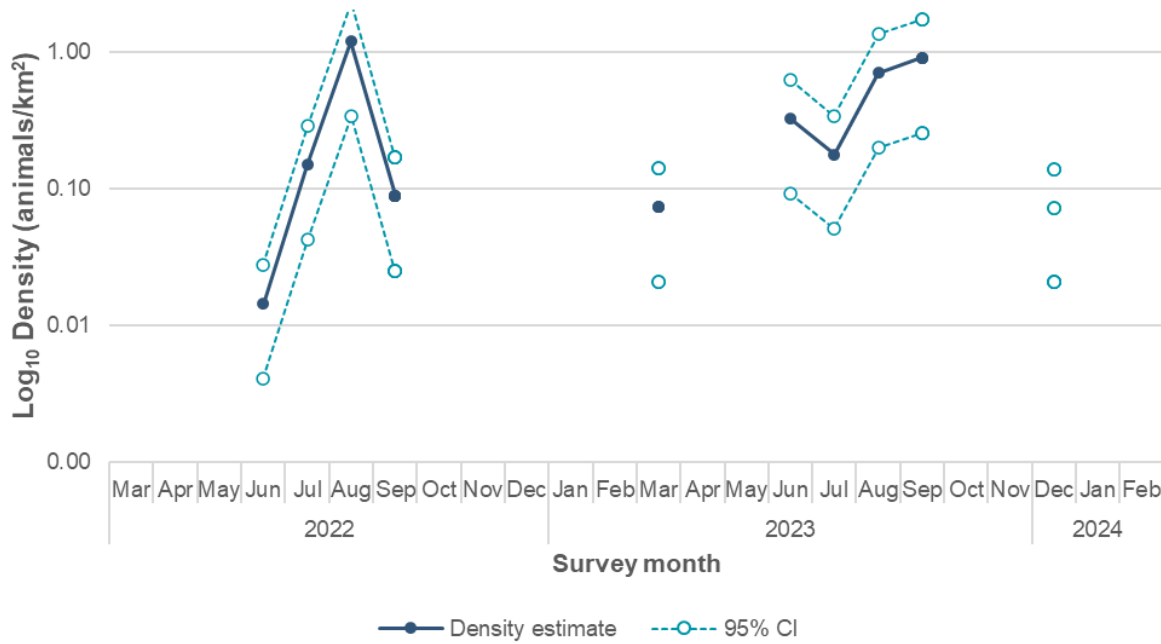


Figure 3.31: Estimated Absolute Density of White-Beaked Dolphin (Corrected for Availability Bias) for Each Survey Over the DAS Area, With Bootstrapped 95% CI, Presented on a log₁₀ Scale

- 3.2.35 The overall estimated mean absolute density of white-beaked dolphin, estimated from data pooled across all transects and all 24 months of DAS data (Table 3.14) was 0.168 animals/km² (95% CLs = 0.048, 0.316; CV = 2.068).
- 3.2.36 The maximal mean absolute density estimates for respective temporal divisions were:
- monthly: 1.028 animals/km² (95% CLs = 0.297, 1.935; CV = 0.361) (August); and
 - seasonal: 0.463 animals/km² (95% CLs = 0.134, 0.872; CV = 1.036) (summer).

Table 3.14: Design-Based Estimates for Mean Relative and Absolute Abundance and Density of White-Beaked Dolphin Over the DAS Area, Across Monthly, Seasonal and Annual Scales

Temporal scale	Relative estimates		Absolute estimates				
	Mean abundance	Mean density (animals/km ²)	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Month							
January	0	0.000	0	0.000	0.000	0.000	-
February	0	0.000	0	0.000	0.000	0.000	-
March	15	0.007	80	0.040	0.012	0.075	1.414
April	0	0.000	0	0.000	0.000	0.000	-
May	0	0.000	0	0.000	0.000	0.000	-
June	66	0.033	367	0.184	0.053	0.346	1.293
July	64	0.032	355	0.178	0.051	0.335	0.130
August	369	0.185	2,049	1.028	0.297	1.935	0.361
September	196	0.098	1,087	0.546	0.157	1.026	1.164
October	0	0.000	0	0.000	0.000	0.000	-
November	0	0.000	0	0.000	0.000	0.000	-
December	15	0.007	80	0.040	0.012	0.075	1.414
Meteorological season							
Winter	5	0.002	27	0.013	0.004	0.025	2.449
Spring	5	0.002	27	0.013	0.004	0.025	2.449
Summer	167	0.083	923	0.463	0.134	0.872	1.036
Autumn	66	0.033	363	0.182	0.052	0.342	2.200
Annual							
Year 1	47	0.023	260	0.130	0.038	0.248	0.835
Year 2	74	0.037	410	0.206	0.061	0.390	0.483
Overall	61	0.030	335	0.168	0.048	0.316	2.068

Extended DAS Area

- 3.2.37 White-beaked dolphin was identified during six of the ten surveys of the Extended DAS Area, with peaks in recorded presence during August 2022 and 2023 (Figure 3.30) and a maximal absolute density of 1.281 animals/km² during August 2022 (95% CLs = 0.260, 2.547).
- 3.2.38 A peak in estimated absolute density for the Extended DAS Area was observed in August 2022, with a maximal absolute density of 1.281 animals/km² (95% CLs = 0.260, 2.547). Due to the large variability in the number of observations of white-beaked dolphin across surveys, with very low densities in some months and higher densities in others (range of absolute density = 0.000, 1.281 ; CV = 1.680), monthly trends are not always easy to interpret visually on a linear scale due to the large variation in values (Figure 3.32).
- 3.2.39 Data were therefore also plotted on a log₁₀ scale (Figure 3.33), where monthly variation is more apparent, however noting the Extended DAS Area was surveyed only in April to August each year and therefore does not demonstrate seasonality.

