Outer Dowsing Offshore Wind

Preliminary Environmental Information Report

Volume 2, Appendix 11.1: Marine Mammals Technical Baseline

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OUTER DOWSING OFFSHORE WIND

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Outer Dowsing Offshore Wind
Marine Mammal Baseline Characterisation

Authors:	Wright, P; Stevens, A and Sinclair RR
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1 Introduction

The purpose of this document is to provide a characterisation of the baseline environment to understand the range of species, the abundance and the density of marine mammals that could potentially be impacted by the Outer Dowsing Offshore Wind (the Project). The baseline data have been compiled through a combination of literature reviews and data obtained from site-specific surveys. The abundance and density estimates identified in this baseline characterisation form the basis of the quantitative impact assessment presented in the Preliminary Environmental Information Report (PEIR).

The key marine mammal species considered (based on the results of the site-specific surveys at the Project) are harbour porpoise (*Phocoena phocoena*), bottlenose dolphins (*Tursiops truncatus*), white-beaked dolphins (*Lagenorhynchus albirostris*), minke whales (*Balaenoptera acutorostrata*), harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*).

Other marine mammals that have been sighted in the east coast of England but are considered to be only occasionally or rarely present include: common dolphins (*Delphinus delphis*), fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*) (Reid *et al.*, 2003).

2 Study Area

The Project marine mammal study area varies depending on the species, considering individual species ecology and behaviour. The marine mammal study area has been defined at two spatial scales:

- Regional Scale study area: provides a wider geographic context in terms of the species present and their estimated densities and abundance. This scale defines the appropriate reference populations for the assessment. The regional study area for each species is as follows:
  - Harbour porpoise: North Sea Management Unit (MU);
  - Bottlenose dolphin: Greater North Sea MU;
  - White-beaked dolphin: Celtic and Greater North Seas MU;
  - Minke whale: Celtic and Greater North Seas MU;
  - Harbour seals: Southeast England MU; and
  - Grey seals: combined Southeast and Northeast England MUs.
- The Project study area: includes the survey area for the Project site-specific surveys (the Project array area + 4 km buffer) to provide an indication of the local densities of each species across the wind farm array area (Figure 2.1).

The marine mammal study area (regional MUs and survey area) is shown in Figure 2.2.

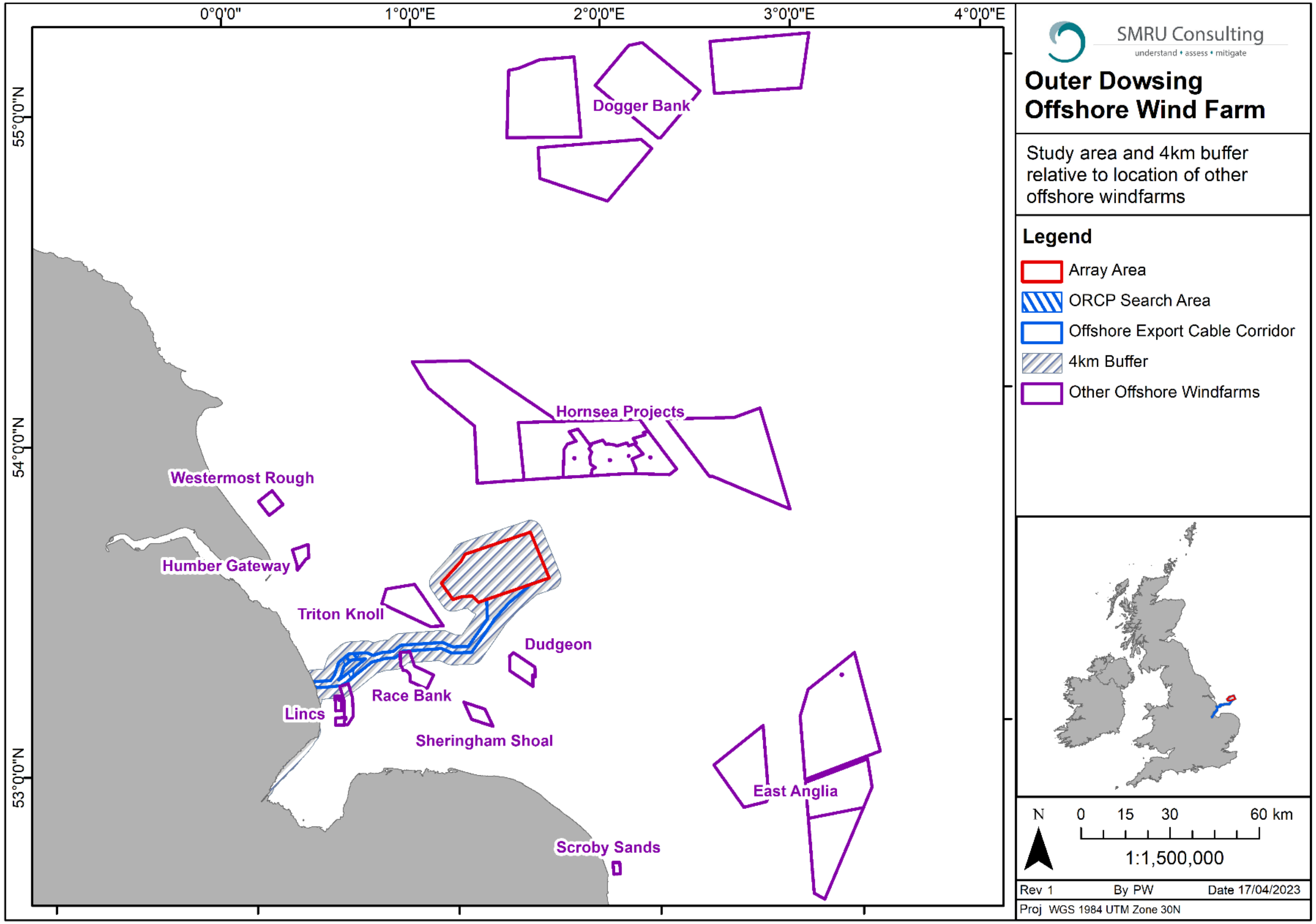

Figure 2.1 Marine mammal Project study area, relative to the location of pre-existing wind farms.

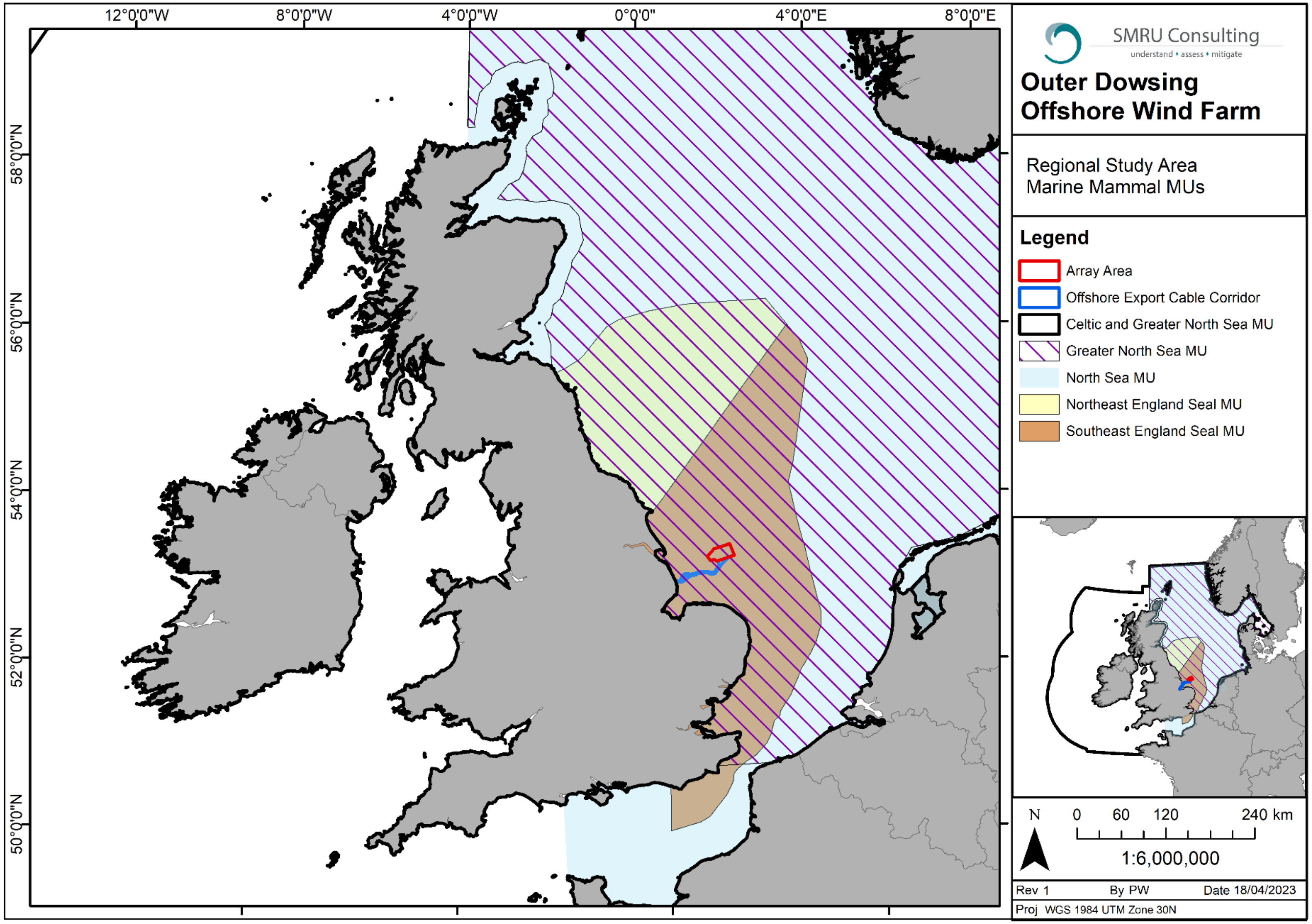

Figure 2.2: Marine mammal regional study area (MUs).

3 Protected Areas

There are several protected areas for marine mammals within their respective MUs (Table 3.1 and Figure 3.1). The Project array area is partly located within the summer portion of the Southern North Sea Special Area of conservation (SAC) for porpoise and is in relatively close proximity to the Humber Estuary SAC for grey seals and The Wash SAC for harbour seals. Given that the MUs vary in size, it should be noted that not all of these protected areas are located within English waters.

Table 3.1 Designated protected areas for marine mammals

Protected Area	Designation	Species	Minimum distance from the Project array area (km)
Southern North Sea	SAC	Harbour porpoise (primary reason)	Partially overlaps
The Wash	SAC	Harbour seal (primary reason)	48 km
Humber Estuary	SAC	Grey seal (qualifying feature)	55 km
Berwickshire and North Northumberland Coast	SAC	Grey seal (primary reason)	260 km
Southern Trench	MPA	Minke whale (primary reason)	450 km
Moray Firth	SAC	Bottlenose dolphin (primary reason)	580 km
Sea of the Hebrides	MPA	Minke whale (primary reason)	910 km

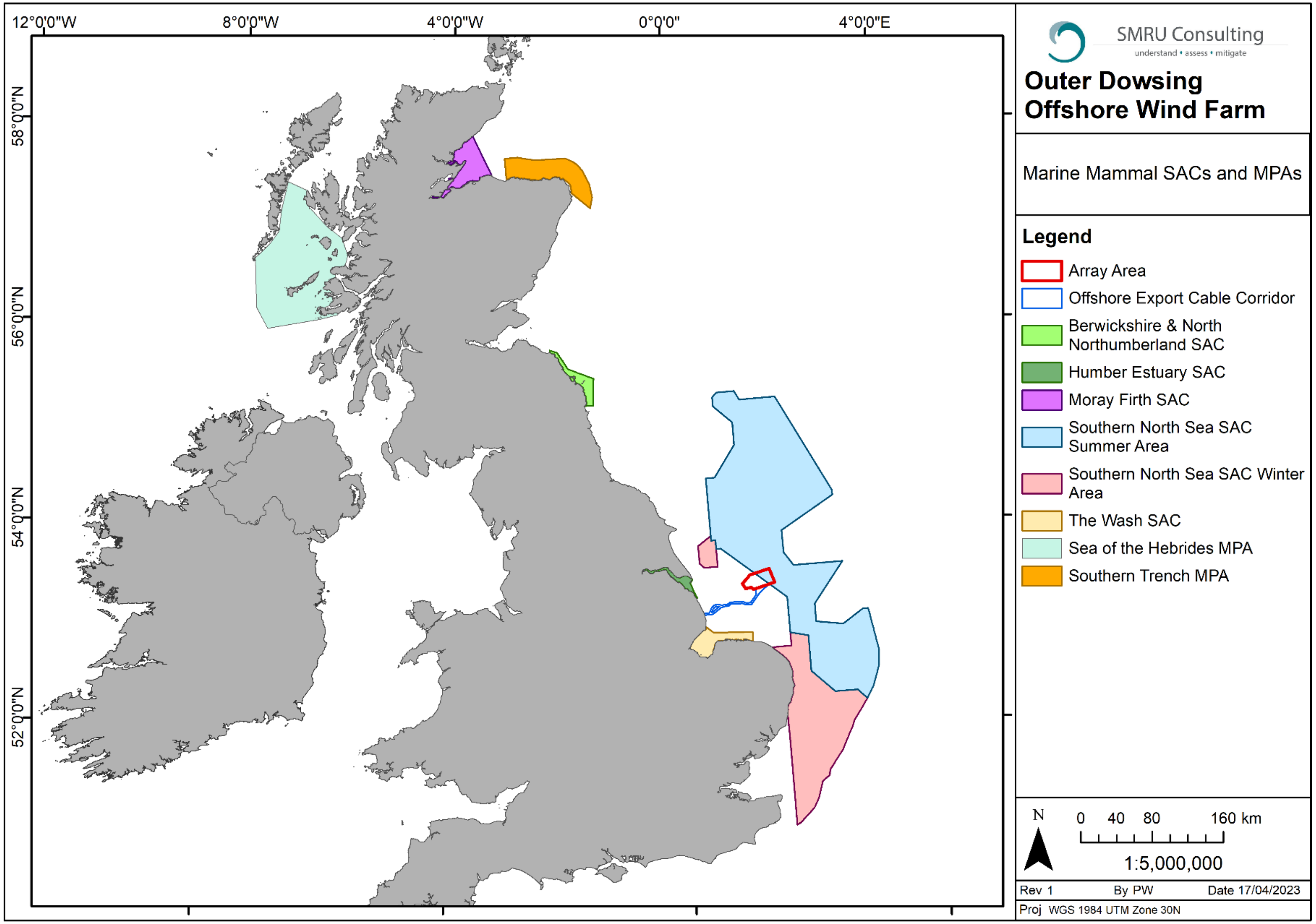

Figure 3.1 Marine mammal SACs and MPAs.

4 Data Sources

Table 4.1 and the following sections provide detail on the key data sources used to characterise the baseline study area for marine mammals in relation to the Project. This section details the survey and analysis methodology implemented in each study and the potential limitations associated with these. The actual results of the surveys in terms of the species presence are detailed in subsequent species-specific sections.

The data sources used to characterise the marine mammal baseline are in line with those recommended by Natural England (2021) (see Table 4.1).

Table 4.1 Marine mammal baseline datasets

SOURCE	DESCRIPTION	SPATIAL COVERAGE
Site-specific aerial surveys for the Project (HiDef, 2022).	Site-specific baseline characterisation digital video aerial surveys (March 2021 – February 2022, note, year 2 survey data were not available for PEIR).	The Project array area plus 4 km buffer.
The Project geophysical surveys (Seiche, 2022b, a)	Marine Mammal Observer (MMO) and Passive Acoustic Monitoring (PAM) detections during surveys conducted between August 2021 – January 2022. MMO and PAM detected during surveys conducted between April 2022 and July 2022.	The Project array area plus 500 m buffer, plus coverage of the Silver Pit area to the west of the Project array.
Small Cetaceans in European Atlantic waters and the North Sea (SCANS) III (Hammond *et al.*, 2021)	Combination of vessel and aerial surveys conducted in 2016.	North Sea and European Atlantic continental shelf waters. The Project is located in aerial survey block O.
Joint Cetacean Protocol (JCP) Phase III (Paxton *et al.*, 2016)	38 data sources (aerial, vessel and land-based surveys) between 1994-2010. Species abundance estimates provided for each season for specific areas of commercial interest for all offshore development types (i.e., Oil & Gas, Offshore Renewables, Decommissioning Projects).	UK waters. Nearest areas of commercial interest for which data are available are Norfolk Bank and South Dogger Bank.
JCP Data Analysis Tool	The JCP Phase III Data Analysis Product will be used to extract abundance estimates averaged for summer 2007-2010 and scaled to the SCANS III estimates for user specified areas.	UK waters. User specified area for data extraction.
Marine Ecosystems Research	Species distribution maps available at monthly and 10 km^2 density scale. Collation	European Atlantic Waters.

SOURCE	DESCRIPTION	SPATIAL COVERAGE
Programme (MERP) (Waggitt *et al.*, 2020)	of data from JCP (aerial and vessel), 1980 – 2018.	
Harbour porpoise densities (Heinänen and Skov, 2015)	Vessel and aerial surveys, 1994 – 2011.	UK waters.
Sea Watch Foundation Sightings	Sightings recorded.	Lincolnshire.
The Wildlife Trust (TWT) data	Sightings recorded.	Lincolnshire.
Nearby OWF surveys	Site-specific data collated at nearby offshore wind farms: • Hornsea Projects • Dudgeon & Sheringham Shoal Extensions • Race Bank • Triton Knoll • Sheringham Shoal • Dudgeon • Lincs • Lynn • Inner Dowsing	Coverage includes the offshore wind farm array areas plus buffer (varies by site).
Special Committee on Seals (SCOS) reports (SCOS, 2021)	Scientific Advice on Matters Related to the Management of Seal Populations. This outlines the current status of both harbour and grey seals in the UK.	UK wide.
Seal haul-out data provided by the Sea Mammal Research Unit (SMRU)	August haul-out surveys of harbour and grey seals.	UK wide.
Seal haul-out data in the Greater Thames Estuary (Cox *et al.*, 2020)	Seal population data for the Greater Thames Estuary between 2003 to 2019.	Greater Thames Estuary.
Grey seal pup counts (provided by SMRU)	Surveys of the main UK grey seal breeding colonies annually between mid-September	UK wide.

SOURCE	DESCRIPTION	SPATIAL COVERAGE
	and late-November to estimate the numbers of pups born at the main breeding colonies.	
Seal telemetry data (provided by SMRU)	A total of 86 harbour seals have been tagged in the Southeast England MU since 2003. A total of 33 grey seals have been tagged in the Southeast England MU since 1988 and a further 31 have been tagged in the Northeast England MU.	UK wide.
Seal habitat preference maps (Carter *et al.*, 2020, Carter *et al.*, 2022)	Habitat modelling was used, matching seal telemetry data to habitat variables, to understand the species-environment relationships that drive seal distribution. Haul-out count data were then used to generate predictions of seal distribution at sea from all known haul-out sites. This resulted in predicted distribution maps on a 5x5 km grid. The estimated density surface gives the percentage of the British Isles at sea population (excluding hauled-out animals) estimated to be present in each grid cell at any one time during the main foraging season.	UK waters.
EU seal telemetry data	Telemetry data from various studies on grey (Brasseur *et al.*, 2015a, Brasseur *et al.*, 2015b, Vincent *et al.*, 2017, Aarts *et al.*, 2018) and harbour seals (Brasseur *et al.*, 2012, Brasseur and Kirkwood, 2015, Vincent *et al.*, 2017) tagged in the Netherlands, France and the Wadden Sea to assess connectivity with European sites.	EU.

4.1 Site-specific surveys

The site-specific baseline characterisation surveys conducted for the Project consist of monthly high-resolution digital video aerial surveys conducted by HiDef Aerial Surveying Limited (HiDef). The surveys will be conducted from March 2021 to February 2023, with two surveys per month undertaken between March and September 2022[1]. The aim of these surveys for marine mammals is to collect data on the abundance and distribution of marine mammals to characterise the baseline to inform an Environmental Impact Assessment (EIA). Specifically, one objective was to obtain species specific density estimates for the site which can be used during the impact assessment to quantitatively predict the potential for impacts on each marine mammal species from construction, operation, and decommissioning. Full details of the year 1 site-specific surveys can be found in the year 1 survey report: HiDef (2022).

[1] At present, analysed site-specific survey data is only available until February 2022 and, therefore, only these data will be under consideration at the PEIR stage.

Survey transects were designed to cover the Project array area plus a 4 km buffer. In Year 1, this resulted in an overall survey area of 1822.11 km^2 (Figure 4.1). Transects were spaced 1.5 km apart and placed approximately perpendicular to the depth contours along the coast to reduce the variation in abundance estimates between transects by ensuring each transect was sampling a similar range of habitats. Surveys were undertaken using a specialist survey aircraft flown at approximately 550 m. The aircraft was equipped with four HiDef Gen II cameras with a resolution of 2 cm Ground Sample Distance (GSD) which each sampled a strip of 125 m width. A separation between cameras of approximately 25 m resulted in a combined sampled width of 500 m within a 575 m strip. The same transect lines were flown during each survey but slight variations in effort occurred due to variable start and stop times and minor deviations in the flight path (Table 4.2). The survey design aimed to achieve a minimum of 15% site coverage and a site coverage of 16.4% was achieved during each month in Year 1 (Table 4.2).

Data analysis for these surveys involved a two-stage process including a review of video footage with a 20% random sample used for audit, and then detected individuals were identified to species and/or species group level, also with 20% selected at random for auditing. Both stages in this audit process require 90% agreement to be achieved. Using non-parametric, bootstrap methods, species specific density estimates for the site were calculated including the corresponding standard deviation, 95% confidence intervals and coefficient of variance.

For harbour porpoise, the availability bias was then accounted for using data on the proportion of time tagged harbour porpoise spend at the surface (Teilmann *et al.*, 2013a). Due to variations in sea state and turbidity, the depth to which porpoise are visible for detection will differ both within and between surveys. Therefore, all porpoise detections were categorised as either “snapshot surfacing” (dorsal fin was clear of the water surface) or not, to determine the proportion of encounters where the animal was at the surface. The relative density estimate was then multiplied by the proportion of encounters at the surface and divided by the estimated time spent at the surface from Teilmann *et al.* (2013a) to derive the adjusted estimates of density and abundance. This process was not conducted for the other marine mammal species as correction factors for the time spent at the surface are not yet available for other species. Therefore, the data presented for other marine mammal species are relative abundance only.

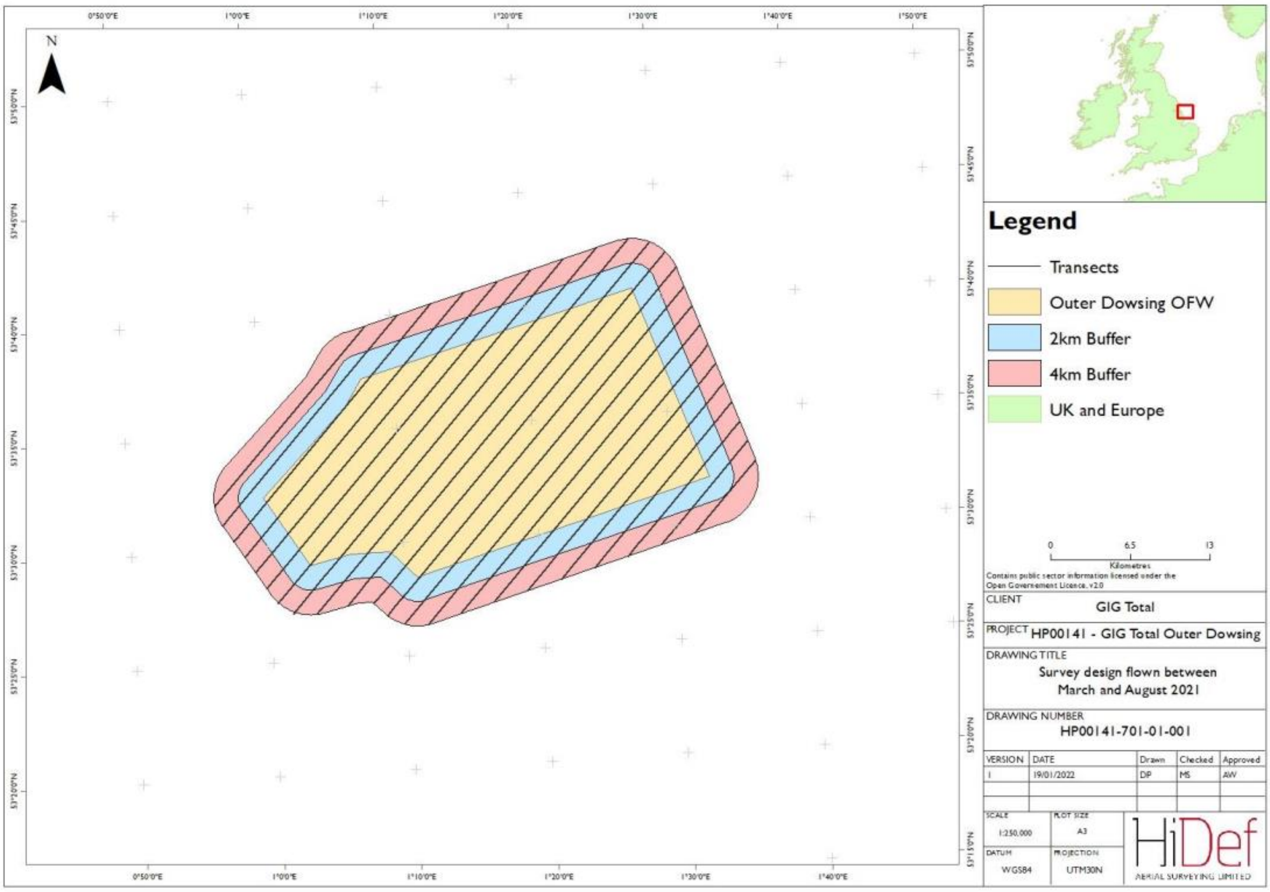

Figure 4.1 The Project survey design (HiDef, 2022).

Table 4.2 Survey effort across the development area plus 4 km buffer (HiDef, 2022).

Month	Number of transects analysed	Total length of transects analysed (km)	Area covered (km^2)	% covered
22 Mar 2021	22	607.36	151.84	16.4
04 Apr 2021	22	607.88	151.97	16.4
12 May 2021	22	608.74	152.19	16.4
09 Jun 2021	22	605.53	151.38	16.4
24 Jul 2021	22	606.71	151.68	16.4
14 Aug 2021	22	608.53	152.13	16.4
07 Sept 2021	22	606.83	151.71	16.4
09 Oct 2021	22	608.92	152.23	16.4
02 Nov 2021	22	608.29	152.07	16.4
15 Dec 2021	22	606.51	151.63	16.4
06 Jan 2022	22	606.50	151.63	16.4
23 Feb 2022	22	606.59	151.65	16.4

4.2 The Project geophysical surveys

A geophysical survey of the Project survey area was undertaken on the MV *Guard Celena* from 20-Aug-21 to 16-Jan-22. During the survey, a total of 744 hours and 26 minutes of Marine Mammal Observer (MMO) effort and 733 hours 50 minutes of Passive Acoustic Monitoring (PAM) effort was conducted: this resulted in a total survey effort of 1478 hours 16 minutes. There were visual observations of one harbour porpoise, two grey seals and one harbour seal (Seiche, 2022b). From 09-Apr-22 to 23-Jul-22, additional surveys were conducted of the Project area. During the surveys, a total of 1799 hours and 55 minutes was achieved for the MMO and PAM effort. There were visual observations of harbour porpoise, harbour seal, grey seal and unidentified seals (Seiche, 2022a). It should be noted that the results from the geophysical survey provide sightings information only to indicate the presence of species and no density estimates are available as part of this survey.

4.3 Nearby OWF surveys

4.3.1 Greater Wash strategic area aerial surveys

Between November 2005 and September 2006, 14 ornithological aerial surveys were undertaken on behalf of the Department for Energy Security and Net Zero (DESNZ) (then known as the Department of Trade and Industry (DTi)) (Department of Trade and Industry, 2006). Incidental sightings of marine mammals were recorded during the surveys, and therefore the data collected in blocks GW3, GW4 AND GW5 have been used in the baseline characterisations for several OWFs in the area (Sheringham Shoal, Triton, Lincs) (Figure 4.2) (Scira Offshore Energy Limited, 2006, Centrica energy, 2010, RWE npower renewables, 2011). The methodology of the surveys was based on that recommended by Collaboration for Offshore Wind Research in the Environment (COWRIE) (Camphuysen *et al.*, 2004). Transects of 20-65 km were flown at 2 km intervals at approximate speeds of 200 km/h. The flight time was 4 hours centred around midday (GTM) and undertaken during good weather conditions (<15 knots wind speeds). As the focus of ornithological surveys are to collect data on bird species, the sightings presented for marine mammals from surveys such as these may not be representative, and therefore do not present density estimates.

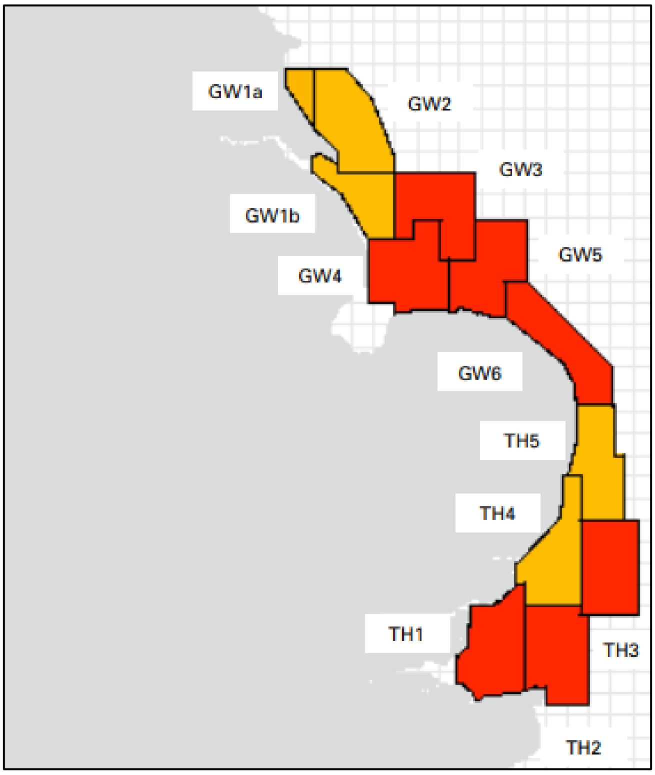

Figure 4.2 The Greater Wash Strategic Area survey blocks (Department of Trade and Industry, 2006).

4.3.2 Hornsea Offshore Wind Farms

4.3.2.1 Hornsea Four baseline surveys

Between April 2006 and March 2018, monthly site-specific aerial surveys were undertaken for the Hornsea Four OWF (Figure 4.3) (Orsted, 2021). In total, 24 surveys were conducted using an aircraft equipped with HiDef Gen II cameras with sensors set to a resolution of 2 cm GSD, sampling a strip of 125 m width with intervals of ~20 m. The survey design consisted of transects 2.5 km apart covering the Hornsea Four site, plus a 4 km buffer, resulting in a sampled area of 156.3 km^2 (10% coverage of the survey area). The surveys were undertaken in sea states 1 to 6, with the majority conducted in sea state four (51.0%). Data processing techniques used for these surveys were the same as those for the site-specific surveys for the Project (see section 4.1). Across the surveys, harbour porpoise, white-beaked dolphins and minke whales were recorded.

