BERWICK BANK WIND FARM
OFFSHORE ENVIRONMENTAL IMPACT ASSESSMENT

ANNEX A: MARINE MAMMAL AERIAL SURVEY DATA INTERIM DATA ANALYSES

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1. INTRODUCTION

1. Berwick Bank Wind Farm Limited (BBWFL) is a wholly owned subsidiary of SSE Renewables Limited (hereafter referred to as SSER) and will hereafter be referred to as 'the Applicant'. The Applicant is proposing the development of the Berwick Bank Wind Farm Project (hereafter referred to as the 'Proposed Development'), an offshore wind farm off the east coast of Scotland. The Proposed Development array area is located in the outer Firth of Forth and Forth of Tay, approximately 38 km east of the Scottish Borders coastline (St Abb's Head) and 48 km to the East Lothian coastline. The Proposed Development array area will be connected to a Scottish Power Energy Networks (SPEN) substation at Branxton via a Proposed Development export cable corridor.

2. To inform the baseline for marine mammals and offshore ornithology, the Applicant has commissioned aerial surveys, to be undertaken by HiDef, across the Proposed Development array area, plus an appropriate buffer. The aerial surveys commenced in March 2019 and were undertaken monthly, with a total of 25 months of data collected up until April 2021.

3. The extent of the aerial survey area provides an indication of marine mammal activity over the Proposed Development array area and beyond and therefore will be useful to determine where Zones of Influence (ZoIs) for some impacts associated with the Proposed Development extend further than the Proposed Development array area (although may not cover the full extent of the ZoI for all impacts e.g. piling noise). The aerial survey area also covers the offshore section (area beyond 12 nm from the coast) of the Proposed Development export cable corridor. Marine mammal data collected during these aerial surveys complements the existing site-specific boat based survey data that is available and was collected for the former Firth of Forth Zone during December 2009 to November 2011 as well as other published data sources for the region.

2. METHODOLOGY

2.1. STUDY AREA

4. The study area for the aerial surveys was delineated as the boundary of the Proposed Development array area plus an approximate 16 km buffer (hereafter referred to as the 'aerial study area')[1]. This whole area, including the buffer, is henceforth referred to as the 'aerial survey area' and will inform the baseline for those impacts which may potentially extend beyond the boundaries of the Proposed Development array area. The aerial survey area covers a total area of 4,980 km^2 (Figure 2.1).

2.2. SURVEY APPROACH

5. Aerial surveys of seabirds and marine mammals commenced in March 2019 and continued monthly until April 2021 to allow 25 months of data collection including any additional surveys to account for 'missing transects' within the data set (see section 2.5.2).

6. The surveys were conducted by HiDef from an aircraft, flying at an operational speed of 220 km per hour (equivalent to 120 kn) at a survey height of approximately 550 m above sea level (ASL). The aircraft was equipped with four HiDef Gen II cameras with a set resolution of 2 cm ground sample distance (GSD) and at an altitude of 550 m. Each camera surveyed a strip width of 125 m. The cameras were set such that a gap of approximately 20 m between the strips was maintained thereby ensuring that there was no overlap between the strips. For four cameras there was therefore a combined survey width of 500 m.

7. A total of 37 transects were spaced 2 km apart across the aerial survey area. The transects followed the routes shown in Figure 2.1. Position data for the aircraft was recorded using a Garmin Global Positioning System (GPS) Map 296 receiver with differential GPS to give 1 m accuracy and allowed recording updates at one second intervals to match to bird and marine mammal observations.

8. The total length covered by the transects each month was approximately 2,490 km. Data from two cameras (0.25 km combined width) were subsampled to provide a minimum target of 10% coverage of the total aerial survey area and optimal target of 12.49% coverage (~620 km^2).

[1] The aerial study area has been defined based on the array boundaries which were available at the Berwick Bank Wind Farm Offshore Scoping Report was produced (SSER, 2021a). The Proposed Development array area has been subsequently amended and reduced in size, however, the aerial study area remains the same and therefore the buffer may extend further than 16 km in some areas.

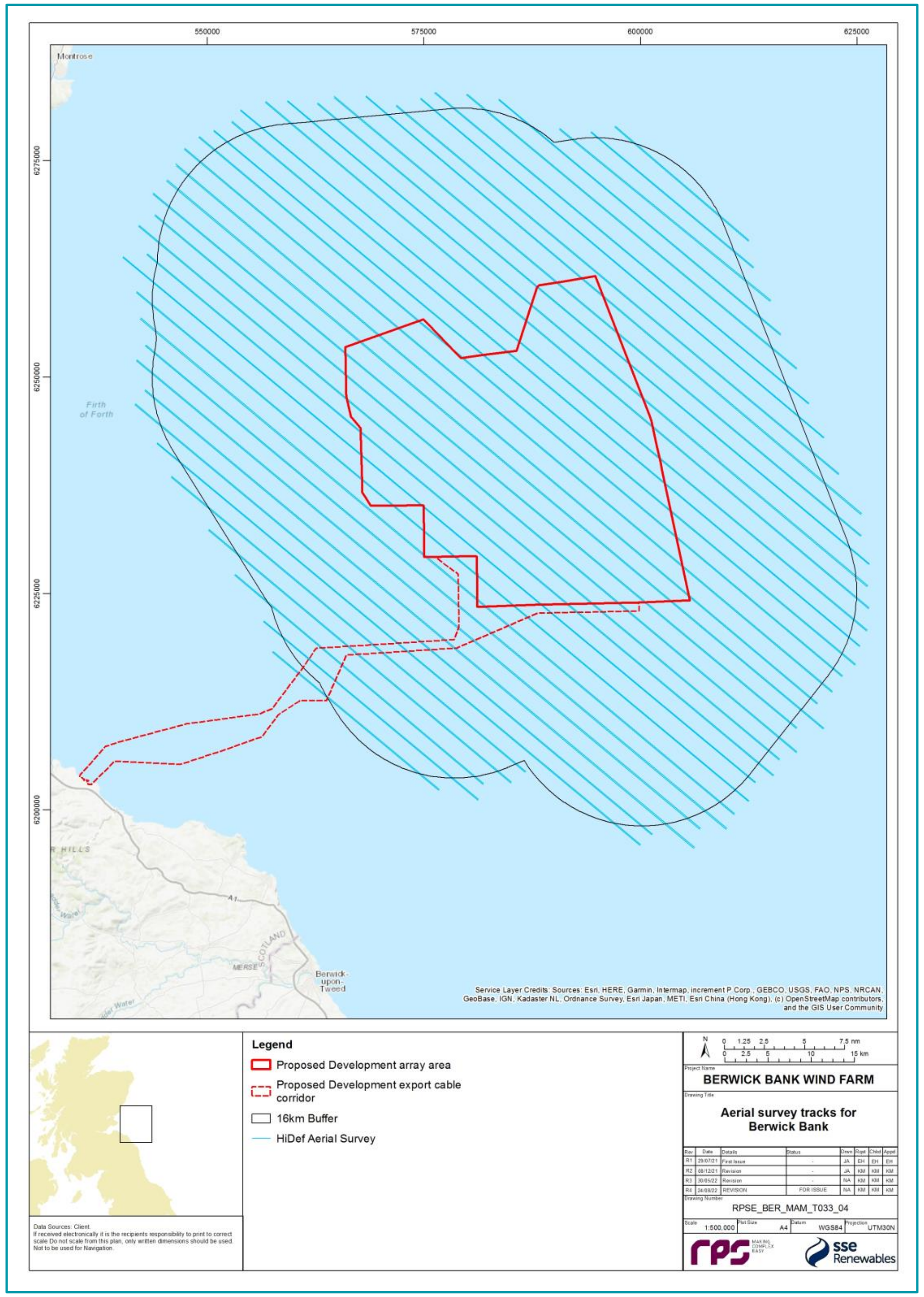


Figure 2.1: Strip Transects at 2 km Spacing for Monthly Site-Specific Aerial Surveys Across the Aerial Survey Area (March 2019 to April 2021)

2.3. PROCESSING OF AERIAL DATA

9. Digital aerial imagery, collected via the high definition cameras, was reviewed by a team of trained and experienced professionals within HiDef, using high resolution viewing screens. Objects were marked, and their location recorded, before being passed to the second stage of species identification. Here, experienced marine surveyors used high definition digital imagery to identify each marked object to species level where possible. Other features (such as fixed structures, fishing vessels, dredgers, construction vessels, ferries, yachts or recreational vessels, etc.) were also recorded.

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

11. For marine mammals, surveyors assigned the following classifications to each image:

- 'surfacing at red line': the dorsal fin (cetaceans) or head (pinnipeds) was above the water surface in the middle frame of the video sequence;
- 'surfacing': part of the animal appeared above the water surface in any of the frames, but not the dorsal fin or head in the middle frame of the sequence;
- 'submerged': no part of the animal appeared above the surface in any of the frames; or
- 'unknown': it was not fully clear from the footage whether an animal was surfacing or just submerged.

12. A qualitative measurement of the confidence in the identification was also provided as follows:

- 'definite': as certain as is reasonably possible;
- 'probable': very likely to be this species or species group; or
- 'possible': more likely to be this species or species group than anything else.

13. An additional 'blind' review was undertaken on a subset (20%) of the data as part of HiDef's Quality Assurance (QA) process. The reviewed data was compared to the original and if there was less than 90% agreement then all the data were re-reviewed.

14. All data were geo-referenced, taking into account the offset from the transect line of the cameras, which gives a higher degree of positional accuracy to each geo-referenced object. These were compiled into a single output. Geographical Information System (GIS) files for the 'Observation' and 'Track' data were provided by HiDef in ArcGIS shapefile format, using UTM30N projection, WGS84 datum.

15. On receipt of the georeferenced aerial survey data, an additional QA on the data was carried out by RPS. Track lines for each camera reel were plotted in GIS and the total effort was subsequently calculated for each transect flown and compared with the minimum target of 10.0% coverage (optimal coverage of 12.49%) of the aerial survey area. Where the optimal coverage was not met, further detail was sought from HiDef to understand why this was the case. In addition, the marine mammal sightings data were reviewed and any anomalies were highlighted and discussed with HiDef to validate the data. Further detail is provided in section 3.1.1 (Table 3.1).

2.4. DATA ANALYSES

2.4.1. SUMMARY STATISTICS

16. Summary statistics were produced to describe the data for each of the key species or species groups within the aerial survey dataset. As described in paragraph 15, data were presented to show the survey effort achieved in each month of survey against the minimum target of 10.0% coverage and the optimal

coverage of 12.49% coverage of the aerial survey area, and a description of any remedial action taken to address data gaps from delayed surveys was given.

17. Raw count data for each of the species or species groups was presented for each month of survey to highlight the frequency of sightings in each identification category. These raw count data were also spatially mapped in GIS to illustrate the distribution of sightings across the aerial survey area.

18. Further summary data were also produced to describe the number of sightings that fell into the different surfacing classifications (paragraph 11) and the different confidence classifications (paragraph 12).

19. Sightings data were effort corrected in each month of the survey to show counts per unit effort (i.e. per km of trackline flown) and are referred to as ‘encounter rate’. These effort-corrected data allowed comparisons across months where different effort occurred; for example, for months which included weather downtime.

2.4.2. DENSITY ESTIMATES WITH BOOTSTRAPPING

20. For those species where there were sufficient sightings, seasonal relative densities were estimated from the count data. To provide estimates of relative density and associated variance, the data were analysed using a non-parametric bootstrap approach with replacement (Buckland *et al*., 2001). Bootstrapping is a commonly applied approach to produce an approximate distribution of the empirical data, particularly where the sample size is insufficient for straightforward statistical inference. The resampling generates a probability distribution which is subsequently used to produce estimates of accuracy (e.g. standard errors, confidence intervals). Mean monthly densities were resampled with replacement (1,000 times) to generate an estimated value for overall uncorrected density (D) and upper and lower 95% confidence intervals (CIs) for the aerial survey area.

21. Density estimates with bootstrapping were undertaken for grey seal *Halichoerus grypus* with the inclusion of data for ‘seal species’ on the assumption that most seals within the site were likely to be grey seal. This is supported by the at-sea maps (Russell *et al.,* 2017) and telemetry data (Sinclair, 2021) which showed that grey seals are more likely to use the offshore waters in the vicinity of the Proposed Development whilst harbour seal *Phoca vitulina* densities are very low in the offshore areas (see section 6.3 of the Marine Mammal Technical Report). Note that telemetry data suggest that there is some movement of harbour seals within the very north-west of the Proposed Development array area (closest boundary to the Firth of Tay and Eden Estuary) and therefore the presence of this species has not been discounted only that there are insufficient data to allow density estimates in this report.

2.4.3. MODEL-BASED DENSITY ESTIMATES

22. Data were imported into R v1.4.1717 (R Core Team, 2021) and the MRSea package (Scott-Hayward *et al*., 2013a) was used in the analysis to best predict the density of marine mammals within the aerial survey area: Proposed Development array area plus ~16 km buffer. To account for the missing data appropriately, a Spatially Adaptive Local Smoothing Algorithm (SALSA; (Walker *et al.,* 2010) was used within MRSea (Scott-Hayward *et al*., 2013a; 2013b). This approach allowed us to adjust for the presence of missing data by (a) exploiting empirical relationships between abundance and other variables (depth and distance to coast) and (b) exploiting commonalities between distributions in different months.

23. Originally it was proposed that months were modelled separately, however this approach failed due to data being too sparse to fit MRSea models. Data was pooled across months within seasons (winter: December, January and February; spring: March, April and May; summer: June, July, August; and autumn: September, October and November) to overcome this issue, incorporating the biological assumption that species behave similarly within each season. The following covariates were used within modelling to predict species distribution:

- bathymetry;
- distance to coast;
- X and Y coordinates; and
- season.

24. The degree of smoothing for each species and season was determined within the MRSea software using tenfold cross validation and the best model was used to predict species distribution. To reduce instance of edge effects near the edge of the aerial survey area, output maps were clipped to a smaller area: Proposed Development array area plus ~12 km buffer. Within each of the models, separate maps with associated 95% lower and upper confidence intervals were also produced for each species and season.

25. Before any analyses could take place, the data had to be pre-processed to ensure no transects start or end times/locations differed (start and end times/locations were within both 10 seconds and 600 m of each other). In 14 cases this deviation occurred and so were removed from further analysis. One transect also had missing start/end times and so was also removed. Data from reel ref 13-03-37.333 related to different cameras on the same survey and so was removed. In total, 903 transects were used in the analysis, these transects covered a total aerial survey area of 15,658.32 km^2 (Figure 2.2). The spatial coverage of the monthly surveys used in analysis is shown in Figure 2.3.

