Digital video aerial surveys of seabirds and marine mammals at Erebus:
2-year Report
October 2019 to September 2021

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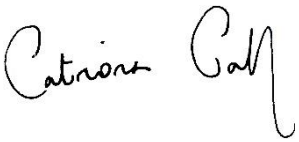
Checked by	Catriona Gall		14/10/2021
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Executive Summary

In October 2019, Blue Gem Wind commissioned HiDef Aerial Surveying Limited (HiDef) to undertake a programme of high-resolution digital video aerial surveys for marine megafauna, ornithological and human activity over the proposed Erebus offshore wind development site.

Project Erebus is located in Welsh waters of the Celtic Sea, approximately 35 km off the Pembrokeshire coast.

Monthly surveys were flown from October 2019 to September 2021, providing 24 surveys in total. HiDef designed a survey that placed 1km-spaced transects across Erebus, including a 4km buffer around the site ('the survey area'), comprising a total survey area of 200.11 km^2.

The HiDef surveys were undertaken using an aircraft equipped with four (4) HiDef Gen II cameras with sensors set to a resolution of 2cm Ground Sample Distance (GSD). Each camera sampled a strip of 125 m width, separated from the next camera by ~25 m, which provides a combined sampled width of 500 m within a 575 m overall strip. However, to ensure that sufficient footage is available to allow either a design-based or model-based analysis, footage from only two (2) of the four (4) cameras was analysed. The remaining footage is available for analysis at a later stage if required.

Data analysis followed a two-stage process in which video footage was reviewed (with a 20% random sample used for audit) then the detected objects were identified to species or species group level (again with 20% selected at random for audit). The audit of both stages requires 90% agreement to be achieved.

Density and abundance estimates were calculated using strip transect analysis and a statistical technique called kernel density estimation ('KDE') was used to create density surface maps.

Surveys were successful in recording a total of 34,462 birds of 19 species and 2,028 marine mammals of six species in 24 months. A further 1,526 birds and 52 marine mammals were recorded which were not assigned to species level. The identification rate achieved to species level was 95.57% across the survey programme. The primary observations from the surveys were that:

- The seasonal changes in the numbers of seabirds recorded was consistent with the Erebus project's proximity to seabird breeding colonies along the Pembrokeshire coast;
- Kittiwakes *Rissa tridactyla* and gannets *Morus bassanus* were recorded at relatively high densities during the winter and breeding season, respectively;
- Great black-backed gulls *Larus marinus* and lesser black-backed gulls *Larus fuscus* were recorded in relatively low numbers, with peaks in autumn and summer, respectively;
- Guillemots *Uria aalge* and *Manx shearwaters Puffinus puffinus* were recorded in the highest numbers; and
- Common dolphins *Delphinus delphis* were found in very high densities across the survey area, however harbour porpoise *Phocoena phocoena* were present in comparatively low numbers, with peaks in February and March 2021.

The work undertaken by HiDef collected 24 months of continuous data, satisfying the survey requirements of the contract.

1 Introduction

1 Erebus is a proposed offshore wind farm, located 35km off the Pembrokeshire coast in the north Celtic Sea. The project, commissioned by Blue Gem Wind, covers a proposed area of approximately 43km^2. The site will comprise of a floating wind demonstration project with a total export capacity of up to 100MW.

2 In September 2019, Blue Gem Wind commissioned HiDef Aerial Surveying Limited (HiDef) to undertake a programme of high-resolution digital video aerial surveys of marine megafauna (defined within this report as cetaceans, pinnipeds or other large, non-avian marine fauna), ornithological and anthropogenic activity to support development proposals for the proposed Erebus Wind Farm.

3 HiDef designed the survey methodology to provide information suitable to support Blue Gem Wind's proposal to develop at Erebus for which an accurate ornithological and marine megafaunal assessment of abundances and distributions is required to enable environmental assessment to take place.

4 Several important bird sites which have been classified as Special Protection Areas (SPA) under the European Council (EC) Directive 2009/147/EC on the Conservation of Wild Birds ('the Birds Directive') are located in the vicinity of the survey area.

5 Erebus borders the southern edge of the Skomer, Skokholm and Seas off Pembrokeshire SPA. The site is classified for the protection of four seabird species; European storm-petrel *Hydrobates pelagicus*, Manx shearwater *Puffinus puffinus*, Atlantic puffin *Fratercula arctica* and lesser black-backed gull *Larus fuscus,* as well as qualifying for its breeding seabird assemblage (JNCC, 2017). In close proximity is the Grassholm SPA, situated 25 km north-east. The SPA encompasses a 2km buffer around Grassholm island, which hosts the third largest colony of northern gannets *Morus bassanus* globally; approximately 12.5% of the breeding North Atlantic population (JNCC, 2016).

6 Out with these sites, the nearest prominent SPA designated for seabird species is the Saltee Islands SPA; located off County Wexford, Ireland, approximately 95km to the northwest. The site is classified for the protection of fulmar *Fulmarus glacialis*, gannet, shag *Phalacrocorax aristotelis*, kittiwake *Rissa tridactyla*, guillemot *Uria aalge*, razorbill *Alca torda* and puffin (NPWS, 2011).

7 Lundy Island in the Bristol Channel lies 71km to the east of Erebus and following a programme to remove mammalian predators holds a rapidly expanding breeding population of Manx shearwaters and puffins (Booker & Price 2014).

8 Seabirds are likely to use the surrounding waters of these locations for feeding and post-breeding dispersal, with many species foraging long distances from their breeding colonies. Gannets have been recorded foraging a maximum distance of up to 709km and kittiwake up to 770km (Woodward *et al.*, 2019). Of these species, focus will particularly be upon gannet, kittiwake, lesser black-backed gull and great black-backed gull *Larus marinus* due to their higher risk of collision and guillemot, razorbill, puffin and Manx shearwater due to their risk of displacement.

9 Marine mammals are also likely to be present year-round within the survey area. Harbour porpoise *Phocoena phocoena* are listed as an Annex II species under the EU Habitats Directive and are a qualifying feature for both the West Wales Marine SAC (JNCC, 2019a), located approximately 10km north-east of Erebus, and the Bristol Channel Approaches SAC (JNCC, 2019b), located approximately 26km south-

east. Additionally, the Pembrokeshire Marine SAC, approximately 16km north of Erebus, is designated for the protection of grey seal (JNCC, 2015b). Beyond this, the nearest SACs designated for marine mammals are likely to be that of Cardigan Bay SAC, designated for Bottlenose dolphin (JNCC, 2015a), and those along Irish coastlines, such as the Saltee Islands SAC, also designated for grey seal (NPWS, 2011).

10 This report provides the results from 24 surveys undertaken between October 2019 and September 2021, prior to the construction of Erebus Wind Farm. Observations and survey effort are summarised and results from analyses are presented as density surface distribution maps, abundance estimates with confidence intervals and summarised data on behaviour and age. A discussion is provided as to the representativeness of the results in relation to the wider region.

2 Methods

2.1 Survey flights

11 A series of strip transects were flown monthly between October 2019 and September 2021, following the protocol agreed in September 2019 (document reference: HP00113-001). Two surveys were flown in June 2020, more than two weeks apart, to account for an inability to fly in May 2020 (Table 3).

12 HiDef designed the survey methodology to provide information suitable to support Blue Gem Wind's proposal to develop at Erebus for which an accurate assessment of abundance and distribution of seabirds and marine mammals is required to enable environmental assessment to take place.

13 The survey design produced by HiDef placed transects 1km apart across the survey area, including a 4km buffer around the development site (Figure 1). This comprised a total survey area of approximately 200km^2.

14 The transect-based survey design placed strip transects, extending roughly north to south, approximately perpendicular to the depth contours along the coast. This design ensures each transect samples a similar range of habitats (primarily relating to water depth) to reduce variation in bird and mammal abundance estimates between transects.

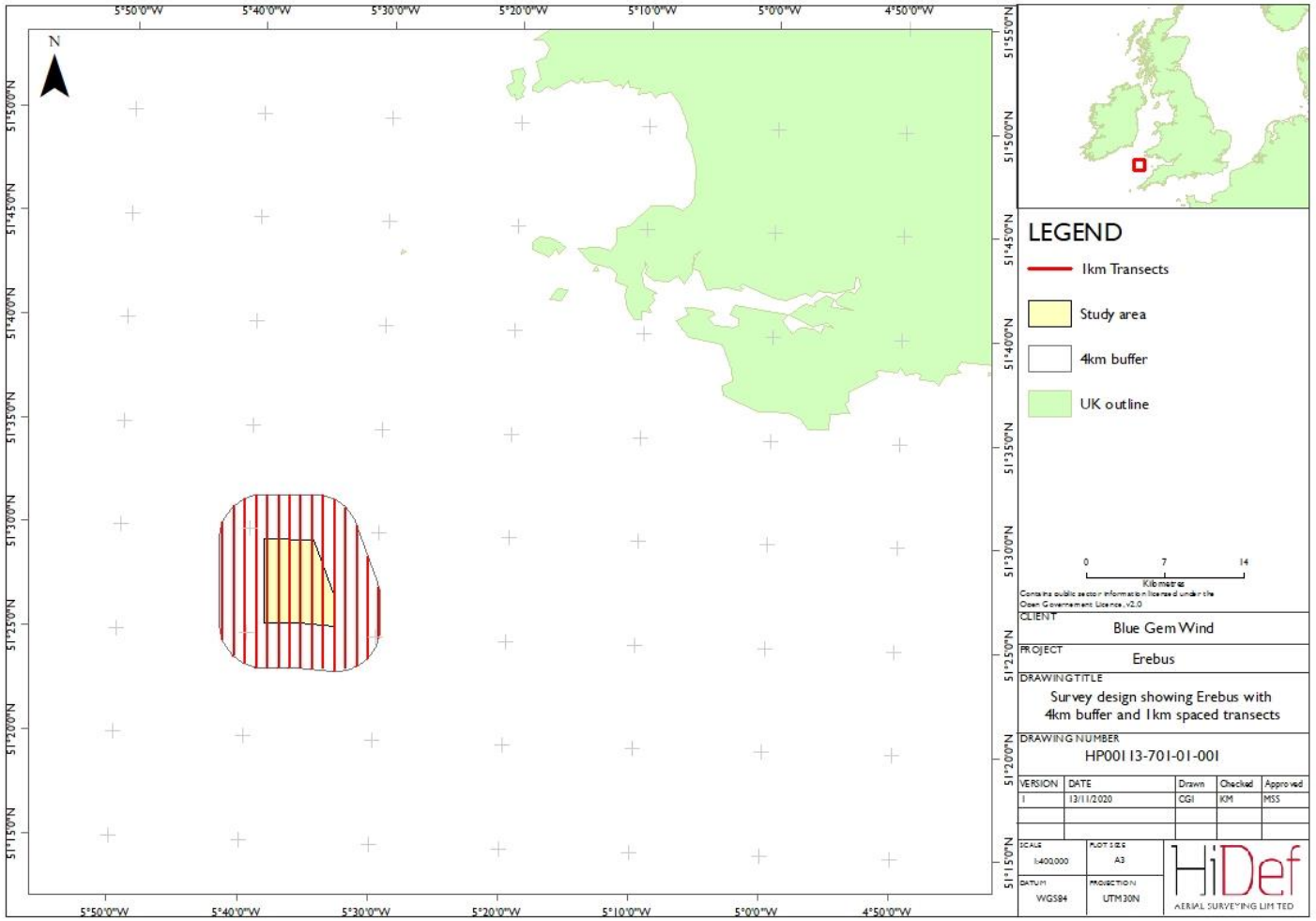
15 Surveys were undertaken using an aircraft equipped with four HiDef Gen II cameras with sensors set to a resolution of 2cm Ground Sample Distance (GSD). Each camera sampled a strip of 125m width, separated from the next camera by ~25m, providing a combined sampled width of 500m within a 575m overall strip.

16 To allow 25% site coverage while ensuring an adequate number of transects, HiDef agreed with Blue Gem Wind that only data from two cameras would be processed to ensure sufficient coverage and number of transects with the remaining unprocessed data archived.

17 The surveys were flown along the transect pattern shown in Figure 1 at a height of approximately 550m above sea level (ASL) (~1800'). Flying at this height ensures that there is no risk of flushing those species easily disturbed by aircraft noise. Thaxter *et al.* (2016) recommends a minimum flight altitude of 460-500m ASL.

18 Position data for the aircraft was captured from a Garmin GPSMap 296 receiver with differential GPS enabled to give 1m accuracy for the locations of fauna, which sent recording updates at one second intervals for later matching to bird and marine mammal observations.

Figure 1 **Survey design showing Erebus with 4 km buffer and 1km spaced transects**



2.2 Data Review and Object Detection

19 Data were viewed by trained reviewers who marked any objects in the footage as requiring further analysis, as well as determining which were birds, marine megafauna (defined within this report as cetaceans, pinnipeds or other large, non-avian marine fauna) or anthropogenic objects such as ships or buoys.

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

21 Objects were only recorded where they reached a reference line in the middle of the operator's screen (known as 'the red line') which defines the true transect width of 125m for each camera. By excluding objects that do not cross the red line, biases to abundance estimates caused by flux (movement of objects in the video footage relative to the aircraft, such as where the survey craft is buffeted by airflow) were eliminated.

2.3 Object Identification

22 Images marked as requiring further analysis were reviewed by the ID Team; specialist ornithologists[1] and marine mammal specialists[2] for identification to the lowest taxonomic level possible and for assessment of the approximate age and the sex of each animal, as well as any behaviour traits visible from the imagery.

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

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

25 It is important to note that these confidence ratings are not a standardised assessment. The likelihood of achieving a definite or probable identification is not consistent for all component members of a species group. For example, someone undertaking identification of a large auk species will find it easier to be confident of guillemot identification than razorbill. Confidence scores should not be used to filter

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

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

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

or weight the probability of 'large auk' being one species or another in any analysis, as this will lead to biased results, particularly if the identification rate is low.

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

27 Marine mammals and other marine megafauna were recorded using the same process. Animals were first assigned to a species group (e.g. 'cetacean species') and then given a species level identification (e.g. 'harbour porpoise', 'minke whale' or 'No ID'). If a precise species group could not be ascertained, then the record was assigned to a broader group category (e.g. 'seal or small cetacean species') and the species level recorded as 'No ID'. In the case of marine mammals, surfacing behaviour was also recorded as either 'surfacing', 'surfacing at red line', 'submerged' or 'unknown'. Surfacing behaviour was defined as any part of the non-avian animal's body breaking the surface of the water in any frame. However, for the purposes of calculating availability bias (2.6.3), harbour porpoise surfacing behaviour was also classified if the animal's dorsal fin was above the water in the frame nearest to the 'red line' on the operator's screen ('surfacing at red line'). Sexing and aging of marine mammals was carried out where possible.

28 Anthropogenic activity was recorded as either 'man-made object', 'fishing boat' or 'other boat'. Further details were noted in the comments, including further specifying the type of object (e.g. 'fishing buoy', 'marker buoy', 'wind turbine').

2.4 Data quality check

29 HiDef's method is designed to ensure low rejection of data on grounds of quality, such as low cloud, sun glare or other issues. Care is taken to avoid survey in low cloud or poor visibility by selection of survey days with the correct survey conditions. In the unlikely event that low cloud occurs during a survey, the pilot is instructed to either avoid areas affected and return to those at the end of the survey, return to a nearby base and wait for cloud to clear or abandon the survey. Sun glare is avoided by design of the survey rig which uses angled cameras on a rotating plinth. This means that the cameras are angled away from any sun glare at all times, with the camera rig rotated in between transects to ensure that this angle is maintained.

30 For each individual survey, one of the cameras (known as the 'weather camera'), recorded weather conditions such as sea state. Operators carrying out bird and mammal identification carried out environmental checks of the data and scored the sea state level based on the WMO Sea State code, in which score 6 or more is a high degree of sea state in which the data were not used as it would affect detection rates (Table 1).

Table 1 Scoring criteria for recording sea state as outlined by the WMO Sea State code

WMO Sea State Code	Wave height	Characteristics
0	0 metres	Calm (glassy)
1	0 to 0.1 metres	Calm (rippled)
2	0.1 to 0.5 metres	Smooth (wavelets)
3	0.5 to 1.25 metres	Slight (first whitecaps)
4	1.25 to 2.5 metres	Moderate (many whitecaps)
5	2.5 to 4 metres	Rough (some spray)
6	4 to 6 metres	Very rough (large waves, many whitecaps, much spray)
7	6 to 9 metres	High (streaks of wind-blown foam)
8	9 to 14 metres	Very high
9	Over 14 metres	Phenomenal

2.5 Final processing

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

2.6 Data analysis

2.6.1 Data treatment

32 All observations were compiled for analysis and presentation. Records identified to species level were separated out from records of individuals identified to group level only, and the following analyses undertaken on both datasets. No apportioning of 'unidentified' birds or mammals to species level was undertaken. All confidence levels of species identifications were used in the analysis.

2.6.2 Abundance Estimates

33 The abundance of each species observed was estimated separately using a design-based strip transect analysis.

34 Each transect is treated as an independent analysis unit, and the assumption is made that transects can be treated as statistically independent random samples from the site. The length and breadth (i.e. the width of the field of view of the camera) of each transect multiplied give the transect area; dividing the number of observations on that transect by the transect area gives a point estimate of the density of that species for the transect. The density of animals at the site (and hence the population size), the standard deviation, the 95% Confidence Intervals (CIs) and coefficient of variance (CV) are then estimated using a non-parametric bootstrap method with replacement (Buckland *et al.*, 2001).

35 The upper and lower 95% confidence intervals were performed by way of a blocked bootstrapping technique to ensure equal transect effort was sampled across each iteration. This was done by using transect ID as the sampling unit with replacement, and then randomly sampling until the total length of

the sampled transects equalled approximately the same length as the total survey length. A total of 5,000 bootstrap iterations were performed from which we calculated the mean and standard deviation of the sampled means, as well as the relative standard error as defined by the standard deviation divided by the mean (or the "Coefficient of Variation", CV). Data were processed in the R programming language (version 3.4.3) and code can be provided on request.

36 The density estimate is expressed as the average number of animals per square km surveyed over the whole site, and the population estimate is then calculated as the average density multiplied by the area of the whole site. The standard deviation is a measure of the variance of the population estimate, standardised by the number of samples (transects). The upper and lower CI define the range that the population estimate falls within with 95% certainty. The CV is a measure of the precision of the population and density estimates.

37 For most species these abundance estimates relate to absolute abundance, but for diving species (auks and marine mammals) the abundance relates to relative abundance due to a proportion of animals being submerged at the time of survey. In Section 2.6.3 we describe our method for taking account of species availability to generate estimates of absolute abundance.

2.6.3 Availability bias

38 In wildlife surveys, a proportion of seabirds or marine mammals that spend any time underwater, especially while feeding, will not be detectable at the surface. This "availability bias" leads to an under-estimate of their abundance during surveys. For species that make long dives underwater, this bias might be significant (for example, shag).

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

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

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

Where s is the average time spent at the surface, t is the window of time that the animal is within view and d is the average time below the surface. In the case of digital video surveys, the value of t is negligibly small and is treated as 0.

41 Due to a lack of diving rate data for many species, availability bias corrections were only conducted on four species: guillemots, razorbills, puffins and harbour porpoises.

2.6.3.1 Seabirds

42 Using Barlow's method, we calculate the proportion of time that an animal is available at the surface (Pr (visible)) for guillemot and razorbill. Absolute density, corrected for availability, is then obtained by dividing the density of birds observed by the Pr(visible).

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

44 Thus, the proportion of time that guillemots and razorbills are available at the surface (Pr(visible)) was estimated at 0.7595 and 0.8182, respectively.

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

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

2.6.3.2 Marine mammals

47 Harbour porpoise abundance is also affected by availability bias, and further complicated because detections of animals are possible while they are submerged. There are two approaches to using known diving rates to correct for availability bias for this species: to apply a correction factor to the density of animals that were recorded surfacing only using data on the surfacing rates from tagged animals; or to apply a correction factor to the density of all animals (at the surface and subsurface) using the proportion of time spent at known depths by tagged animals.

48 The depth above which animals are available for detection is not known and is likely to vary according to the turbidity of the water, and perhaps other factors, but has been estimated to be 2m by Teilmann *et al.* (2013) when correcting for availability bias during visual aerial surveys of harbour porpoise.

49 Teilmann *et al.* (2013) provides detailed information which accommodates variation in time of year, geographical location and time of day in the proportion of time spent in the surface 2m of the water column and breaking the surface. All of these metrics relate to model outputs in Teilmann *et al.* (2013) and are used to refine the predicted amount of time that harbour porpoise spend surfacing in the outputs.

50 The tagging study of Teilmann *et al.* (2013) did not extend to the area of sea surrounding Erebus, and no other data are available on surfacing behaviour for this species in the relevant area. For our analysis, we assumed that diving behaviour in the wind farm area is comparable to that of the study area of Teilmann *et al.* (2013).

51 To estimate the density of surfacing harbour porpoise all detectable animals were used, and we calculated the proportion where the dorsal fin was snapshot surfacing. Snapshot surfacing indicates where the dorsal fin is clear of the water surface in the middle frame of the sequence in which the animal is present (crossing 'the red line'). This was done using data from all months combined because sample sizes were too small to be accurate when calculating the surfacing proportions in individual months. We multiplied the calculated density of harbour porpoise by the proportion of snapshot surfacing encounters in our surveys and divided this by the proportion of surfacing behaviour from Teilmann *et al.* (2013) in Table 2, to derive the estimates of absolute density and abundance.

Table 2 Correction factors used to account for availability bias for harbour porpoise at different times of the year and at different times of the day (after Teilmann *et al.*, 2013)

Month	Behaviour			
	Surface		0 – 2 m	
	09:00 – 15:00	15:00 – 21:00	09:00 – 15:00	15:00 – 21:00
January	0.0490	0.0476	0.4381	0.418614
February	0.0398	0.0384	0.3748	0.355348
March	0.0543	0.0529	0.4637	0.444271
April	0.0646	0.0632	0.5708	0.551331
May	0.0563	0.0549	0.5262	0.506735
June	0.0518	0.0503	0.5093	0.489809
July	0.0493	0.0479	0.5116	0.492099
August	0.0530	0.0516	0.4508	0.431293
September	0.0420	0.0406	0.4468	0.427348
October	0.0413	0.0399	0.4422	0.42276
November	0.0406	0.0392	0.4439	0.424431
December	0.0429	0.0415	0.4790	0.459555

2.6.4 Density mapping

52 Density maps were created to display the distribution of key species only. For diving species (guillemot and razorbill), density mapping was undertaken using 'relative' density estimates, *prior* to adjustment for availability bias.

53 The density maps have been derived using a Watson-Nadaraya type kernel density estimation ('KDE') technique (Simonoff, 1996). In KDE, a small 'window' function (the kernel) is used to calculate a local density at each point in the study area. To evaluate the density at a given point, the kernel is centred on that point and all the observations within the window are summed to obtain a local count. The total area of the transect(s) intersecting the window is then summed to obtain a local measure of effort. By dividing the local count by the local effort, a local density estimate is obtained. To build a density map, the study area is covered with a fine mesh of study points and the density is calculated at each point in the mesh in turn.

54 Kernel techniques are robust and not as complex as other density estimation techniques because they have few parameters; as a result, they are arguably the easiest density surface technique to reproduce independently. The only variables are the size and shape of the kernel or window function. For these

analyses, we have used a Gaussian window function, which has the advantages of being smooth, rotationally symmetric, and easy to compute. The shape of the Gaussian window is determined by a single width parameter; the selection of this parameter is the only variable in the computation of the density maps.

55 Rather than set the width parameter arbitrarily, we have used a leave-one-out cross validation method. Cross validation estimates the predictive power of a model by removing some of the data from the data set and using the remainder of the data and the model to predict the values for the data that was removed. The closer the predicted values represent the removed data, the better the model performance and the width parameter used in the model.

56 To apply cross validation to the survey area, each transect is subdivided into 1km long segments. To evaluate a particular choice of kernel width, each segment is removed in turn, then the kernel and remaining data are used to predict the density of the missing segment and subtract the known value from the prediction to obtain an error score. This process is repeated for every segment and the error scores for all segments are squared and summed to give a total performance score for that particular choice of kernel width. The kernel width is then varied and the process repeated; if the new score is lower than the old, the new kernel width is a better choice than the previous value. An exhaustive search over all kernel widths is then used to identify the best global choice. The result is a smooth density estimate which has been derived without any manual parameter selection. The whole process is repeated from scratch for each map, as different kernel sizes are appropriate for different species.

57 It should be noted that several of the KDE maps are effectively flat (i.e., they appear the same colour throughout the study area). These correspond to distributions where the density surface as obtained from a small local kernel was not effective at predicting missing data; this can happen with evenly distributed birds, but mainly happens for very sparse distributions. In the case of sparse distributions, the 'flat' map does not necessarily mean that the true underlying distribution is 'flat'; it could mean that the data doesn't contain enough evidence to determine what the underlying distribution is. It is therefore useful to refer back to the population estimates for the corresponding map when looking at these 'flat' densities; we have also overlaid the relevant observations as dots to help with interpretation of the maps. In extreme cases, the kernel density maps were not included in the results section, and the data were only presented as dot maps. This occurred where there were fewer than five observations of the species in question.

58 For less abundant bird and non-avian species, as well as those identified to group level, density mapping was not undertaken. Instead, distribution is illustrated by dot maps.

3 Results

3.1 Survey effort

59 The date, number of transects and survey effort (as expressed by length of transects) undertaken between October 2019 and September 2021 are shown in Table 3. The number of transects and the total length of transects are those used in subsequent analyses (see Figure 2 to Figure 3 for the aircraft flight pattern). Variation in presentation of track data is due to differing GPS equipment used in some surveys. Transect lines flown were the same for each survey; however, effort differed slightly due to slight differences in start and stop times and minor deviations of the aircraft from the transect line. As an indication, total lengths of analysed transects presented a mean of 203.21 ± 1.34 km (SD) and a difference of 7.12 km was found between the smallest and largest lengths analysed. The minor differences observed throughout the survey period are, therefore, thought to be negligeable and to not affect the survey results.

Table 3 Survey effort across the Erebus survey area between October 2019 and September 2021

Survey date	Survey Number	Number of transects analysed	Total length of transects analysed (km)	Area Covered (km²)	Area Covered (%)
22 October 2019	1	15	203.37	50.84	25.41
08 November 2019	2	15	203.46	50.87	25.42
04 December 2019	3	15	203.27	50.82	25.40
18 January 2020	4	15	202.87	50.72	25.35
04 February 2020	5	15	197.05	49.26	24.62
03 March 2020	6	15	203.27	50.82	25.40
04 April 2020	7	15	203.23	50.81	25.39
08 June 2020	8	15	203.29	50.82	25.40
24 June 2020	9	15	203.62	50.90	25.44
23 July 2020	10	15	203.02	50.76	25.37
31 August 2020	11	15	203.82	50.96	25.47
12 September 2020	12	15	203.33	50.83	25.40
15 October 2020	13	15	203.55	50.89	25.43
22 November 2020	14	15	204.17	51.04	25.51
31 December 2020	15	15	203.23	50.81	25.39
16 January 2021	16	15	203.83	50.96	25.46
22 February 2021	17	15	203.59	50.90	25.43

Survey date	Survey Number	Number of transects analysed	Total length of transects analysed (km)	Area Covered (km²)	Area Covered (%)
05 March 2021	18	15	203.39	50.85	25.41
10 April 2021	19	15	203.58	50.89	25.43
14 May 2021	20	15	203.87	50.97	25.47
15 June 2021	21	15	203.49	50.87	25.42
14 July 2021	22	15	203.48	50.87	25.42
16 August 2021	23	15	203.60	50.90	25.44
01 September 2021	34	15	203.69	50.92	25.45

Figure 2 **Tracks flown over the survey area between October 2019 and September 2020**

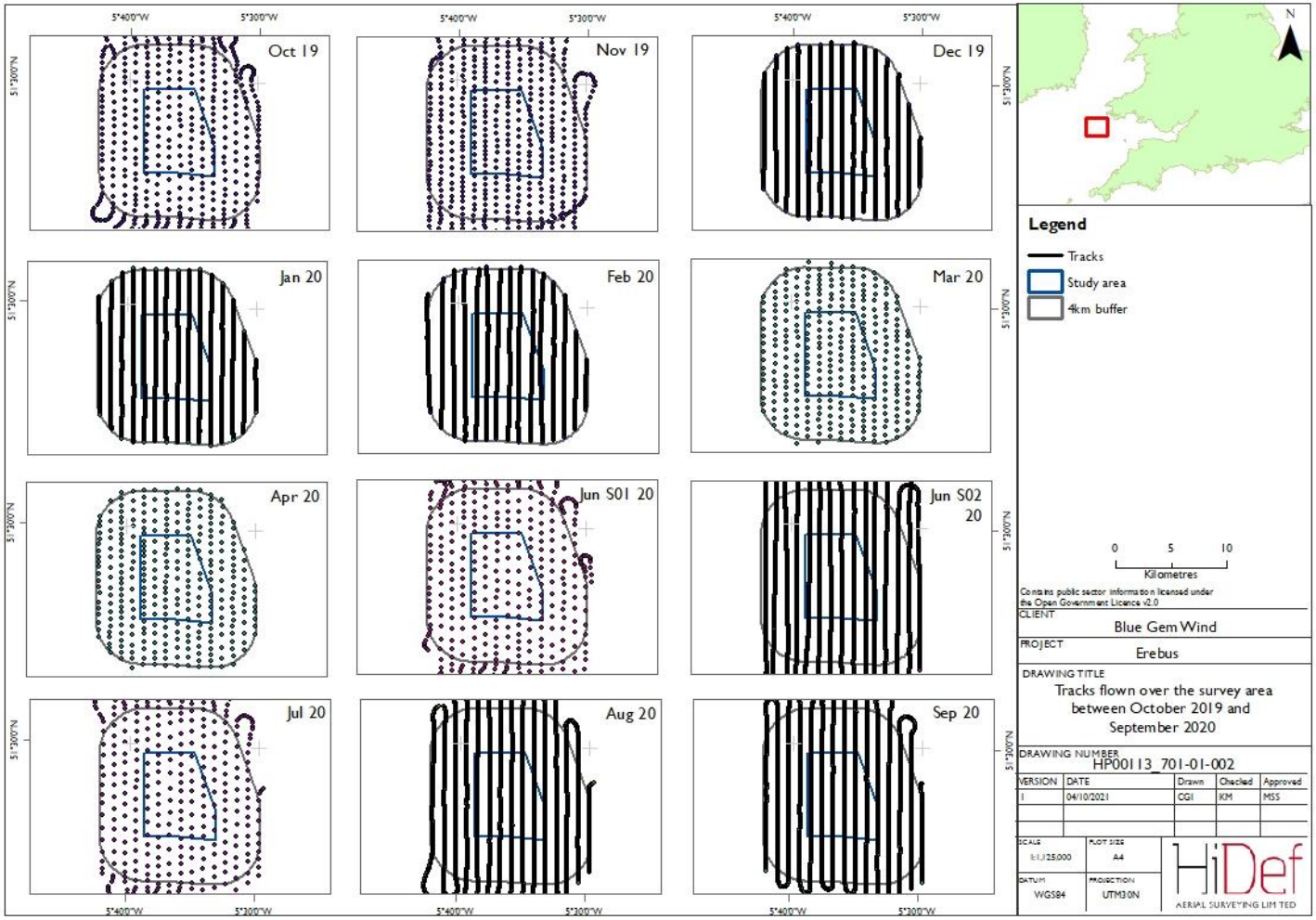
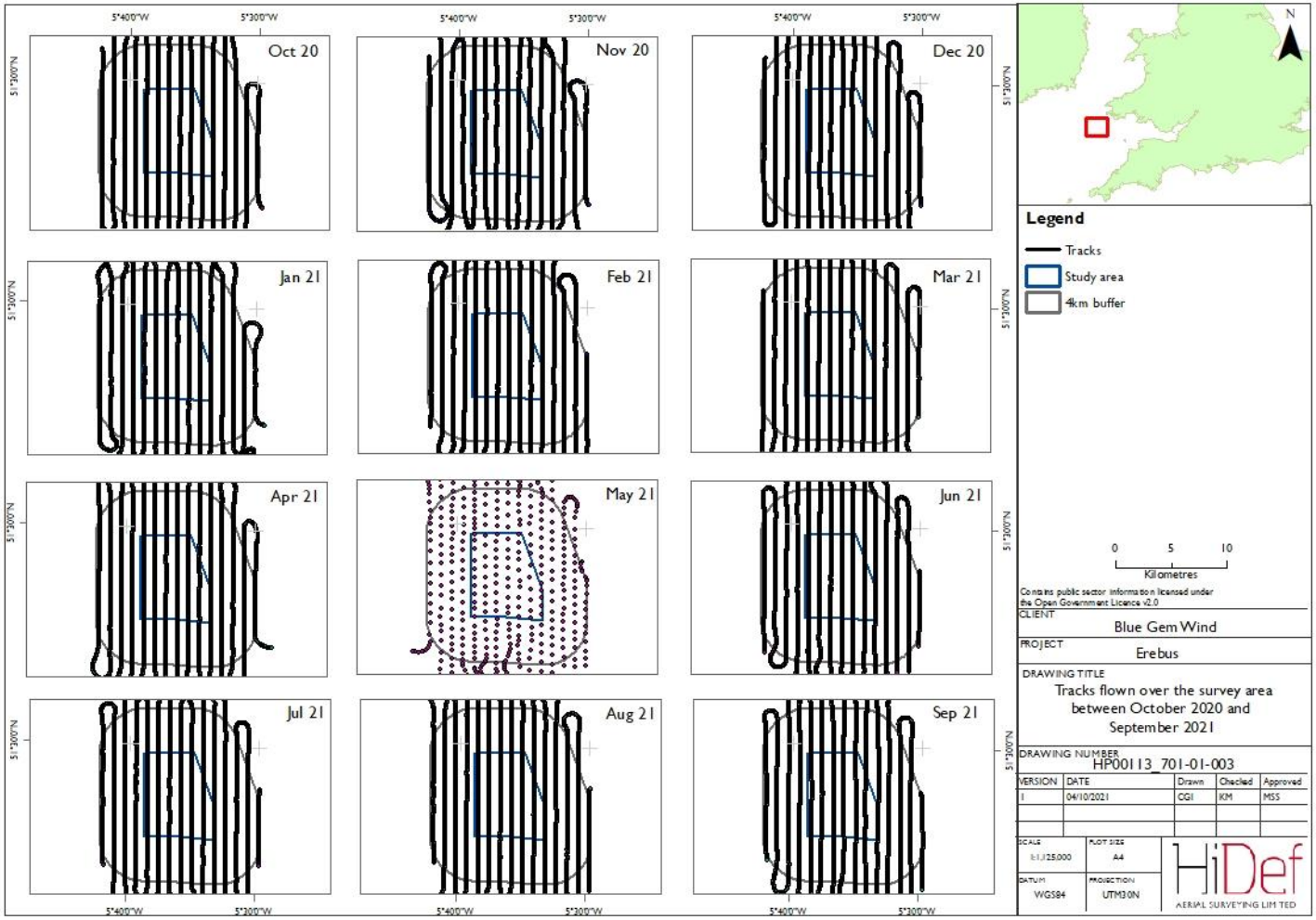


Figure 3 **Tracks flown over the survey area between October 2020 and September 2021**



3.2 Survey results

60 Each animal was assigned to at least a species group and where possible these were also assigned a further species level identification with confidence levels of 'Possible', 'Probable' or 'Definite' (2.3). Any animals that could not be identified to species level were assigned to a category 'No ID' in the species column. The analysis of data to species level uses all levels of identification confidence. The overall identification rate of birds and non-avian animals to species level (not including 'No ID's) for the 26 surveys are given in Table 4.

61 The total number of objects detected in each survey, as well as uncorrected numbers of species and species groups are presented in Table 4 to Table 7. Some observations fall outside the study area and thus are not included in analysis presented in Section 3.3 onwards.

Table 4 Survey identification rates at Erebus survey area between October 2019 and September 2021

Survey date	ID rate (%)
22 October 2019	94.44
08 November 2019	97.92
04 December 2019	93.11
18 January 2020	93.93
04 February 2020	91.22
03 March 2020	97.42
04 April 2020	96.07
08 June 2020	96.96
24 June 2020	95.24
23 July 2020	96.63
31 August 2020	97.89
12 September 2020	96.68
15 October 2020	94.55
22 November 2020	97.78
31 December 2020	95.87
16 January 2021	94.99
22 February 2021	91.07
05 March 2021	90.1
10 April 2021	96.57
14 May 2021	95.19

Survey date	ID rate (%)
15 June 2021	96.87
14 July 2021	97.91
16 August 2021	97.42
01 September 2021	97.80
Average	**95.57**

Table 5 Number of animals detected during each survey assigned to species level for the Year 1, between October 2019 and September 2020

Species	Scientific name	2019			2020									Yr 1 Total
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	
Kittiwake	*Rissa tridactyla*	995	567	123	19	33	13	4	0	3	2	18	5	1782
Sabine's Gull	*Xema sabini*	1	0	0	0	0	0	0	0	0	0	0	0	1
Black-headed gull	*Chroicocephalus ridibundus*	0	0	2	0	0	0	0	0	0	0	0	0	2
Little gull	*Hydrocoloeus minutus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Common gull	*Larus canus*	1	3	6	0	0	0	0	0	0	0	0	0	10
Great black-backed gull	*Larus marinus*	48	14	6	0	0	2	0	0	0	5	1	0	76
Herring gull	*Larus argentatus*	0	6	7	0	3	4	0	0	1	6	0	0	27
Lesser black-backed gull	*Larus fuscus*	9	2	0	1	2	2	4	0	2	29	0	0	51
Sandwich tern	*Thalasseus sandvicensis*	0	0	0	0	0	0	0	0	0	0	0	1	1
Common tern	*Sterna hirundo*	0	0	0	0	0	0	0	0	0	0	0	0	0
Arctic tern	*Sterna paradisaea*	0	0	0	0	0	0	0	0	0	0	0	0	0
Great skua	*Stercorarius skua*	0	0	0	0	0	0	0	0	0	0	0	1	1
Guillemot	*Uria aalge*	2698	1140	617	260	65	151	77	29	272	182	6503	2235	14229
Razorbill	*Alca torda*	665	463	65	42	5	17	59	0	3	3	25	43	1390
Puffin	*Fratercula arctica*	12	0	4	0	0	4	391	0	156	4	9	2	582
Fulmar	*Fulmarus glacialis*	0	136	0	2	3	11	4	0	1	2	1	1	161
Manx shearwater	*Puffinus puffinus*	0	0	0	0	0	0	1	143	732	693	383	3	1955

Species	Scientific name	2019			2020									Yr 1 Total
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	
Gannet	*Morus bassanus*	142	119	8	1	6	23	22	38	86	141	87	22	695
Grey heron	*Ardea cinerea*	0	0	0	0	0	0	0	0	0	0	0	0	0
Basking shark	*Cetorhinus maximus*	0	0	1	0	0	0	0	10	1	0	1	0	13
Blue shark	*Prionace glauca*	0	0	0	0	0	0	0	0	1	0	0	0	1
Bluefin Tuna	*Thunnus thynnus*	0	0	0	0	0	0	0	0	0	0	1	0	1
Ocean sunfish	*Mola mola*	0	0	0	0	0	0	0	0	5	0	0	0	5
Grey seal	*Halichoerus grypus*	0	1	0	0	0	0	0	0	0	0	0	0	1
Minke whale	*Balaenoperta acutorostrata*	0	0	0	0	0	0	0	0	3	0	0	0	3
Common dolphin	*Delphinus delphis*	0	40	11	275	36	24	15	226	142	251	68	232	1320
Risso's dolphin	*Grampus griseus*	0	0	1	0	0	0	0	0	0	0	0	0	1
Bottlenose Dolphin	*Tursiops truncatus*	0	0	0	0	0	6	0	0	2	0	0	0	8
Harbour porpoise	*Phocoena phocoena*	0	0	1	8	0	8	0	1	0	0	4	0	22
Total		**4571**	**2491**	**852**	**608**	**153**	**265**	**577**	**447**	**1410**	**1318**	**7101**	**2545**	**22338**

Table 6 Number of animals detected during each survey assigned to species level for the Year 2, between October 2020 and September 2021

Species	Scientific name	2020			2021									Yr 2 Total	Grand Total
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
Kittiwake	*Rissa tridactyla*	187	40	304	420	25	12	0	0	0	0	0	3	991	2773
Sabine's Gull	*Xema sabini*	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Black-headed gull	*Chroicocephalus ridibundus*	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Little gull	*Hydrocoloeus minutus*	2	1	0	1	0	0	0	0	0	0	0	0	4	4
Common gull	*Larus canus*	0	0	0	0	4	0	0	0	0	0	2	0	6	16
Great black-backed gull	*Larus marinus*	8	12	4	0	2	0	1	0	0	0	1	0	28	104
Herring gull	*Larus argentatus*	2	6	0	0	50	0	0	0	0	2	0	0	60	87
Lesser black-backed gull	*Larus fuscus*	0	1	0	0	0	2	0	1	24	10	4	0	42	93
Sandwich tern	*Thalasseus sandvicensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Common tern	*Sterna hirundo*	0	0	0	0	0	0	0	0	0	0	1	1	2	2
Arctic tern	*Sterna paradisaea*	0	0	0	0	0	0	0	4	2	0	1	0	7	7
Great skua	*Stercorarius skua*	0	0	0	0	0	0	0	0	0	0	0	1	1	2
Guillemot	*Uria aalge*	2751	1918	662	670	261	1872	441	384	262	107	29	27	9384	23613
Razorbill	*Alca torda*	117	41	252	307	29	42	43	17	6	0	0	0	854	2244
Puffin	*Fratercula arctica*	0	0	0	0	0	6	74	67	181	10	4	3	345	927
Fulmar	*Fulmarus glacialis*	0	8	1	3	32	3	1	2	4	1	2	3	60	221
Manx shearwater	*Puffinus puffinus*	1	0	0	0	0	1	12	9	712	16	52	310	1113	3068
Gannet	*Morus bassanus*	104	1	8	0	39	65	48	43	56	41	56	140	601	1296

Species	Scientific name	2020			2021									Yr 2 Total	Grand Total
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
Grey heron	*Ardea cinerea*	0	0	0	0	1	0	0	0	0	0	0	0	1	1
Basking shark	*Cetorhinus maximus*	0	0	0	0	0	0	0	0	0	0	0	0	0	13
Blue shark	*Prionace glauca*	0	0	0	0	0	0	0	0	1	0	0	0	1	2
Bluefin Tuna	*Thunnus thynnus*	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ocean sunfish	*Mola mola*	0	0	0	0	0	0	0	0	3	0	0	0	3	8
Grey seal	*Halichoerus grypus*	0	0	0	0	1	2	0	0	0	0	0	0	3	4
Minke whale	*Balaenoptera acutorostrata*	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Common dolphin	*Delphinus delphis*	116	3	9	13	66	152	12	8	96	78	1	55	609	1929
Risso's dolphin	*Grampus griseus*	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Bottlenose Dolphin	*Tursiops truncatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Harbour porpoise	*Phocoena phocoena*	8	0	2	0	23	24	2	0	2	0	0	0	61	83
Total		**3296**	**2031**	**1242**	**1414**	**533**	**2181**	**634**	**535**	**1349**	**265**	**153**	**543**	**14176**	**36514**

Table 7 **Number of objects with no species ID detected during each survey assigned to species groups for the Year 1, between October 2019 and September 2020**

Species group (No ID)	2019			2020									Yr 1 Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	
Wader species	0	3	0	0	0	0	0	0	0	0	0	0	3
Small gull species	7	0	0	0	0	0	0	0	1	1	0	0	9
Large gull species	4	0	2	0	0	0	0	0	0	1	0	0	7
Gull species	2	3	1	1	0	0	0	0	0	1	0	1	9
Arctic / common tern	0	0	0	0	0	0	0	0	0	0	3	0	3
Tern species	0	0	0	0	0	0	0	0	0	0	2	0	2
Tern / small gull species	1	0	0	0	0	0	0	0	0	0	1	0	2
Large auk	168	38	50	15	10	6	1	0	10	5	37	40	380
Auk species	68	6	9	4	2	0	19	0	21	5	46	24	204
Auk / small gull	9	1	0	1	1	0	0	0	0	0	6	2	20
Large auk / diver species	0	0	0	0	0	0	0	0	0	0	1	0	1
Auk / shearwater species	6	1	0	0	0	0	3	6	37	25	60	7	145
Fulmar / gull species	3	0	0	0	0	0	0	1	0	0	2	0	6
Shearwater species	0	0	0	0	0	0	0	0	1	0	0	0	1
Gannet species	1	0	0	0	0	0	0	0	0	0	0	0	1
Passerine species	0	0	0	0	0	0	0	0	0	0	0	0	0
Small bird species	0	0	0	0	0	0	0	0	4	0	0	0	4
Seal species	0	0	0	0	0	1	0	0	0	0	0	0	1

Species group (No ID)	2019			2020									Yr 1 Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	
Dolphin species	0	0	0	1	8	7	0	1	0	5	0	2	24
Cetacean species	0	0	2	0	1	0	0	1	5	0	0	0	9
Seal / small cetacean species	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**269**	**52**	**64**	**22**	**22**	**14**	**23**	**9**	**79**	**43**	**158**	**76**	**831**

Table 8 **Number of objects with no species ID detected during each survey assigned to species groups for the Year 2, between October 2020 and September 2021**

Species group (No ID)	2020			2021									Yr 2 Total	Grand Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep		
Wader species	0	0	0	0	0	0	0	0	0	0	0	4	4	7
Small gull species	4	0	0	0	0	0	0	0	0	0	0	0	4	13
Large gull species	1	2	0	0	0	0	0	0	0	0	0	0	3	10
Gull species	0	1	0	0	1	0	0	0	0	0	0	1	3	12
Arctic / common tern	0	0	0	0	0	0	0	0	2	0	0	0	2	5
Tern species	0	0	0	0	0	0	0	0	1	0	0	0	1	3
Tern / small gull species	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Large auk	86	26	45	60	36	185	9	10	2	0	0	0	459	839
Auk species	36	13	3	0	1	29	6	15	16	3	2	1	125	329
Auk / small gull	20	4	5	14	0	6	0	0	0	0	0	1	50	70
Large auk / diver species	2	0	0	0	0	0	0	0	0	0	0	0	2	3
Auk / shearwater species	2	0	0	0	0	0	7	5	18	1	0	4	37	182
Fulmar / gull species	2	0	0	0	5	0	0	0	0	0	0	0	7	13
Shearwater species	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Gannet species	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Passerine species	30	0	0	0	0	0	0	0	0	0	0	0	30	30
Small bird species	0	0	0	0	0	0	0	0	1	0	1	0	2	6
Seal species	0	1	0	1	0	0	1	0	1	0	0	0	4	5

Species group (No ID)	2020			2021									Yr 2 Total	Grand Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep		
Dolphin species	0	1	4	0	1	1	0	0	2	2	0	0	11	35
Cetacean species	1	0	0	0	0	1	0	0	0	0	0	0	2	11
Seal / small cetacean species	0	0	0	0	0	0	0	0	1	0	0	0	1	1
Total	**184**	**48**	**57**	**75**	**44**	**222**	**23**	**30**	**44**	**6**	**3**	**11**	**747**	**1578**

3.3 Species

62 Density estimates calculated for the whole survey area, as well as 95% confidence limits of population estimates, are presented for key species only. Density and population estimates for all species and species groups, as well as measures of standard deviation and CV, are presented in Appendix 1. An explanation of these elements is presented Table 9.