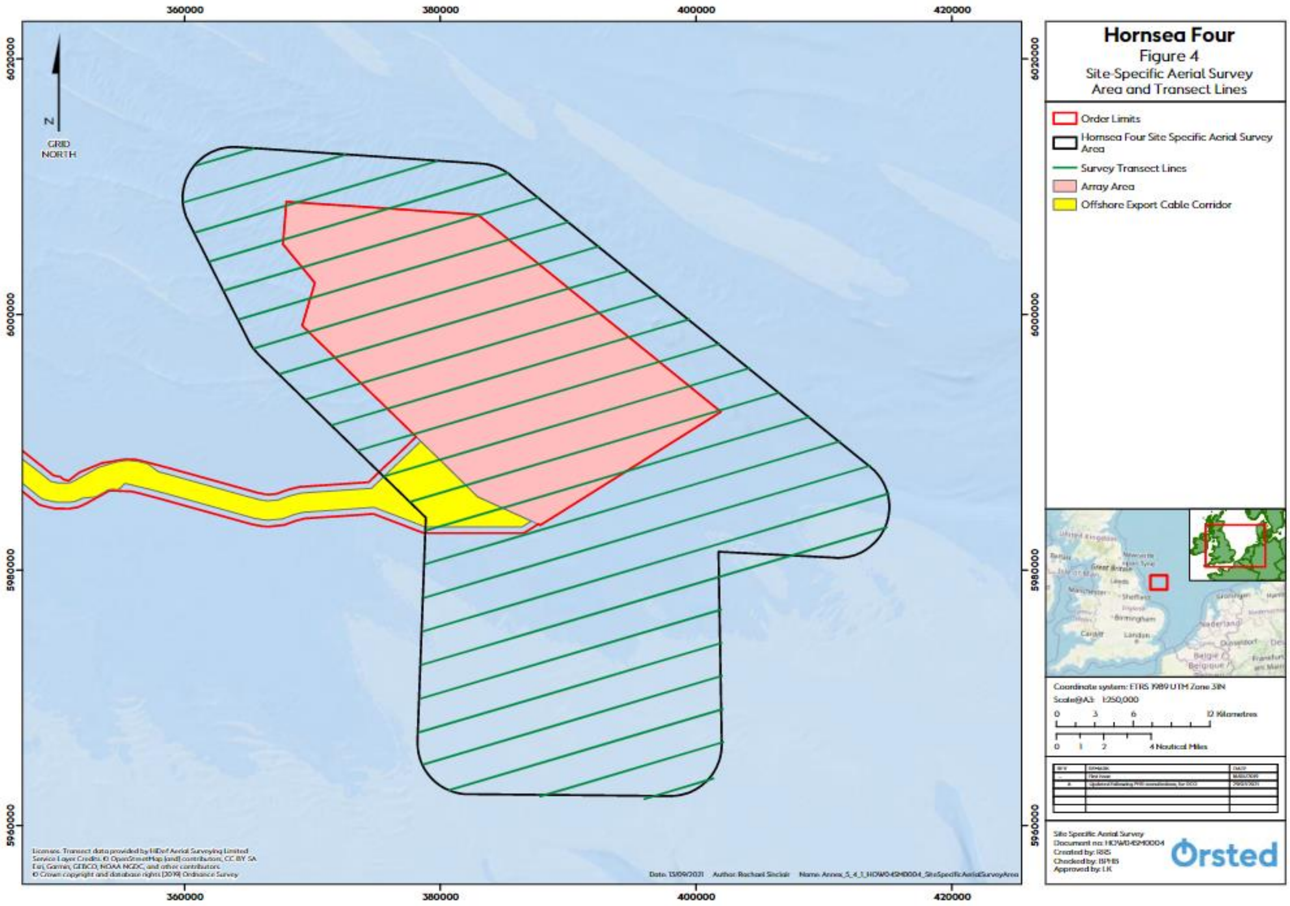

Figure 4.3 Hornsea Four site-specific baseline survey design (Orsted, 2021).

4.3.2.2 Former Hornsea Zone surveys

Between March 2010 and February 2013, ornithological and marine mammal boat-based surveys were undertaken within the Former Hornsea Zone, plus a 10 km buffer (Figure 4.4) (Orsted, 2021). Across the survey area, transects were spaced 6 km apart, with spacings of 2 km apart in the Hornsea Project One and Hornsea Project Two areas. In total, a 1,457.8 km transect length was achieved for the 6 km spacings and 1,141.7 km for the 2 km spacings, resulting in a total transect length of 2,599.6 km across the entire survey area. Additionally, acoustic surveys were undertaken between July 2011 and February 2013 using a towed hydrophone. The primary use of this was to detect vocalising harbour porpoise and resulted in 4,186 detections across the whole survey area. The survey data was processed using distance analysis to estimate the abundance of marine mammals (see Orsted (2021) for further details). Harbour porpoise, minke whale and white-beaked dolphins were recorded during the surveys.

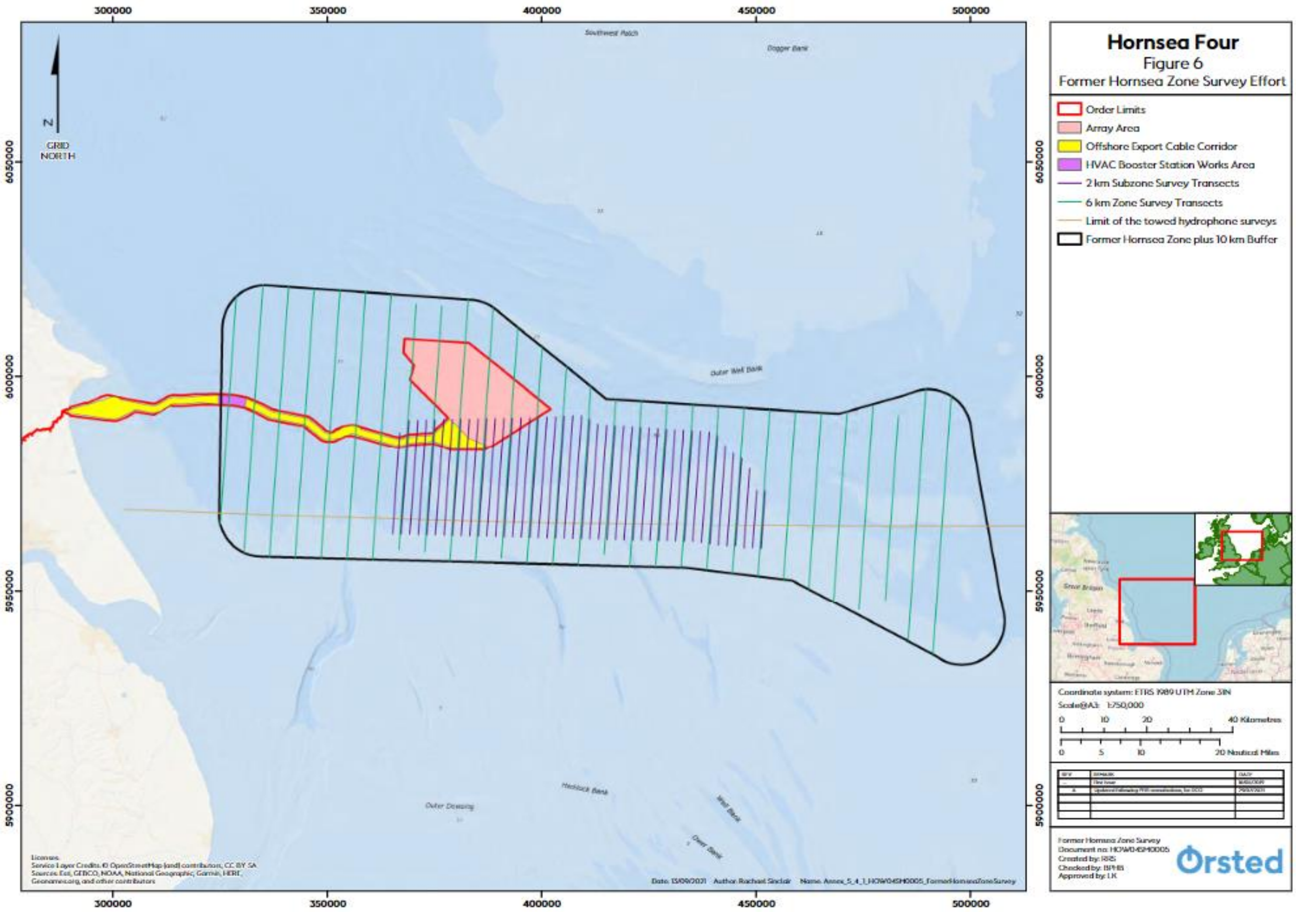

Figure 4.4 Former Hornsea Zone survey design (Orsted, 2021).

4.3.3 Dudgeon & Sheringham Shoal Extension Offshore Wind Farms

From May 2018 to April 2020, HiDef conducted site-specific marine mammal and seabird aerial surveys for the Dudgeon & Sheringham Shoal Extension OWF (Royal HaskoningDHV, 2021). The surveys were conducted monthly, except for between April 2019 and August 2019 in which two surveys were conducted per month. The survey area covered Dudgeon and Sheringham, plus a 4 km buffer (Figure 4.5). Survey transect spacings (2.5 km) and the data processing techniques were the same as those for the site-specific surveys for the Project (Section 4.1). Across the surveys, harbour porpoise were the most frequently sighted marine mammal species, with low sightings of minke whale, grey seals and harbour seals. Density estimates were provided for all four species observed during the site-specific surveys.

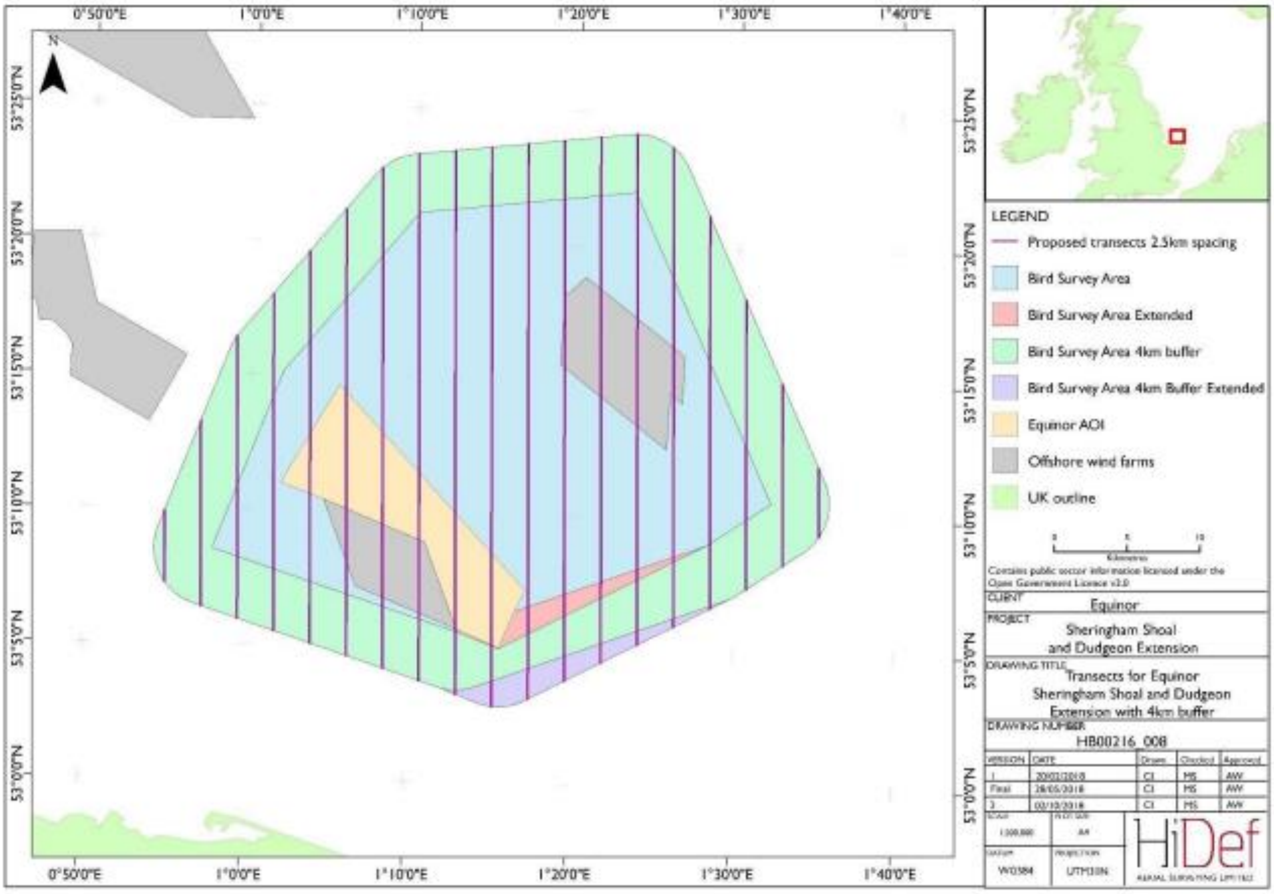

Figure 4.5 Dudgeon and Sheringham Shoal Extension survey design (Royal HaskoningDHV, 2021).

4.3.4 Triton Knoll Offshore Wind Farm

For the Triton Knoll OWF, 36 marine mammal and ornithological boat-based surveys were carried out from January 2008 to December 2009 (RWE npower renewables, 2011). Surveys were conducted once or twice a month and covered the site, plus a 1 km buffer (Figure 4.6). A total of 6,173 km^2 was surveyed for marine mammals and 52% of the surveys were conducted above sea state 2. In addition, survey data from the Greater Wash strategic area was used to inform the Triton Knoll OWF baseline characterisation. During these surveys, harbour porpoise were the most commonly sighted marine mammal species, with lower sightings of bottlenose dolphin, harbour seal, grey seal and unidentified marine mammals. No density estimates were available from these surveys.

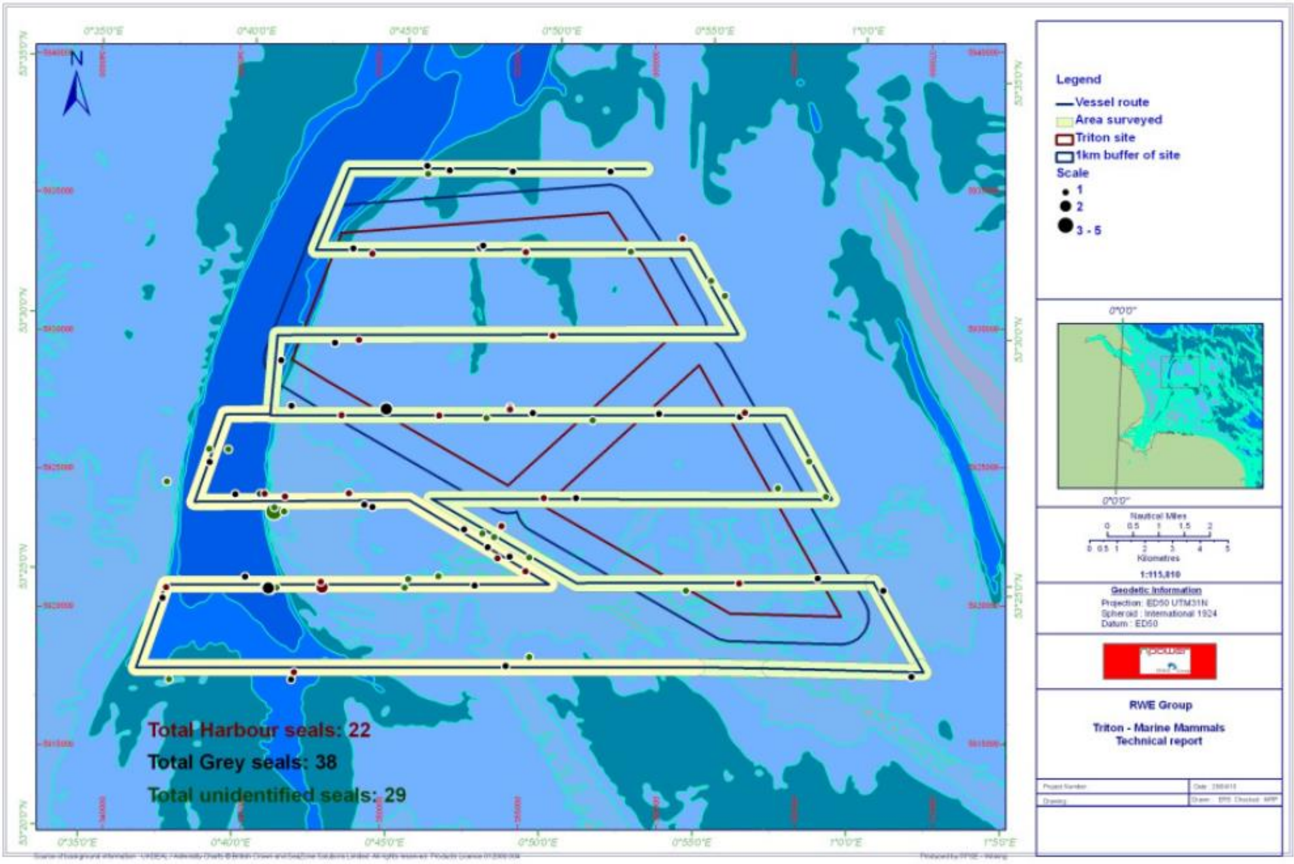

Figure 4.6 The Triton Knoll OWF survey design, including the locations of the recorded seal sightings (RWE npower renewables, 2011).

4.3.5 Race Bank OWF

Between December 2005 and October 2007, monthly ornithological boat-based surveys were conducted for the Race Bank OWF, in which incidental sightings of marine mammals were recorded (Centrica, 2009). The survey area covered the proposed site, plus a 1 km buffer (Figure 4.7). The transect lines ranged from 2-15.6 km in length and covered an area of 138.33 km. In addition, survey data from the Greater Wash strategic area was used to inform the Race Bank OWF baseline characterisation. Across the surveys, there were recorded sightings of harbour porpoise, grey seal and harbour seal.

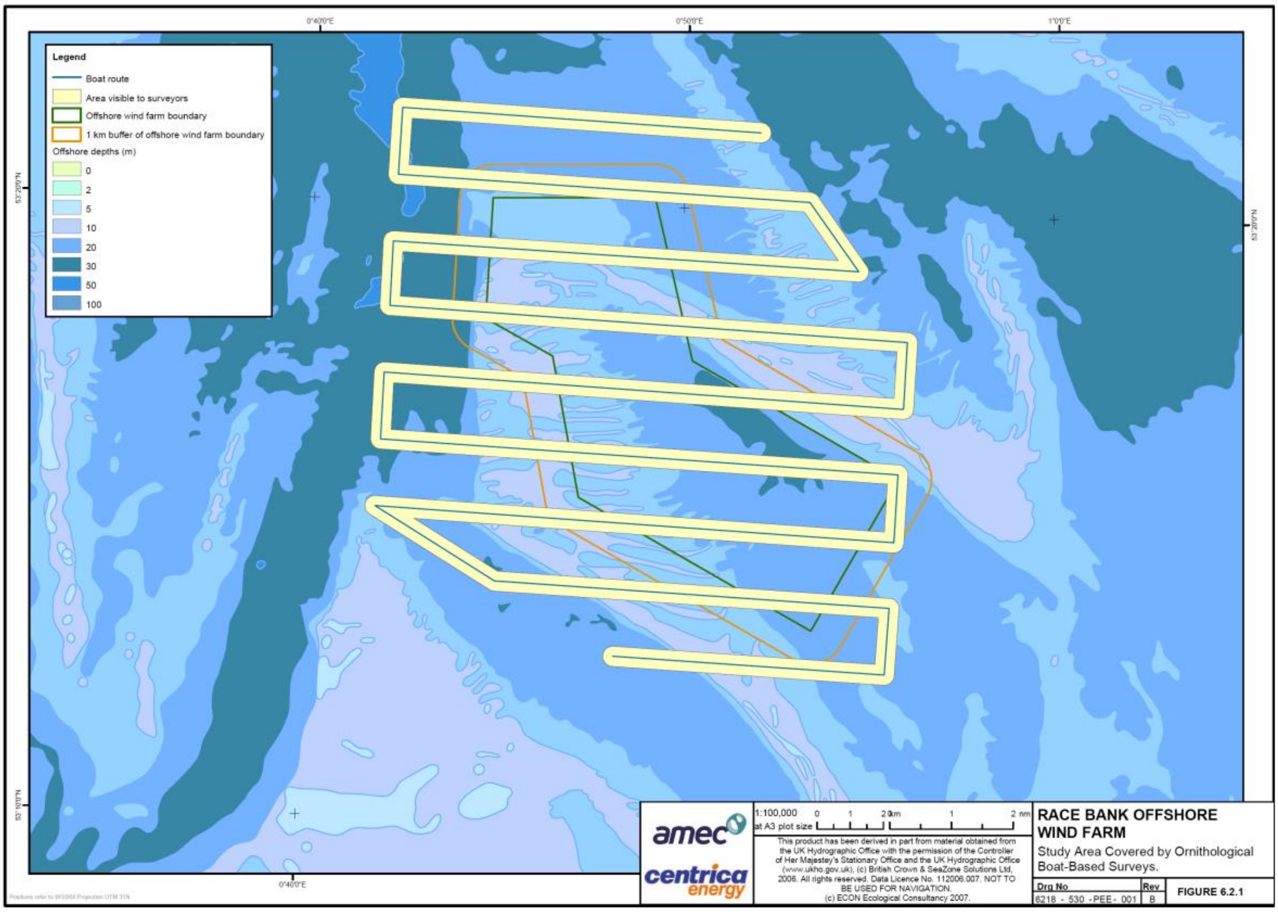

Figure 4.7 Race Bank OWF survey design (Centrica, 2009).

4.3.6 Dudgeon OWF

From December 2007 to April 2009, boat-based ornithological surveys were carried out for the Dudgeon OWF (Royal Haskoning, 2009) (Figure 4.8). The surveys covered the study area of 65.5 km^2, including a 1 km buffer. Across these surveys, harbour porpoise, harbour seal and grey seal were sighted.

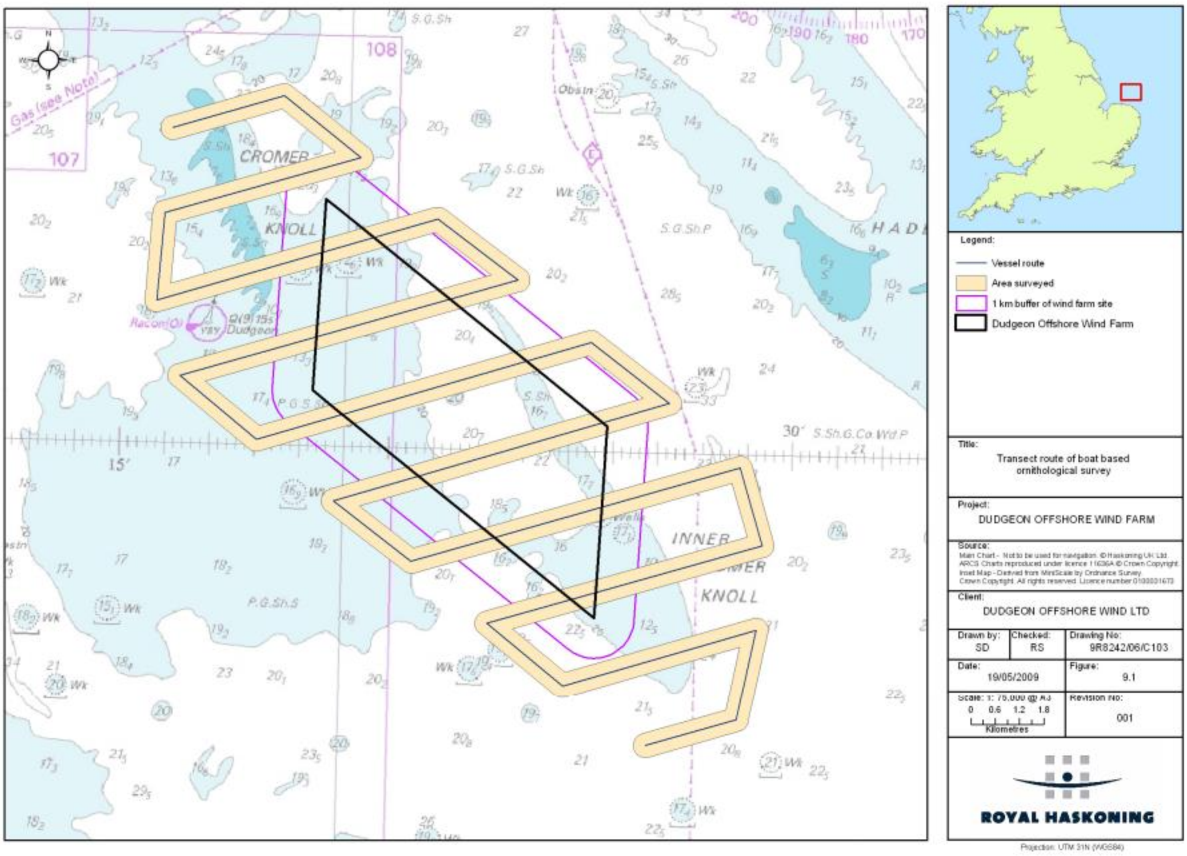

Figure 4.8 The boat-based survey design for Dudgeon Offshore Wind Farm (Royal Haskoning, 2009).

4.3.7 Sheringham Shoal OWF

Between November 2004 and January 2006, boat-based ornithological surveys were carried out for Sheringham Shoal OWF (Scira Offshore Energy Limited, 2006) (Figure 4.9). During these surveys incidental marine mammal sightings were recorded within the area of the wind farm (35 km^2) and up to a 1.5 km buffer distance. In total, a transect length of 89 km was achieved. Across the 29 surveys, harbour porpoise, harbour seal and grey seals were sighted. In addition, survey data from the Greater Wash strategic area was used to inform the Sheringham Shoal OWF baseline characterisation.

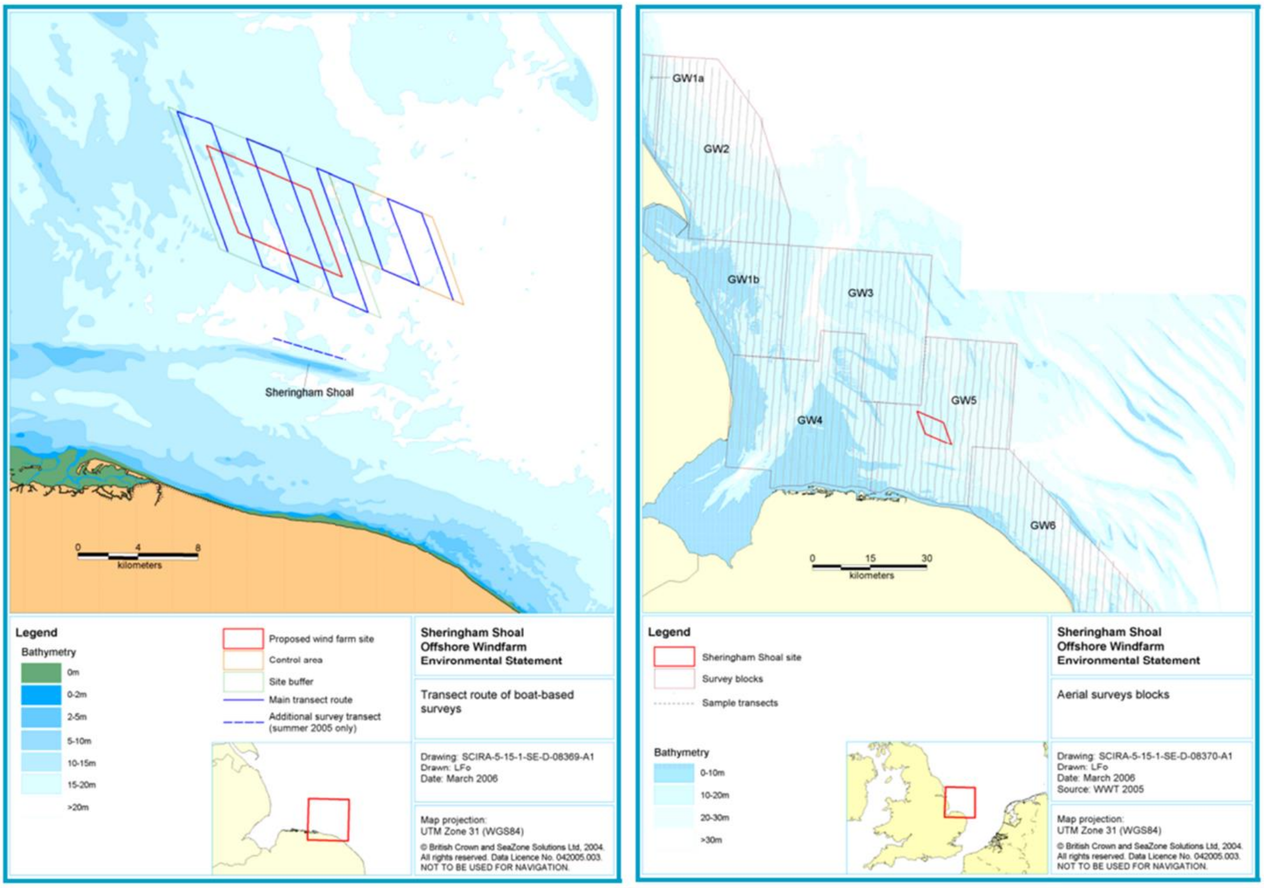

Figure 4.9 Sheringham Shoal boat-based (left) and aerial Greater Wash strategic area (right) ornithological survey design (Scira Offshore Energy Limited, 2006).

Boat-based construction monitoring surveys were also conducted during the construction period from 2009 – 2014, with a total of 106 surveys conducted (22 in each monitoring year except for the 2010-2011 period where 18 surveys were undertaken). To allow for comparison with the baseline surveys, the same basic transect route was used during construction monitoring, but with extended transect lines to incorporate the increased buffer area. Transect lines were moved eastward in October 2010 to ensure the turbine locations were avoided. Harbour porpoise, harbour seal and grey seals were observed during these surveys (ECON Ecological Consultancy Ltd, 2014).

4.3.8 Lincs OWF

Monthly boat-based ornithological surveys were conducted from April 2004 to March 2006 for the Lincs OWF (Figure 4.10) (Centrica energy, 2010). The surveys were carried out across 9 transect lines (including 3 control transects) in the Lincs project area, including a 1 km buffer. There were four additional boat-based ornithological surveys conducted from June to July 2006 covering a study area of 406.51 km^2 (including a buffer of 500m) (ECON Ecological Consultancy Ltd, 2006). Incidental marine mammal sightings were recorded throughout both survey periods, including harbour porpoise, harbour seal and grey seal.

In 2004, Ecologic UK Ltd conducted a dedicate porpoise survey using boat-based visual and acoustic survey methods determine the extent of the porpoise population in the Lincs OWF area, compromising a series of transects approximately 5 miles long and spaced 1.5 miles apart. During the surveys, there were visual observations of harbour porpoise, harbour seal and grey seal, and possible porpoise detections were made (Ecologic UK Ltd, 2021).

In addition, survey data from the Greater Wash strategic area was used to inform the Lincs OWF baseline characterisation.