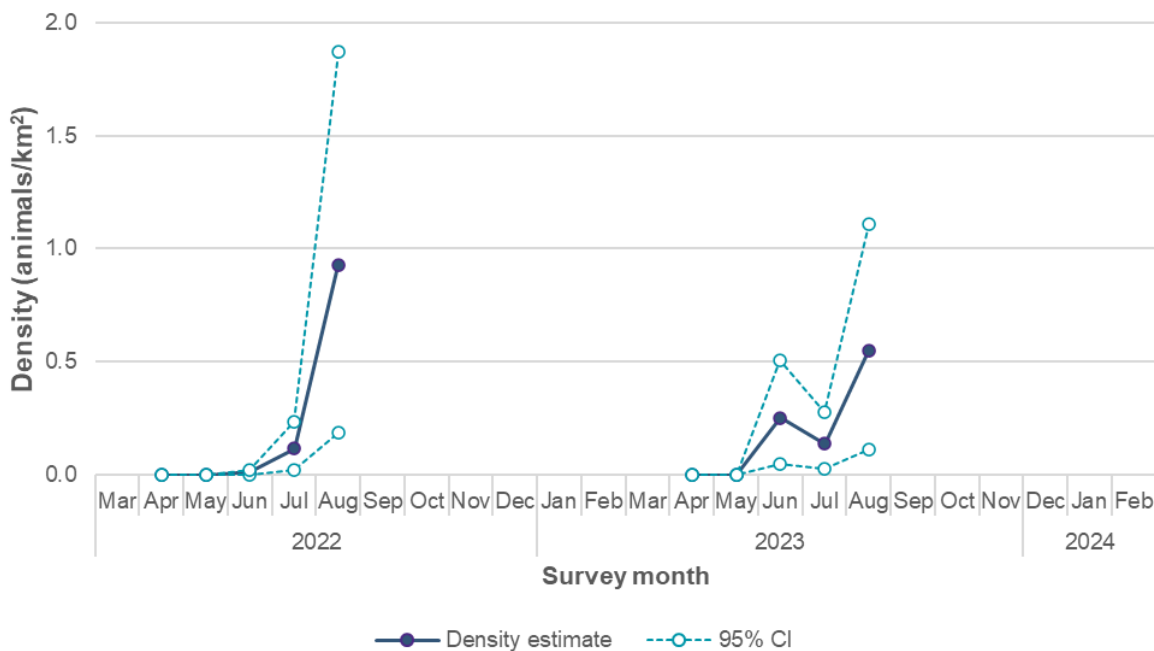


Figure 3.32: Estimated Absolute Density of White-Beaked Dolphin for Each Survey Over the Extended DAS Area, with Bootstrapped 95% CI

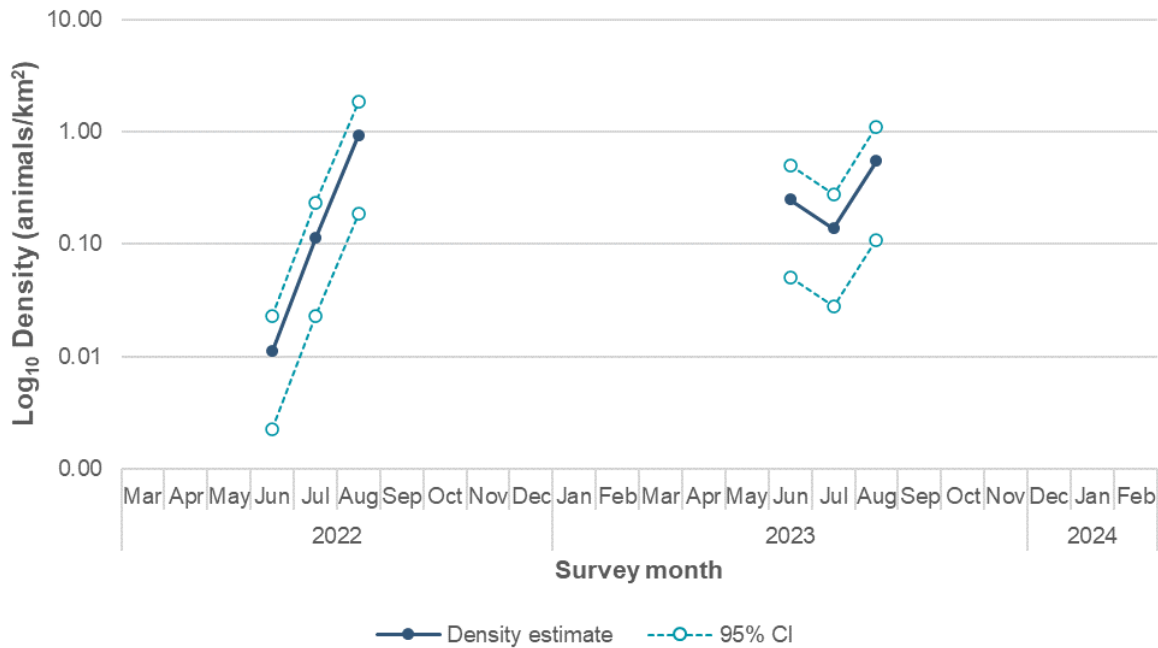


Figure 3.33: Estimated Absolute Density of White-Beaked Dolphin for Each Survey Over the Extended DAS Area, With Bootstrapped 95% CI, Presented on a log₁₀ Scale