63 For certain diving species (guillemots, razorbills and puffins, and harbour porpoise), density estimates were adjusted to account for availability bias (2.6.3) and estimate absolute abundance. The adjusted (absolute) density and abundances provide the best estimate of abundance at the time of survey. No calculation of availability bias was carried out for any other species due to the low numbers present and/or lack of information about diving patterns. Absolute density and abundance estimates can be found in Appendix II and are presented in this section instead of relative density for the relevant key species.

64 Distribution patterns of the most abundant species are presented as density maps, in which a density surface depicts the estimated density of individuals per km². Distributions of less abundant and unidentified species are presented as dot maps only.

65 Anthropogenic activity is presented as dot maps for reference only.

Table 9 Terms used in density and abundance analysis

Term	Definition
Density estimate *(animals/km^2)*	The average number of animals per square km surveyed over the whole area (Erebus site plus 4km buffer)
Population estimate *(number)*	The mean number of animals estimated to exist across the whole survey area (Erebus site plus 4km buffer)
95% confidence intervals or 'limits' of population *(CI)*	A measure of uncertainty in the mean value. If the analysis was repeated, 95% of the time the mean population estimate would fall within this upper and lower boundary. The smaller the relative CI range, the more confident we can be that the mean estimate is an accurate reflection of the true population size.
Standard deviation *(SD)* of population estimate	The amount of variation or dispersion of a set of values. A low SD indicates that the bootstrap values tend to be close to the mean of the set.
CV (%)	The coefficient of variation is a standard measure that describes the dispersion of data points around the mean. The lower the CV the more precise the estimate. It is calculated as the SD / mean.
Relative abundance	In the case of diving birds and mammals, this is the estimated population size based on animals recorded on or above the sea surface and does not account for any that may be diving and thus submerged at the time of survey.
Absolute abundance	The most accurate estimate of population size. In the case of diving birds and mammals, this includes an estimate for the number that are believed to be submerged at the time of survey.

3.3.1 All birds

66 The total number of birds recorded across the survey programme, including those partially and fully identified, are presented below (Table 10; Figure 4), whilst the distribution and density of all birds are presented between Figure 5and Figure 6. In both years, avian abundance increased during the post-breeding migration periods, with marked peaks in October and November in both years. Generally, fewer birds were recorded in the winter and early spring during the Year 1 and summer during the Year 2, particularly in February 2020 and August 2021.

67 The monthly density maps indicate birds were present across the whole survey area. Generally, elevated densities occurred between August and November, with birds appearing to concentrate evenly across the survey area.

Table 10 Number of birds recorded to species level between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
All birds	4840	2502	900	346	130	233	585	217	1330	1105	7185	2387	20963
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
All birds	3355	2074	1284	1475	486	2223	642	557	1287	191	155	499	13499

Figure 4 Number of birds recorded to species level between October 2019 and September 2021

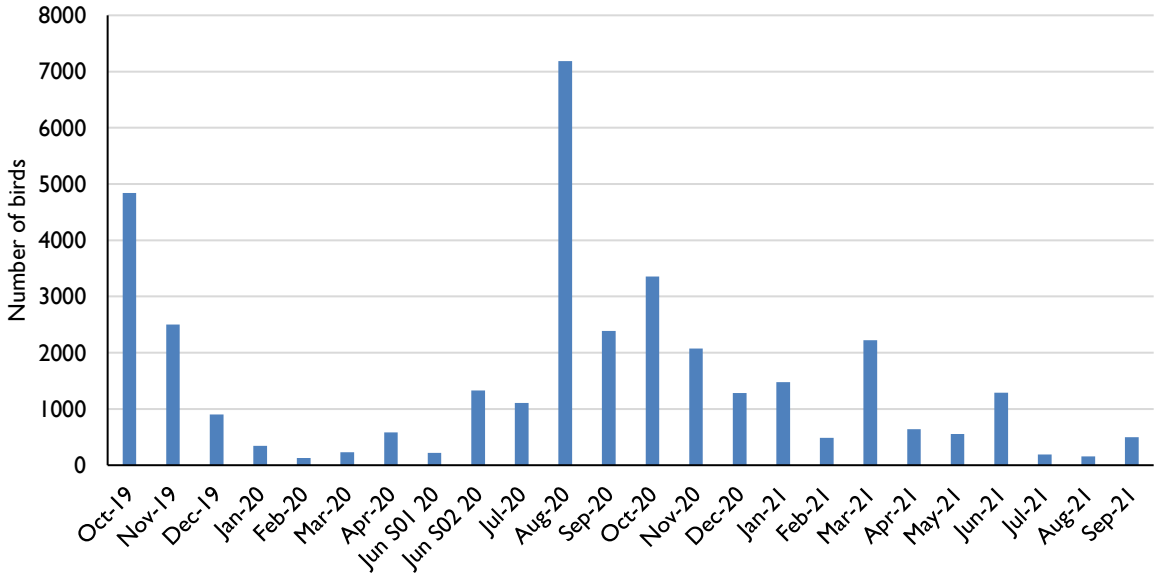


Figure 5 Density of all birds (number/km²) and number of detections per segment between October 2019 and September 2020 (Year 1)

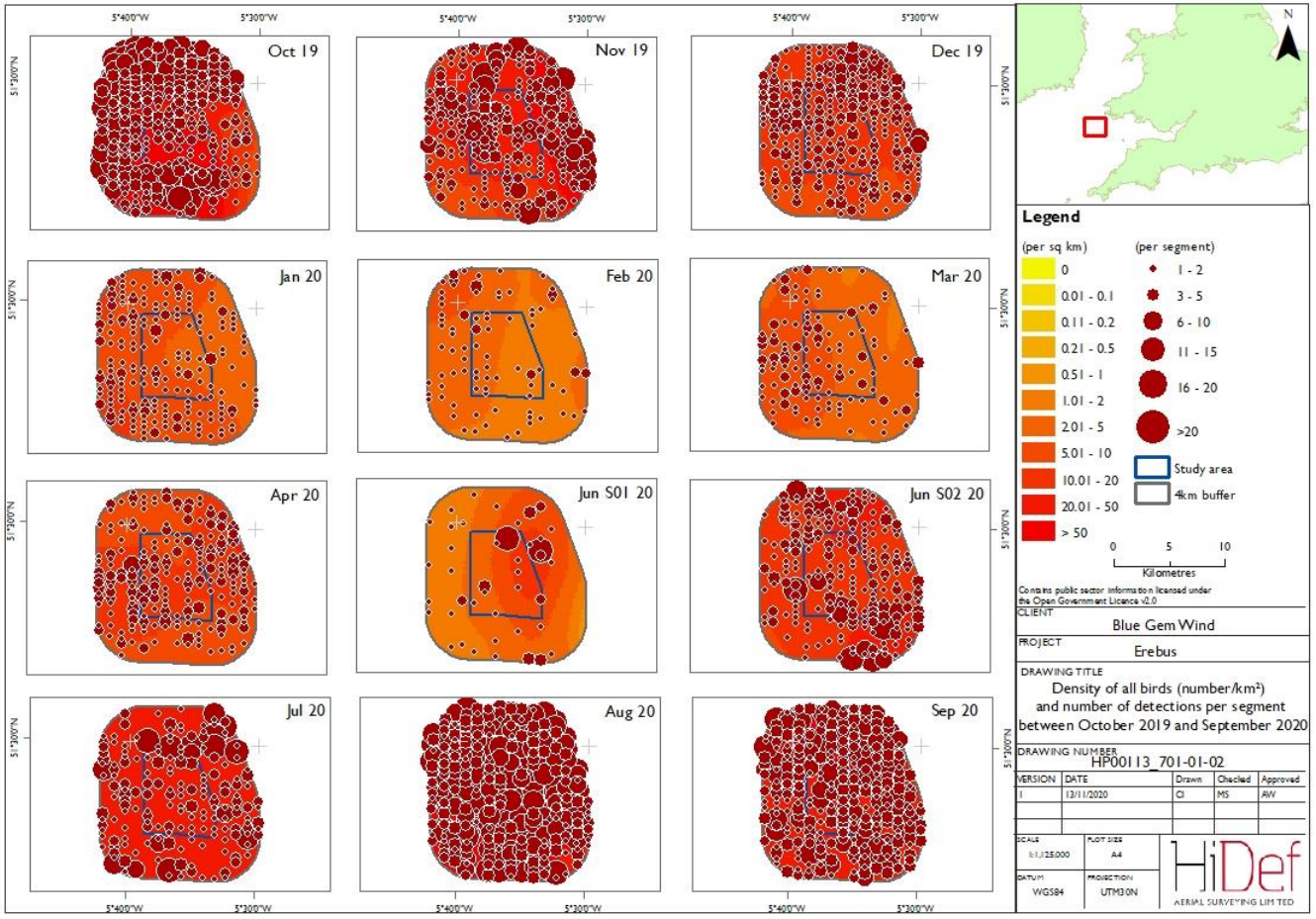
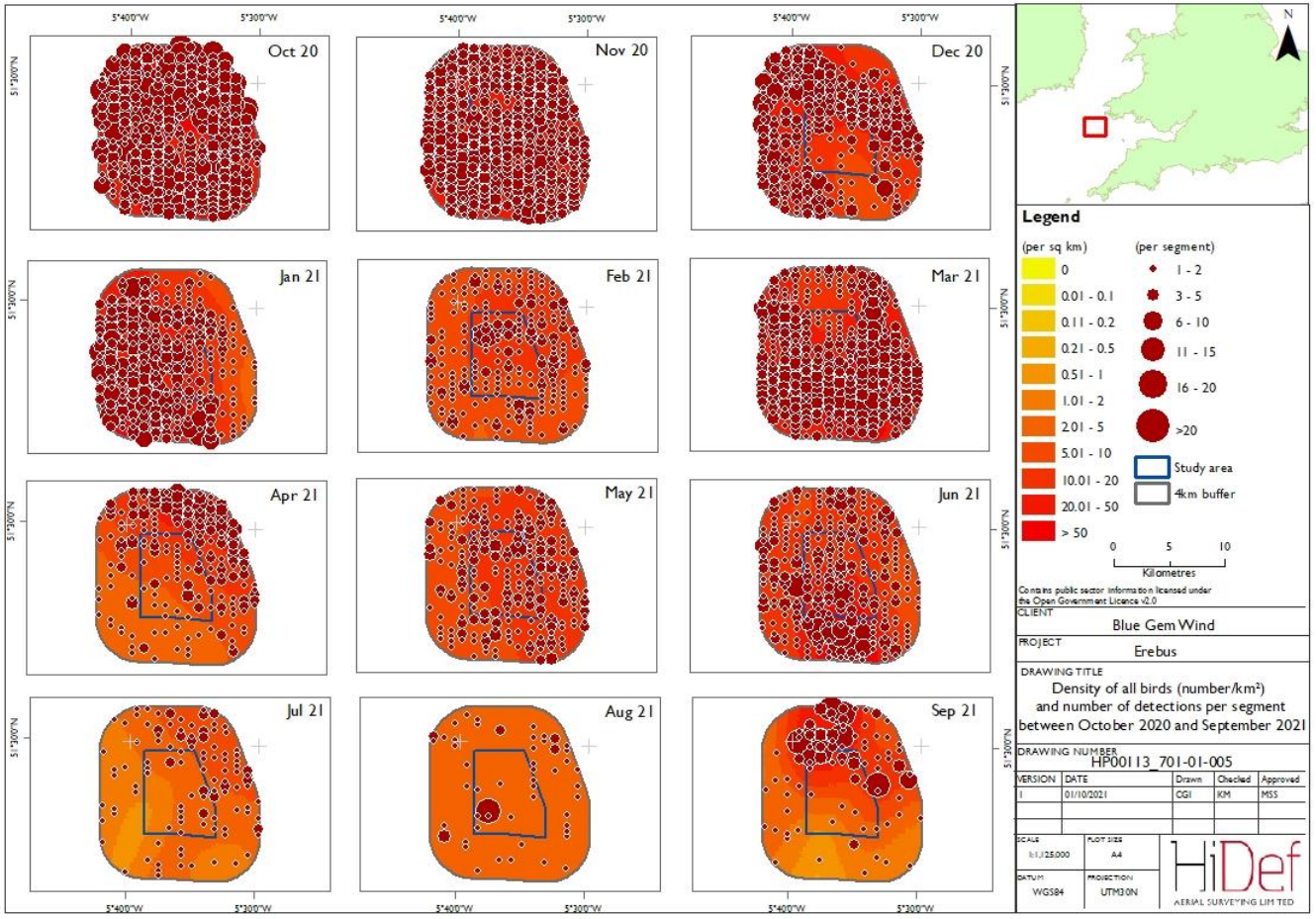


Figure 6 Density of all birds (number/km²) and number of detections per segment between October 2020 and September 2021 (Year 2)



3.3.2 Kittiwake

68 Kittiwakes were the most abundant gull species recorded during the study, with 2,773 total records (Table 11; Figure 7). Abundance varied between years, with approximately twice as many birds observed in Year 1 compared to Year 2, peaking in October 2019 and January 2021. Generally, numbers were lowest between April and September in both years.

69 In the months where kittiwakes were observed, density and population estimates fluctuated, ranging from 4 birds (±95% CI 0 – 12) in September 2021 to 3,913 birds (±95% CI 1,420 – 6,849; Figure 8) in October 2019, equating to 0.02 birds/km^2 and 19.55 birds/km^2 respectively. No kittiwakes were observed in June S01 2020 and between April 2021 and August 2021.

70 The distribution of kittiwakes varied considerably, with a widespread distribution observed throughout the survey period, with particular concentrations towards the southwest part of the survey area for the months of October 2019, August 2020 and June 2021 (Figure 10 to Figure 11).

71 The majority of aged birds, (93%), were recorded as adults (Table 12), with low numbers of juvenile and immature birds recorded during the study. Relatively high numbers of juvenile birds were recorded in October 2020 accounting for approximately 23% of all aged birds in this month.

72 Generally, more kittiwakes were recorded sitting on the water than flying, equating to 56% and 44% respectively (Table 13). Only one individual was recorded as taking off, occurring in December 2020. Many kittiwakes flew in southerly directions, such as in November and December 2019, and December 2020 (Figure 9) Many birds also flew in an easterly direction such as in October 2019 and 2020, and January 2021.

Table 11 Number of kittiwakes recorded to species level between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Kittiwake	995	567	123	19	33	13	4	0	3	2	18	5	1782
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Kittiwake	187	40	304	420	25	12	0	0	0	0	0	3	991

Figure 7 **Number of kittiwakes recorded to species level between October 2019 and September 2021**

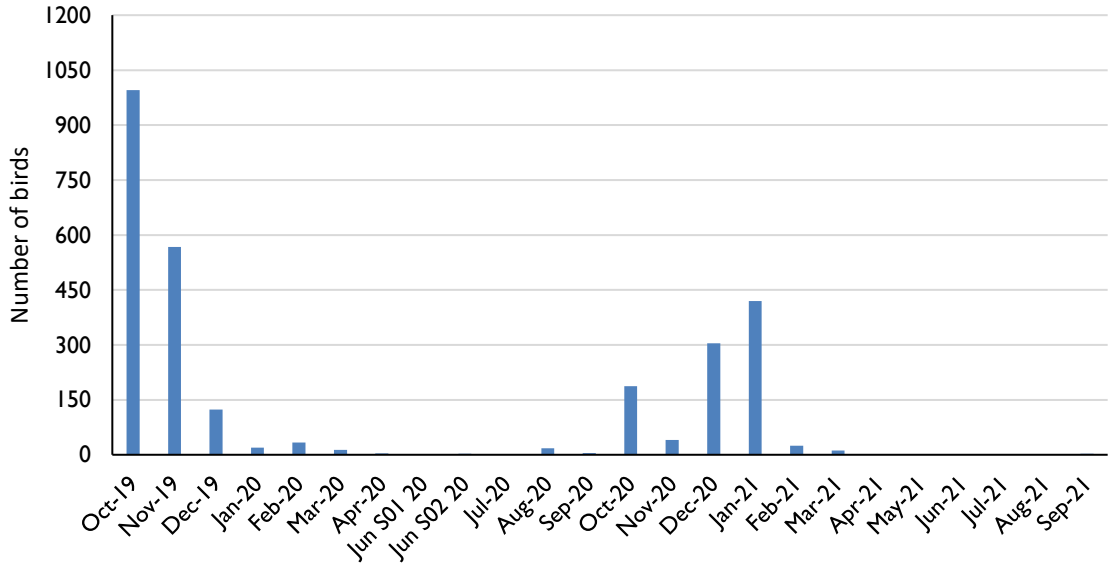


Figure 8 **Kittiwake population estimates with lower and upper 95% confidence intervals between October 2019 and September 2021**

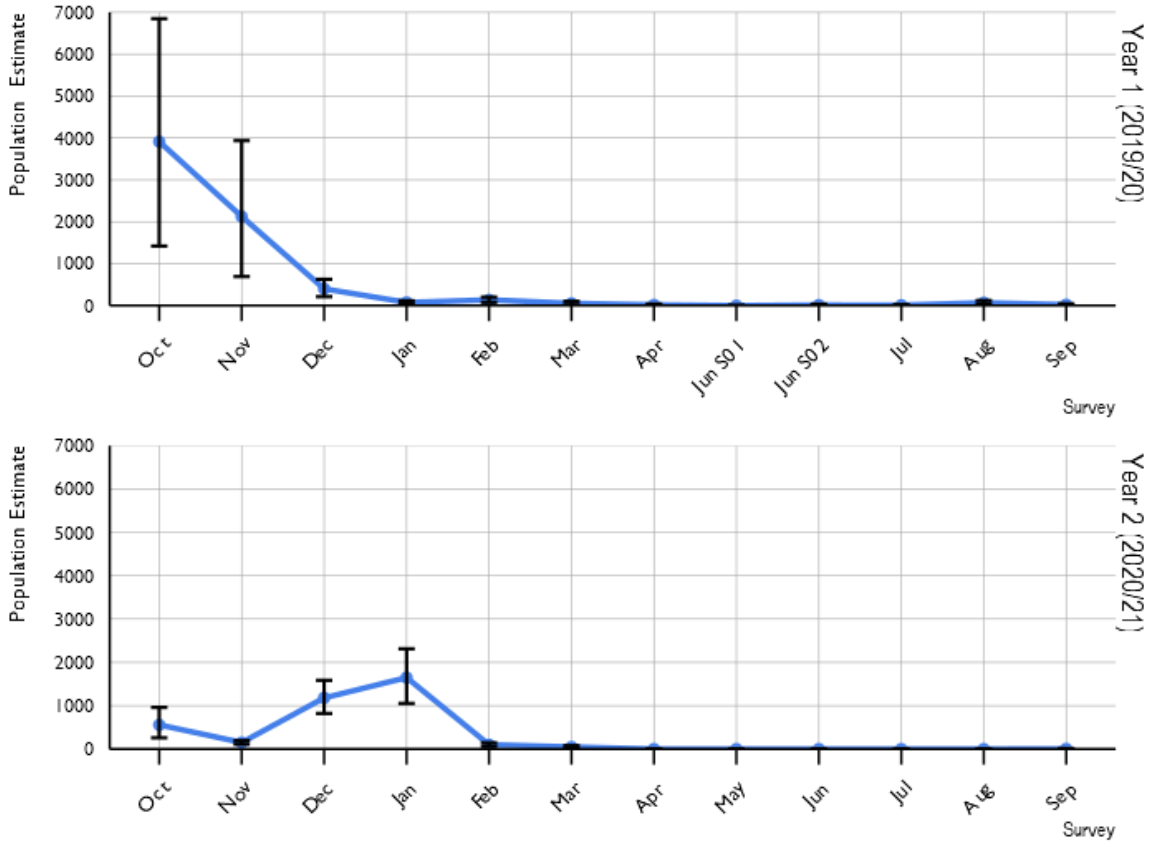


Table 12 Summary of kittiwake ages between October 2019 and September 2021

Survey date	Number recorded as adult	Number recorded as immature	Number recorded as juvenile	Number recorded as unknown	% adult (from aged birds)	Total
Oct-19	185	0	5	805	97%	995
Nov-19	248	1	6	312	97%	567
Dec-19	79	0	5	39	94%	123
Jan-20	15	0	0	4	100%	19
Feb-20	27	3	0	3	90%	33
Mar-20	10	0	0	3	100%	13
Apr-20	0	1	0	3	0%	4
Jun S01 20	0	0	0	0	–	0
Jun S02 20	3	0	0	0	100%	3
Jul-20	0	0	0	2	–	2
Aug-20	2	0	5	11	29%	18
Sep-20	5	0	0	0	100%	5
Oct-20	66	0	20	101	77%	187
Nov-20	35	0	3	2	92%	40
Dec-20	187	0	19	98	91%	304
Jan-21	180	10	0	230	95%	420
Feb-21	15	1	0	9	94%	25
Mar-21	8	0	0	4	100%	12
Apr-21	0	0	0	0	–	0
May-21	0	0	0	0	–	0
Jun-21	0	0	0	0	–	0
Jul-21	0	0	0	0	–	0
Aug-21	0	0	0	0	–	0
Sep-21	2	0	0	1	100%	3
Total	**1067**	**16**	**63**	**1627**	**85%**	**2773**

Table 13 Summary of kittiwake behaviours (for birds in which behaviour could be determined) between October 2019 and September 2021

Survey date	Number recorded diving	Number recorded flying	Number recorded sitting	Number recorded taking off	% Flying	Total
Oct-19	0	230	765	0	23	995
Nov-19	0	256	311	0	45	567
Dec-19	0	90	33	0	73	123
Jan-20	0	15	4	0	79	19
Feb-20	0	31	2	0	94	33
Mar-20	0	9	4	0	69	13
Apr-20	0	1	3	0	25	4
Jun S01 20	0	0	0	0	0	0
Jun S02 20	0	3	0	0	100	3
Jul-20	0	0	2	0	0	2
Aug-20	0	8	10	0	44	18
Sep-20	0	5	0	0	100	5
Oct-20	0	98	89	0	52	187
Nov-20	0	39	1	0	98	40
Dec-20	0	206	97	1	68	304
Jan-21	0	196	224	0	47	420
Feb-21	0	17	8	0	68	25
Mar-21	0	8	4	0	67	12
Apr-21	0	0	0	0	0	0
May-21	0	0	0	0	0	0
Jun-21	0	0	0	0	0	0
Jul-21	0	0	0	0	0	0
Aug-21	0	0	0	0	0	0
Sep-21	0	2	1	0	67	3
Total	**0**	**1214**	**1558**	**1**	**44**	**2773**

Figure 9 **Summarised direction of flying kittiwakes between October 2019 and September 2021**

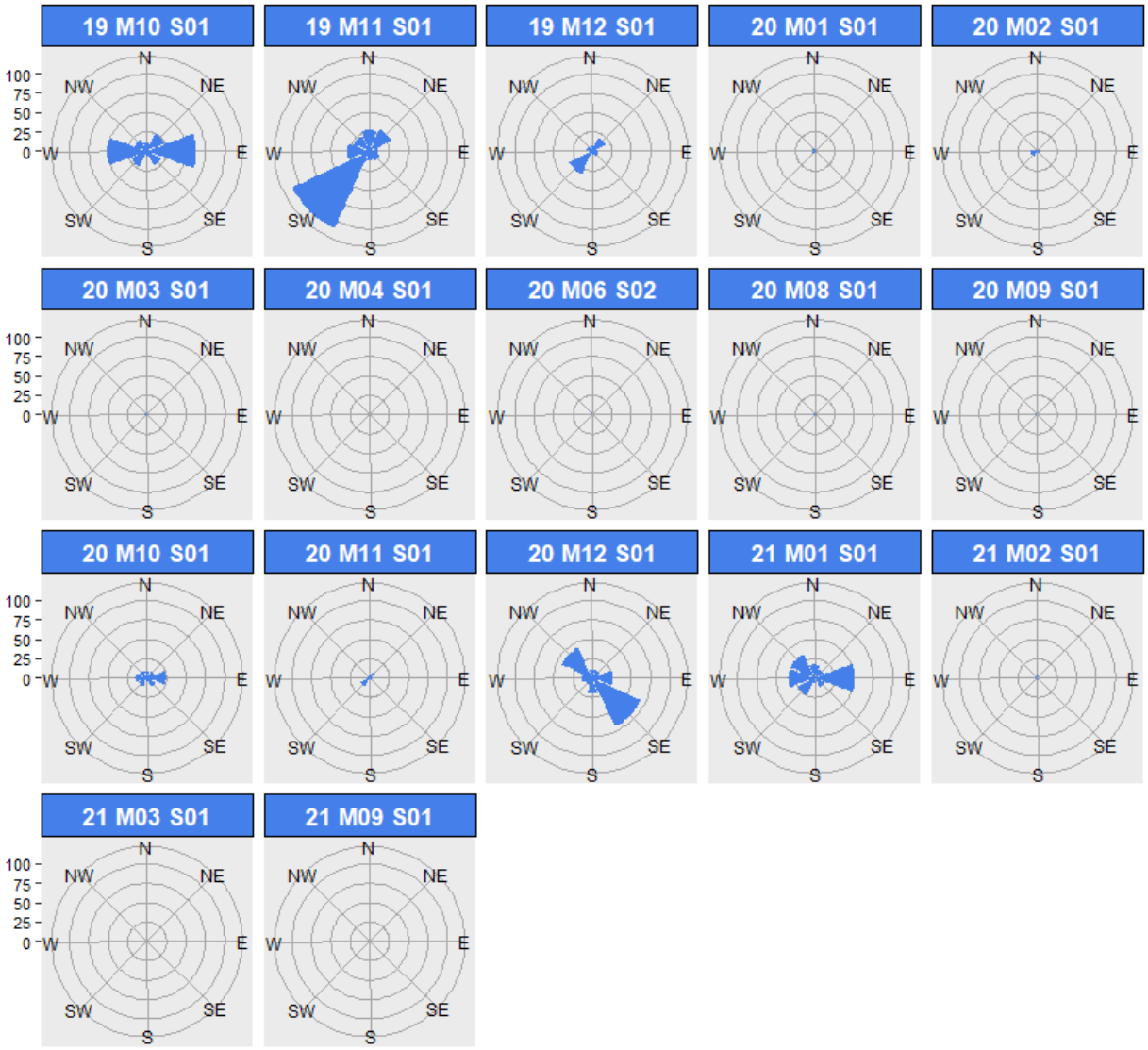


Figure 10 Density of kittiwakes (number/km²) and number of detections per segment between October 2019 and September 2020

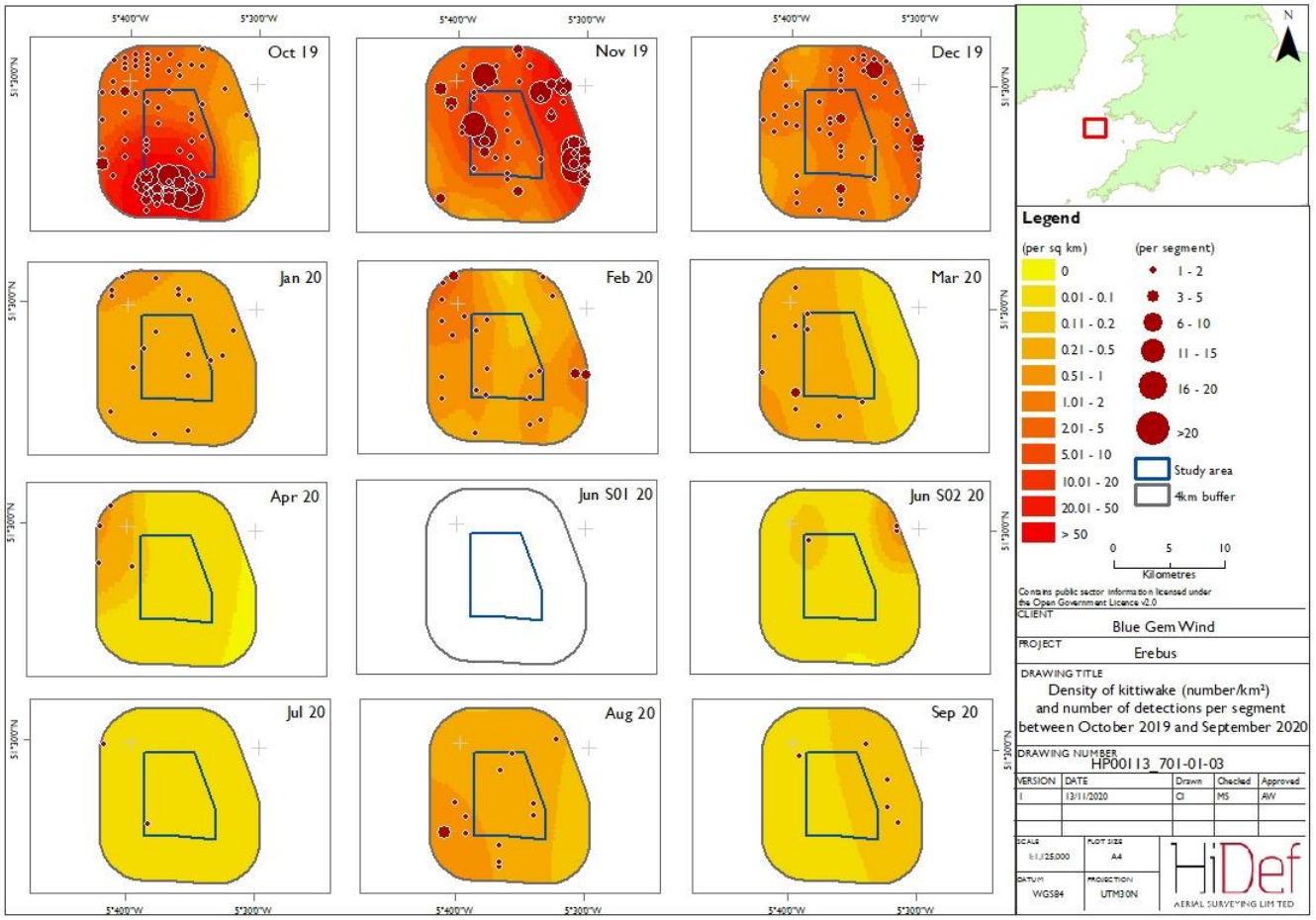
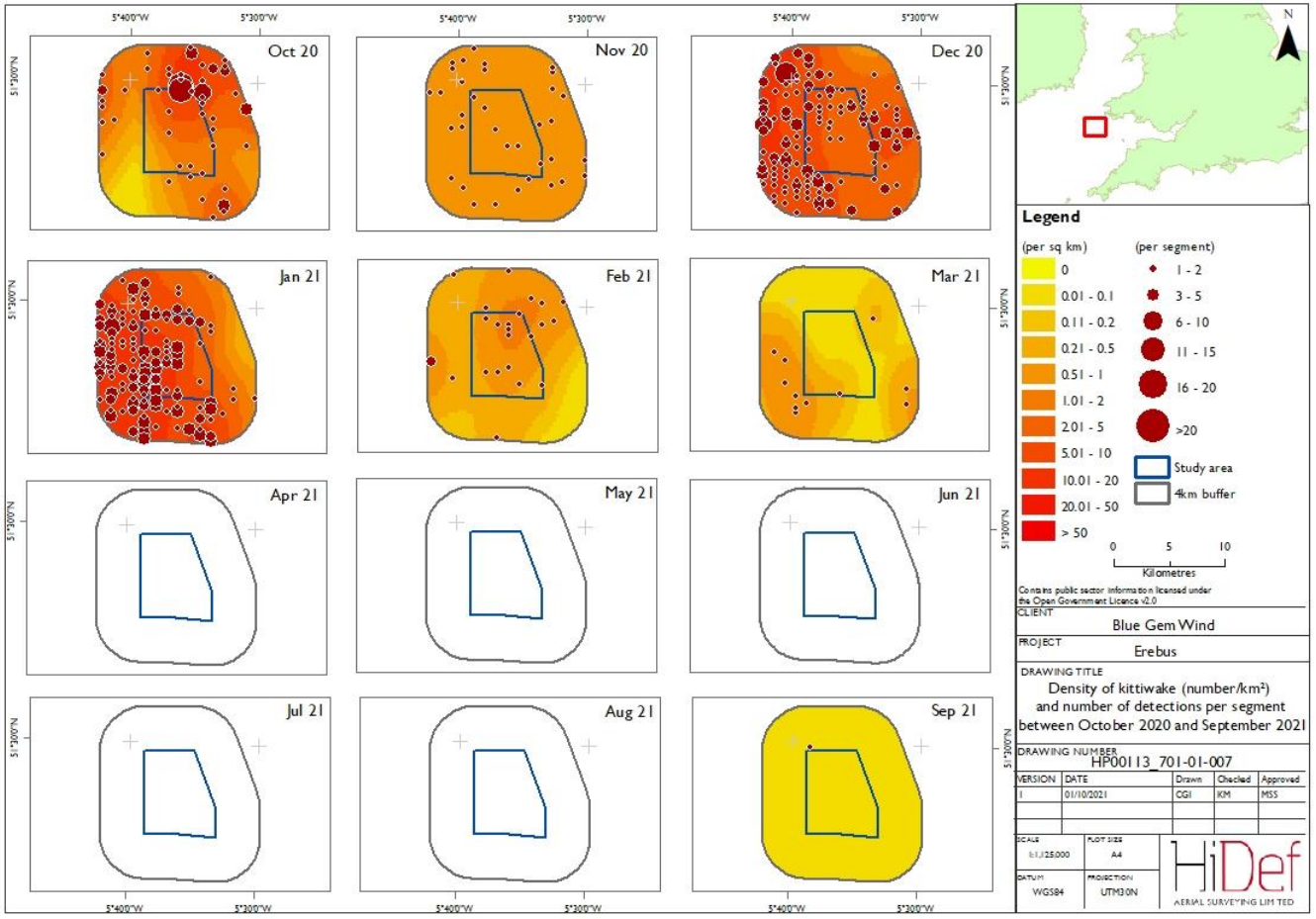


Figure 11 Density of kittiwakes (number/km²) and number of detections per segment between October 2020 and September 2021



3.3.3 Great black-backed gull

73 Great black-backed gulls were recorded in relatively low numbers throughout the survey period, peaking in autumn and early winter in both years during the non-breeding period (Table 14; Figure 12). In both 2020 and 2021, observations were considerably lower or null between January and September. More than twice as many birds were recorded in Year 1 compared to Year 2.

74 Densities of greater black-backed gulls fluctuated throughout the study period, with low densities estimated between January and September in both years, ranging between 0 birds/km^2 and 0.1 birds/km^2 in 2020, equating to population estimates ranging from 0 birds (±95% CI 0 – 0) to 20 birds (±95% CI 0 – 51); and ranging between 0 birds/km^2 and 0.04 birds/km^2 in 2021, equating to population estimates ranging from 0 birds (±95% CI 0 – 0) to 8 birds (±95% CI 0 – 19) (Figure 13). Peak abundance was estimated at 189 birds (±95% CI 59 – 362) in October 2019, equating to a density estimate of 0.94 birds/km^2.

75 In many months, observations were too few to allow inference of great black-backed gull distributions throughout the survey region (Figure 15 to Figure 16). For those where distributions could be assessed, selection towards the north of the survey area tends to be observed, to the exception of October 2019, where important densities of great black-backed gulls were observed in the southern part of the survey area. Generally, most observations of great black-backed gulls were recorded within the 4km buffer zone and not within the windfarm site.

76 Of the birds that could be aged, the majority (71%) were recorded as adults, with 11 immature birds recorded throughout the study period (Table 15). Only one juvenile was observed in October 2019. More than twice as many great black-backed gulls were recorded as sitting on the water compared to flying, (Table 16).

77 There were surveys in which no data regarding flight direction were available. To allow for clear interpretation of results, only surveys which contained flight direction data were displayed (Figure 14). Flight direction did not present any pattern throughout the survey period.

Table 14 Number of great black-backed gulls recorded to species level between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Great black-backed gull	48	14	6	0	0	2	0	0	0	5	1	0	76
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Great black-backed gull	8	12	4	0	2	0	1	0	0	0	1	0	28

Figure 12 **Number of great black-backed gulls recorded to species level between October 2019 and September 2021**

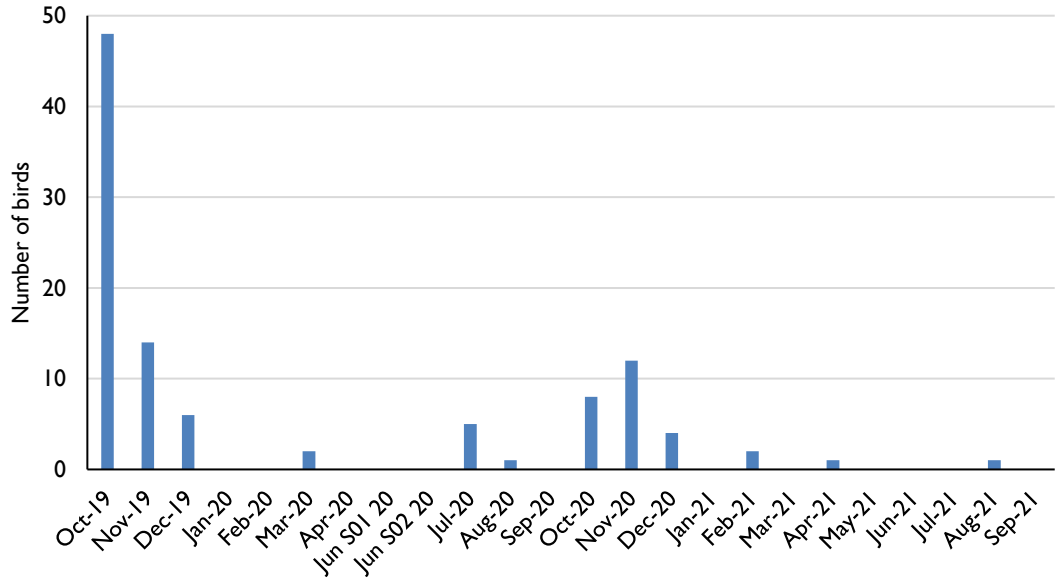


Figure 13 **Great black-backed gull population estimates with lower and upper 95% confidence intervals between October 2019 and September 2021**

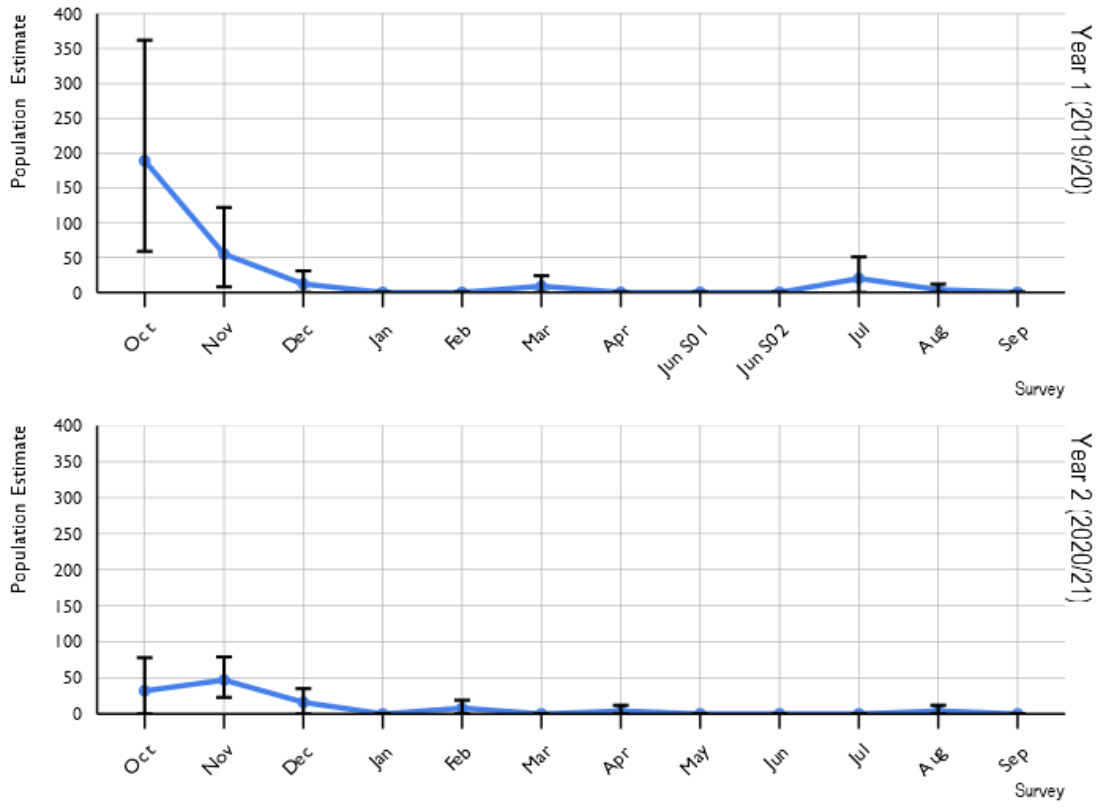


Table 15 Summary of great black-backed gull ages between October 2019 and September 2021

Survey date	Number recorded as adult	Number recorded as immature	Number recorded as juvenile	Number recorded as unknown	% adult (from aged birds)	Total
Oct-19	13	0	1	34	93%	48
Nov-19	0	3	0	11	0%	14
Dec-19	1	0	0	5	100%	6
Jan-20	0	0	0	0	–	0
Feb-20	0	0	0	0	–	0
Mar-20	2	0	0	0	100%	2
Apr-20	0	0	0	0	–	0
Jun S01 20	0	0	0	0	–	0
Jun S02 20	0	0	0	0	–	0
Jul-20	4	1	0	0	80%	5
Aug-20	0	1	0	0	0%	1
Sep-20	0	0	0	0	–	0
Oct-20	0	2	0	6	0%	8
Nov-20	6	4	0	2	60%	12
Dec-20	2	0	0	2	100%	4
Jan-21	0	0	0	0	–	0
Feb-21	1	0	0	1	100%	2
Mar-21	0	0	0	0	–	0
Apr-21	0	0	0	1	–	1
May-21	0	0	0	0	–	0
Jun-21	0	0	0	0	–	0
Jul-21	0	0	0	0	–	0
Aug-21	0	0	0	1	–	1
Sep-21	0	0	0	0	–	0
Total	**29**	**11**	**1**	**63**	**63**	**104**

Table 16 Summary of great black-backed gull behaviours (for birds in which behaviour could be determined) between October 2019 and September 2021