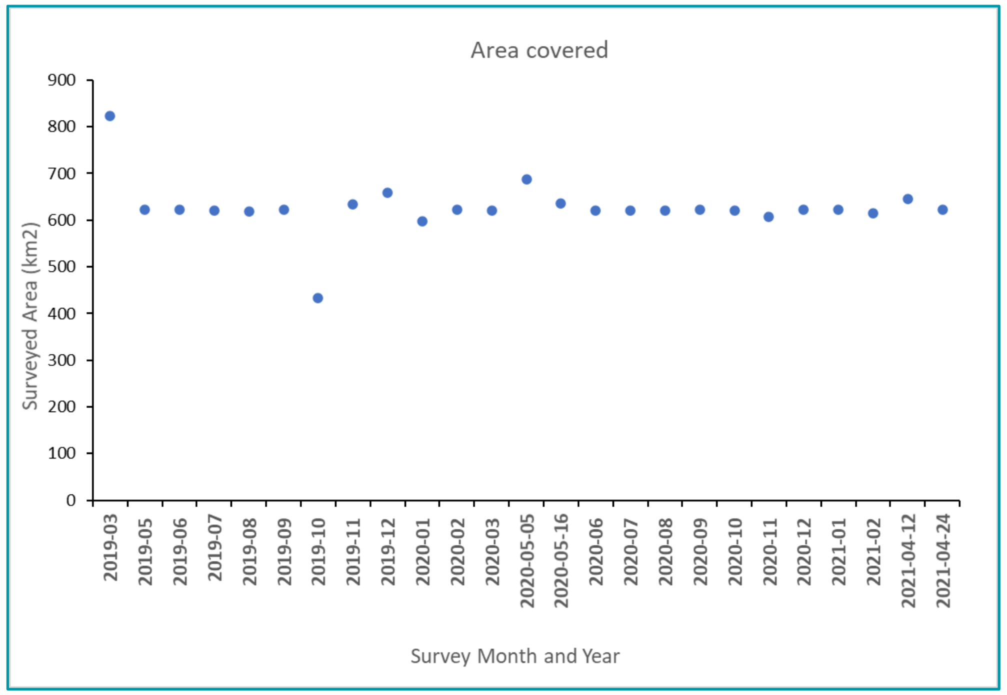
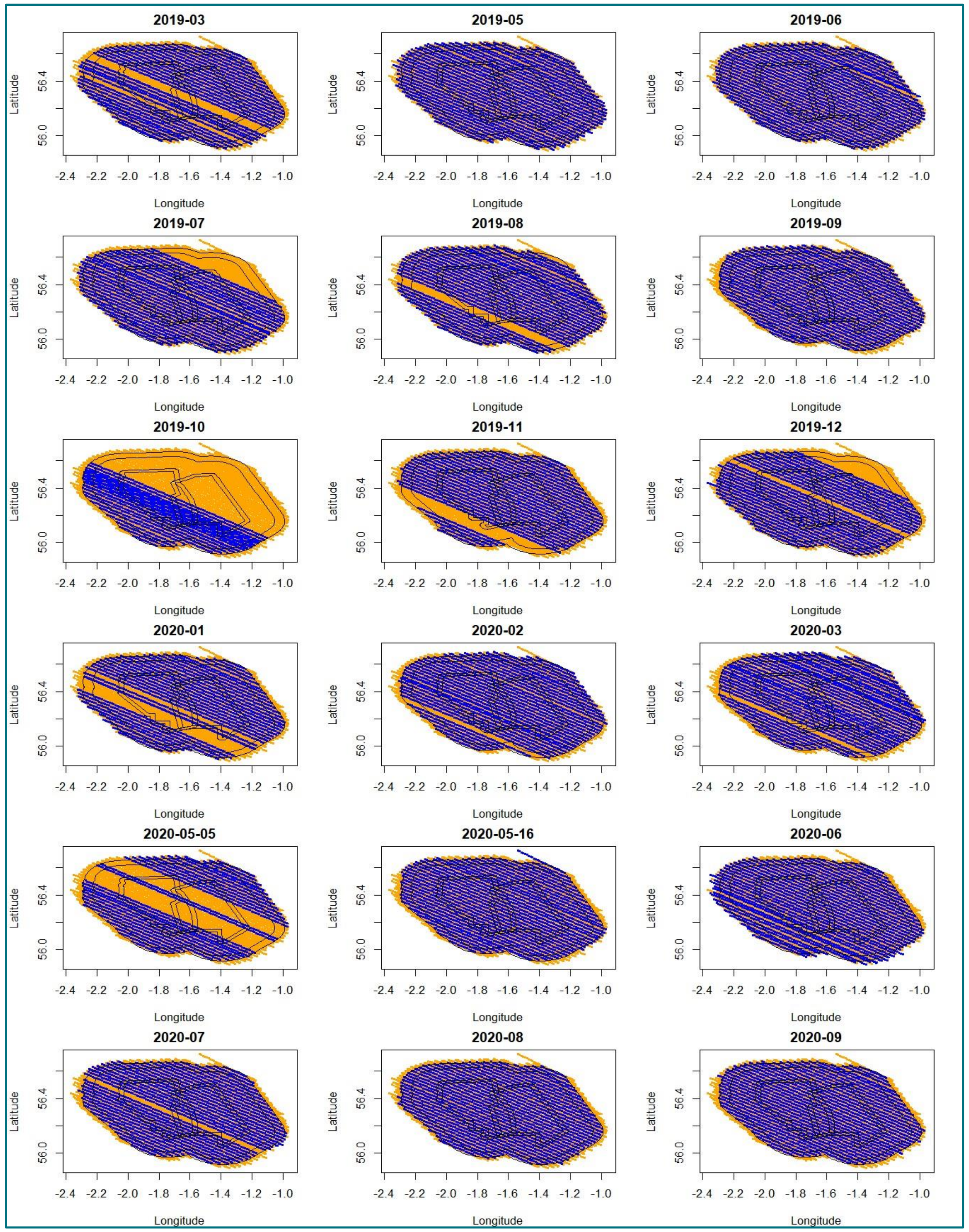
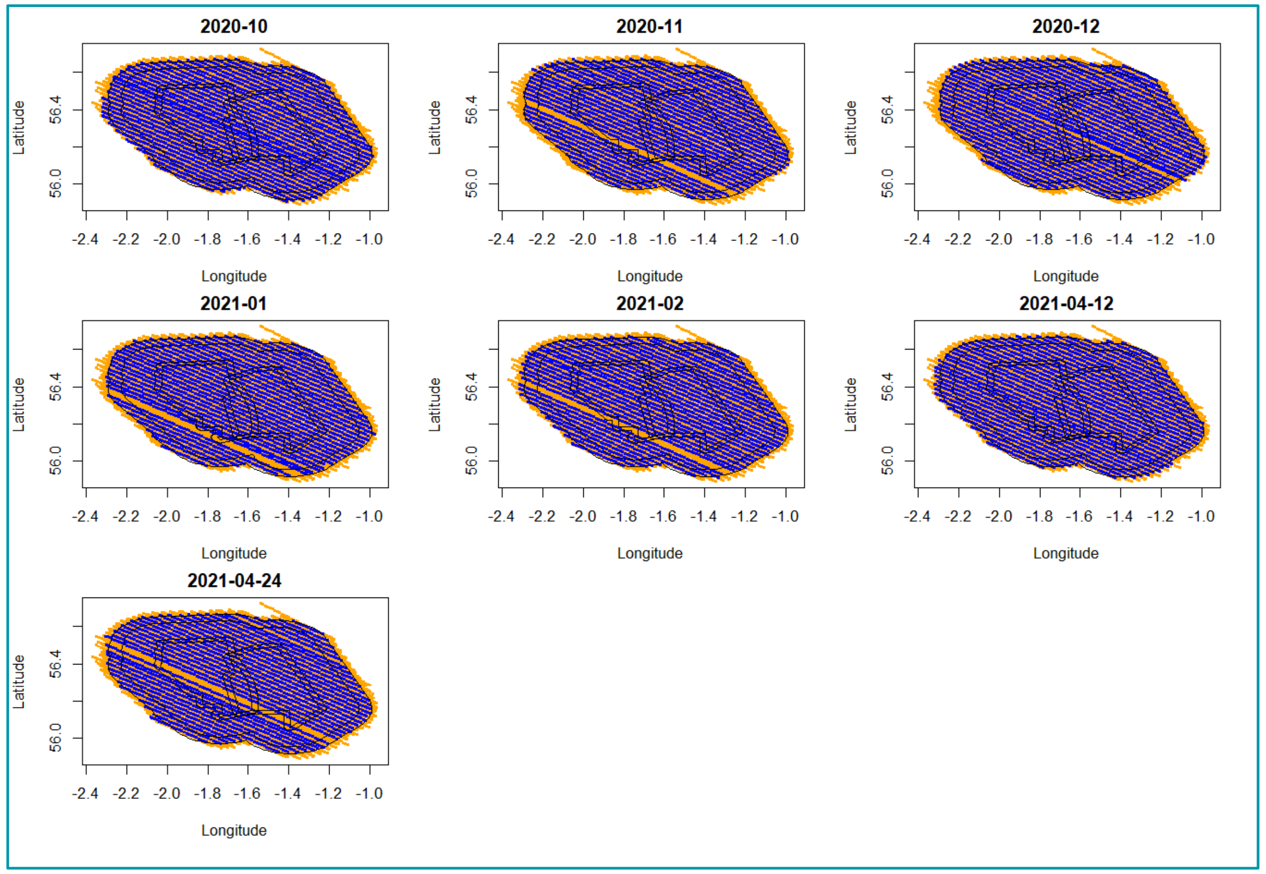


Figure 2.2: Transect Coverage for Each Month Used Within the Analysis





Note: Points surveyed in any month are shown in orange, points surveyed in the month of focus in blue. The footprint boundaries of the original Berwick Bank and Marr bank wind farms (which have now been superseded) (without buffer and plus 2 km buffer) are shown in black. Buffers of ~12 km and ~16 km around initial Berwick Bank Wind Farm Proposal and the Marr Bank Wind Farm Proposal Study Areas) are shown at the edge of the study area.

Figure 2.3: Levels of Missing Data in Each Monthly Survey (with Deviated Transects Removed)

26. For the purposes of modelling, the transects were split into 1 km sections (with a final section of less than 1 km on each transect, to make sure no data were omitted). The number of records for each species (across cameras) was then summed within each of these sections. To perform this aggregation, each record was mapped on to the nearest point of the transect line (i.e. the straight line between the transect start and transect end locations). Records did not always lie directly on this line and the distribution of distances between records, and the nearest point on the (camera-specific grey) transect line is shown in Figure 2.4.

27. After removing the 15 transects, a total of 1,994 records of harbour porpoise *Phocoena phocoena* and 619 records of grey seal plus seal species (see paragraph 21) were used to predict densities within the initial Berwick Bank Wind Farm Proposal and the Marr Bank Wind Farm Proposal survey sites.

28. Mean seasonal abundance estimates were calculated using the summed density estimates within square kilometre grid cells. Rather than do this for the clipped area (i.e. Proposed Development array area plus

~12 km buffer) the data were scaled back up to the Proposed Development array area plus ~16 km buffer based its' total area of 4,980 km^2.

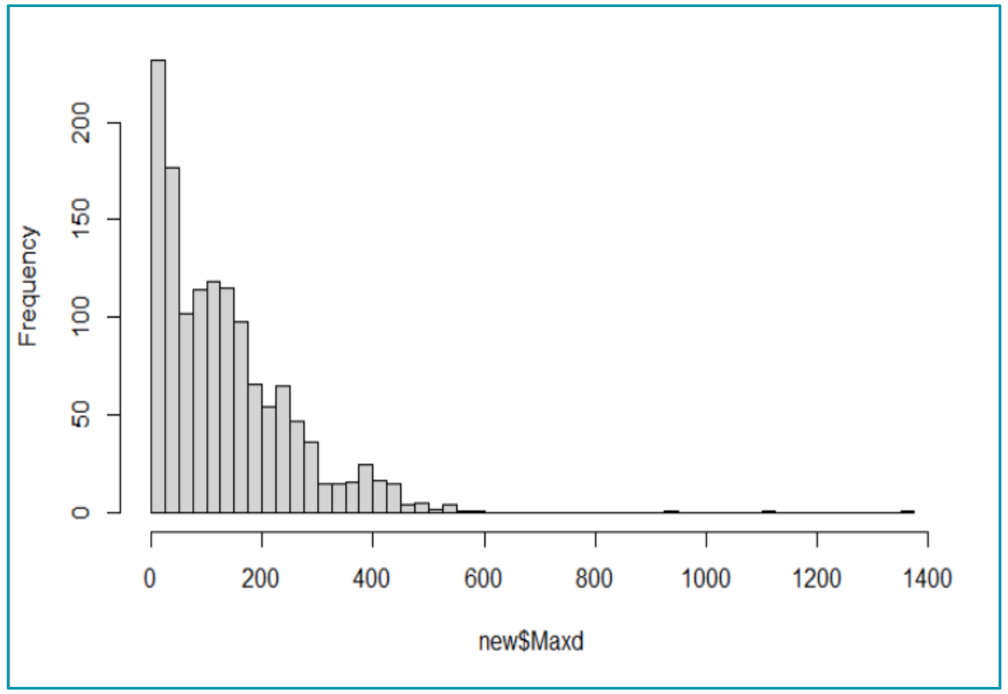


Figure 2.4 Distances from Harbour Porpoise and Seal Records to the Nearest Point on the Straight Line Between the Camera Specific Transect Start and Transect End Point

2.4.4. CORRECTION FACTORS

29. Noting that the density estimates are relative and do not account for availability bias during the video surveys (see section 2.5.3) a literature review was undertaken to determine appropriate correction factors for the key species. Further detail on the correction factors is provided in section 3.5 on a species-by-species basis.

2.5. DATA LIMITATIONS

2.5.1. SNAP SHOT DATA

30. 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. However, for the Marine Mammal Technical Report the aerial survey data will be interpreted in the context of previous monthly boat-based survey data collected for the former Firth of Forth Zone and in the context of historic published information available for this region, therefore providing a robust baseline.

2.5.2. DELAYED SURVEYS AND MISSED TRANSECTS

31. Logistical issues and/or Covid-19 restrictions also prevented the survey being flown in some months (April 2019, January 2020 and April 2020) or resulted in very incomplete surveys (January 2021). Remedial measures to improve the data set were made including a survey in February 2020 to replace the delayed January 2020 survey, an additional survey in early May 2020 to represent the delayed April 2020 survey and an additional survey later in January 2021 to replace the incomplete first January survey. Furthermore, the survey programme was subsequently extended to include two surveys flown in April 2021 to provide two additional data sets for the month of April.

32. For those months where the target trackline could not be achieved (e.g. due to weather downtime), where possible, the data from other cameras for transects adjacent to the missed area were processed to provide additional data for the aerial survey zone as a whole.

2.5.3. BIAS

33. 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.

34. 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 (see section 3.1.3), 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.

35. Estimates of availability bias during aerial surveys are often based on studies looking at diving behaviour of a species, which provide a correction factor for the proportion of time that animals are under the sea surface and therefore not available for detection. For the purpose of this assessment, correction factors were derived from studies in both the North Sea and other regions (e.g. harbour porpoise diving behaviour in the Baltic and North Seas; grey seal diving behaviour in the North Sea) (see sections 3.5.2 and 3.5.3). The caveat here is that species correction factors are unlikely to be a true representation of availability bias from one region to another, or from one month to the next, due to the potential spatial and temporal differences in environmental conditions. However, a precautionary approach was taken by reviewing the literature to compare correction factors from different studies and different months and then applying a conservative estimate (see section 3.5).

36. Perception bias – where an animal is available for detection, but the detection is missed – is less of a limiting factor during digital aerial surveys compared to visual boat based surveys since the high definition video utilised during digital aerial surveys captures all animals on the sea surface, or just under the sea surface, and the detection is not influenced by the ability of an observer to detect an animal. In addition, during data processing, a 20% subsample of the data were quality assured to ensure that images were not overlooked and therefore the potential for perception bias is negligible (see section 2.3).

37. 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.

2.5.4. SPECIES IDENTIFICATION

38. Animals were identified first to a species group (e.g. seals) and then to species level where possible (for example grey seal or harbour seal). For seals, the identification to species level is more difficult as it is not always possible to distinguish between species where an individual is submerged. A subsample of data was subject to an external QA process by a third-party marine mammal expert to ensure agreement in identification. Where a full species identification could not be made, rather than discarding data, where possible the animal sighting was assigned to a species based on the representation of the key species within the aerial survey area (see paragraph 56).

3. RESULTS

3.1. SUMMARY DATA

3.1.1. SURVEY EFFORT

39. A summary of the survey effort in terms of transect lengths flown compared to the target coverage, is presented in Table 3.1. Table 3.1 also provides reasons where target coverage was not met, and the remedial action taken to address data gaps.

Table 3.1: Monthly Survey Effort Across the Aerial Survey Area (Minimum Target of 10.0% Coverage; Optimal Target of 12.49% Coverage)

Date	Sum of Transect Lengths Reviewed and ID'd (km)	Area Covered Based on 125 m Strip Width (km^2)	Percentage of Aerial Survey Area Covered (%)	Notes on Missing Transects and Remedial Action Taken for Data Gaps
28 March 2019		825.28	16.57	Optimal target coverage achieved. Two transects missed due to camera fault.
April 2019	-	-	-	Survey not undertaken due to poor weather during scheduled survey dates. Survey extended to April 2021.
14 May 2019	2492.69	623.17	12.51%	Optimal target coverage achieved.
21 June 2019	2488.6	622.15	12.49%	Optimal target coverage achieved.
23 July 2019	2095.22	621.15	12.47%	Optimal target coverage achieved. Eight transects missed in the north of the aerial survey area (time lost due to industrial action at airport) therefore additional camera data from two adjacent transects were processed.
06 August 2019	2307.8	618.96	12.43%	Optimal target coverage achieved. Two transects missed in the southern half of the aerial survey area.
15 September 2019	2489.89	622.47	12.50%	Optimal target coverage achieved.
17 October 2019	1890.5	655.7	13.17%	Optimal target coverage achieved. 12 transects missed in north of the aerial survey area (time lost due to industrial action at airport). Additional camera data analysed.
19 November 2019	2188.78	633.47	12.72%	Optimal target coverage achieved. Four transects missed due to aircraft being stalled at Dundee airport leading to late start.
07 December 2019	2247.63	663.21	13.32%	Optimal target coverage achieved. 12 transects missed therefore additional cameras analysed.
05 February 2020*	2050.5	597.44	12.00%	Minimum target coverage achieved. Four transects missed due to technical issue with the aircraft.
19 February 2020	2487.25	621.81	12.49%	Optimal target coverage achieved.
21 March 2020	2393.62	598.41	12.02%	Minimal target coverage achieved.
April 2020	-	-	-	Survey not undertaken due to Covid-19 restrictions.
05 May 2020**	1758.89	704.53	14.15%	Optimal target coverage achieved. Eight transects not flown due to technical issues with aircraft therefore additional cameras analysed.
16 May 2020	2488.9	622.23	12.49%	Optimal target coverage achieved.
09 June 2020	2485.35	621.34	12.48%	Optimal target coverage achieved.
12 July 2020	2484.53	621.13	12.47%	Optimal target coverage achieved.
09 August 2020	2485.3	621.33	12.48%	Optimal target coverage achieved.
06 September 2020	2487.12	621.78	12.48%	Optimal target coverage achieved.
16 October 2020	2485.51	621.38	12.48%	Optimal target coverage achieved.
05 November 2020	2486.1	621.52	12.48%	Optimal target coverage achieved.
01 December 2020	2486.86	621.72	12.48%	Optimal target coverage achieved.
17 January 2021	-	-	-	Insufficient survey coverage therefore survey repeated.
19 January 2021	2486.71	621.68	12.48%	Optimal target coverage achieved.
16 February 2021	2482.62	620.66	12.46%	Optimal target coverage achieved.
12 April 2021	2489.56	622.39	12.50%	Optimal target coverage achieved.
24 April 2021	2487.17	621.79	12.48%	Optimal target coverage achieved.