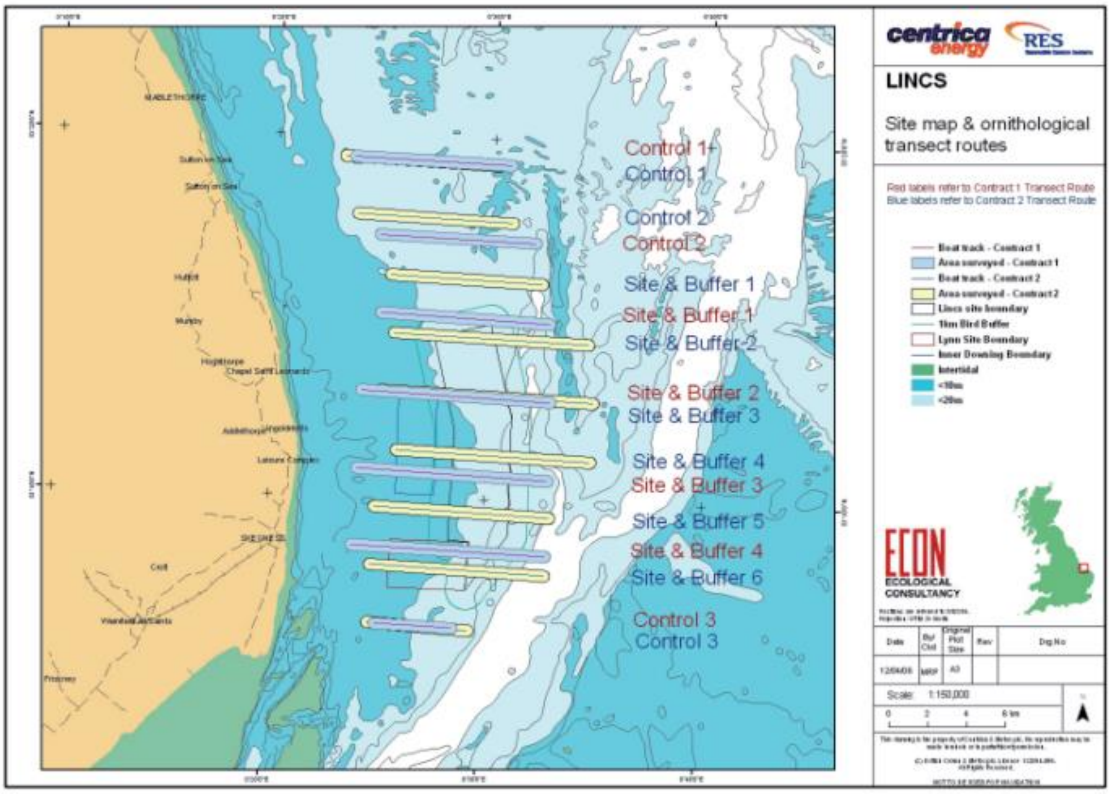

Figure 4.10 The Lincs OWF survey design and transect routes form the ornithological surveys (Centrica energy, 2010).

4.3.9 Lynn and Inner Dowsing OWFs

Ornithological surveys were conducted for Lynn and Inner Dowsing, in which marine mammal sightings were recorded (AMEC Offshore Wind Power Limited, 2002, Offshore Wind Power Limited, 2003). The surveys were carried out between October 2001 and October 2002, covering an area of approximately 25 km^2, including a 700-900 m buffer for each wind farm (Figure 4.11). The transects were spaced at 1.1 to 1.5 km intervals and all surveys were conducted at a speed of approximately 10 knots. A control site was studied in parallel to the wind farm survey areas and the survey methods followed the European Seabirds at Sea (ESAS) protocols. Across the 17 surveys, low numbers of harbour porpoise, harbour seal, grey seal and unidentified seals were recorded.

During the construction of Lynn and Inner Dowsing, boat-based ornithological surveys were carried out between July and December 2007 (RPS, 2008). Incidental marine mammal sightings were recorded throughout. The surveys covered the OWF sites, plus a 1 km buffer for both sites, and a control site (Figure 4.12). The methodology of the surveys was based on that recommended by COWRIE, including transect widths of 300 m and a ship speed of ~10 knots, and therefore not designed for marine mammal surveys. Across the surveys, harbour seals, grey seals and unidentified seal sightings were recorded. No post-construction monitoring was conducted as it was not required by the FEPA Licences (RPS, 2014).

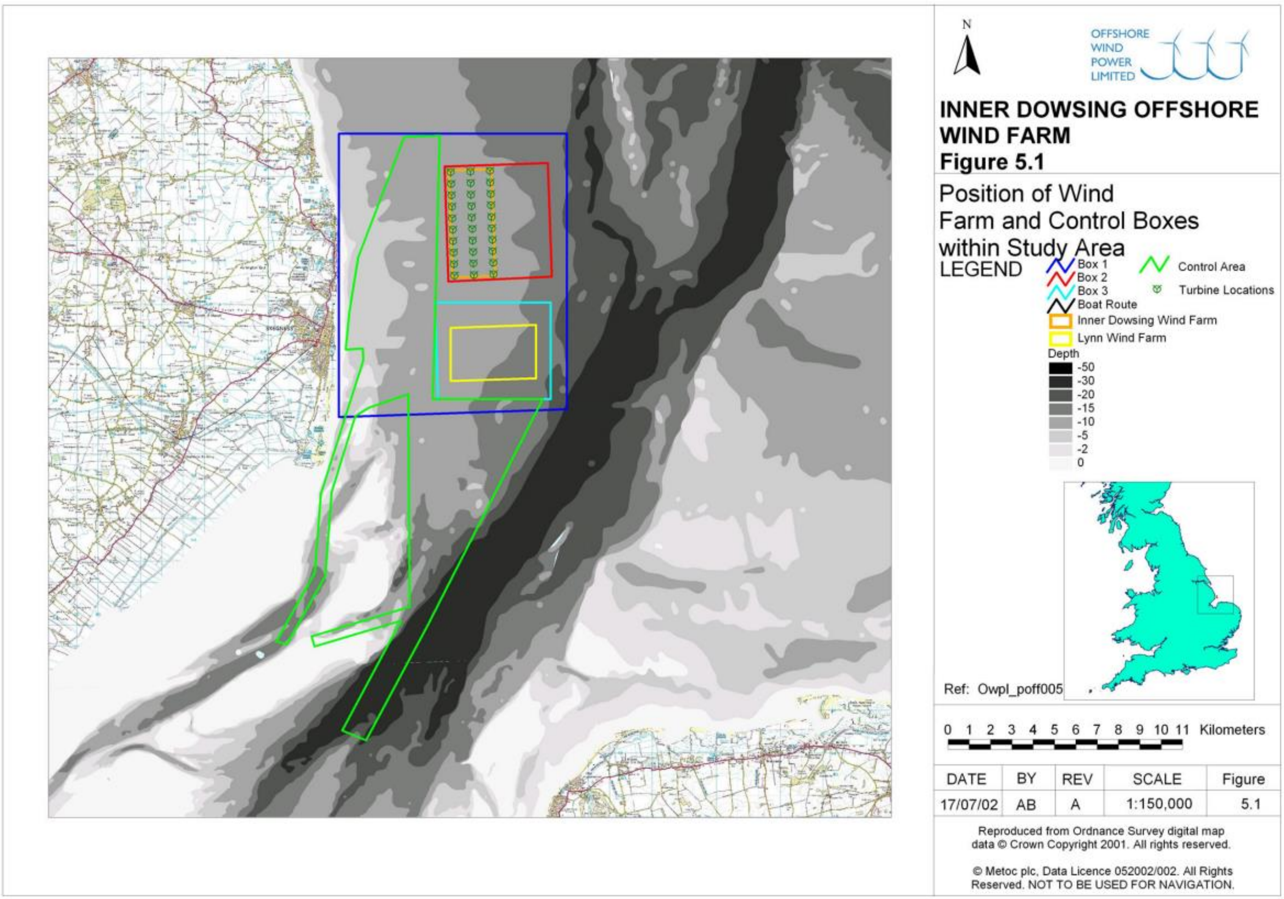

Figure 4.11 The Lynn and Inner Dowsing OWF survey areas (Offshore Wind Power Limited, 2003, Centrica energy, 2010).

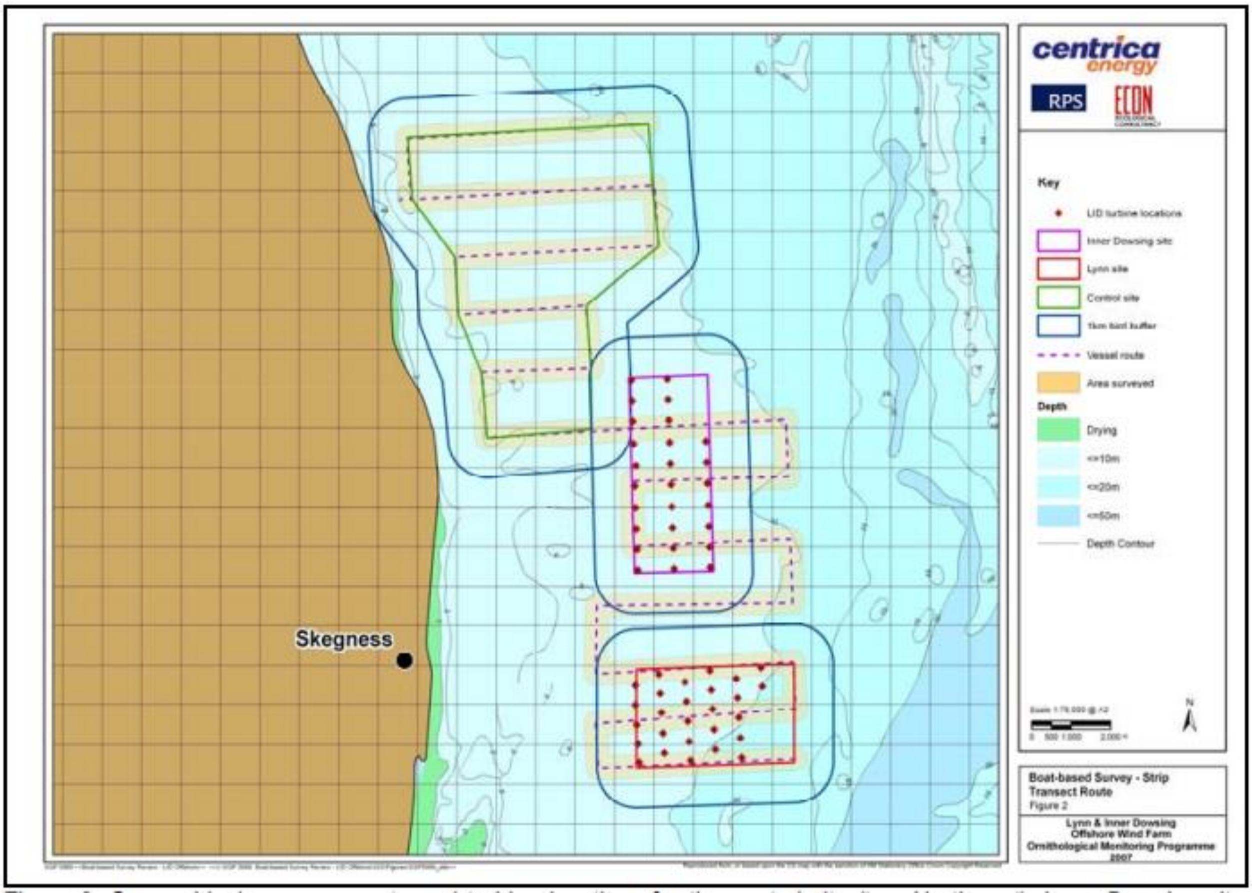

Figure 4.12 The design for the Lynn and Inner Dowsing monitoring surveys during construction (RPS, 2008).

4.4 Small Cetaceans in the European Atlantic and North Sea (SCANS)

The main objective of the SCANS surveys was to estimate small cetacean abundance and density in the North Sea and European Atlantic continental shelf waters. The SCANS I surveys were completed in 1994, SCANS II in July 2005 and SCANS III in July 2016 and all comprised a combination of vessel and aerial surveys. Both aerial and boat-based survey methodologies were designed to correct for availability and detection bias and allow the estimation of absolute abundance (Hammond *et al.*, 2017, Hammond *et al.*, 2021). The aerial surveys involved a single aircraft method using circle-backs (or race-track) methods whereas the boat-based surveys involved a double platform 'primary' and 'secondary' tracker methodology.

The Project is located in SCANS III survey block O (Hammond *et al.*, 2021) where aerial surveys were undertaken during June and July 2016 (Figure 4.13). Aerial surveys in this area covered 60,198 km^2 and 3,242.8 km of primary search effort was undertaken.

As part of SCANS III, the survey data were modelled in relation to spatially linked environmental features to produce density surface maps for the following cetacean species: harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin, striped dolphin, long-finned pilot whale, beaked whale species, minke whale and fin whale (Lacey *et al.*, 2022). The cetacean data used in the models were the same as those obtained in 2016 that were used to provide block specific abundance estimates in Hammond *et al.* (2021). The environmental covariates used in the density surface modelling were selected due to their potential to explain the additional variability in the cetacean density estimates (for example, depth of the seabed, sea surface temperature (see Lacey *et al.* (2022) for the full list of environmental covariates). The models were fitted using a spatial resolution of 10 km and predicted onto a 10 x 10 km spatial grid. Using the predicted density estimates from the surface models, density and abundance estimates can be generated for an entire survey area or a defined area within it, such as the Project site.

While the SCANS surveys provide sightings, density and abundance estimates at a wide spatial scale, the surveys are conducted during a single month, every 11 years and therefore do not provide any fine scale temporal or spatial information on species abundance and distribution. Furthermore, due to the change in survey blocks used across the SCANS surveys direct comparison between the surveys for abundance and density information is not possible.

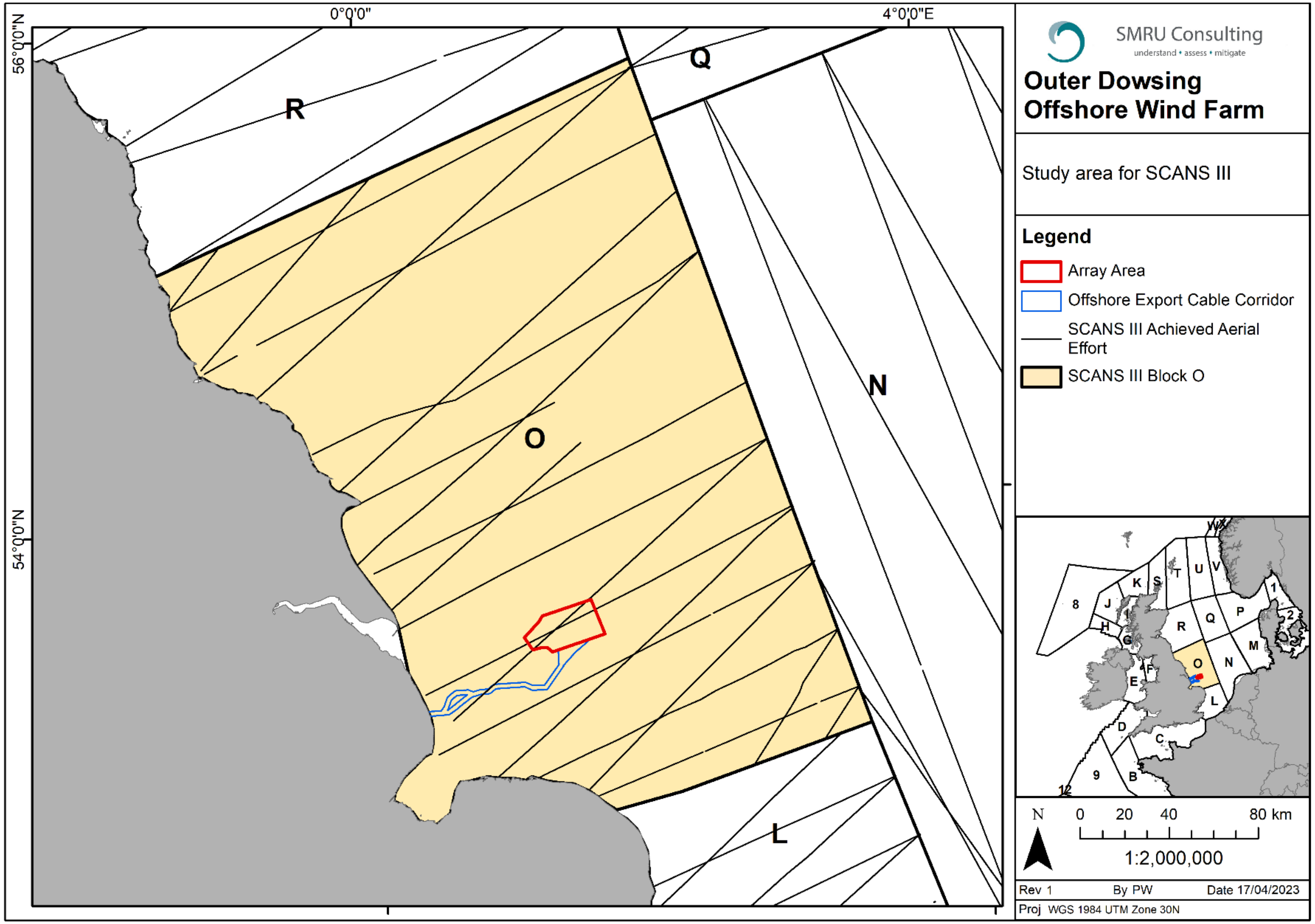

Figure 4.13 SCANS III survey block O and aerial transect effort in relation to the Project

4.5 Joint Cetacean Protocol (JCP)

4.5.1 JCP Phase III

The JCP Phase III analysis included datasets from 38 sources, totalling over 1.05 million km of survey effort between 1994 and 2010 from a variety of platforms (Paxton *et al.*, 2016). The JCP Phase III analysis was conducted to combine these data sources to estimate spatial and temporal patterns of abundance for seven species of cetaceans (harbour porpoise, minke whales, bottlenose dolphins, common dolphins, Risso's dolphins, white-beaked dolphins, and white-sided dolphins). The JCP Phase III analysis provided abundance estimates for specific areas of commercial interest for offshore developments. The Project does not directly overlap with any of these commercial areas, however, those of most relevance to the Project are the South Dogger Bank and Norfolk Bank areas (Figure 4.14). South Dogger Bank is located to the north of the Project site and covers an area of 14,265 km^2. Norfolk Bank is located to the east of East Anglia and to the south of the Project site, covering an area of 14,295 km^2 (Paxton *et al.*, 2016).

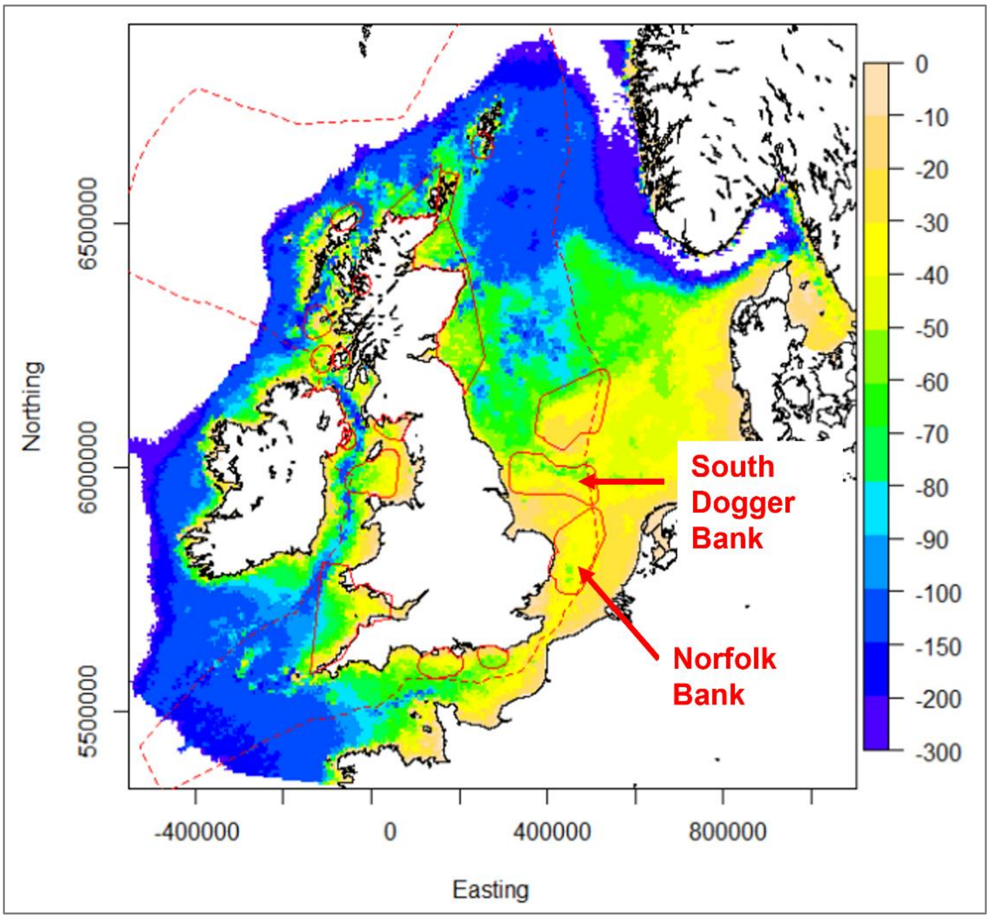

Figure 4.14 The Phase III region showing (red) areas of interest for offshore development where estimates of abundance are of special commercial interest (red dashed line = British exclusive economic zone, colour = depth in m) (Paxton *et al.*, 2016).

4.5.2 JCP data analysis tool

In 2017, JNCC released the JCP Phase III Data Analysis Product[2] that can be used to extract the cetacean abundance estimates for summer 2007-2010 (average) for a user specified area (the Project array area, plus a 50 km buffer) (Figure 4.15). This code was originally created by Charles Paxton at CREEM and was modified by JNCC to include abundance estimates that are scaled to the SCANS III results.

[2] https://hub.jncc.gov.uk/assets/01adfabd-e75f-48ba-9643-2d594983201e

It should be noted that there are several limitations of this dataset. The data are between 10 and 26 years old and as such, do not provide a recent density estimate against which to assess impacts. The authors state that the JCP database provides relatively poor spatial and temporal coverage, that the results should be considered indicative rather than an accurate representation of species distribution, and that due to the patchy distribution of data, the estimates are less reliable than those obtained from SCANS surveys. In addition, the authors categorically state that the JCP Phase III outputs cannot be used to provide baseline data for impact monitoring of short-term change or to infer abundance at a finer scale than 1,000 km^2 because of issues relating to standardizing the data (such as corrections for undetected animals and potential biases) from so many different platforms/methodologies and the strong assumptions that had to be made when calculating detection probability. In addition, the density estimates obtained from the Data Analysis Tool is an averaged density estimate for the summer 2007-2010 and are therefore not representative of densities at other times of the year.

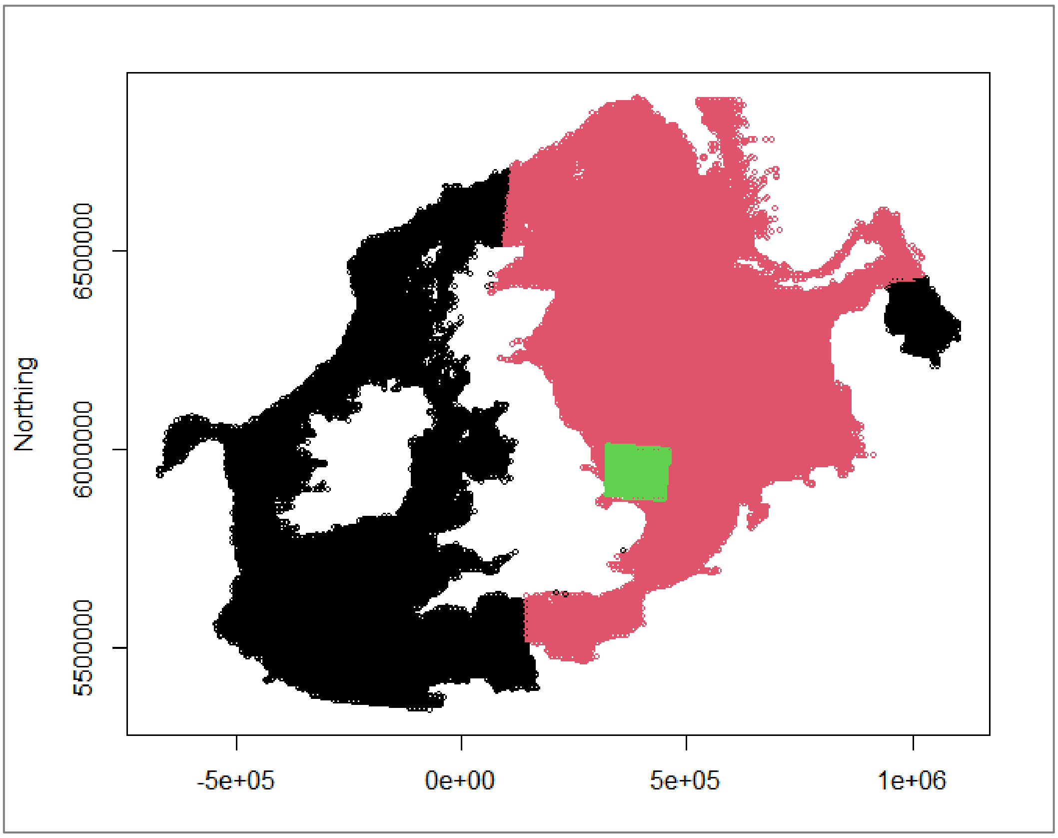

Figure 4.15 The user specified area used to extract cetacean abundance and density estimates from the JCP III R code. The map shows the whole area under consideration (black + pink + green), the harbour porpoise North Sea MU (pink) and the specific area of interest (green).

4.5.3 Porpoise high density areas

Heinänen and Skov (2015) conducted a detailed analysis of 18 years of survey data on harbour porpoise around the UK between 1994 and 2011 held in the Joint Cetacean Protocol (JCP) database. The goal of this analysis was to try to identify "discrete and persistent areas of high density" that might be considered important for harbour porpoise with the ultimate goal of determining SACs for the species. The analysis grouped data into three subsets: 1994-1999, 2000-2005 and 2006-2011 to account for patchy survey effort and analysed summer (April-September) and winter (October-March) data separately to explore whether distribution patterns were different between seasons and to examine the degree of persistence between the subsets. The authors note that "*due to the uneven survey effort over the modelled period, the uncertainty in modelled distributions vary to a large extent*". In addition, the authors stated that "*model uncertainties are particularly high during* *winter*". The uncertainties in the modelled distributions were taken into account when designating the draft SACs so that only areas with high confidence were retained (IAMMWG, 2015b).

4.6 MERP distribution maps

The aim of the MERP project (Marine Ecosystems Research Programme) was to produce species distribution maps of cetaceans and seabirds at basin and monthly scales for the purposes of conservation and marine management. A total of 2.68 million km of survey data in the Northeast Atlantic between 1980 and 2018 were collated and standardized. Only aerial and vessel survey data were included where there were dedicated observers and where data on effort, survey area and transect design were available. The area covered by Waggitt *et al.* (2020) comprised an area spanning between Norway and Iberia on a north-south axis, and Rockall to the Skagerrak on an east-west axis.

Waggitt *et al.* (2020) predicted monthly and 10 km^2 densities for each species (animals/km^2) and estimated the probability of encountering animals using a binomial model (presence-absence model) and estimated the density of animals if encountered using a Poisson model (count model). The product of these two components were used to present final density estimations (Barry and Welsh, 2002). The outputs of this modelling were monthly predicted density surfaces for 12 cetacean species at a 10 km resolution. There is no indication of whether the more recent sightings data are weighted more heavily than older data, which limits interpretation of how predictive the maps are to current distribution patterns. Therefore, while the density estimates obtained from these maps for harbour porpoise are representative of relative density compared to other sites around the UK, they are not considered to be suitable density estimates for use in quantitative impact assessment and are provided in this baseline characterisation for illustrative purposes only. This is especially key when considering harbour porpoise since previous survey efforts (SCANS I, II and III) have shown a southwards movement of harbour porpoise in the Southern North Sea.

4.7 Sea Watch Foundation and The Wildlife Trust (TWT) data

The Project has reached out to the Sea Watch Foundation and The Wildlife Trust for the relevant data for the Project. To date, no response has been received however, this information will be included in the ES if available.

4.8 SCOS

Under the Conservation of Seals Act 1970 (in England) and the Marine (Scotland) Act 2010, the Natural Environment Research Council (NERC) (now part of UK Research and Innovation) provides scientific advice to government on matters related to the management of UK seal populations through the advice provided by SCOS. SMRU provides this advice to SCOS on an annual basis through meetings and an annual report. The report includes advice on matters related to the management of seal populations, including general information on British seals, information on their current status and addresses specific questions raised by regulators and stakeholders.

4.8.1 Haul-out counts

Surveys of harbour seals are carried out during the summer months. The main population surveys are carried out when harbour seals are moulting, during the first three weeks of August, as this is the time of year when the largest numbers of seals are ashore. Grey seals are also counted on all harbour seal surveys, although these data do not necessarily provide a reliable index of population size. Grey seals aggregate in the autumn to breed at traditional colonies, therefore their distribution during the breeding season can be very different to their distribution at other times of the year.

The surveys are conducted in August primarily for harbour seals, though grey seals are comprehensively counted too. The survey methodology employed across this area is oblique aerial photography from fixed-wing aircraft and all seals were photographed from an altitude of approximately 100 m. In addition to the

August moult surveys, in 2011 and 2018 harbour seal pup surveys were conducted in late June/early July using the same methodology.

In order to estimate the number of seals present within the MU, the haul-out counts within the MU are scaled to account for the estimated proportion of seals at sea at the time of the count. For harbour seals, the percentage of the total population hauled-out during the August surveys is 72% (Lonergan *et al.*, 2013). For grey seals, the percentage of the total population hauled-out during the August surveys is 25.15% (SCOS, 2022)(see SCOS-BP 21/02).

4.8.2 Grey seal pup counts

SMRU's main surveys of grey seals are designed to estimate the numbers of pups born at the main breeding colonies around Scotland. Breeding grey seals are surveyed biennially between mid-September and late November using large-format vertical photography from a fixed-wing aircraft. The SMRU grey seal pup counts round the UK are augmented by surveys conducted by Scottish Natural Heritage, The National Trust, Lincolnshire Wildlife Trust and Friends of Horsey Seals.

4.9 Seal habitat preference

The seal at-sea usage maps were created to predict the at-sea density of seals in order to inform impact assessments and marine spatial planning. The original SMRU seal density maps were produced as a deliverable of Scottish Government Marine Mammal Scientific Support Research Program (MMSS/001/01) and were published in Jones *et al.* (2015). These were revised to include new seal telemetry and haul-out count data and modifications have been made to the modelling process (Russell *et al.*, 2017). The analysis uses telemetry data from 270 grey seals and 330 harbour seals tagged in the UK between 1991-2015, and haul-out count data from 1996-2015 to produce UK-wide maps of estimated at-sea density with associated uncertainty. The combined at-sea usage and haul-out data were scaled to the population size estimate from 2015.

A key limitation of the at-sea usage maps is that there was a lot of "null-usage" in the data, where only a subset of all available haul-out sites were visited by a tagged animal. For haul-out sites where no animal had been tagged, or where no tagged animal had visited, it had to be assumed that usage declined monotonically with distance from the haul-out which mean that potential hotspots around these haul-outs will have been missed.

Given the limitations of the at-sea usage maps, and the fact that the grey seal at-sea usage maps were informed mainly by old, low resolution tracking data, DESNZ funded a large-scale deployment of high resolution GPS telemetry tags on grey seals around the UK, and analyses to create up-to-date estimates of the at-sea distribution for both seal species (Carter *et al.*, 2020, Carter *et al.*, 2022). Telemetry data from 114 grey seals and 239 harbour seals were included in the analysis (Figure 4.16). To estimate the at-sea distribution, a habitat modelling approach was used, matching seal telemetry data to habitat variables (such as water depth, seabed topography, sea surface temperature) to understand the species-environment relationships that drive seal distribution. Haul-out count data (Figure 4.17) were then used to generate predictions of seal distribution at sea from all known haul-out sites in the British Isles. This resulted in predicted distribution maps on a 5x5 km grid. The estimated density surface gives the percentage of the British Isles at-sea population (excluding hauled-out animals) estimated to be present in each grid cell at any one time during the main foraging season.

The predicted habitat usage data is representative of spring distributions for harbour seals and summer distributions for grey seals since the majority of telemetry tracking data were collected in these seasons (Carter *et al.*, 2020). This is likely to be representative of seal distribution during the main foraging season, but is not considered to be representative of expected distributions during the breeding season where seal haul-out and movement patterns are markedly different. It is assumed in the habitat preference maps that there is temporal stability in the distribution of seals out with the breeding season.