Survey date	Number recorded diving	Number recorded flying	Number recorded sitting	Number recorded taking off	% Flying	Total
22 October 2019	0	4	44	0	8	48
08 November 2019	0	3	11	0	21	14
04 December 2019	0	2	4	0	33	6
18 January 2020	0	0	0	0	0	0
04 February 2020	0	0	0	0	0	0
03 March 2020	0	2	0	0	100	2
04 April 2020	0	0	0	0	0	0
08 June 2020	0	0	0	0	0	0
24 June 2020	0	0	0	0	0	0
23 July 2020	0	5	0	0	100	5
31 August 2020	0	1	0	0	100	1
12 September 2020	0	0	0	0	0	0
15 October 2020	0	2	6	0	25	8
22 November 2020	0	10	2	0	83	12
31 December 2020	0	2	2	0	50	4
16 January 2021	0	0	0	0	0	0
22 February 2021	0	1	1	0	50	2
05 March 2021	0	0	0	0	0	0
10 April 2021	0	0	1	0	0	1
14 May 2021	0	0	0	0	0	0
15 June 2021	0	0	0	0	0	0
14 July 2021	0	0	0	0	0	0
16 August 2021	0	0	1	0	0	1
01 September 2021	0	0	0	0	0	0
Total	**0**	**32**	**72**	**0**	**31**	**104**

Figure 14 **Summarised direction of flying great black-backed gulls between October 2019 and September 2021**

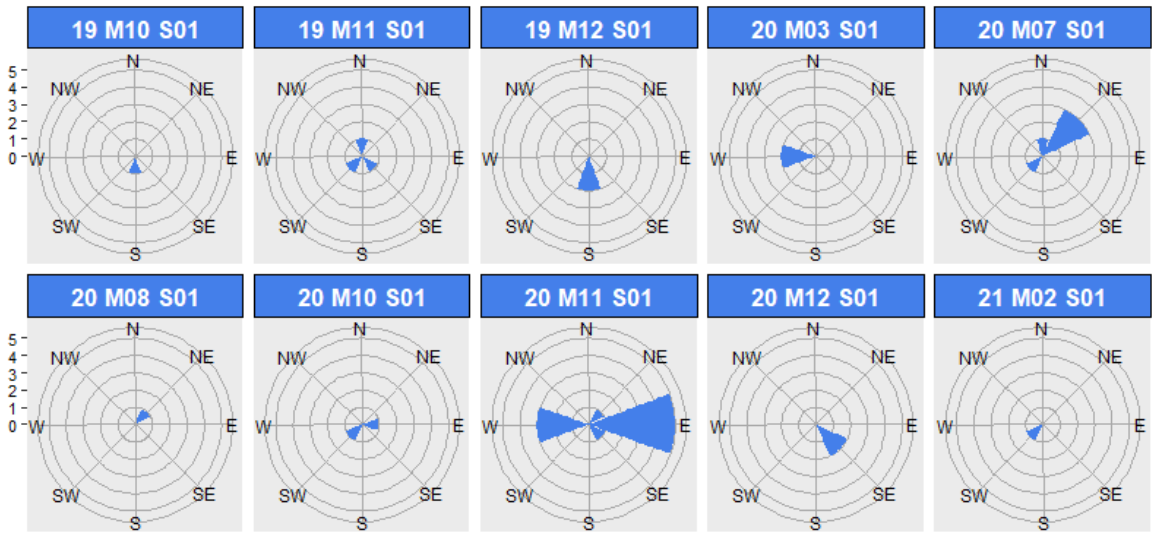


Figure 15 Density of great black-backed gulls (number/km²) and number of detections per segment between October 2019 and September 2020

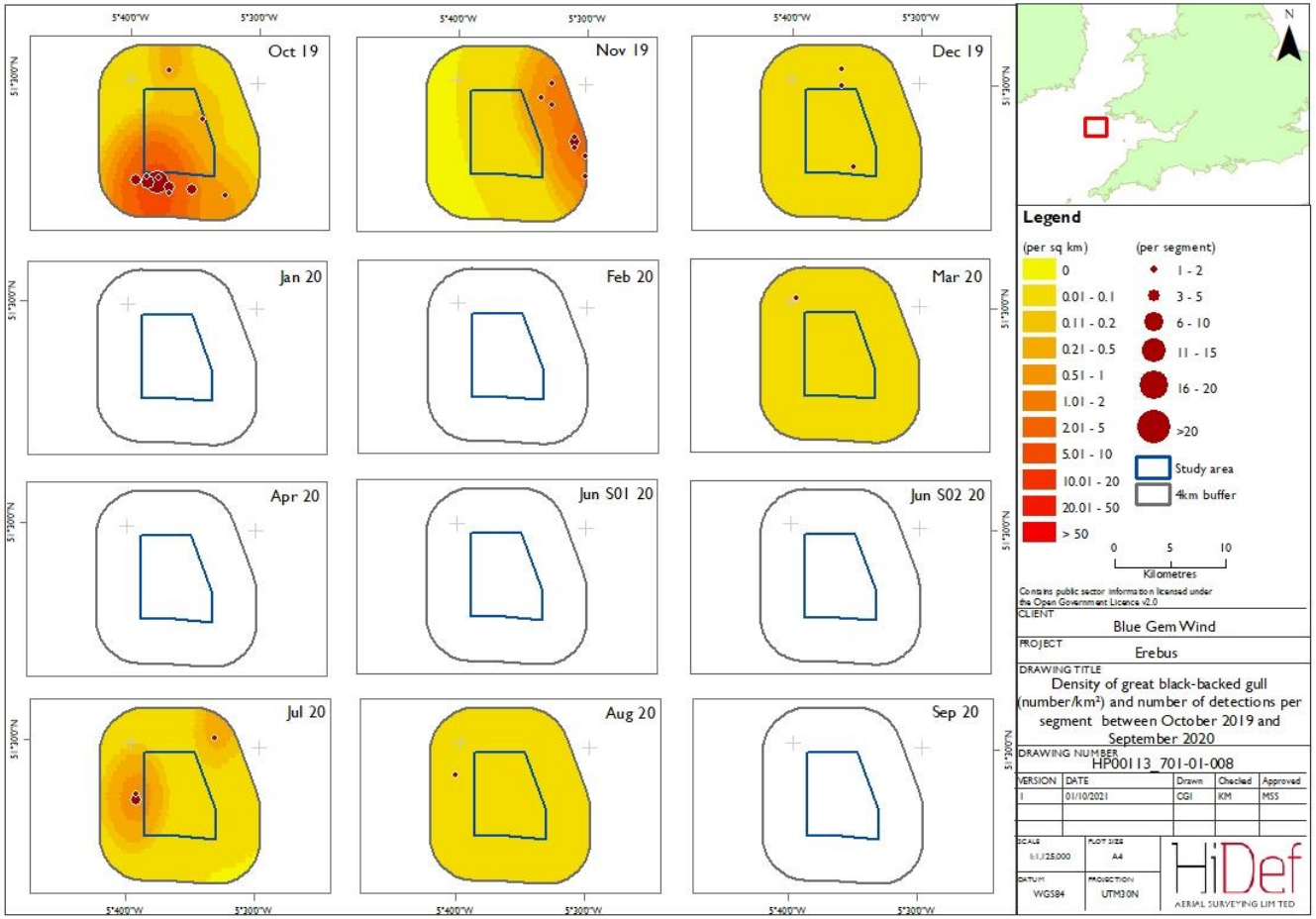


Figure 16 Density of great black-backed gulls (number/km²) and number of detections per segment between October 2020 and September 2021

3.3.4 Lesser black-backed gull

78 Lesser black-backed gulls were predominately recorded during the summer, with very few birds present over the wintering and spring period, as the species is partially migratory (Table 17; Figure 17). Similar numbers of lesser black-backed gulls were recorded in Year 1 and Year 2 of the study.

79 Density estimates presented similar patterns between the Year 1 and Year 2 of the survey, ranging from 0 birds/km^2 and 0.57 birds/km^2. Peak abundances were observed during the summer with 114 birds (±95% CI 50 – 196) in July 2020 and 87 birds (±95% CI 45 – 133) in June 2021 (Figure 18). Outside of the observed summer peaks, density estimates were much lower, ranging between only 0 and 0.18 birds/km^2.

80 In months with low observations, no clear distribution pattern could be determined for the species (Figure 20 to Figure 21). However, in months with greater number of observations, such as July 2020, June and July 2021, lesser black-backed gulls were concentrated more towards the northwest of the survey area. Generally, throughout the survey period, most observations of lesser black-backed gulls were recorded within the 4km buffer zone and not within the Erebus site.

81 Throughout the two years of data collection, 83% of lesser black-backed gulls could be aged, of which 95% were recorded as adults, with only four immature birds recorded during the study (Table 18). No juvenile birds were recorded.

82 On average, 84% of birds were recorded flying throughout the survey period, primarily during summer months (Table 19). In October 2019 and February 2020, more birds were observed sitting on the water than flying.

83 There were surveys in which no data regarding flight direction were available. To allow for clear interpretation of results, only surveys which contained flight direction data were displayed. During summer months, lesser black-backed gulls were mainly flying towards southern directions, particularly in July 2020, June and August 2021 (Figure 19).

Table 17 Number of lesser black-backed gulls recorded to species level between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Lesser black-backed gull	9	2	0	1	2	2	4	0	2	29	0	0	51
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Lesser black-backed gull	0	1	0	0	0	2	0	1	24	10	4	0	42

Figure 17 **Number of lesser black-backed gulls recorded to species level between October 2019 and September 2021**

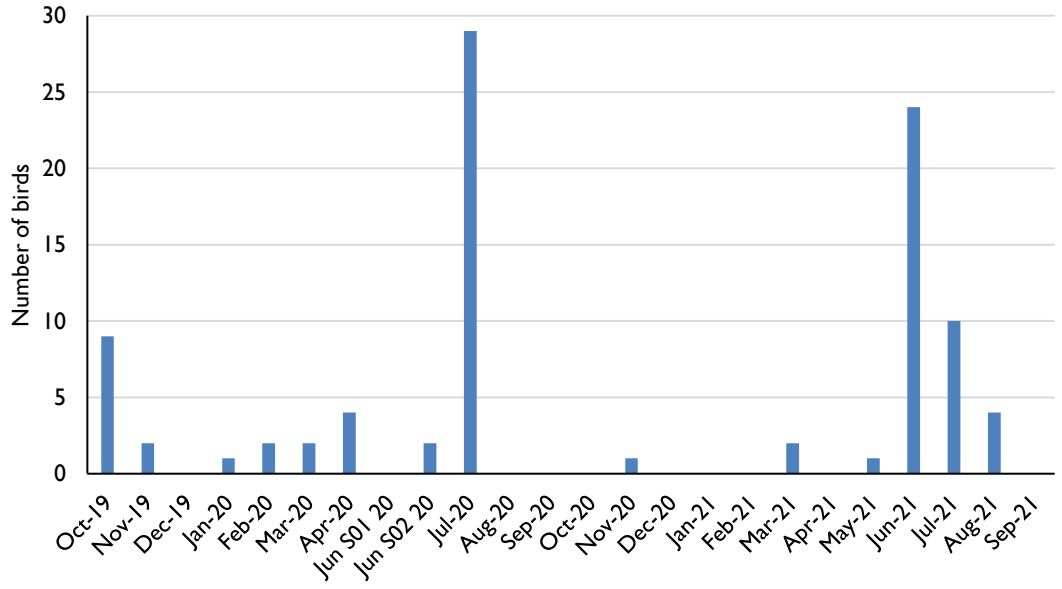


Figure 18 **Lesser black-backed gull population estimates with lower and upper 95% confidence intervals between October 2019 and September 2021**

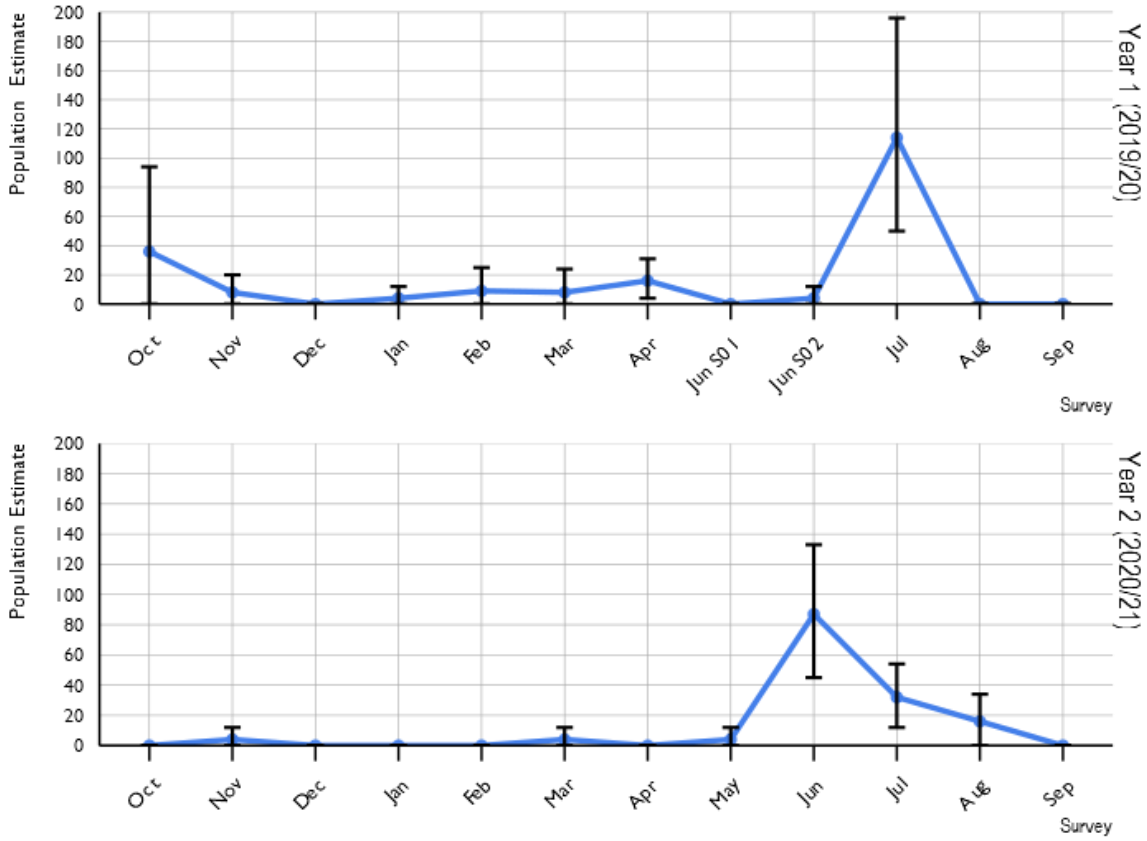


Table 18 Summary of lesser black-backed gull ages between October 2019 and September 2021

Survey date	Number recorded as adult	Number recorded as immature	Number recorded as juvenile	Number recorded as unknown	% adult (from aged birds)	Total
Oct-19	2	0	0	7	100%	9
Nov-19	2	0	0	0	100%	2
Dec-19	0	0	0	0	–	0
Jan-20	1	0	0	0	100%	1
Feb-20	0	0	0	2	–	2
Mar-20	2	0	0	0	100%	2
Apr-20	3	0	0	1	100%	4
Jun S01 20	0	0	0	0	–	0
Jun S02 20	2	0	0	0	100%	2
Jul-20	25	1	0	3	96%	29
Aug-20	0	0	0	0	–	0
Sep-20	0	0	0	0	–	0
Oct-20	0	0	0	0	–	0
Nov-20	1	0	0	0	100%	1
Dec-20	0	0	0	0	–	0
Jan-21	0	0	0	0	–	0
Feb-21	0	0	0	0	–	0
Mar-21	2	0	0	0	100%	2
Apr-21	0	0	0	0	–	0
May-21	0	1	0	0	0%	1
Jun-21	22	1	0	1	96%	24
Jul-21	10	0	0	0	100%	10
Aug-21	1	1	0	2	50%	4
Sep-21	0	0	0	0	–	0
Total	**73**	**4**	**0**	**16**	**100**	**93**

Table 19 Summary of lesser black-backed gull behaviours (for birds in which behaviour could be determined) between October 2019 and September 2021

Survey date	Number recorded diving	Number recorded flying	Number recorded sitting	Number recorded taking off	% Flying	Total
22 October 2019	0	1	8	0	11	9
08 November 2019	0	2	0	0	100	2
04 December 2019	0	0	0	0	0	0
18 January 2020	0	1	0	0	100	1
04 February 2020	0	0	2	0	0	2
03 March 2020	0	2	0	0	100	2
04 April 2020	0	4	0	0	100	4
08 June 2020	0	0	0	0	0	0
24 June 2020	0	2	0	0	100	2
23 July 2020	0	26	3	0	90	29
31 August 2020	0	0	0	0	0	0
12 September 2020	0	0	0	0	0	0
15 October 2020	0	0	0	0	0	0
22 November 2020	0	1	0	0	100	1
31 December 2020	0	0	0	0	0	0
16 January 2021	0	0	0	0	0	0
22 February 2021	0	0	0	0	0	0
05 March 2021	0	2	0	0	100	2
10 April 2021	0	0	0	0	0	0
14 May 2021	0	1	0	0	100	1
15 June 2021	0	23	1	0	96	24
14 July 2021	0	10	0	0	100	10
16 August 2021	0	3	1	0	75	4
01 September 2021	0	0	0	0	0	0
Total	**0**	**78**	**15**	**0**	**84**	**93**

Figure 19 **Summarised direction of flying lesser black-backed gulls between October 2019 and September 2021**

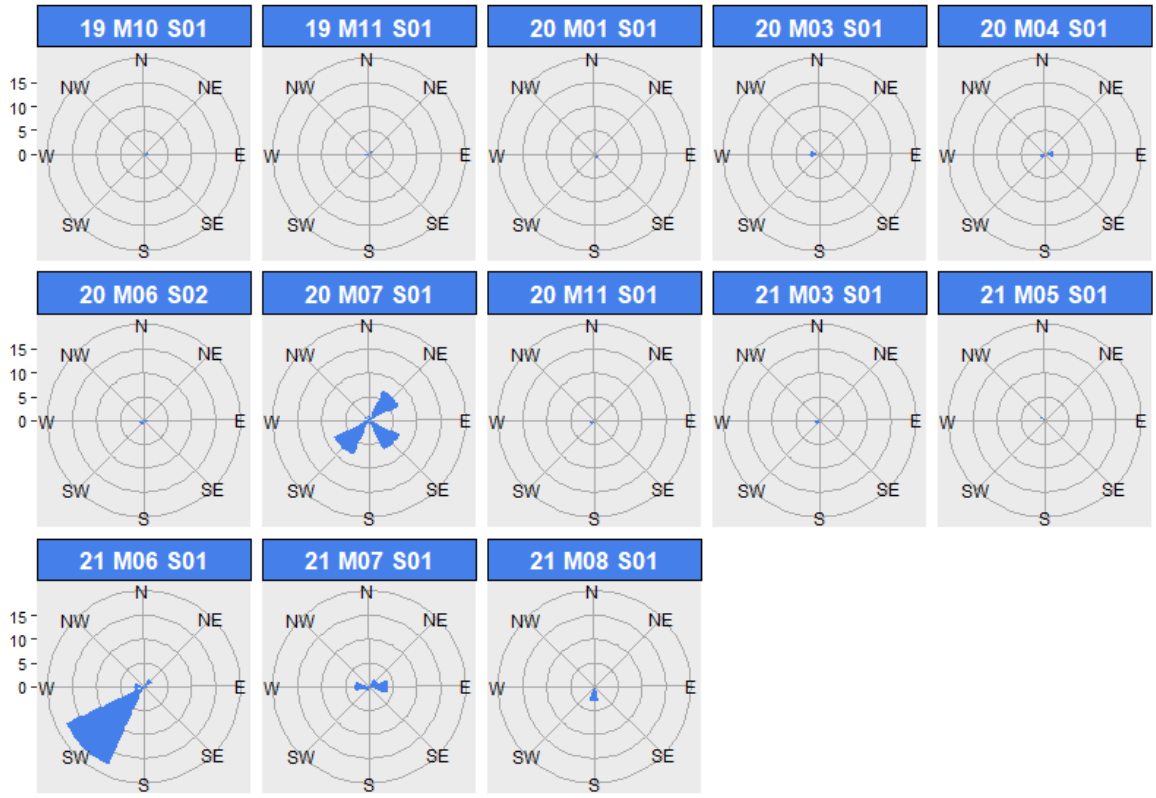
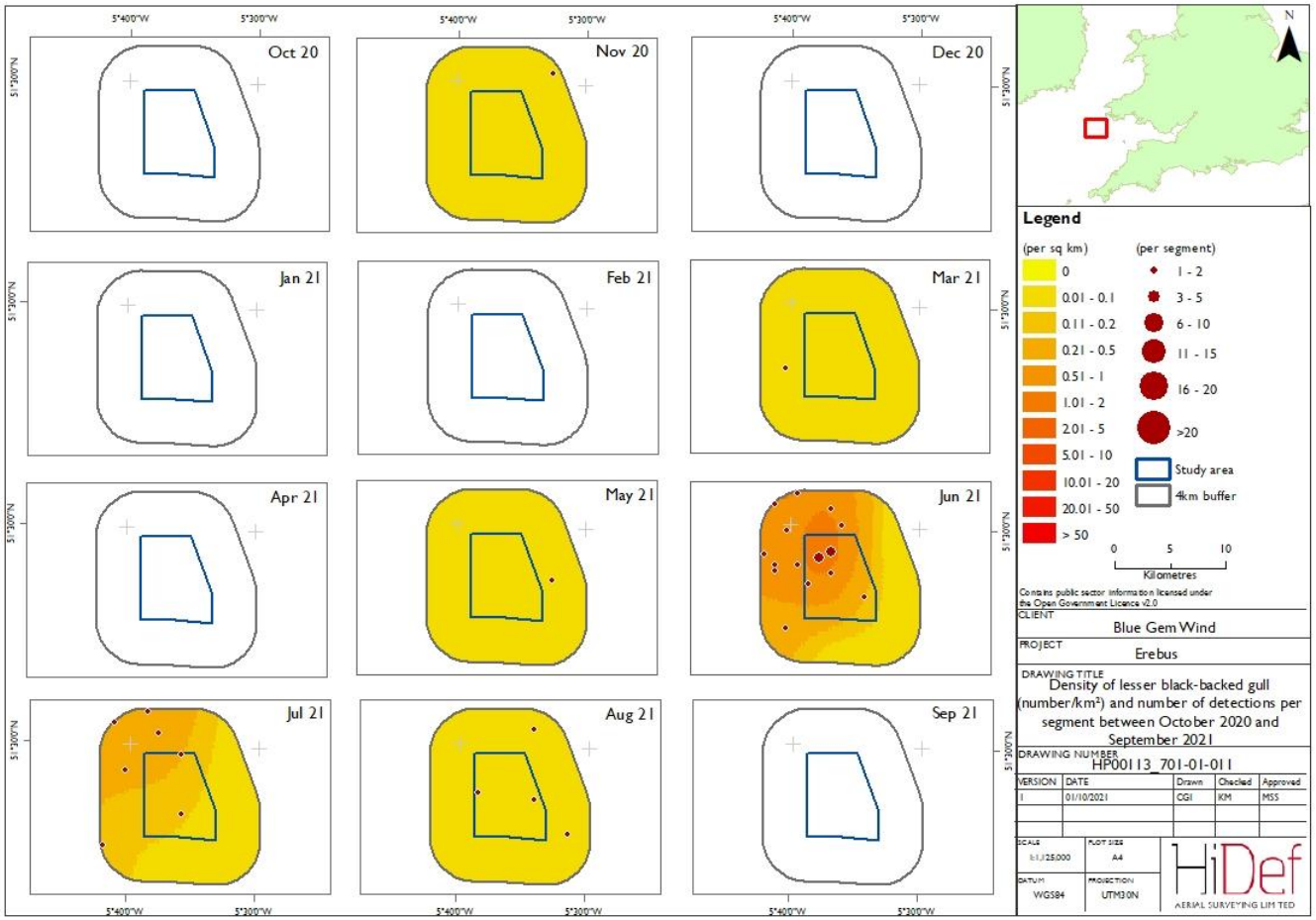


Figure 20 Density of lesser black-backed gulls (number/km²) and number of detections per segment between October 2019 and September 2020

Figure 21 Density of lesser black-backed gulls (number/km²) and number of detections per segment between October 2020 and September 2021



3.3.5 Guillemot

84 Guillemots were the most abundant species recorded during the survey programme, occurring in highest densities in late summer and autumn, with peak observations recorded in August 2020 (Table 20; Figure 22). Significantly more birds were recorded during the Year 1 compared to the Year 2, with lower densities occurring between January and July in the Year 1 and between April and September in the Year 2.

85 Absolute density and abundance estimates varied throughout the survey period (Figure 23). Absolute densities peaked at 160.77 birds/km^2 in August 2020 (Year 1) and 64.76 birds/km^2 in October 2020 (Year 2), equating to absolute abundance estimates for the region of 32,172 birds (±95% CI 25,271 – 38,804) and 12,962 birds (±95% CI 11,259 – 14,900) respectively.

86 Guillemots were generally widely dispersed across the study area throughout the survey period, however birds appeared to select the west of the region in October 2019 and June 2021, compared to the east of the region in November 2019, December 2020 and April 2021 (Figure 25 to Figure 26).

87 As is expected for the species, most birds were recorded as sitting on the water, with only 3% of birds recorded as flying during the project programme (Table 21). Two birds were recorded taking off and two birds were recorded diving.

88 There were surveys in which no data regarding flight direction were available. To allow for clear interpretation of results, only surveys which contained flight direction data were displayed (Figure 24). No particular pattern in flight direction can be concluded due to the considerable variation between months, with many birds flying both northeast and southwest for December 2019, March and April 2021.

Table 20 Number of guillemots recorded to species level between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Guillemot	2698	1140	617	260	65	151	77	29	272	182	6503	2235	14229
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Guillemot	2751	1918	662	670	261	1872	441	384	262	107	29	27	9384

Figure 22 **Number of guillemots recorded to species level between October 2019 and September 2021**

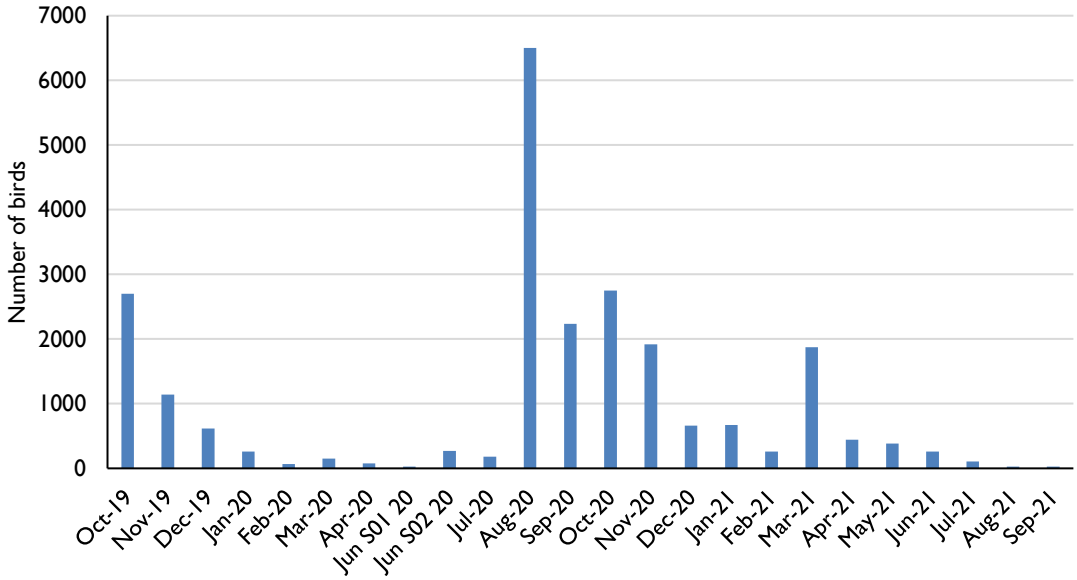


Figure 23 **Adjusted (absolute) guillemot population estimates with lower and upper 95% confidence intervals between October 2019 and September 2021**

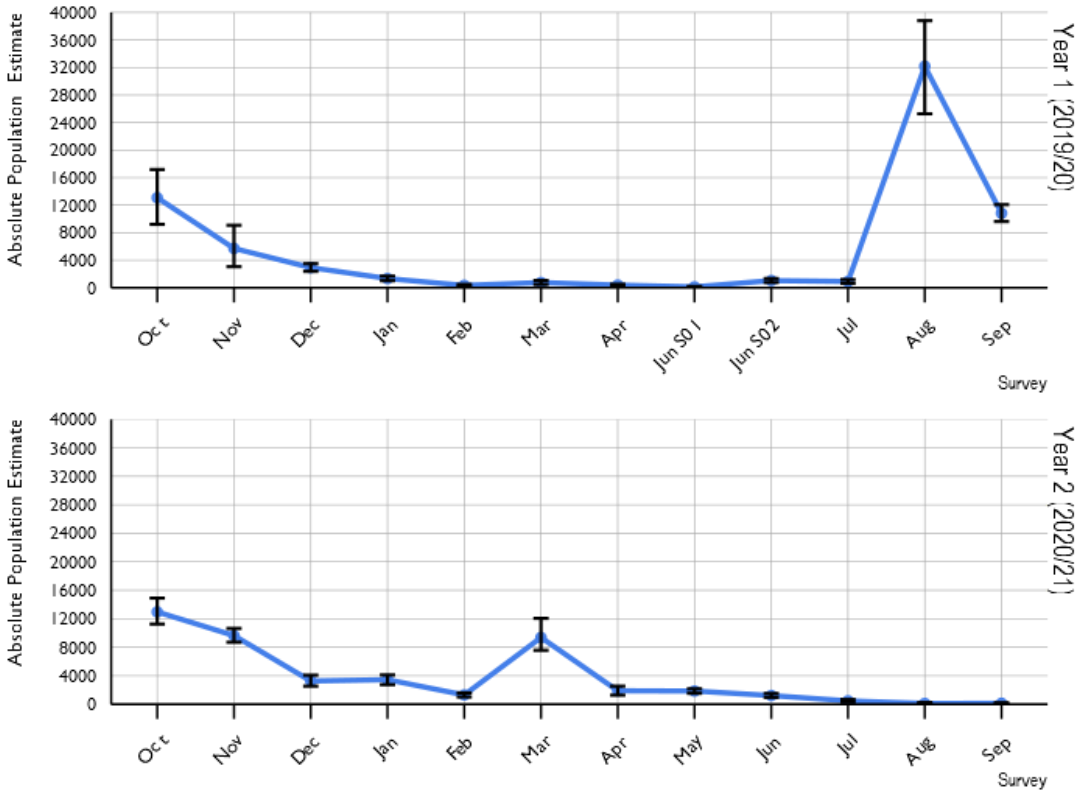


Table 21 Summary of guillemot behaviours (for birds in which behaviour could be determined) between October 2019 and September 2021

Survey date	Number recorded diving	Number recorded flying	Number recorded sitting	Number recorded taking off	% Flying	Total
22 October 2019	0	77	2621	0	3	2698
08 November 2019	0	52	1088	0	5	1140
04 December 2019	1	123	493	0	20	617
18 January 2020	0	6	254	0	2	260
04 February 2020	0	4	61	0	6	65
03 March 2020	0	14	137	0	9	151
04 April 2020	0	5	72	0	6	77
08 June 2020	0	2	27	0	7	29
24 June 2020	0	6	266	0	2	272
23 July 2020	0	7	174	1	4	182
31 August 2020	1	8	6494	0	0	6503
12 September 2020	0	0	2235	0	0	2235
15 October 2020	0	49	2702	0	2	2751
22 November 2020	0	54	1863	1	3	1918
31 December 2020	0	3	659	0	0	662
16 January 2021	0	10	660	0	1	670
22 February 2021	0	36	225	0	14	261
05 March 2021	0	91	1781	0	5	1872
10 April 2021	0	65	376	0	15	441
14 May 2021	0	32	352	0	8	384
15 June 2021	0	15	247	0	6	262
14 July 2021	0	1	106	0	1	107
16 August 2021	0	0	29	0	0	29
01 September 2021	0	0	27	0	0	27
Total	**2**	**660**	**22949**	**2**	**3**	**23613**

Figure 24 **Summarised direction of flying guillemots between October 2019 and September 2021**

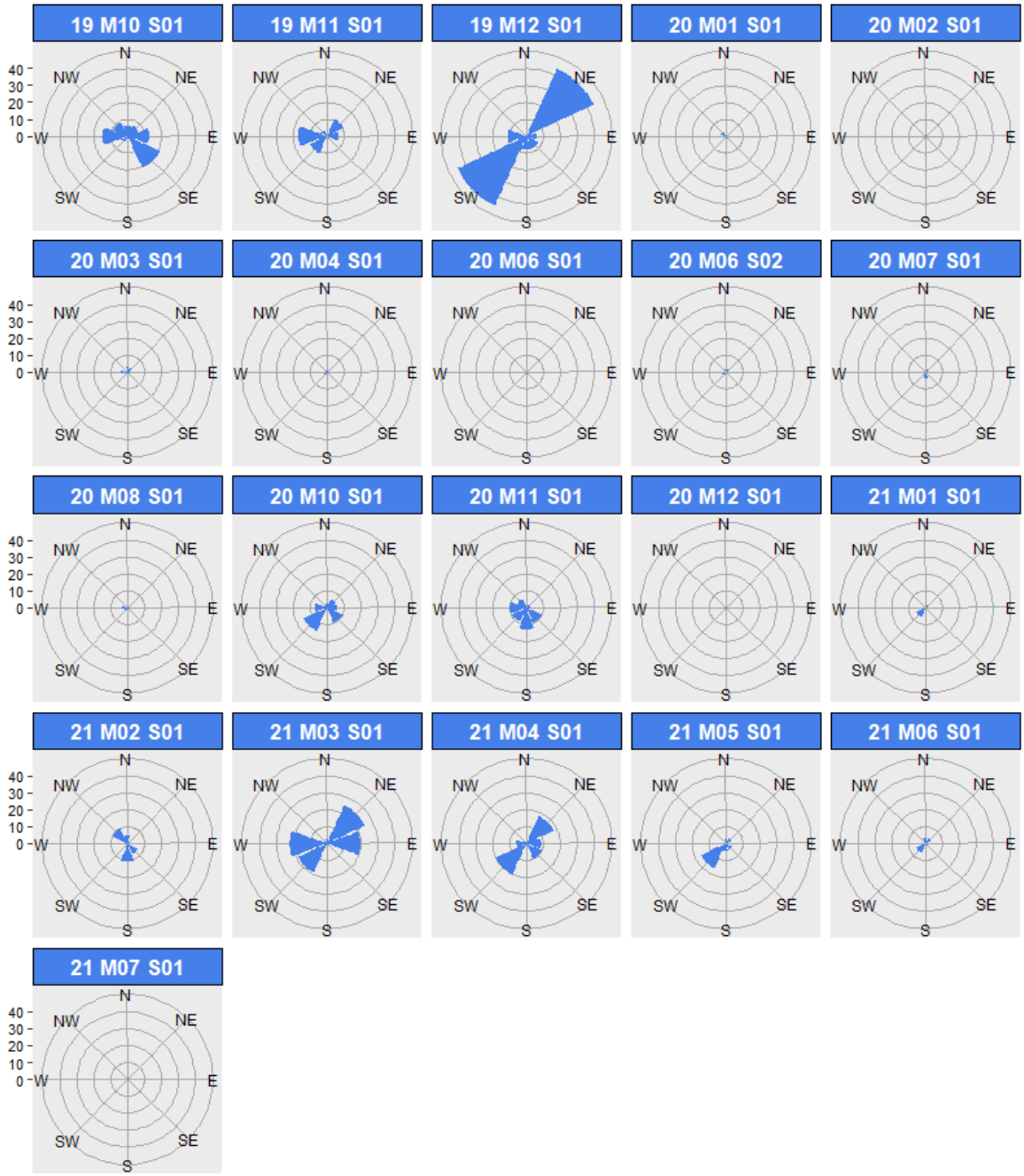


Figure 25 Relative density of guillemots (number/km²) and number of detections per segment between October 2019 and September 2020

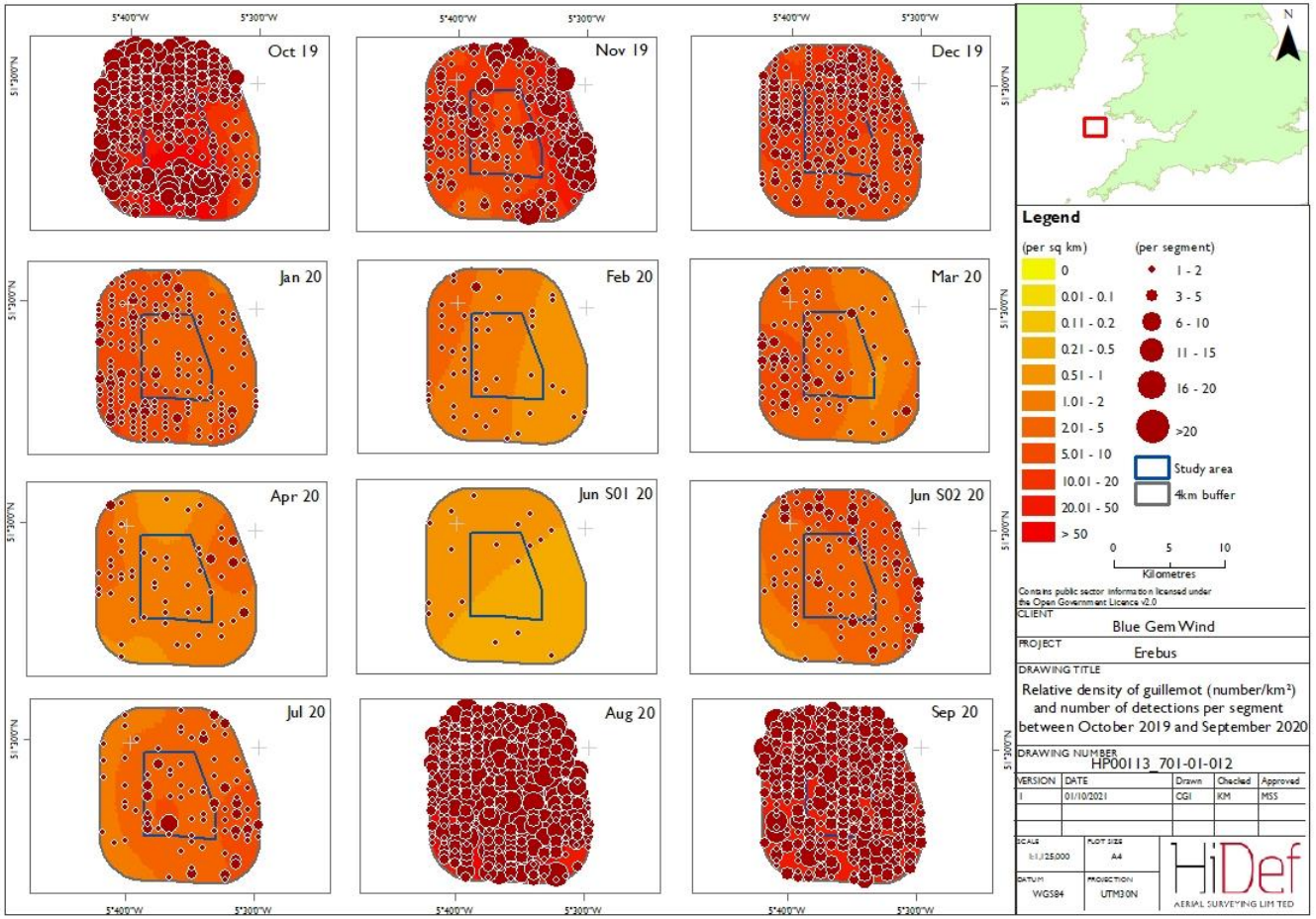
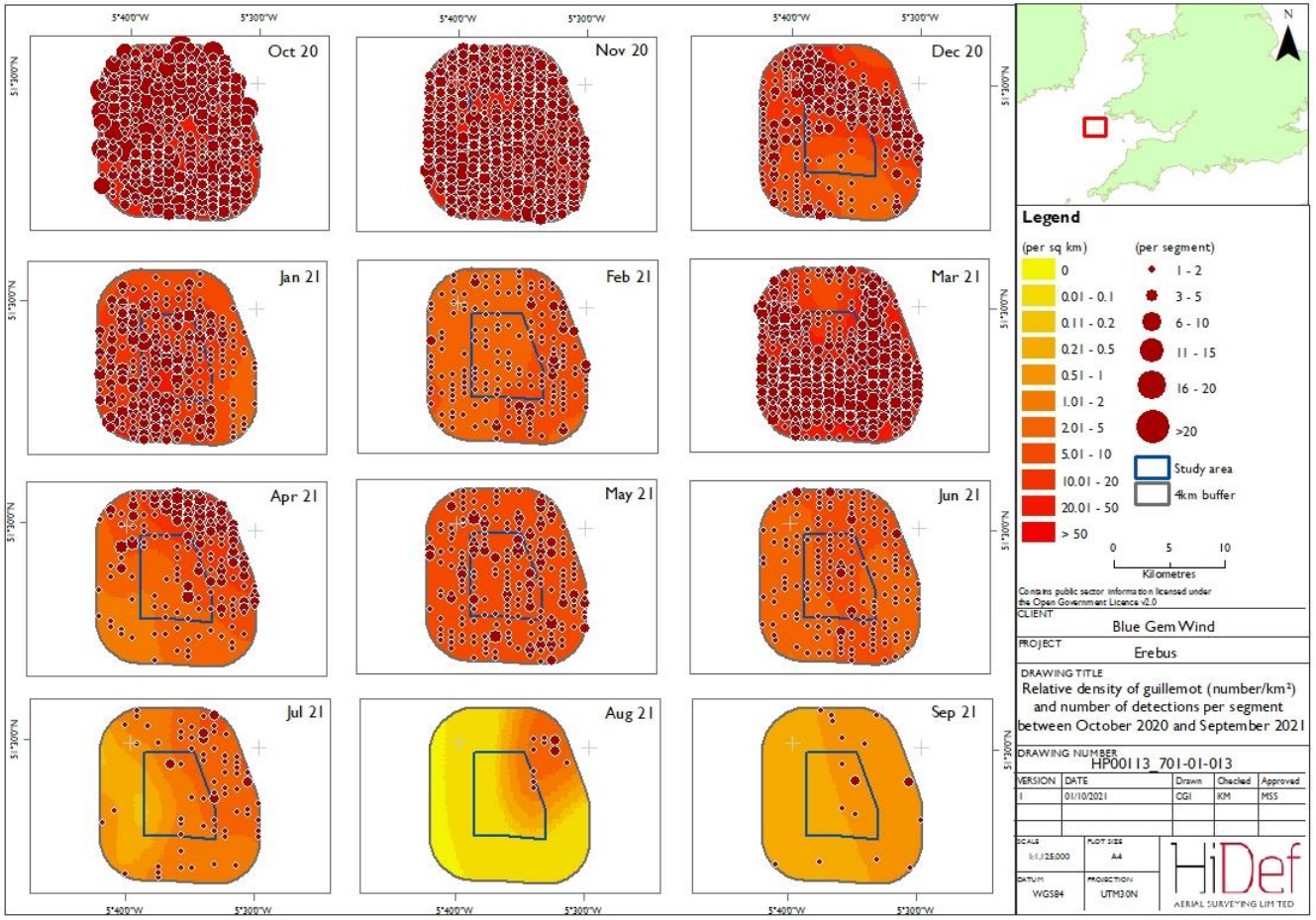


Figure 26 Relative density of guillemots (number/km²) and number of detections per segment between October 2020 and September 2021



3.3.6 Razorbill

89 Razorbills were relatively abundant, with peak observations generally recorded between October and January, (Table 22; Figure 27). Almost twice as many birds were observed in Year 1 as compared to Year 2.

90 Absolute density and abundance estimates varied throughout the survey period (Figure 28). The peak estimate for the area were associated with the October 2019 survey, with absolute density estimates calculated at 15.53 birds/km^2, equating to an absolute abundance for the region of 3,108 birds (±95% CI 1,956 – 4,685). Peak absolute densities for Year 2, occuring in January 2021, were calculated at 7.37 birds/km^2, corresponding to absolute estimates of abundance of 1,474 birds (±95% CI 744 – 2,328).

91 Distributions of razorbills were widespread in many months, with high densities of birds mostly observed within the 4km buffer area (Figure 30 to Figure 31). Considerable variation in razorbill distribution was observed, such as in July 2021 when the west of the region appeared to be selected, whereas , birds were predominantly recorded in the north and east in November 2019 and December 2020. The south of the region was also selected, such as in October 2019.

92 As is expected for the species, the majority of razorbills were recorded sitting on the water, with 5% of birds recorded flying across the entire study period (Table 23).

93 There were surveys in which no data regarding flight direction were available. To allow for clear interpretation of results, only surveys which contained flight direction data were displayed (Figure 29). Many razorbills flew westwards, such as in October 2019 and 2020, November 2019 and February 2021.