[*]For the purposes of analyses the 05 February 2020 dataset will serve as the dataset for January 2020.

**For the purposes of analyses the 05 May 2020 dataset will serve as the dataset for April 2020.

3.1.2. SPECIES COUNTS

40. Harbour porpoise accounted for the highest number of sightings identified to species level (based on raw count data) across the aerial survey area and was recorded in all survey months (Table 3.2). Grey seal accounted for the second highest number of sightings and was recorded in all but one month over the survey period. For other sightings identified to species level – minke whale *Balaenoptera acutorostrata* and white-beaked dolphin *Lagenorhynchus albirostris* – both the number and frequency of sightings was small, Table 3.2). There were also a number of cetacean sightings that could not be assigned to species level, although the numbers of these sightings were also low. Similarly, as described previously there were a large number of sightings classified as 'seal species' due to the issue of identifying to species level from aerial survey data. For the purposes of further analyses these were assigned to grey seal as this was the most commonly occurring seal species across the aerial survey area (see paragraph 21).

Table 3.2: Monthly Raw Sightings Data (Number of Animals) (Uncorrected for Effort) Across the Aerial Survey Area

Month	Harbour Porpoise	Minke Whale	White-beaked Dolphin	Bottlenose Dolphin *Tursiops truncatus*	Grey Seal	Harbour seal	Cetacean Species	Seal/Small Cetacean Species	Seal Species	Total
28 March 2019	38				1			1	10	**50**
14 May 2019	181	6			16			6	65	**274**
21 June 2019	57	1	6		4			2	17	**87**
23 July 2019	54	13	3		9		1		13	**93**
06 August 2019	28	2			7				6	**43**
15 September 2019	20		4		6		3	3	7	**43**
17 October 2019	25			1	12		1	5	13	**57**
19 November 2019	14				1				9	**24**
07 December 2019	3				1			2	6	**13**
05 February 2020*	9				2		6		2	**20**
19 February 2020	12				4			1		**17**
21 March 2020	11						1		3	**15**
05 May 2020**	475	3			3			2	16	**499**
16 May 2020	24	1			3			2	3	**33**
09 June 2020	58		1		7		1	2	32	**101**
12 July 2020	77	13	7		7			1	20	**125**
09 August 2020	39	5			7				25	**76**
06 September 2020	80	3	24		11			4	68	**190**
16 October 2020	15				11		1	2	17	**46**
05 November 2020	17	1			4			1	10	**33**
01 December 2020	46				9			6	31	**92**
19 January 2021	38				8	1		1	33	**81**
16 February 2021	39				2	1		2	11	**55**
12 April 2021	149			6	12			4	9	**180**
24 April 2021	525	9			33	1		5	38	**611**
TOTALS	**2034**	**57**	**45**	**7**	**180**	**3**	**14**	**54**	**464**	**2858**

*For the purposes of analyses the February 2020 dataset will serve as the dataset for January 2020.

**For the purposes of analyses the 5 May 2020 dataset will serve as the dataset for April 2020.

3.1.3. SURFACING CATEGORIES

41. During winter months (December, January and February) and early spring (March) the numbers of sightings based on submerged animals were lower compared to sightings of animals on the surface ('surfacing' or 'surfacing at red line') (Figure 3.1). In contrast, for most other months, the number of sightings based on animals submerged or on the surface are not dissimilar. In September 2019 and April 2020 the number of sightings based on submerged animals were higher compared to surfacing animals. Whether these seasonal differences are related to water clarity at different times of year is unknown as there were no data available on turbidity at the times of the aerial surveys. However, it is considered likely that as water clarity decreases (e.g. during winter months), the depth at which an animal is able to be detected would decrease and therefore the proportion of animals recorded when submerged would also decrease during those months.

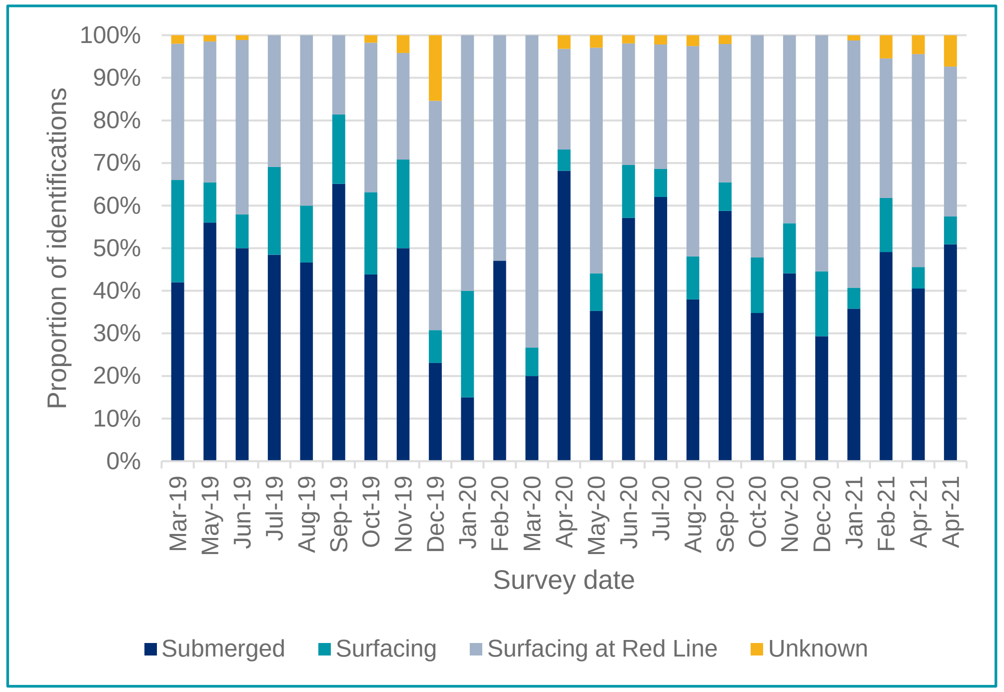


Figure 3.1: Summary Data Showing Surfacing Categories by Month Combined Across Species

42. There were also inter-species differences noted in the surfacing categories for the more abundant species. Harbour porpoise and minke whale were most often recorded as 'submerged' whilst white-beaked dolphin, grey seal and seal species were most often recorded as they surfaced ('surfacing' plus 'surfacing at red line') (Figure 3.2). This highlights the potential differences in availability bias between species.

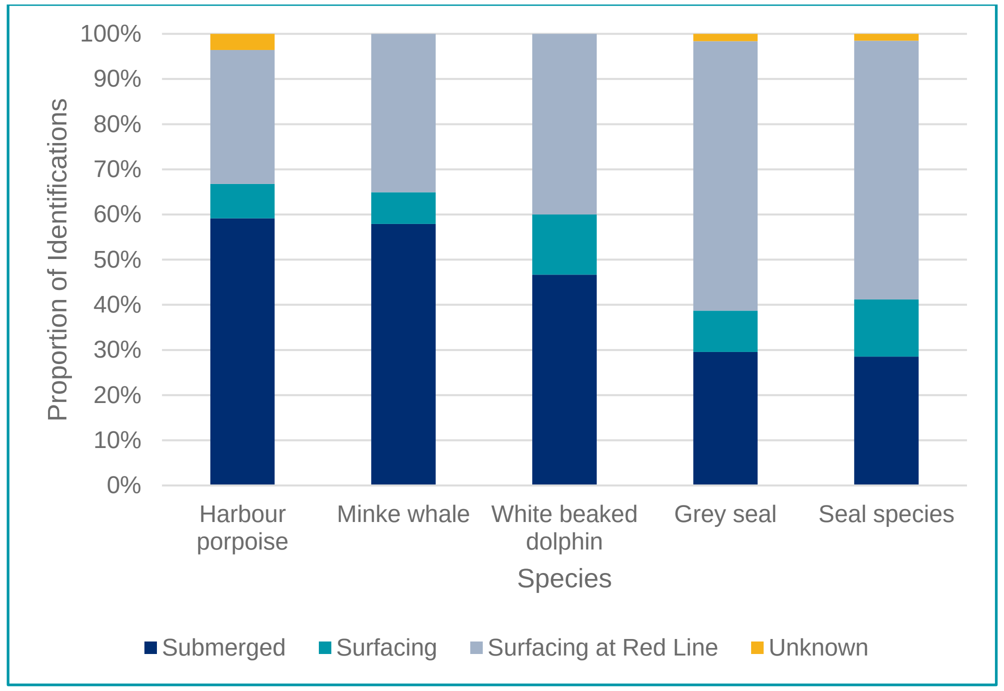


Figure 3.2: Summary Data Showing Surfacing Categories by Species Combined Across Months

3.1.4. CONFIDENCE ASSESSMENT

43. Confidence in identification varied by species/species group (Figure 3.3). Where an animal was identified to species level there was a high level of confidence in the identification and subsequently most identifications were classified as 'definite'. Seals were the hardest group to identify to a high level of confidence. A total of 180 animals were identified as 'definite' grey seals whilst a further 464 animals were identified as seal species (i.e. could not be assigned to either grey seal or harbour seal). Of the seal species, 283 animals were 'definite' identifications, 35 were 'probable' identifications and 146 were 'possible identifications. A small number of sightings (54) could only be identified as 'seal or small cetacean species'. A summary of the proportion of sightings assigned to the different confidence levels (CLs) for each species is illustrated below (Figure 3.3).

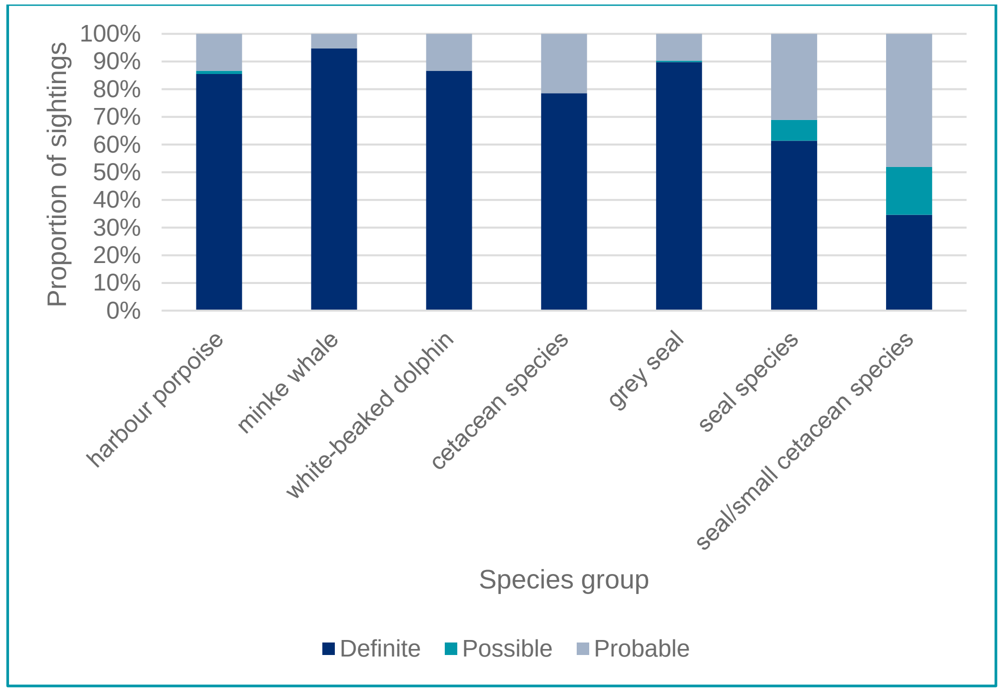


Figure 3.3: Proportion of Marine Mammal Sightings Classified as 'Definite', 'Possible' or 'Probable'

3.2. DISTRIBUTION OF SIGHTINGS

44. Sightings of marine mammals were spatially distributed throughout the aerial survey area. Figure 3.4 to Figure 3.10 show the distribution of the sightings overlaid on the transects flown each month (i.e. highlighting where there were missed transects and therefore no sightings data). In most months there was no distinct clustering of sightings in one area. The exception was in April 2020 when there was a cluster of harbour porpoise sightings to the north-east of the aerial survey area (Figure 3.7). Also, in May 2019 and June 2019 the majority of sightings were in the south-east half of the aerial survey area (Figure 3.4).

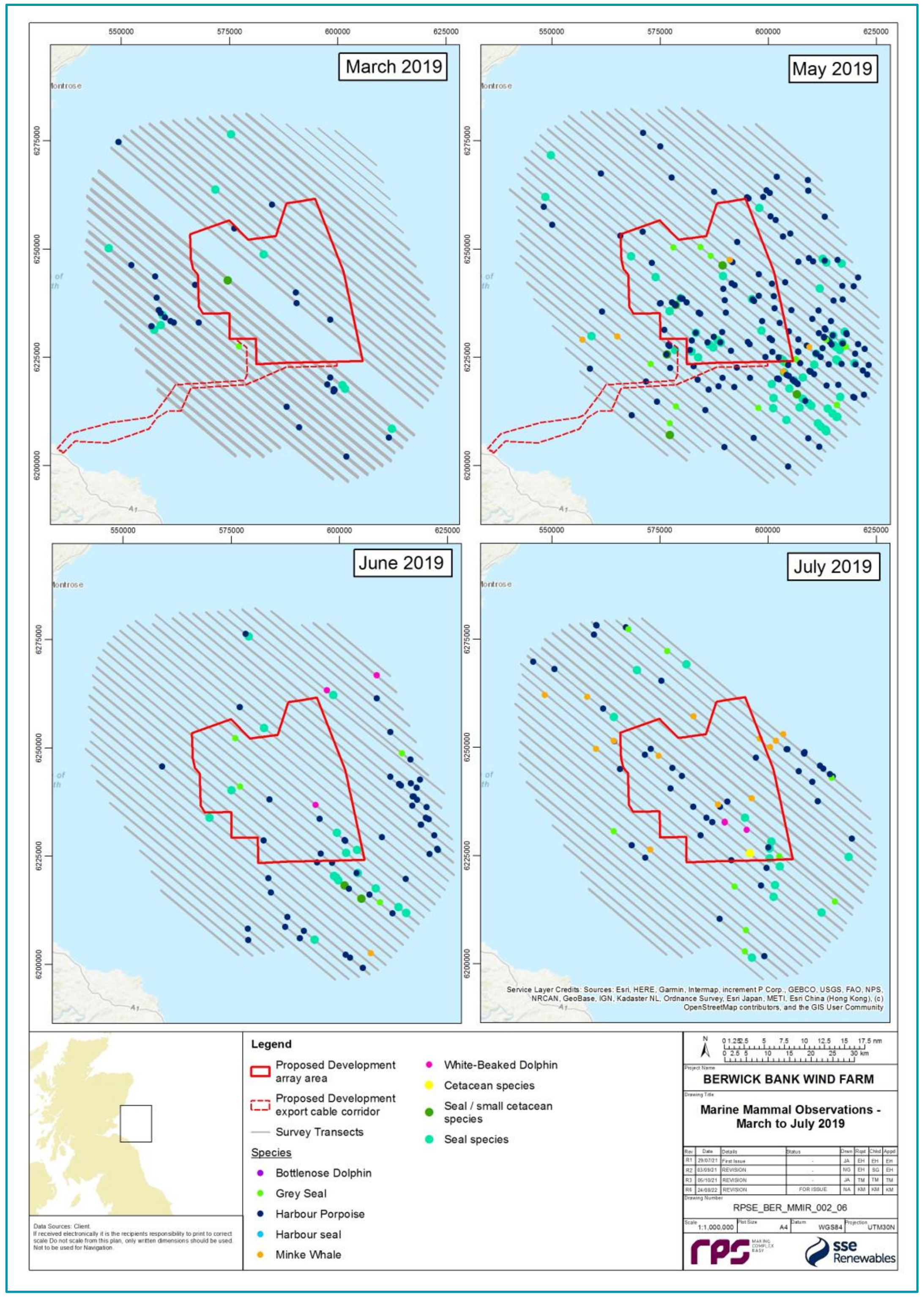


Figure 3.4: Distribution of Sightings of Marine Mammals in the Aerial Survey Area Overlaid on Transects Flown each Month: March, May, June and July 2019