In order to estimate the number of seals present in a specific area, the value provided in the relevant cell(s) (percentage of the British Isles at-sea population excluding hauled-out animals) were scaled by the total British

Isles at-sea population estimate (~150,700 grey seals and ~42,800 harbour seals) (Carter *et al.*, 2020) to estimate the number of animals present within the 5x5 km cell. This value can then be divided by 25 to obtain the density of seals per km^2.

The main limitation of this dataset is that only seals tagged in the British Isles were included in the analysis. Therefore, the habitat preference maps may underestimate the number of seals present in each grid cell as it does not account for those seals from haul-outs along the French coast or the Wadden Sea. In addition, there have been no tagging studies of grey seals in the south-England MU, and therefore the predicted at-sea distributions in this MU may not be representative of the true at-sea distribution.

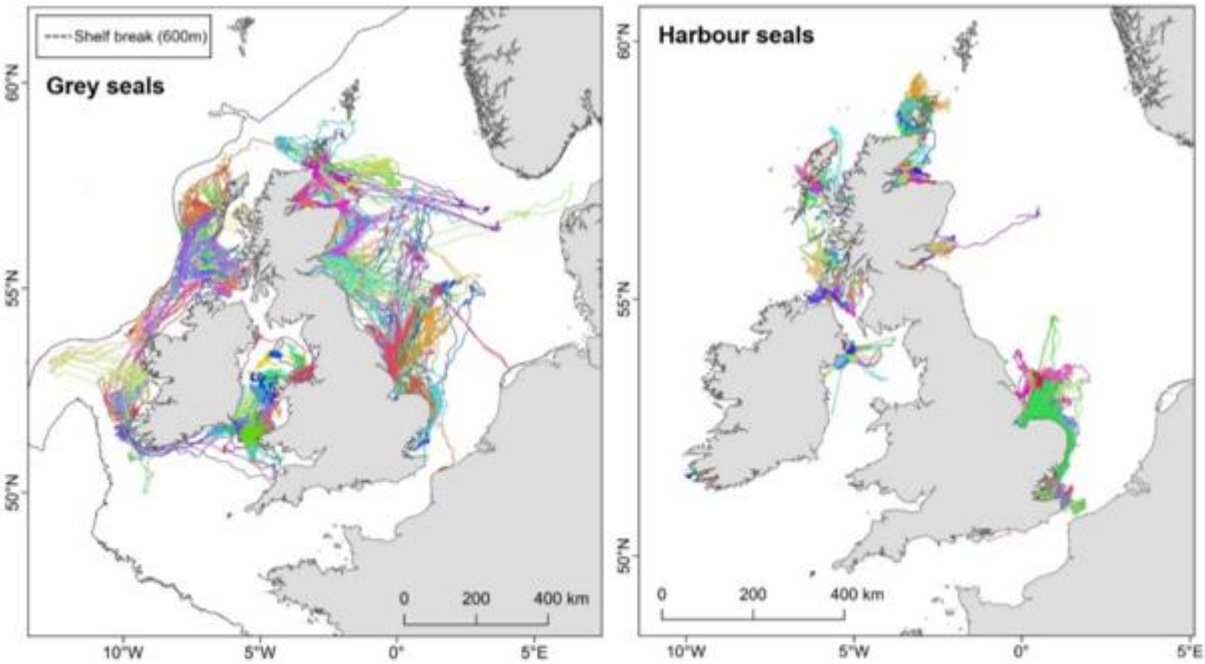

Figure 4.16 GPS tracking data for grey and harbour seals available for habitat preference models (Carter *et al.*, 2020).

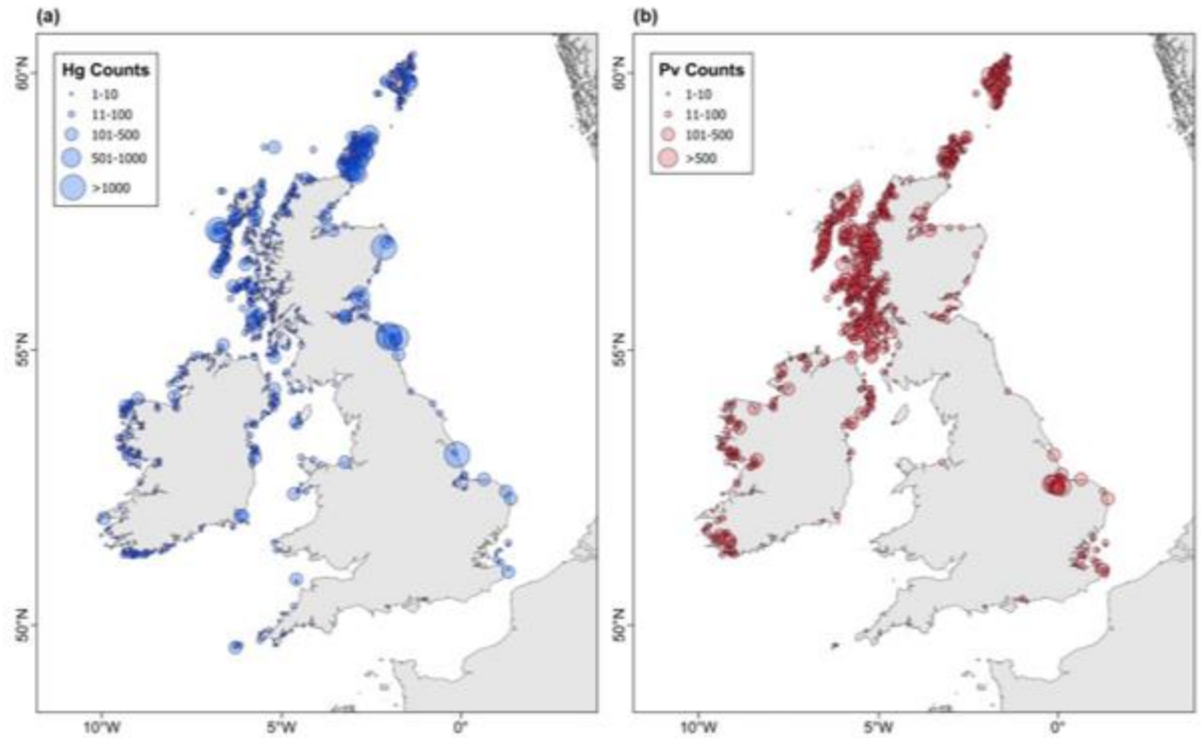

Figure 4.17 Most recent available August count data for (a) grey and (b) harbour seals per 5 km x 5 km haul-out cell used in the distribution analysis (Carter et al. 2020).

4.10 Seal telemetry

SMRU has developed telemetry tags on grey seals and harbour seals in the UK since 1988 and 2001, respectively. These tags transmit data on seal locations with the tag duration (number of days) varying between individual deployments (e.g. Carter *et al.*, 2020, Carter *et al.*, 2022). There are two types of telemetry tag which differ by their data transmission methods. Data transmission can be through the Argos satellite system (Argos tags) or mobile phone network (phone tags). Both types of transmission result in location fixes, but data from phone tags comprise better quality (GPS quality) and more frequent locations. The telemetry data were used to illustrate the distribution of seals at sea and to investigate connectivity between the Project and seal SACs (see section 9 and 10 for harbour and grey seal respectively).

Vincent *et al.* (2017) provide data on haul-outs and telemetry data for both harbour and grey seals along the French coast of the English Channel. Between 1999 and 2014 a total of 45 grey seals and 28 harbour seals were tagged and tracked for more than a month (Figure 4.18). Measures were taken in order to avoid issues of over-estimation amongst coastal locations, created due to seals spending reduced amounts of time underwater at these locations, potentially transmitting GPS and Argos transmissions more frequently. The measures included that for each density map, only locations within a 20-minute interval were interpolated from the raw data. Maps were generated using the at-sea distribution of individuals, interpolated locations within 0.1° grids which encompassed both the entire English Channel area and the southern Celtic Sea. All these locations were weighted separately for grey and harbour seals by capture site. This considered the abundance of days in which tracking data of seals was recorded for each study site.

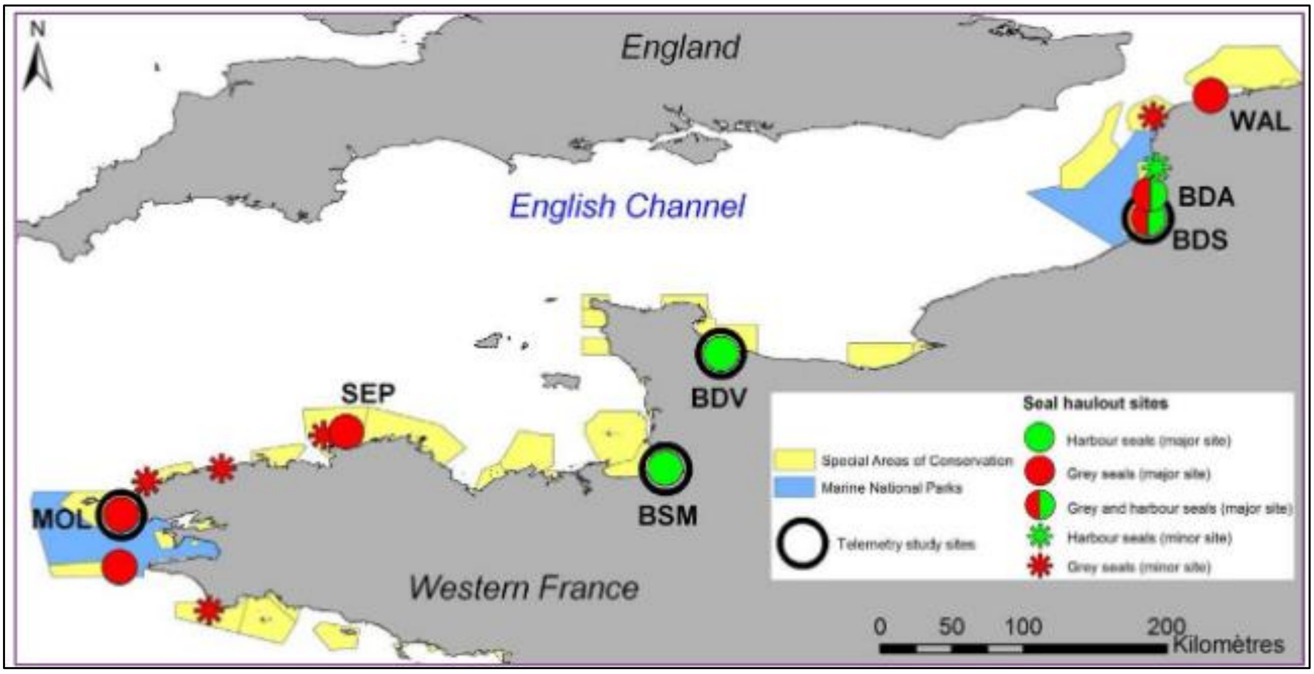

Figure 4.18 Map of all grey seals (red) and harbour seal (green) haul-out sites in metropolitan France (Vincent et al 2017). Circles indicate haul-out sites where the seasonal maximum number of seals exceeds 50 individuals. Stars indicate smaller haul-out sites used by fewer seals, not detailed in this study. Symbols surrounded by thick, black circles show the seal colonies where telemetry was conducted. Marine Protected Areas are also shown, including Special Areas of Conservation and Marine National Parks. Nature Reserves are not visible but also encompass some haul-out sites, in SEP, BDS and BDV for instance. Haul-out sites are: Molene Archipelago (MOL), Sept iIes Archipelago (SEP), Baie du Mont-Saint-Michel (BSM), Baie des Veys (BDV), Baie de Somme (BDS), Baie d'Authie (BDA) and Walde (WAL).

5 Harbour porpoise

5.1 MU

Harbour porpoise are distributed globally and can be found in shallow waters (<200 m) around the UK. The population estimate for the North Sea MU based on SCANS III data is 346,601 harbour porpoise (95% CI: 289,498 – 419,967, CV: 0.09) (IAMMWG, 2022). The conservation status of harbour porpoise in UK waters has been updated in JNCC (2019a) which concludes a favourable assessment of future prospects and range, but an unknown conclusion for population size and habitat. This resulted in an overall assessment of conservation status of "Unknown" and an overall trend in Conservation status of "Unknown". A trend analysis indicates that the harbour porpoise abundance in the North Sea is stable and has not changed since 1994, although the associated confidence intervals are quite wide (Hammond *et al.*, 2021). Harbour porpoise are listed as Least Concern on the IUCN red list, but as an Annex II species of the Habitats Directive, the designation of SACs is required as a component of their conservation. There is one SAC designated for harbour porpoise within the North Sea MU (Table 3.1).

5.2 Site-specific surveys

Harbour porpoises were the most frequently sighted marine mammal species in the site-specific baseline surveys to date (March 2021 – February 2022) consisting of 561 sightings (89% of the identified marine mammal sightings; Table 5.1). Harbour porpoise were observed in all months of the Year 1 survey.

Animals that were below 2 m depth were unavailable to be detected in the surveys, and therefore a correction factor was applied to the data. As described in Voet *et al.* (2017), the correction factor is based on the proportion of time spent at depth obtained from telemetry data from 35 harbour porpoise tagged around Denmark (Teilmann *et al.*, 2013b). This resulted in corrected harbour porpoise density estimates for the

Project site (Table 5.2), with an average monthly density estimate of 2.375 porpoise/km^2 throughout the first year. The maximum density estimate of 5.68 harbour porpoise/km^2 occurred in Sep-21, and were also similarly high in Jun-21 (5.34 harbour porpoise/km^2). Density estimates were lowest in the winter months from Dec-21 to Feb-22 where densities were ≤0.53 harbour porpoise/km^2 (Table 5.2 and Figure 5.1).

Harbour porpoise were observed across the survey area, both within the development area and the 2 km and 4 km buffers (Figure 5.2 and Figure 5.3). The area of highest densities varies seasonally across the survey area; highest densities were in the west of the development area in Sep-21 and in Nov-21 the density was higher in the south-east of the development area and 4 km buffer.

It was also noted that between May-21 and Jul-21 there were 15 adult-juvenile pairs observed, indicating this area may be used by harbour porpoise as a nursey ground.

Table 5.1 Number of harbour porpoise recorded from the HiDef surveys (the Project array area plus 4 km buffer) between March 2021 and February 2022 (HiDef, 2022).

Year 1	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
Harbour porpoise	61	37	80	107	34	41	98	28	49	9	10	7	561

Table 5.2 Adjusted density and population estimates for harbour porpoise in the Project survey area from the HiDef surveys between March 2021 and February 2022, taking into account the number of animals that are estimated as being unavailable for detection (HiDef, 2022)

Harbour porpoise	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (#/km^2)	Population estimate	Lower 95% CI	Upper 95% CI	Density estimate (#/km^2)	Population estimate	Lower 95% CI	Upper 95% CI
22-Mar-21	0.39	364	263	467	2.68	2500	1807	3208
04-Apr-21	0.24	226	127	354	1.39	1305	733	2044
12-May-21	0.54	497	381	620	3.58	3293	2524	4108
09-Jun-21	0.72	663	503	859	5.34	4916	3730	6370
24-Jul-21	0.22	208	152	266	1.66	1574	1150	2013
14-Aug-21	0.27	251	143	367	1.9	1766	1006	2583
07-Sep-21	0.64	593	449	782	5.68	5266	3988	6945
09-Oct-21	0.2	184	109	269	1.81	1662	984	2429
02-Nov-21	0.32	301	172	470	2.94	2765	1580	4318
15-Dec-21	0.06	55	29	85	0.52	478	252	739
06-Jan-22	0.07	62	7	144	0.53	472	53	1096
23-Feb-22	0.05	42	18	73	0.47	394	169	684
Average	**0.31**	**287**	**-**	**-**	**2.375**	**2199**	**-**	**-**

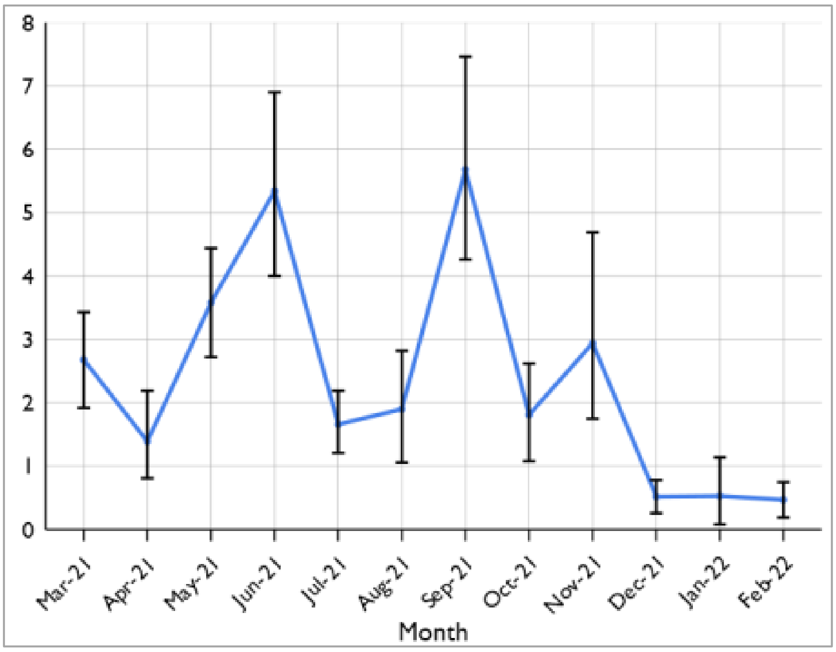

Figure 5.1 Harbour porpoise absolute density estimates (#/km²), with 95% confidence intervals, in the Project survey area, between March 2021 and February 2022 (HiDef, 2022).

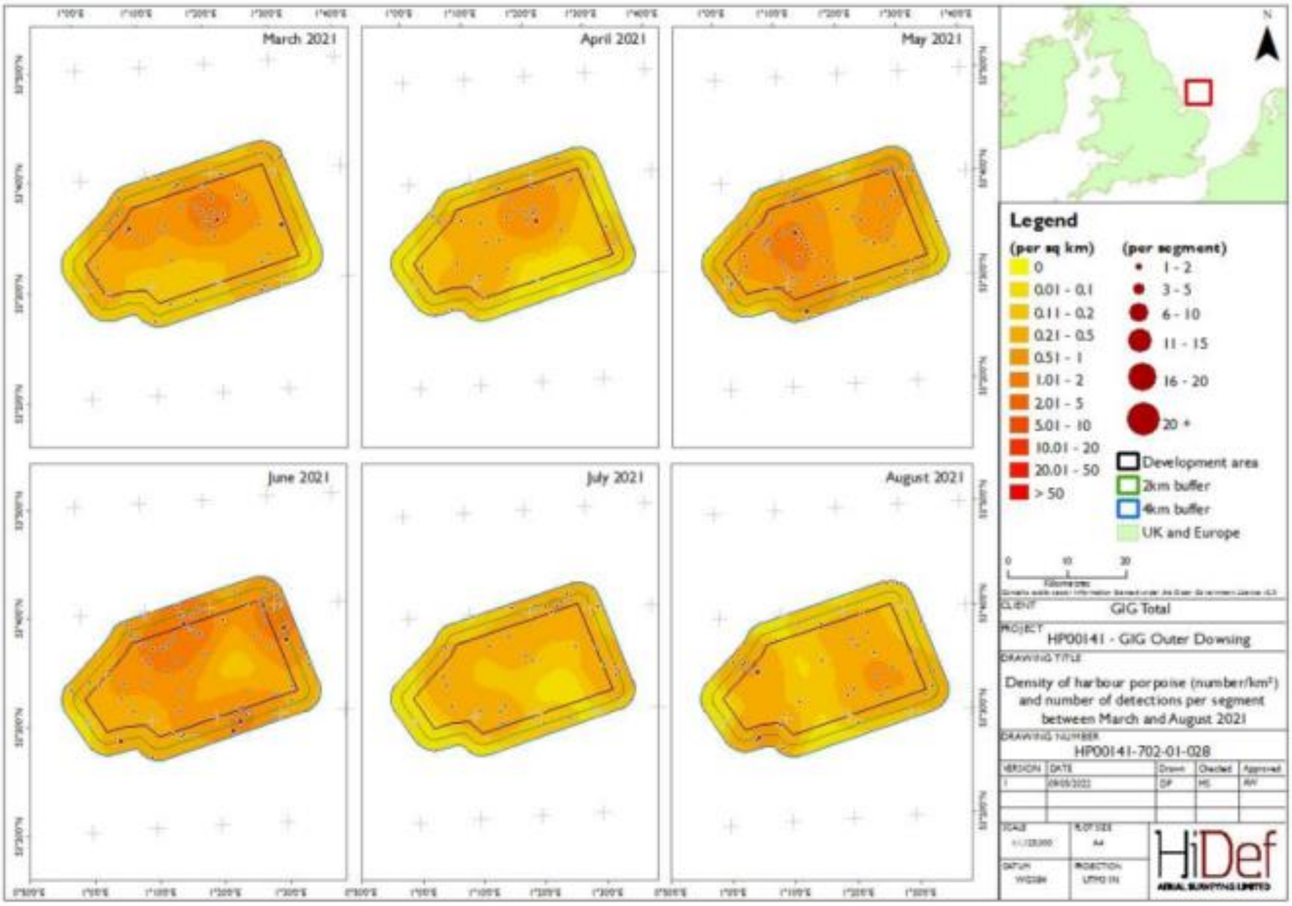

Figure 5.2 Density of harbour porpoises (number/km²) and number of detections per segment in the Project survey area between March and August 2021 (HiDef, 2022).

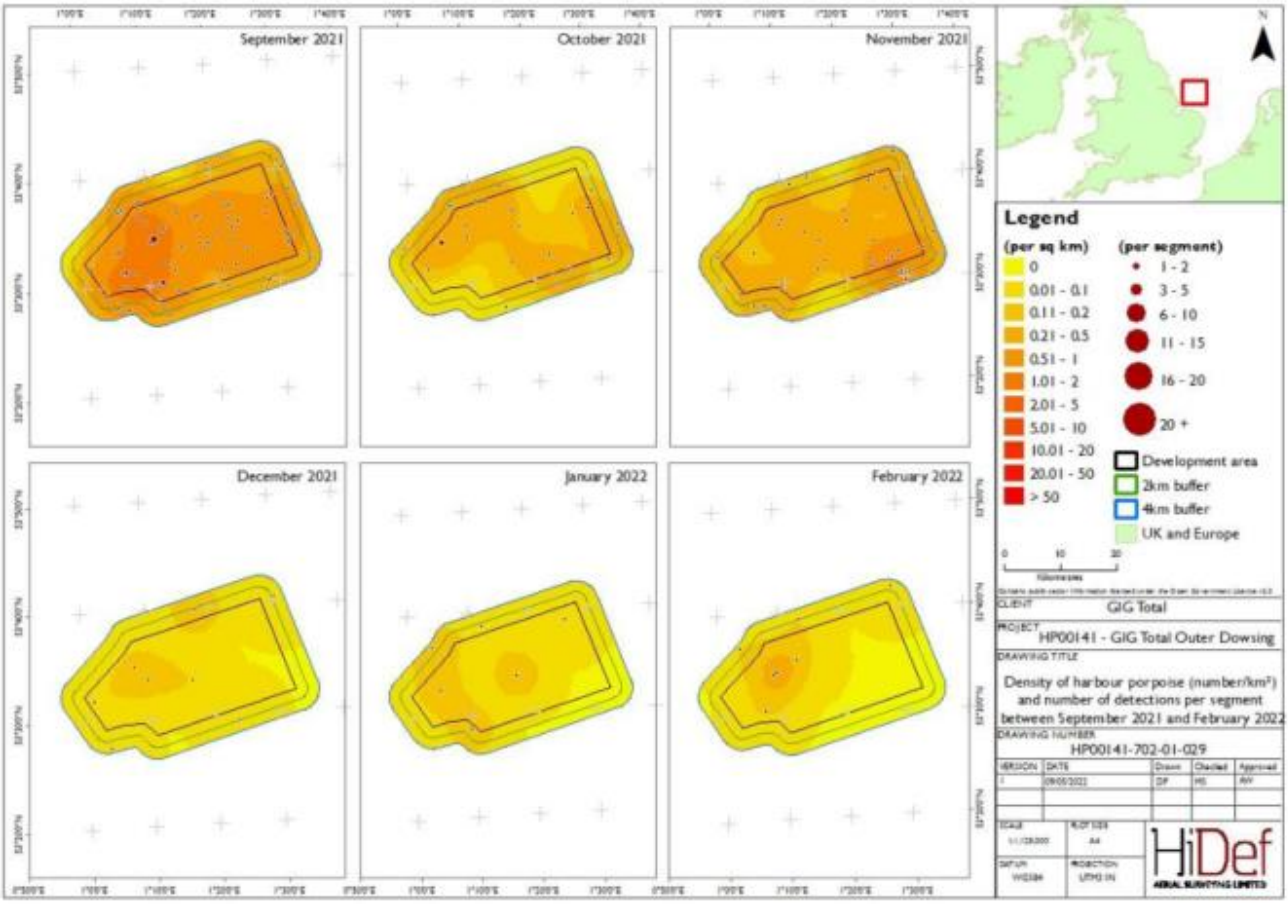

Figure 5.3 Density of harbour porpoises (number/km²) and number of detections per segment in the Project survey area between September 2021 and February 2022 (HiDef, 2022).

5.3 The Project geophysical surveys

During the 2021 geophysical survey, there was one incidental sighting of harbour porpoise on 20-Aug-21 whilst the vessel was in transit (Seiche, 2022b). During the 2022 geophysical surveys, three harbour porpoise were sighted (08-Apr-2022, 29-Apr-2022 and 18-May-2022) (Seiche, 2022a).

5.4 Nearby OWF surveys

Harbour porpoises were confirmed to be present at all nearby OWFs considered during their site-specific surveys. There were also three possible harbour porpoise acoustic detections during baseline monitoring conducted in the Lincs OWF area in addition to visual observations.

A total of 1,327 harbour porpoises were recorded during the Hornsea Four site-specific surveys, which equated to an adjusted average density of 1.74 harbour porpoise/km^2. However, there was interannual variation with higher densities during year 1 of the surveys (862 recorded, 2.24 harbour porpoise/km^2) compared year 2 of the surveys (465 recorded, 1.26 harbour porpoise/km^2). In addition, there were clear seasonal patterns with more harbour porpoise sighted in summer (Jun, Jul, Aug: 0.846 harbour porpoise/km^2) compared to winter (Dec, Jan, Feb: 0.094 harbour porpoise/km^2). It is also important to highlight that usage of the survey area was not uniform, with more sightings in the southern part of the survey area. During the three years of the Former Hornsea Zone surveys, 6,504 harbour porpoise were recorded. Harbour porpoise were present throughout the entire survey area, with patchily distributed densities with the Former Hornsea Zone (Orsted, 2021).

Density estimates were available from the Dudgeon and Sheringham Shoal extension site-specific surveys conducted from May 2018 to April 2020 produced a maximum (corrected) average winter density of

0.65 harbour porpoise/km^2 and a maximum average summer density of 1.46 harbour porpoise/km^2, indicating a seasonal pattern of porpoise presence. The maximum average annual density was calculated as 1.05 harbour porpoise/km^2 (Royal HaskoningDHV, 2021).

Harbour porpoise densities were also calculated during the Sheringham Shoal baseline and construction monitoring. The maximum density calculated was 0.4 harbour porpoise/km^2 within the 2km buffer in October 2009 (Year 1 of construction), with the majority of density values falling between 0.05 and 0.25 harbour porpoise/km^2 (ECON Ecological Consultancy Ltd, 2014).

5.5 SCANS

In SCANS III survey block O (Figure 5.4) there was an estimated block-wide abundance of 53,485 harbour porpoise (95% CI: 37,413 – 81,695, CV: 0.209) and an estimated density of 0.888 harbour porpoise/ km^2 (CV: 0.209).

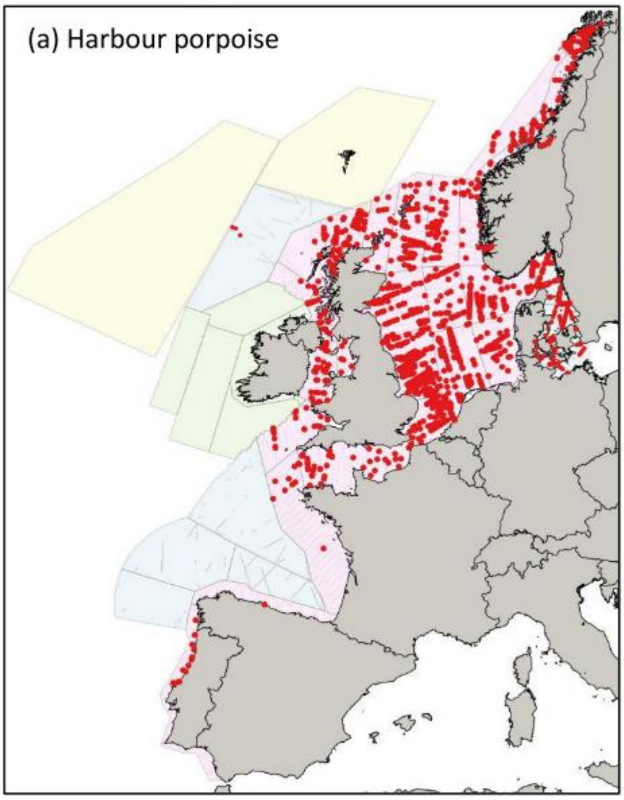

Figure 5.4 Distribution of harbour porpoise sightings during the SCANS III surveys (Hammond *et al.*, 2021).

The SCANS surveys of the whole of the North Sea show southwards shift in distribution of the North Sea harbour porpoise population between the survey years of 1994 (SCANS I) and 2005 (SCANS II); this pattern of higher densities in the southern North Sea persisted in the most recent 2016 surveys (Figure 5.5). The SCANS III data, while limited to summer months only, do provide a robust absolute density estimate for harbour porpoise, that has been corrected for availability and perception bias.

The SCANS III data was used to obtain predicted density surfaces (Lacey *et al.*, 2022). This shows that the predicted SCANS III harbour porpoise distribution across the MU during the summer is not uniform, with higher densities found in the southern North Sea, with densities decreasing into the central and northern North Sea (Lacey *et al.*, 2022). There is also an indication that the 2016 distribution extended further into the English Channel than previously modelled. However, the predicted density is still low in this region (Hammond *et al.*, 2021). Densities around the rest of the UK are typically low at <0.50 harbour porpoise/km^2 (Lacey *et al.*, 2022). The Project falls within an area with relatively high predicted densities. Within the Project survey area, the maximum predicted density was 1.25 harbour porpoise/km^2 and 1.55 harbour porpoise/km^2 within the ECC (Figure 5.5).