Table 22 Number of razorbills recorded to species level between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Razorbill	665	463	65	42	5	17	59	0	3	3	25	43	1390
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Razorbill	117	41	252	307	29	42	43	17	6	0	0	0	854

Figure 27 **Number of razorbills recorded to species level between October 2019 and September 2021**

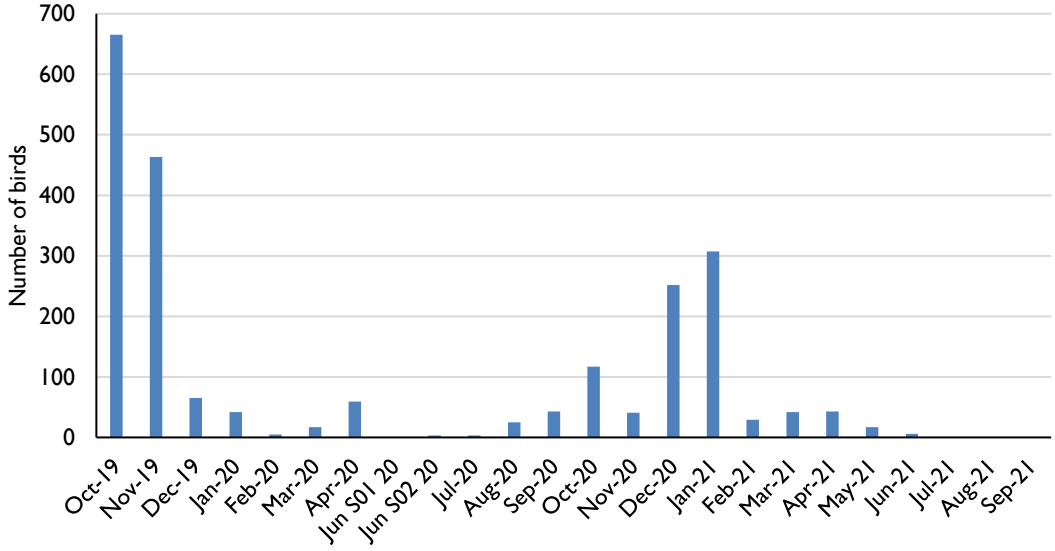


Figure 28 **Adjusted (absolute) razorbill population estimates with lower and upper 95% confidence intervals between October 2019 and September 2021**

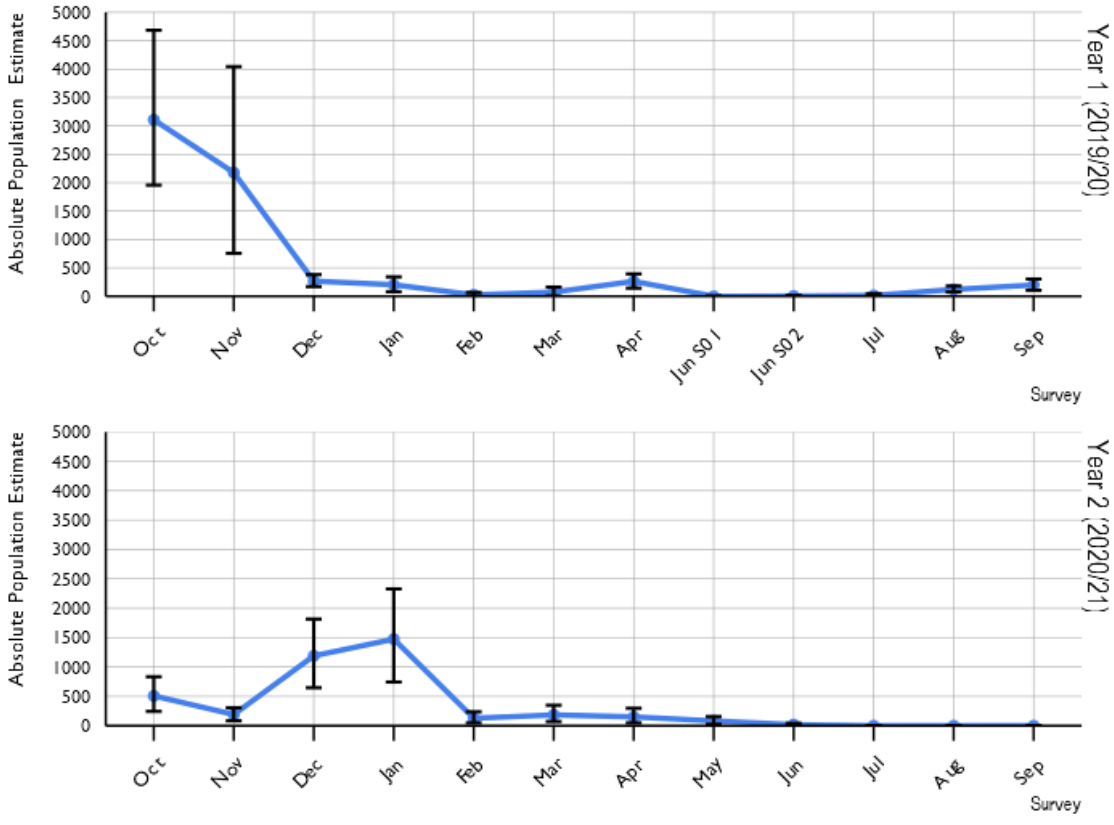


Table 23 Summary of razorbill behaviours (for birds in which behaviour could be determined) between October 2019 and September 2021

Survey date	Number recorded diving	Number recorded flying	Number recorded sitting	Number recorded taking off	% Flying	Total
22 October 2019	0	30	635	0	5	665
08 November 2019	0	18	445	0	4	463
04 December 2019	0	3	62	0	5	65
18 January 2020	0	1	41	0	2	42
04 February 2020	0	1	4	0	20	5
03 March 2020	0	9	8	0	53	17
04 April 2020	0	3	56	0	5	59
08 June 2020	0	0	0	0	0	0
24 June 2020	0	2	1	0	67	3
23 July 2020	0	0	3	0	0	3
31 August 2020	0	0	25	0	0	25
12 September 2020	0	0	43	0	0	43
15 October 2020	0	23	94	0	20	117
22 November 2020	0	6	35	0	15	41
31 December 2020	0	0	252	0	0	252
16 January 2021	0	1	306	0	0	307
22 February 2021	0	15	14	0	52	29
05 March 2021	0	4	38	0	10	42
10 April 2021	0	5	38	0	12	43
14 May 2021	0	0	17	0	0	17
15 June 2021	0	1	5	0	17	6
14 July 2021	0	0	0	0	0	0
16 August 2021	0	0	0	0	0	0
01 September 2021	0	0	0	0	0	0
Total	**0**	**122**	**2122**	**0**	**5**	**2244**

Figure 29 **Summarised direction of flying razorbills between October 2019 and September 2021**

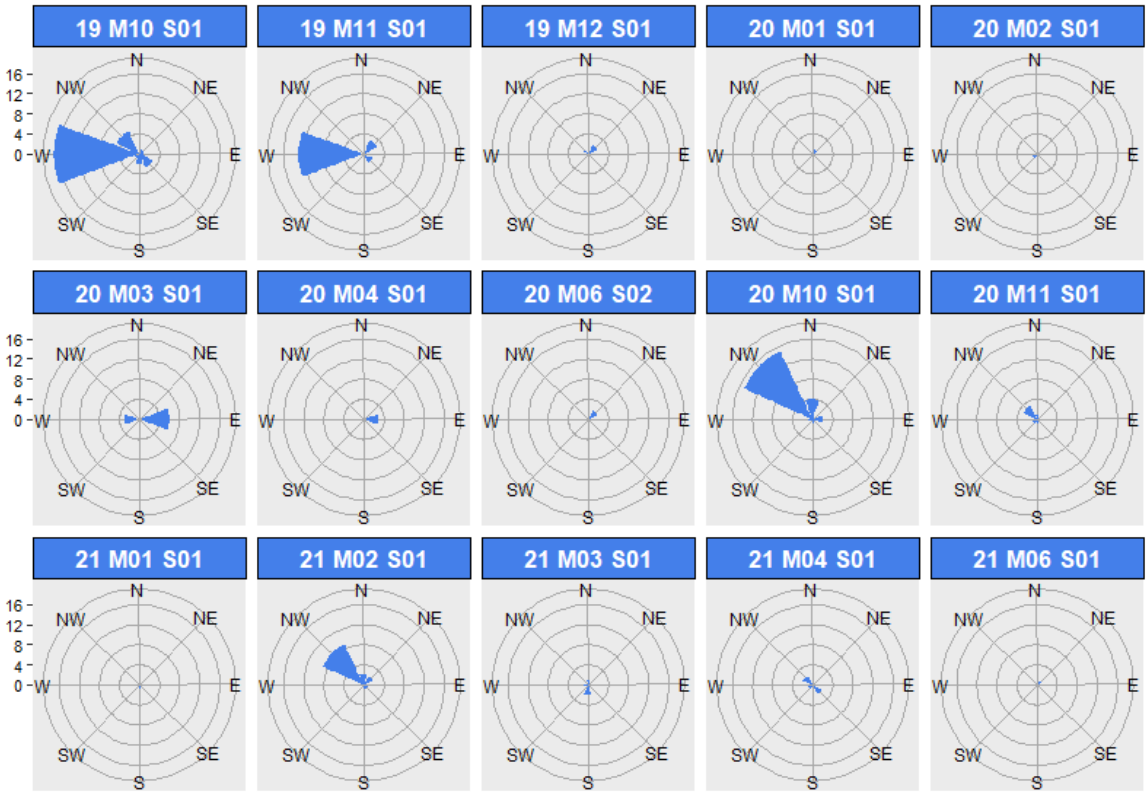


Figure 30 **Relative density of razorbills (number/km²) and number of detections per segment between October 2019 and September 2020**

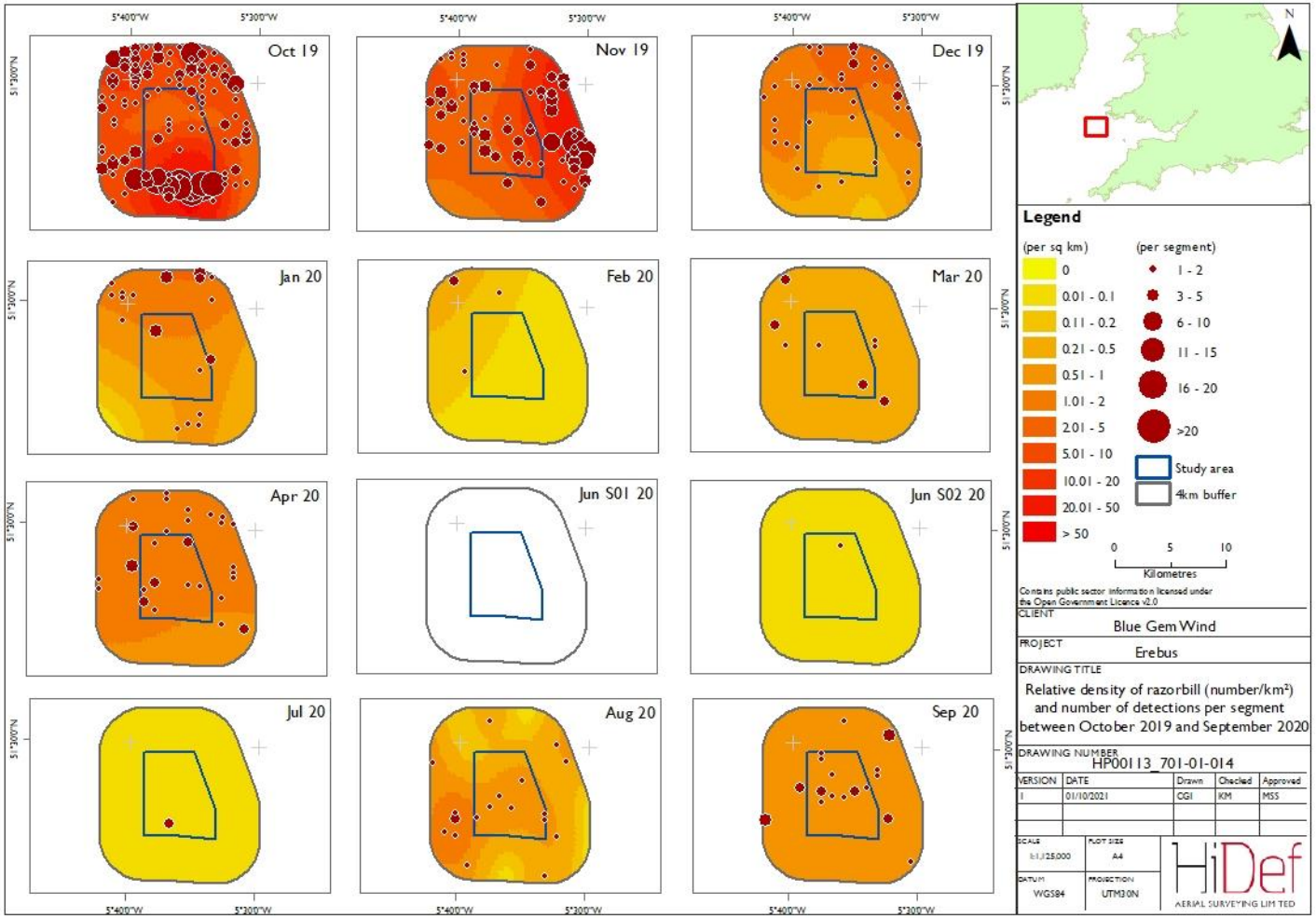
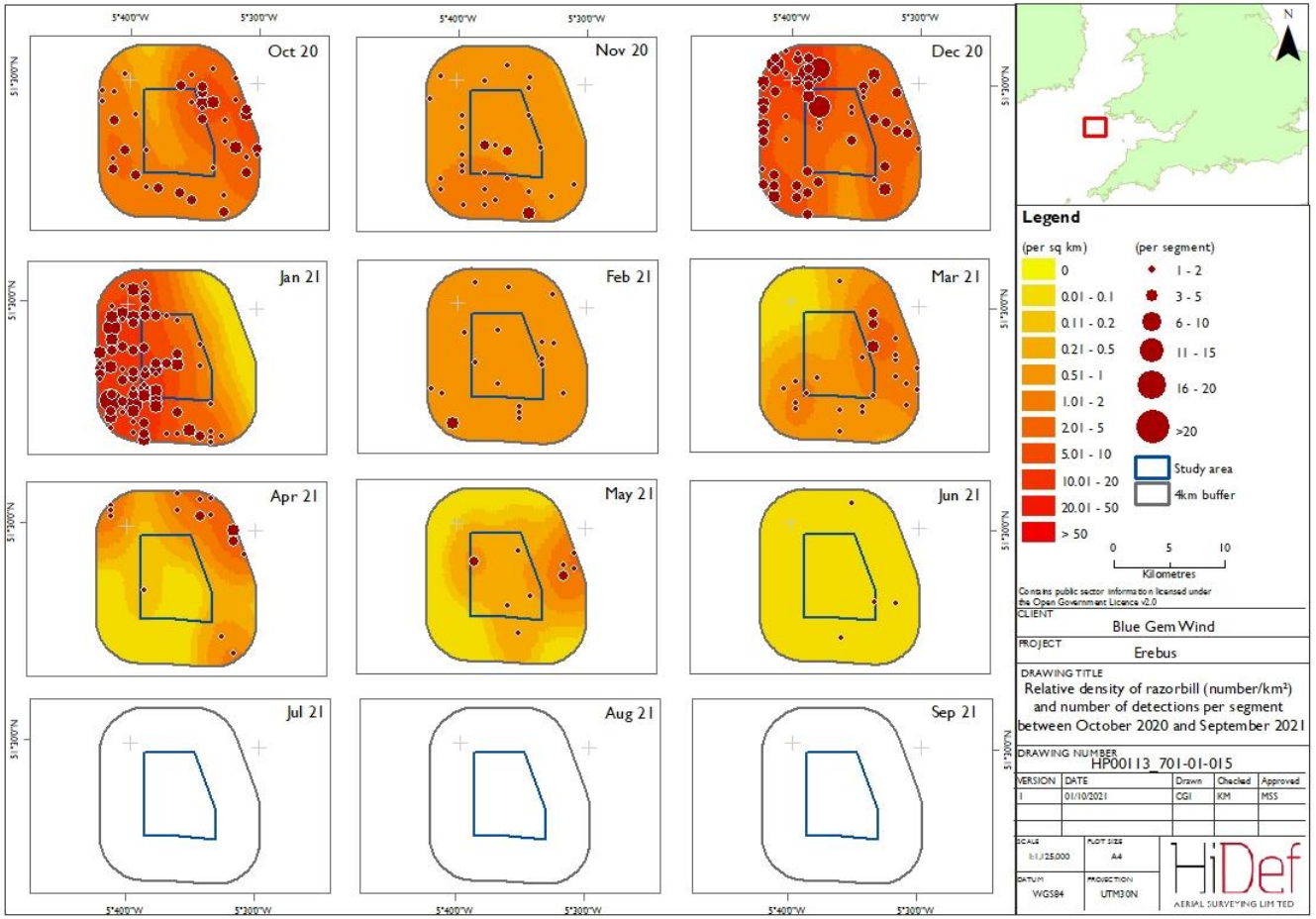


Figure 31 **Relative density of razorbills (number/km²) and number of detections per segment between October 2020 and September 2021**



3.3.7 Puffin

94 Puffins were generally recorded with the highest numbers between April and June during the breeding period in all years (Table 24; Figure 32). Almost twice as many birds were observed in Year 1 compared to Year 2.

95 For the months where puffins were recorded, absolute densities fluctuated between 0.05 birds/km^2 in September 2020 and 2021 and 8.33 birds/km^2 in April 2020, equating to absolute abundances for the region of 9 birds (±95% CI 0 – 23) and 1669 birds (±95% CI 1374 – 1960), respectively (Figure 33).

96 Out with the breeding season, reliable conclusions regarding the distribution of puffins throughout the survey region could not be reached due to low numbers of observations. Within the breeding season birds were distributed throughout the survey area with similar densities observed both within the wind farm site and the 4km buffer zone (Figure 35 to Figure 36).

97 Across the two-year period, only 3% of birds were observed flying with the rest of the birds sitting on the water (Table 25).

98 There were surveys in which no data regarding flight direction were available. To allow clear interpretation of results, only surveys which contained flight direction data are displayed (Figure 34). Many birds were recorded flying north in April and June S02 2020, however fewer birds were also recorded flying southwest in both March 2020 and April 2021.

Table 24 Number of puffins recorded to species level between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Puffin	12	0	4	0	0	4	391	0	156	4	9	2	582
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Puffin	0	0	0	0	0	6	74	67	181	10	4	3	345

Figure 32 **Number of puffins recorded to species level between October 2019 and September 2021**

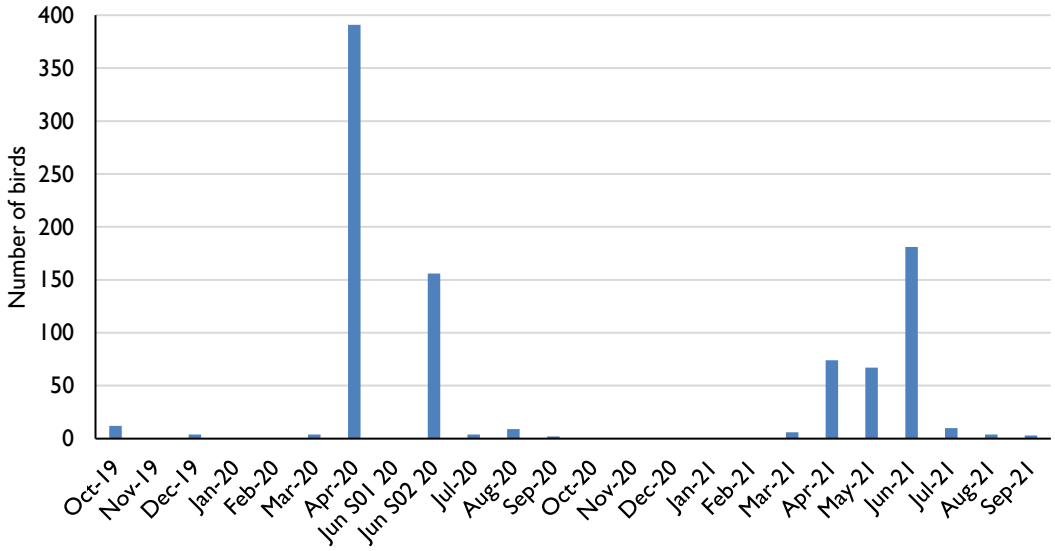


Figure 33 **Adjusted (absolute) puffin population estimates with lower and upper 95% confidence intervals between October 2019 and September 2021**

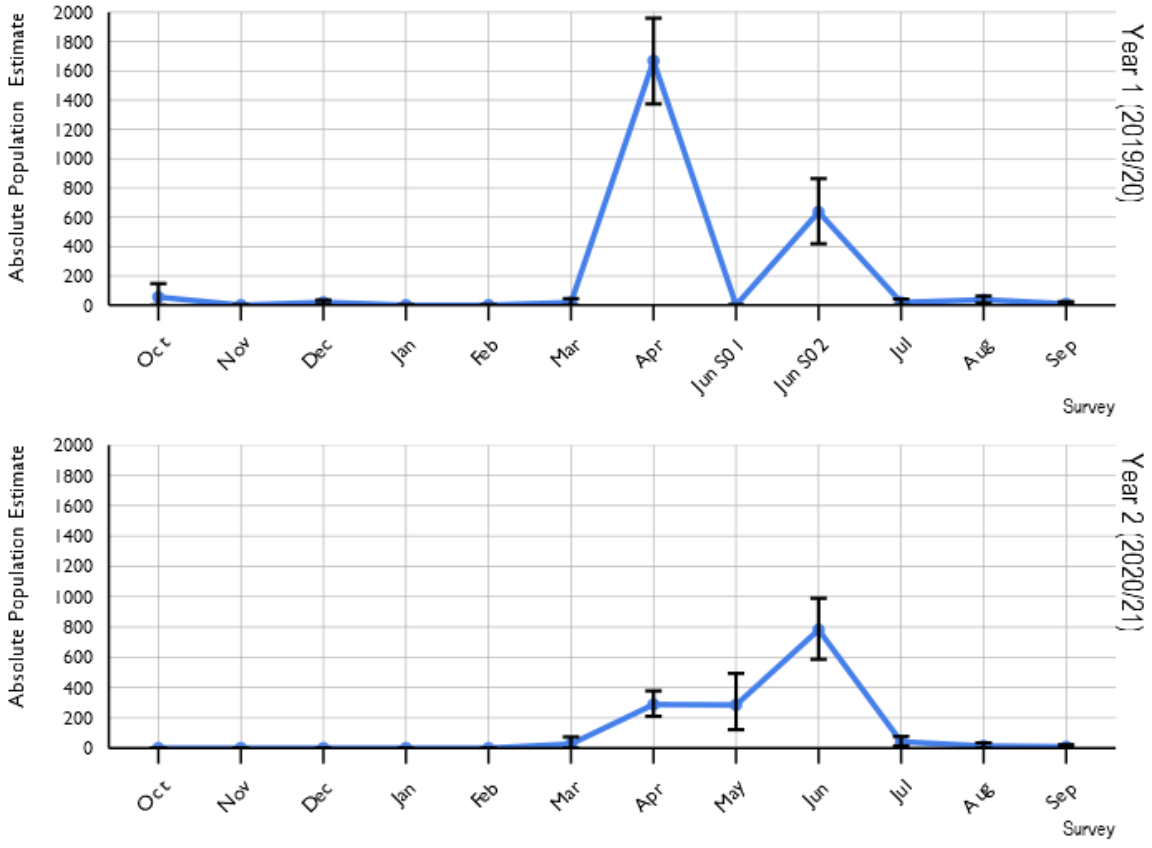


Table 25 Summary of puffin behaviours (for birds in which behaviour could be determined) between October 2019 and September 2021

Survey date	Number recorded diving	Number recorded flying	Number recorded sitting	Number recorded taking off	% Flying	Total
22 October 2019	0	1	11	0	8	12
08 November 2019	0	0	0	0	0	0
04 December 2019	0	0	4	0	0	4
18 January 2020	0	0	0	0	0	0
04 February 2020	0	0	0	0	0	0
03 March 2020	0	3	1	0	75	4
04 April 2020	0	7	384	0	2	391
08 June 2020	0	0	0	0	0	0
24 June 2020	0	7	149	0	4	156
23 July 2020	0	0	9	0	0	9
31 August 2020	0	0	2	0	0	2
12 September 2020	0	0	0	0	0	0
15 October 2020	0	0	0	0	0	0
22 November 2020	0	0	0	0	0	0
31 December 2020	0	0	0	0	0	0
16 January 2021	0	0	0	0	0	0
22 February 2021	0	0	0	0	0	0
05 March 2021	0	2	4	0	33	6
10 April 2021	0	3	71	0	4	74
14 May 2021	0	1	66	0	1	67
15 June 2021	0	4	177	0	2	181
14 July 2021	0	0	10	0	0	10
16 August 2021	0	0	4	0	0	4
01 September 2021	0	0	3	0	0	3
Total	**0**	**28**	**895**	**0**	**3**	**923**

Figure 34 **Summarised direction of flying puffins between October 2019 and September 2021**

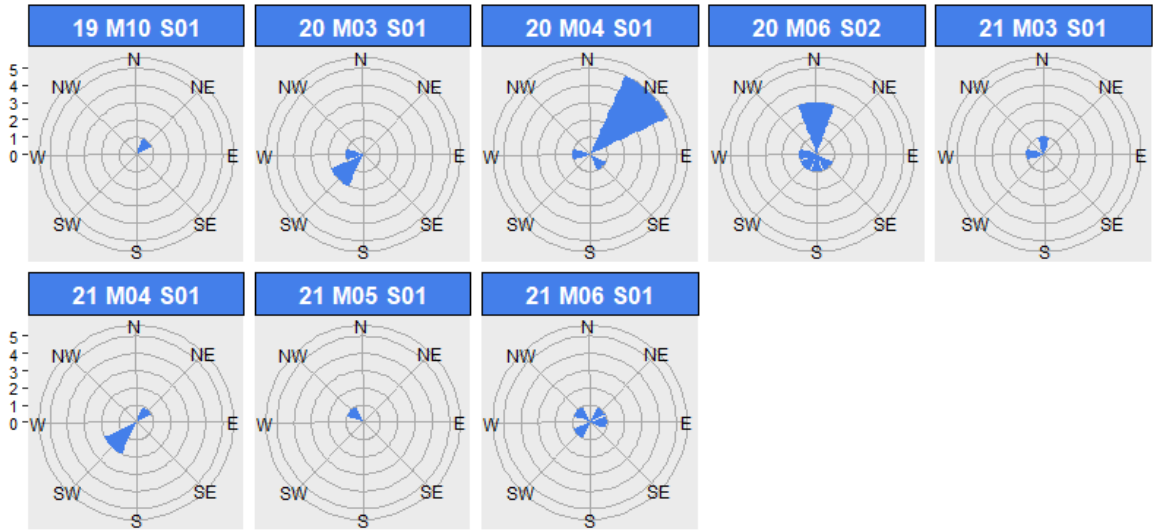


Figure 35 Relative density of puffins (number/km²) and number of detections per segment between October 2019 and September 2020

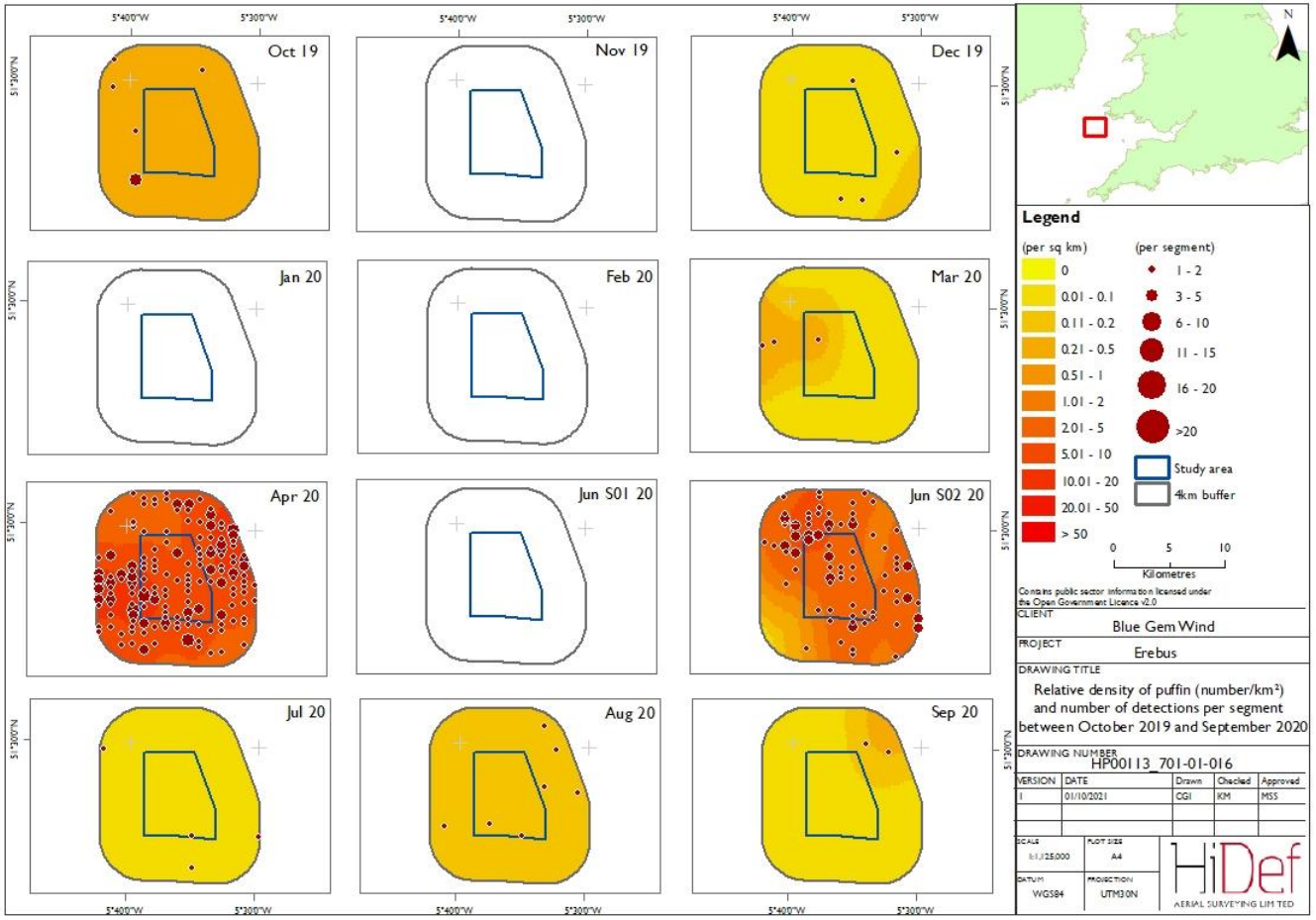
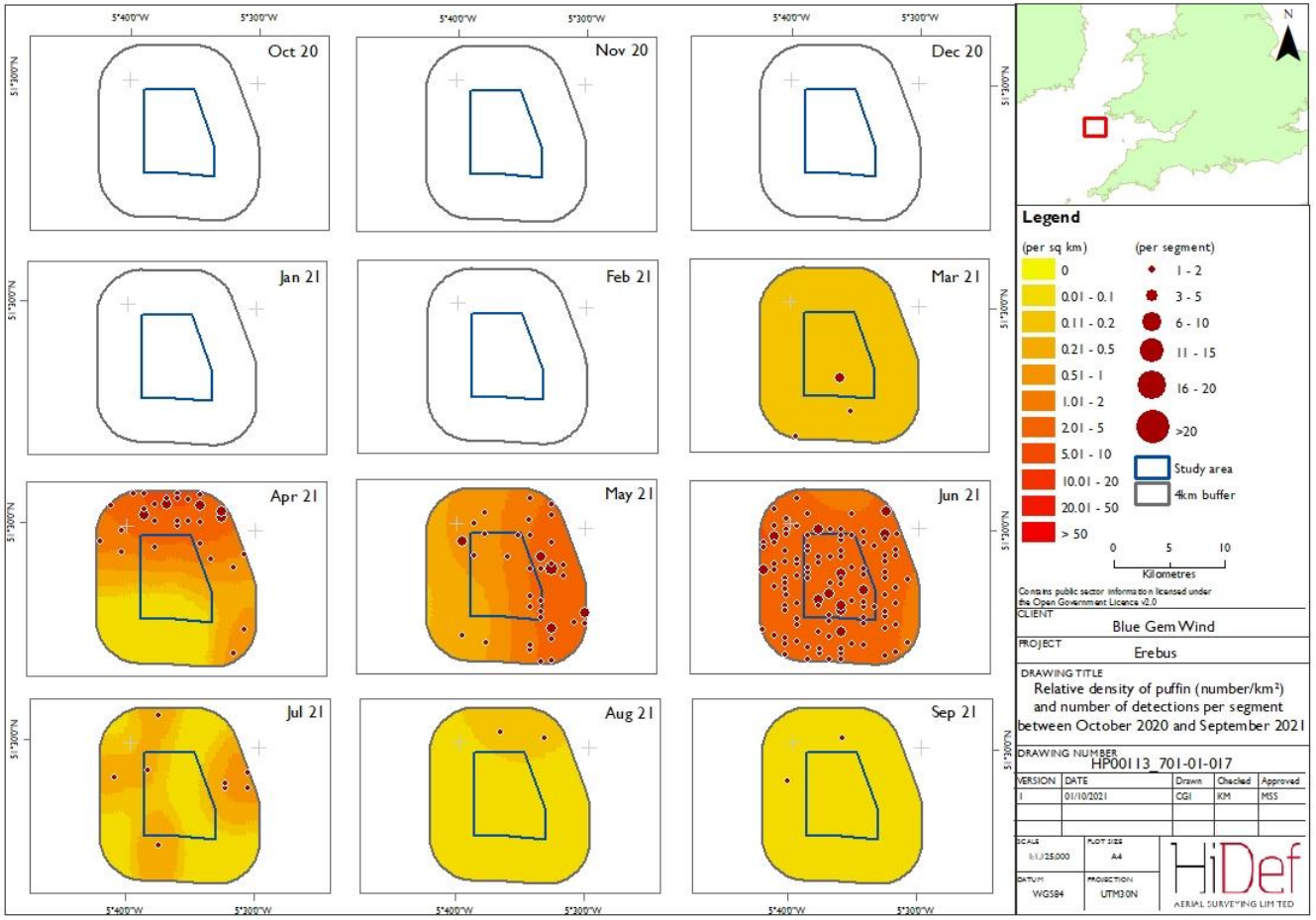


Figure 36 Relative density of puffins (number/km²) and number of detections per segment between October 2019 and September 2020



3.3.8 Fulmar

99 Fulmars were most abundant during the non-breeding season, with fewer birds recorded during the summer months (Table 26; Figure 37). More than twice as many birds were observed in Year 1 compared to Year 2.

100 Observations of fulmars peaked in November 2019, with over four times as many observations than the next highest peak, with a peak abundance estimate of 537 birds (±95% CI 20 – 1,463); (Figure 38). Abundance estimates for the survey area were generally very low over the summer breeding period, ranging between 4 birds (±95% CI 0 – 12) and 16 birds (±95% CI 0 – 35) between April and September 2020 and 4 birds (±95% CI 0 – 12) and 16 birds (±95% CI 4 – 31) over the same period in 2021.

101 In months where densities were high, such as in November 2019 and February 2021, fulmars appeared to select the north of the region, with high densities mostly observed within the wind farm site (Figure 40 to Figure 41).The other months in the survey presented no clear distribution pattern due to the low observation numbers.

102 Throughout the survey programme 60% of birds were recorded as sitting on the water and 37% of birds were recorded flying (Table 27). All seven birds recorded taking off were observed during the same month November 2019. In this same month, three times more birds were observed sitting on the water than flying, while twice as many birds were observed sitting on the water compared to flying in February 2021.

103 There were surveys in which no data regarding flight direction were available. To allow for clear interpretation of results, only surveys which contained flight direction data were displayed (Figure 39). No obvious patterns in flight direction could be determined during the survey period.

Table 26 Number of fulmars recorded to species level between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Fulmar	0	136	0	2	3	11	4	0	1	2	1	1	161
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Fulmar	0	8	1	3	32	3	1	2	4	1	2	3	60

Figure 37 **Number of fulmars recorded to species level between October 2019 and September 2021**

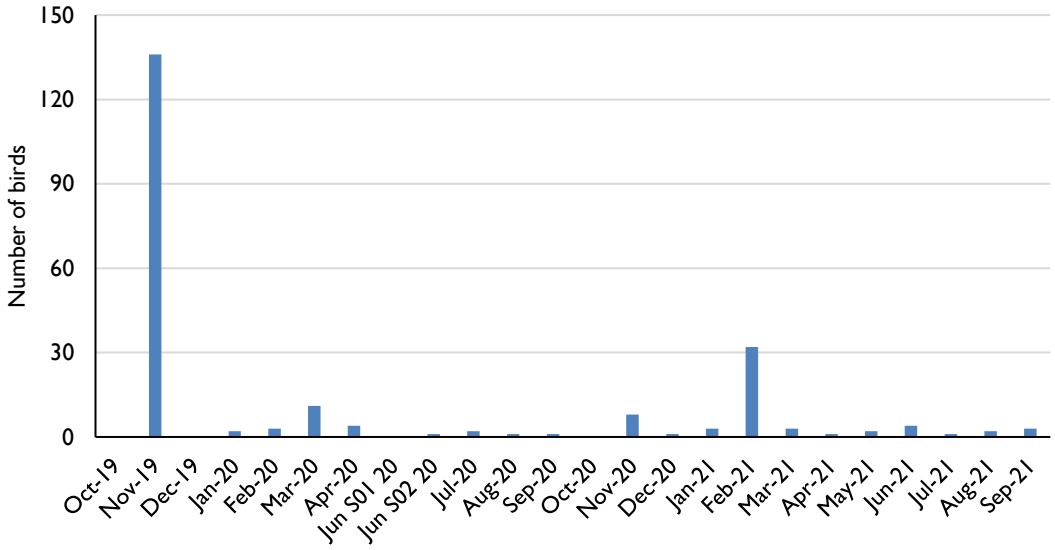


Figure 38 **Fulmar population estimates with lower and upper 95% confidence intervals between October 2019 and September 2021**

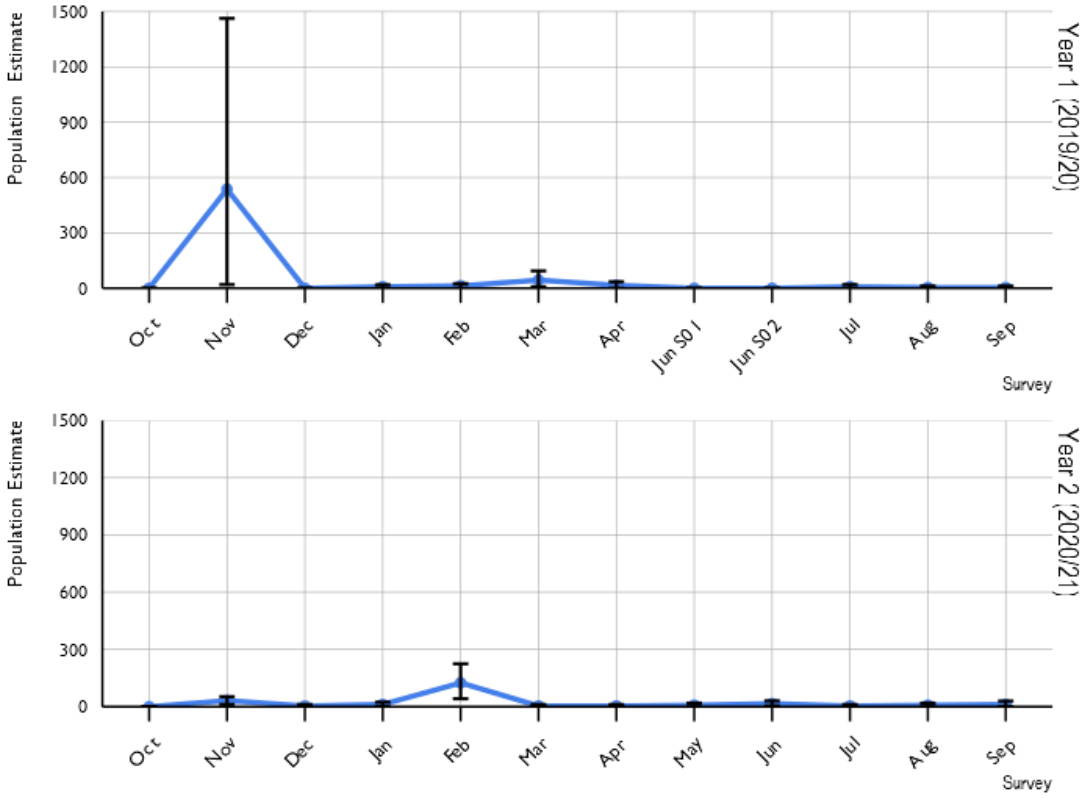


Table 27 Summary of fulmar behaviours (for birds in which behaviour could be determined) between October 2019 and September 2021

Survey date	Number recorded diving	Number recorded flying	Number recorded sitting	Number recorded taking off	% Flying	Total
22 October 2019	0	0	0	0	0	0
08 November 2019	0	32	97	7	24	136
04 December 2019	0	0	0	0	0	0
18 January 2020	0	1	1	0	50	2
04 February 2020	0	2	1	0	67	3
03 March 2020	0	10	1	0	91	11
04 April 2020	0	2	2	0	50	4
08 June 2020	0	0	0	0	0	0
24 June 2020	0	1	0	0	100	1
23 July 2020	0	1	1	0	50	2
31 August 2020	0	0	1	0	0	1
12 September 2020	0	1	0	0	100	1
15 October 2020	0	0	0	0	0	0
22 November 2020	0	6	2	0	75	8
31 December 2020	0	1	0	0	100	1
16 January 2021	0	3	0	0	100	3
22 February 2021	0	12	20	0	38	32
05 March 2021	0	0	3	0	0	3
10 April 2021	0	0	1	0	0	1
14 May 2021	0	2	0	0	100	2
15 June 2021	0	3	0	0	100	3
14 July 2021	0	1	0	0	100	1
16 August 2021	0	1	1	0	50	2
01 September 2021	0	2	1	0	67	3
Total	**0**	**81**	**132**	**7**	**37**	**220**

Figure 39 Summarised direction of flying fulmars between October 2019 and September 2021

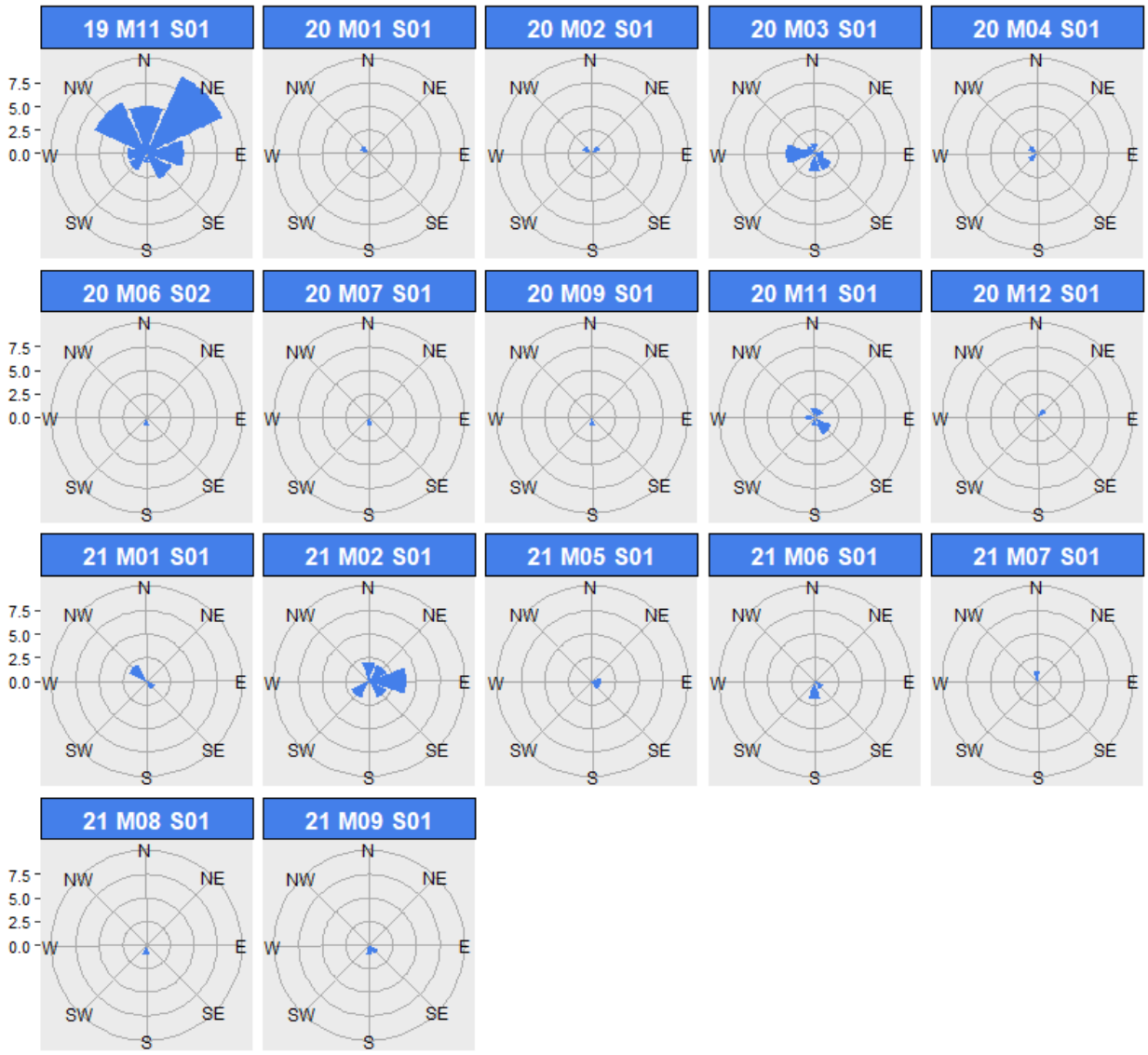


Figure 40 Density of fulmars (number/km²) and number of detections per segment between October 2019 and September 2020