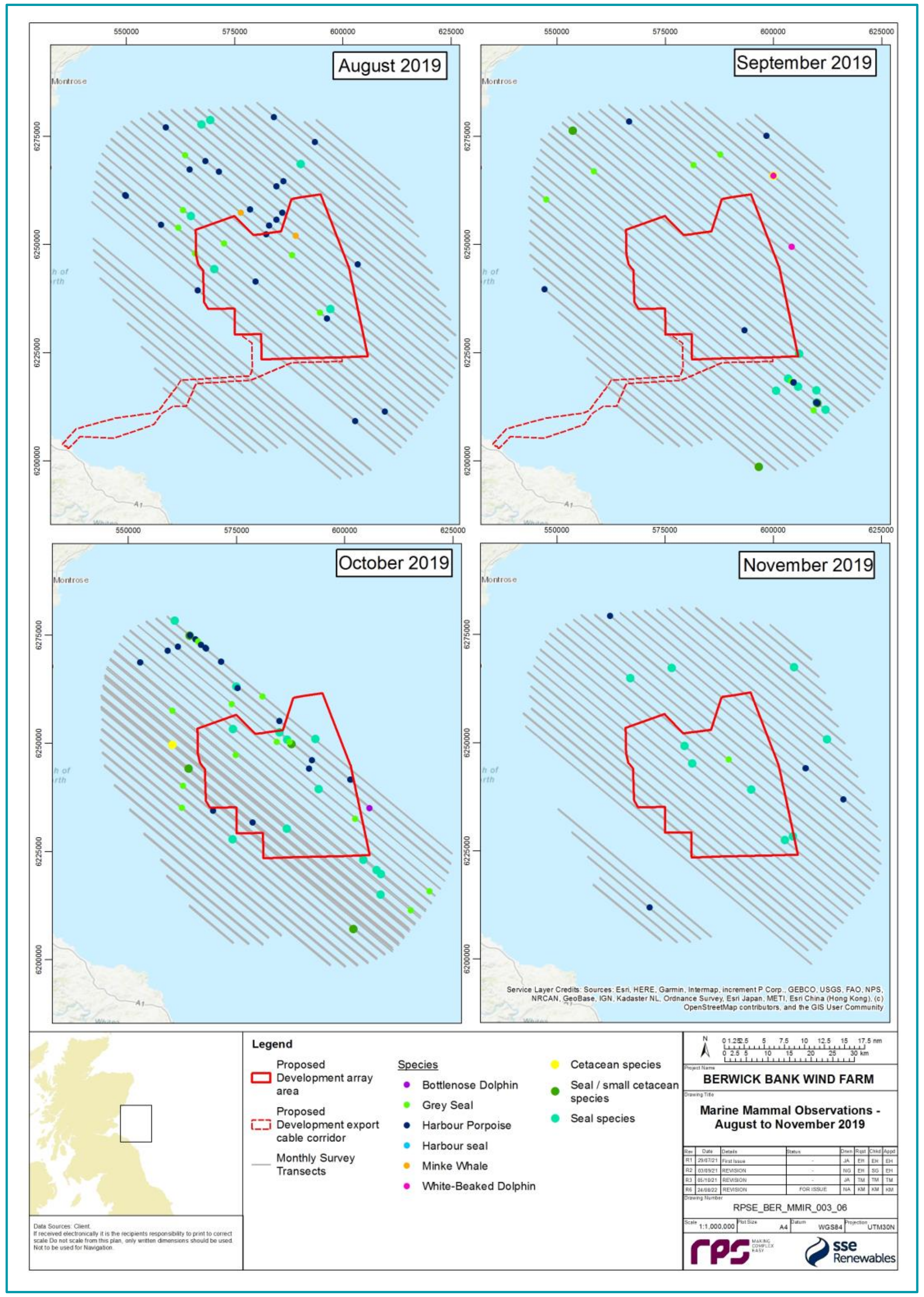


Figure 3.5: Distribution of Sightings of Marine Mammals in the Aerial Survey Area Overlaid on Transects Flown Each Month: August, September, October and November 2019

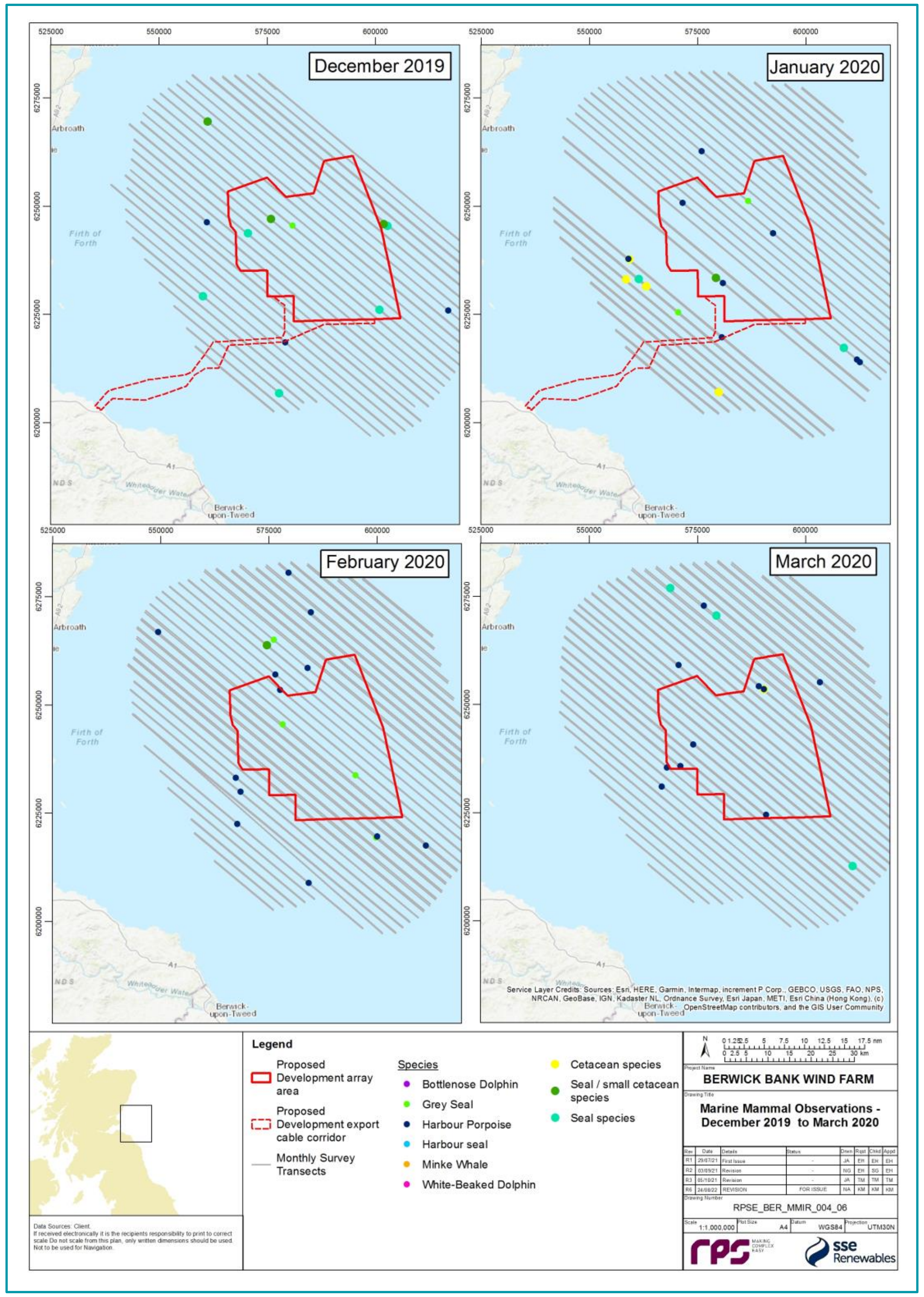


Figure 3.6: Distribution of Sightings of Marine Mammals in the Aerial Survey Area Overlaid on Transects Flown Each Month: December 2019 and January, February and March 2020

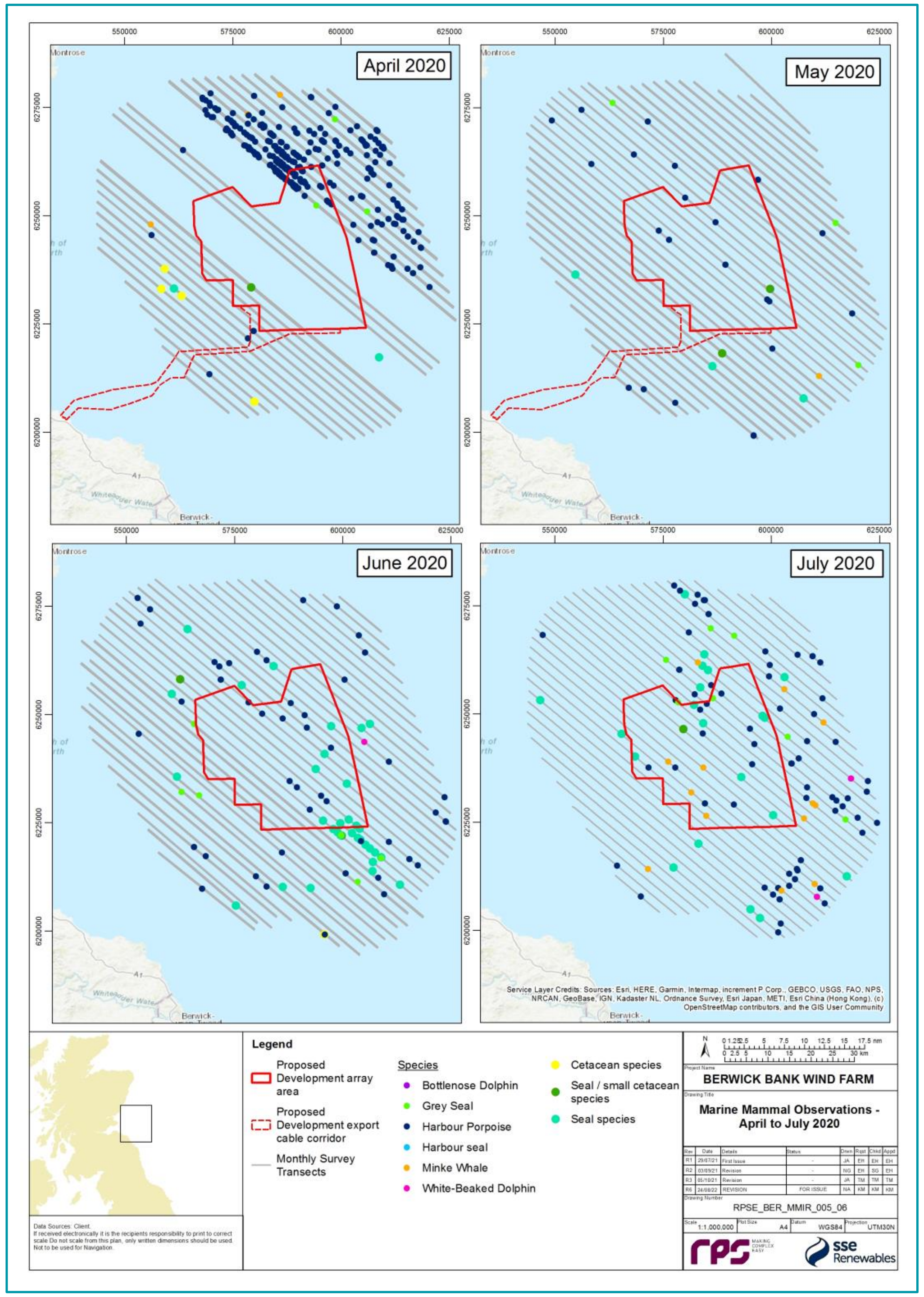


Figure 3.7: Distribution of Sightings of Marine Mammals in the Aerial Survey Area Overlaid on Transects Flown Each Month: April, May, June and July 2020

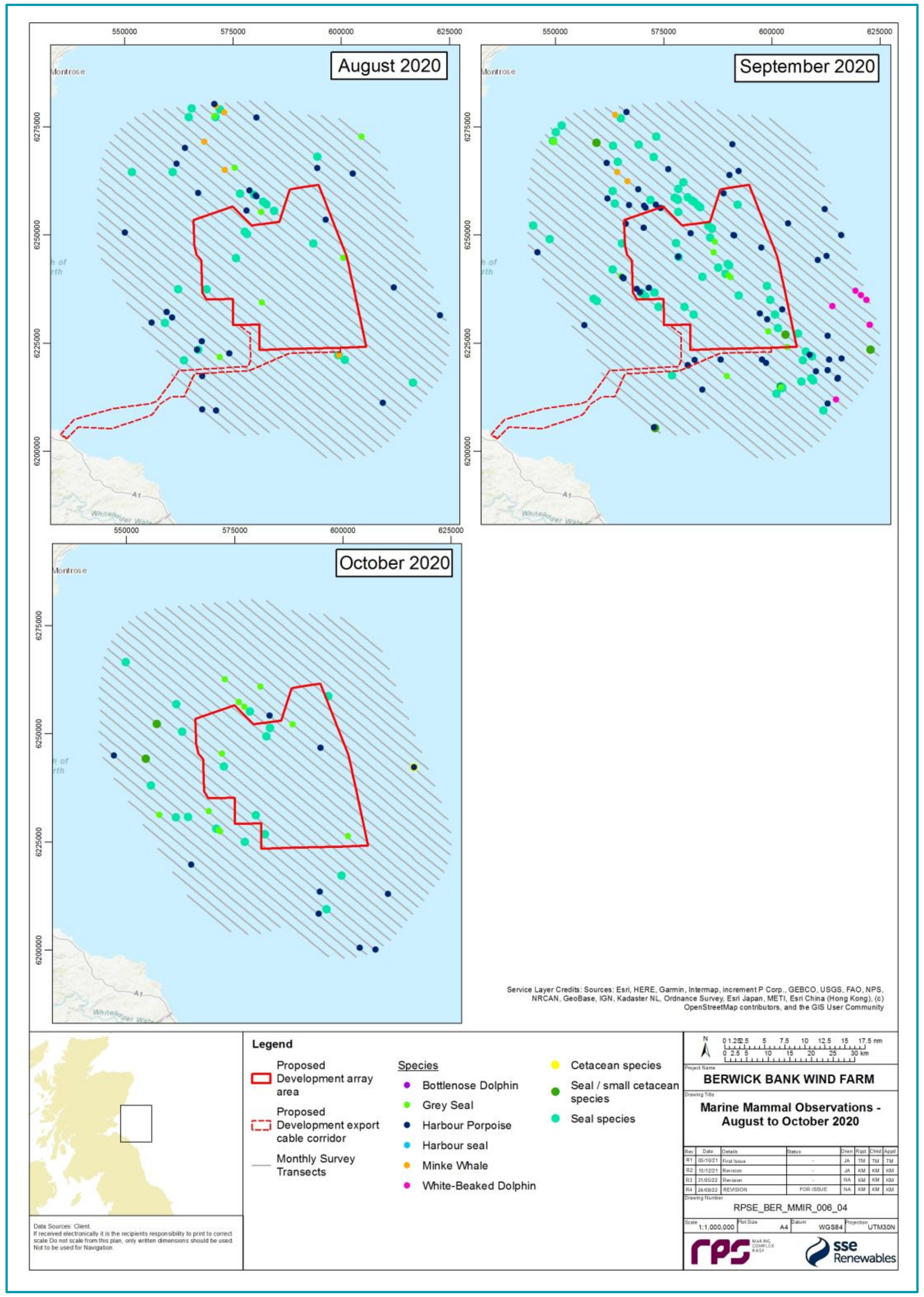


Figure 3.8: Distribution of Sightings of Marine Mammals in the Aerial Survey Are Overlaid on Transects Flown Each Month: August, September and October 2020

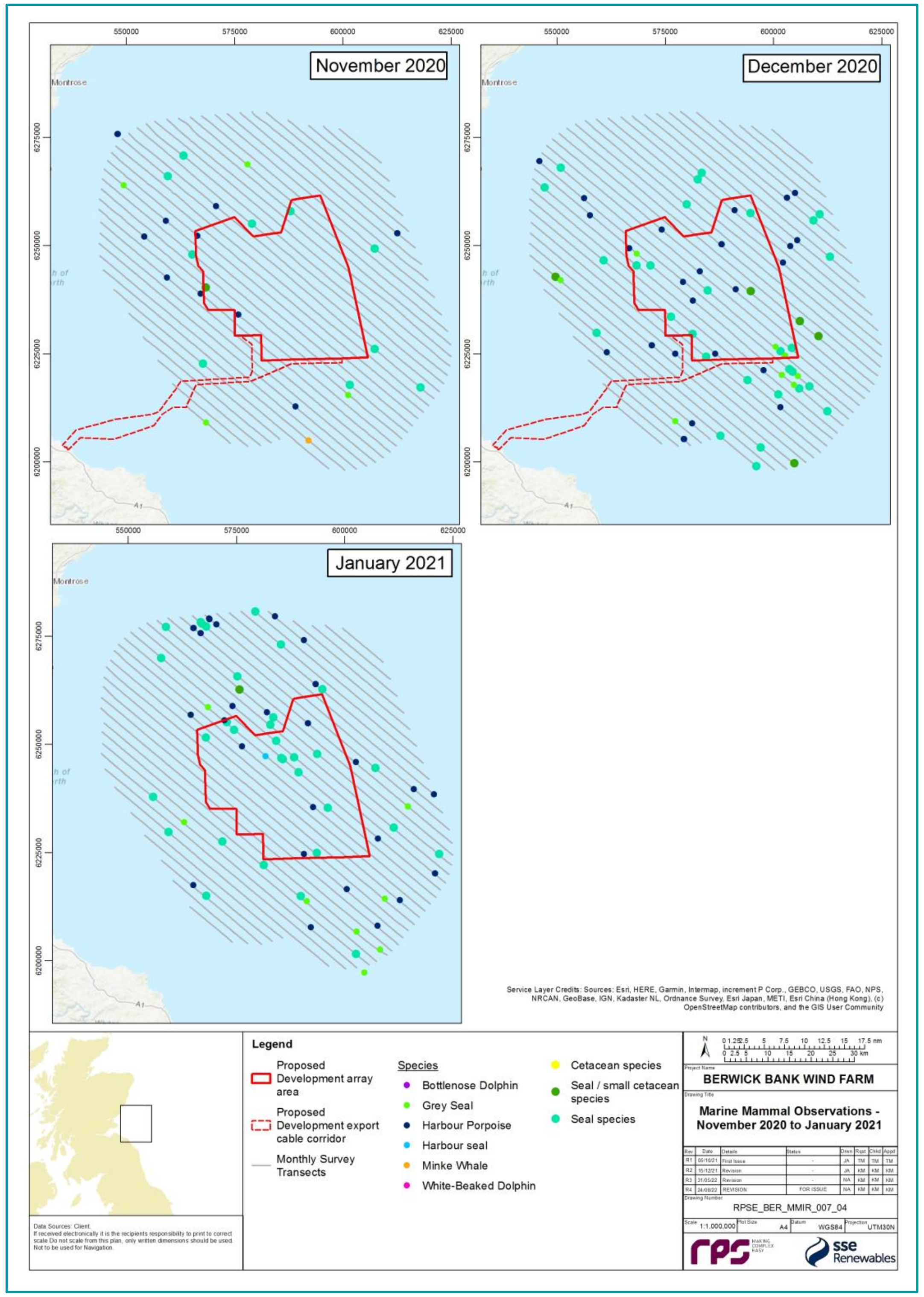


Figure 3.9: Distribution of Sightings of Marine Mammals in the Aerial Survey Area Overlaid on Transects Flown Each Month: November and December 2020 and January 2021