3.2.40 The overall estimated mean absolute density of white-beaked dolphin for the Extended DAS Area, estimated from data pooled across all transects and all months of Extended DAS data (Table 3.15) was 0.243 animals/km² (95% CLs = 0.061, 0.499; CV = 1.680). The maximal mean absolute density estimates for respective temporal divisions were:

- monthly: 0.915 animals/km² (95% CLs = 0.231, 1.880; CV = 0.566) (August); and
- yearly: 0.282 animals/km² (95% CLs = 0.057, 0.560; CV = 0.404) ('Year 1').

Table 3.15: Design-Based Estimates for Mean Relative and Absolute Abundance and Density of White-Beaked Dolphin over the Extended DAS Area, Across Monthly, Seasonal and Annual Scales

Temporal scale	Relative estimates		Absolute estimates				
	Mean abundance	Mean density (animals/km ²)	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Month							
January	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-
April	0	0.000	0	0.000	0.000	0.000	-
May	0	0.000	0	0.000	0.000	0.000	-
June	86	0.031	476	0.172	0.043	0.352	1.321
July	64	0.023	352	0.127	0.032	0.261	0.130
August	457	0.165	2,536	0.915	0.231	1.880	0.566
September	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-
Annual							
Year 1	141	0.051	781	0.282	0.057	0.560	0.404
Year 2	102	0.037	565	0.204	0.041	0.405	0.235
Overall	122	0.044	673	0.243	0.061	0.499	1.680

Model-Based Analysis

- 3.2.41 Modelling of white-beaked dolphin was only possible when pooled across the whole 24 months of DAS Area data, due to the comparative low frequency of occurrence and identification of this species during the DAS Area campaign.
- 3.2.42 The MRSea model included water depth and seabed ruggedness as explanatory environmental variables. However, the model fitted to 24 months of DAS data fitted the data poorly, as indicated by the extremely low values for concordance correlation and marginal r^2 in Table 3.16. Given the low statistical power of this model, the contribution of environmental variables to white-beaked dolphin distribution has not been presented, as these estimates would not be an accurate reflection of their influence.

Table 3.16: Metrics of MRSea Model Fit and Modelled Absolute Abundance and Density of White-Beaked Dolphin Across the 24-month DAS Area Data Collection Period

Parameter	Value
Temporal division	Overall DAS campaign
Concordance correlation	0.0052
Marginal r^2	0.0032
Mean abundance	311
Mean density (animals/km ²)	0.156
Lower 95% CL	0.084
Upper 95% CL	0.286
CV	1.25

- 3.2.43 Predicted estimates of absolute density and abundance (Table 3.16) correspond well with those calculated from the design-based analysis (Table 3.14).