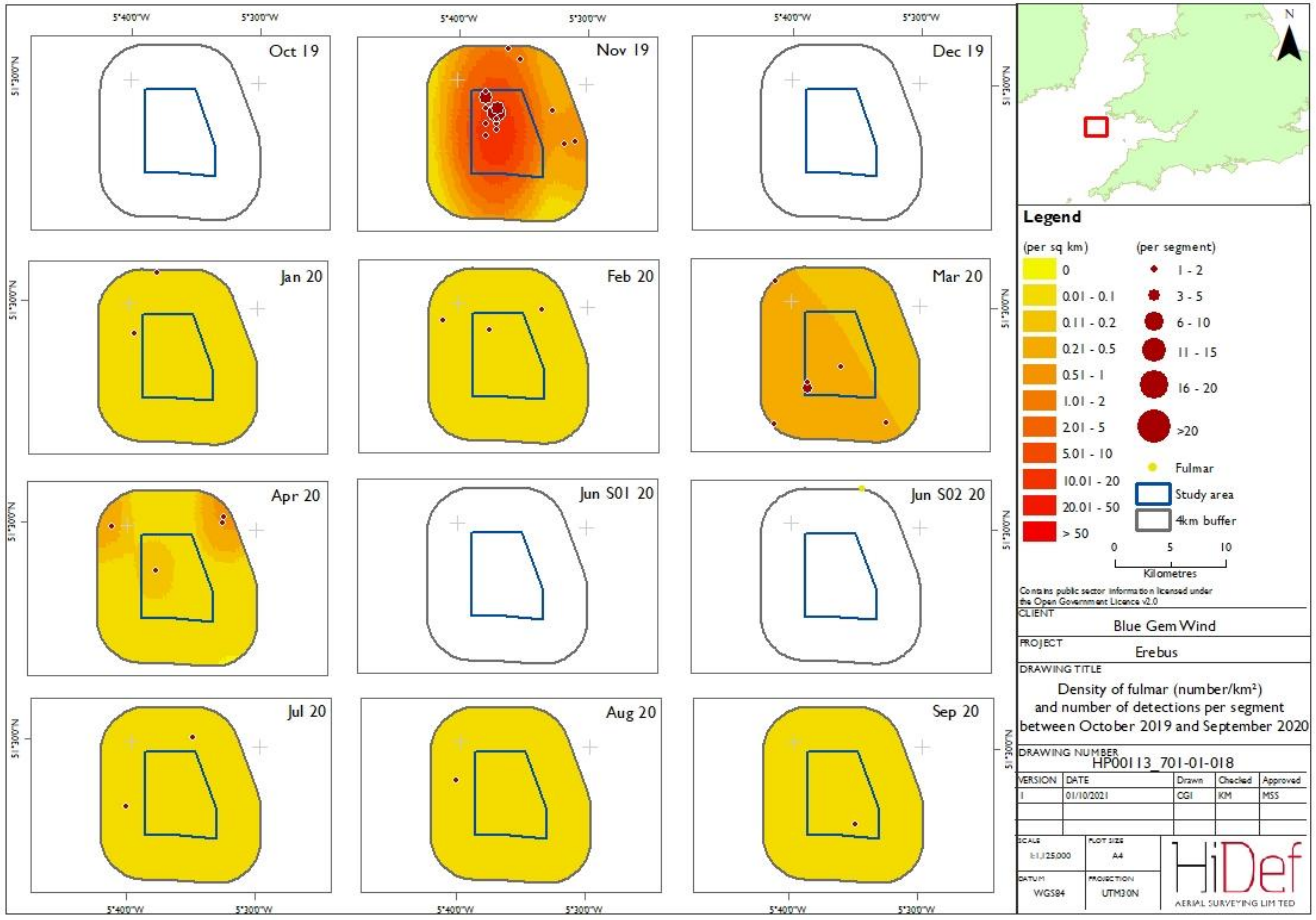
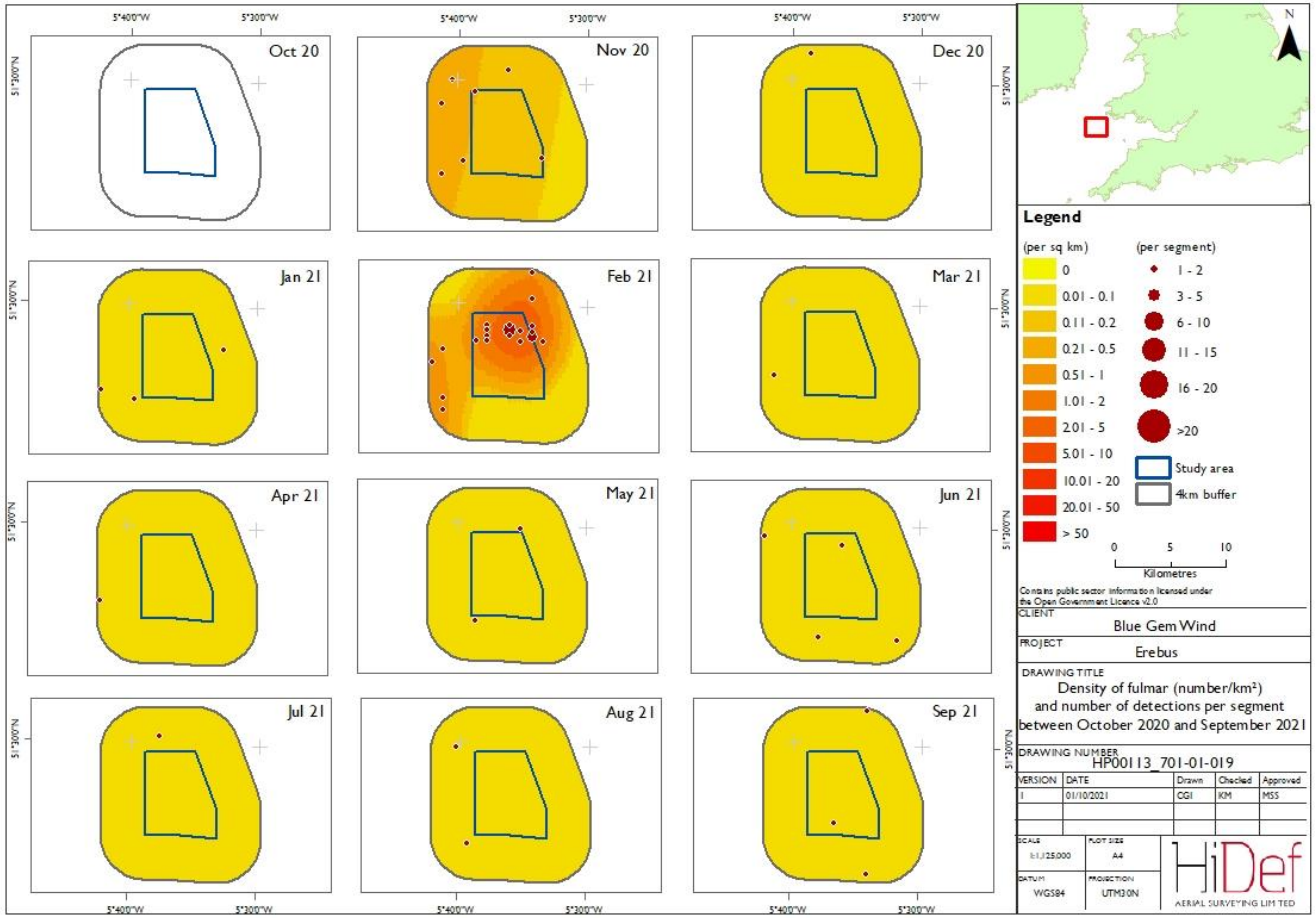


Figure 41 Density of fulmars (number/km²) and number of detections per segment between October 2020 and September 2021



3.3.9 Manx shearwater

104 Manx shearwater were the third most abundant species observed during the survey period, and predominately present during the breeding season, peaking in June for both 2020 and 2021 (Table 28; Figure 42). More birds were recorded in Year 1 compared to Year 2.

105 Densities of Manx shearwater were the highest between June S01 and August in 2020 and June and September in 2021, ranging between 2.82 birds/km² and 13.51 birds/km² and between 0.8 birds/km² and 13.99 birds/km², respectively. Peak abundance estimates for each survey year equated to 2704 birds (±95% CI 1366 – 4291) in July 2020 and 2800 birds (±95% CI 1024 – 5163) in June 2021 (Figure 43).

106 Although conclusions regarding distribution could not be made throughout the survey period, Manx shearwater were mainly distributed in greater densities in the 4km buffer area rather than the Erebus site (Figure 45 to Figure 46). Across the project, 61% of birds were recorded as sitting on the water and 29% of birds were recorded as flying (Table 29).

107 There were surveys in which no data regarding flight direction were available. To allow for clear interpretation of results, only surveys which contained flight direction data are displayed (Figure 44). No obvious patterns in flight direction could be determined during the survey period.

Table 28 Number of Manx shearwaters recorded to species level between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Manx shearwater	0	0	0	0	0	0	1	143	732	693	383	3	1955
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Manx shearwater	1	0	0	0	0	1	12	9	712	16	52	310	1113

Figure 42 **Number of Manx shearwaters recorded to species level between October 2019 and September 2021**

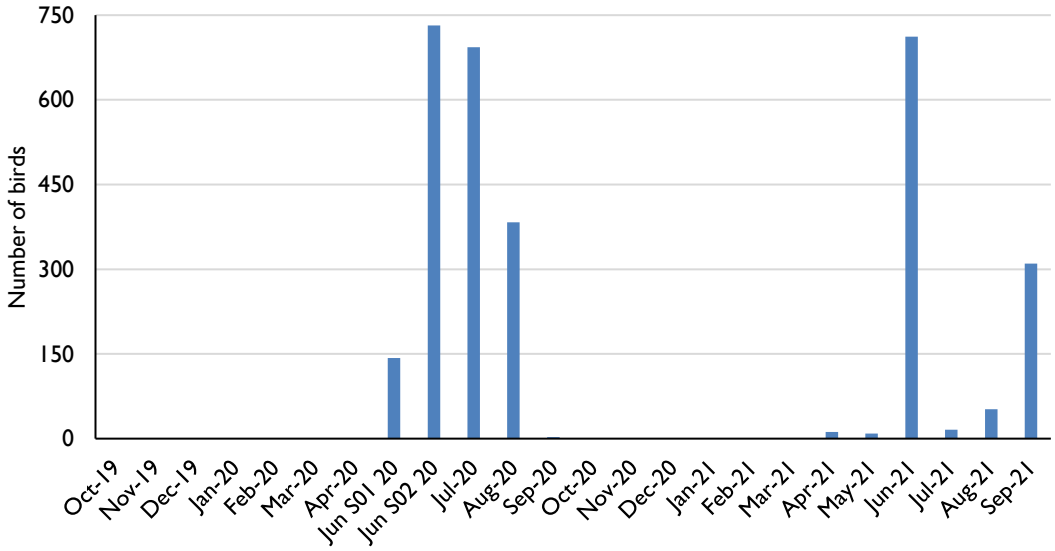


Figure 43 **Manx shearwater population estimates with lower and upper 95% confidence intervals between October 2019 and September 2021**

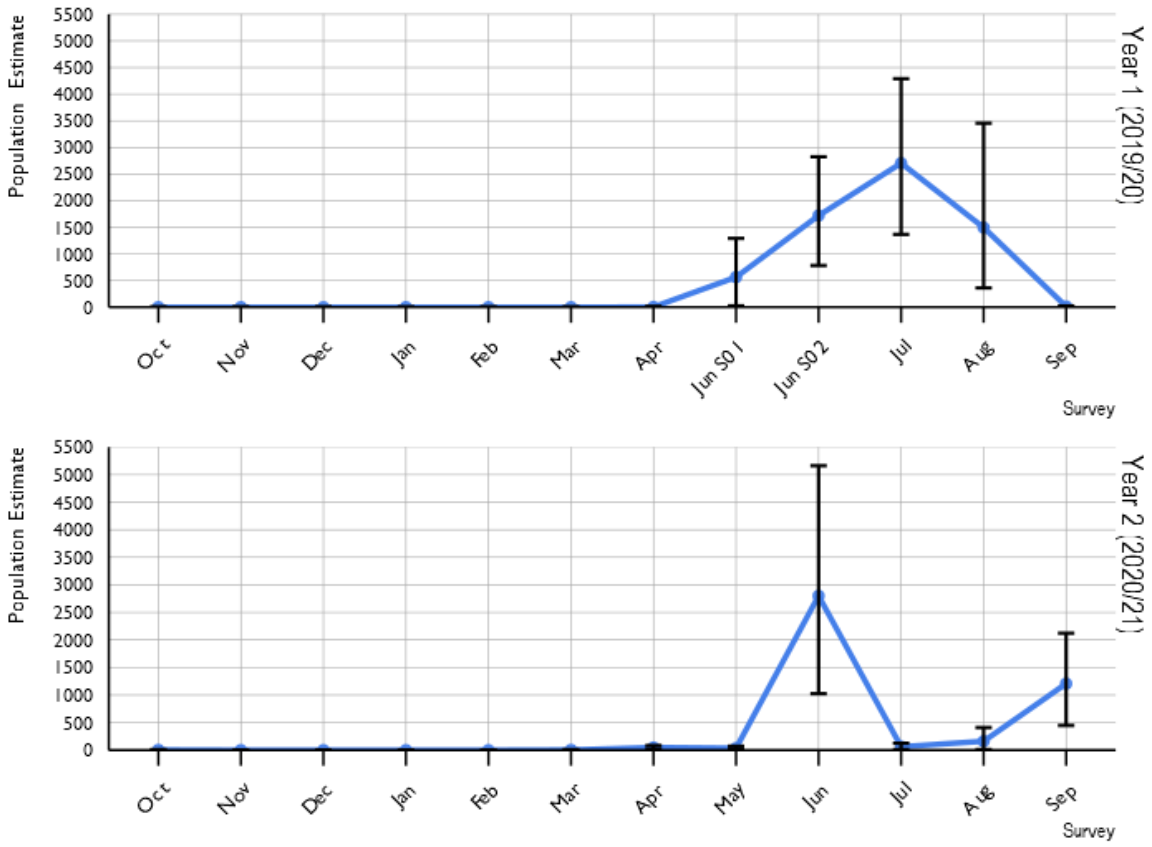


Table 29 Summary of Manx shearwater behaviours (for birds in which behaviour could be determined) between October 2019 and September 2021

Survey date	Number recorded diving	Number recorded flying	Number recorded sitting	Number recorded taking off	% Flying	Total
22 October 2019	0	0	0	0	0	0
08 November 2019	0	0	0	0	0	0
04 December 2019	0	0	0	0	0	0
18 January 2020	0	0	0	0	0	0
04 February 2020	0	0	0	0	0	0
03 March 2020	0	0	0	0	0	0
04 April 2020	0	1	0	0	100	1
08 June 2020	0	39	21	83	27	143
24 June 2020	0	396	205	131	54	732
23 July 2020	0	65	623	5	9	693
31 August 2020	0	111	270	2	29	383
12 September 2020	0	0	2	1	0	3
15 October 2020	0	1	0	0	100	1
22 November 2020	0	0	0	0	0	0
31 December 2020	0	0	0	0	0	0
16 January 2021	0	0	0	0	0	0
22 February 2021	0	0	0	0	0	0
05 March 2021	0	1	0	0	100	1
10 April 2021	0	5	7	0	42	12
14 May 2021	0	4	5	0	44	9
15 June 2021	0	138	560	14	19	712
14 July 2021	0	13	3	0	81	16
16 August 2021	0	21	20	11	40	52
01 September 2021	0	99	153	58	32	310
Total	**0**	**894**	**1869**	**305**	**29**	**3068**

Figure 44 **Summarised direction of flying Manx shearwaters between October 2019 and September 2021**

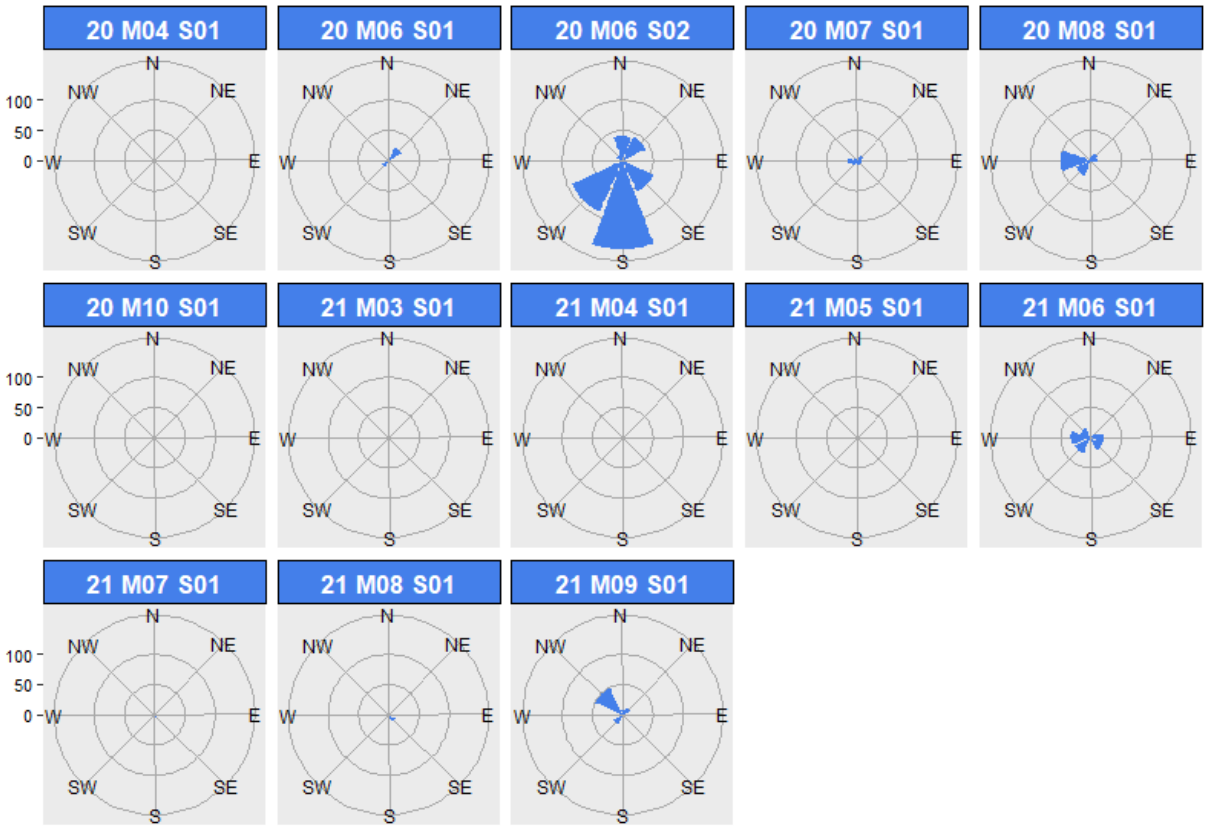


Figure 45 Density of Manx shearwaters (number/km²) and number of detections per segment between October 2019 and September 2020.

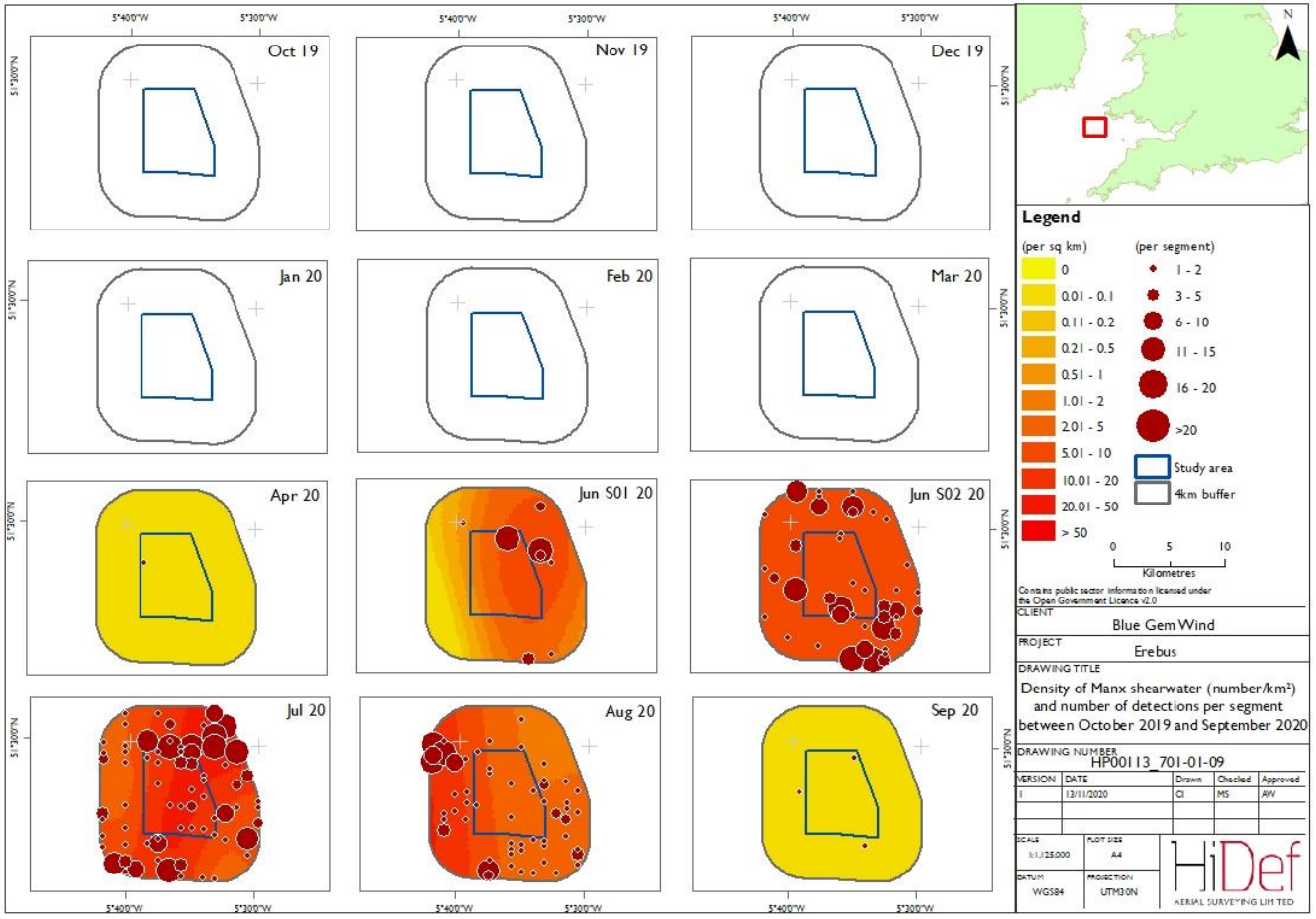
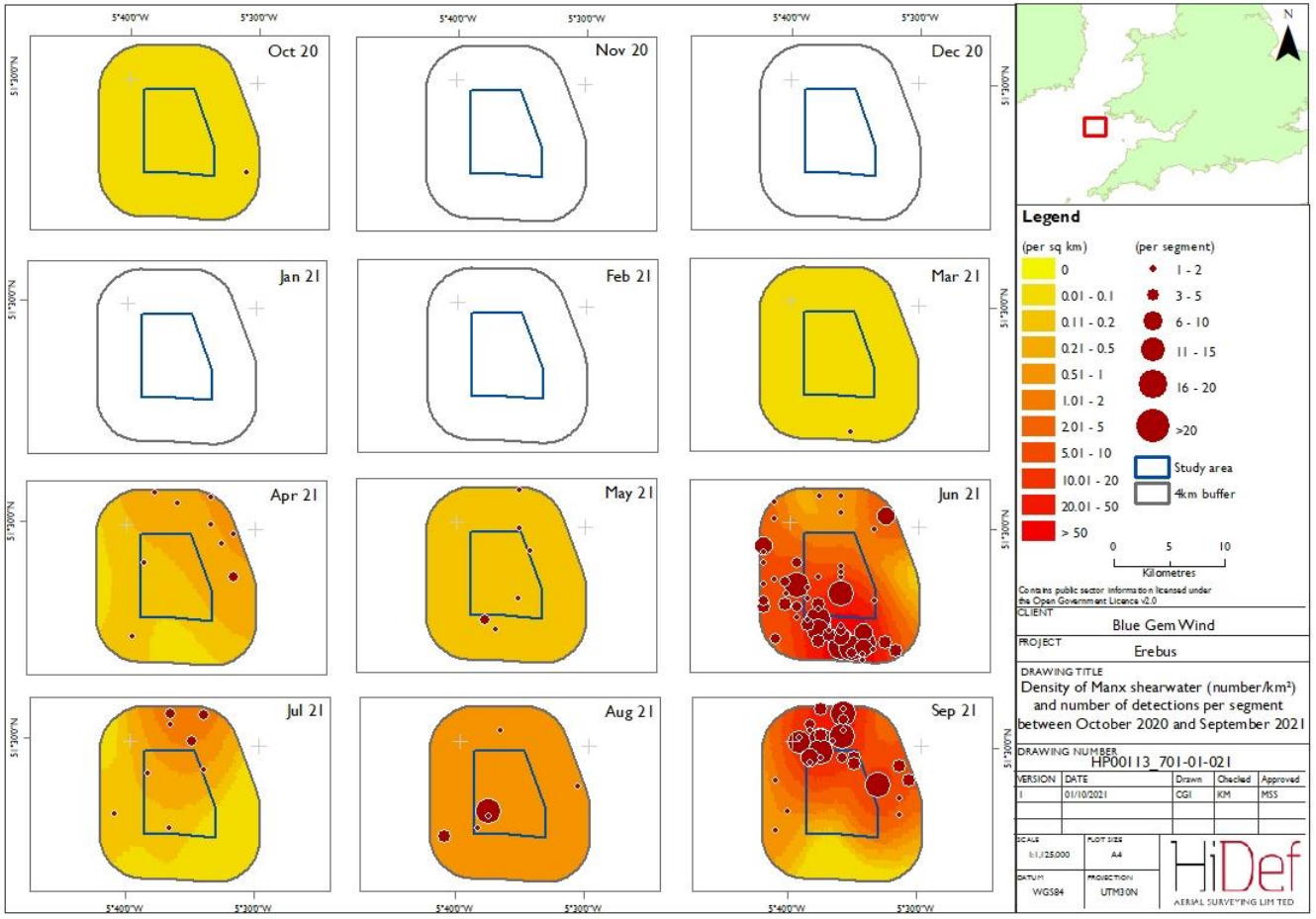


Figure 46 Density of Manx shearwaters (number/km²) and number of detections per segment between October 2020 and September 2021



3.3.10 Gannet

108 Gannets were recorded during the study in great numbers between March and October for both 2020 and 2021, with very low numbers during the winter (Table 30; Figure 47). Similar numbers of gannets were observed between the Year 1 and Year 2, although numbers of birds varied between the two breeding seasons covered during the survey period.

109 Despite consistently higher records within the breeding seasons, highest numbers of gannets were recorded on the October 2019, September 2021 and July 2020 surveys, equating to abundance estimates for the survey area of 559 birds (±95% CI 202– 988), 550 birds (±95% CI 146 – 1,068) and 499 birds (±95% CI 260 – 784) respectively (Figure 48).

110 Consequently, gannet distribution varied between months, with some selection towards the west of the region observed, such as in October 2019 and July 2020, although the majority of the birds present were widespread throughout the survey period (Figure 50 to Figure 51).

111 Of the birds that could be aged, the majority (99%) were recorded as adults, with six immature and one juvenile bird observed across the survey period (Table 31). As expected, the proportion of younger birds increased during the summer breeding season. A large proportion of gannets were recorded as flying during the surveys (62%; Table 32) and five birds were recorded taking off.

112 Many gannets flew in southwest directions, such as in August 2020 and September 2021, however birds were also observed flying towards northern directions, such as in June 2020 and 2021 (Figure 49).

Table 30 Number of gannets recorded to species level between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Gannet	142	119	8	1	6	23	22	38	86	141	87	22	695
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Gannet	104	1	8	0	39	65	48	43	56	41	56	140	601

Figure 47 **Number of gannets recorded to species level between October 2019 and September 2021**

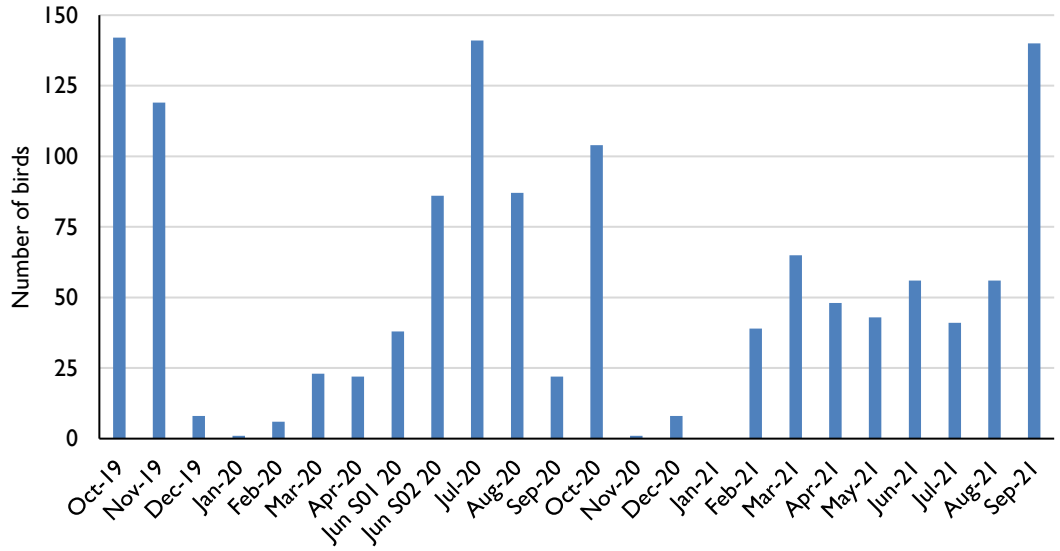


Figure 48 **Gannet population estimates with lower and upper 95% confidence intervals between October 2019 and September 2021**

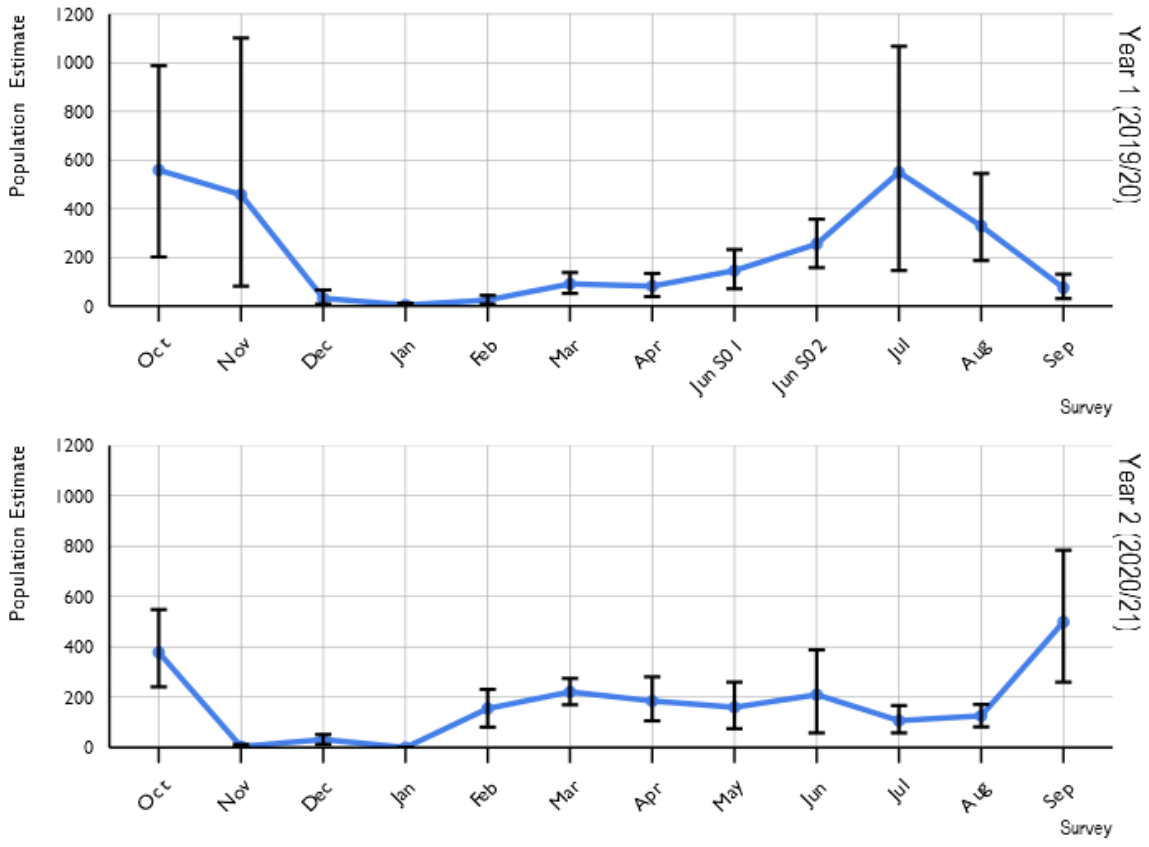


Table 31 Summary of gannet ages between October 2019 and September 2021

Survey date	Number recorded as adult	Number recorded as immature	Number recorded as juvenile	Number recorded as unknown	% adult (from aged birds)	Total
Oct-19	46	2	0	94	96%	142
Nov-19	14	0	0	105	100%	119
Dec-19	5	0	0	3	100%	8
Jan-20	1	0	0	0	100%	1
Feb-20	4	0	0	2	100%	6
Mar-20	21	0	0	2	100%	23
Apr-20	19	0	0	3	100%	22
Jun S01 20	28	0	0	10	100%	38
Jun S02 20	83	2	0	1	98%	86
Jul-20	58	1	0	82	98%	141
Aug-20	78	0	1	8	99%	87
Sep-20	20	0	0	2	100%	22
Oct-20	36	0	0	68	100%	104
Nov-20	1	0	0	0	100%	1
Dec-20	1	0	0	7	100%	8
Jan-21	0	0	0	0	–	0
Feb-21	37	0	0	2	100%	39
Mar-21	52	0	0	13	100%	65
Apr-21	46	0	0	2	100%	48
May-21	41	0	0	2	100%	43
Jun-21	52	1	0	3	98%	56
Jul-21	34	0	0	7	100%	41
Aug-21	55	0	0	1	100%	56
Sep-21	81	0	0	59	100%	140
Total	**813**	**6**	**1**	**476**	**99%**	**1296**

Table 32 Summary of gannet behaviours (for birds in which behaviour could be determined) between October 2019 and September 2021

Survey date	Number recorded diving	Number recorded flying	Number recorded sitting	Number recorded taking off	% Flying	Total
Oct-19	0	14	128	0	10	142
Nov-19	0	14	105	0	12	119
Dec-19	0	5	3	0	62	8
Jan-20	0	1	0	0	100	1
Feb-20	0	6	0	0	100	6
Mar-20	0	21	2	0	91	23
Apr-20	0	19	3	0	86	22
Jun S01 20	0	34	4	0	89	38
Jun S02 20	0	85	1	0	99	86
Jul-20	0	59	82	0	42	141
Aug-20	0	83	4	0	95	87
Sep-20	0	19	3	0	86	22
Oct-20	0	37	66	1	36	104
Nov-20	0	1	0	0	100	1
Dec-20	0	1	7	0	12	8
Jan-21	0	0	0	0	0	0
Feb-21	0	38	1	0	97	39
Mar-21	0	52	13	0	80	65
Apr-21	0	47	1	0	98	48
May-21	0	41	2	0	95	43
Jun-21	0	52	3	1	93	56
Jul-21	0	34	7	0	83	41
Aug-21	0	55	1	0	98	56
Sep-21	0	80	57	3	57	140
Total	**0**	**798**	**493**	**5**	**62%**	**1296**

Figure 49 **Summarised direction of flying gannets between October 2019 and September 2021**

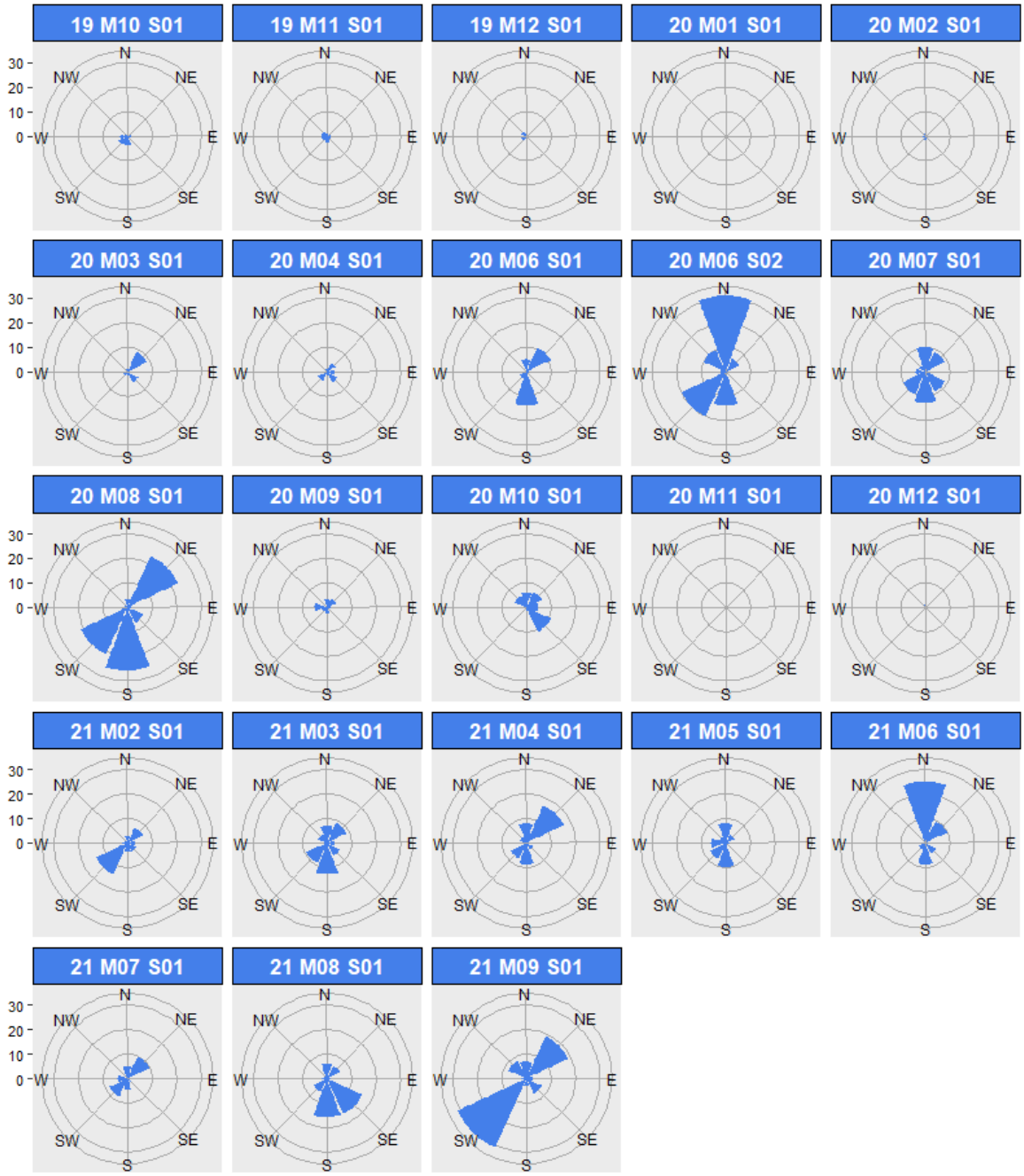


Figure 50 Density of gannets (number/km²) and number of detections per segment between October 2019 and September 2020

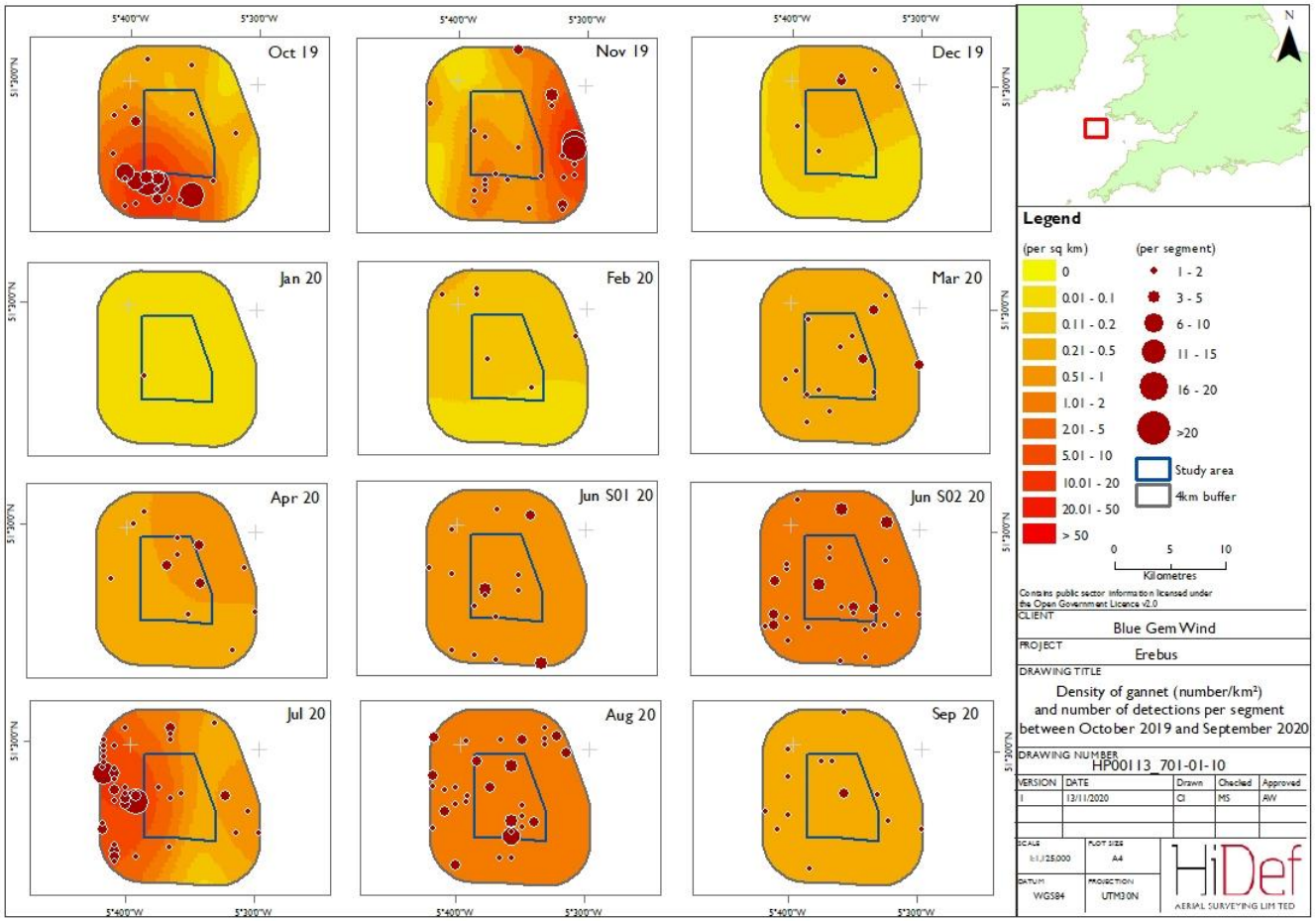
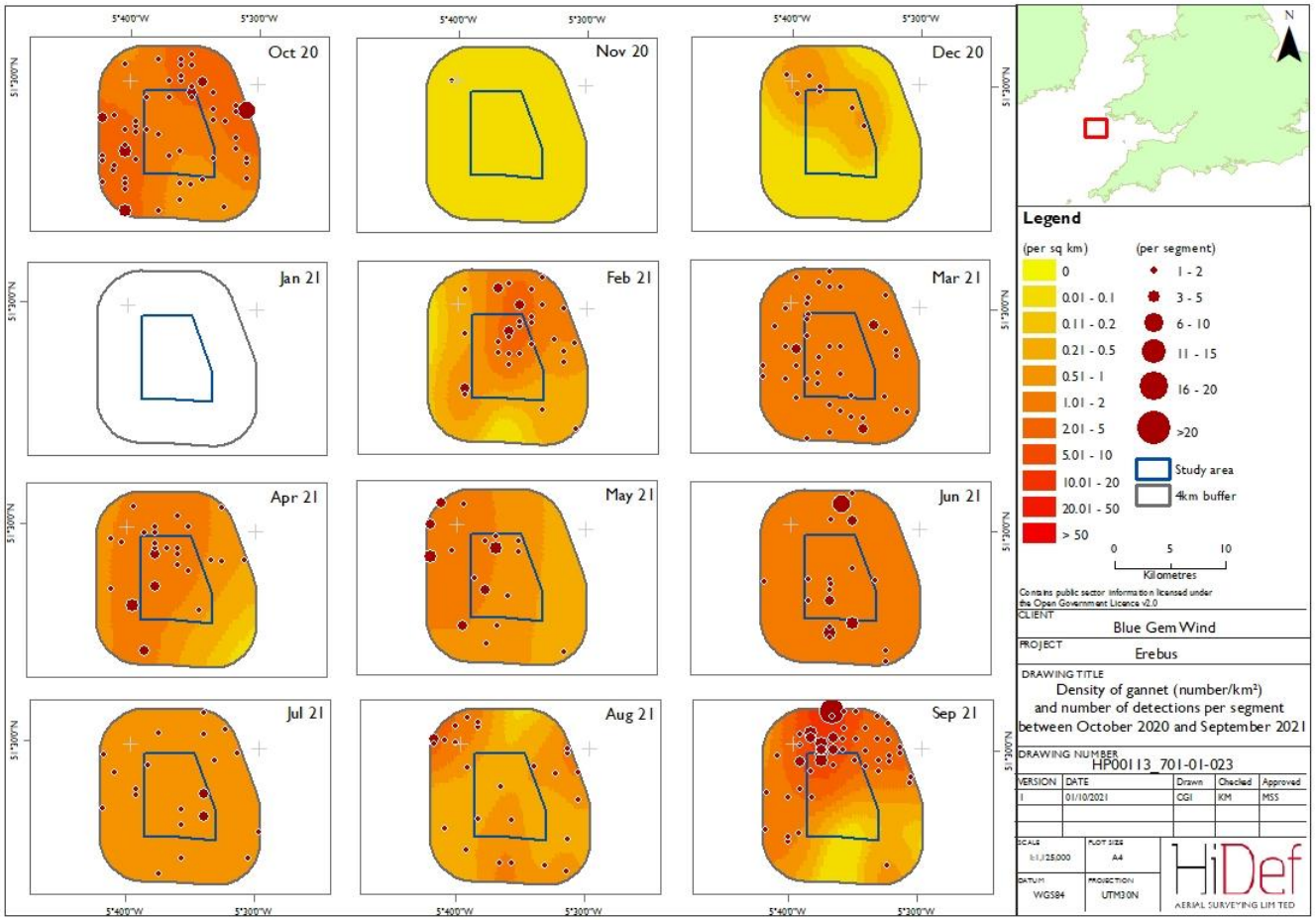


Figure 51 Density of gannets (number/km²) and number of detections per segment between October 2020 and September 2021



3.3.11 Less abundant bird species

113 Less abundant species are classified based on their total number of appearances throughout the survey period. Generally, a bird species is said to be less abundant when less than 100 observations are made.