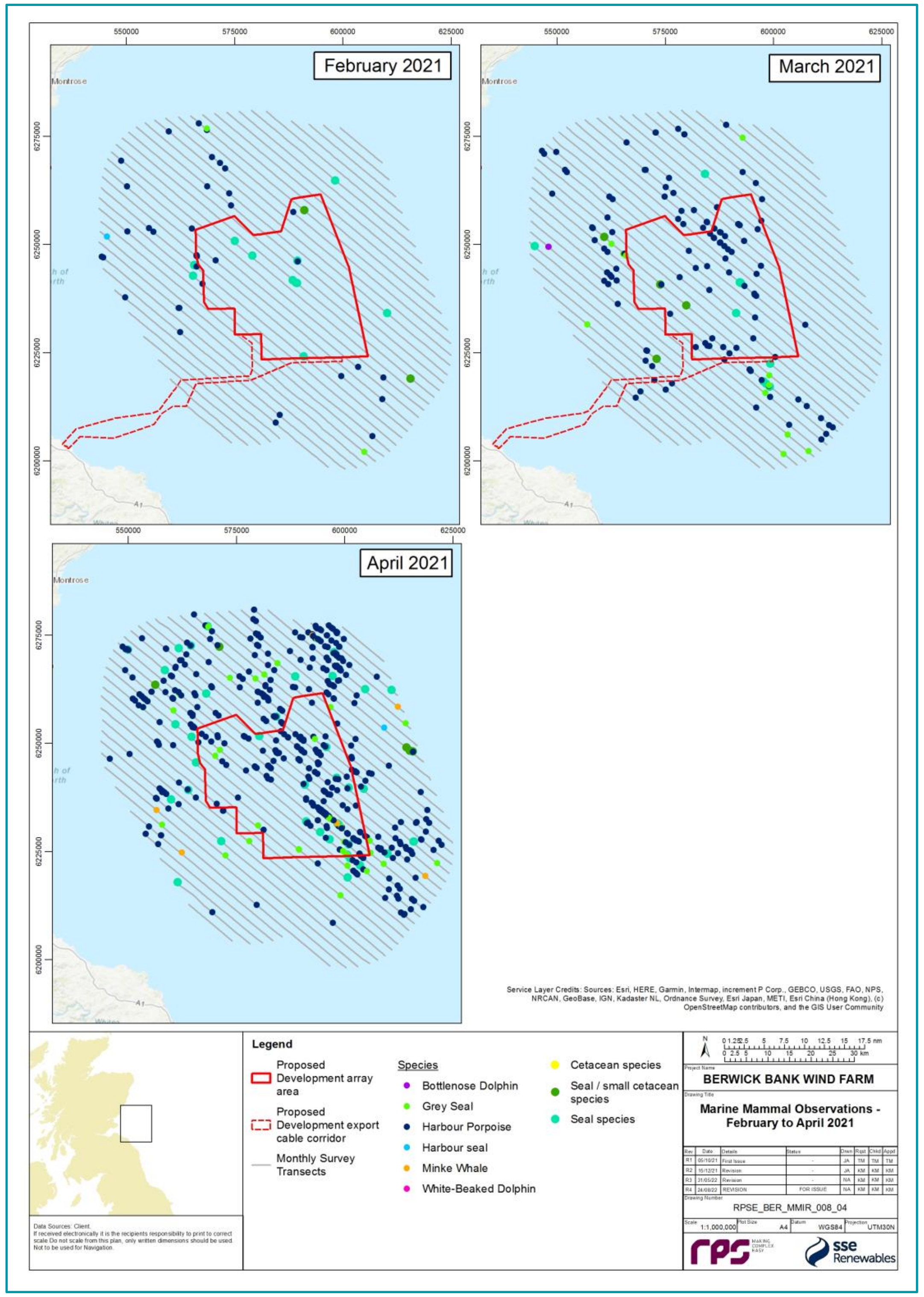


Figure 3.10: Distribution of Sightings of Marine Mammals in the Aerial Survey Area Overlaid on Transects Flown Each Month: February, March and April 2021

3.3. ENCOUNTER RATE

45. Encounter rate varied across species and intra-specifically across months. The highest encounter rate for a given species or species group was for harbour porpoise for which, a mean of 0.037 animals per km (95% CI [0.011, 0.062]) was estimated. Seal species were found to have the second highest encounter rate with grey seal the third highest. Assuming that seal species were grey seal (see paragraph 21) and summing these two identifications gave a mean encounter rate of 0.011 animals per km (95% CI [0.014, 0.007]).

46. The mean encounter rates for minke whale and white-beaked dolphin were comparatively low with 0.001 (95% CI [0.0003, 0.002]) and 0.0007 (95% CI [0, 0.0003]) animals per km, respectively. Note, however, that this is based on averaging across all months including those when these species are unlikely to occur within the aerial survey area due to their seasonality. This seasonality is taken into consideration later in this report in the estimates of density, with months when a species is unlikely to be present are excluded to ensure that more precautionary estimates of density were derived (see section 3.5).

47. Very low encounter rates were found for the species groups 'cetacean species' and 'seal/small cetacean' (Table 3.3). Based on the frequency of occurrence of known species across the aerial survey area, individuals identified as 'cetacean species' were most likely to be harbour porpoise, whilst those identified as 'seal/small cetacean' were most likely to be harbour porpoise or grey seal.

48. The encounter rate (averaged across all months) for bottlenose dolphin was very low with only 0.0001 (95% CI [0, 0.0003]) animals per km.

Table 3.3: Monthly Encounter Rate (Number of Animals per km of Trackline) of Marine Mammals Within the Aerial Survey Area. An Estimate for Grey Seal Including Seal Species is Presented in Italics

Month	Trackline Length (km)	Harbour Porpoise	Minke Whale	White-Beaked Dolphin	Bottlenose Dolphin	Cetacean Species	Seal/Small Cetacean	Grey Seal	Harbour Seal	Seal Species	Grey Seal + Seal Species
28 March 2019	2299.21	0.0165	0	0	0	0	0.0004	0.0004	0	0.0043	0.0048
14 May 2019	2492.38	0.0726	0.0024	0	0	0	0.0024	0.0064	0	0.0261	0.0325
21 June 2019	2490.98	0.0229	0.0004	0.0024	0	0	0.0008	0.0016	0	0.0068	0.0084
23 July 2019	2190.78	0.0246	0.0059	0.0014	0	0.0005	0	0.0041	0	0.0059	0.01
06 August 2019	2321.12	0.0121	0.0009	0	0	0	0	0.003	0	0.0026	0.0056
15 September 2019	2489.68	0.008	0	0.0016	0	0.0012	0.0012	0.0024	0	0.0028	0.0052
17 October 2019	1894.02	0.0063	0	0	0.0005	0.0005	0.0026	0.0048	0	0.0042	0.009
19 November 2019	2194.33	0.0064	0	0	0	0	0	0.0005	0	0.0041	0.0046
07 December 2019	2248.69	0.0013	0	0	0	0	0.0009	0.0004	0	0.0022	0.0027
05 February 2020*	2145.21	0.0033	0	0	0	0.0028	0	0.0005	0	0.0009	0.0014
19 February 2020	2487.69	0.0048	0	0	0	0	0.0004	0.0016	0	0	0.0016
21 March 2020	2488.58	0.0048	0	0	0	0.0004	0	0	0	0.0012	0.0012
05 May 2020**	1759.04	0.2769	0.0017	0	0	0	0.0011	0.0017	0	0.0097	0.0114
16 May 2020	2487.14	0.0105	0.0004	0	0	0	0.0008	0.0016	0	0.0016	0.0032
09 June 2020	2488.04	0.0237	0	0.0004	0	0.0004	0.0008	0.0032	0	0.0141	0.0173
12 July 2020	2488.15	0.0313	0.0052	0.0028	0	0	0.0004	0.0028	0	0.008	0.0109
09 August 2020	2488.04	0.0157	0.002	0	0	0	0	0.0028	0	0.0104	0.0133
06 September 2020	2487.99	0.033	0.0012	0.0096	0	0	0.0016	0.0056	0	0.0273	0.033
16 October 2020	2488.85	0.0064	0	0	0	0.0004	0.0008	0.0044	0	0.0072	0.0117
05 November 2020	2490.06	0.0068	0.0004	0	0	0	0.0004	0.0016	0	0.004	0.0056
01 December 2020	2489.71	0.0189	0	0	0	0	0.0024	0.0036	0	0.0129	0.0165
19 January 2021	2489.76	0.0153	0	0	0	0	0.0004	0.0032	0.0004	0.0133	0.0165
16 February 2021	2489.03	0.0173	0	0	0	0	0.0008	0.0008	0.0004	0.0044	0.0052
12 April 2021	2490.11	0.061	0	0	0.0024	0	0.0016	0.0052	0	0.0036	0.0088
24 April 2021	2489.17	0.2117	0.0036	0	0	0	0.002	0.0149	0.0004	0.0153	0.0301
Mean	2374.71	0.0365	0.001	0.0007	0.0001	0.0002	0.0009	0.0031	0.00005	0.0077	0.0108
95% CI [±]	79.06	0.0257	0.0007	0.0008	0.0002	0.0002	0.0003	0.0012	0.0001	0.0028	0.0036
Minimum	1759.04	0.0013	0	0	0	0	0	0	0	0	0.0012
Maximum	2492.38	0.2769	0.0059	0.0096	0.0024	0.0028	0.0026	0.0149	0.0004	0.0273	0.033

49. Harbour porpoise and grey seal including seal species were encountered in every month of the year, whilst minke whale and white-beaked dolphin were only observed during the summer months.

50. For harbour porpoise, monthly encounter rate varied across months with the encounter rate for April 2020 and April 2021 estimated to be considerably higher compared to all other months of the year (Figure 3.11). Minke whale were mostly encountered during the spring and summer months (with the encounter rate peaking in July 2019 at 0.0062 animals per km (Figure 3.12). This seasonality corroborates observations from previous surveys undertaken in waters off the north-east coast of Scotland with minke whales showing seasonal peaks during summer months (e.g. MacLeod *et al*., 2007; Weir *et al*., 2007). White-beaked dolphin was only encountered during the summer and early autumn and the encounter rate peaked in September 2020 at 0.0096 animals per km (Figure 3.12).

51. There was seasonal variation in the encounter rate for grey seal including seal species. Encounter rates appeared to be highest in late spring through to early autumn and lower over the winter/early spring months (Figure 3.13). The highest encounter rate was calculated for May 2019 at 0.0325 animals per km (Figure 3.13).

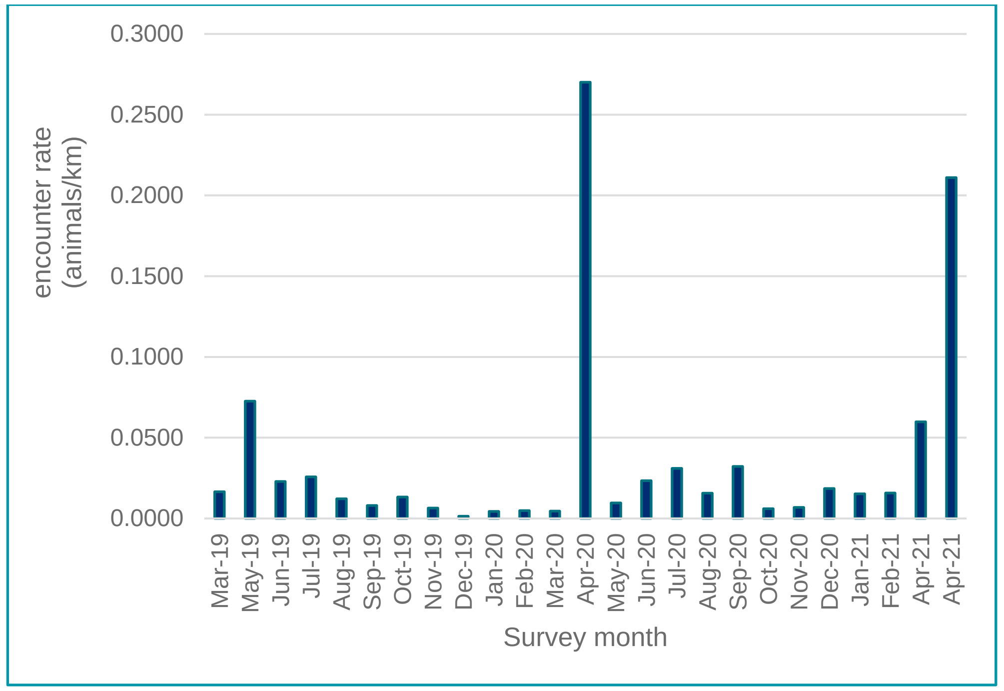


Figure 3.11: Monthly Encounter Rate of Harbour Porpoise Across the Aerial Survey Area

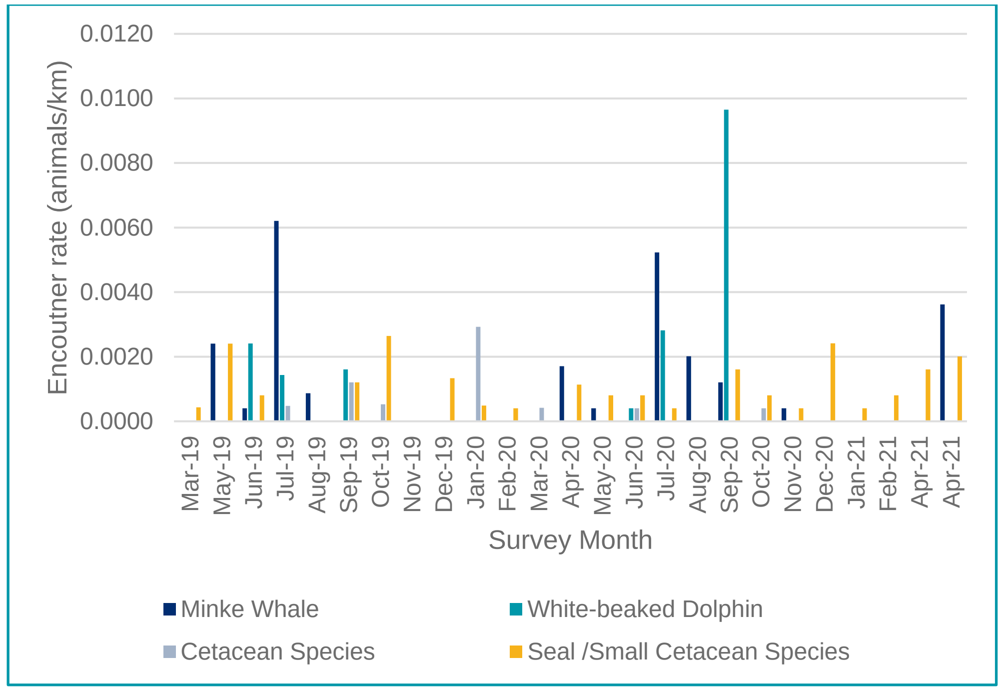


Figure 3.12: Monthly Encounter Rate of Minke Whale, White-Beaked Dolphin, Cetacean Species and Seal/Small Cetacean Species

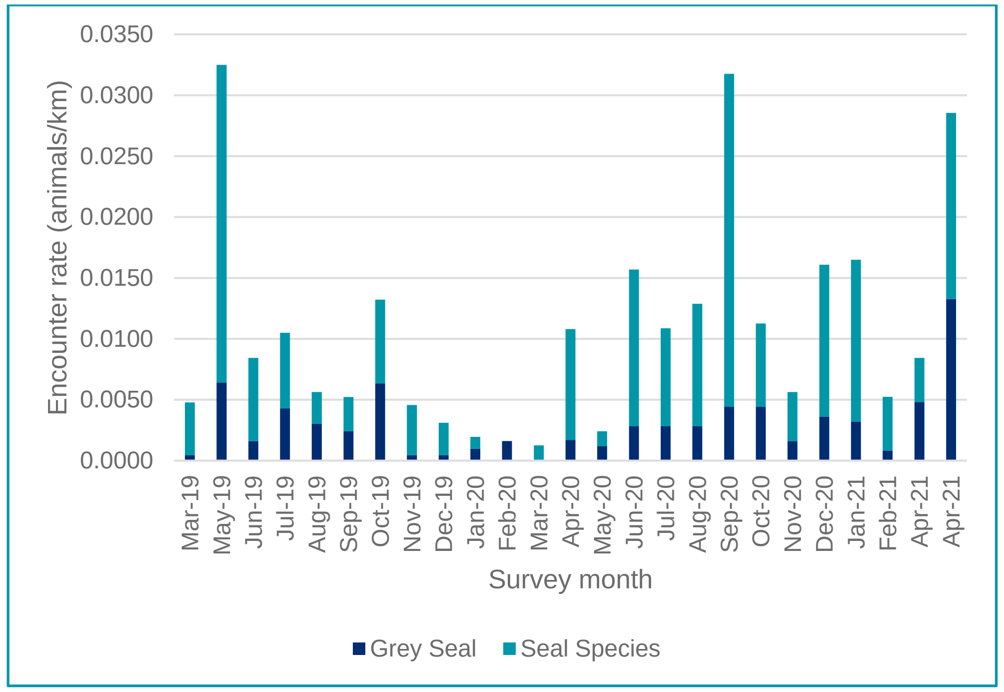


Figure 3.13: Monthly Encounter Rate of Grey Seal Including Seal Species Combined

3.4. GROUP SIZE

52. Group size varies by species and across the months (Table 3.4). The largest group sizes were recorded for harbour porpoise with an average across all sightings over the 25 months of 2.75 animals (95% CI [1.71, 3.79]) (Table 3.4). Figure 3.14 shows the monthly variation in the mean and maximum group size for harbour porpoise. The high count of harbour porpoise in the months of May and April (Table 3.2) coincided with large groups of animals sighted within the aerial survey area. For example, in April a maximum group size of 49 animals was recorded whilst the overall mean for this month was 6.6 animals.