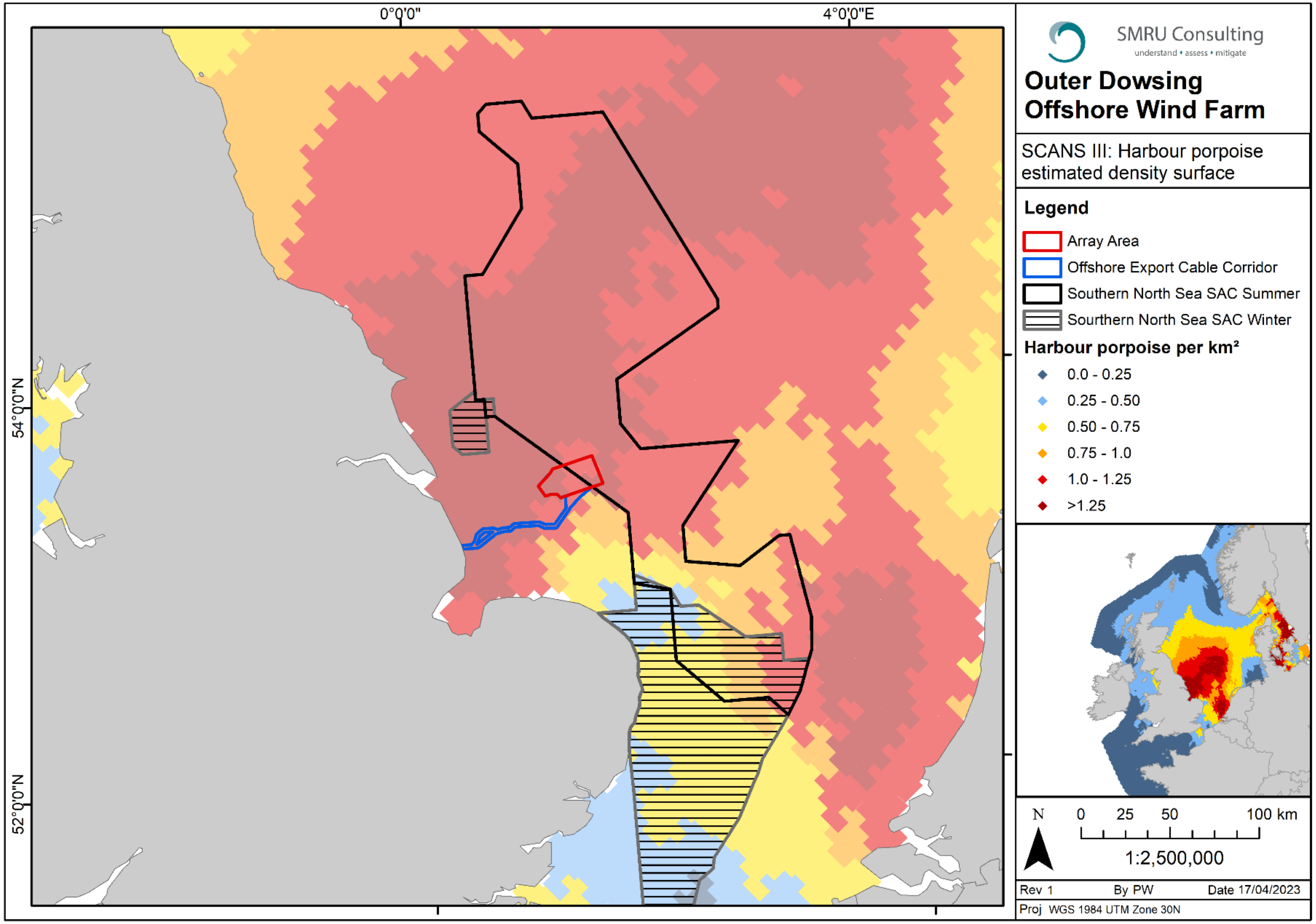

Figure 5.5 Estimated density surface for harbour porpoise using SCANS III data. Data from Lacey *et al.* (2022).

5.6 JCP

5.6.1 JCP Phase III

Paxton *et al.* (2016) used the JCP dataset to provide estimates of the density of harbour porpoise (Figure 5.6 and Figure 5.7) at South Dogger Bank (14,265 km^2) and Norfolk Bank (14,295 km^2) (neither area overlaps directly with the Project but are located to the north and south of the Project site). At South Dogger Bank, the density is estimated to be greatest during winter at 1.290 harbour porpoises/km^2 (95% CI: 0.878-1.847) and lowest during autumn at 0.351 harbour porpoises/km^2 (95% CI: 0.260-0.520). The same seasonal pattern in density is estimated at Norfolk Bank, albeit at an overall lower density, with 0.958 harbour porpoise/km^2 (95% CI: 0.490-1.833) during winter and 0.280 harbour porpoises/ km^2 (95% CI: 0.126-0.595) in autumn (Table 5.3).

Table 5.3 JCP Phase III abundance and density estimates for harbour porpoise in 2010 for the South Dogger Bank and Norfolk Bank regions (Paxton *et al.*, 2016).

Season	Abundance point estimate	95% CI	Density (#/km^2)
South Dogger Bank			
Winter	18,400	12,500 - 26300	1.290
Spring	7,000	4,000 – 13,6000	0.491
Summer	9,700	6,700 – 13,200	0.680
Autumn	5,000	3,700 – 7,400	0.351
Average	**10,025**	**-**	**0.703**
Norfolk Bank			
Winter	13,700	7,000 – 26,200	0.958
Spring	5,300	2,600 – 15,600	0.372
Summer	7,100	3,600 – 12,700	0.498
Autumn	4,000	1,800 – 8,500	0.280
Average	**7,525**	**-**	**0.528**

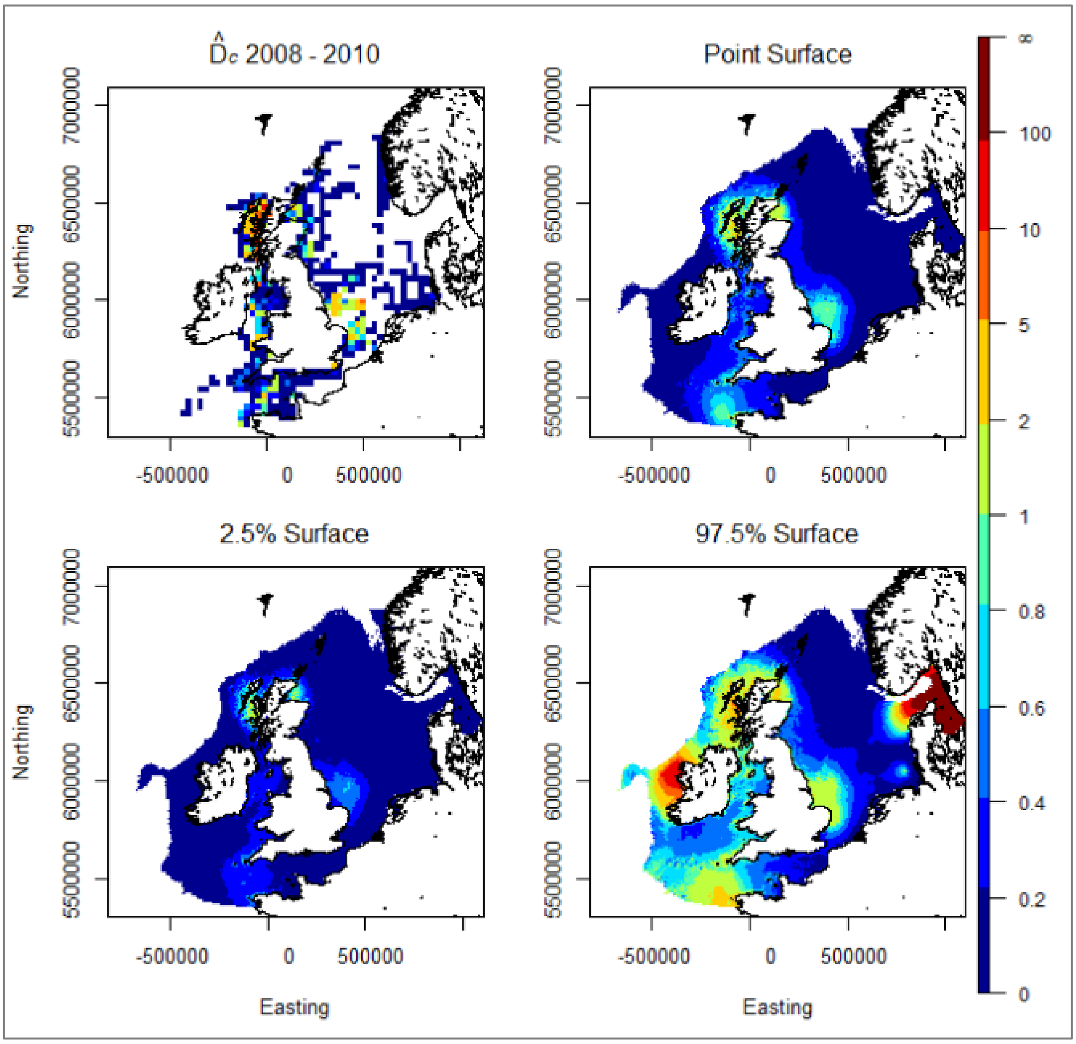

Figure 5.6 Predicted harbour porpoise densities for summer 2010 (Paxton *et al.*, 2016). Top left; input densities (summer all years), top right; point estimate of cell densities, bottom left; lower (2.5%) confidence limit on cell densities, bottom right; upper (97.5%) confidence limit on cell densities (dolphins/km²). Note that the top left plot exaggerates the spatial coverage of the relevant effort.

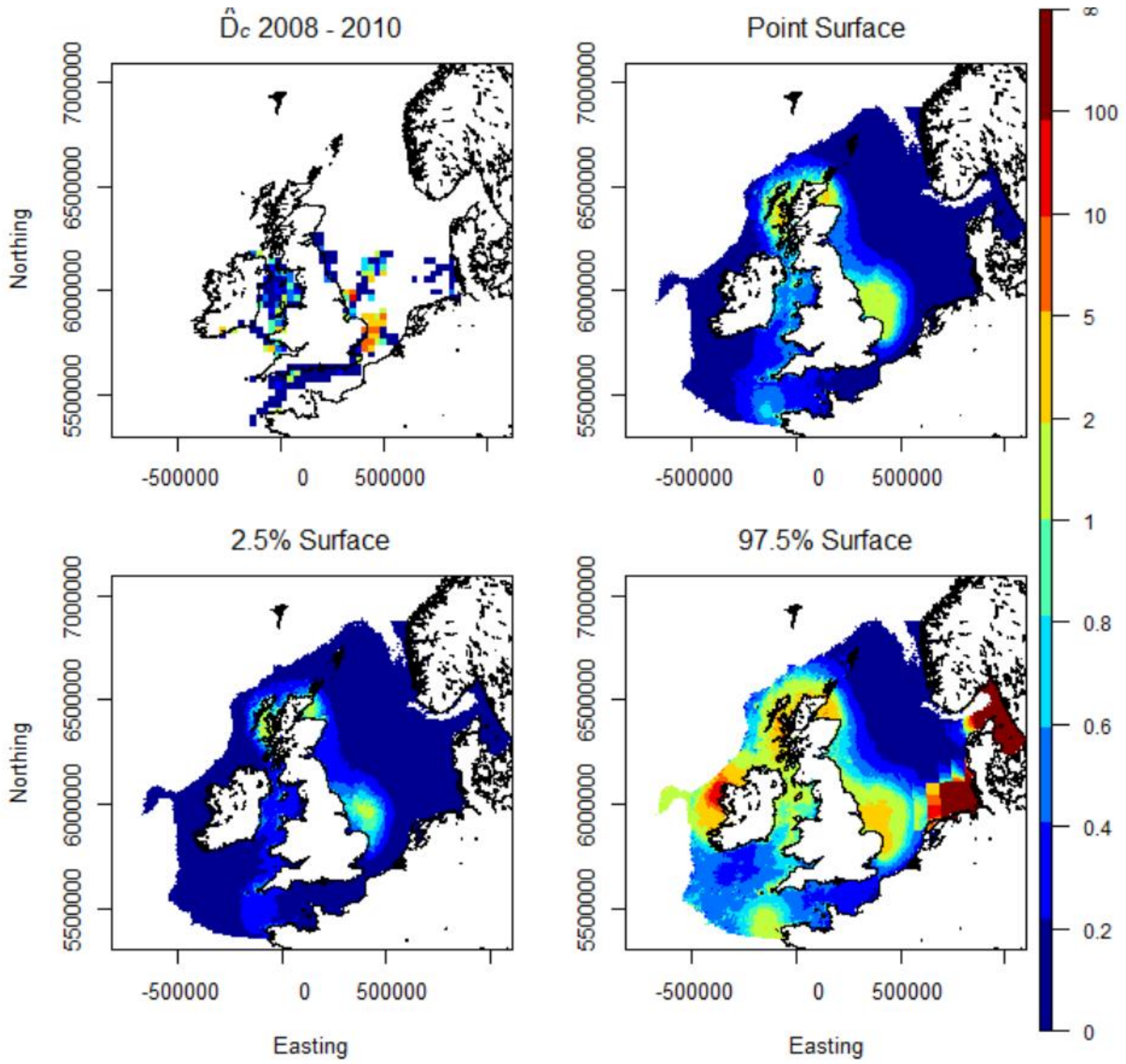

Figure 5.7 Predicted harbour porpoise densities for winter 2010 (Paxton *et al.*, 2016). Top left; input densities (summer all years), top right; point estimate of cell densities, bottom left; lower (2.5%) confidence limit on cell densities, bottom right; upper (97.5%) confidence limit on cell densities (dolphins/km^2). Note that the top left plot exaggerates the spatial coverage of the relevant effort.

5.6.2 JCP data analysis tool

The JCP Phase III Data Analysis Product provided a high estimate of 2.77 harbour porpoise/km^2 (95% CI: 1.48-3.78) in the vicinity of the Project, averaged for the summer 2007-2010 (Table 5.4). It is important to note that this estimate is for the summer months only and is not representative of densities at other times of the year. Other sources such as the JCP Phase III data (Paxton *et al.*, 2016) showed a higher expected harbour porpoise density during winter months and, therefore, the summer densities presented in Table 5.4 are likely lower than the densities that would be expected in this area during the winter.

Table 5.4 JCP Phase III Data Analysis Product abundance and density estimates for harbour porpoise for the user specified area (see Figure 4.15) averaged for the summer 2007-2010.

	Abundance	Density (#/km^2)
Point estimate	48,736	2.77
Lower confidence interval	26,037	1.48
Upper confidence interval	66,428	3.78

5.6.3 Porpoise high density areas

Discrete and persistent areas of relatively high harbour porpoise densities in the wider UK marine area were identified by Heinänen and Skov (2015) through the use of detailed analyses of 18 year of survey data as part of the JCP. The analysis conducted by Heinänen and Skov (2015) showed that density estimates were high throughout parts of the North Sea in both summer and winter (>2 porpoise/km^2), and as such the Southern North Sea SAC for harbour porpoise was designated. Specifically, high density areas were highlighted off the east of the Norfolk coast up to >3 harbour porpoise/km^2. In the vicinity of the Project, harbour porpoise were predicted to be present in higher densities during winter with a result of 2.1-2.4 harbour porpoise/km^2 (winter 2009). In contrast, during summer, the predicted densities were lower at a maximum of 0.912 harbour porpoise/km^2, suggesting seasonal variation at the Project site (Figure 5.8).

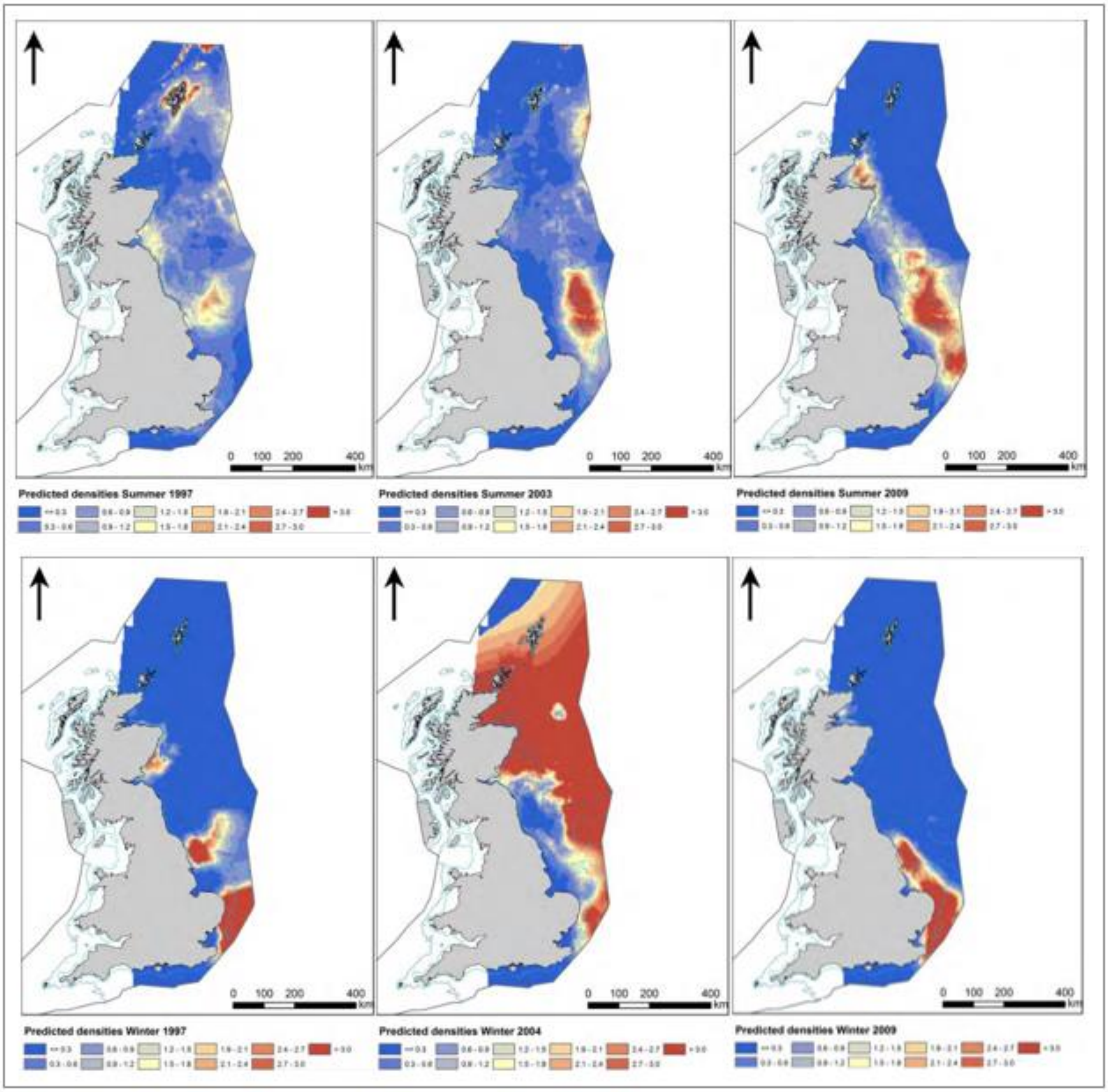

Figure 5.8 Predicted densities (#/km^2) during summer (top panel) and winter (bottom panel) in management unit 1 for three different years in each model period (Heinänen and Skov 2015).

5.6.4 MERP distribution maps

The year-round high density in the southern North Sea has also been demonstrated by the analyses presented in Waggitt *et al.* (2020). Density maps were produced by Waggitt *et al.* (2020) as part of the MERP project (Figure 5.9) which shows higher densities expected offshore and in the mid North Sea compared to the southern North Sea and English Channel. However, these maps are not considered to be suitable for quantitative impact assessments (see Section 4.6) and are provided in this baseline characterisation for illustrative purposes only.

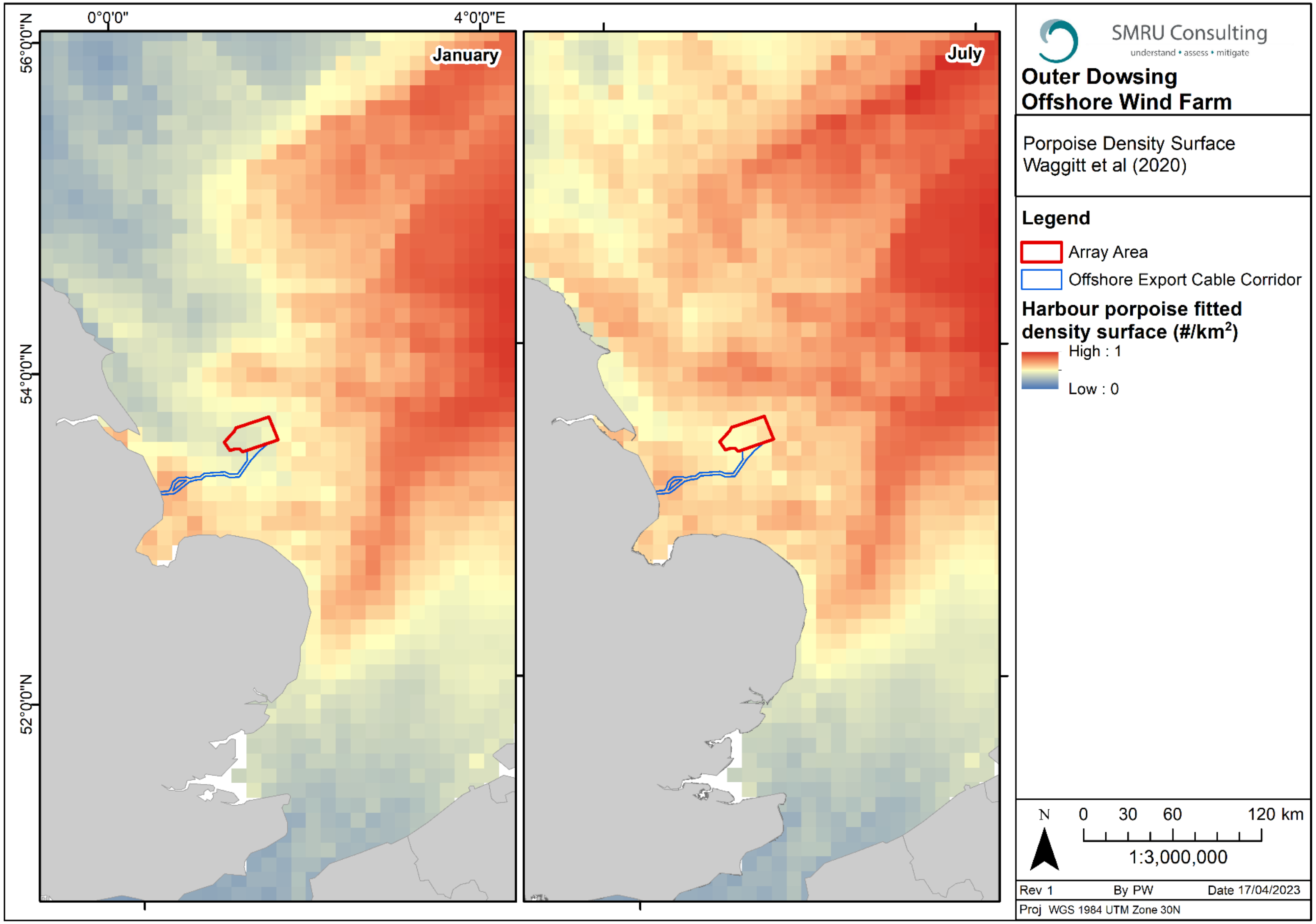

Figure 5.9 Harbour porpoise estimated density surfaces for January and July. Data from Waggitt et al. (2020).

5.7 Sea Watch Foundation and The Wildlife Trust

No data received to date.

5.8 Summary

It is anticipated that harbour porpoise will be present on a year-round basis at the Project site. Heinänen and Skov (2015) and Paxton *et al.* (2016) suggest that harbour porpoise density in the area differs by season, with higher densities in winter (though the data are highly variable). Density estimates obtained for harbour porpoise vary considerably from 0.280 harbour porpoise/km^2 to 2.77 harbour porpoise/km^2. The adjusted average density estimate obtained from the site-specific surveys (2.375 porpoise/km^2) is considered to be the best density estimate to take forward to the quantitative impact assessment as it is one of the highest density estimates available, is the most up to date value and is representative of the site-specific area. This is considered more appropriate to use than the slightly higher value obtained from the JCP tool (2.77 harbour porpoise/km^2) as this is an averaged summer density estimate from 2007-2010 and is, therefore, not as recent an estimate.

Table 5.5 Harbour porpoise density estimates.

Source	Area	Temporal	Density (#/km^2)
HiDef site-specific surveys	**The Project survey area**	**Monthly average Year 1**	**2.375**
Hornsea Four site-specific surveys	Hornsea Four survey area	Average winter	0.49
Hornsea Four site-specific surveys	Hornsea Four survey area	Average summer	3.8
Hornsea Four site-specific surveys	Hornsea Four survey area	Monthly average	1.74
Dudgeon and Sheringham Shoal extension site-specific surveys	Dudgeon and Sheringham Shoal extension survey area	Average winter	0.65
Dudgeon and Sheringham Shoal extension site-specific surveys	Dudgeon and Sheringham Shoal extension survey area	Average summer	1.46
Dudgeon and Sheringham Shoal extension site-specific surveys	Dudgeon and Sheringham Shoal extension survey area	Average annual	1.05
Sheringham Shoal construction monitoring	Sheringham Shoal survey area + 2km buffer	October 2009	0.4
SCANS III block density	Block O	Summer 2016	0.888
SCANS III density surfaces	The Project site	Summer 2016	1.29
SCANS III density surfaces	The Project ECC	Summer 2016	1.55
JCP Phase III	South Dogger Bank	Winter 2010	1.290
JCP Phase III	South Dogger Bank	Spring 2010	0.491
JCP Phase III	South Dogger Bank	Summer 2010	0.680
JCP Phase III	South Dogger Bank	Autumn 2010	0.351
JCP Phase III	South Dogger Bank	Average annual 2010	0.703
JCP Phase III	Norfolk Bank	Winter 2010	0.958
JCP Phase III	Norfolk Bank	Spring 2010	0.372
JCP Phase III	Norfolk Bank	Summer 2010	0.498
JCP Phase III	Norfolk Bank	Autumn 2010	0.280
JCP Phase III	Norfolk Bank	Average annual 2010	0.528
JCP data analysis tool	User specified area	Summer 2007-2010	2.77
Heinänen and Skov (2015)	The Project area	Summer 2009	0.9 - 1.2
Heinänen and Skov (2015)	The Project area	Winter 2009	2.1 - 2.4

6 Bottlenose dolphin

6.1 MU

Bottlenose dolphins are found worldwide, and several distinct MUs exist for this species in European waters. The Project is located within the Greater North Sea MU, which has a population estimate, based on SCANS III data, of 2,022 bottlenose dolphins (95% CI: 548 – 7,453, CV: 0.75) (IAMMWG, 2022). The previous assessment undertaken was unable to provide a population estimate for this MU due to a lack of sightings in the area (IAMMWG, 2015a). Bottlenose dolphins are classified as a Priority Species under the UK Post-2010 Biodiversity Framework and listed as Least Concern by the IUCN red list. The conservation status of bottlenose dolphin in the UK concludes a favourable assessment of range, but an unknown conclusion for all other factors, resulting in an "Unknown" overall assessment of conservation status. As bottlenose dolphins are also listed under Annex II of the EU Habitats Directive, SACs must be assigned to aid in the protection of this species. There is one bottlenose dolphin SAC in the Greater North Sea MU, which is the Moray Firth SAC, located approximately 580 km from the Project.

6.2 Site-specific surveys

No bottlenose dolphins have been identified in Year 1 of the site-specific baseline surveys to date (March 2021 – February 2022).

6.3 The Project geophysical surveys

No bottlenose dolphin were detected during the geophysical surveys of the Project area (Seiche, 2022b, a).

6.4 Nearby OWF surveys

No bottlenose dolphins were sighted during the site-specific aerial surveys at Hornsea Four. The only sighting of bottlenose dolphins at nearby OWF sites was during the site-specific surveys for Triton Knoll. One dolphin was observed during boat surveys and one during aerial surveys. These sightings were not sufficient to provide a density estimate for the survey area. The lack of sightings from the nearby OWFs does, however, suggest the density of bottlenose dolphins in the area is likely to be very low.

6.5 SCANS

No bottlenose dolphins were sighted in SCANS III survey block O, within which the Project is located (Figure 6.1).

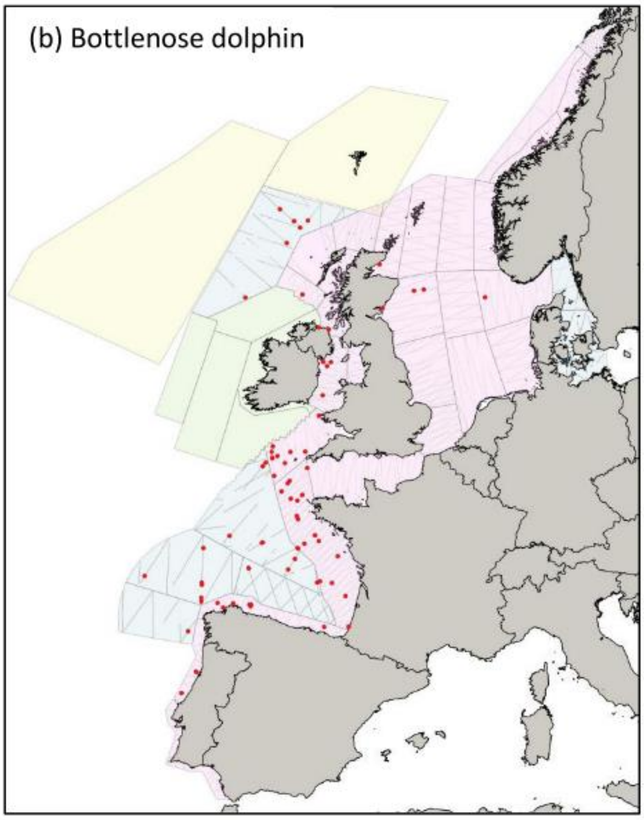

Figure 6.1 Distribution of bottlenose dolphin sightings during the SCANS III surveys (Hammond *et al.*, 2021).

The SCANS III data was used to obtain predicted density surfaces (Lacey *et al.*, 2022). Whilst the density is anticipated to be low at the Project, the modelled distribution in 2016 shows that densities are expected to be higher in other areas such as the Celtic Sea and Bay of Biscay (Lacey *et al.*, 2022). Data were extracted from the density surface, which showed that there was a maximum of 0.002 bottlenose dolphin/km^2 within the array area, with a similarly low maximum density of 0.002 bottlenose dolphin/km^2 within the ECC. Due to the nature of coastal dolphin populations around the UK, large scale surveys such as SCANS are not designed to collect data at a spatial scale suitable to capture sufficient information to obtain abundance estimates for small coastal populations of bottlenose dolphins. It is, therefore, typically more appropriate to use mark-recapture analysis from photo-ID data such as that used by Arso Civil *et al.* (2019) to obtain abundance estimates for these small coastal populations (Lacey *et al.*, 2022).