114 Less abundant species were recorded sporadically with twice as many birds observed during the Year 2 compared to the Year 1 (Table 33; Figure 52; Figure 53). The list of less abundant species for this survey period includes: Sabine's gull (*Xema sabini*), black-headed gull (*Chroicocephalus ridibundus*), little gull (*Hydrocoloeus minutus*), common gull *(Larus canus*), herring gull (*Larus argentatus*), sandwich tern (*Thalasseus sandvicensis*), common tern (*Sterna hirundo*), Arctic tern (*Sterna paradisaea*), great skua (*Stercorarius skua*) and grey heron (*Ardea cinerea*). Density and abundance of the less abundant species can be found in Appendix I. Detections are shown in Figure 54Figure 54 to Figure 55.

115 In Year 1, most of the less abundant bird observations could be attributed to herring gulls, whose numbers peaked in December 2019. Also during December, common and black headed gulls were detected. In Year 2, herring gulls were also the most often detected species of the less abundant bird category, particularly during February 2021.

116 Terns were more common in Year 2 than Year 1. A single sandwich tern was detected in September 2020 and none were detected in Year 2. The Arctic term was detected in Year 2 during May, June and August whilst none were detected in Year 1.

Table 33 Number of less abundant bird species recorded between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Less abundant birds	2	9	15	0	3	4	0	0	1	6	0	2	42
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Less abundant birds	4	7	0	1	55	0	0	4	2	2	4	2	81

Figure 52 **Number of less abundant bird species observed between October 2019 and September 2020**

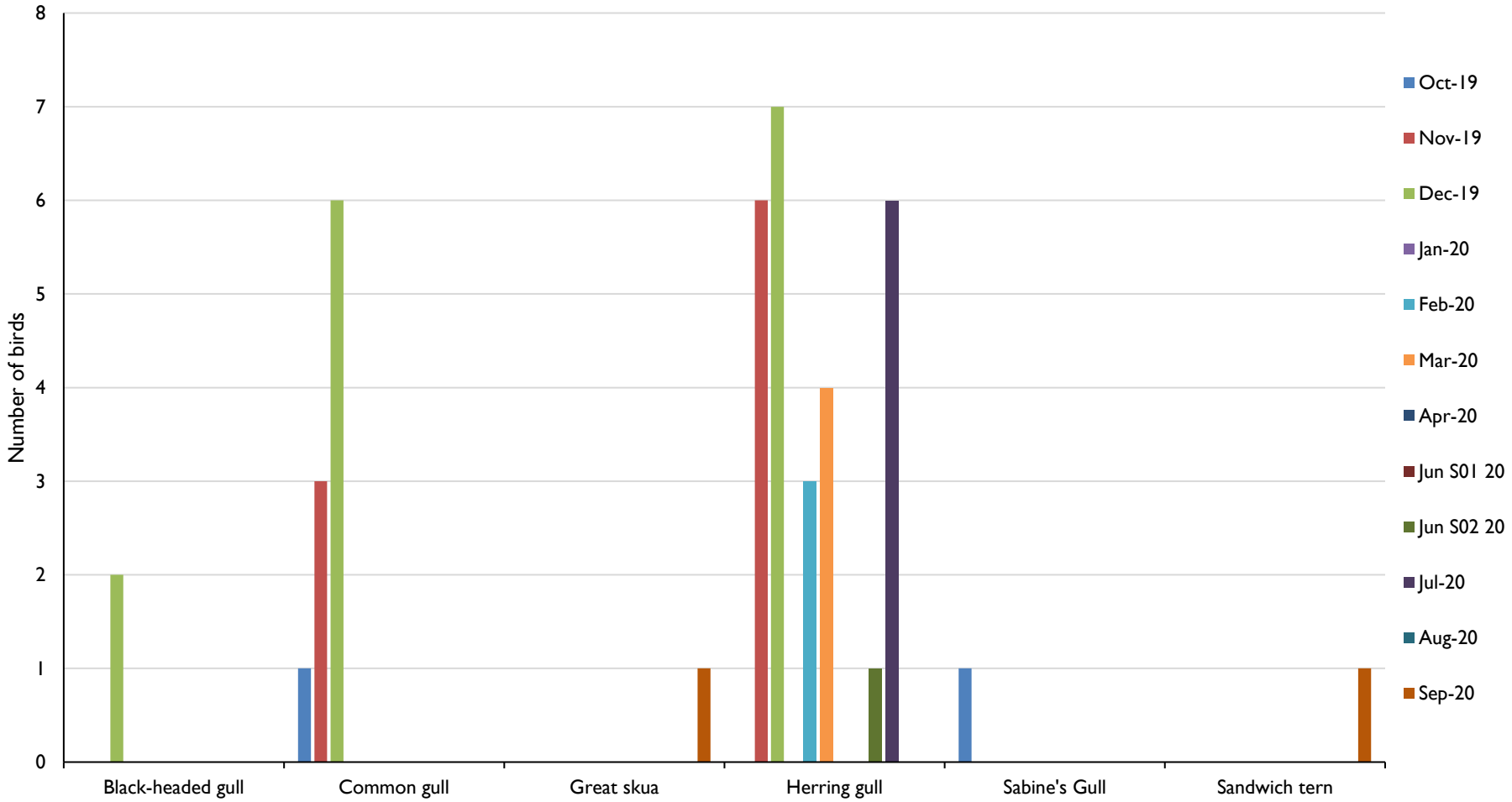


Figure 53 Number of less abundant bird species observed between October 2020 and September 2021

Note: 50 herring gulls in February 2021

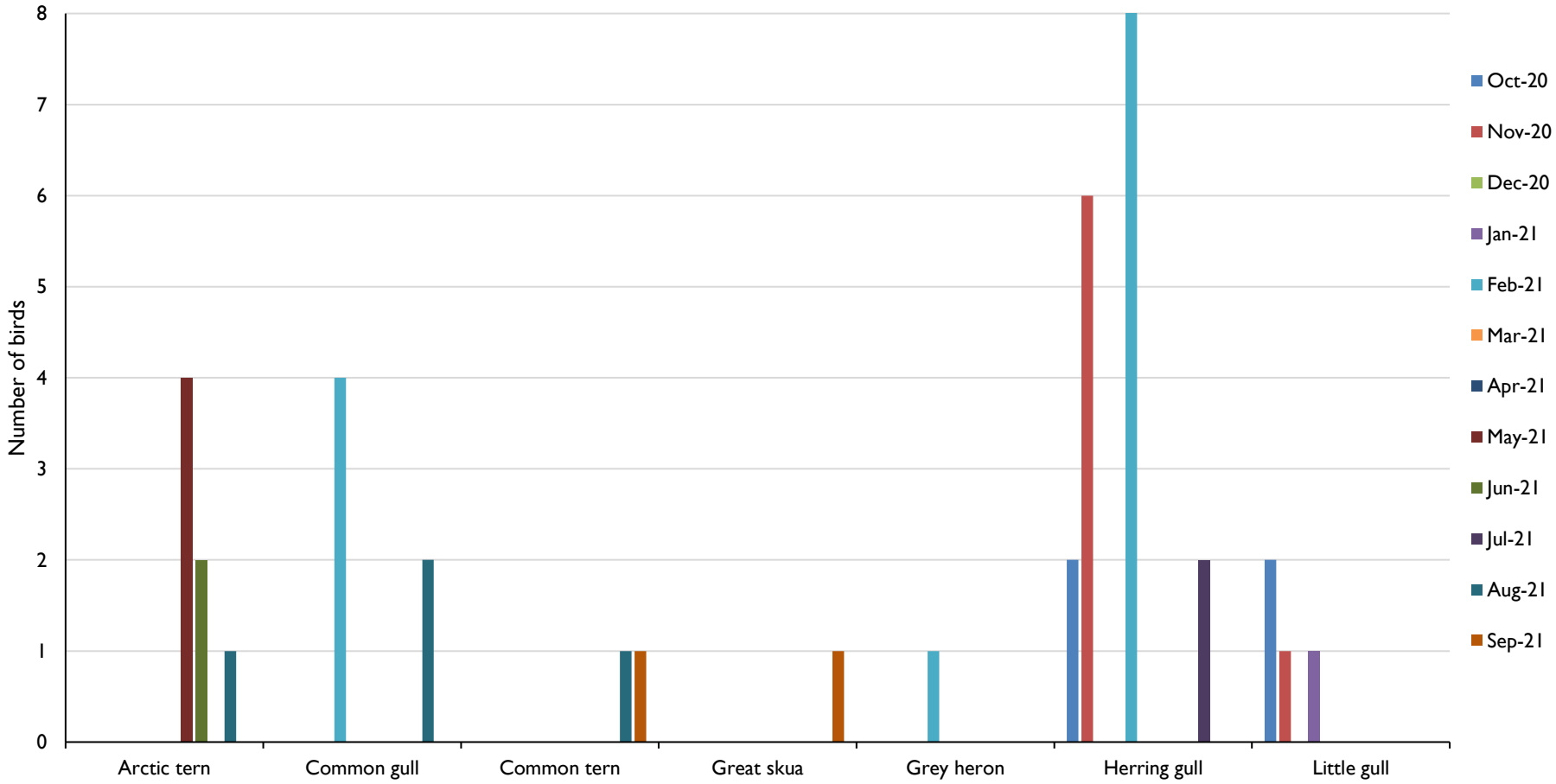


Figure 54 Observations of less abundant bird species between October 2019 and September 2020

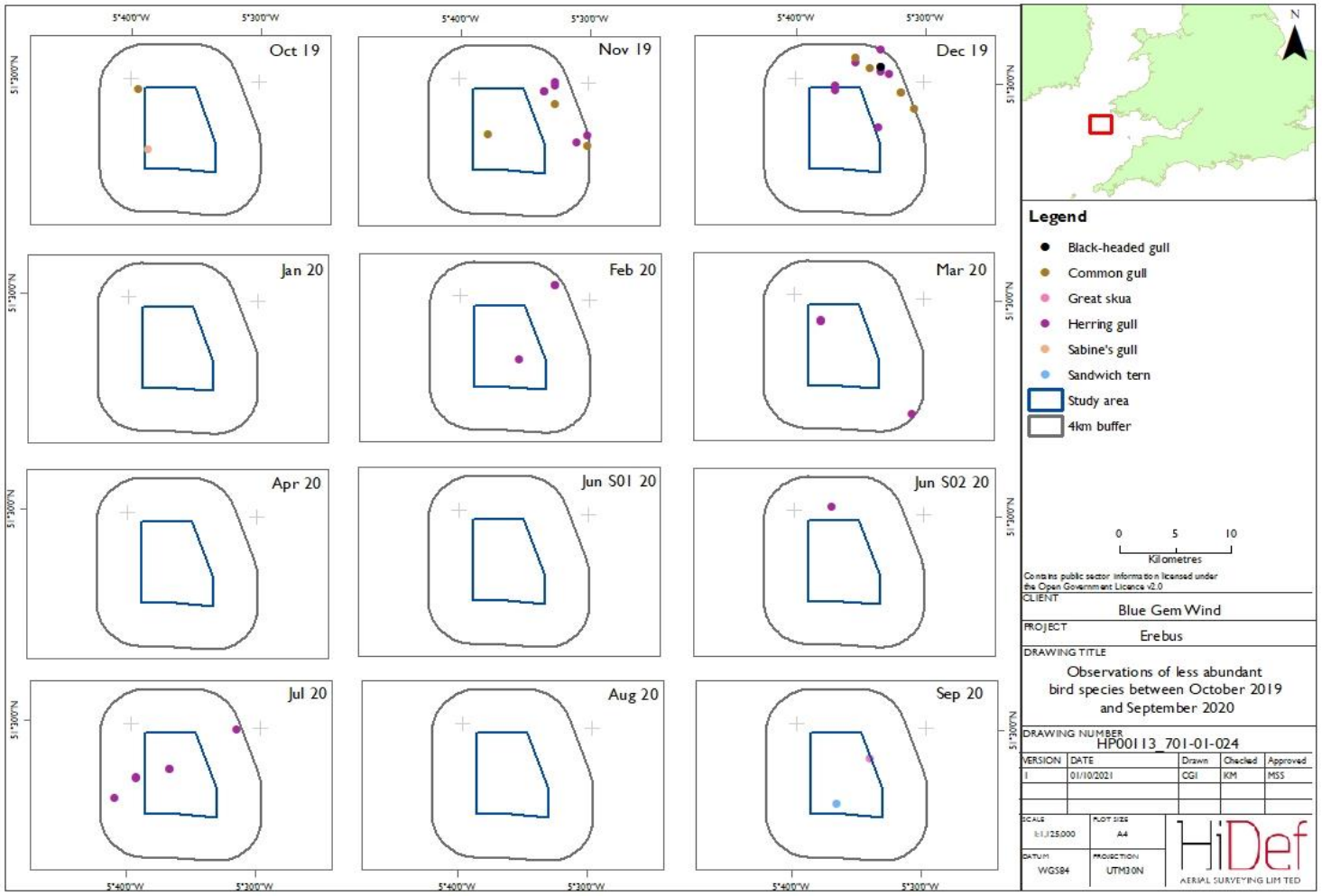


Figure 55 Observations of less abundant bird species between October 2020 and September 2021

3.3.12 Unidentified birds

117 The number of unidentified birds observed (those assigned to species group but not species) are presented in Table 34; Figure 56 and Figure 57.

118 Unidentified birds were assigned to a species group based on how well any identification features present could distinguish them from similar species. Identification features can sometimes be obscured, often when the bird is sitting or diving, for example by waves, body positioning or other environmental factors.

119 The small, dark appearance of auks can make them hard to differentiate in certain lights. Birds that could only be either of the two large auk species (razorbill and guillemot) based on size were classed as 'large auks'. Where size was not measurable, for example due to a bird diving, then a smaller species such as puffin could not be entirely ruled out. In this case, the bird was assigned to a wider group; 'auk species'. Sometimes obscured images of birds may make it hard to rule out the possibility of unrelated species. In this case, a bird was instead assigned to a mixed group e.g., 'auk / shearwater species'.

120 Similar methods were used for other species groups. 'Small gull species' would encompass the possibility of anything smaller than a kittiwake in size, whilst 'large gull species' would encompass herring gulls, lesser black-backed gulls and great black-backed gulls. If there is any uncertainty between the two, then the bird was assigned to the wider 'gull species' group.

121 High numbers of unidentified birds were primarily due to difficulties differentiating between razorbill and guillemot. These are especially problematic to identify in autumn when juvenile birds are more abundant, and further complicated with the presence of large numbers of Manx shearwater which can appear similar in shape and size. Distributions of unidentified birds across the Erebus survey area are displayed from Figure 58 to Figure 59.

Table 34 Number of unidentified birds recorded between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
No ID birds	269	52	62	21	13	6	23	7	74	38	158	74	797
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
No ID birds	183	46	53	74	43	220	22	30	40	4	3	11	729

Figure 56 Number of unidentified birds observed between October 2019 and September 2020

Note: 168 large auks in October 2019

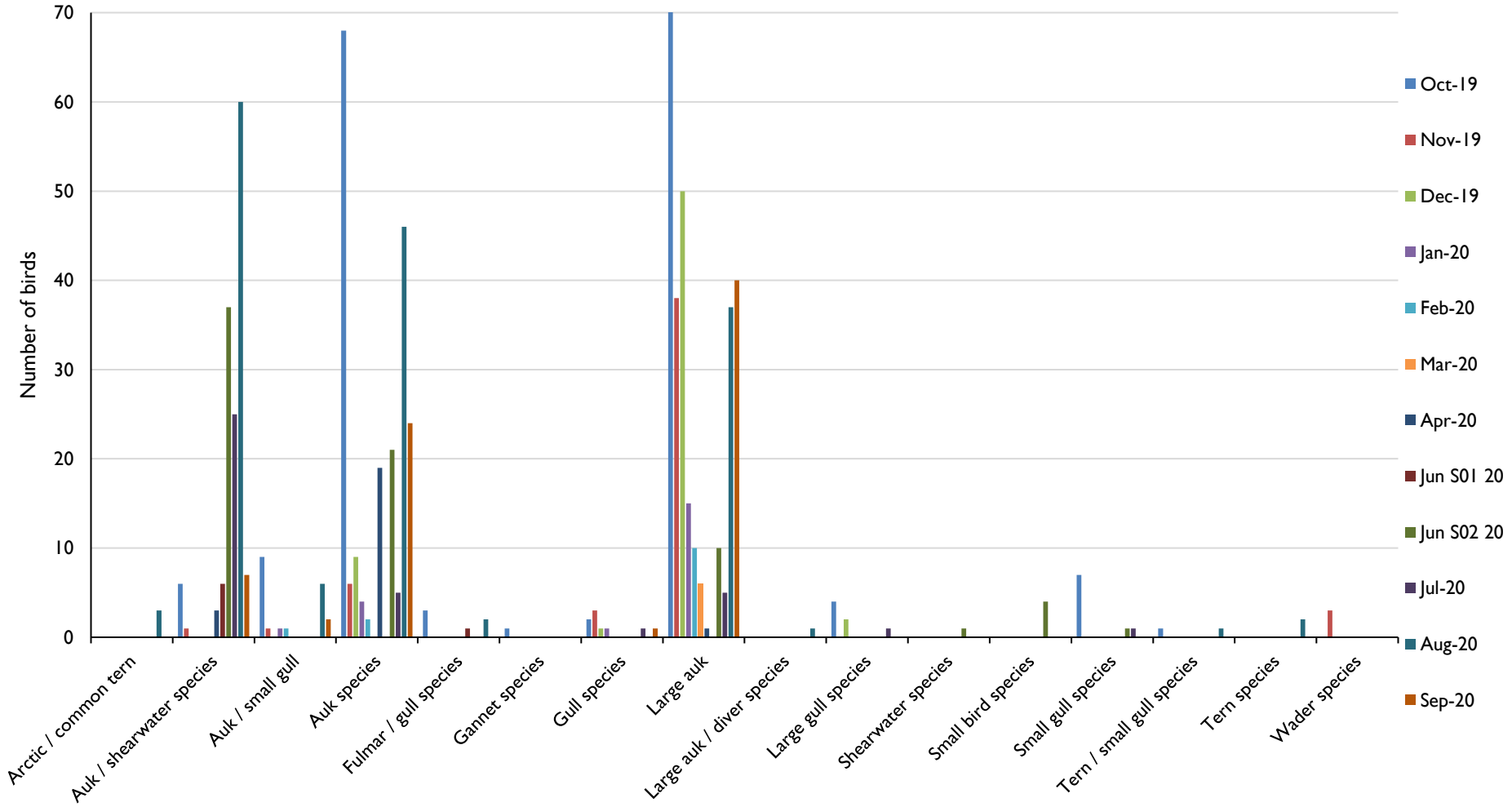


Figure 57 Number of unidentified birds observed between October 2020 and September 2021

Note: 86 and 185 large auks in October 2020 and March 2021 respectively

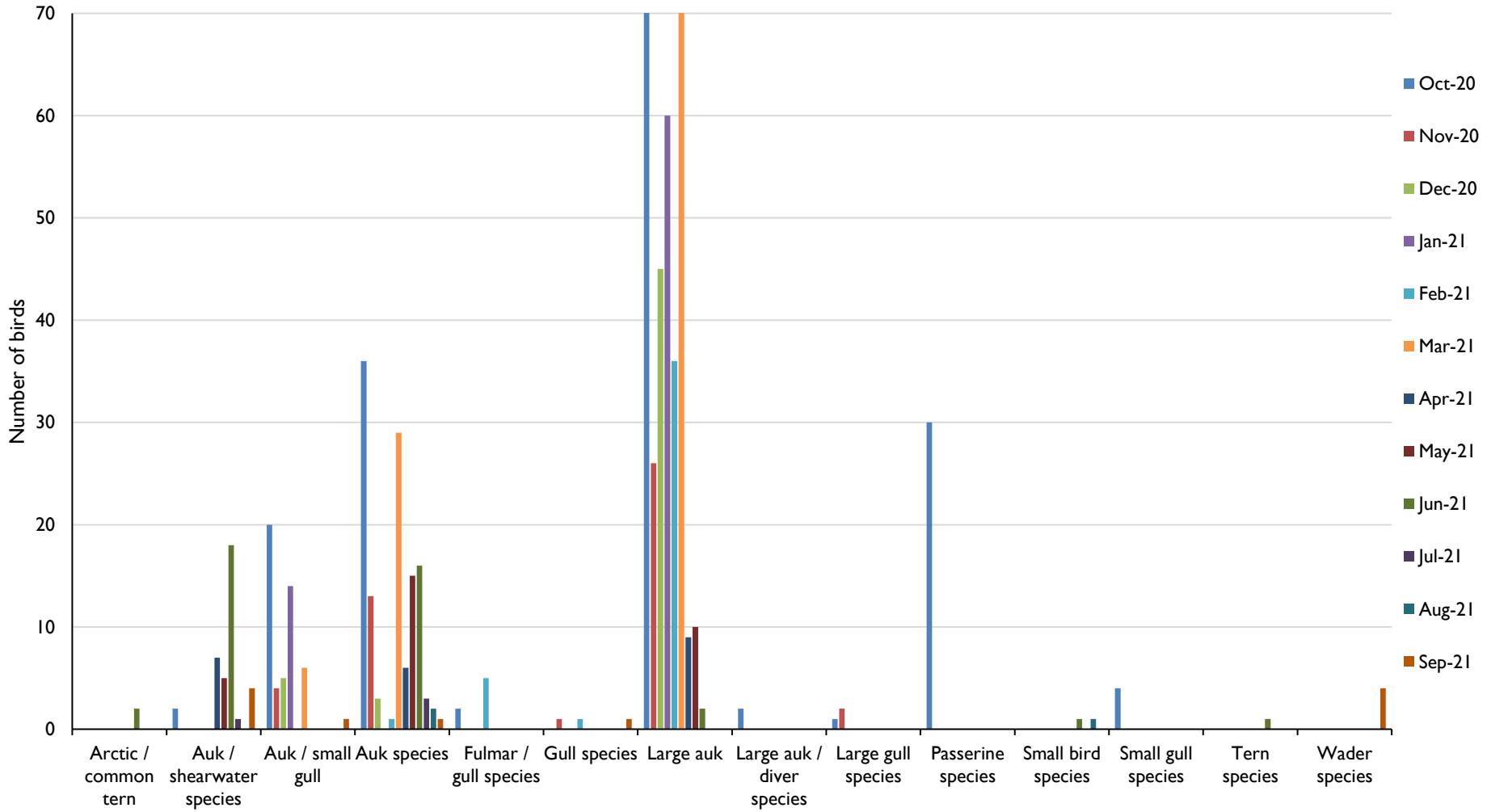


Figure 58 Observations of unidentified bird species between October 2019 and September 2020

Figure 59 Observations of unidentified bird species between October 2020 and September 2021

3.3.13 All non-avian animals

122 Non-avian animals were present throughout the survey period, with overall higher abundances during the summer (Table 35; Figure 60). The monthly density maps for all non-avian animals combined show widespread observations throughout the survey area, such as in June 2020, July 2020 and March 2021 (Figure 61 to Figure 62). In some months, such as June 2020, selection towards the north of the region was observed, while the south of the region was also utilised in October 2020.

123 A summary of surfacing behaviour for all non-avian animals is presented in Table 36. Over the entire study period 16% of non-avian animals were 'snapshot' surfacing.

Table 35 Number of non-avian animals recorded between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Non-avian animals	0	41	16	284	45	46	15	239	159	256	74	234	1375
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Non-avian animals	125	5	15	14	91	180	15	8	106	80	1	55	677

Figure 60 Number of non-avian animals recorded between October 2019 and September 2021

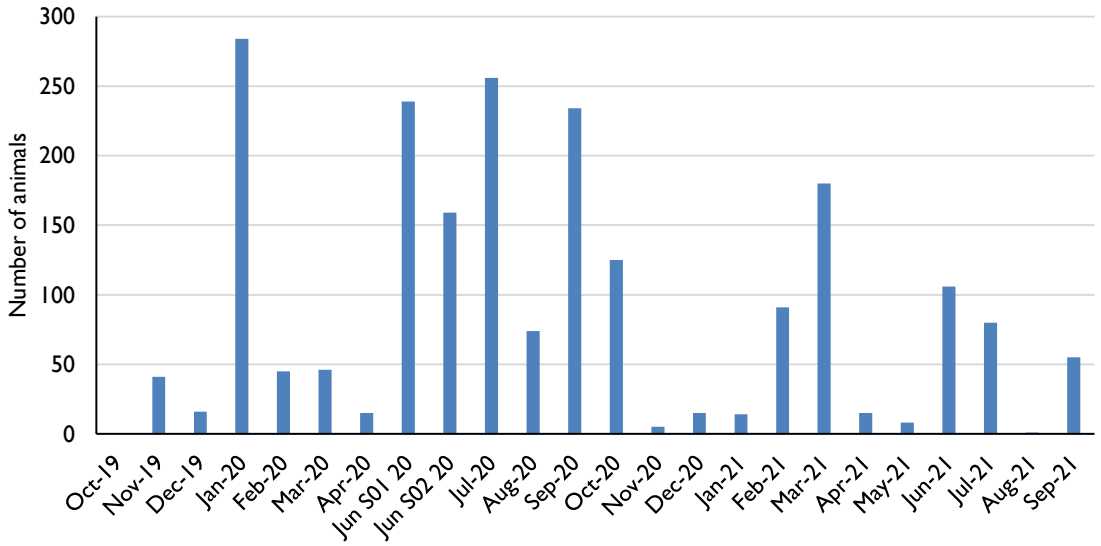


Table 36 Summary of surfacing behaviour for all non-avian animals between October 2019 and September 2021

Species	Submerged	Surfacing	Snapshot surfacing	Unknown	% Snapshot Surfacing	Total
Basking shark	13	0	0	0	0	13
Blue shark	2	0	0	0	0	2
Bluefin tuna	1	0	0	0	0	1
Bottlenose dolphin	7	0	1	0	13	8
Common dolphin	1398	170	310	51	16	1929
Grey seal	0	0	4	0	100	4
Harbour porpoise	46	6	23	8	28	83
Minke whale	3	0	0	0	0	3
Ocean sunfish	6	0	2	0	25	8
Risso's dolphin	0	0	1	0	100	1
Cetacean species	8	0	2	1	18	11
Dolphin species	33	1	0	1	0	35
Seal / small cetacean species	0	0	0	1	0	1
Seal species	1	2	1	1	20	5
Total	**1518**	**179**	**344**	**63**	**16**	**2104**

Figure 61 Density of all non-avian animals (number/km²) and number of detections per segment between October 2019 and September 2020

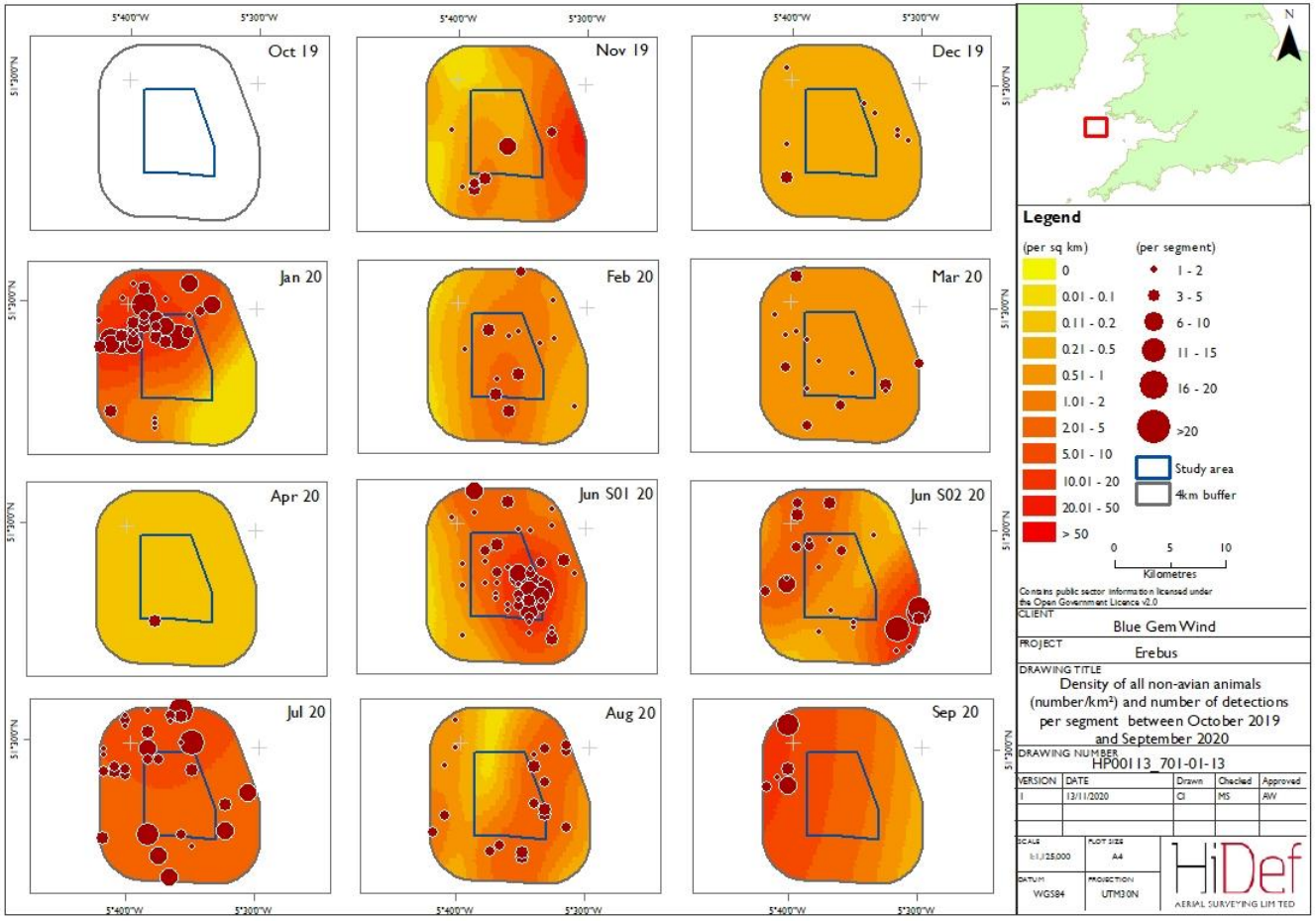
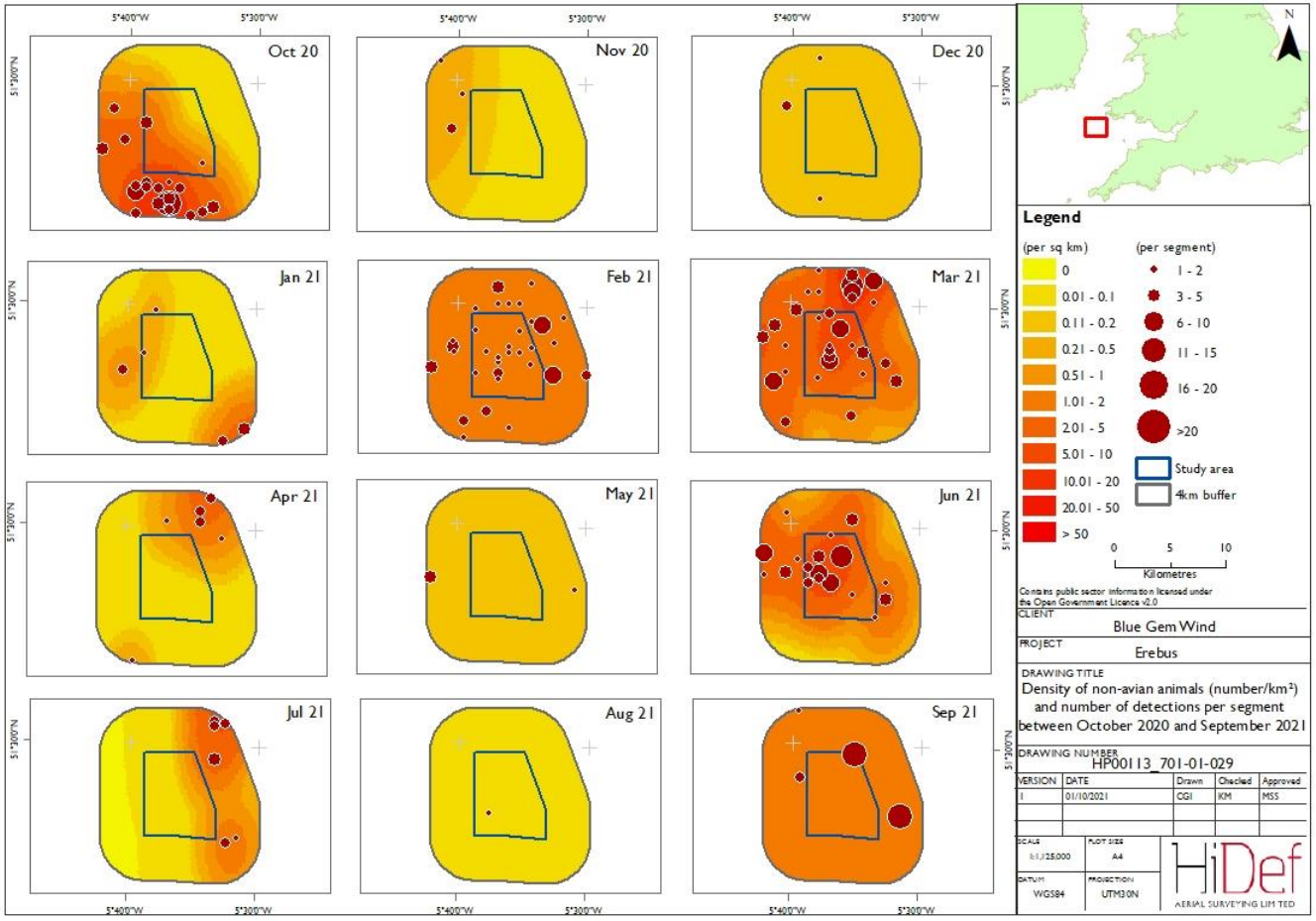


Figure 62 Density of all non-avian animals (number/km²) and number of detections per segment between October 2020 and September 2021



3.3.14 Common dolphin

124 Common dolphins were the most abundant marine mammal species observed throughout the study period, with notable peaks recorded in January 2020 and July 2020 (Table 37; Figure 63). Over twice as many common dolphins were observed in Year 1 compared to Year 2.

125 Densities of common dolphins fluctuated throughout the study period, ranging from 0.02 dolphins/km² in August 2021 to 5.41 dolphins/km² in January 2020, equating to 4 animals (±95% CI 0 – 12) and 1082 animals (±95% CI 678 – 1,493) respectively (Figure 64). Variation in abundance estimates between months makes it difficult to determine any seasonal patterns in distribution for the species.

126 The distribution of common dolphins varied throughout the survey area (Figure 65 to Figure 66), with higher densities observed in the north of the survey area in January 2020, while animals were widespread for the rest of the survey period. In some months, low numbers of common dolphins were recorded, leading to no clear patterns in distribution.

Table 37 Number of common dolphins recorded between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Common dolphin	0	40	11	275	36	24	15	226	142	251	68	232	1320
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Common dolphin	116	3	9	13	66	152	12	8	96	78	1	55	609

Figure 63 Number of common dolphins recorded between October 2019 and September 2021

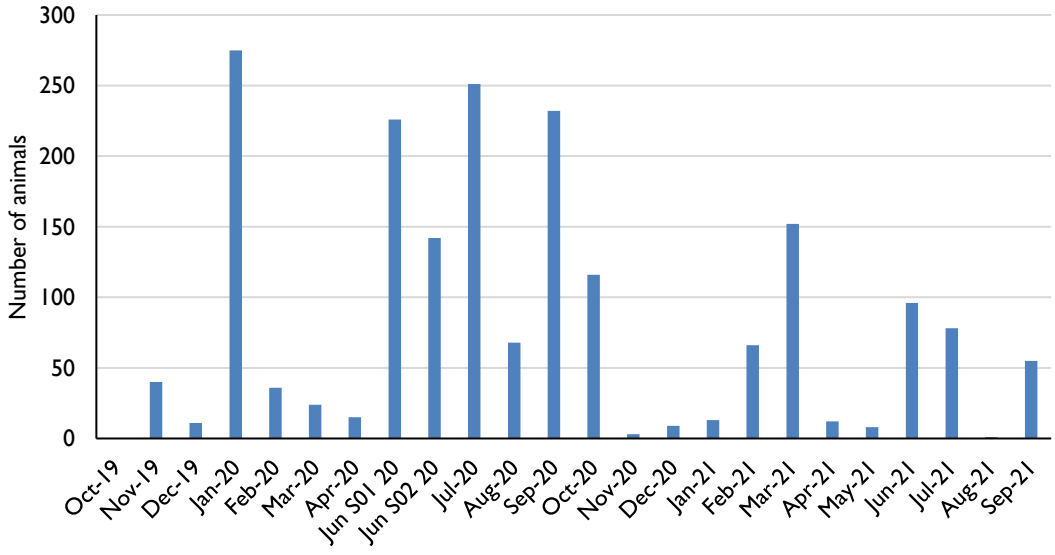


Figure 64 **Common dolphin population estimates with lower and upper 95% confidence intervals between October 2019 and September 2021**

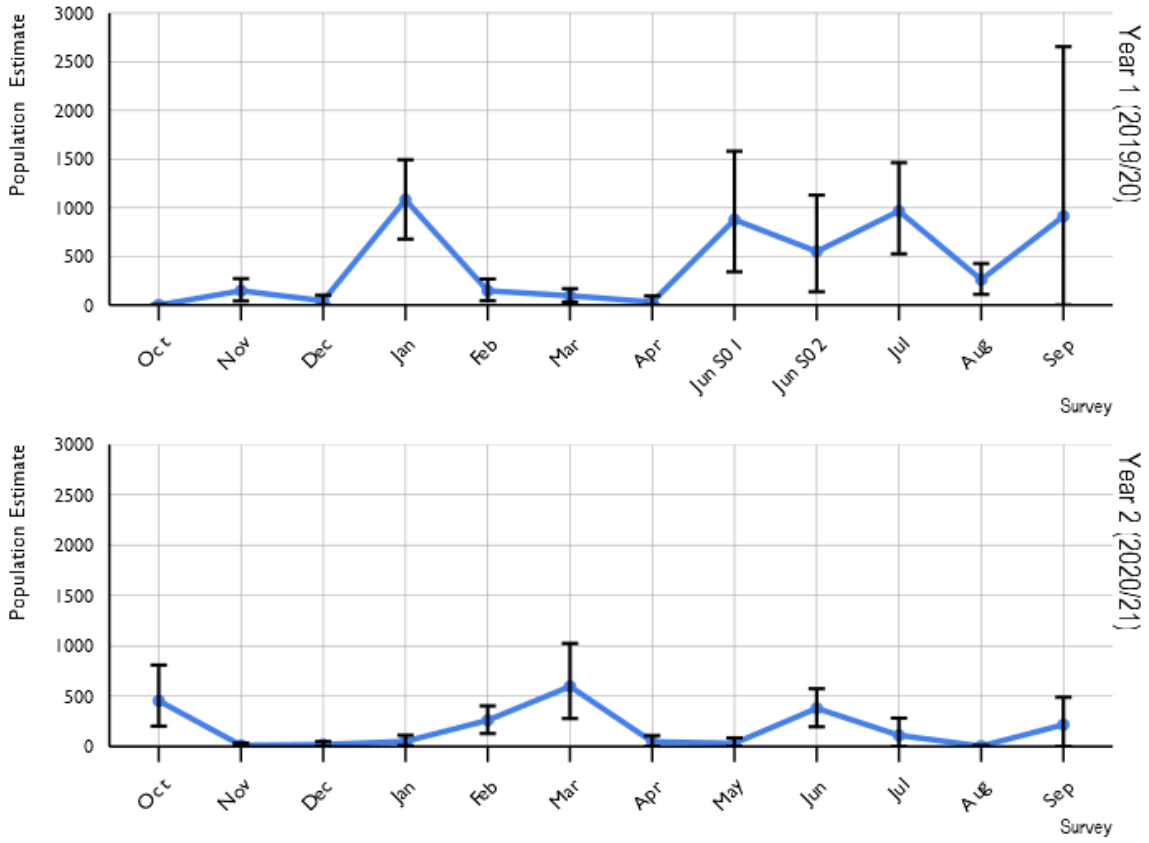


Figure 65 **Density of common dolphin (number/km²) and number of detections per segment between October 2019 and September 2020**

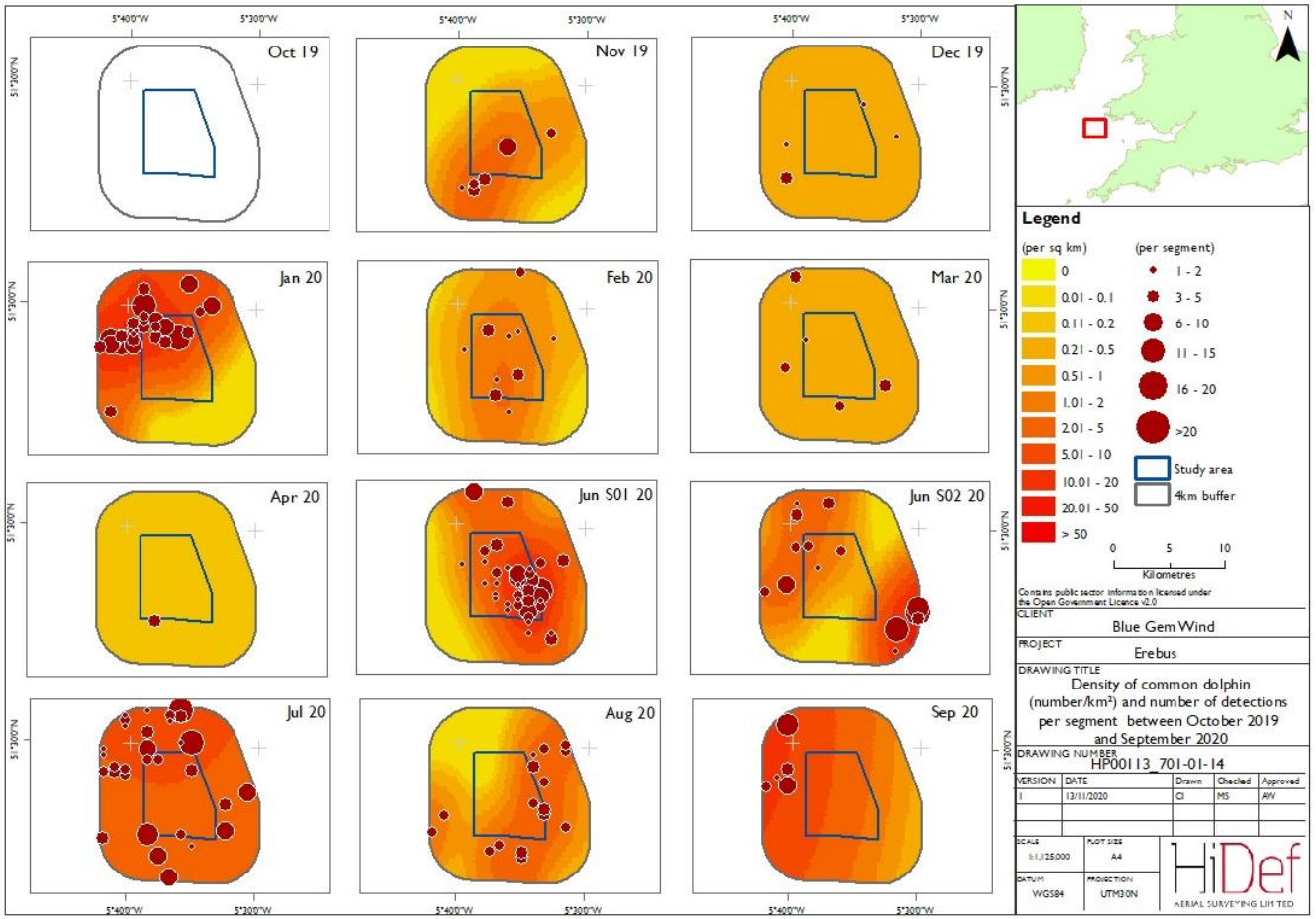
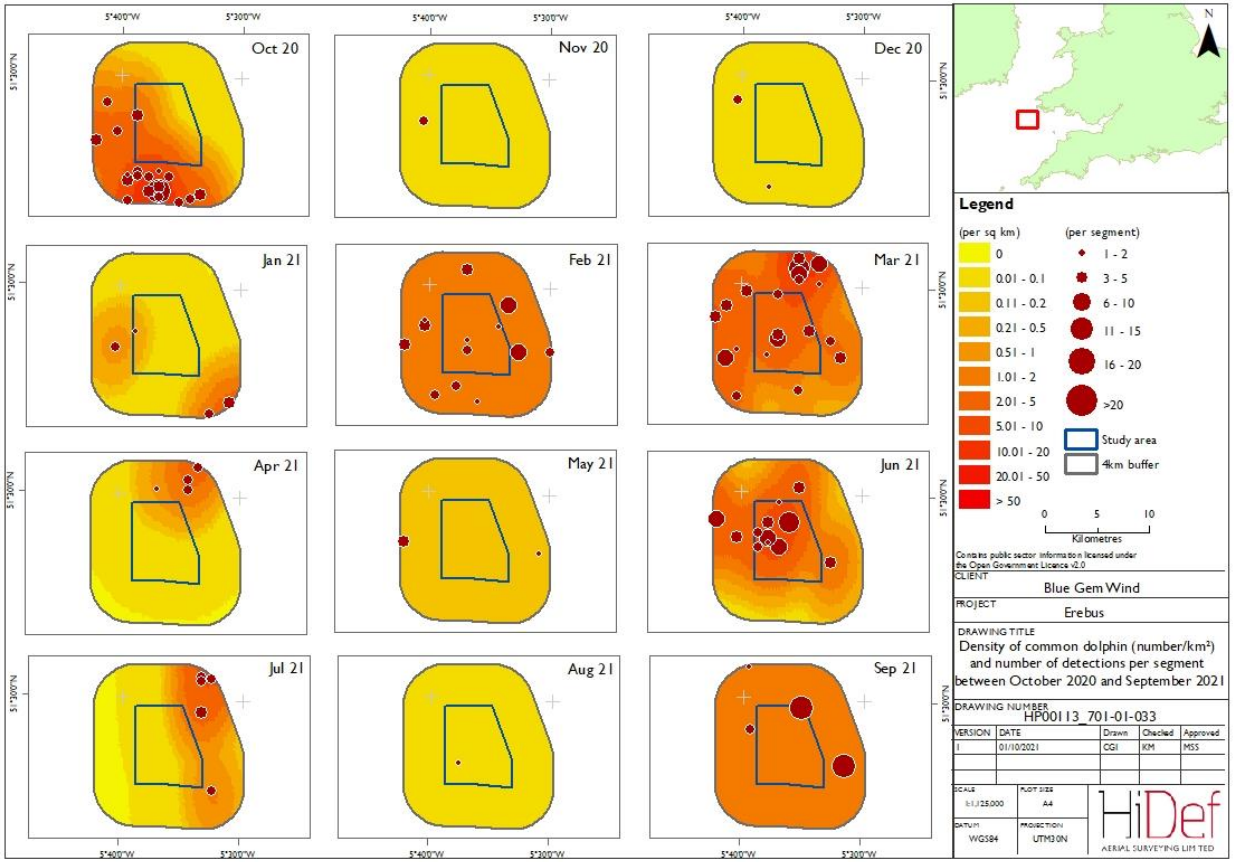


Figure 66 Density of common dolphin (number/km²) and number of detections per segment between October 2020 and September 2021



3.3.15 Harbour porpoise

127 Harbour porpoise were the second most abundant marine mammal species observed throughout the study period, with peaks recorded in February and March 2021 (Table 38; Figure 67). Harbour porpoises were mostly observed during late winter/ spring period. Approximately three times more harbour porpoise were observed in Year 2 compared to Year 1.