53. The second highest group size was recorded for white-beaked dolphin, with a mean group size across all sightings of 2.81 animals (95% CI [1.89, 3.72]; Table 3.4). Maximum group sizes of 10 animals were recorded for the month of September (Table 3.4). In the 25 months of survey, most sightings of minke whale were of a single animal (mean 1.11, 95% CI [1.01, 1.22]) with a maximum of three animals recorded in the month of April (Table 3.4).

54. On average, across all sightings, the mean group size of grey seal was 1.19 animals (95% CI [1.09, 1.29]) (Table 3.4). Maximum group sizes were recorded for grey seal in the month of April when seven animals were sighted in one group (Figure 3.15).

55. For the two sightings of bottlenose dolphin, one sighting was of a single animal (October 2019) whilst the other sighting was a group of six animals (April 2021).

Table 3.4: Monthly Mean and Maximum Group Sizes for Species Sightings Across the Aerial Survey Area

Month	Harbour porpoise		White-beaked dolphin		Minke whale		Bottlenose dolphin		Grey seal	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
April	6.66	39.00			1.50	3.00	6.00		1.61	7.00
Jan	1.81	5.00							1.33	2.00
Feb	1.38	4.00							1.00	1.00
Mar	1.67	6.00							1.00	1.00
May	6.55	49.00			1.00	1.00			1.21	3.00
Jun	1.68	7.00	1.75	3.00	1.00	1.00			1.09	2.00
Jul	2.24	9.00	2.00	4.00	1.13	2.00			1.14	2.00
Aug	1.86	6.00			1.17	2.00			1.17	2.00
Sep	2.76	11.00	4.67	10.00	1.00	1.00			1.33	3.00
Oct	1.79	6.00					1.00		1.15	2.00
Nov	2.58	12.00			1.00	1.00			1.00	1.00
Dec	2.08	8.00							1.25	3.00
Mean	**2.75**	**13.50**	**2.81**	**5.67**	**1.11**	**1.57**	**3.5**	**3.5**	**1.19**	**2.42**
95% CI [±]	**1.04**	**8.26**	**0.91**	**2.14**	**0.10**	**0.45**	**2.0**	**2.0**	**0.10**	**0.92**

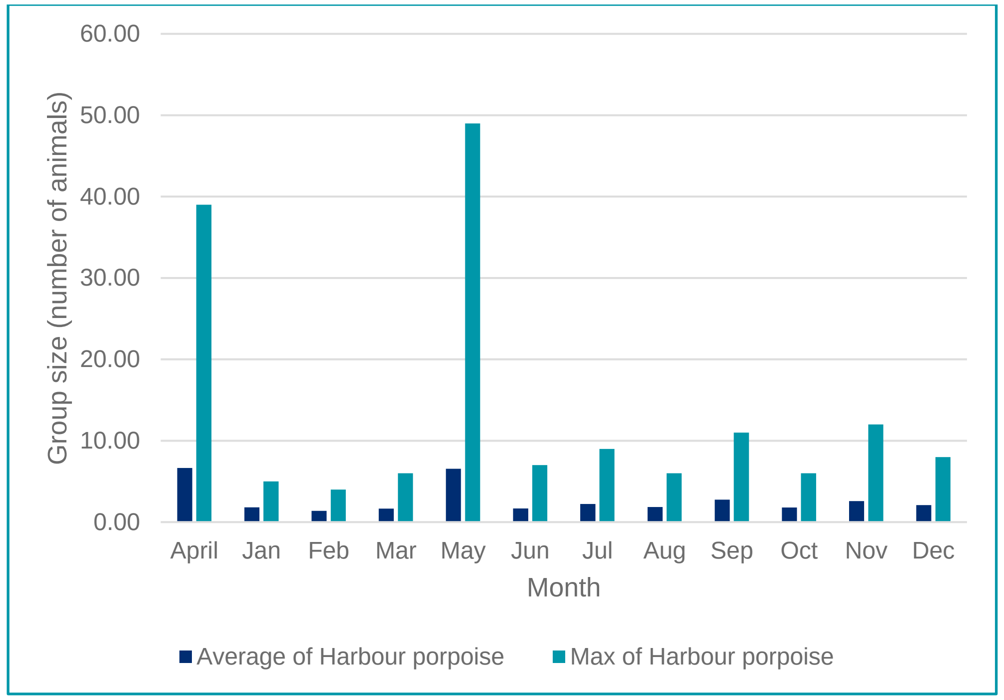


Figure 3.14: Monthly Mean and Maximum Group Sizes (Number of Animals) for Harbour Porpoise

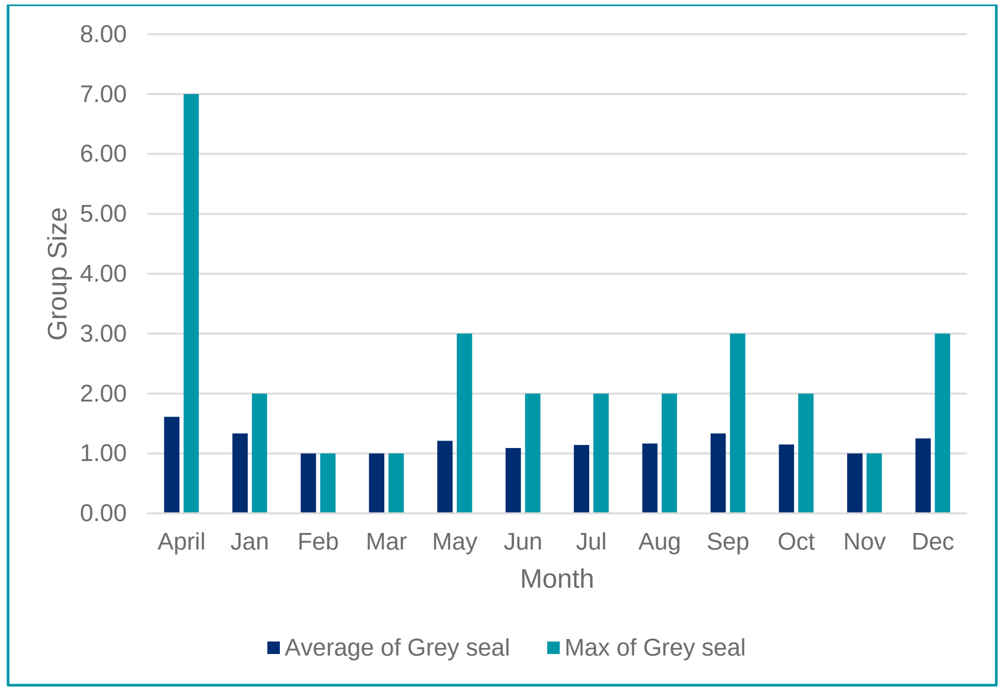


Figure 3.15: Monthly Mean and Maximum Group Sizes (Number of Animals) for Grey Seal

3.5. DENSITY ESTIMATES

56. Monthly mean densities of marine mammals were produced from the count data. For minke whale and white beaked dolphin, the densities were estimated only those months where animals were likely to be present in the aerial survey area: mid-spring to early autumn for minke whale and summer to early autumn for white-beaked dolphin. An overall mean was estimated across these selected months and therefore was more precautionary than averaging across all survey months as the absence of animals at certain times of year would bring the mean value down.

57. As described in paragraph 40, based on the frequency of occurrence of known species across the aerial survey area, unidentified seal species were considered most likely to be grey seal. This classification of unidentified seals recordings as the most commonly sighted species is a common approach for analysis of marine mammal data collected via aerial surveys and allows for more conservative estimates of density by including all data. Whilst unidentified seals were assigned to grey seal, it is noted that this does not discount the possibility that unidentified seal species may have been harbour seal. Subsequently, the published at-sea densities of harbour seal have been sourced to provide a robust baseline characterisation for this species (e.g. Carter *et al.*, 2020).

58. Similarly, there were a small number of unidentified cetacean species and unidentified seal/small cetacean species. Due to the low number of sightings for other key marine mammal species (white-beaked dolphin, bottlenose dolphin, and minke whale) it was necessary to explore published density estimates to inform the marine mammal baseline characterisation, including both previous site-specific data from Seagreen 1 or other Firth of Forth and Firth of Tay offshore wind farms (Neart na Gaoithe and Inch Cape) and broadscale data such as SCANS-III density estimates.

59. Previously published density estimates for marine mammals are discussed and presented in the Marine Mammal Technical Report; this report focusses on densities derived from the recent aerial surveys only.

3.5.2. HARBOUR PORPOISE

Design-based approach

60. Bootstrapping was undertaken (1,000 simulations) to produce confidence intervals from the mean monthly densities of harbour porpoise (Wessa, 2019) (Figure 3.16). Peaks in density were estimated for the months of May 2019 and April 2020 with a maximum of 0.290 (95% CI [0.133, 0.487]) animals per km^2 and 0.674 (95% CI [0.308, 1.131]) animals per km^2 respectively. Due to the large variance in the data across months, the seasonal patterns are not easy to interpret from a linear scale (Figure 3.17). Therefore, data were replotted showing the mean density on a log scale (Figure 3.18). Here, the seasonality is more evident and suggests that densities are higher in spring and summer months with lower values in late autumn and winter (Figure 3.18). The overall mean relative density of harbour porpoise, estimated from data pooled across all transects and all months, with bootstrapping was 0.127 animals per km^2 (95% CI [0.067, 0.191]). A relative high coefficient of variation (CV = 1.61) was calculated for mean monthly density, with high variance most likely to be a result of the large densities seen in May 2019 and April 2020 (Figure 3.17).

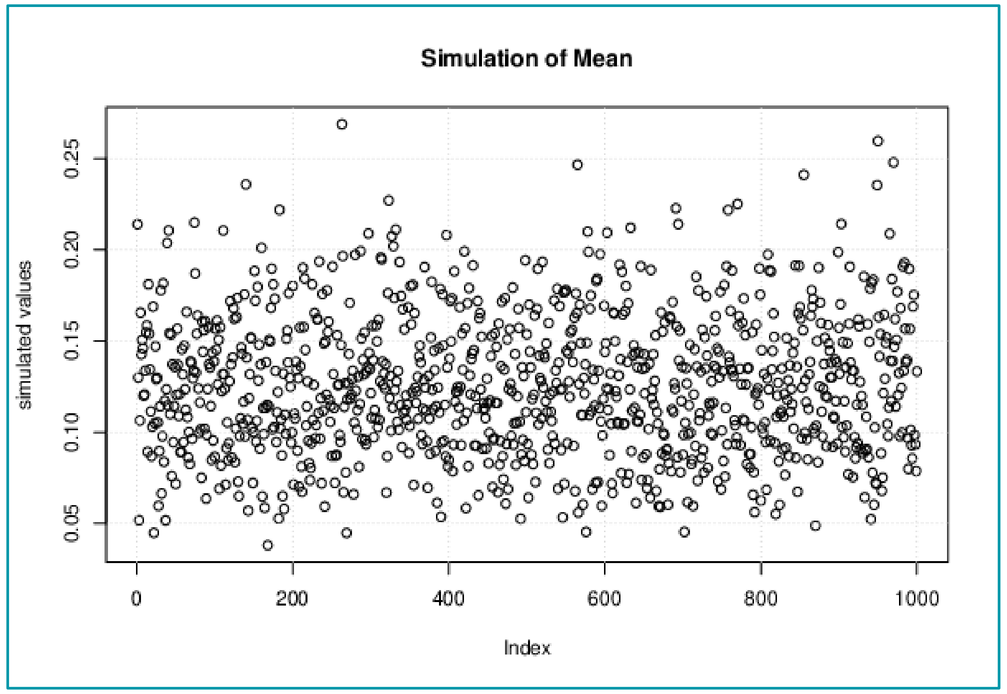


Figure 3.16: Simulation of Mean for Monthly Relative Density Estimates of Harbour Porpoise

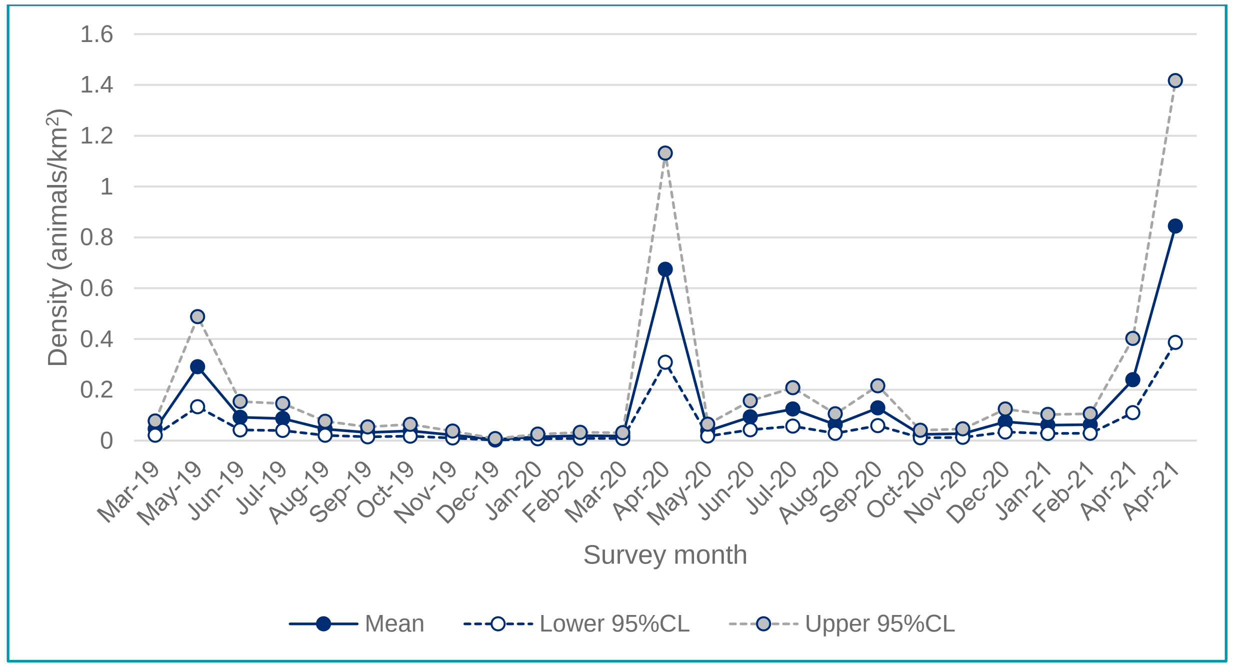


Figure 3.17: Estimated Monthly Mean Density (Relative) of Harbour Porpoise Over the Aerial Survey Area (Linear Scale). Graph Illustrates the Estimated Densities for Each Month of Survey (Solid Line) and 95% Confidence Intervals (Dotted Lines) Estimated Using Bootstrapping

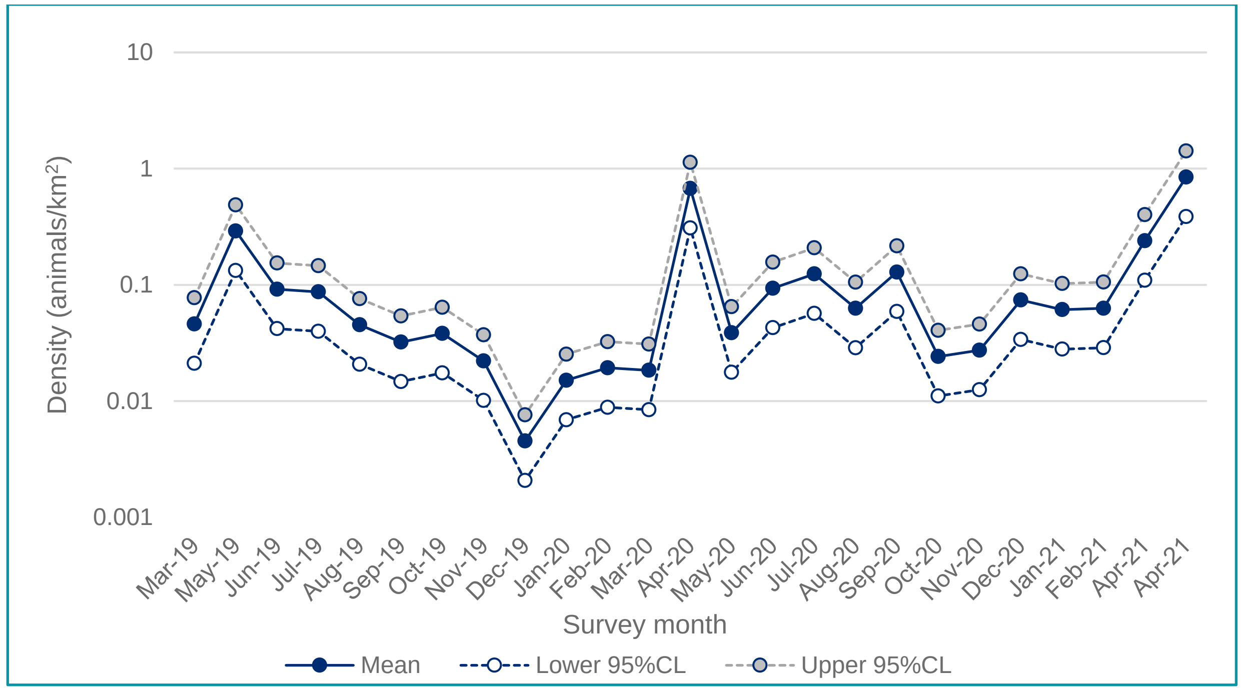


Figure 3.18: Estimated Monthly Mean Density (Relative) of Harbour Porpoise Over the Aerial Survey Area (Log Scale). Graph Illustrates the Estimated Densities for Each Month of Survey (Solid Line) and 95% Confidence Intervals (Dotted Lines) Estimated Using Bootstrapping

61. Mean seasonal densities were also estimated for winter (December, January, February), spring (March, April and May), summer (June, July and August) and autumn (September, October, November) and these are presented in Table 3.5.