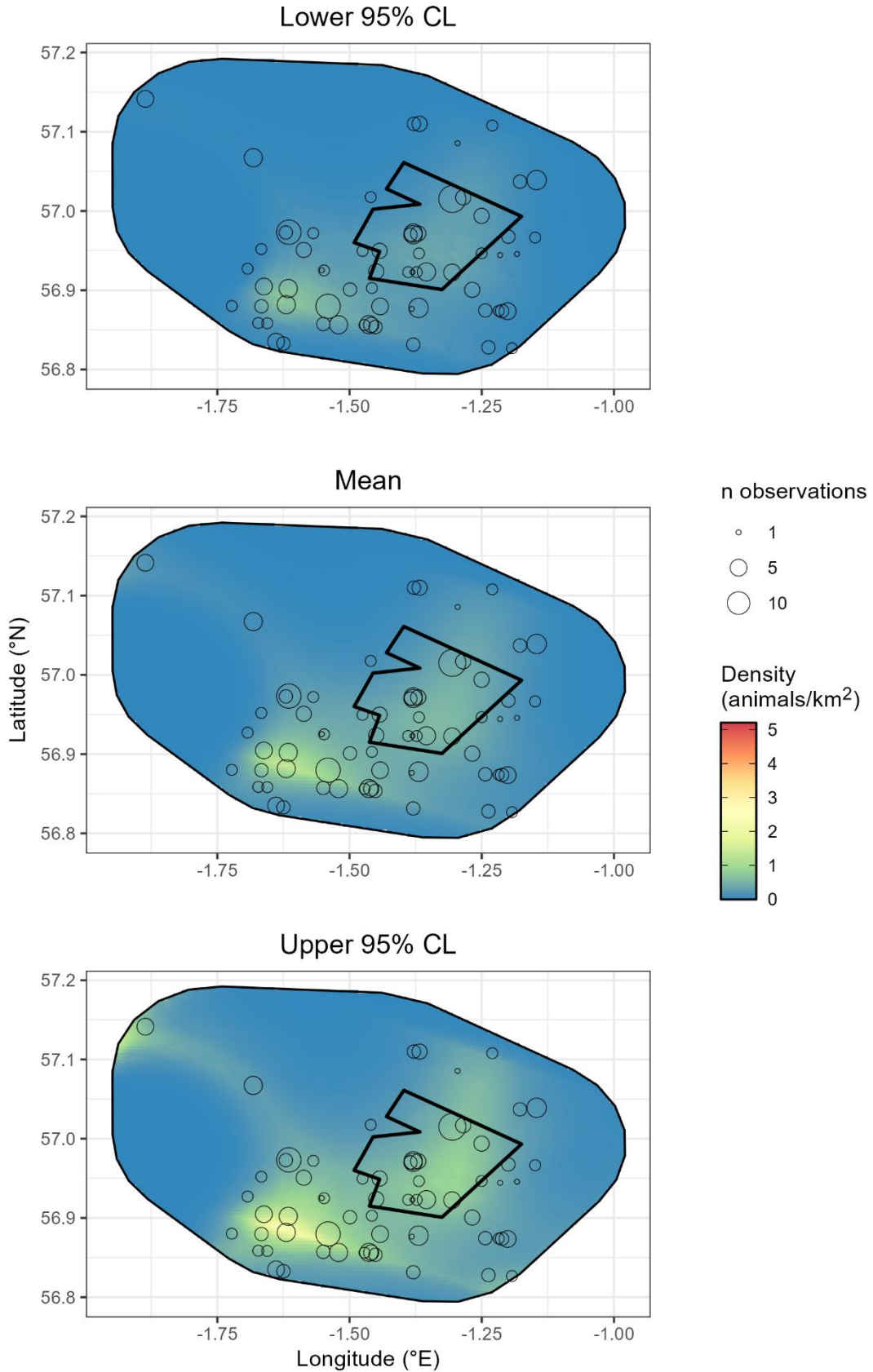


Figure 3.34: Overall Predicted Mean Absolute Density of White-Beaked Dolphin, with 95% CLs, Across the DAS Area for the Whole 24-month Period of DAS Data. Dashed Line Indicates the Array Site Boundary

Minke Whale

Design-Based Analysis

- 3.2.44 Raw counts of minke whale (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 DAS campaign.
- 3.2.45 Relative estimates were then adjusted for availability bias with a correction factor of 0.44 (see Paragraph 2.6.13) to provide estimates of absolute abundance and density, with 95% CLs obtained via bootstrapping (1,000 simulations) (Wessa, 2019). The simulated mean absolute densities resulting from the bootstrapping process for the DAS Area is presented in Figure 3.35 and for the Extended DAS Area in Figure 3.36.

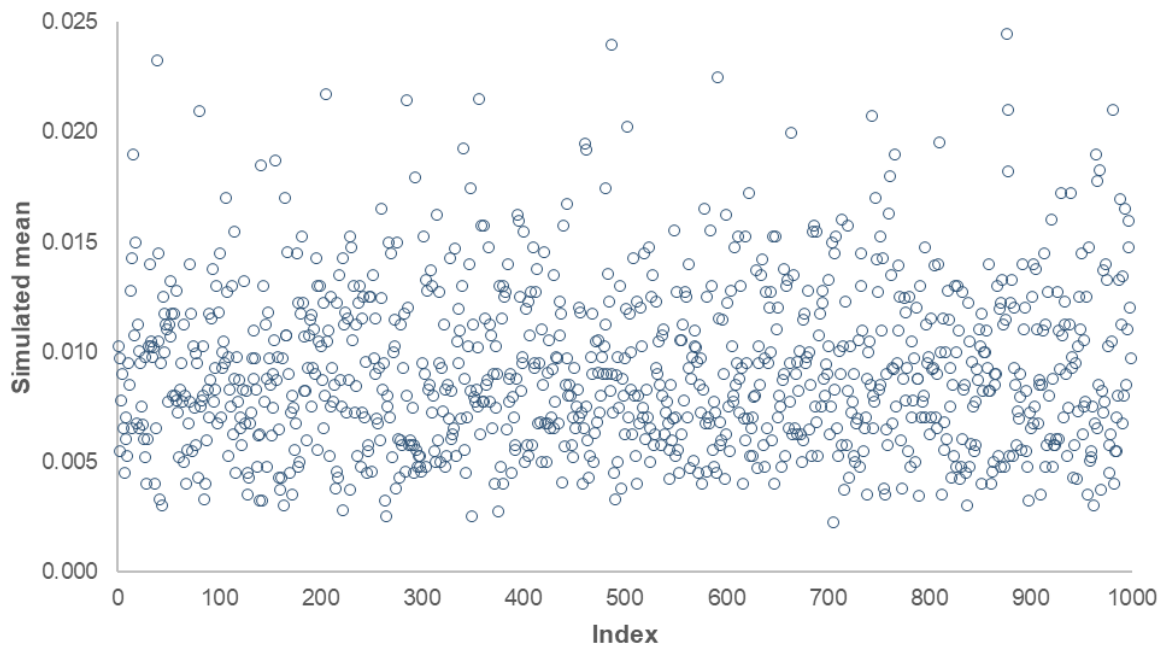


Figure 3.35: Bootstrapped Simulation (n = 1,000) of Mean Monthly Absolute Density for Minke Whale Across the DAS Area