128 Harbour porpoise were absent in a total of 13 surveys. However, for months when animals were observed, and when correcting for individuals likely to be submerged at the time of the survey (availability bias section 2.6.3), abundances ranged between 8 animals (±95% CI 0 – 24) in June 2020 and 243 animals (±95% CI 131– 360) in February 2021 (Figure 68).

129 The distribution of harbour porpoises varied throughout the survey area (Figure 69 to Figure 70), with animals observed in the north of the survey area in January and March 2020, and February and March 2021. In the rest of the survey months, low numbers of harbour porpoises were recorded, leading to no clear patterns in distribution.

Table 38 Number of harbour porpoise recorded between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Harbour porpoise	0	0	1	8	0	8	0	1	0	0	4	0	22
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Harbour porpoise	8	0	2	0	23	24	2	0	2	0	0	0	61

Figure 67 Number of harbour porpoise recorded between October 2019 and September 2021

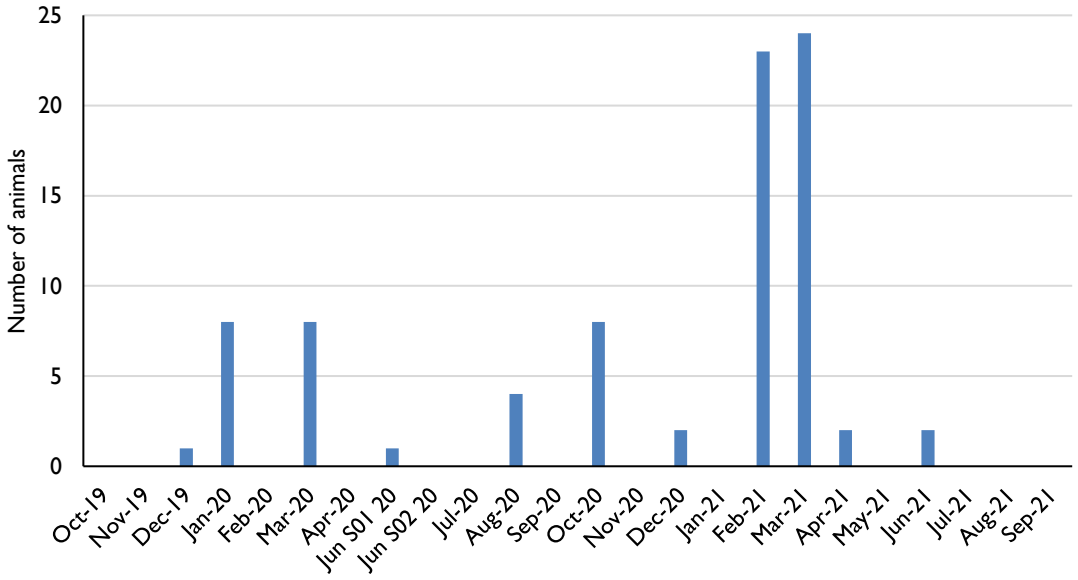


Figure 68 **Adjusted (absolute) harbour porpoise population estimates with lower and upper 95% confidence intervals between October 2019 and September 2021**

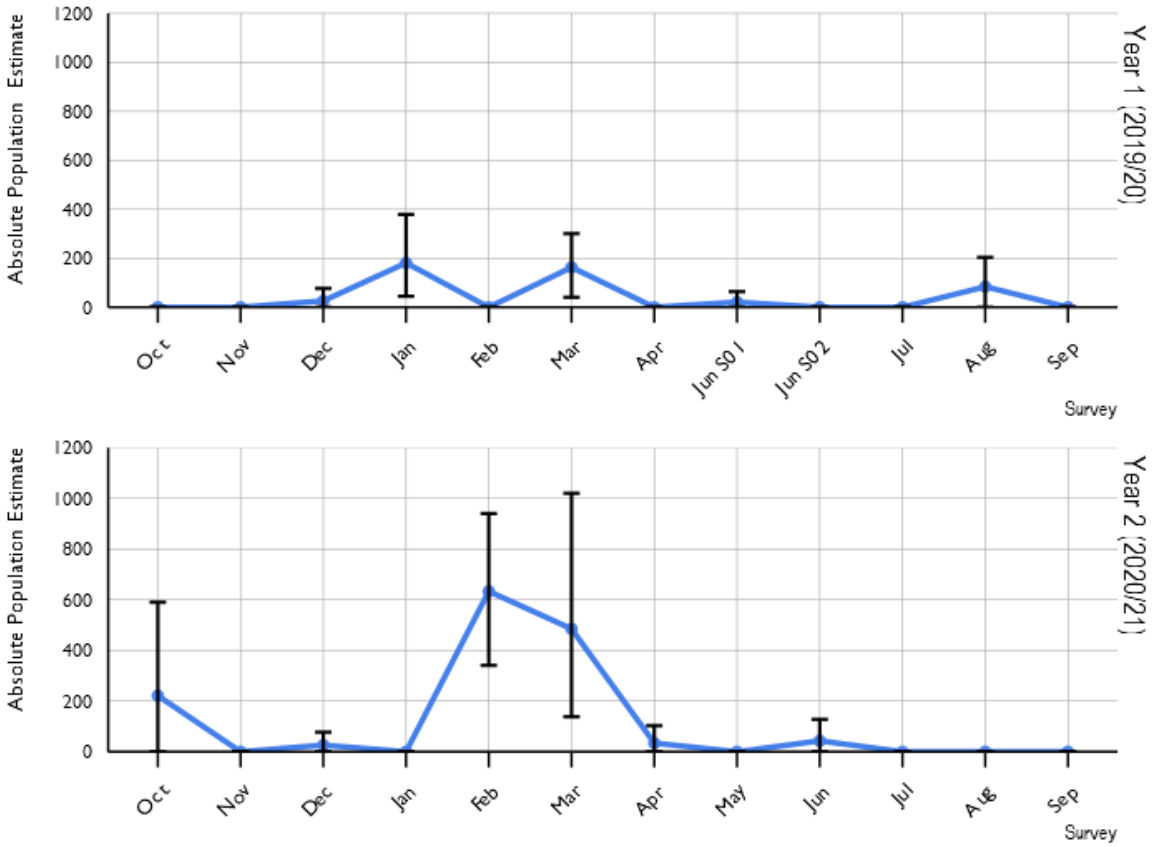


Figure 69 **Relative density of harbour porpoises (number/km²) and number of detections per segment area between October 2019 and September 2020**

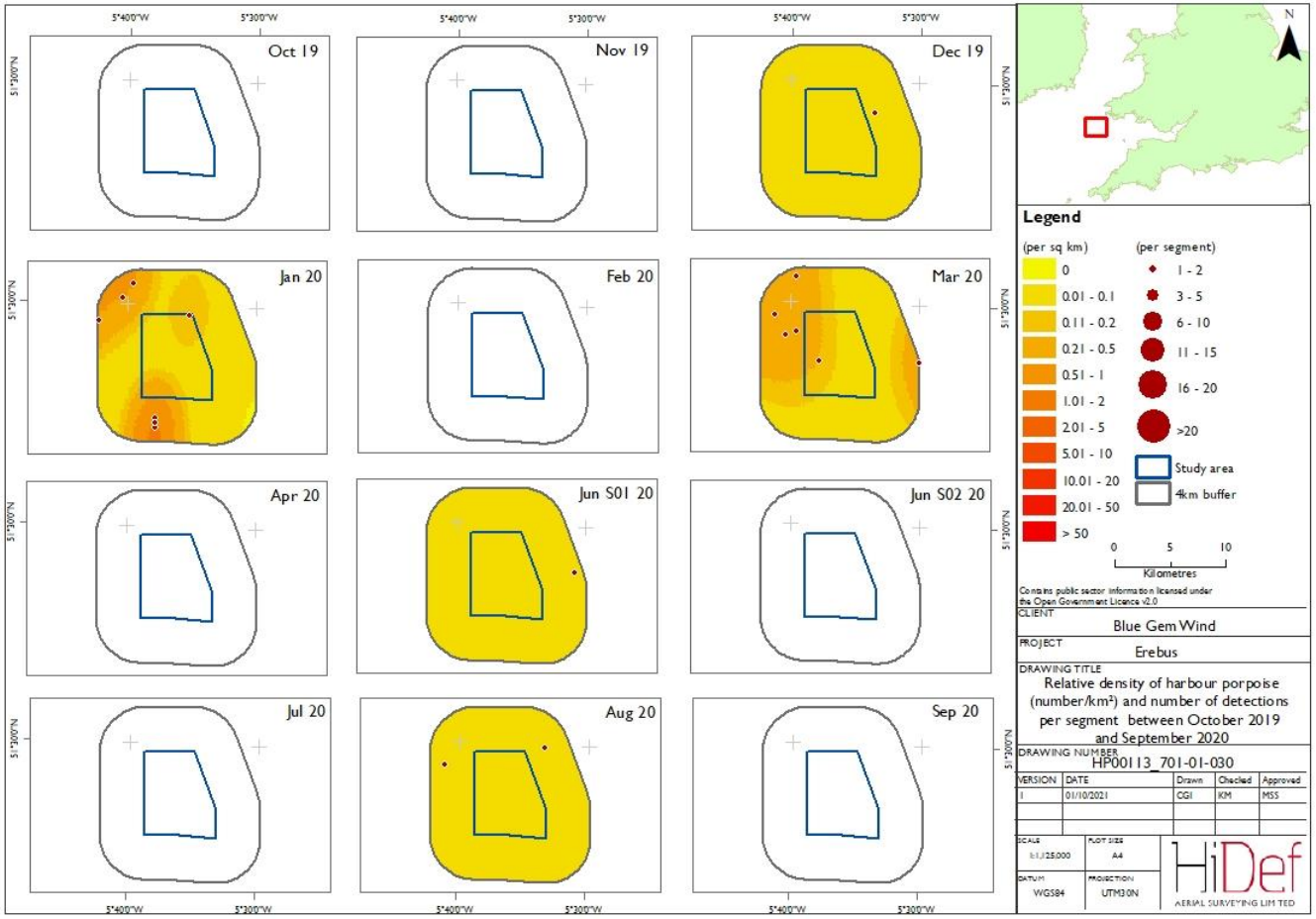
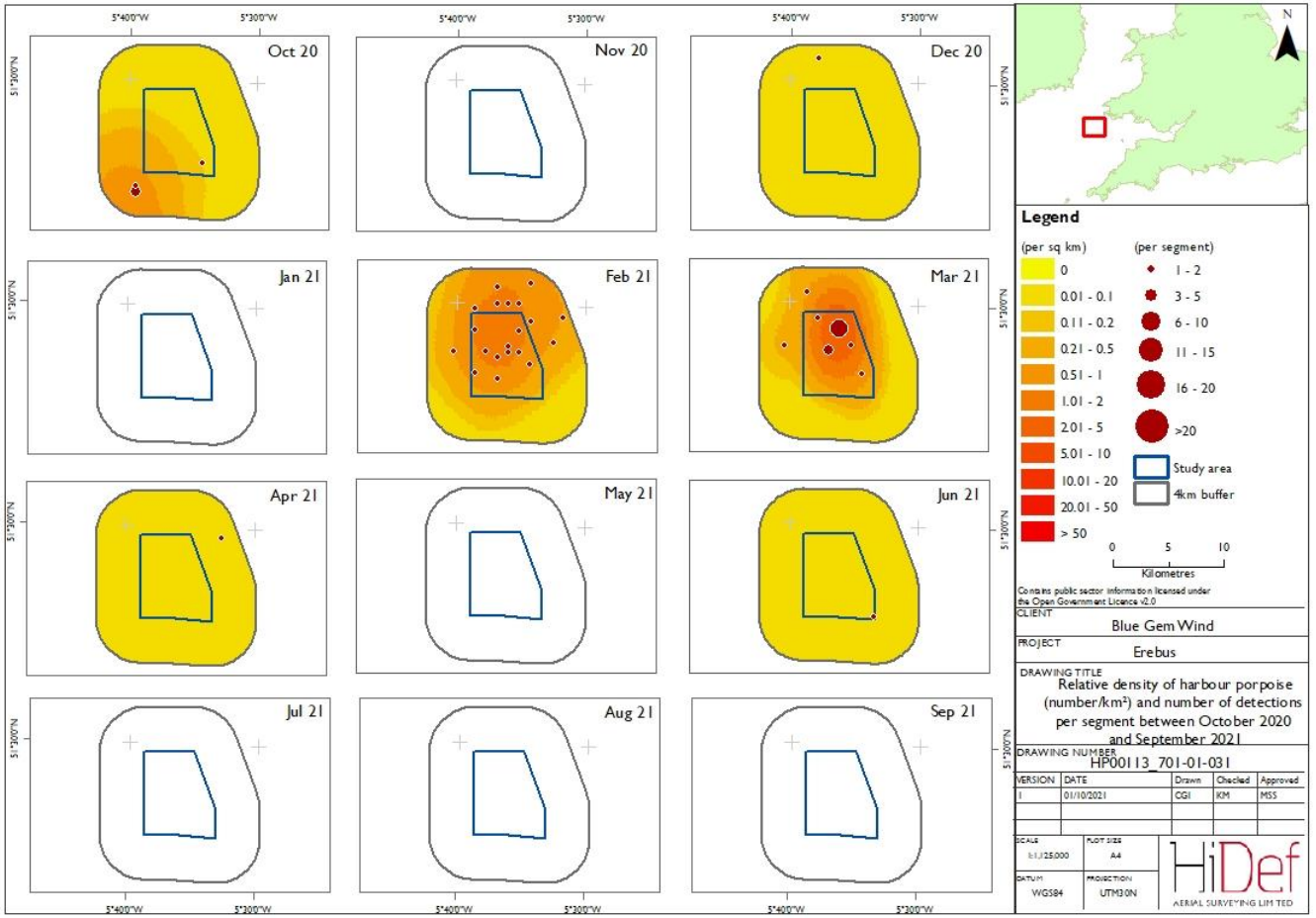


Figure 70 **Relative density of harbour porpoises (number/km²) and number of detections per segment between October 2020 and September 2021**



3.3.16 Less abundant non-avian animal species

130 Several other non-avian animal species were recorded during the project (Table 39; Figure 71 and Figure 72), the distributions of which can be found in (Figure 73 and Figure 74). Basking shark were the most numerous, with a number of other mammalian species recorded in individual detections including bottlenose dolphin, Risso's dolphin and minke whale.

Table 39 Number of less abundant non-avian animals recorded between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Less abundant non-avian animals	0	1	2	0	0	6	0	10	12	0	2	0	33
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Less abundant non-avian animals	0	0	0	0	1	2	0	0	4	0	0	0	7

Figure 71 **Number of less abundant non-avian animals recorded between October 2019 and September 2020**

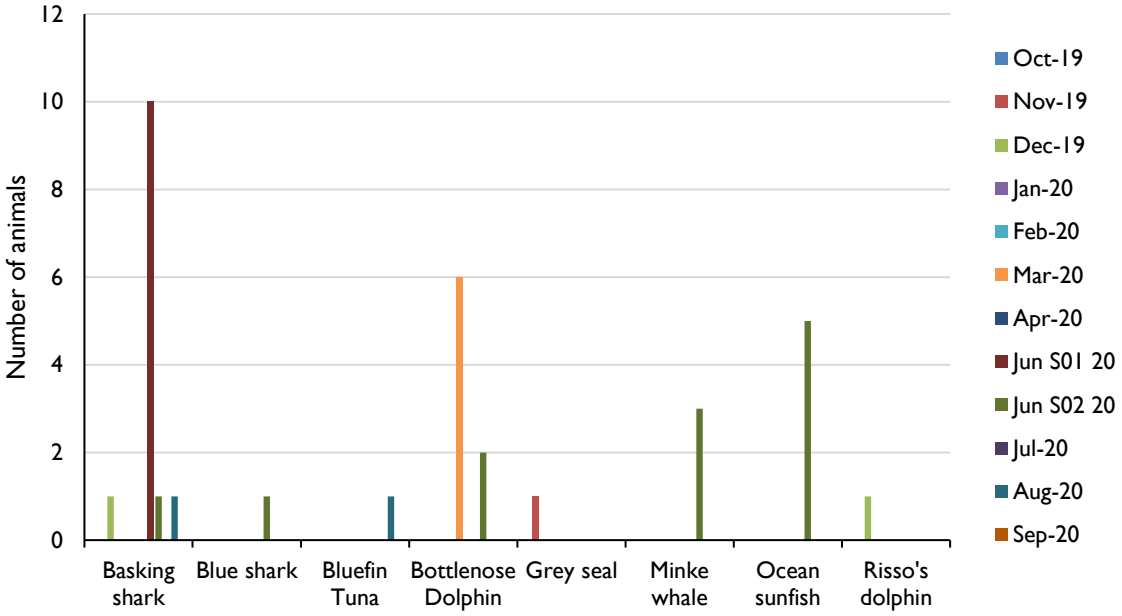


Figure 72 **Number of less abundant non-avian animals recorded between October 2020 and September 2021**

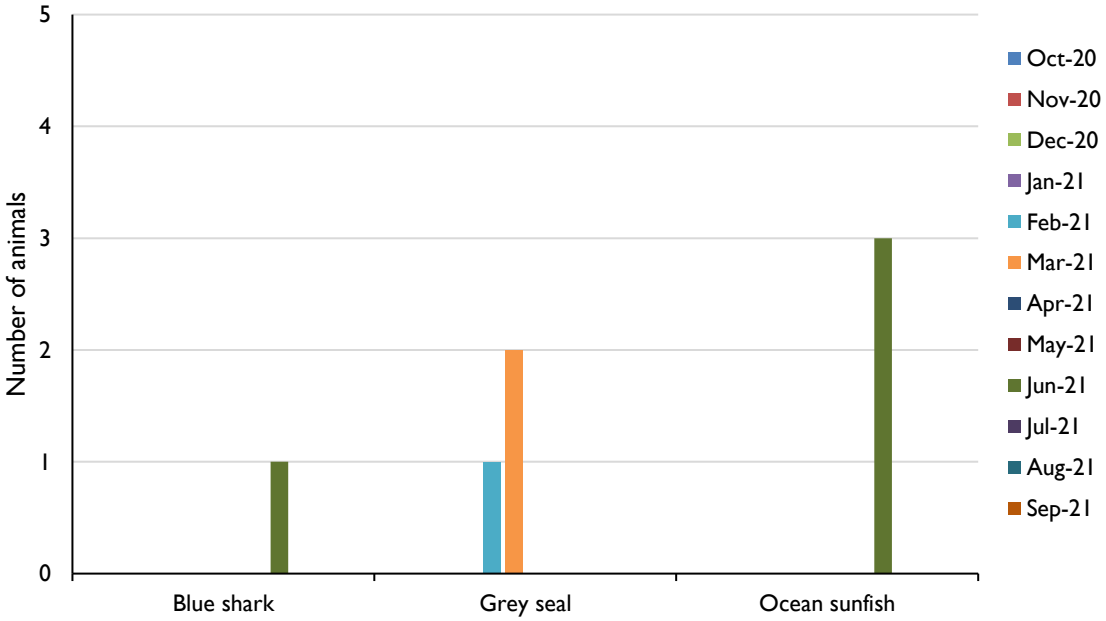


Figure 73 Observations of less abundant non-avian animal species between October 2019 and September 2020

Figure 74 Observations of less abundant non-avian animal species between October 2020 and September 2021

3.3.17 Unidentified non-avian animals

131 Varying numbers of unidentified non-avian animals were observed throughout the survey programme (Table 40; Figure 75 and Figure 76). The distributions of all unidentified non-avian animals can be found in Figure 77 to Figure 78.

Table 40 Number of unidentified non-avian animals recorded between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
No ID non-avian animals	0	0	2	1	9	8	0	2	5	5	0	2	34
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
No ID non-avian animals	1	2	4	1	1	2	1	0	4	2	0	0	18

Figure 75 Number of unidentified non-avian animals observed between October 2019 and September 2020

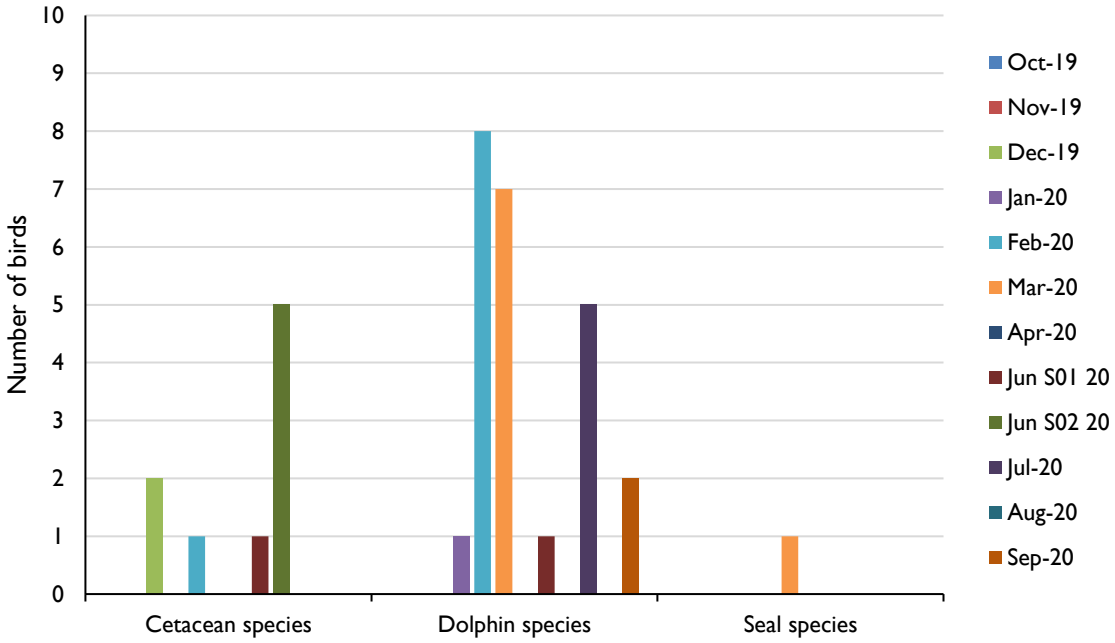


Figure 76 Number of unidentified non-avian animals observed between October 2020 and September 2021

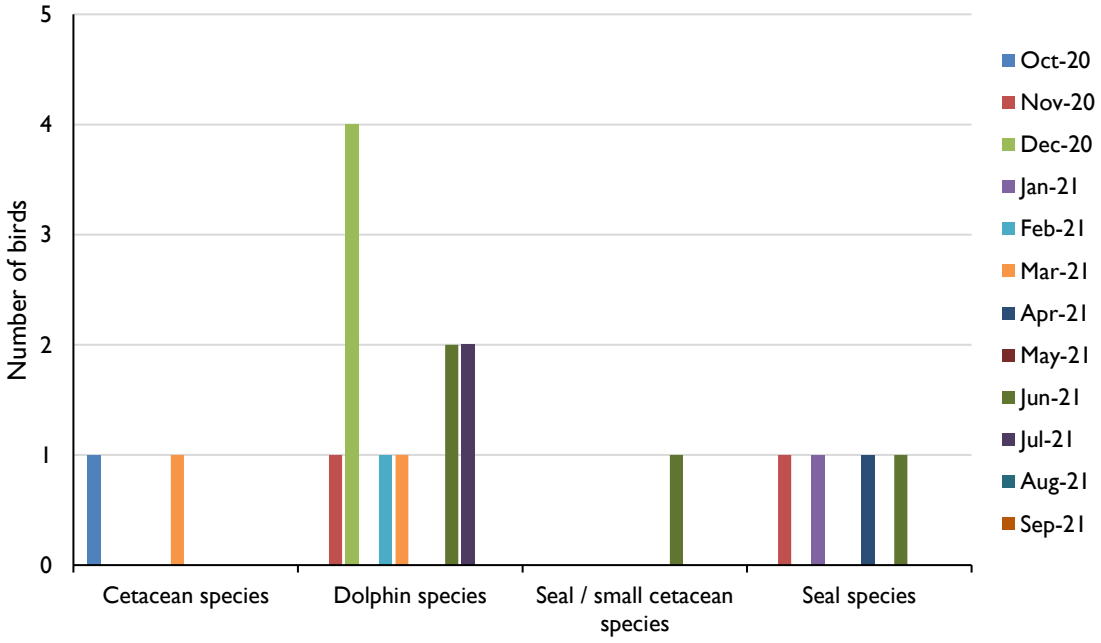


Figure 77 Observations of unidentified non-avian animal species between October 2019 and September 2020

Figure 78 Observations of unidentified non-avian animal species between October 2020 and September 2021

3.3.18 Anthropogenic activity

132 Anthropogenic activity, such as man-made objects and vessel traffic, was observed throughout the survey period (Table 41; Figure 79). Detections are shown in Figure 80 to Figure 81.

Table 41 Number of anthropogenic objects recorded between October 2019 and September 2021

Survey	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun S01	Jun S02	Jul	Aug	Sep	Year 1 Total
Anthropogenic activity	2	6	3	2	1	3	0	1	2	0	0	0	20
Survey	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year 2 Total**
Anthropogenic activity	1	1	0	1	2	0	1	1	0	0	0	3	10

Figure 79 Number of anthropogenic objects observed between October 2019 and September 2021

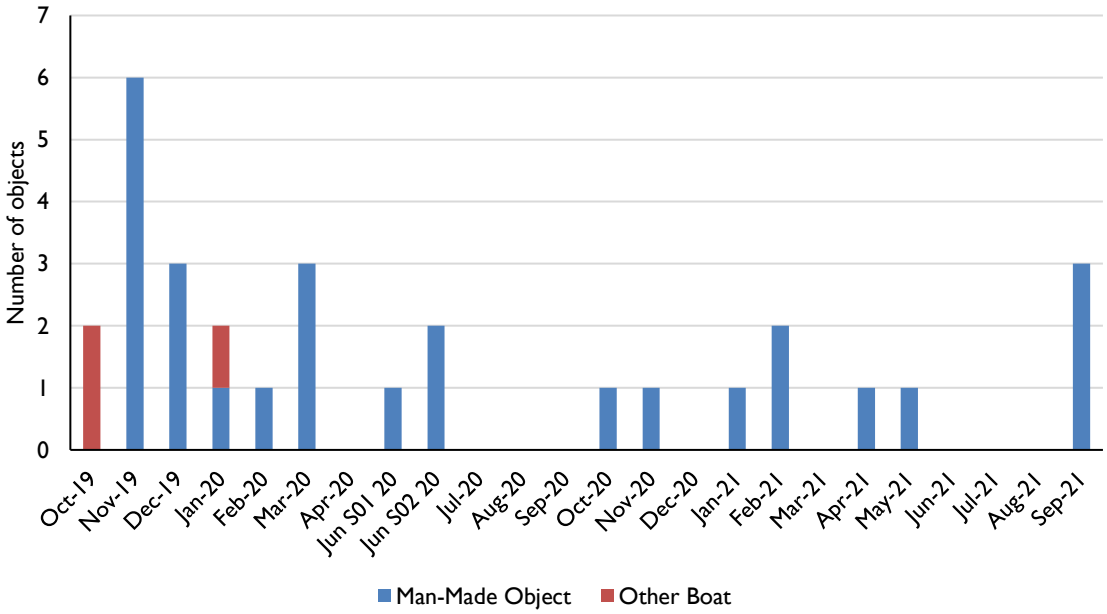


Figure 80 Observations of anthropogenic objects between October 2019 and September 2020

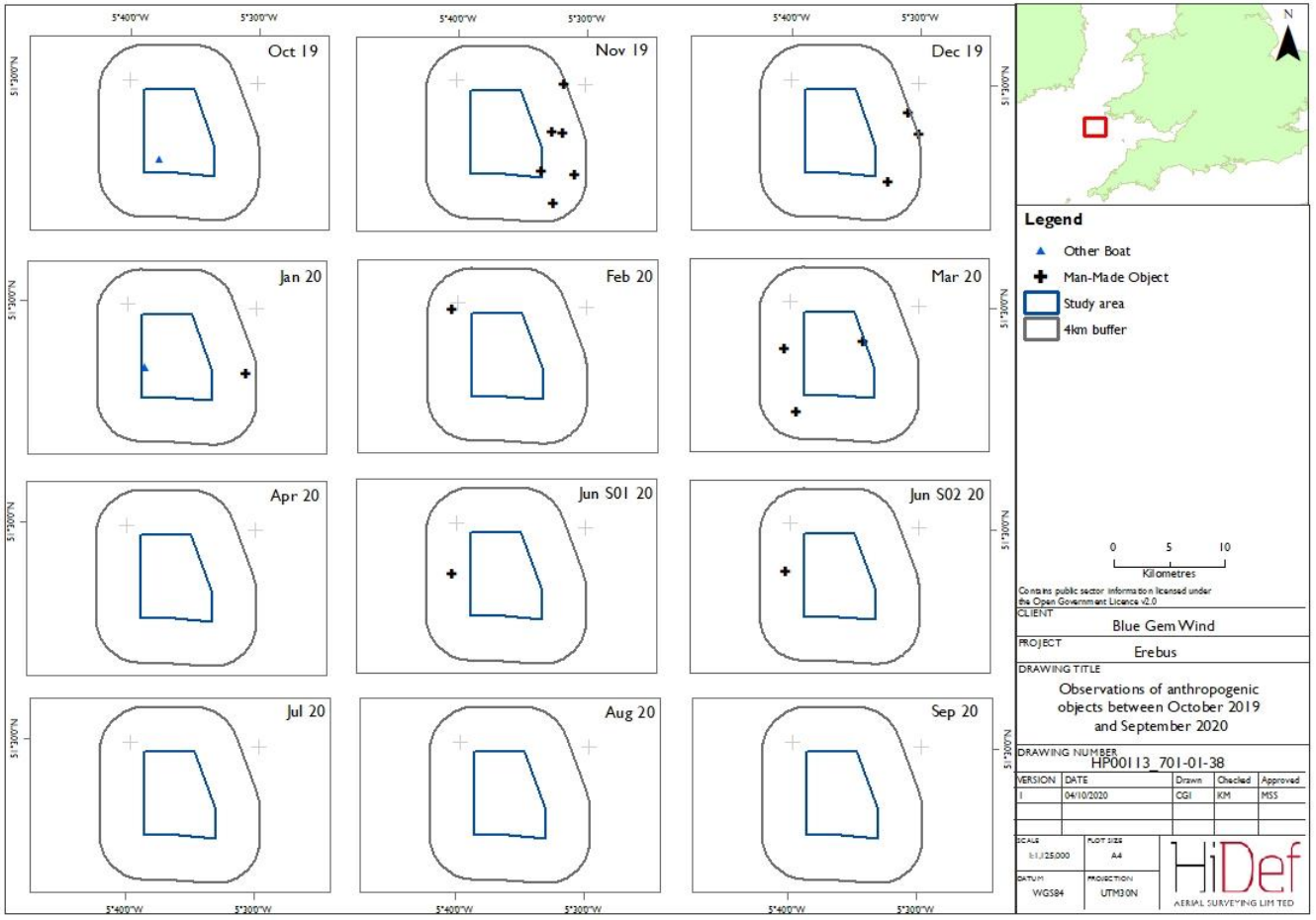


Figure 81 Observations of anthropogenic objects between October 2020 and September 2021

4 Discussion and conclusions

133 Over a two-year period, an area of 200.11km^2 encompassing the proposed Erebus offshore wind farm, 35km off the Pembrokeshire coast in the north Celtic Sea, was surveyed monthly to characterise the marine fauna of the area.

134 Surveys successfully recorded 34,462 birds of 19 species and 2,028 marine mammals of six species in 24 months. A further 1,526 birds and 52 marine mammals were recorded which were not assigned to species level. In addition, 13 basking shark, 2 blue shark, 1 bluefin tuna and a number of sunfish were also observed.

135 Large aggregations of seabirds were observed, likely attributed to optimum foraging and nesting opportunities near the site. Use of the site differed vastly by season, with species such as kittiwake, guillemot and razorbill present through the winter, whilst puffin, Manx shearwater and gannet were present in high numbers in the breeding season.

136 The abundance of certain species dropped significantly in the second year of surveying, such as kittiwake, great black-backed gull, guillemot, razorbill, puffin, Manx shearwater and common dolphin. The abundances and distributions of marine species are highly variable and can be influenced by a variety of factors, including sea surface temperatures and prey distributions (Wanless et al., 2018). Both climate change and fishing are likely to affect prey resources and marine animal distributions (Furness, 2002; MacDonald et al., 2015). Guillemots in south-western colonies rely more on sprats and gadoids as their primary food source than their north-eastern counterparts, and chick diets studied throughout the UK varied accordingly to patterns expected from rising sea temperatures and impacts of fishing (Anderson et al., 2014). Recent reports have suggested an increase in low quality Gadid prey in the diets of guillemot chicks on Skomer island, highlighting a possible shift in prey availability (Riordan and Birkhead, 2018). However, whilst the difference in the number of birds present between survey years may appear stark, it is hard to conclude anything other than natural variation, especially when analysing seasonal data over such a small period in time and across a relatively small survey area.

137 Kittiwakes were the third most abundant species recorded in the survey area. Birds were almost exclusively present in the non-breeding season, with very low numbers occurring during the summer breeding season. Kittiwakes breed in colonies to the north between April and August, before heading offshore to winter at sea (Mitchell *et al.,* 2004). Birds are most closely associated to their nest sites between May and July (Furness, 2015), with the nearest prominent colonies being on Skomer and Skokholm Island and those along Irish coastlines. Birds are likely to be in attendance during these months. Timings of peak abundances suggest that the Erebus survey area was used primarily after the autumn dispersal of birds from colonies to locations further offshore (post-breeding migration) and again during the return migration period.

138 Great black-backed gulls were recorded in low numbers sporadically through the survey period, with the more prominent peaks in abundance occurring in the non-breeding season; primarily October and November. Adult birds in Great Britain are somewhat sedentary, remaining relatively close to breeding grounds, with immature birds migrating further distances. The autumn dispersal of birds from colonies begins in July/August, with peak autumn migration occurring anywhere between July and October (Furness, 2015). Whilst the peaks in October may be partially explained by the movement of birds dispersing from UK colonies, numbers around this time may be bolstered by the arrival of Norwegian migrants (Wernham *et al.* 2002).

139 Lesser black-backed gulls were recorded in relatively low numbers, with more notable peaks in the breeding season. The UK breeding season runs from April to August, with birds migrating south for the winter. Eggs are laid from April to June, with chicks hatching between May and July and taking approximately five weeks to fledge (Ross-Smith *et al.*, 2014). The autumn migration of birds starts from as early as late June / July (Furness, 2015). The July 2020 and June 2021 peaks occur at the end of the chick-rearing period when both adults and chicks are likely to disperse out to sea. However, it is hard to ascertain whether the age data collated supports this, with no juvenile birds recorded during these months. Interestingly, the vast majority of birds in these months (93% and 96% respectively) were recorded flying, in predominantly southerly directions, suggesting these may be passage birds.

140 Guillemots were the most abundant species recorded, present year-round but occurring in highest abundances in the non-breeding season. In Year 1, peak abundance occurred in August, coinciding with post-breeding dispersal, when birds move to moulting areas and are completely flightless. Despite this, only 4 juveniles were present out of 6,503 birds, suggesting the area is not used for dispersal with chicks. Numbers remained high from September to November, suggesting birds also utilise the area for post-moult dispersal and as a wintering area. In 2021, seasonal use of the site appeared to change, with the highest densities of birds occurring in March, suggesting birds are aggregating prior to the breeding season. However, unlike 2020, almost no birds were recorded during post-breeding dispersal period. Seabird aggregations are highly variable and correlated to changes in a number of environmental factors, including sea surface temperatures and sandeel distributions. Although there may be changes in the seasonal use of the site, it has the potential to hold large aggregations of birds, found in high densities across the whole survey area, in both the Erebus boundary and buffer. Displacement by wind farms is likely to be an issue for this species (Furness and Wade, 2013).

141 Razorbills were recorded in large numbers in the non-breeding season, with relatively low numbers observed in the rest of the year. As with guillemots, razorbills spend the winter offshore, returning to coastal colonies to breed between March and July. The markedly high abundances in October 2019 occur during post-breeding migration (August to October; Furness, 2015), and suggest the site was used post-moulting. Additionally, high abundances in November and December, during what is the modal time for migration-free winter, coupled with high proportions of sitting birds, suggests a winter population does exist in the area. No birds were observed between July and September 2021, reflecting patterns seen in guillemot.

142 The breeding season of puffins runs from April to July (Kober *et al.*, 2010), but can extend into early August (Furness, 2015). Puffins were recorded in relatively high abundance across the survey area between April and June, with few to no birds recorded out with the breeding season. During these breeding months, birds are found in high densities around their colonies, such as Skomer and Skokholm (Kober et al., 2010), with a mean max foraging distance of 119.6km (±131.2) taken from multiple studies (Woodward *et al.*, 2019). The large April peak occurs prior to egg-laying, which commences in early May, whilst the June peak occurs during chick-rearing. During these surveys, birds were distributed widely across the survey area, including both the Erebus boundary and buffer.

143 Very low numbers of fulmar were recorded through the survey period, save for an anomalous peak in November 2019, with population estimates reaching 537 birds (±95% CI 20 – 1,463). Fulmars are highly pelagic, spending most of their time at sea, especially post-breeding. This peak falls within the modal month for migration-free winter (Furness, 2015). The high proportion of birds sitting on the water during this month suggests the site was used for foraging during the winter period in that year. Subsidiary peaks were also recorded in March 2020 and February 2021, coinciding with the return migration period.

144 Manx shearwaters were the second most abundant bird species. Large population estimates were recorded across both breeding seasons (April to September), peaking at 2,704 birds (±95% CI 1366 - 4291) in July 2020 and 2,800 birds (±95% CI 1024 – 5163) in June 2021. High densities of birds occurred within both the Erebus boundary and buffer. Manx shearwaters have particularly large foraging ranges, so may come from a range of northern colonies, but in particular, birds will be closely linked to the large colonies at Skomer and Skokholm. As with both guillemot and razorbill, these birds may be at risk of displacement (Furness and Wade, 2013).

145 Large numbers of gannets were present across the breeding season. This is unsurprising given the site's proximity to the island of Grassholm, the third largest gannetry in the UK, supporting 36,011 pairs (Pritchard *et al.*, 2021). Birds return to the island from late February, with eggs laid in April and chicks hatching from early June. Adults remain close until the chick is fully fledged 90 days later. Foraging gannets range widely from their colonies, with a mean range of 160.6km from Grassholm itself (Woodward *et al.*, 2019), and this may explain the high abundances in mid-summer, with almost no young birds present in the survey area. Abundance generally peaked in late summer and autumn, coinciding with the post-breeding migration period. Low numbers of observations between November and February can likely be attributed to migration south to Biscay and Africa (Deakin *et al.*, 2019). In October, November and July, high densities of birds were recorded in the south, east and west respectively, echoing the distributions of other species at this time which may indicate highly productive feeding areas.

146 Common dolphins *Delphinus delphis* were the most abundant marine mammal recorded and fourth most abundant species present overall. Population estimates fluctuated through the survey period, with peak abundance reaching 1,086 animals (±95% CI 682 – 1489) in January 2020 and similar estimates occurring through the proceeding summer months. Since these estimates do not account for individuals diving at the time of the survey, the true values are likely to be much larger. A relatively high population estimate for the species is to be expected in the study region, since common dolphins are one of the most numerous cetacean species in the north-east Atlantic (Murphy *et al.*, 2013).