62. Relative density estimates of harbour porpoise can be corrected for availability bias using a 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 (Teilman *et al.,* 2013). Notably, in this study Teilman *et al*. (2013) found no significant difference in diving behaviour between geographic areas or in relation to the size of the animals, 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 (Teilman *et al.,* 2013).

63. Similarly, fine scale movements of harbour porpoise in the Danish North Sea were investigated by van Beest *et al.* (2018). GPS and dive recorder (V-tags) were used to record the diving behaviour of tagged individuals and the 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 is the same as to the value estimated by Teilman *et al.* (2013).

64. Using the most conservative correction factor (0.425), the mean corrected density estimate (from the bootstrapped average) across all monthly surveys for the aerial survey area was estimated as 0.298 animals per km^2 (95% CI [0.159, 0.449]).

Table 3.5: Seasonal and Overall Monthly Mean Densities for Harbour Porpoise

Season	Mean relative density (Animals per km^2)	95% CI	Mean absolute density (Animals per km^2)	95% CI
Winter	0.039	0.016 to 0.064	0.093	0.037 to 0.149
Spring	0.307	0.063 to 0.552	0.723	0.149 to 1.298
Summer	0.084	0.062 to 0.106	0.198	0.146 to 0.249
Autumn	0.045	0.012 to 0.078	0.107	0.029 to 0.184
All months	**0.127**	**0.067 to 0.191**	**0.298**	**0.159 to 0.449**

Model based approach

65. Harbour porpoise abundance varied across season, with high densities across the aerial survey area observed during the spring (March, April and May) months (Table 3.6). Seasonal density maps for harbour porpoise distribution are shown in Figure 3.20. To derive densities per km^2, the raw density per season was scaled to cell size and divided by the total survey area (initial Berwick Bank Wind Farm Proposal and the Marr Bank Wind Farm Proposal survey areas plus ~12 km buffer). The average density across all months was 0.127 (95% CI [0.066, 0.277]).

66. Mean abundance estimates were calculated per season and the estimated were scaled up to estimate the abundance within the Proposed Development array area plus ~16 km buffer (Table 3.6).

Table 3.6: Harbour Porpoise Modelled Relative Density Estimates by Season for Proposed Development Including Lower Confidence Intervals (LCI) and Upper Confidence Intervals (UCI). Mean Seasonal Abundance is Scaled up to the Proposed Development Array Area Plus ~16 km Buffer

Season	Mean relative abundance	Mean Relative Density (Animals per km^2)	LCI	UCI
Winter	195	0.039	0.019	0.083
Spring	1746	0.351	0.187	0.687
Summer	375	0.076	0.042	0.145
Autumn	204	0.041	0.015	0.192
All months	**-**	**0.127**	**0.066**	**0.277**

67. Correcting these estimates based on the 0.425 availability bias of harbour porpoise (see paragraph 64) provided a mean absolute density across all months of 0.299 (95% CI [0.155, 0.652]). This estimate is the same as that derived using the bootstrapping approach (see Table 3.5:). Corrected seasonal estimates of density are presented in Table 3.7.

Table 3.7: Harbour Porpoise Modelled Absolute Density Estimates by Season for Proposed Development Including LCI and UCI. Mean Seasonal Abundance is Scaled up to the Proposed Development Array Area Plus ~16 km Buffer

Season	Mean absolute abundance	Mean absolute Density (Animals per km^2)	LCI	UCI
Winter	460	0.092	0.045	0.195
Spring	4108	0.826	0.440	1.616
Summer	883	0.179	0.099	0.341
Autumn	479	0.096	0.035	0.452
All months		**0.299**	**0.155**	**0.652**

68. The distribution maps of harbour porpoise suggest that, during spring at least, the eastern part of the aerial survey area is favoured by harbour porpoise (Figure 3.19 and Figure 3.20).

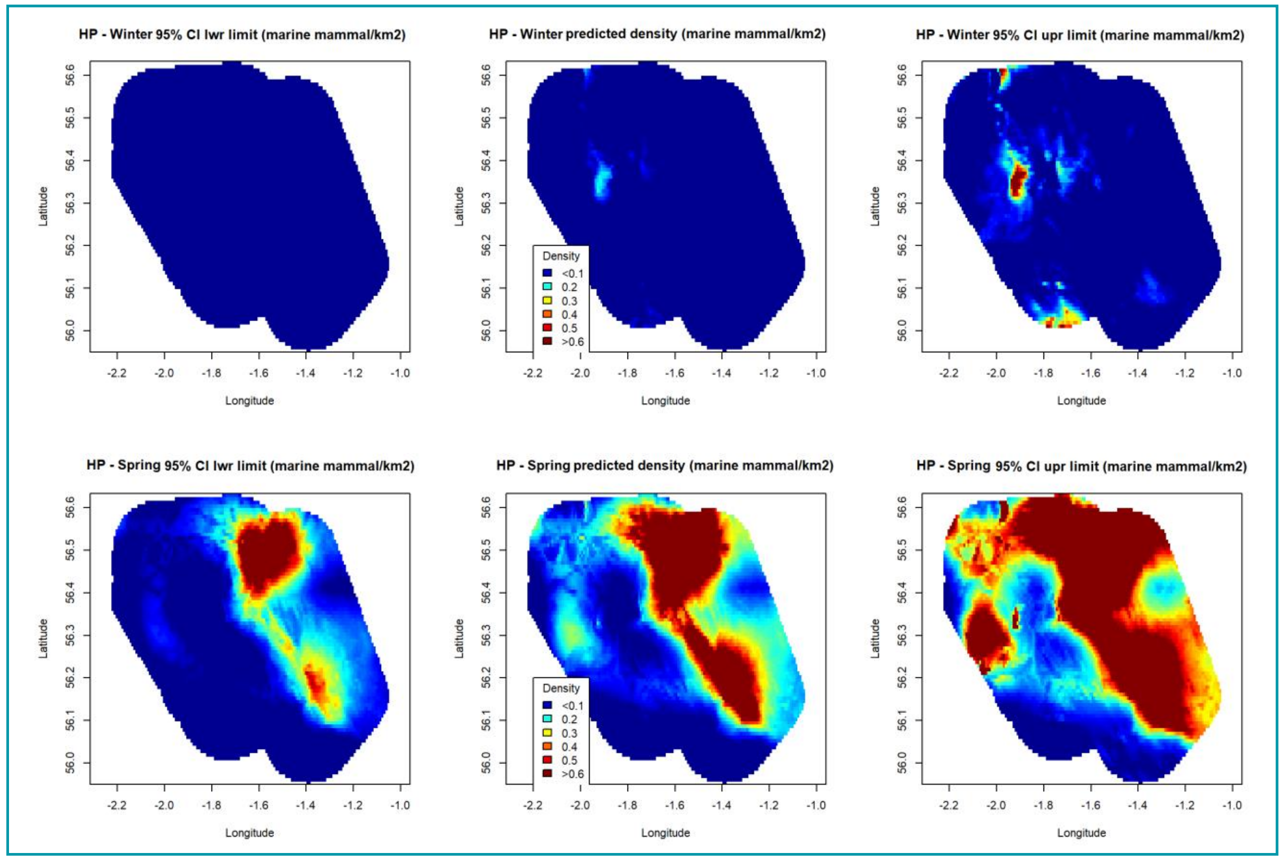


Figure 3.19: Harbour Porpoise Predicted Density (Centre Panels) and Lower (Left Panels) and Upper (Right Panels) 95% CI by Season for Berwick Bank Wind Farm Plus ~12 km Buffer

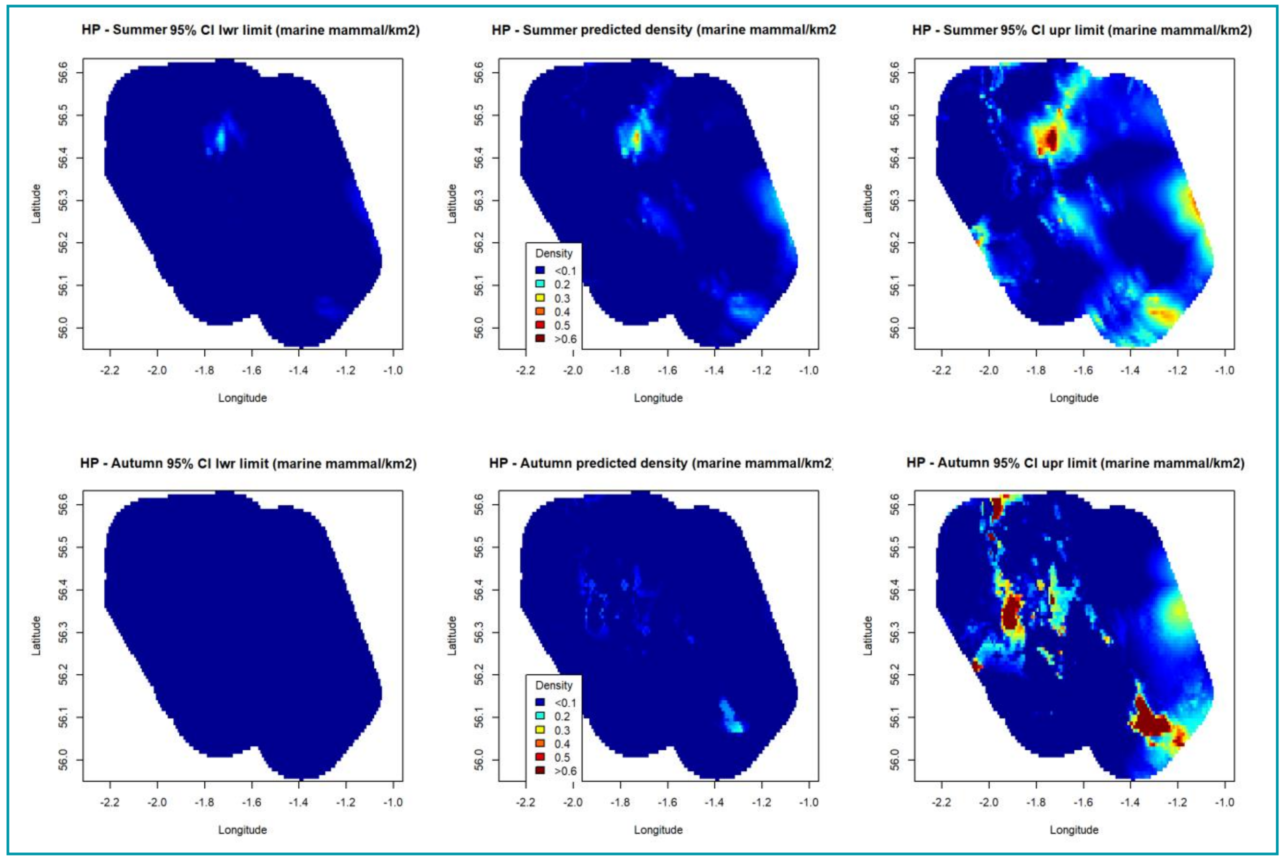


Figure 3.20: Harbour Porpoise Predicted Density (Centre Panels) and Lower (Left Panels) and Upper (Right Panels) 95% CI by Season for Initial Berwick Bank Wind Farm Study Area Plus ~12 km Buffer

3.5.3. MINKE WHALE

69. Minke whale was sighted in low numbers during mid-spring to early autumn only (Table 3.2). Mean relative density and CV were therefore estimated from data during this period (taken as the months April to September inclusive) when minke would be expected to be present within the aerial survey area and also including any outlier months when they were also sighted within the aerial survey area (i.e. November 2020). A total of 12 months were therefore included for analyses. Bootstrapping was undertaken (1,000 simulations) to produce confidence intervals from the mean monthly densities (Wessa, 2019). An overall mean of 0.007 (95% CI [0.004, 0.010]) animals per km^2 was calculated with a maximum density value of 0.021 animals per km^2 recorded during July 2020. As with harbour porpoise a relative high coefficient of variation (CV = 1.06) was estimated, reflecting the small number of sightings of minke whale, which some months (July 2019 and 2020) showing higher numbers of animals compared to other months.

70. 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, availability bias would be approximately 0.44 and consequently mean

absolute density can be approximated as 0.016 (95% CI [0.009, 0.023]) animals per km^2 with a maximum of 0.047 animals per km^2 in July 2020.

3.5.4. WHITE BEAKED DOLPHIN

71. White-beaked dolphin was sighted in low numbers during the summer months only. Mean relative density and CV were therefore estimated from data collected during the months of June to September inclusive from the averaged densities in these months only (n=8 months included for analyses). An overall mean of 0.009 (95% CI [0.003, 0.017]) animals per km^2 was estimated via bootstrapping (Wessa, 2019). Peak densities were recorded during September 2020 when 24 animals were counted, equating to a density of 0.039 animals per km^2.

72. There is limited information on diving and surfacing times of white-beaked dolphin and consequently many studies report relative density estimates only (see 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). Therefore, based on these data, availability bias would be 0.18 and consequently absolute mean density can be approximated as 0.05 (95% CI [0.017, 0.094]) animals per km^2 with a monthly peak of 0.217 animals per km^2.

3.5.5. GREY SEAL

Design-based approach

73. Relative densities of grey seal plus seal species across the aerial survey area were, on average, very low for all seasons. Relative densities of grey seal plus seal species peaked in May 2019 and September 2020 with means of 0.130 (95% CI [0.087, 0.174]) animals per km^2 and 0.127 (95% CI [0.085, 0.171]) animals per km^2 respectively (Figure 3.21). Bootstrapping (Wessa, 2019) was undertaken to generate confidence intervals and the overall monthly mean relative density of grey seal plus seal species estimated from data pooled across all transects was 0.041 animals per km^2 (95% CI [0.030, 0.054]). Variance was high (CV = 0.881), most likely due to the relatively higher peaks in sightings in May 2019 and September 2020.