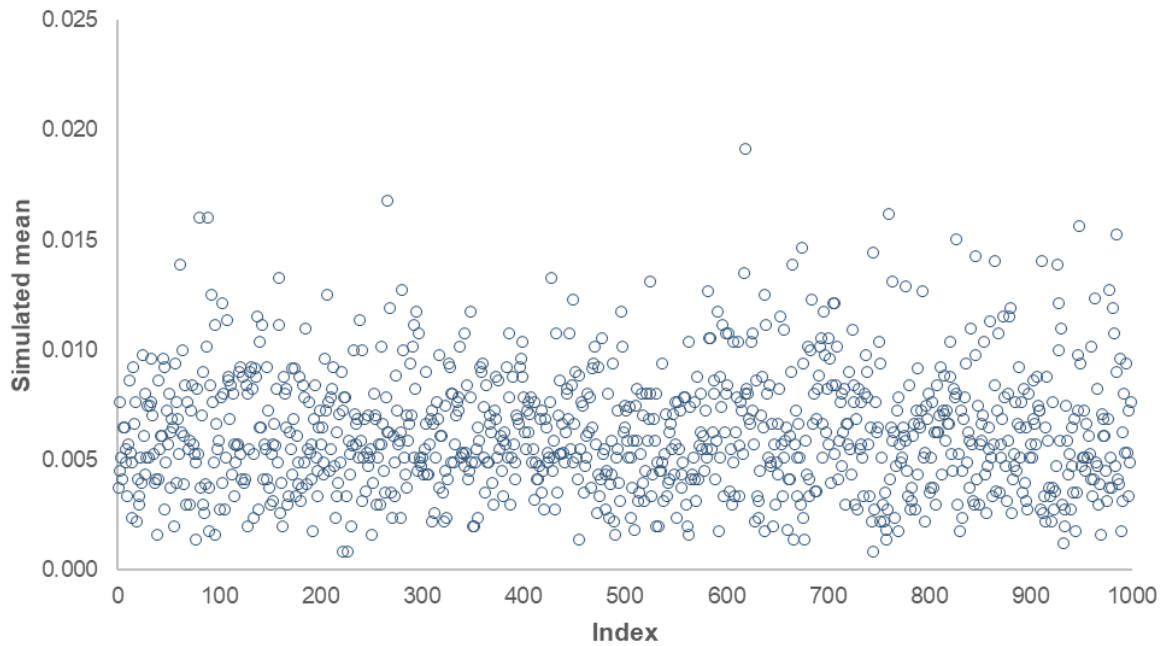


Figure 3.36: Bootstrapped Simulation (n = 1,000) of Mean Monthly Absolute Density for Minke Whale Across the Extended DAS Area

DAS Area

- 3.2.46 Estimated absolute density of minke whale (corrected for availability bias) for each survey over the DAS Area only (24-month DAS campaign) are presented in Figure 3.37 with bootstrapped 95% CI. A peak in estimated absolute density was observed in August 2022, with a maximal absolute density of 0.091 animals/km² (95% CLs = 0.036, 0.179). Low densities were observed across the survey campaign (0.000 animals/km² to 0.091 animals/km², CV = 1.964).
- 3.2.47 Data were therefore also plotted on a log₁₀ scale (Figure 3.14), displaying no clear seasonal pattern, with a clear peak in August 2023 (as seen on the linear scale in Figure 3.13).

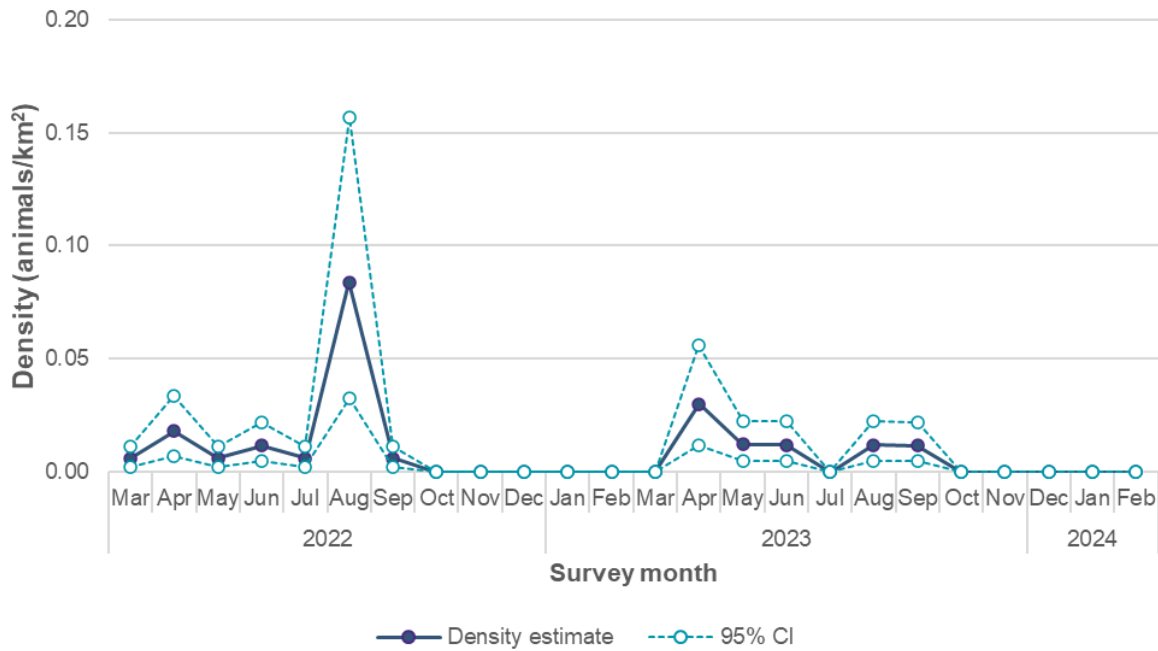


Figure 3.37: Estimated Absolute Density of Minke Whale (Corrected for Availability Bias) for Each Survey Over the DAS Area, With Bootstrapped 95% CI