147 Harbour porpoise were recorded in comparatively low numbers to common dolphin, with absolute population estimates reaching 633 animals (±95% CI 341 - 940) after accounting for diving animals, and no animals observed in some surveys. The estimated abundance of harbour porpoise was highest during January – March compared to other times of year; the Bristol Channel Approaches SAC was identified based on there being persistent higher densities of porpoise during the winter months.

148 Other marine megafauna were recorded, including basking shark *Cetorhinus maximus*, bottlenose dolphin *Tursiops truncatus* and minke whale *Balaenoptera acutorostrata* within the Erebus boundary and bluefin tuna *Thunnus thynnus*, blue shark *Prionace glauca*, grey seal and Risso's dolphin *Grampus griseus* within the buffer. However, these species were recorded in low numbers.

149 The study provided robust distribution and density data for multiple seabird and marine mammal species in the northern Celtic Sea off the east coast of Pembrokeshire, Wales. Regular data collection spanning a 24-month pre-construction period was essential to determine distribution and abundance, needed to inform the environmental impact assessment of the Erebus offshore wind farm, and to evaluate its potential effects on seabirds and marine mammals.

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Appendix 1: Non-adjusted abundance estimates

150 The density, total estimated population, upper and lower 95% CI, standard deviation and CV for each species and species group have been calculated using strip transect analysis and are presented for each of the 24 surveys undertaken. An explanation of these elements can be found in Table 9.

Table 42 Abundance and density estimates of species groups in the survey area during Survey 1 on 22 October 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	91.52	18314	12302	24614	3141	17.15%
Species group						
Small gull species	19.67	3937	1405	6885	1388	35.25%
Black-backed gull species	0.37	75	0	194	53	71.16%
Large gull species	0.83	166	47	314	69	41.60%
Gull species	0.04	8	0	19	5	63.35%
Tern / small gull species	0.02	4	0	12	4	94.22%
Large auk	65.21	13049	9341	17168	2020	15.48%
Auk species	1.98	396	222	584	95	23.93%
Auk / small gull	0.27	55	16	102	23	40.53%
Auk / shearwater species	0.12	24	0	64	19	78.55%
Fulmar / gull species	0.06	12	0	24	6	49.80%
Gannet species	2.83	566	203	994	205	36.16%

Table 43 Abundance and density estimates of species in the study area during Survey 1 on 22 October 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	19.65	3933	1375	6944	1427	36.27%
Common gull	0.02	4	0	12	4	92.21%
Great black-backed gull	0.95	190	59	363	79	41.49%
Lesser black-backed gull	0.18	36	0	97	27	74.62%
Guillemot	49.86	9979	7183	12944	1493	14.95%
Razorbill	12.84	2570	1662	3789	548	21.29%
Puffin	0.23	47	0	115	31	65.13%
Gannet	2.82	564	215	991	200	35.43%

Table 44 Abundance and density estimates of species groups in the study area during Survey 2 on 08 November 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	47.76	9558	5149	15342	2616	27.37%
All non-avian animals	0.74	149	43	273	60	40.01%
Species group						
Wader species	0.06	12	0	36	12	93.52%
Small gull species	10.46	2094	692	3911	839	40.04%
Large gull species	0.42	84	16	171	40	48.07%
Gull species	0.23	47	4	120	34	71.98%
Large auk	31.42	6288	3447	9868	1659	26.38%
Auk species	0.12	24	0	57	15	63.41%
Auk / small gull	0.1	20	0	46	12	58.88%
Auk / shearwater species	0.02	4	0	12	4	93.34%
Fulmar / gull species	2.73	546	23	1447	431	78.90%
Gannet species	2.31	463	82	1141	315	67.91%
Seal species	0.02	4	0	12	4	94.92%
Dolphin species	0.73	146	42	274	61	41.61%

Table 45 Abundance and density estimates of species in the survey area during Survey 2 on 08 November 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	10.6	2121	746	3966	847	39.89%
Common gull	0.06	12	0	27	7	53.16%
Great black-backed gull	0.27	55	8	122	30	54.28%
Herring gull	0.12	24	4	47	12	47.11%
Lesser black-backed gull	0.04	8	0	20	6	69.66%
Guillemot	21.83	4369	2347	6902	1174	26.86%
Razorbill	8.87	1776	695	3260	664	37.36%
Fulmar	2.7	541	20	1435	420	77.72%
Gannet	2.29	458	83	1141	313	68.41%
Grey seal	0.02	4	0	12	4	94.36%
Common dolphin	0.72	145	39	269	60	41.27%

Table 46 Abundance and density estimates of species groups in the survey area during Survey 3 on 04 December 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	16.44	3290	2725	3891	301	9.14%
All non-avian animals	0.32	64	12	136	32	50.50%
Species group						
Small gull species	2.07	415	220	648	111	26.69%
Black-backed gull species	0.02	4	0	12	4	95.04%
Large gull species	0.14	28	8	49	11	37.05%
Gull species	0.08	16	4	30	7	40.98%
Large auk	13.7	2743	2294	3247	243	8.85%
Auk species	0.26	52	19	95	20	38.62%
Auk / small gull	0.04	8	0	20	6	63.98%
Gannet species	0.16	32	8	65	15	47.69%
Shark species	0.02	4	0	12	4	92.82%
Dolphin species	0.24	48	8	108	27	57.01%
Cetacean species	0.06	12	0	31	9	69.51%

Table 47 Abundance and density estimates of species in the survey area during Survey 3 on 04 December 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	2	400	208	639	111	27.66%
Black-headed gull	0.04	8	0	24	8	94.02%
Common gull	0.1	20	4	39	9	43.69%
Great black-backed gull	0.06	12	0	31	9	68.60%
Herring gull	0.12	24	4	46	11	44.16%
Guillemot	11.67	2336	1942	2759	207	8.82%
Razorbill	1.1	221	144	301	41	18.40%
Puffin	0.08	16	4	30	7	41.55%
Gannet	0.16	32	8	64	15	47.74%
Basking shark	0.02	4	0	12	4	93.92%
Common dolphin	0.22	44	0	104	27	61.55%
Harbour porpoise	0.02	4	0	12	4	94.98%

Table 48 Abundance and density estimates of species groups in the survey area during Survey 4 on 18 January 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	6.78	1357	1142	1591	117	8.61%
All non-avian animals	5.58	1117	713	1532	212	18.92%
Species group						
Small gull species	0.38	76	42	114	19	24.94%
Large gull species	0.02	4	0	12	4	95.04%
Gull species	0.02	4	0	12	4	94.83%
Large auk	6.16	1234	1024	1465	113	9.11%
Auk species	0.14	28	8	53	12	42.68%
Auk / small gull	0.02	4	0	12	4	96.17%
Fulmar / gull species	0.04	8	0	20	5	62.74%
Gannet species	0.02	4	0	12	4	93.47%
Dolphin species	5.43	1088	679	1499	211	19.35%
Cetacean species	0.16	32	8	64	15	47.18%

Table 49 Abundance and density estimates of species in the survey area during Survey 4 on 18 January 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.37	75	41	115	19	24.99%
Lesser black-backed gull	0.02	4	0	12	4	92.55%
Guillemot	5.1	1022	803	1251	115	11.20%
Razorbill	0.83	166	73	271	51	30.49%
Fulmar	0.04	8	0	19	5	63.51%
Gannet	0.02	4	0	12	4	94.88%
Common dolphin	5.43	1086	682	1489	210	19.28%
Harbour porpoise	0.16	32	8	65	15	47.91%

Table 50 Abundance and density estimates of species groups in the survey area during Survey 5 on 04 February 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	2.64	529	383	688	79	14.92%
All non-avian animals	0.92	184	73	306	60	32.21%
Species group						
Small gull species	0.65	131	73	193	32	23.96%
Large gull species	0.06	13	0	32	9	68.54%
Gull species	0.04	9	0	25	8	92.52%
Large auk	1.61	322	209	439	59	18.31%
Auk species	0.06	13	0	25	6	48.57%
Auk / small gull	0.04	9	0	20	6	65.19%
Fulmar / gull species	0.06	13	0	25	7	49.50%
Gannet species	0.12	25	8	44	10	37.87%
Dolphin species	0.9	181	73	301	60	32.92%
Cetacean species	0.02	5	0	13	4	97.99%

Table 51 Abundance and density estimates of species in the survey area during Survey 5 on 04 February 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.67	135	76	198	32	23.10%
Herring gull	0.06	13	0	31	9	67.62%
Lesser black-backed gull	0.04	9	0	25	8	95.11%
Guillemot	1.32	265	171	368	50	18.86%
Razorbill	0.1	21	0	47	12	59.74%
Fulmar	0.06	13	0	25	7	50.73%
Gannet	0.12	25	8	44	10	38.55%
Common dolphin	0.73	147	45	272	58	39.58%

Table 52 Abundance and density estimates of species groups in the survey area during Survey 6 on 03 March 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	4.57	915	667	1168	130	14.16%
All non-avian animals	0.83	166	76	262	48	28.69%
Species group						
Small gull species	0.26	52	16	101	22	42.56%
Black-backed gull species	0.02	5	0	12	4	92.24%
Large gull species	0.14	28	0	61	16	55.38%
Large auk	3.39	680	485	901	107	15.64%
Small auk	0.06	12	0	30	8	68.22%
Auk species	0.02	4	0	12	4	95.04%
Large auk / diver species	0.02	4	0	12	4	96.55%
Fulmar / gull species	0.21	43	8	94	23	53.74%
Gannet species	0.45	91	51	138	23	24.84%
Seal species	0.02	4	0	12	4	95.25%
Dolphin species	0.65	130	54	213	41	31.01%
Cetacean species	0.16	32	8	59	13	40.85%

Table 53 Abundance and density estimates of species in the survey area during Survey 6 on 03 March 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.26	52	16	99	22	42.71%
Great black-backed gull	0.04	8	0	24	8	93.77%
Herring gull	0.08	16	0	42	12	73.30%
Lesser black-backed gull	0.04	9	0	24	8	93.41%
Guillemot	2.94	590	408	787	99	16.76%
Razorbill	0.33	67	24	114	24	34.67%
Puffin	0.08	16	0	35	9	54.47%
Fulmar	0.22	44	8	94	24	53.32%
Gannet	0.45	92	51	139	23	24.77%
Common dolphin	0.47	95	28	165	36	37.89%
Bottle-nosed dolphin	0.04	8	0	20	6	68.29%
Harbour porpoise	0.16	32	8	59	13	40.50%

Table 54 Abundance and density estimates of species groups in the survey area during Survey 7 on 04 April 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	10.83	2167	1820	2510	177	8.14%
All non-avian animals	0.16	32	0	94	30	93.16%
Species group						
Small gull species	0.06	12	0	24	7	51.52%
Black-backed gull species	0.04	8	0	20	6	66.08%
Large gull species	0.04	8	0	20	6	64.60%
Large auk	1.99	398	293	502	54	13.33%
Auk species	8.08	1618	1329	1888	140	8.64%
Auk / small gull	0.02	4	0	12	4	97.91%
Auk / shearwater species	0.08	16	0	47	15	95.03%
Fulmar / gull species	0.08	16	0	34	9	53.88%
Shearwater species	0.02	4	0	12	4	93.63%
Gannet species	0.41	83	41	132	24	28.99%

Table 55 Abundance and density estimates of species in the survey area during Survey 7 on 04 April 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.08	16	0	36	9	56.53%
Lesser black-backed gull	0.08	16	4	30	7	42.14%
Guillemot	1.5	300	221	380	41	13.56%
Razorbill	1.08	217	134	309	45	20.76%
Puffin	7.17	1435	1195	1672	122	8.44%
Fulmar	0.08	16	0	35	9	54.93%
Manx shearwater	0.02	4	0	12	4	94.41%
Gannet	0.41	83	39	136	25	29.66%
Common dolphin	0.16	32	0	94	30	94.61%

Table 56 Abundance and density estimates of species groups in the survey area during Survey 8 on 08 June 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	4.21	842	284	1615	352	41.80%
All non-avian animals	4.63	927	383	1646	330	35.54%
Species group						
Large auk	0.4	80	38	126	23	28.73%
Auk species	0.1	20	0	42	11	51.23%
Auk / shearwater species	0.51	102	0	267	74	72.58%
Fulmar / gull species	0.02	4	0	12	4	94.10%
Shearwater species	2.42	484	92	1013	253	52.20%
Gannet species	0.73	146	73	230	41	27.65%
Shark species	0.2	40	19	66	13	30.91%
Dolphin species	4.34	869	342	1577	324	37.23%
Cetacean species	0.04	8	0	20	6	66.18%

Table 57 Abundance and density estimates of species in the survey area during Survey 8 on 08 June 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Guillemot	0.49	99	56	144	23	22.91%
Manx shearwater	2.85	570	31	1294	327	57.26%
Gannet	0.73	147	73	226	40	26.78%
Basking shark	0.2	40	19	66	13	31.20%
Common dolphin	4.38	876	341	1592	325	37.01%
Harbour porpoise	0.02	4	0	12	4	97.93%

Table 58 Abundance and density estimates of species groups in the survey area during Survey 9 on 24 June 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	17.69	3541	2423	4907	639	18.04%
All non-avian animals	3.07	616	179	1213	272	44.13%
Species group						
Small gull species	0.06	12	0	31	9	69.02%
Large gull species	0.04	8	0	20	6	63.39%
Large auk	4.14	828	626	1043	107	12.81%
Small auk	0.36	72	24	128	27	37.50%
Auk species	2.66	534	370	707	87	16.19%
Auk / shearwater species	0.77	154	63	272	56	35.97%
Shearwater species	8.38	1677	751	2773	527	31.39%
Gannet species	1.27	256	161	360	52	20.12%
Small bird species	0.08	16	4	35	9	52.45%
Fish species	0.1	20	8	35	8	35.98%
Shark species	0.02	4	0	12	4	92.47%
Dolphin species	2.81	564	148	1130	258	45.67%
Cetacean species	0.14	28	4	66	17	58.01%

Table 59 Abundance and density estimates of species in the survey area during Survey 9 on 24 June 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.06	12	0	31	9	69.50%
Herring gull	0.02	4	0	12	4	94.66%
Lesser black-backed gull	0.02	4	0	12	4	96.49%
Guillemot	3.97	796	604	1017	105	13.14%
Razorbill	0.02	4	0	12	4	94.18%
Puffin	2.73	547	370	723	91	16.66%
Manx shearwater	8.57	1716	786	2842	532	30.96%
Gannet	1.28	257	161	359	51	19.60%
Basking shark	0.02	4	0	12	4	96.32%
Ocean sunfish	0.1	20	8	35	7	35.55%
Minke whale	0.04	8	0	20	5	63%
Common dolphin	2.78	556	140	1140	264	47.42%
Bottle-nosed dolphin	0.04	9	0	24	8	93.01%

Table 60 Abundance and density estimates of species groups in the survey area during Survey 10 on 23 July 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	21.55	4314	2835	6022	819	18.98%
All non-avian animals	4.91	982	517	1492	250	25.40%
Species group						
Small gull species	0.04	8	0	20	6	66.38%
Black-backed gull species	0.16	32	11	59	13	39.67%
Large gull species	0.65	130	62	215	40	30.62%
Gull species	0.02	4	0	12	4	95.43%
Large auk	3.23	646	469	833	94	14.45%
Small auk	0.08	17	0	36	10	56.25%
Auk species	0.42	84	31	144	29	34.63%
Auk / small gull	0.02	4	0	12	4	91.38%
Auk / shearwater species	0.99	198	68	358	75	37.91%
Fulmar / gull species	0.04	8	0	19	6	64.52%
Shearwater species	13.24	2650	1417	4150	715	26.96%
Gannet species	2.74	549	137	1072	242	44.10%
Dolphin species	4.91	984	514	1512	256	25.99%

Table 61 Abundance and density estimates of species in the survey area during Survey 10 on 23 July 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.04	8	0	20	6	64.61%
Great black-backed gull	0.1	20	0	53	15	74.67%
Herring gull	0.12	24	4	46	11	44.50%
Lesser black-backed gull	0.57	115	49	198	39	33.71%
Guillemot	3.52	705	521	893	96	13.54%
Razorbill	0.06	13	0	36	12	93.21%
Puffin	0.08	16	0	35	9	56.49%
Fulmar	0.04	8	0	20	6	63.47%
Manx shearwater	13.46	2693	1391	4303	752	27.90%
Gannet	2.73	548	142	1060	238	43.47%
Common dolphin	4.83	967	515	1466	245	25.34%

Table 62 Abundance and density estimates of species groups in the survey area during Survey 11 on 31 August 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	135.54	27122	22414	31871	2448	9.02%
All non-avian animals	1.41	283	131	461	85	30.04%
Species group						
Small gull species	0.31	63	20	116	25	39.60%
Black-backed gull species	0.02	4	0	12	4	94.50%
Arctic / common tern	0.06	12	0	24	6	50.31%
Tern species	0.04	8	0	20	6	63.99%
Tern / small gull species	0.02	4	0	12	4	93.72%
Large auk	122.51	24517	19232	29777	2699	11.01%
Auk species	1.57	315	202	449	64	20.19%
Auk / small gull	0.12	24	8	43	9	38.26%
Large auk / diver species	0.02	4	0	12	4	93.13%
Auk / shearwater species	1.54	308	223	389	43	13.81%
Fulmar / gull species	0.08	16	4	30	7	39.70%
Shearwater species	7.25	1451	312	3429	905	62.34%

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Gannet species	1.66	333	190	548	95	28.55%
Fish species	0.02	4	0	12	4	95.92%
Shark species	0.02	4	0	12	4	94.49%
Dolphin species	1.29	259	111	421	81	31.25%
Cetacean species	0.08	16	0	39	11	64.46%

Table 63 Abundance and density estimates of species in the survey area during Survey 11 on 31 August 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.33	67	26	120	25	36.60%
Great black-backed gull	0.02	4	0	12	4	94.99%
Guillemot	122.38	24490	19198	29716	2695	11%
Razorbill	0.49	98	61	151	24	24.41%
Puffin	0.16	32	12	54	11	33.87%
Fulmar	0.02	4	0	12	4	93.35%
Manx shearwater	7.46	1494	361	3454	907	60.69%
Gannet	1.64	329	187	545	96	29.16%
Basking shark	0.02	4	0	12	4	94.23%
Bluefin Tuna	0.02	4	0	12	4	96.16%
Common dolphin	1.3	261	110	427	81	30.92%
Harbour porpoise	0.08	16	0	39	11	66.02%

Table 64 Abundance and density estimates of species groups in the survey area during Survey 12 on 12 September 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	43.85	8775	7750	9848	539	6.14%
All non-avian animals	4.63	927	0	2683	846	91.28%
Species group						
Small gull species	0.1	20	4	39	9	45.13%
Gull species	0.02	4	0	12	4	93.44%
Tern species	0.02	4	0	12	4	96.47%
Skua species	0.02	4	0	12	4	93.12%
Large auk	42.45	8494	7532	9545	520	6.12%
Auk species	0.55	110	71	151	21	18.38%
Auk / small gull	0.04	8	0	20	6	65.72%
Auk / shearwater species	0.14	28	8	54	12	42.98%
Fulmar / gull species	0.02	4	0	12	4	95.44%
Shearwater species	0.06	12	0	24	6	49.49%
Gannet species	0.37	76	31	131	26	34.11%
Dolphin species	4.49	899	0	2689	836	93.02%

Table 65 Abundance and density estimates of species in the survey area during Survey 12 on 12 September 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.1	20	4	39	9	44.48%
Sandwich tern	0.02	5	0	12	4	93.37%
Great skua	0.02	4	0	12	4	93.27%
Guillemot	41.05	8215	7277	9179	487	5.93%
Razorbill	0.81	162	84	253	44	26.81%
Puffin	0.04	8	0	19	6	64.41%
Fulmar	0.02	4	0	12	4	94.70%
Manx shearwater	0.06	12	0	24	6	49.45%
Gannet	0.37	75	31	129	26	34.27%
Common dolphin	4.48	896	0	2651	821	91.53%

Table 66 Abundance and density estimates of species groups in the survey area during Survey 13 on 15 October 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	59.81	11968	10500	13525	791	6.61%
All non-avian animals	2.46	492	213	874	170	34.47%
Species group						
Small gull species	2.47	495	260	788	137	27.57%
Black-backed gull species	0.04	8	0	19	5	62.63%
Large gull species	0.16	33	0	88	26	80.41%
Gull species	0.02	4	0	12	4	93.91%
Large auk	52.61	10529	9243	11962	697	6.61%
Auk species	1.1	220	126	328	53	23.80%
Auk / small gull	0.79	159	46	305	67	42.27%
Large auk / diver species	0.04	8	0	24	8	101.37%
Auk / shearwater species	0.06	12	0	26	7	52.05%
Fulmar / gull species	0.04	8	0	20	6	65.68%
Gannet species	1.89	379	238	546	79	20.89%
Passerine species	0.6	120	0	351	113	94.33%
Dolphin species	2.29	458	206	820	162	35.39%
Cetacean species	0.17	35	0	91	26	73.57%

Table 67 Abundance and density estimates of species in the study area during Survey 13 on 15 October 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	2.78	556	258	961	181	32.57%
Little gull	0.02	4	0	12	4	95.83%
Great black-backed gull	0.16	32	0	78	22	68.94%
Herring gull	0.04	8	0	20	6	64.74%
Guillemot	49.43	9892	8580	11287	691	6.98%
Razorbill	2.15	431	269	618	89	20.54%
Manx shearwater	0.02	4	0	12	4	98.25%
Gannet	1.89	378	241	548	80	21.07%
Common dolphin	2.27	454	203	809	161	35.49%
Harbour porpoise	0.15	31	0	87	26	82.45%

Table 68 Abundance and density estimates of species groups in the study area during Survey 14 on 22 November 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	39.76	7957	7292	8672	351	4.41%
All non-avian animals	0.1	20	0	46	12	58.99%
Species group						
Small gull species	0.76	154	110	203	24	15.26%
Large gull species	0.41	83	39	132	24	29.04%
Gull species	0.02	4	0	12	4	96.45%
Large auk	37.81	7567	6938	8222	335	4.42%
Auk species	0.53	107	43	182	36	33.10%
Auk / small gull	0.08	16	0	35	9	54.75%
Fulmar / gull species	0.16	32	12	53	11	32.51%
Gannet species	0.02	4	0	12	4	92.89%
Seal species	0.02	4	0	12	4	93.74%
Dolphin species	0.08	16	0	42	12	72.50%

Table 69 Abundance and density estimates of species in the survey area during Survey 14 on 22 November 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.75	150	110	192	22	14.16%
Little gull	0.02	4	0	12	4	93.50%
Great black-backed gull	0.23	47	23	79	15	31.24%
Herring gull	0.12	24	0	58	16	66.31%
Lesser black-backed gull	0.02	4	0	12	4	95.09%
Guillemot	36.79	7363	6706	8056	344	4.67%
Razorbill	0.8	161	79	250	44	27.33%
Fulmar	0.16	32	12	53	11	32.78%
Gannet	0.02	4	0	12	4	95.45%
Common dolphin	0.06	12	0	35	12	92.70%

Table 70 Abundance and density estimates of species groups in the survey area during Survey 15 on 31 December 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	24.33	4869	3669	6218	648	13.31%
All non-avian animals	0.12	24	0	58	16	63.73%
Species group						
Small gull species	5.83	1166	803	1560	192	16.44%
Black-backed gull species	0.06	12	4	24	6	48.77%
Large gull species	0.02	4	0	12	4	94.74%
Large auk	17.76	3554	2630	4626	513	14.41%
Auk species	0.29	59	20	106	23	37.35%
Auk / small gull	0.2	40	8	78	18	45.57%
Fulmar / gull species	0.02	4	0	12	4	93.16%
Gannet species	0.16	32	15	52	10	31.60%
Dolphin species	0.1	20	0	50	13	66.21%
Cetacean species	0.02	4	0	12	4	92.40%

Table 71 Abundance and density estimates of species in the survey area during Survey 15 on 31 December 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	5.89	1180	820	1586	193	16.34%
Great black-backed gull	0.08	16	0	35	9	52.54%
Guillemot	12.39	2480	1940	3113	297	11.94%
Razorbill	4.87	975	526	1485	245	25.12%
Fulmar	0.02	4	0	12	4	96.32%
Gannet	0.16	32	12	52	10	31.44%
Common dolphin	0.1	20	0	49	14	65.80%
Harbour porpoise	0.02	4	0	12	4	94.74%

Table 72 Abundance and density estimates of species groups in the survey area during Survey 16 on 16 January 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	28.82	5767	4098	7573	892	15.46%
All non-avian animals	0.27	55	12	112	26	47.16%
Species group						
Small gull species	8.22	1646	1029	2289	324	19.66%
Large auk	20.06	4015	2891	5192	590	14.68%
Auk species	0.2	41	0	112	35	84.86%
Auk / small gull	0.34	68	16	147	38	55.19%
Fulmar / gull species	0.06	12	0	24	6	50.71%
Seal species	0.02	4	0	12	4	95.15%
Dolphin species	0.26	52	8	109	27	51.04%

Table 73 Abundance and density estimates of species in the survey area during Survey 16 on 16 January 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	8.23	1648	1051	2311	323	19.60%
Little gull	0.02	4	0	12	4	94.56%
Guillemot	13.13	2628	2108	3115	260	9.88%
Razorbill	6	1202	586	1867	330	27.41%
Fulmar	0.06	12	0	24	7	51.13%
Common dolphin	0.25	51	8	112	27	52.56%

Table 74 Abundance and density estimates of species groups in the survey area during Survey 17 on 22 February 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	9.55	1912	1591	2282	178	9.27%
All non-avian animals	1.79	359	234	497	68	18.98%
Species group						
Small gull species	0.53	107	65	151	23	21.16%
Large gull species	1.04	208	19	538	157	75.30%
Gull species	0.06	12	0	31	8	66.37%
Large auk	6.41	1283	1112	1464	91	7.07%
Auk species	0.02	4	0	12	4	95.50%
Fulmar / gull species	0.73	146	50	259	55	37.20%
Gannet species	0.77	154	79	232	39	25.37%
Small bird species	0.02	4	0	12	4	94.82%
Seal species	0.02	4	0	12	4	95.08%
Dolphin species	1.31	263	132	409	70	26.56%
Cetacean species	0.45	90	49	136	22	24.53%

Table 75 Abundance and density estimates of species in the survey area during Survey 17 on 22 February 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.49	99	59	141	22	21.31%
Common gull	0.08	16	4	30	7	42.12%
Great black-backed gull	0.04	8	0	19	5	63.74%
Herring gull	0.99	198	12	526	153	77.24%
Guillemot	5.13	1026	859	1217	93	9%
Razorbill	0.57	114	63	171	28	24.43%
Fulmar	0.62	125	42	225	48	37.91%
Gannet	0.77	155	81	231	39	24.75%
Grey heron	0.02	4	0	12	4	94.65%
Grey Seal	0.02	4	0	12	4	95%
Common dolphin	1.3	261	130	404	70	26.76%
Harbour porpoise	0.45	91	50	135	22	24.31%

Table 76 Abundance and density estimates of species groups in the survey area during Survey 18 on 05 March 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	42.34	8474	6952	10695	1003	11.83%
All non-avian animals	3.54	708	380	1111	190	26.71%
Species group						
Small gull species	0.24	48	20	77	15	31.07%
Large gull species	0.02	4	0	12	4	95.12%
Large auk	40.01	8007	6540	10212	989	12.34%
Auk species	0.73	146	93	205	29	19.80%
Auk / small gull	0.1	20	8	35	8	37.29%
Auk / shearwater species	0.02	4	0	12	4	92.71%
Fulmar / gull species	0.02	4	0	12	4	96.18%
Gannet species	1.1	220	172	273	27	11.90%
Seal species	0.04	8	0	24	8	92.39%
Dolphin species	3.01	604	282	1018	192	31.79%
Cetacean species	0.5	100	31	205	47	47.02%

Table 77 Abundance and density estimates of species in the survey area during Survey 18 on 05 March 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.24	48	20	78	15	31.23%
Lesser black-backed gull	0.02	4	0	12	4	95.34%
Guillemot	36.02	7209	5881	9213	906	12.56%
Razorbill	0.77	155	70	268	52	33.08%
Puffin	0.12	24	0	58	15	63.63%
Fulmar	0.02	4	0	12	4	94.90%
Manx shearwater	0.02	4	0	12	4	95.71%
Gannet	1.1	221	170	275	27	12.15%
Grey Seal	0.04	8	0	24	8	93.39%
Common dolphin	2.98	597	278	1025	193	32.26%
Harbour porpoise	0.47	94	27	198	47	49.93%

Table 78 Abundance and density estimates of species groups in the survey area during Survey 19 on 10 April 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	10.94	2190	1732	2679	244	11.12%
All non-avian animals	0.3	60	16	121	27	45.37%
Species group						
Large gull species	0.02	4	0	12	4	94.42%
Large auk	8.21	1643	1220	2089	223	13.55%
Small auk	0.22	44	16	76	16	36%
Auk species	1.02	205	143	271	33	16.08%
Auk / shearwater species	0.41	83	32	143	29	33.92%
Fulmar / gull species	0.02	4	0	12	4	95.66%
Shearwater species	0.1	20	4	39	9	44.71%
Gannet species	0.92	185	108	275	44	23.54%
Seal species	0.02	4	0	12	4	92.74%
Dolphin species	0.23	47	0	105	27	56.53%
Cetacean species	0.04	8	0	24	8	93.62%

Table 79 Abundance and density estimates of species in the survey area during Survey 19 on 10 April 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Great black-backed gull	0.02	4	0	12	4	98.24%
Guillemot	7.49	1499	1104	1905	202	13.43%
Razorbill	0.63	127	43	238	51	40.27%
Puffin	1.24	248	183	314	34	13.60%
Fulmar	0.02	4	0	12	4	97.51%
Manx shearwater	0.24	48	19	84	17	35.26%
Gannet	0.92	185	106	281	45	24.15%
Common dolphin	0.24	48	0	109	28	57.57%
Harbour porpoise	0.04	8	0	24	8	96.67%

Table 80 Abundance and density estimates of species groups in the survey area during Survey 20 on 14 May 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	10.42	2086	1786	2394	156	7.44%
All non-avian animals	0.16	32	0	91	25	77.68%
Species group						
Large gull species	0.02	4	0	12	4	96.42%
Arctic / common tern	0.06	12	0	36	12	94.64%
Tern species	0.02	4	0	12	4	91.93%
Large auk	7.66	1533	1318	1759	113	7.33%
Auk species	1.55	311	170	480	80	25.63%
Auk / shearwater species	0.12	24	4	51	13	52.85%
Fulmar / gull species	0.04	8	0	19	5	62.52%
Shearwater species	0.18	36	4	74	18	49.66%
Gannet species	0.8	160	78	260	47	29.42%
Dolphin species	0.16	32	0	85	24	76.14%

Table 81 Abundance and density estimates of species in the survey area during Survey 20 on 14 May 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Lesser black-backed gull	0.02	4	0	12	4	94.87%
Arctic tern	0.08	16	0	47	15	94.98%
Guillemot	7.18	1438	1239	1641	103	7.16%
Razorbill	0.33	67	22	123	27	39.65%
Puffin	1.21	244	110	409	78	31.74%
Fulmar	0.04	8	0	19	5	63.07%
Manx shearwater	0.18	36	8	72	18	48.55%
Gannet	0.8	160	75	260	48	29.49%
Common dolphin	0.16	32	0	86	24	75.34%

Table 82 Abundance and density estimates of species groups in the survey area during Survey 21 on 15 June 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	24.51	4905	2890	7466	1195	24.36%
All non-avian animals	2.09	418	226	624	101	24.13%
Species group						
Large gull species	0.43	87	46	133	22	25.47%
Arctic / common tern	0.08	16	0	47	15	93.37%
Tern species	0.02	4	0	12	4	96.78%
Large auk	4.64	929	767	1113	91	9.76%
Auk species	3.78	758	576	946	94	12.35%
Auk / shearwater species	1.26	252	76	460	99	39.10%
Fulmar / gull species	0.08	16	4	30	7	42.49%
Shearwater species	13.14	2629	997	4892	1022	38.85%
Gannet species	1.04	209	53	385	87	41.26%
Small bird species	0.02	4	0	12	4	92.27%
Fish species	0.06	12	0	24	6	49.51%
Shark species	0.02	4	0	12	4	96.69%

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Seal species	0.02	4	0	12	4	94.29%
Dolphin species	1.93	386	193	587	103	26.47%
Cetacean species	0.04	8	0	24	8	93.87%
Seal / small cetacean species	0.02	4	0	12	4	95.73%

Table 83 Abundance and density estimates of species in the survey area during Survey 21 on 15 June 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Lesser black-backed gull	0.43	87	45	133	23	25.94%
Arctic tern	0.04	8	0	24	8	92.54%
Guillemot	4.71	943	779	1126	91	9.56%
Razorbill	0.08	16	4	30	7	41.26%
Puffin	3.35	672	505	847	87	12.95%
Fulmar	0.08	16	4	31	7	43.11%
Manx shearwater	13.99	2800	1024	5163	1106	39.49%
Gannet	1.05	210	58	388	86	40.78%
Blue shark	0.02	4	0	12	4	97.95%
Ocean sunfish	0.06	12	0	24	6	49.62%
Common dolphin	1.9	380	196	574	98	25.66%
Harbour porpoise	0.04	8	0	24	8	93.08%

Table 84 Abundance and density estimates of species groups in the survey area during Survey 22 on 14 July 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	3.13	627	478	778	78	12.41%
All non-avian animals	0.59	118	0	290	77	64.45%
Species group						
Large gull species	0.2	40	16	66	13	32.25%
Large auk	1.77	354	231	487	67	18.74%
Auk species	0.25	51	20	87	18	34.16%
Auk / shearwater species	0.04	8	0	19	5	63.53%
Fulmar / gull species	0.02	4	0	12	4	92.08%
Shearwater species	0.31	63	15	127	29	45.96%
Gannet species	0.53	107	58	170	29	26.98%
Dolphin species	0.59	119	0	288	76	63.23%

Table 85 Abundance and density estimates of species in the survey area during Survey 22 on 14 July 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Herring gull	0.04	8	0	19	6	62.90%
Lesser black-backed gull	0.16	32	12	54	11	33.80%
Guillemot	1.82	364	235	503	68	18.68%
Puffin	0.18	36	12	67	15	40.35%
Fulmar	0.02	4	0	12	4	94.78%
Manx shearwater	0.31	63	12	126	29	45.78%
Gannet	0.53	107	58	167	29	26.89%
Common dolphin	0.55	111	0	283	75	67.82%

Table 86 Abundance and density estimates of species groups in the survey area during Survey 23 on 16 August 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	2.13	427	265	645	101	23.66%
All non-avian animals	0.02	4	0	12	4	93.69%
Species group						
Large gull species	0.08	16	0	34	9	52.84%
Gull species	0.06	12	0	24	6	48.65%
Large auk	0.44	88	12	183	45	51.26%
Auk species	0.08	16	0	34	9	53.69%
Fulmar / gull species	0.04	8	0	19	6	65.27%
Shearwater species	0.81	162	12	414	117	71.91%
Gannet species	0.63	126	83	172	24	18.43%
Small bird species	0.02	4	0	12	4	95.61%
Dolphin species	0.02	4	0	12	4	94.98%

Table 87 Abundance and density estimates of species in the survey area during Survey 23 on 16 August 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Common gull	0.04	8	0	20	6	63.19%
Great black-backed gull	0.02	4	0	12	4	92.82%
Lesser black-backed gull	0.08	16	0	34	9	54.01%
Guillemot	0.44	88	11	185	46	52.26%
Puffin	0.06	12	0	30	8	67.88%
Fulmar	0.04	8	0	19	5	63.74%
Manx shearwater	0.8	161	12	410	114	70.50%
Gannet	0.63	126	82	171	23	17.91%
Common dolphin	0.02	4	0	12	4	95.39%

Table 88 Abundance and density estimates of species groups in the survey area during Survey 24 on 01 September 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	9.39	1880	1018	2922	491	26.11%
All non-avian animals	1.09	219	0	491	126	57.56%
Species group						
Wader species	0.08	16	0	47	15	92.95%
Small gull species	0.02	4	0	12	4	94.79%
Gull species	0.02	5	0	12	4	91.68%
Arctic / common tern	0.02	4	0	12	4	95.29%
Skua species	0.02	4	0	12	4	92.75%
Large auk	0.45	91	38	154	30	32.85%
Auk species	0.06	12	0	24	6	50.71%
Auk / shearwater species	0.14	28	12	46	9	32.06%
Fulmar / gull species	0.06	12	0	30	8	66.62%
Shearwater species	6.02	1205	456	2099	425	35.23%
Gannet species	2.52	504	266	796	137	27.04%
Dolphin species	1.09	218	0	488	125	57.21%

Table 89 Abundance and density estimates of species in the survey area during Survey 24 on 01 September 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.02	4	0	12	4	96.17%
Common tern	0.02	4	0	12	4	94.19%
Great skua	0.02	4	0	12	4	94.79%
Guillemot	0.49	99	46	161	30	29.69%
Puffin	0.04	9	0	20	6	62.83%
Fulmar	0.06	12	0	30	8	67.63%
Manx shearwater	6.03	1208	447	2123	428	35.37%
Gannet	2.49	499	260	784	135	27.06%
Common dolphin	1.08	217	0	490	127	58.53%

Appendix II: Adjusted abundance estimates

151 Relative density and abundance estimates for three diving bird species (guillemot, razorbill and puffin) and one marine mammal species (harbour porpoise) were adjusted to account for the number of animals diving at the time of survey (availability bias) as outlined in section 2.6.3. The adjusted or 'absolute' density and population estimates and upper and lower 95% CIs for the four species are presented here for each of the 24 surveys undertaken, alongside the unadjusted 'relative' estimates.

An explanation of these elements can be found in Table 9.

Table 90 **Adjusted density and population estimates for guillemot in the Erebus survey area between October 2019 and September 2021, taking into account the number of birds that are estimated as being unavailable for detection**

Guillemot	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
22-Oct-19	50.05	10016	7178	13072	65.35	13079	9221	17173
08-Nov-19	21.97	4396	2398	6958	28.54	5713	3065	9075
04-Dec-19	11.68	2337	1959	2770	14.63	2927	2390	3495
18-Jan-20	5.11	1023	797	1254	6.7	1341	1028	1696
04-Feb-20	1.32	265	174	365	1.71	345	215	489
03-Mar-20	2.95	591	400	794	3.8	759	487	1061
04-Apr-20	1.5	300	224	382	1.95	390	273	510
08-Jun-20	0.49	99	56	144	0.63	128	67	199
24-Jun-20	3.96	793	607	1005	5.2	1043	777	1347
23-Jul-20	3.52	705	521	896	4.58	917	651	1198
31-Aug-20	122.38	24490	19198	29716	160.77	32172	25271	38804
12-Sep-20	41.04	8212	7291	9158	54.06	10819	9629	12087
15-Oct-20	49.39	9884	8606	11289	64.76	12962	11259	14900
22-Nov-20	36.8	7365	6723	8064	48.16	9639	8701	10642
31-Dec-20	12.38	2478	1944	3080	16.29	3263	2545	4087

Guillemot	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
16-Jan-21	13.14	2630	2103	3130	17.22	3448	2752	4120
22-Feb-21	5.13	1028	852	1221	6.53	1306	1034	1601
05-Mar-21	35.94	7192	5884	9104	46.82	9371	7576	12065
10-Apr-21	7.47	1496	1114	1888	9.46	1895	1269	2545
14-May-21	7.17	1436	1236	1643	9.27	1857	1545	2170
15-Jun-21	4.69	939	768	1132	6.1	1222	963	1512
14-Jul-21	1.81	362	239	501	2.39	478	309	668
16-Aug-21	0.43	87	8	182	0.58	116	11	248
01-Sep-21	0.49	99	47	158	0.65	130	62	208

Table 91 Adjusted density and population estimates for razorbill in the Erebus survey area between October 2019 and September 2021, taking into account the number of birds that are estimated as being unavailable for detection

Razorbill	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
22-Oct-19	12.8	2562	1678	3804	15.53	3108	1956	4685
08-Nov-19	8.87	1775	683	3283	10.87	2177	756	4044
04-Dec-19	1.1	221	142	301	1.33	267	170	382
18-Jan-20	0.83	167	75	271	1.01	203	82	342
04-Feb-20	0.1	21	0	48	0.12	25	0	67
03-Mar-20	0.33	67	26	115	0.37	74	5	162
04-Apr-20	1.08	217	129	306	1.31	263	143	395
08-Jun-20	0	0	0	0	0	0	0	0
24-Jun-20	0.02	4	0	12	0.02	5	0	15
23-Jul-20	0.06	12	0	36	0.07	15	0	44
31-Aug-20	0.49	98	61	151	0.6	121	75	182
12-Sep-20	0.8	161	83	252	0.99	198	104	304
15-Oct-20	2.16	432	275	618	2.53	508	245	833
22-Nov-20	0.8	161	77	250	0.95	191	85	307
31-Dec-20	4.85	971	521	1470	5.95	1190	647	1816

Razorbill	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
16-Jan-21	6	1202	591	1896	7.37	1474	744	2328
22-Feb-21	0.57	114	64	168	0.64	128	48	237
05-Mar-21	0.77	154	67	272	0.92	185	72	349
10-Apr-21	0.63	127	46	240	0.75	151	48	298
14-May-21	0.34	68	23	122	0.42	83	24	155
15-Jun-21	0.08	16	4	30	0.09	19	0	41
14-Jul-21	0	0	0	0	0	0	0	0
16-Aug-21	0	0	0	0	0	0	0	0
01-Sep-21	0	0	0	0	0	0	0	0

Table 92 Adjusted density and population estimates for puffin in the Erebus survey area between October 2019 and September 2021, taking into account the number of birds that are estimated as being unavailable for detection

Puffin	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
22-Oct-19	0.24	48	0	118	0.28	55	0	147
08-Nov-19	0	0	0	0	0	0	0	0
04-Dec-19	0.08	16	4	28	0.09	19	5	35
18-Jan-20	0	0	0	0	0	0	0	0
04-Feb-20	0	0	0	0	0	0	0	0
03-Mar-20	0.08	16	0	35	0.08	18	0	45
04-Apr-20	7.16	1433	1195	1661	8.33	1669	1374	1960
08-Jun-20	0	0	0	0	0	0	0	0
24-Jun-20	2.74	548	383	723	3.17	636	419	864
23-Jul-20	0.08	16	0	35	0.09	19	0	42
31-Aug-20	0.16	32	12	54	0.19	37	14	62
12-Sep-20	0.04	8	0	20	0.05	9	0	23
15-Oct-20	0	0	0	0	0	0	0	0
22-Nov-20	0	0	0	0	0	0	0	0
31-Dec-20	0	0	0	0	0	0	0	0

Puffin	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
16-Jan-21	0	0	0	0	0	0	0	0
22-Feb-21	0	0	0	0	0	0	0	0
05-Mar-21	0.12	24	0	58	0.13	27	0	74
10-Apr-21	1.24	248	186	313	1.43	288	210	378
14-May-21	1.21	243	110	408	1.42	285	122	493
15-Jun-21	3.36	672	500	854	3.9	781	586	989
14-Jul-21	0.18	36	12	66	0.21	42	14	77
16-Aug-21	0.06	12	0	31	0.07	14	0	35
01-Sep-21	0.04	8	0	20	0.05	9	0	22

Table 93 Adjusted density and population estimates for harbour porpoise in the Erebus survey area between October 2019 and September 2021, taking into account the number of animals that are estimated as being unavailable for detection

Harbour porpoise	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
22-Oct-19	0	0	0	0	0	0	0	0
08-Nov-19	0	0	0	0	0	0	0	0
04-Dec-19	0.02	4	0	12	0.13	26	0	77
18-Jan-20	0.16	32	8	67	0.9	181	45	379
04-Feb-20	0	0	0	0	0	0	0	0
03-Mar-20	0.16	32	8	59	0.82	163	41	301
04-Apr-20	0	0	0	0	0	0	0	0
08-Jun-20	0.02	4	0	12	0.11	21	0	64
24-Jun-20	0	0	0	0	0	0	0	0
23-Jul-20	0	0	0	0	0	0	0	0
31-Aug-20	0.08	16	0	39	0.42	84	0	204
12-Sep-20	0	0	0	0	0	0	0	0
15-Oct-20	0.16	33	0	88	1.07	221	0	590
22-Nov-20	0	0	0	0	0	0	0	0
31-Dec-20	0.02	4	0	12	0.13	26	0	77

Harbour porpoise	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
16-Jan-21	0	0	0	0	0	0	0	0
22-Feb-21	0.45	91	49	135	3.13	633	341	940
05-Mar-21	0.47	95	27	200	2.4	485	138	1020
10-Apr-21	0.04	8	0	24	0.17	34	0	103
14-May-21	0	0	0	0	0	0	0	0
15-Jun-21	0.04	8	0	24	0.21	43	0	128
14-Jul-21	0	0	0	0	0	0	0	0
16-Aug-21	0	0	0	0	0	0	0	0
01-Sep-21	0	0	0	0	0	0	0	0