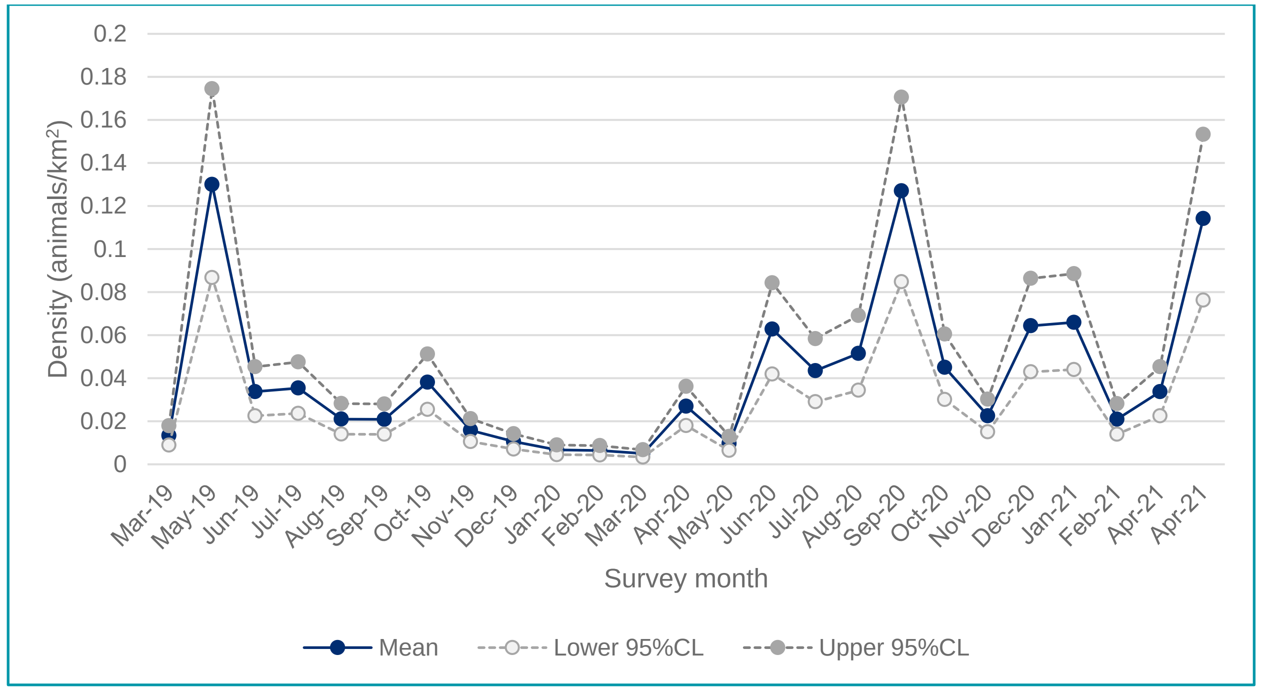


Figure 3.21: Estimated Monthly Mean Density (Relative) of Grey Seal Over the Aerial Survey Area. Graph Illustrates the Estimated Densities for Each Month of Survey (Solid Line) and 95% Confidence Intervals (Dotted Lines) Estimated Using Bootstrapping

74. The densities shown in Figure 3.21 are relative values and do not account for availability bias of this species during aerial surveys. 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%, and this was slightly lower during short duration trips (83.4%) (Thompson *et al.,* 1991). Therefore, it follows that the average proportion of time a travelling grey seal would be available for detection ranges between 15.7% and 16.6%.

75. Similarly, telemetry data from tags deployed by the Sea Mammal Research Unit (SMRU) on grey seals in the North Sea recorded 1,551 grey seal dives. These data were analysed for the Hornsea Three OWF (to estimate detection probability) and showed that 60% of surfacing periods were between 15 s and 45 s, with an average of 40 s (Orsted, 2018). Dive durations varied between 20 s and 496 s with an average of 216 s (Orsted, 2018). The average values reported from the telemetry data were used to estimate the proportion of time that grey seals were surfacing compared to diving to give an indication of the availability bias for the site-specific aerial surveys. The estimated availability was calculated as 15.6% and was therefore similar to the figures cited by Thompson *et al.* (1991) (paragraph 74).

76. As with harbour porpoise, it was assumed that all animals on (or near) the surface were available for detection during the aerial surveys (i.e. no perception bias) (section 2.5.3). The correction factor for availability bias, based on the telemetry studies described above, was 15.6% as the most conservative estimate. Thus, the estimates for absolute density for grey seal plus seal species across the aerial survey area ranged between 0 animals and 0.833 animals per km^2 (May 2019 with the highest densities) and the mean corrected density value across all transects and all seasons was 0.263 (95% CI [0.175, 0.353]) animals per km^2.

Table 3.8: Seasonal and Overall Monthly Densities Modelled for Grey Seal Plus Seal Species

Season	Mean relative density (Animals per km^2)	95% CI	Mean absolute density (Animals per km^2)	95% CI
Winter	0.029	0.006 to 0.052	0.187	0.041 to 0.332
Spring	0.041	0.009 to 0.086	0.305	0.058 to 0.502
Summer	0.048	0.030 to 0.053	0.265	0.190 to 0.340
Autumn	0.045	0.011 to 0.078	0.288	0.074 to 0.502
All months	**0.041**	**0.030 to 0.054**	**0.263**	**0.175 to 0.353**

Model-based approach

77. Grey seal plus seal species densities were similar across seasons (Table 3.9), with persistent hot spots observed in the southern Proposed Development array area plus ~12 km buffer. Seasonal density maps for grey seal plus seal species are shown in Figure 3.23. To derive densities per km^2, the raw density per season was scaled to cell size and divided by the total survey area (Berwick Bank and Marr Bank plus ~12 km buffer). The average density across all months was 0.043 (95% CI [0.024, 0.083]) animals per km^2.

78. Mean abundance estimates were calculated per season by summing the average densities per square kilometre grid cell and the estimated were scaled up to estimate the abundance within the Proposed Development array area plus ~16 km buffer (Table 3.9).

Table 3.9: Grey Seal Plus Seal Species Modelled Relative Density Estimates by Season for the Proposed Development including LCI and UCI. Abundance Estimates are Scaled Up to the Proposed Development Array Area Plus ~16 km Buffer

Season	Mean Relative abundance	Mean Relative Density (Animals per km^2)	LCI	UCI
Winter	247	0.029	0.013	0.074
Spring	422	0.050	0.028	0.094
Summer	381	0.045	0.026	0.082
Autumn	401	0.048	0.030	0.082
All months		**0.043**	**0.024**	**0.083**

79. Correcting these estimates based on the 0.156 availability bias of grey seal (see paragraph 76) provided a mean absolute density across all months of 0.276 (95% CI [0.154, 0.532]). This estimate is very similar to the estimate derived using the bootstrapping approach (mean = 0.263; see Table 3.5:). Corrected seasonal estimates of density are presented in Table 3.10.

Table 3.10: Grey Seal Plus Seal Species Modelled Absolute Density Estimates by Season for the Proposed Development Including LCI and UCI. Abundance Estimates are Scaled Up to the Proposed Development Array Area Plus ~16 km Buffer

Season	Mean Absolute abundance	Mean Absolute Density (Animals per km^2)	LCI	UCI
Winter	938	0.186	0.083	0.474
Spring	1605	0.321	0.179	0.603
Summer	1448	0.288	0.167	0.526
Autumn	1524	0.308	0.192	0.526
All months		**0.276**	**0.154**	**0.532**

80. For all seasons, grey seal plus seal species appears to occur in highest densities towards the southeast of the aerial survey area (Figure 3.22 and Figure 3.23).

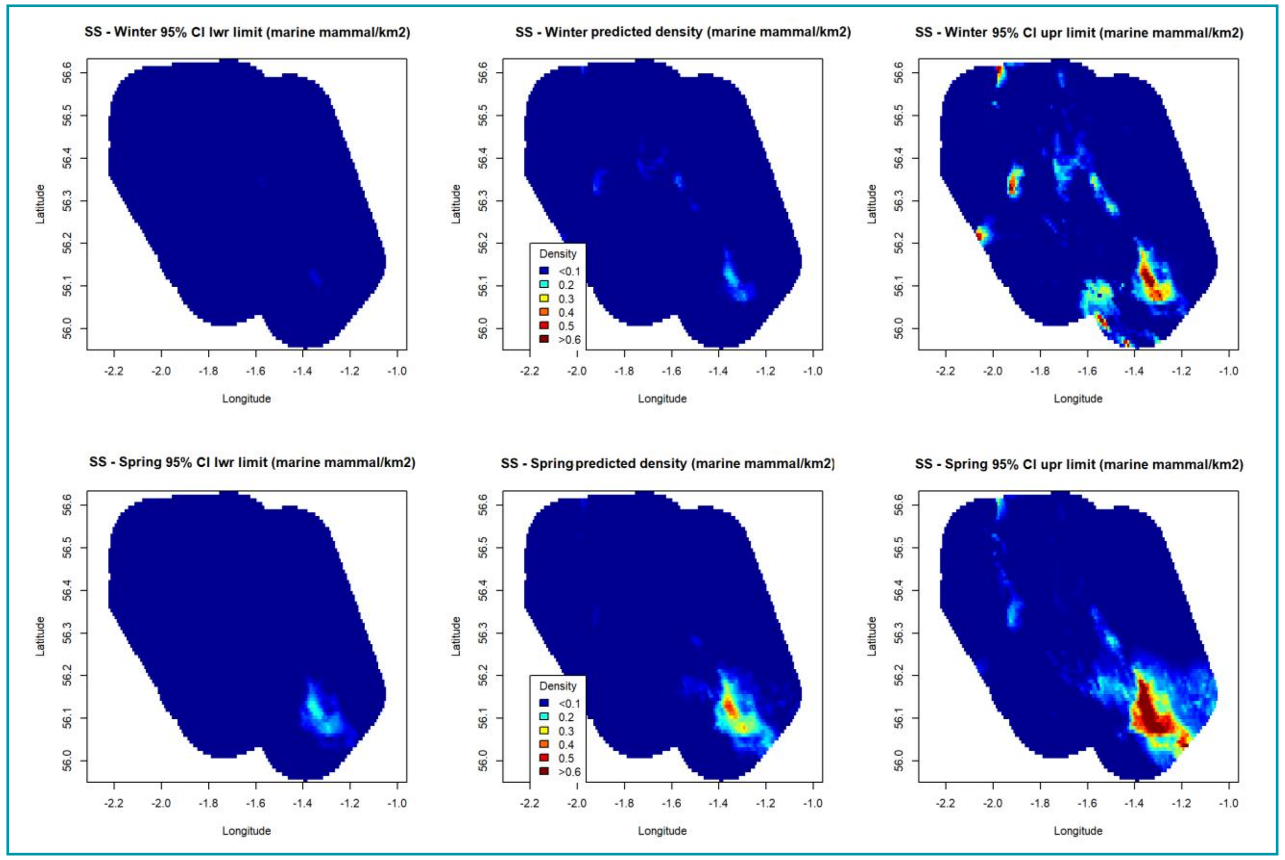


Figure 3.22: Grey Seal Plus Seal Species Predicted Density (Centre Panels) and Lower (Left Panels) and Upper (Right Panels) 95% CI by Season for Initial Berwick Bank Wind Farm Plus ~12 km Buffer

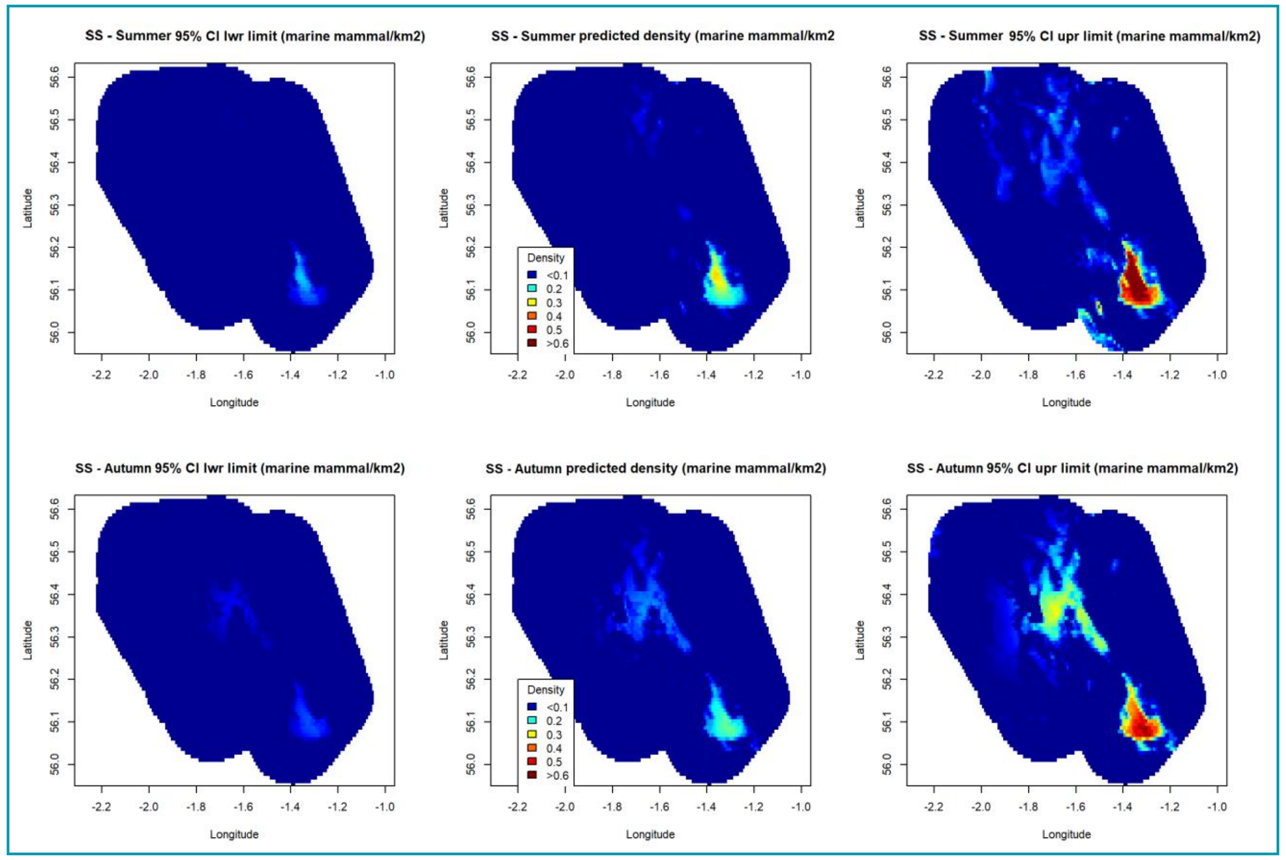


Figure 3.23: Grey Seal Plus Seal Species Predicted Density (Centre Panels) and Lower (Left Panels) and Upper (Right Panels) 95% CI by Season for Initial Berwick Bank Wind Farm Plus ~12 km Buffer

3.5.6. SUMMARY OF DENSITIES

81. A summary of the mean monthly densities across the aerial survey area estimated from the aerial sightings data is provided in Table 3.11. Densities are presented as relative values and approximations of absolute values based on availability bias estimated from studies looking at diving behaviour of different species (noting the caution with applying such values of availability bias). The use of these correction factors to approximate absolute densities were presented as part of the Marine Mammal Road Map consultation process for the Proposed Development.

Table 3.11: Summary of Mean Monthly Densities for Each Species in the Aerial Survey Area

Species	Mean Relative Density (Animals per km^2)	Availability Bias Correction Factor Applied	Mean Corrected Density (Animals per km^2)	Corrected 95% CI (lower)	Corrected 95% CI (upper)
Harbour porpoise (bootstrapping)	0.127	0.425	0.298	0.159	0.449
Harbour porpoise (MRSea)	0.127	0.425	0.299	0.155	0.652
Grey seal (bootstrapping)	0.041	0.156	0.263	0.175	0.353
Grey seal (MRSea)	0.043	0.156	0.276	0.154	0.532
Minke whale	0.007	0.443	0.016	0.009	0.023
White-beaked dolphin	0.009	0.180	0.050	0.017	0.094

4. SUMMARY

82. This report provides a summary of marine mammal activity recorded during the aerial digital surveys across the Proposed Development array area plus ~16 km buffer.

83. Despite a number of logistical and weather-related constraints - which meant that not all transects could be surveyed in every month - the data were processed to achieve the target coverage of the aerial survey area. In all but two of the 25 months of survey, the optimal target coverage of 12.49% of the aerial survey area was processed by HiDef. The minimal target of >10% was achieved in the remaining two months. Target coverage was achieved by undertaking remedial action to provide data from additional camera reels to cover data gaps.

84. Harbour porpoise was the most frequently recorded species across the aerial survey area, with sightings recorded in all months of the year. Grey seal including 'seal species' were also recorded monthly during the aerial surveys, albeit in relatively small numbers compared to harbour porpoise. Both minke whale and white-beaked dolphin were recorded during the summer months only and bottlenose dolphin was recorded in small numbers in October 2019 and April 2021 only.

85. Peaks in the encounter rate/density of harbour porpoise occurred during April 2020[2] and April 2021. These peaks were considerably higher than the estimates for other months therefore contributing to high variances in the overall estimates of mean density. Grey seal plus seal species had highest encounter rates/densities estimated for May 2019, September 2020 and April 2021. MRSea analyses was undertaken for harbour porpoise and grey seal plus seal species as there were sufficient data to produced spatial estimates of density on a seasonal basis. For both species seasonal peaks were estimated during spring with lower densities estimated during the winter months.

86. For harbour porpoise large group sizes were recorded in the months of April and May, with maximum counts of 39 animals and 49 animals, respectively. White-beaked dolphin and minke whale tended to occur in small groups of one or two animals maximum. The sighting of bottlenose dolphin in April 2021 was of a group of six animals.

87. Where possible, relative density estimates were corrected for availability bias to give absolute densities. Telemetry studies of the diving behaviour of different species were useful in indicating the average proportion of time that individuals of a species may be on, or near, the surface and available for detection. Note that the limitations of using availability bias estimates from published studies are recognised (e.g. potentially subject to geographic, seasonal, diurnal and individual animal variation) and therefore absolute densities are considered to be approximations only.

88. There was no clear spatial pattern in distribution for any of the species across the aerial survey area from the sightings maps, although in April 2020 there was a dense cluster of harbour porpoise sightings in the north-east half of the aerial survey area corresponding to the large group that moved into the area during this month. Spatial density maps suggest, however, that during spring harbour porpoise is more likely to occur in the eastern part of the aerial survey area. Grey seal appears to favour the south-east of the aerial survey area in all seasons of the year.

89. These data suggest seasonality in the occurrence of marine mammals within the aerial survey area. However, interpretation of seasonal differences should be treated with caution due to potential confounding effects of environmental variables during the aerial surveys and the limitations of the 'snap-shot' nature of aerial data.

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[2] Noting that 'April' 2020 was flown in early May 2020.

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