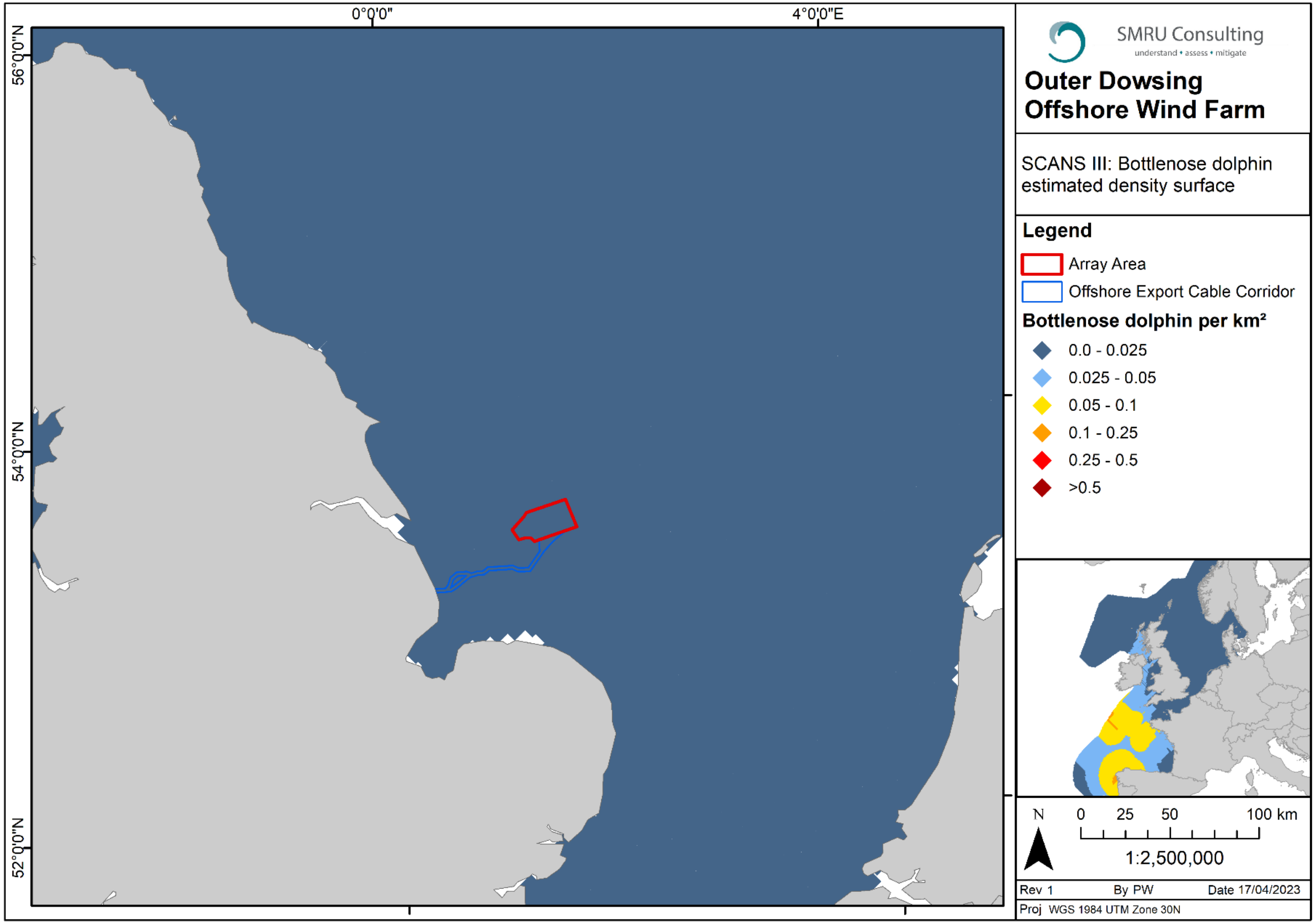

Figure 6.2 Estimated density surface for bottlenose dolphins using the SCANS III data. Data from Lacey *et al.* (2022).

6.6 JCP

6.6.1 JCP Phase III

Paxton *et al.* (2016) used the JCP dataset to provide estimates of the density of bottlenose dolphin (Figure 6.3) at South Dogger Bank (14,265 km^2) and Norfolk Bank (14,295 km^2) during all seasons (neither area overlaps directly with the Project but are located to the north and south of the Project site). All bottlenose dolphin density estimates at both locations were ≤0.002 bottlenose dolphin/km^2 (Table 6.1). Densities are consistently low across all seasons, with a 0 abundance and density estimate during winter 2010 for both areas.

Table 6.1 JCP Phase III abundance and density estimates for bottlenose dolphin in 2010 for the South Dogger Bank and Norfolk Bank regions (Paxton *et al.*, 2016).

Season	Abundance point estimate	95% CI	Density (#/km^2)
South Dogger Bank			
Winter	0	0 – 240	0.000
Spring	30	10 – 110	0.002
Summer	30	10 – 100	0.002
Autumn	10	0 - 30	0.001
Average	**18**	**-**	**0.001**
Norfolk Bank			
Winter	0	0 – 120	0.000
Spring	20	0 – 50	0.001
Summer	20	0 - 60	0.001
Autumn	10	0 - 20	0.001
Average	**13**	**-**	**0.001**

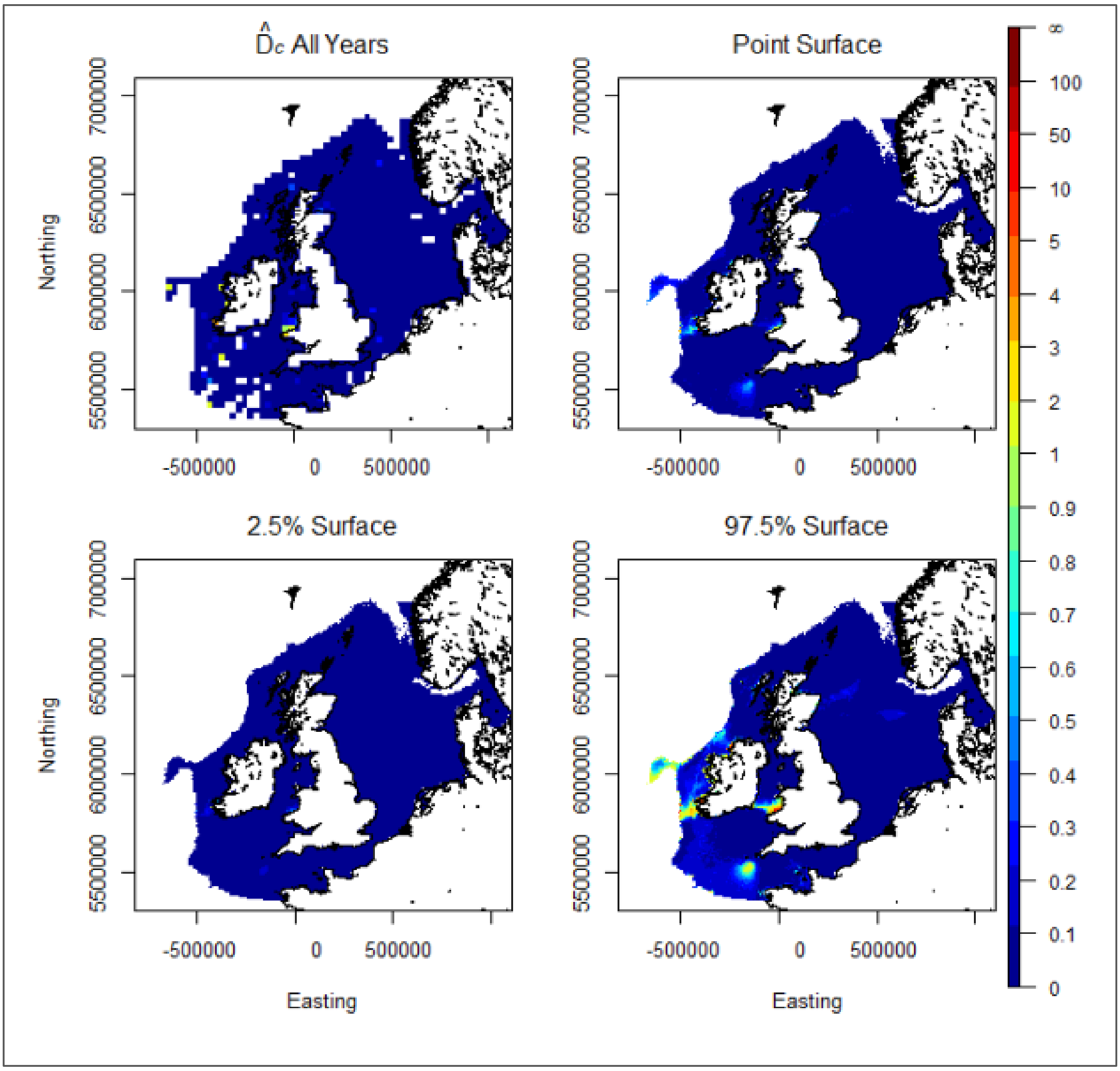

Figure 6.3 Predicted bottlenose dolphin densities for summer 2010 (Paxton *et al.*, 2016). Top left; input densities (summer all years), top right; point estimate of cell densities, bottom left; lower (2.5%) confidence limit on cell densities, bottom right; upper (97.5%) confidence limit on cell densities (dolphins/km²). Note that the top left plot exaggerates the spatial coverage of the relevant effort.

6.6.2 JCP data analysis tool

Utilising the JCP data analysis tool for the user specified area, bottlenose dolphins in the Project area were estimated to have a density of 0.0018 bottlenose dolphin/km^2 (95% CI: 0.0009-0.0031) (Table 6.2). This estimate is for the summer months only and is not representative of densities at other times of the year.

Table 6.2 JCP Phase III Data Analysis Product abundance and density estimates for bottlenose dolphin for the user specified area (see Figure 6.4) averaged for the summer 2007-2010.

	Abundance	Density (#/km^2)
Point estimate	32	0.0018
Lower confidence interval	16	0.0009
Upper confidence interval	55	0.0031

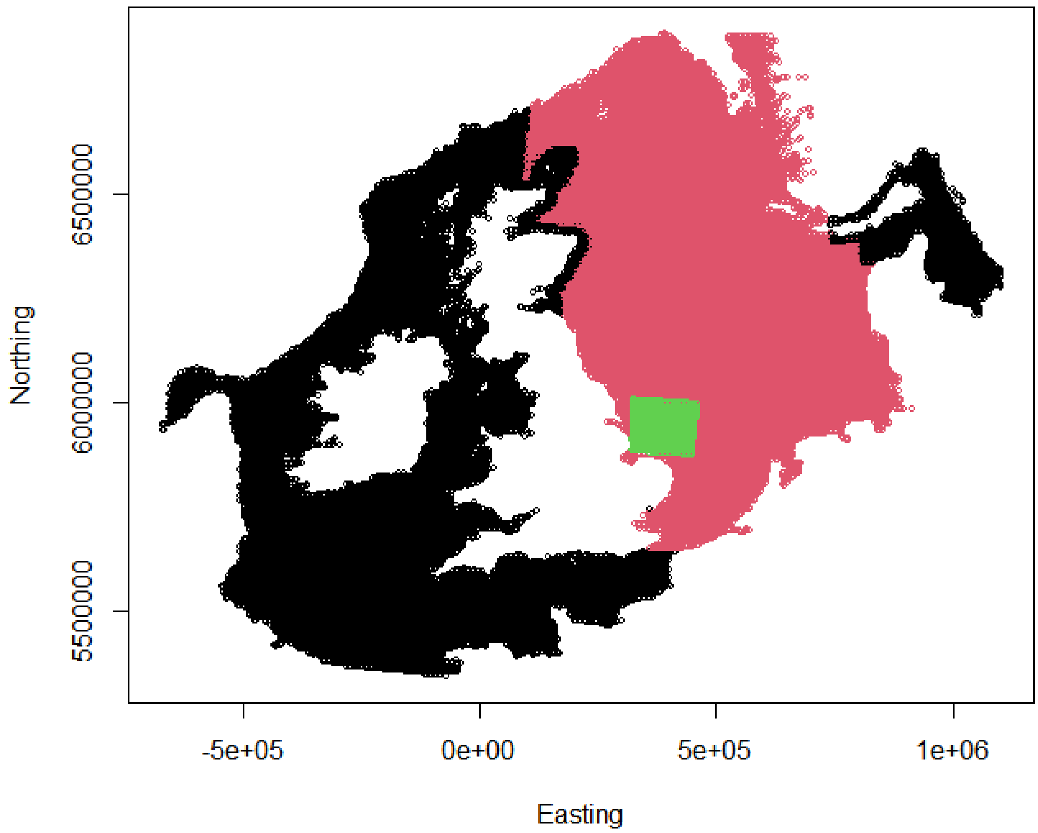

Figure 6.4 The user specified area used to extract bottlenose dolphin abundance and density estimates from the JCP III R code. The map shows the whole area under consideration (black + pink + green), the bottlenose dolphin Greater North Sea MU (pink) and the specified area of interest (green).

6.6.3 MERP distribution maps

The year-round very low density in the southern North Sea has also been demonstrated by the analyses presented in Waggitt *et al.* (2020), and, indeed, densities are estimated to be low within the entirety of the North Sea (Figure 6.5). However, these maps are not considered to be suitable for quantitative impact assessments (see Section 4.6) and are provided in this baseline characterisation for illustrative purposes only.

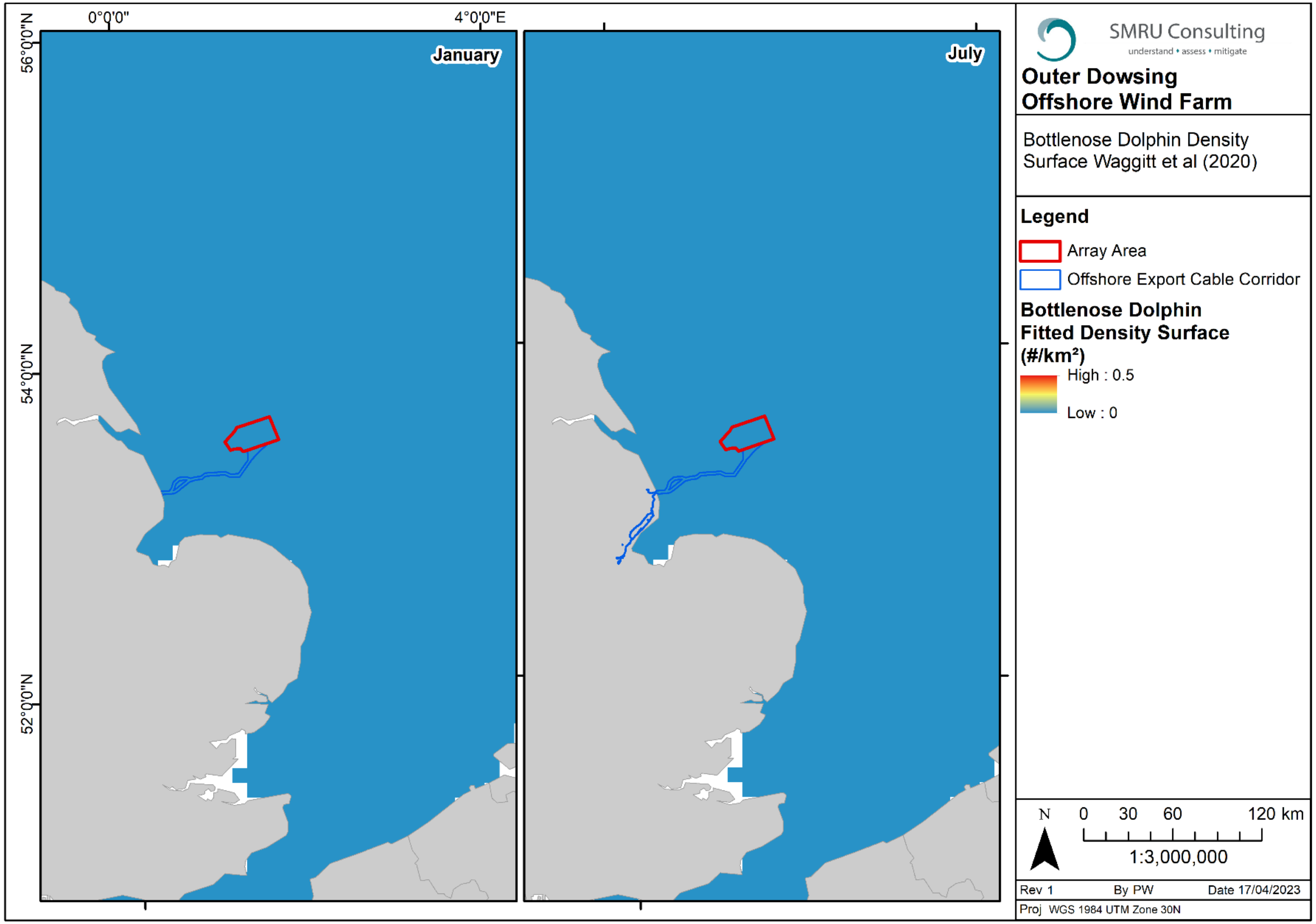

Figure 6.5 Bottlenose dolphin estimated density surfaces for January and July. Data from Waggitt *et al.* (2020).

6.7 Sea Watch Foundation and The Wildlife Trust

No data received to date.

6.8 Bottlenose dolphins in northeast English waters

Since the 1990s, the coastal east Scotland population has been recorded ranging further south in the Tay Estuary and the Firth of Forth and, more recently, the coast of northern England (Wilson et al. 2004, Arso Civil et al. 2019, Arso Civil et al. 2021), indicating expanded home ranges of the Moray Firth bottlenose dolphins. There is no density estimate available for bottlenose dolphins along the east coast of England or in the vicinity of the Project, however, from recent research and citizen science, it is known that bottlenose dolphins are likely to be present to some degree.

The Citizen Fins project is ongoing, with the aim of understanding how the pattern of movements of bottlenose dolphins along the east coast of Scotland and into northeast England is changing. Because it is not currently possible for the Sea Mammal Research Unit (University of St Andrews) and the Lighthouse Field Station (University of Aberdeen) to survey the entirety of the populations distributional range, the Citizen Fins project has been created to allow the public to submit photographs of bottlenose fins in areas not covered by the existing surveys (i.e.: south of St Andrews Bay and the Tay Estuary). The intention is to obtain photographs of sufficient quality that dorsal fins can be matched to the East Coast Scotland Bottlenose Dolphin Photo-ID Catalogue.

Thus far, Citizen Fin images have been submitted for sightings as far south as Flamborough Head (Yorkshire coast). As of April 2022, 1,114 images have been submitted from sites along the east coast of Scotland and northeast England. Of these, 1,053 were suitable for data processing, resulting in the preliminary identification of 98 individual dolphins from the east coast of Scotland population (Arso Civil *et al.*, 2022). It is important to note that these data have yet to be divided to separate the northeast England images from the east Scottish ones. Therefore, the Citizen Fins submissions include some locations from the east-coast of Scotland, and as such, the total number of individuals preliminarily identified may not reflect the number of individuals seen in northeast England. All that can be stated at the current time is that there is preliminary evidence to show that sightings of bottlenose dolphins in northeast English waters have shown matches to the East Coast Scotland population.

6.9 Assumed density estimates

Given the fact that no reliable density estimate is available for coastal bottlenose dolphin in the vicinity of the Project, this baseline characterisation presents four approaches to obtaining an assumed density estimate for coastal bottlenose dolphins in relation to the Project:

1) Assume a uniform density across the GNS MU
2) Assume a uniform density across the CES MU, and assume this applies in English waters too
3) Assume a uniform density within 2 km of the mainland coast in the CES MU, and assume this applies in English waters too
4) Assume a uniform density within the 25 m depth contour of the mainland in the CES MU, and assume this applies in English waters too

6.9.1 Greater North Sea (GNS) MU

Technically, the Project is located within the GNS MU for bottlenose dolphins. According to the IAMMWG (2022), the latest abundance estimate for this MU is 2,022 dolphins, however, data on the distribution of these dolphins within the MU are lacking. Thus, the only possible density estimate that can be assumed using these data is to assume that bottlenose dolphins are uniformly (evenly) distributed across the entire MU. This results in a uniform density estimate of 0.003 dolphins/km^2 across the GNS MU.

6.9.2 Coastal East Scotland (CES) MU

Since the Citizen Fins project has demonstrated that at least a portion of the east coast Scotland population have been sighted in northeast English waters, it could be assumed that the density of dolphins in the vicinity of the Project is similar to that of the density within the CES MU. Unfortunately, density estimates for bottlenose dolphins within this MU are also lacking, since the primary surveys for this species are photo-ID surveys which, while they allow for the estimation of the population size, are not suitable to provide a density estimate within the areas surveyed. Assuming that bottlenose dolphins are uniformly distributed throughout the CES MU, the resulting density estimate is 0.010 dolphins/km^2. Since it is known that bottlenose dolphins within the CES MU are located primarily in the nearshore coastal waters (Quick *et al.*, 2014), it seems prudent to refine this estimate to take this distribution into account.

6.9.3 2 km from the coast and within the 25 m depth contour

It has been reported that, outside of the Moray Firth (in both Tayside and Fife, and between Montrose and Aberdeen), bottlenose dolphins are encountered more often in waters less than 20 m deep and within 2 km of the coast (Quick et al., 2014). Therefore, it could be assumed that they maintain this coastal distribution pattern throughout their range, and so are located in similar environmental conditions in the northeast English waters too.

A 2 km buffer from the coast was created for the mainland Scotland part of the CES MU, and it was assumed that bottlenose dolphins were uniformly spread within this area. This results in a uniform density estimate of 0.110 dolphins/km^2 within 2 km from the mainland coast in the CES MU. It could then be assumed that this density estimate is also valid in the northeast English waters too.

Additionally, to be conservative, it was assumed that bottlenose dolphins are located within the 25 m depth contour of the Scottish mainland within the CES MU (slightly further than the reported 20 m depth contour). Assuming that bottlenose dolphins were uniformly distributed, this results in a density estimate of 0.104 dolphins/km^2 within the 25 m depth contour in the CES MU. It could then be assumed that this density estimate is also valid in the northeast English waters too.

It should be noted that there are no data at all on the distribution of bottlenose dolphins in northeast English waters. Given the very different seascapes and environment between the CES MU and the northeast English waters, it is possible that bottlenose dolphin distribution may differ between these two areas, and that the assumption that they are primarily limited to 2 km from the coast or within the 20 m depth contour is invalid.

6.9.4 Assumption of uniform density

The key issue with using a uniform density estimate, is that bottlenose dolphins are not distributed evenly throughout their range. They are most commonly encountered in groups; for example, between 2017 and 2019 in the Tay Estuary and adjacent waters, estimated group sizes ranged from 1 to 50 animals, with an average group size of 11 across 157 separate encounters (Arso Civil *et al.*, 2021). Thus, a uniform density estimate is not suitable for a species that is known to have a patchy and highly changeable distribution within their range at any one time. While assuming a uniform density estimate is by no means ideal, it is currently the only way to estimate potential densities in the vicinity of the Project in the absence of any data for the northeast English waters.

Table 3 Calculated bottlenose dolphin density estimates.

Calculated Density Method	Area (km^2)	# animals	Density (#/km^2)
Uniform density across the GNS MU	642,520	2,022	0.003
Uniform density across the CES MU	21,579	224	0.010
Uniform density within 2 km of the mainland coast in the CES MU	2,033	224	0.110
Uniform density within the 25 m depth contour of the mainland in the CES MU	2,145	224	0.104

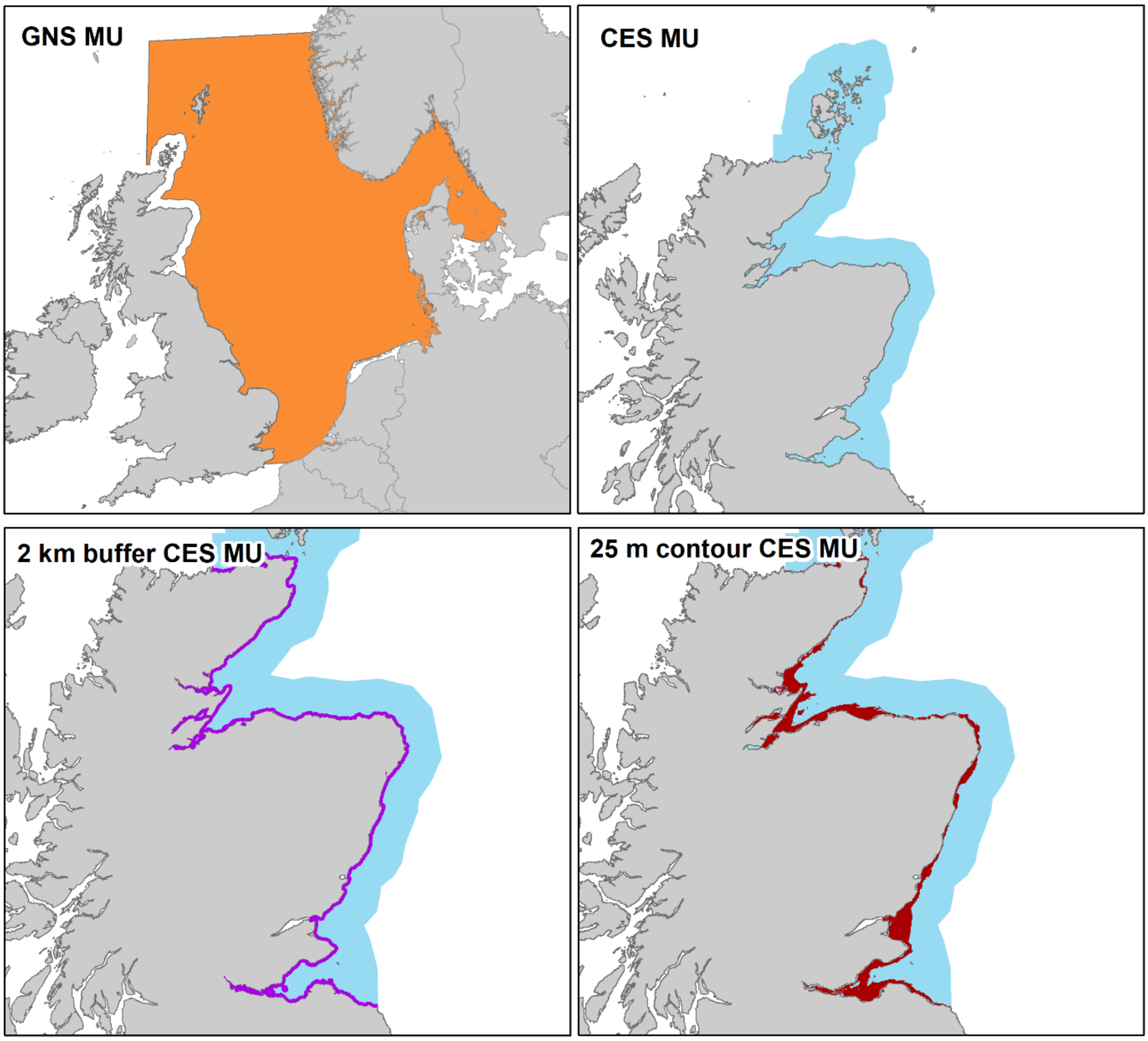

Figure 6.6 Spatial extents used to calculate bottlenose dolphin density estimates.

6.10 Summary

No bottlenose dolphin sightings occurred during the site-specific surveys. Sightings of bottlenose dolphins in the southern North Sea are generally considered to be movements of the east coast of Scotland resident population at the most southerly extent of their range (Thompson *et al.*, 2011, Quick *et al.*, 2014). If bottlenose dolphins are present in the vicinity of the Project, it is expected that these would be at very low densities (Table 6.4). Of the density estimates available, 0.002 dolphins/km^2 is considered to be the best density estimate to take forward to the quantitative impact assessment as this density has been calculated using various data sources across various seasons and years (SCANS III, JCP III South Dogger Bank area and JCP data analysis tool).

Since there is no reliable density estimate for the bottlenose dolphins in the vicinity of the Project, assumptions have had to be made about their distribution based on knowledge of the distribution of bottlenose dolphins in the CES MU. Therefore, it is highly precautionary to assume a density of 0.110 dolphins/km^2 within 2 km of the coast in northeast English waters. The Applicant acknowledges that this density estimate is by no means ideal, however, in the absence of any data on bottlenose dolphin density in the vicinity of the Project or the wider northeast English waters, it serves as a precautionary estimate.

Therefore, acknowledging the lack of data available, the quantitative impact assessment for bottlenose dolphins will present results assuming two different density estimates: 0.002 dolphins/km^2 (throughout the entire impact range) and 0.11 dolphins/km^2 (within 2 km from the coast only).

Table 6.4 Bottlenose dolphin density estimates.

Source	Area	Temporal	Density (#/km^2)
HiDef site-specific surveys	The Project survey area	Monthly average Year 1	0.000
SCANS III	Block O	Summer 2016	0.000
SCANS III density surfaces	**The Project site**	**Summer 2016**	**0.002**
SCANS III density surfaces	**The Project ECC**	**Summer 2016**	**0.002**
JCP Phase III	South Dogger Bank	Winter 2010	0.000
JCP Phase III	**South Dogger Bank**	**Spring 2010**	**0.002**
JCP Phase III	**South Dogger Bank**	**Summer 2010**	**0.002**
JCP Phase III	South Dogger Bank	Autumn 2010	0.001
JCP Phase III	South Dogger Bank	Average annual 2010	0.001
JCP Phase III	Norfolk Bank	Winter 2010	0.000
JCP Phase III	Norfolk Bank	Spring 2010	0.001
JCP Phase III	Norfolk Bank	Summer 2010	0.001
JCP Phase III	Norfolk Bank	Autumn 2010	0.001
JCP Phase III	Norfolk Bank	Average annual 2010	0.001
JCP data analysis tool	**User specified area**	**Summer 2007-2010**	**0.002**
Uniform density within GNS MU			0.003
Uniform density within CES MU			0.010
Uniform density within 2 km from mainland Scotland within CES MU			**0.110**
Uniform density within 25 m depth contour of mainland Scotland within CES MU			0.104

7 White-beaked dolphin

7.1 MU

White-beaked dolphins are wide-spread across the continental shelf in northern Europe. A single MU for white-beaked dolphins has been assigned, labelled the Celtic and Greater North Seas MU. Within this MU, the abundance of white-beaked dolphins is estimated to be 43,951 (95% CI: 28,439 – 67,924, CV: 0.22) (IAMMWG, 2022). This is a slight increase in the previous (revised) estimate presented in 2015 which had an estimated population size of 37,309 animals (95% CI: 21,464 - 64,852, CV:0.29) (IAMMWG, 2015a, 2022).

7.2 Site-specific surveys

A total of three white-beaked dolphins have been identified in the site-specific baseline surveys to date (March 2021 – February 2022) (<1% of the marine mammal sightings). All three were sighted in March 2021 (Table 7.1). The maximum monthly relative density calculated was 0.020 white-beaked dolphin/km^2, resulting in an average monthly relative density of 0.002 white-beaked dolphin/km^2 (Table 7.2). The white-beaked dolphins were observed within the 4 km buffer on the eastern edge of the survey area (Figure 7.1)

Table 7.1 Number of white-beaked dolphin recorded from the HiDef surveys (the Project development area plus 4 km buffer) between March 2021 and February 2022 (HiDef, 2022).

Year 1	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
White-beaked dolphin	3	0	0	0	0	0	0	0	0	0	0	0	3

Table 7.2 Non-Adjusted (relative) density and population estimates for white-beaked dolphin in the Project survey area from the HiDef surveys between March 2021 and February 2022, taking into account the number of animals that are estimated as being unavailable for detection (HiDef, 2022).