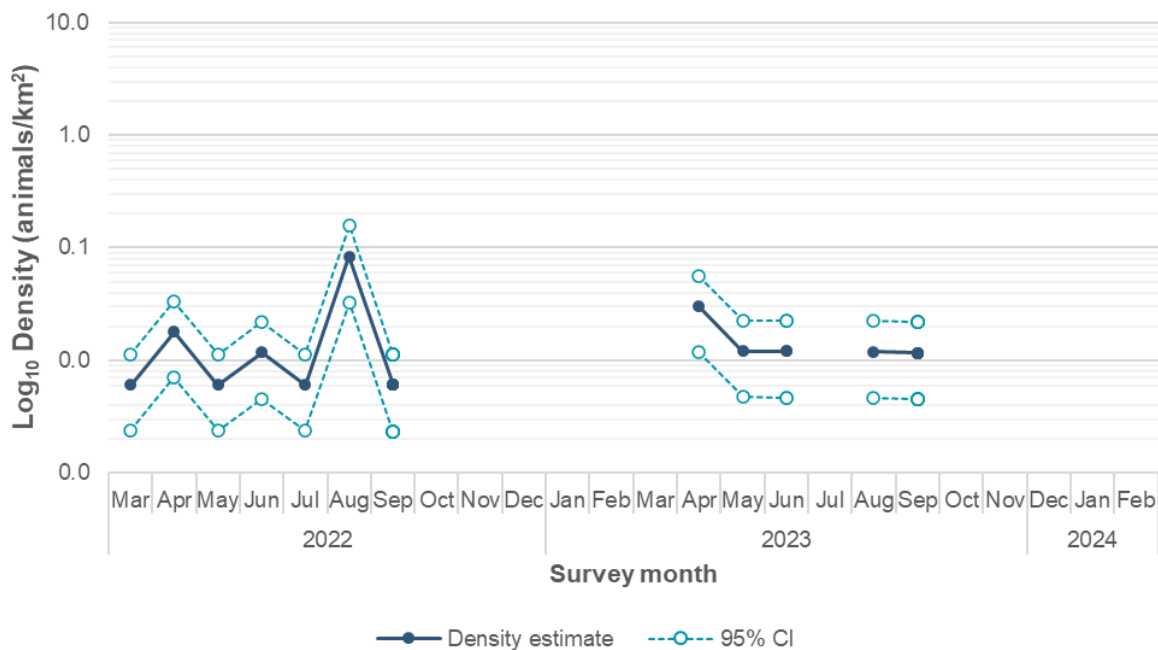


Figure 3.38: Estimated Absolute Density of Minke Whale (corrected for availability bias) for Each Survey over the DAS Area, With Bootstrapped 95% CI, Presented on a log₁₀ Scale

3.2.48 The overall mean absolute density of minke whale for the DAS Area, estimated from data pooled across all transects and all months for the 24-month DAS campaign (Table 3.17), was 0.010 animals/km² (95% CLs = 0.004, 0.018, CV = 1.964).

3.2.49 The maximal mean absolute density estimates for respective temporal divisions were:

- monthly: 0.052 animals/km² (95% CLs = 0.019, 0.096; CV = 1.060) (August);
and
- seasonal: 0.023 animals/km² (95% CLs = 0.008, 0.042; CV = 1.487)
(Summer).

Table 3.17: Design-Based Estimates for Mean Relative and Absolute Abundance and Density of Minke Whale for the DAS Area (24 Months of Survey), Across Monthly, Seasonal and Annual Scales

Temporal scale	Relative estimates		Absolute estimates				
	Mean abundance	Mean density (animals/km ²)	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Month							
January	0	0.000	0	0.000	0.000	0.000	-
February	0	0.000	0	0.000	0.000	0.000	-
March	3	0.001	7	0.003	0.001	0.006	1.414
April	23	0.012	53	0.026	0.010	0.048	0.355
May	9	0.004	20	0.010	0.004	0.018	0.471
June	12	0.006	26	0.013	0.005	0.024	0.010
July	3	0.001	7	0.003	0.001	0.006	1.414
August	46	0.023	104	0.052	0.019	0.096	1.060
September	9	0.004	20	0.010	0.004	0.018	0.459
October	0	0.000	0	0.000	0.000	0.000	-
November	0	0.000	0	0.000	0.000	0.000	-
December	0	0.000	0	0.000	0.000	0.000	-
Meteorological season							
Winter	0	0.000	0	0.000	0.000	0.000	-
Spring	12	0.006	27	0.013	0.005	0.024	0.893
Summer	20	0.010	46	0.023	0.008	0.042	1.487
Autumn	3	0.001	7	0.003	0.001	0.006	1.667