White-beaked dolphin	Non-adjusted (relative) abundance estimates			
	Density estimate (#/km^2)	Population estimate	Lower 95% CI	Upper 95% CI
22-Mar-21	0.020	18	0	55
04-Apr-21	0	0	0	0
12-May-21	0	0	0	0
09-Jun-21	0	0	0	0
24-Jul-21	0	0	0	0
14-Aug-21	0	0	0	0
07-Sep-21	0	0	0	0
09-Oct-21	0	0	0	0
02-Nov-21	0	0	0	0
15-Dec-21	0	0	0	0
06-Jan-22	0	0	0	0
23-Feb-22	0	0	0	0
Average	**0.002**	**1.5**	**-**	**-**

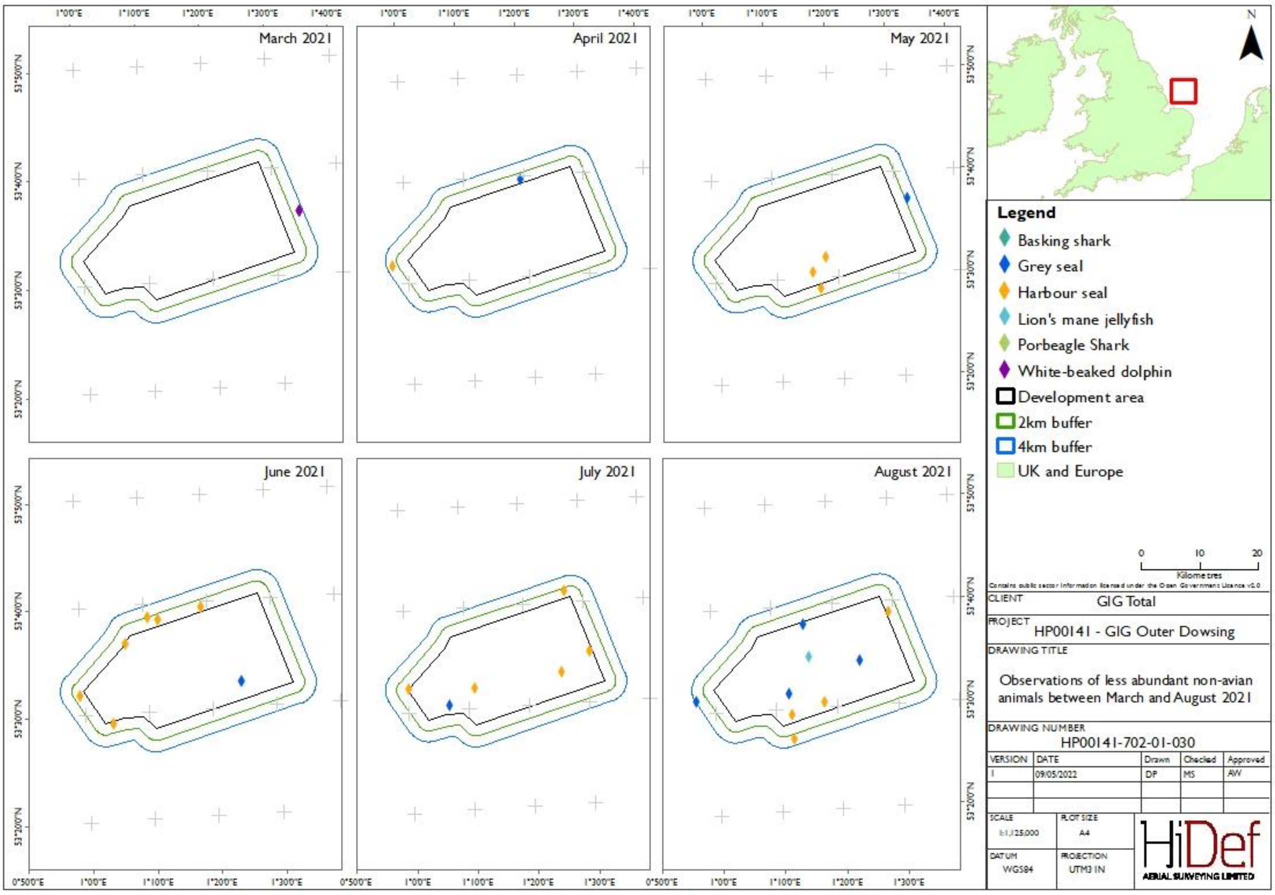

Figure 7.1 Detections of less abundant non-avian animal species, including white-beaked dolphin, in the Outer Dowsing survey area between March and August 2021 (HiDef, 2022).

7.3 The Project geophysical surveys

No white-beaked dolphins were detected during the geophysical surveys of the Project area (Seiche, 2022b, a).

7.4 Nearby OWF surveys

A total of 82 white-beaked dolphins were recorded during the site-specific surveys for Hornsea Four. The sightings were concentrated in the northern part of the survey area, however, due to insufficient data, the spatial patterns cannot be commented on. Sightings of the white-beaked dolphins were higher in autumn and winter months (September to January), compared to summer months. In addition, 78% of the total recorded sightings were from year 1, indicating large annual variation. Due to lack of data, a density estimate could not be provided. During the Former Hornsea Zone surveys, 298 white-beaked dolphins were sighted resulting in an average density of 0.16 white-beaked dolphins/km^2. Similarly, there was a clear seasonal pattern with more sightings in the winter months (November to January) (Orsted, 2021).

There were no sightings of white beaked dolphins during any of the other nearby site-specific OWF surveys using boat based or aerial survey methods.

7.5 SCANS

In SCANS III survey block O (Figure 7.2) there was an estimated block-wide abundance of 143 white-beaked dolphin (95% CI: 0 – 490, CV: 0.970) and an estimated density of 0.002 white-beaked dolphin/ km^2 (CV: 0.907). Compared to the other survey blocks included within the SCANS III survey, block O was estimated to have relatively low densities of white-beaked dolphins. The high degree of uncertainty in the abundance and density estimates provided for block O (CV: 0.907) is also of note.

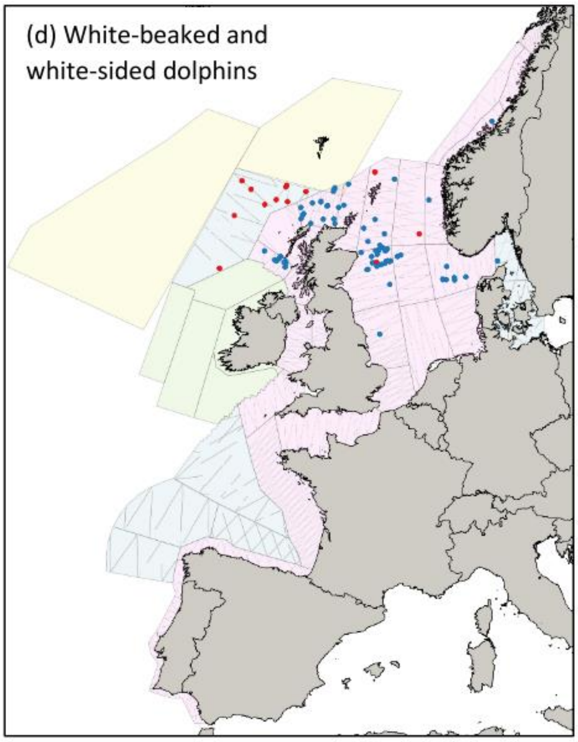

Figure 7.2 Distribution of white-beaked dolphin sightings during the SCANS III surveys – white-beaked dolphins are represented by blue dots (Hammond *et al.*, 2021).

The SCANS III data was used to obtain predicted density surfaces (Lacey *et al.*, 2022). This shows that the Project survey area falls within a uniform low density area (Figure 7.3). Data were extracted from the density surface, which showed a maximum of 0.001 white-beaked dolphin/km^2 in the array area, with slightly higher maximum predicted density of 0.007 white-beaked dolphin/km^2 within the ECC. Using the modelled 2016 distribution, areas of higher density are predicted in the northern North Sea to the east of Scotland and to the north and west of Scotland (Lacey *et al.*, 2022).

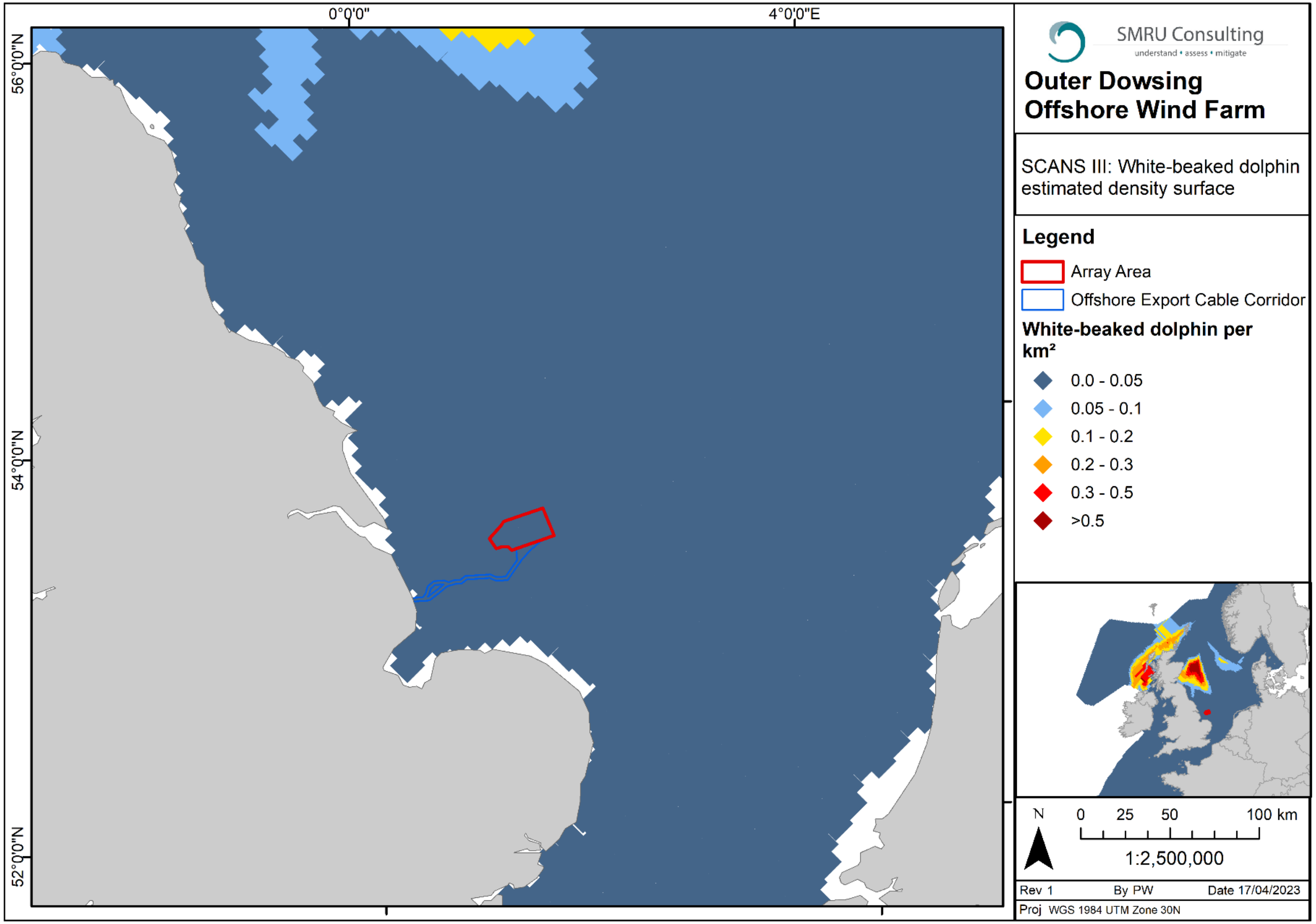

Figure 7.3 Estimated density surface for white-beaked dolphins using SCANS III data. Data from Lacey *et al.* (2022)

7.6 JCP

7.6.1 JCP Phase III

Paxton *et al.* (2016) used the JCP dataset to provide estimates of the density of white-beaked dolphin (Figure 7.4) at South Dogger Bank (14,265 km^2) and Norfolk Bank (14,295 km^2) during all seasons (neither area overlaps directly with the Project but are located to the north and south of the Project site). At South Dogger Bank, spring density estimates were highest at 0.050 white-beaked dolphin/km^2 (95% CI: 0.020 –0.126) and winter density estimates were lowest at 0.012 white-beaked dolphin/km^2 (95% CI: 0.006 –0.027). At Norfolk Bank, spring densities were also estimated as the highest at 0.005 white-beaked dolphin/km^2 (95% CI: 0.002 -0.015), although all densities were low with all other seasons estimated at <0.002 white beaked dolphin/km^2 (Table 7.3).

Table 7.3 JCP Phase III abundance and density estimates for white-beaked dolphin in 2010 for the South Dogger Bank and Norfolk Bank regions (Paxton *et al.*, 2016).

Season	Abundance point estimate	95% CI	Density (#/km^2)
South Dogger Bank			
Winter	170	80 – 380	0.012
Spring	710	290 – 1790	0.050
Summer	290	170 – 610	0.020
Autumn	220	90 - 420	0.015
Average	**348**	**-**	**0.024**
Norfolk Bank			
Winter	20	10 – 40	0.001
Spring	70	30 – 220	0.005
Summer	30	20 – 60	0.002
Autumn	20	10 - 50	0.001
Average	**35**	**-**	**0.002**

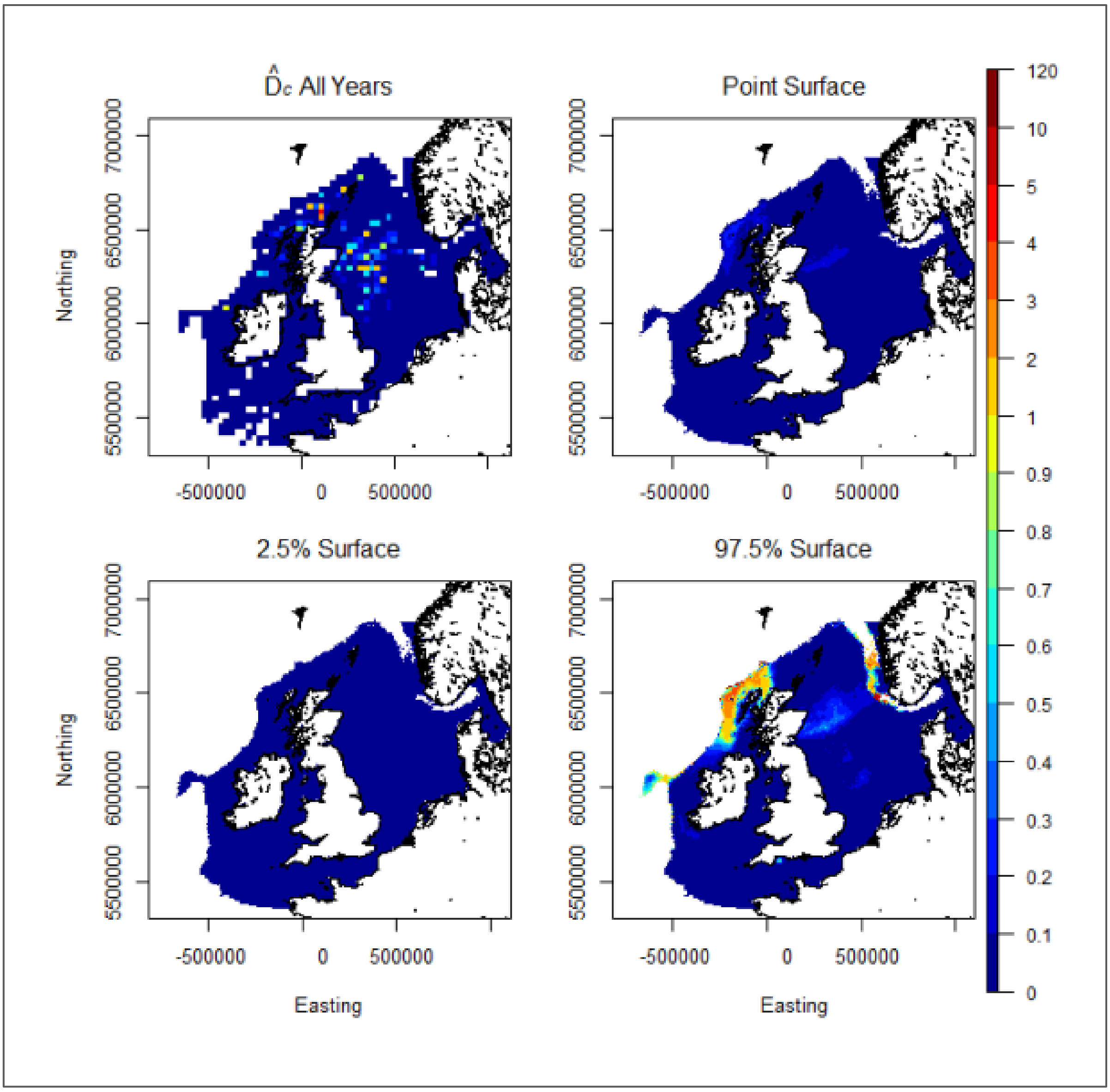

Figure 7.4 Predicted white-beaked dolphin densities for summer 2010 (Paxton *et al.*, 2016). Top left; input densities (summer all years), top right; point estimate of cell densities, bottom left; lower (2.5%) confidence limit on cell densities, bottom right; upper (97.5%) confidence limit on cell densities (dolphins/km^2). Note that the top left plot exaggerates the spatial coverage of the relevant effort.

7.6.2 JCP data analysis tool

Utilising the JCP data analysis tool for the user specified area, white-beaked dolphins in the Project area were estimated to have a density of 0.00 white-beaked dolphin/km^2.

7.6.3 MERP distribution maps

Density distribution maps from Waggitt *et al.* (2020) show a clear pattern of higher densities of white-beaked dolphins within the northern North Sea, particularly around the coast of Scotland, with densities decreasing southwards along the east coast of England (Figure 7.5). Within the Project area and ECC, densities were predominantly low during both winter and summer. However, these maps are not considered to be suitable for quantitative impact assessments (see Section 4.6) and are provided in this baseline characterisation for illustrative purposes only.

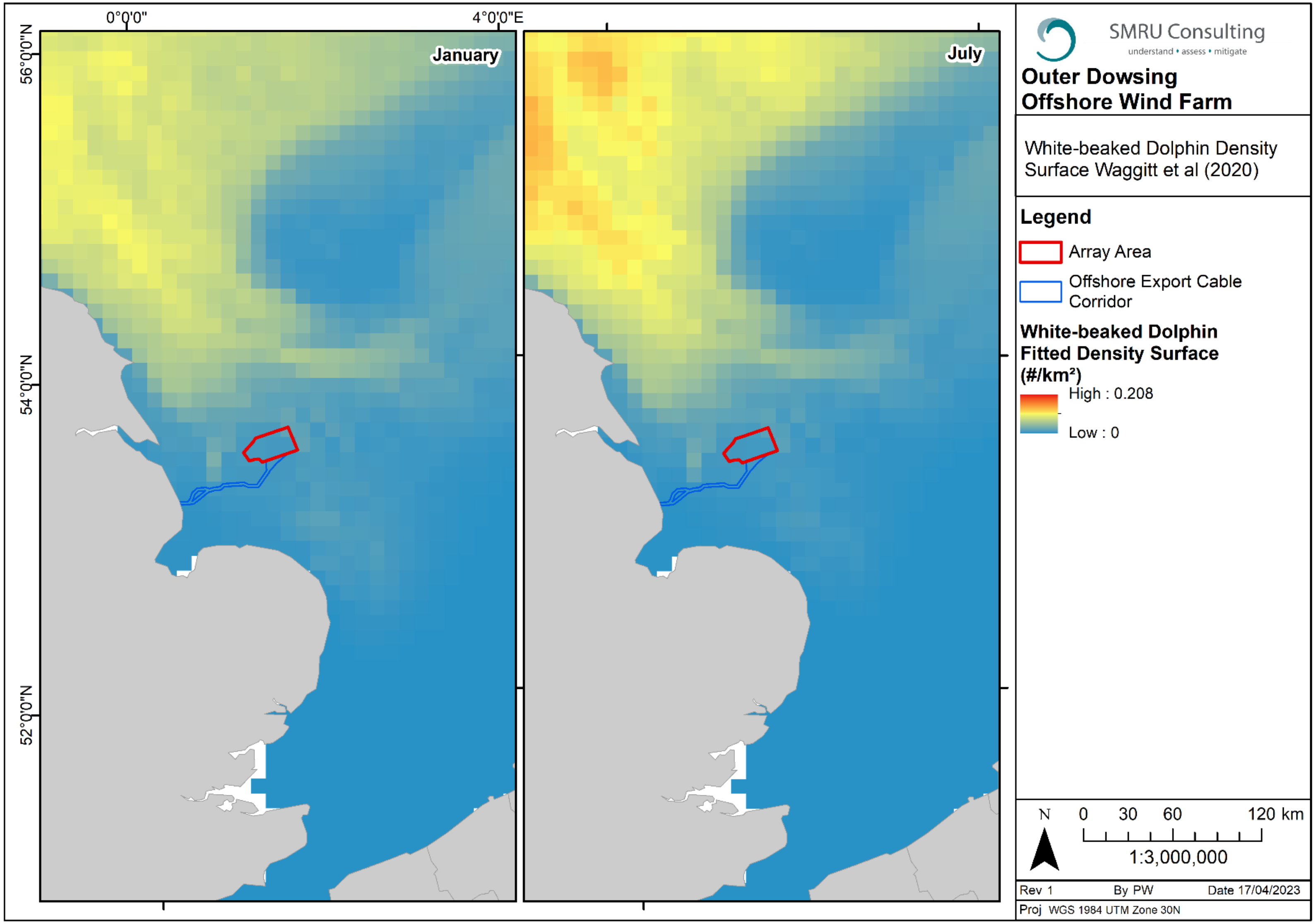

Figure 7.5 White-beaked dolphin estimated density surfaces in January and July. Data from Waggitt *et al.* (2020).

7.7 Sea Watch Foundation and The Wildlife Trust

No data received to date.

7.8 Summary

It is expected that white-beaked dolphins will be present year-round in the vicinity of the Project, although they present at relatively low densities. Density estimates obtained for white-beaked dolphin vary from 0.00 white-beaked dolphin/km^2 to 0.050 white-beaked dolphin/km^2 (Table 7.4). The density estimate that will be taken forward to the quantitative impact assessment will be 0.002 white-beaked dolphin/km^2 as this density estimate was achieved by both the Year 1 site-specific surveys (average monthly) and SCANS III block O and both surveys are recent.

Table 7.4 White-beaked dolphin density estimates.

Source	Area	Temporal	Density (#/km^2)
HiDef site-specific surveys	**The Project survey area**	**Monthly average Year 1**	**0.002**
Hornsea Four site-specific surveys	Hornsea Four survey area	Monthly average	0.16
SCANS III	**Block O**	**Summer 2016**	**0.002**
SCANS III density surfaces	The Project site	Summer 2016	0.001
SCANS III density surfaces	The Project ECC	Summer 2016	0.007
JCP Phase III	South Dogger Bank	Winter 2010	0.012
JCP Phase III	South Dogger Bank	Spring 2010	0.050
JCP Phase III	South Dogger Bank	Summer 2010	0.020
JCP Phase III	South Dogger Bank	Autumn 2010	0.015
JCP Phase III	South Dogger Bank	Average annual 2010	0.024
JCP Phase III	Norfolk Bank	Winter 2010	0.001
JCP Phase III	Norfolk Bank	Spring 2010	0.005
JCP Phase III	Norfolk Bank	Summer 2010	0.002
JCP Phase III	Norfolk Bank	Autumn 2010	0.001
JCP Phase III	Norfolk Bank	Average annual 2010	0.002
JCP data analysis tool	User specified area	Summer 2007-2010	0.000

8 Minke whale

8.1 MU

Minke whales are known to be distributed globally and are listed as Least Concern on the IUCN red list but are protected as an EPS and as a Priority Species under the UK Post-2010 Biodiversity Framework. In European waters, a single MU for minke whales has been assigned, labelled the Celtic and Greater North Seas MU. Within this MU, the abundance of minke whales is estimated to be 20,118 (95% CI: 14,061 – 28,786, CV: 0.18)

(IAMMWG, 2022). The represents a similar value to the previous abundance estimate of 20,136 (95% CI: 11,498 – 35,264, CV: 0.29) (IAMMWG, 2015a). The conservation status of minke whales in UK waters has been assessed as unknown (JNCC, 2019d). Until 2020, there were no protected areas assigned to minke whales in UK waters, but two MPAs have been recently proposed and designated in Scottish waters (Sea of the Hebrides and Southern Trench (Table 3.1).

8.2 Site-specific surveys

No minke whales have been identified in Year 1 of the site-specific baseline surveys to date (March 2021 – February 2022).

8.3 The Project geophysical surveys

No minke whales were detected during the geophysical survey of the Project area (Seiche, 2022b, a).

8.4 Nearby OWF surveys

During the Hornsea Four site-specific surveys, 12 minke whales were recorded throughout the study area. There was insufficient data to comment on the spatial distribution, even though more sightings were recorded in the southern part of the study area. Minke whales were only sighted during the summer months (May to August), indicating a clear seasonal pattern. Due to the lack of data, a density could not be provided. A total of 158 minke whales were sighted during the Former Hornsea Zone surveys, with higher encounter rates in the summer months and absence of whales during the winter months (Orsted, 2021).

The Dudgeon and Sheringham Shoal Extension sitespecific surveys observed one minke whale from 2 years of sitespecific aerial surveys conducted between May 2018 and April 2020 resulting in a relative density estimate of 0.01 minke whale/km^2 for July 2018 (Royal HaskoningDHV, 2021). This is the same density estimate as for the SCANS III survey. Minke whale were not observed during any other nearby sitespecific surveys.

8.5 SCANS

The SCANS III survey of block O (Figure 8.1) consisted of a total of 3,242.8 km of effort. A total of 603 minke whales were estimated to be located within survey block O (95% CI: 109-1,670, CV: 0.657) with an estimated density of 0.010 whales/km^2 (CV: 0.657). Compared to the other survey blocks included within the SCANS III survey, block O was estimated to have relatively low densities of minke whales.

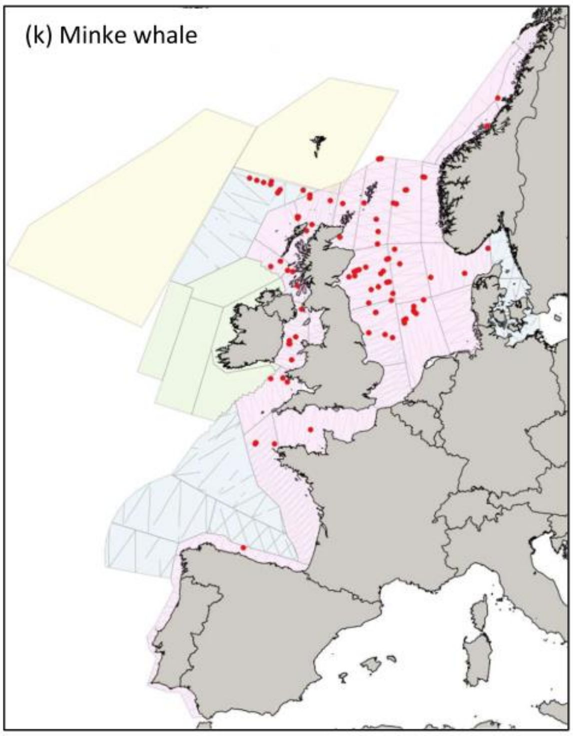

Figure 8.1 Distribution of minke whale sightings during the SCANS III surveys (Hammond *et al.*, 2021).

The SCANS III data was used to obtain predicted density surfaces (Lacey *et al.*, 2022). Around the UK, using the 2016 model, highest predicted densities for minke whale are across the central and north-eastern North Sea and in shelf waters in the west of Scotland (Lacey *et al.*, 2022). The Project array area falls within a low density area of 0.009 minke whale/km^2, with a slightly higher maximum predicted density of 0.011 within the ECC (Figure 8.2, values extracted from the density surface).

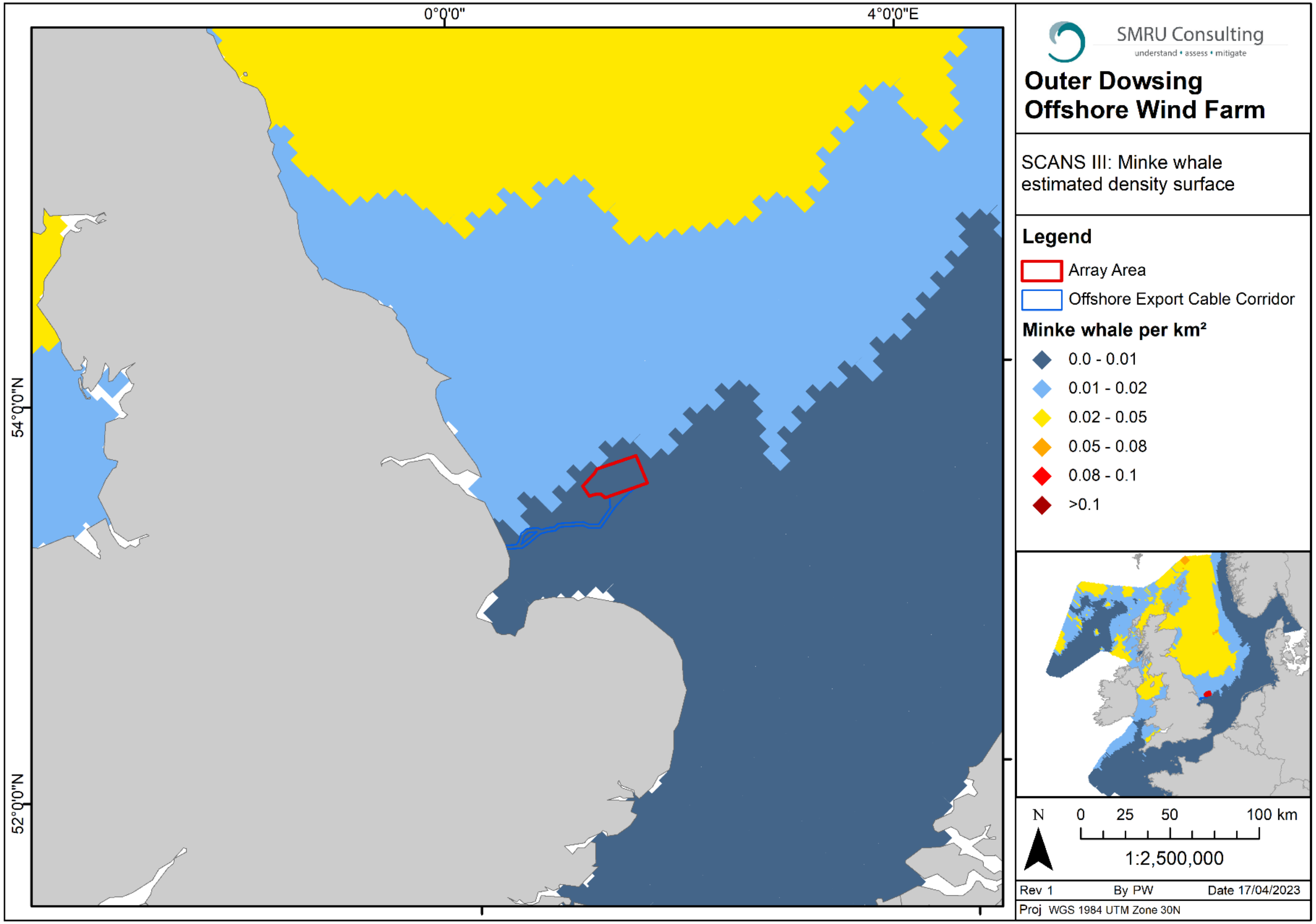

Figure 8.2 Estimated density surface for minke whales using the SCANS III data. Data from Lacey *et al.* (2022)

8.6 JCP

8.6.1 JCP Phase III

Paxton *et al.* (2016) used the JCP dataset to provide estimates of the density of minke whale (Figure 8.3) at South Dogger Bank (14,265 km^2) and Norfolk Bank (14,295 km^2) during all seasons (neither area overlaps directly with the Project but are located to the north and south of the Project site). At South Dogger Bank, summer density estimates are anticipated to be highest at 0.022 minke whale/km^2 (95% CI: 0.012-0.070). Densities in all other seasons were estimated at <0.005 minke whale/km^2. At Norfolk Bank, summer densities were also estimated as the highest at 0.002 minke whale/km^2 (95% CI: 0.001-0.008), although all densities were low with all other seasons estimated at <0.001 minke whale/km^2 (Table 8.1).

Table 8.1 JCP Phase III abundance and density estimates for minke whale in 2010 for the South Dogger Bank and Norfolk Bank regions (Paxton *et al.*, 2016).