Temporal scale	Relative estimates		Absolute estimates				
	Mean abundance	Mean density (animals/km ²)	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Annual							
Year 1	11	0.006	25	0.013	0.005	0.025	0.810
Year 2	7	0.003	15	0.007	0.003	0.014	0.573
Overall	9	0.004	20	0.010	0.004	0.018	1.964

Extended DAS Area

- 3.2.50 Estimated absolute density of minke whale (corrected for availability bias) for each survey over the Extended DAS Area (i.e. April to August in 2022/2023) are presented in Figure 3.18 with bootstrapped 95% CI. The Extended DAS Area was surveyed only in April to August each year and therefore does not demonstrate seasonality.
- 3.2.51 A peak in estimated absolute density for the Extended DAS Area was observed in August 2022, with a maximal absolute density of 0.084 animals/km² (95% CLs = 0.033, 0.175). Due low densities and summer coverage only (range of absolute density = 0.000, 0.084; CV = 1.369), monthly trends are not always easy to interpret visually on a linear scale due to the large variation in values (Figure 3.39).
- 3.2.52 Data were therefore also plotted on a log₁₀ scale (Figure 3.40), where monthly variation is more apparent, however noting the Extended DAS Area was surveyed only in April to August each year and therefore does not demonstrate seasonality.

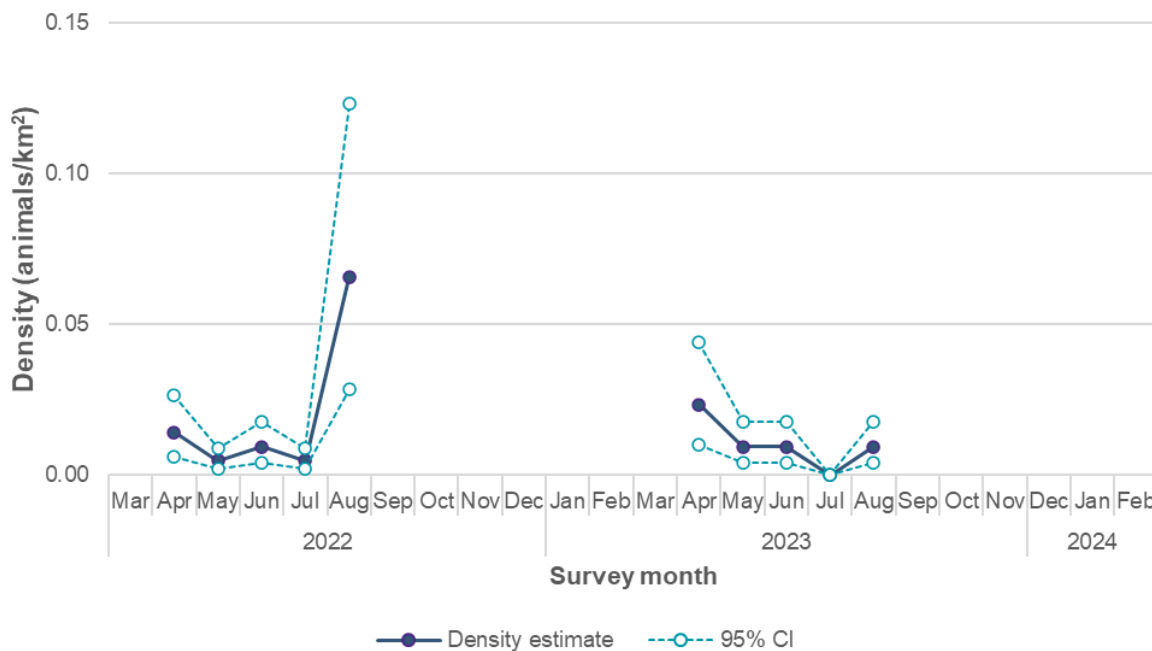


Figure 3.39: Estimated Absolute Density of Minke Whale (Corrected for Availability Bias) for Each Survey Over the Extended DAS Area, with Bootstrapped 95% CI

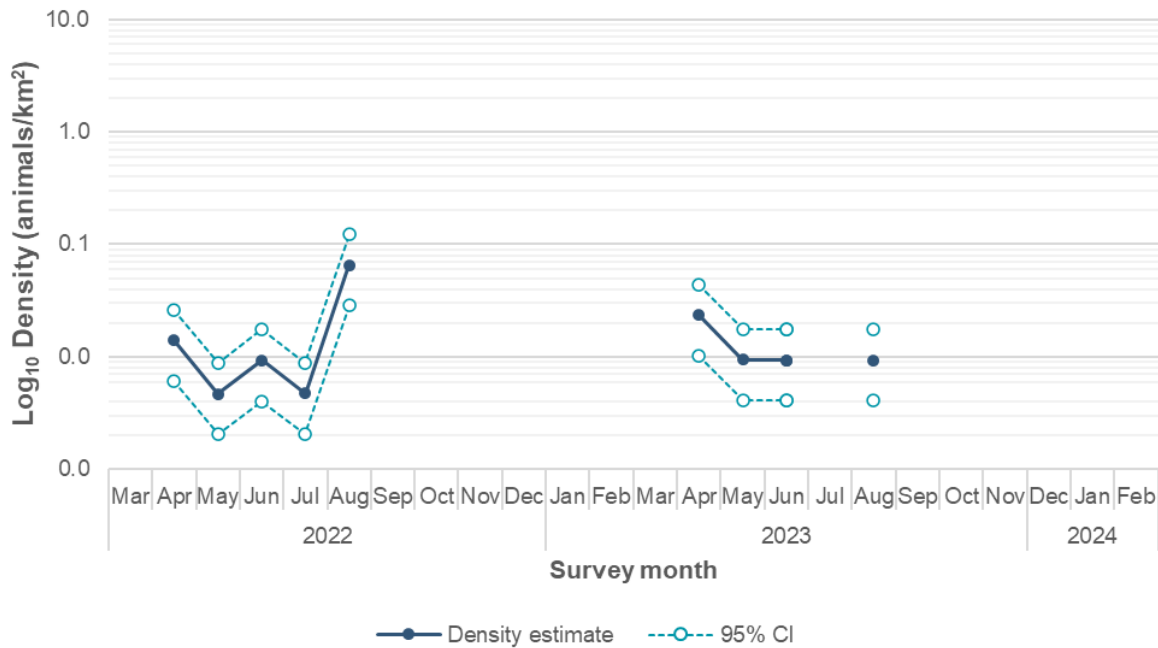


Figure 3.40: Estimated Absolute Density of Minke Whale (Corrected for Availability Bias) for Each Survey Over the Extended DAS Area, with Bootstrapped 95% CI, Presented on a log₁₀ Scale

- 3.2.53 The overall mean absolute density of minke whale for the Extended DAS Area, estimated from data pooled across all transects and all months for the Extended DAS Area (Table 3.18), was 0.018 animals/km² (95% CLs = 0.007, 0.034, CV 1.369).
- 3.2.54 The maximal mean absolute density estimates for respective temporal divisions:
- monthly: 0.047 animals/km² (95% CLs = 0.019, 0.089; CV = 1.131) (August); and
 - yearly: 0.024 animals/km² (95% CLs = 0.010, 0.051, CV = 0.552) ('Year 1').

Table 3.18: Design-Based Estimates for Mean Relative and Absolute Abundance and Density of Minke Whale for the Extended DAS Area, Across Monthly and Annual Scales

Temporal scale	Relative estimates		Absolute estimates				
	Mean abundance	Mean density (animals/km ²)	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Month							
January	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-
April	26	0.009	59	0.021	0.009	0.040	0.158
May	9	0.003	20	0.007	0.003	0.014	0.471
June	15	0.005	33	0.012	0.005	0.022	0.289
July	3	0.001	7	0.002	0.001	0.005	1.414
August	58	0.021	130	0.047	0.019	0.089	1.131
September	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-
Annual							
Year 1	30	0.011	68	0.024	0.010	0.051	0.552
Year 2	14	0.005	32	0.011	0.004	0.023	0.299
Overall	22	0.008	50	0.018	0.007	0.034	1.369

4 Summary

- 4.1.1 This report provides a summary of estimated marine mammal distribution recorded during the 24 months of DAS data collection, between March 2022 and February 2024 across the DAS Area, encompassing the E3 POA plus 12 km buffer. Overall mean absolute density and abundance, estimated for all species across the 24-month DAS campaign for the DAS Area, is summarised in Table 4.1.
- 4.1.2 A mean coverage of 17.32% (345.08 km²) of the DAS Area (1,991.59 km²) was processed by APEM across the 24 months of the DAS campaign, with a minimum coverage of 16.44% (327.39 km²) in November 2023 and a maximum coverage of 17.68% (352.11 km²) in June 2022 (Table 3.1).
- 4.1.3 This report also provides a summary of estimated marine mammal distribution recorded during the summer months over the Extended DAS Area, between April and August 2022 and 2023. Overall mean absolute density and abundance, estimated for all species across the summer Extended DAS campaign, is summarised in Table 4.1.

Table 4.1: Summary of Overall Mean Absolute Density and Abundance, Estimated Across 24 Months of DAS Data Collected Over the DAS Area

	Mean abundance	Mean density (animals/km ²)	Lower 95% CL	Upper 95% CL	CV
Harbour porpoise					
Design-based analysis	1,266	0.635	0.361	1.039	1.290
Model-based analysis	1,156	0.580	0.365	0.856	0.724
Grey seal					
Design-based analysis	239	0.120	0.081	0.161	0.852
Model-based analysis	219	0.056	0.11	0.201	1.117
White-beaked dolphin					
Design-based analysis	335	0.168	0.048	0.316	2.068
Model-based analysis	311	0.156	0.084	0.286	1.250
Minke whale					
Design-based analysis	20	0.010	0.004	0.018	1.964
Model-based analysis	Model-based analysis not possible for minke whale				

Table 4.2: Summary of Overall Mean Absolute Density and Abundance, Estimated Across a Total of 10 Months of DAS Data Collected Over the Extended DAS Area

Species	Mean abundance	Mean density (animals/km²)	Lower 95% CL	Upper 95% CL	CV
Harbour porpoise	1,993	0.698	0.336	1.182	1.110
Grey seal	920	0.332	0.106	0.706	1.644
White-beaked dolphin	673	0.243	0.061	0.499	1.680
Minke whale	50	0.018	0.007	0.034	1.369

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