Season	Abundance point estimate	95% CI	Density (#/km^2)
South Dogger Bank			
Winter	0	0 - 100	<0.0001
Spring	70	0 - 650	0.0049
Summer	310	170 - 1000	0.0217
Autumn	20	0 - 60	0.0014
Average	**100**	**-**	**0.0070**
Norfolk Bank			
Winter	0	0 - 10	<0.001
Spring	10	0 - 80	0.001
Summer	30	10 -120	0.002
Autumn	0	0 - 10	<0.001
Average	**10**	**-**	**0.001**

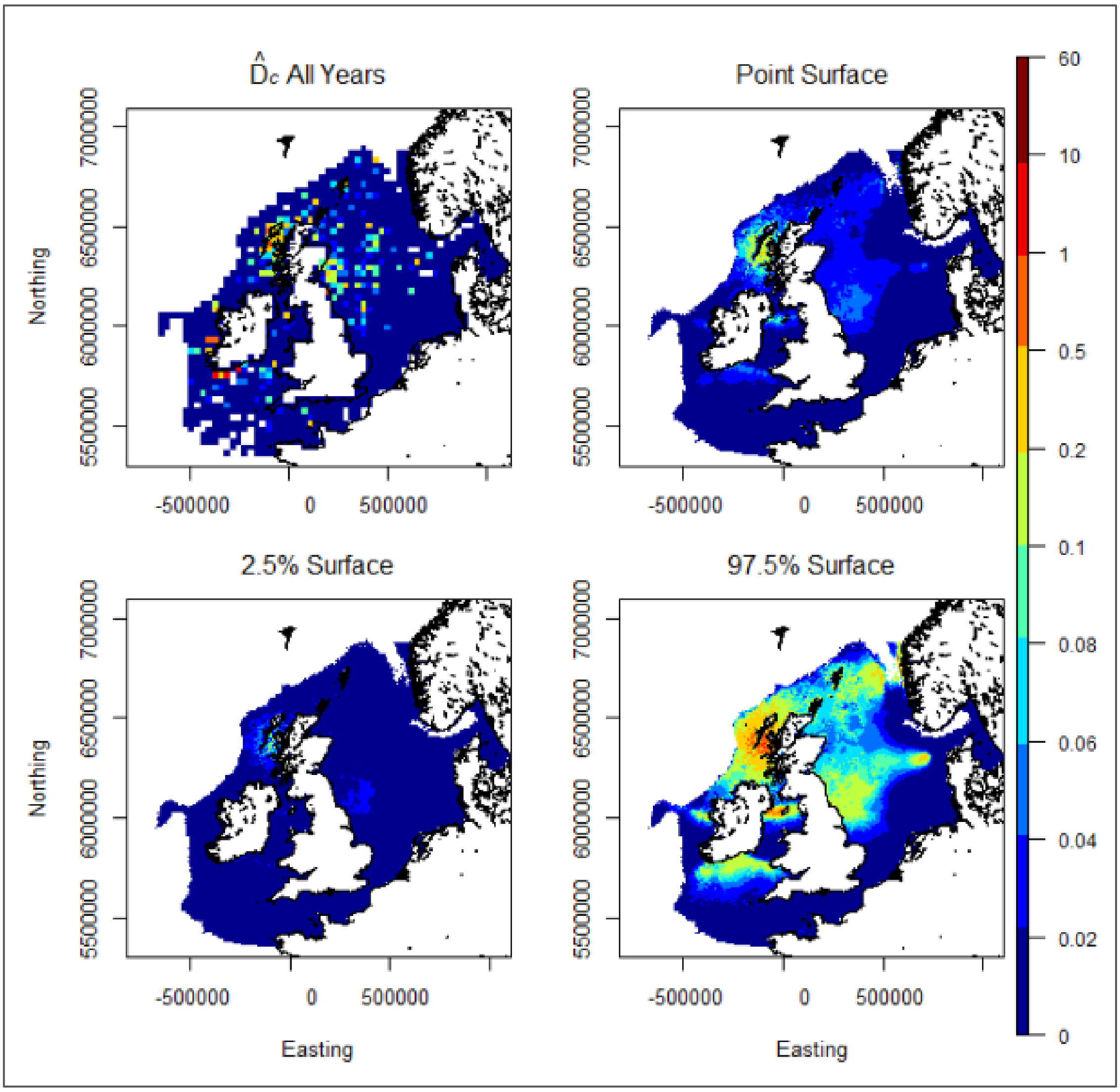

Figure 8.3 Predicted minke whale densities for summer 2010 (Paxton *et al.*, 2016). Top left; input densities (summer all years), top right; point estimate of cell densities, bottom left; lower (2.5%) confidence limit on cell densities, bottom right; upper (97.5%) confidence limit on cell densities (dolphins/km^2). Note that the top left plot exaggerates the spatial coverage of the relevant effort.

8.6.2 JCP data analysis tool

Utilising the JCP data analysis tool for the user specified area, minke whale in the Project area were estimated to have a density of 0.00 minke whales/km^2.

8.6.3 MERP distribution maps

The density distribution maps produced by Waggitt *et al.* (2020) show high density of minke whales within the Northern North Sea, with densities decreasing southwards along the east coast of England, being rare south of Humberside (Figure 8.4). Densities are estimated to be highest in July with low densities during the winter months (Waggitt *et al.*, 2020). This aligns with other data sources e.g. Paxton *et al.* (2016) which suggest that minke whales are seasonal visitors to UK waters, with higher densities predicted in summer months. However, these maps are not considered to be suitable for quantitative impact assessments (see Section 4.6) and are provided in this baseline characterisation for illustrative purposes only.

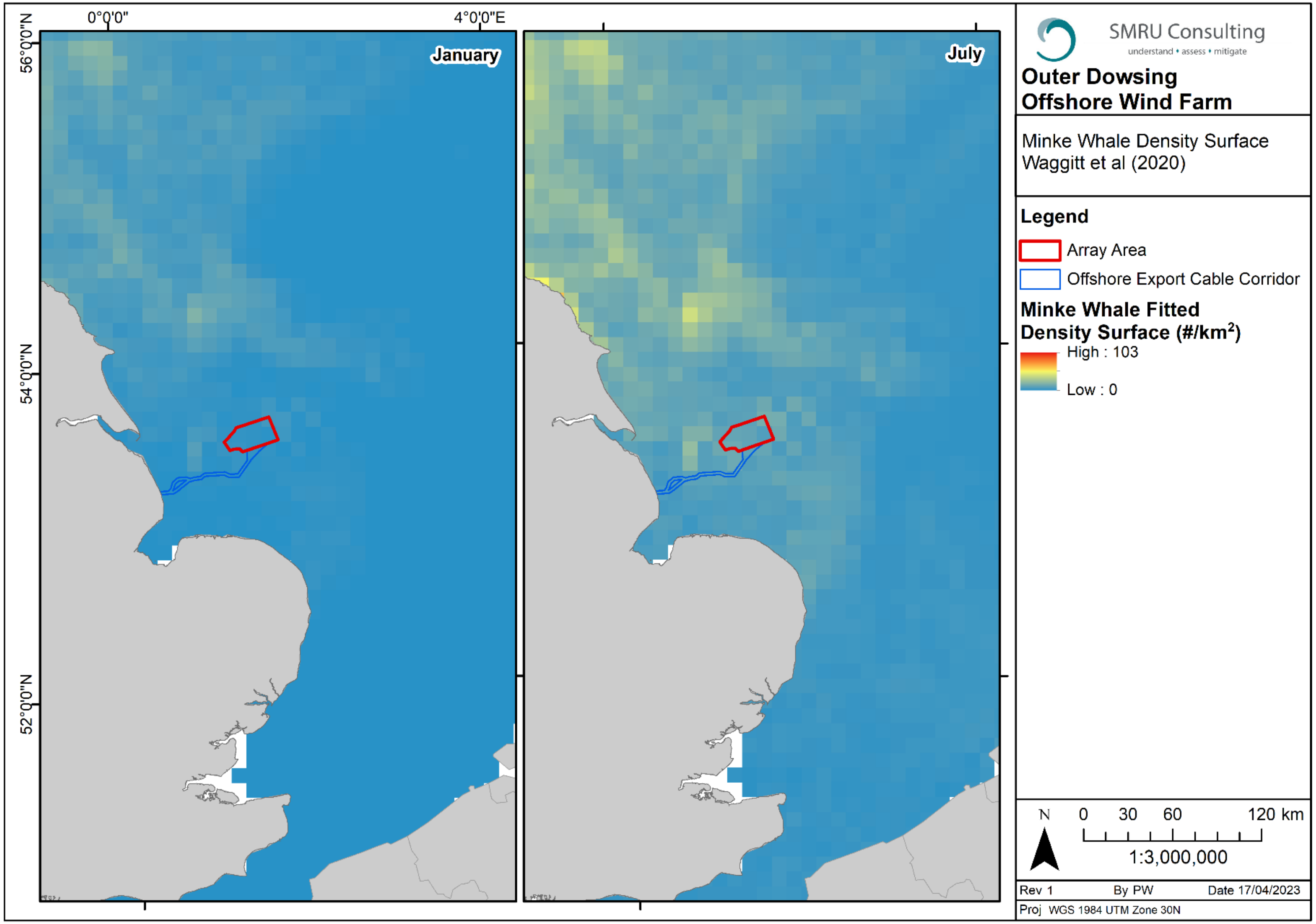

Figure 8.4 Minke whale estimated density surfaces in January and July. Data from Waggitt *et al.* (2020).

8.7 Sea Watch Foundation and The Wildlife Trust

No data received to date.

8.8 Summary

Minke whales are considered to be summer visitors to the Project area and were observed in greatest densities during the summer months (Paxton *et al.*, 2016). Density estimates obtained for minke whale vary from <0.0001 minke whale/km^2 to 0.0217 white beaked dolphin/km^2. It is suggested that the density taken forward to the quantitative impact assessment is 0.010 minke whale/km^2 as this density estimate was achieved by both the nearby Dudgeon and Sheringham Shoal extension site-specific surveys and SCANS III block O, and both sources represent recent estimates. Similar density estimates were also calculated for the Project survey area (0.009 minke whale/km^2) and ECC (0.011 minke whale/km^2) using the SCANS III density surfaces, which further suggests this is an appropriate figure to use.

Table 8.2 Minke whale density estimates.

Source	Area	Temporal	Density (#/km^2)
HiDef site-specific surveys	The Project survey area	Monthly average Year 1	0.00
Dudgeon and Sheringham Shoal extension site-specific surveys	Dudgeon and Sheringham Shoal extension survey area	July 2018	0.01
SCANS III	Block O	Summer 2016	0.010
SCANS III density surfaces	The Project site	Summer 2016	0.009
SCANS III density surfaces	The Project ECC	Summer 2016	0.011
JCP Phase III	South Dogger Bank	Winter 2010	<0.0001
JCP Phase III	South Dogger Bank	Spring 2010	0.0049
JCP Phase III	South Dogger Bank	Summer 2010	0.0217
JCP Phase III	South Dogger Bank	Autumn 2010	0.0014
JCP Phase III	South Dogger Bank	Average 2010	0.0070
JCP Phase III	Norfolk Bank	Winter 2010	<0.001
JCP Phase III	Norfolk Bank	Spring 2010	0.001
JCP Phase III	Norfolk Bank	Summer 2010	0.002
JCP Phase III	Norfolk Bank	Autumn 2010	<0.001
JCP Phase III	Norfolk Bank	Average 2010	0.001
JCP data analysis tool	User specified area	Summer 2007-2010	0.00

9 Harbour seal

The overall Conservation Status of harbour seals in UK waters has been assessed as Unfavourable – Inadequate (JNCC, 2019c). The range of the species was classified as “Favourable”, the habitat was classified as “Unknown” and the population size and future prospects were classified as “Unfavourable – Inadequate”. The 2019 assessment states that there was an increase in harbour seal abundance in the UK since the 2013 assessment, and as a result, the current assessment has improved from Unfavourable-Bad to Unfavourable-Inadequate and the UK wide trend was considered to have changed from declining to improving. The most recent UK wide harbour seal population estimate (based on the 2016-2021 counts) is 43,750 individuals (95% CI:35,800 – 58,300) of which, 5,000 (95% CI: 4,100 – 6,700) were in England (11.4 % of UK total) (SCOS, 2022) (Figure 9.1).

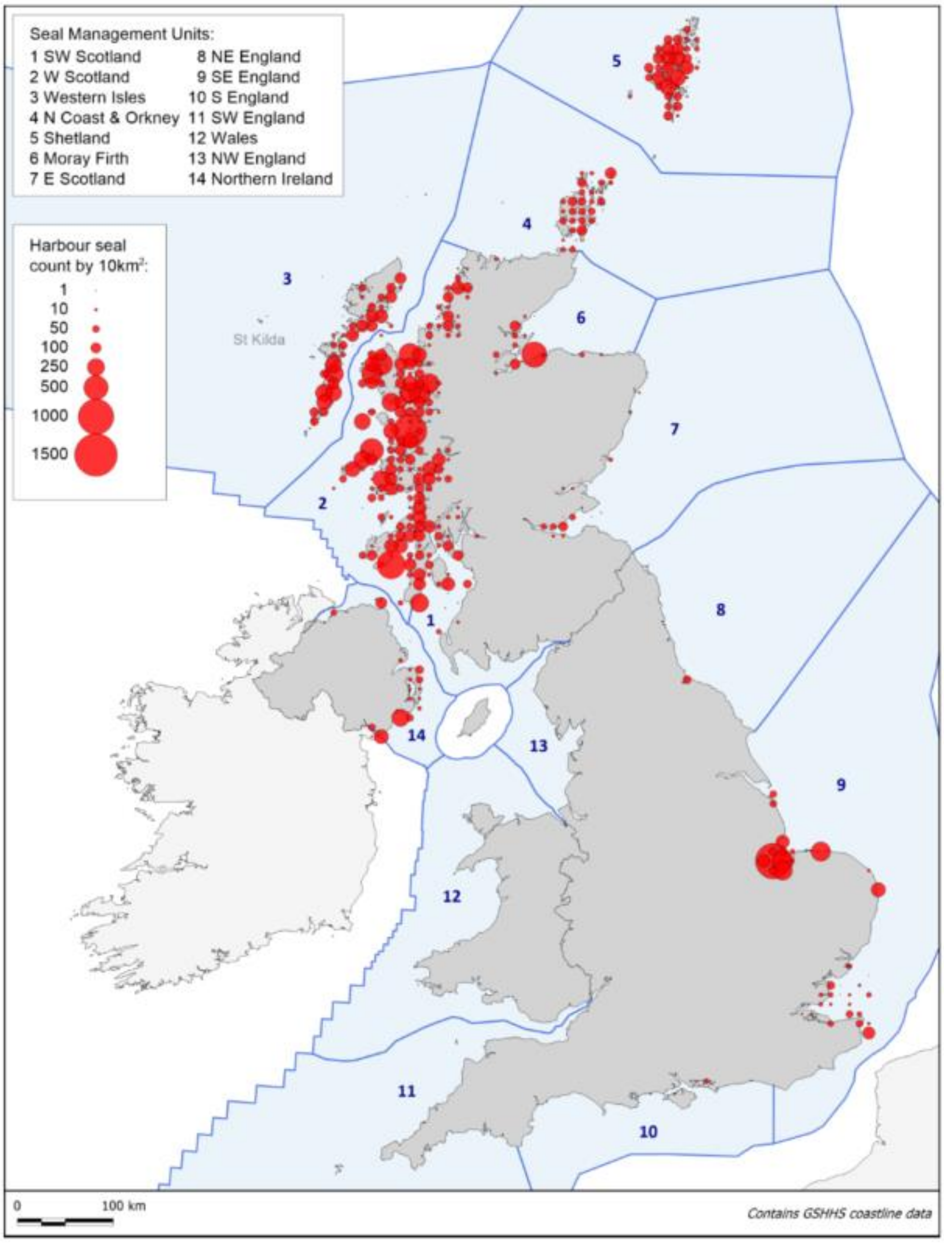

Figure 9.1 August distribution of harbour seals around the British Isles by 10 km squares based on the most recent available haul-out count data collected up until 2019 (SCOS, 2022).

9.1 Site-specific surveys

A total 24 harbour seals have been sighted throughout the survey area, which equates to 4% of the marine mammal sightings to date (March 2021 – February 2022) (Figure 9.2). The sightings reached a peak of 6 harbour seals in September. In addition, there were several unidentified seal species and seal/small cetacean species throughout the survey period, some of which could have been harbour seals (Figure 9.3).

Similarly, during surveys of nearby wind farms, including Triton Knoll, Lincs, Dudgeon and Sheringham Shoal Extensions, harbour seals were observed from boat-based surveys. Seals were also sighted during aerial surveys at Lincs wind farm, although species identification could not be determined. However, due to the lack of recorded sightings, a density estimate could not be reliably calculated.

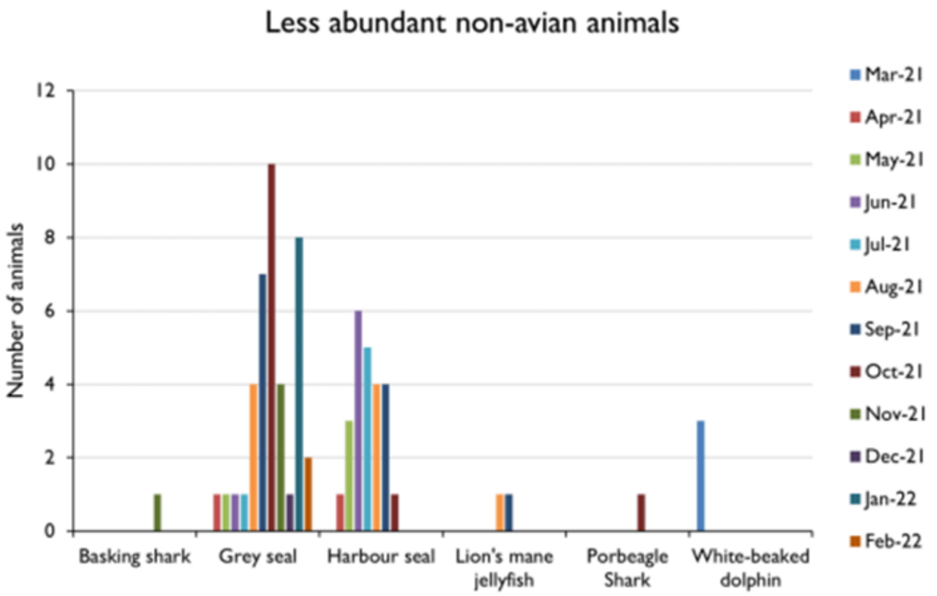

Figure 9.2 The number of less abundant non-avian animals recorded within the Project survey sea, specifically depicting the harbour and grey seal numbers. March 2021 to February 2022 (HiDef, 2022).

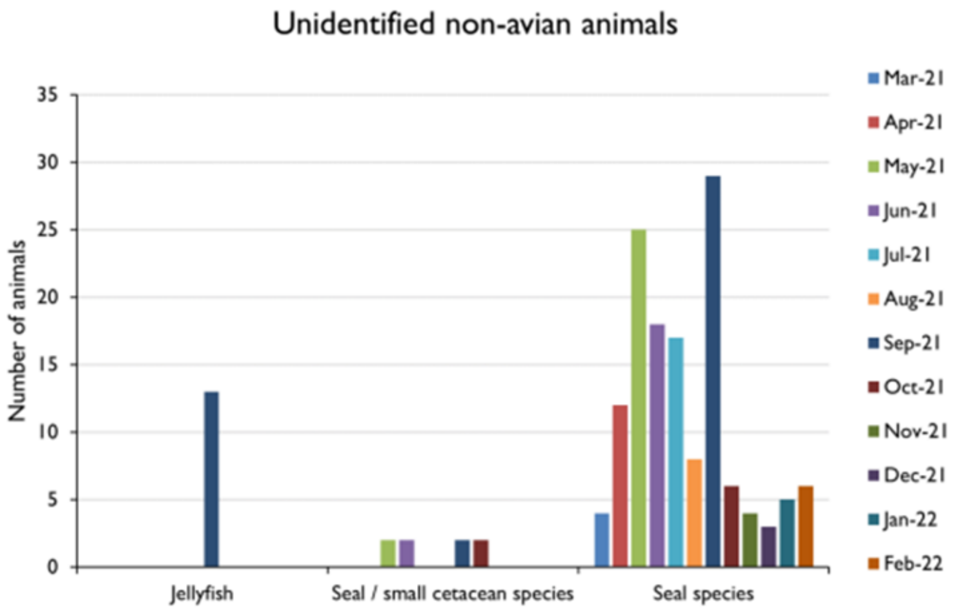

Figure 9.3 Number of unidentified non-avian animals recorded within the Project survey area between March 2021 and February 2022 (HiDef, 2022).

9.2 The Project geophysical surveys

Throughout the 2021 geophysical survey, there were low numbers of harbour seal sightings and unidentified seal sightings, which could have been harbour seals (Seiche, 2022b). During the 2022 survey, one harbour seal and 16 unidentified seals were recorded, which could also have been harbour seals (Seiche, 2022a). However, due to the low number of recorded sightings, a density estimate could not be reliably calculated.

9.3 Haul outs

9.3.1 MU

The Project is located within the Southeast England MU for seals. The Southeast England MU harbour seal count has varied considerably over time (Figure 9.4). The count was a 50% lower in 1989 compared to 1988 as a result of the phocine distemper virus epizootic (PDV). The counts then increased by 6.6% p.a. between 1989 and 2002, however another PDV epizootic outbreak meant that the 2003 count was 30% lower than the 2002 count. Between 2003 and 2017 the counts increased then levelled off. However, in 2019 the count for the Southeast England MU was 27.6% lower than the mean count between 2012-2018, which was thought to be the first indication of a declining population (SCOS, 2021). Counts for 2020 and 2021 have since confirmed that the population has declined. For all sites between Donna Nook and Scroby Sands, there has been a 38% decline in harbour seals counts compared to the mean of the previous five years (2019 – 2021 mean count = 3,080, 2014 – 2018 mean count = 4,296) (SCOS, 2022).

The latest August haul-out count data for harbour seals in the Southeast England MU is the 2016-2021 dataset where 3,494 harbour seals were counted (SCOS, 2022). The 2021 count data can be scaled by the estimated proportion hauled-out (0.72, 95% CI: 0.54-0.88) (Lonergan *et al.*, 2013) to provide an estimate of 4,852 harbour seals in the Southeast England MU in 2021 (95% CI: 3,970 – 6,470).

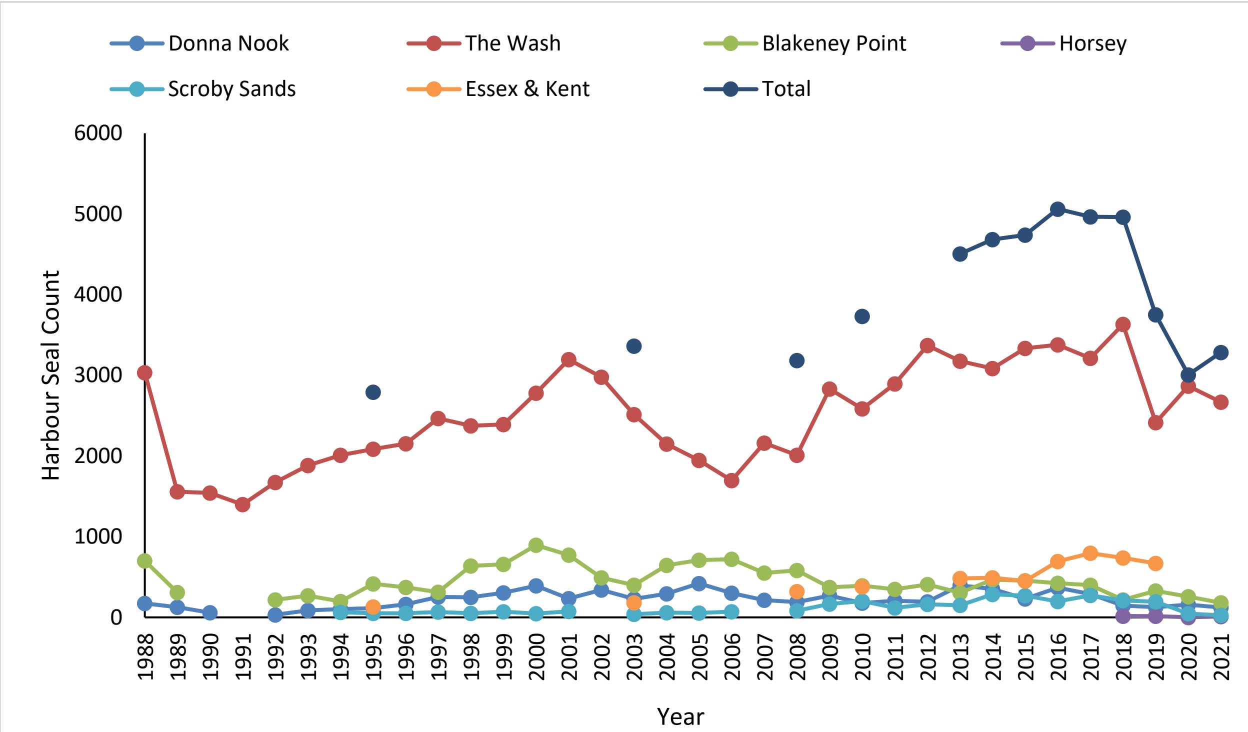

Figure 9.4 Harbour seal haul-out counts across the Southeast England MU over time. Data from SMRU.

As shown in Figure 9.5, The Wash and North Norfolk SAC populations recovered from the PDV outbreak in 2002, reaching a peak between 2014 and 2015. The population has since rapidly declined, and the most recent counts show a 21% decrease in population (2019 – 2021 mean count = 2883: 2014-2018 mean count = 3658). However, the reason for the decline is uncertain and it is unknown as to whether the decrease is the start of a continuing decline or a step change decrease (SCOS, 2022) (see BP 21/06). Similarly, haul-outs Donna Nook, Blakeney and Scroby Sands have all seen a population decline over the past four years (Figure 9.6). Blakeney has seen a gradual decline since 2002, whereas, Donna Nook and Scroby Sands have shown a decrease in 57% and 73%, respectively, when comparing the mean counts from 2014-2018 to those from 2019-2021 (SCOS, 2022) (see BP 21/06).

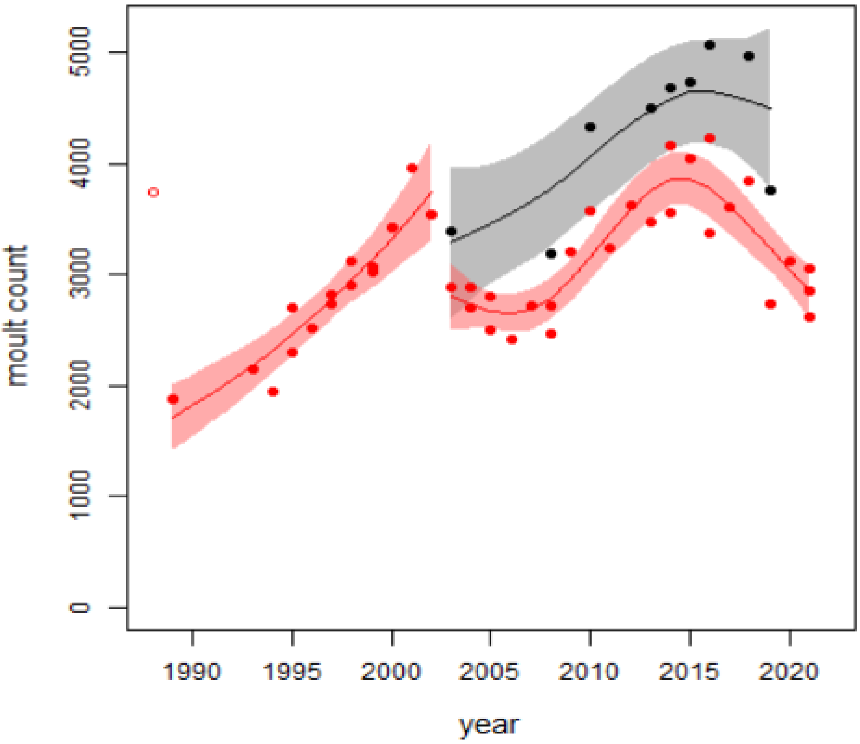

Figure 9.5 The August counts of harbour seals in the Wash and North Norfolk SAC (red) and the total for the Southeast England MU (grey) between 1988 and 2021 (SCOS, 2022) (see BP 21/06).

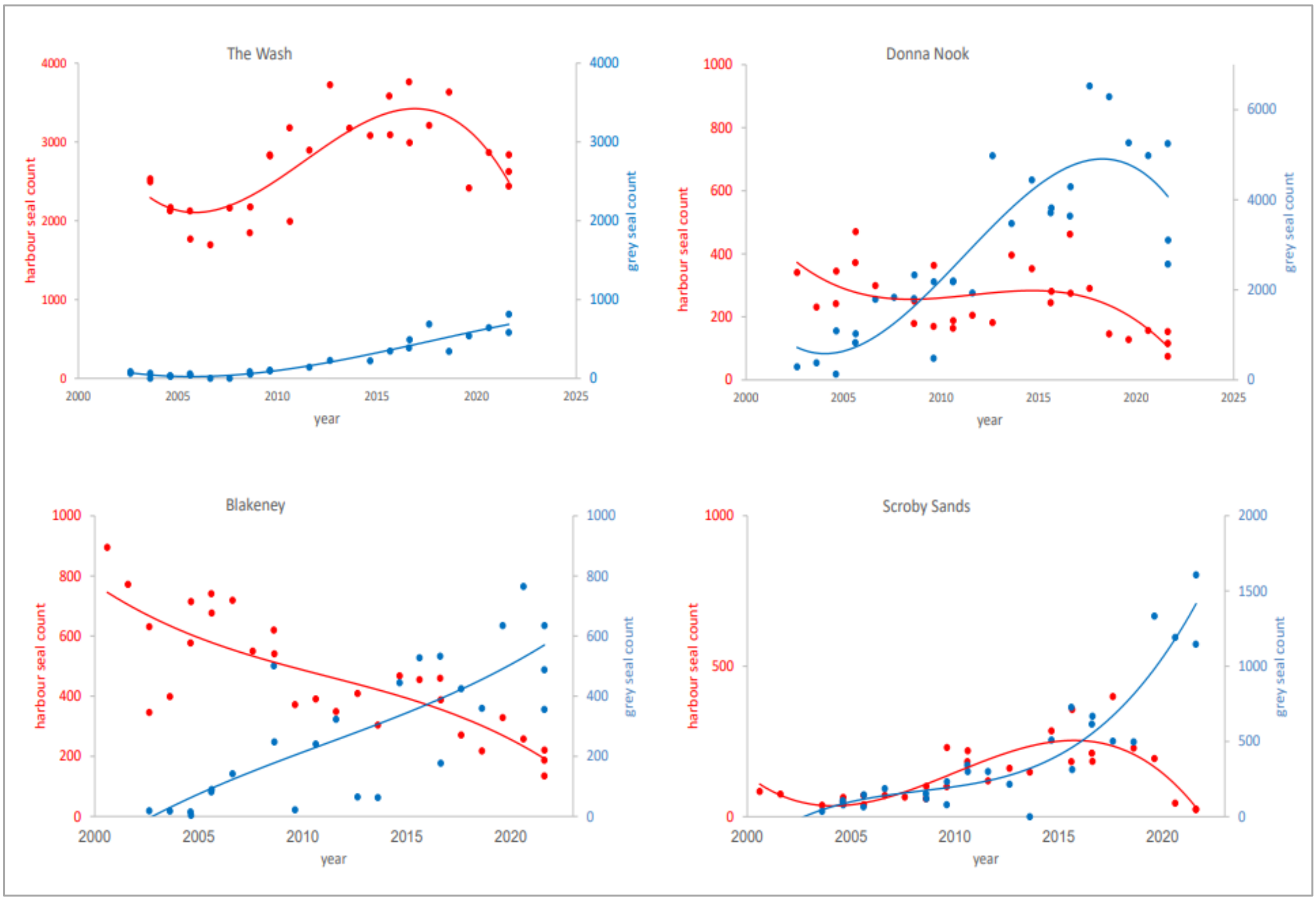

Figure 9.6 The counts of harbour seals (red) and grey seals (blue) from 2002 to 2021 in the Wash, Donna Nook, Blakeney Point and Scroby Sands (SCOS, 2022) (see BP 21/06).

Within the Southeast England MU, most of the harbour seal haul-out sites are located in The Wash or in the Greater Thames Estuary area (Figure 9.7). There are no harbour seal haul-outs located within the Project site boundary or offshore ECC AoS.

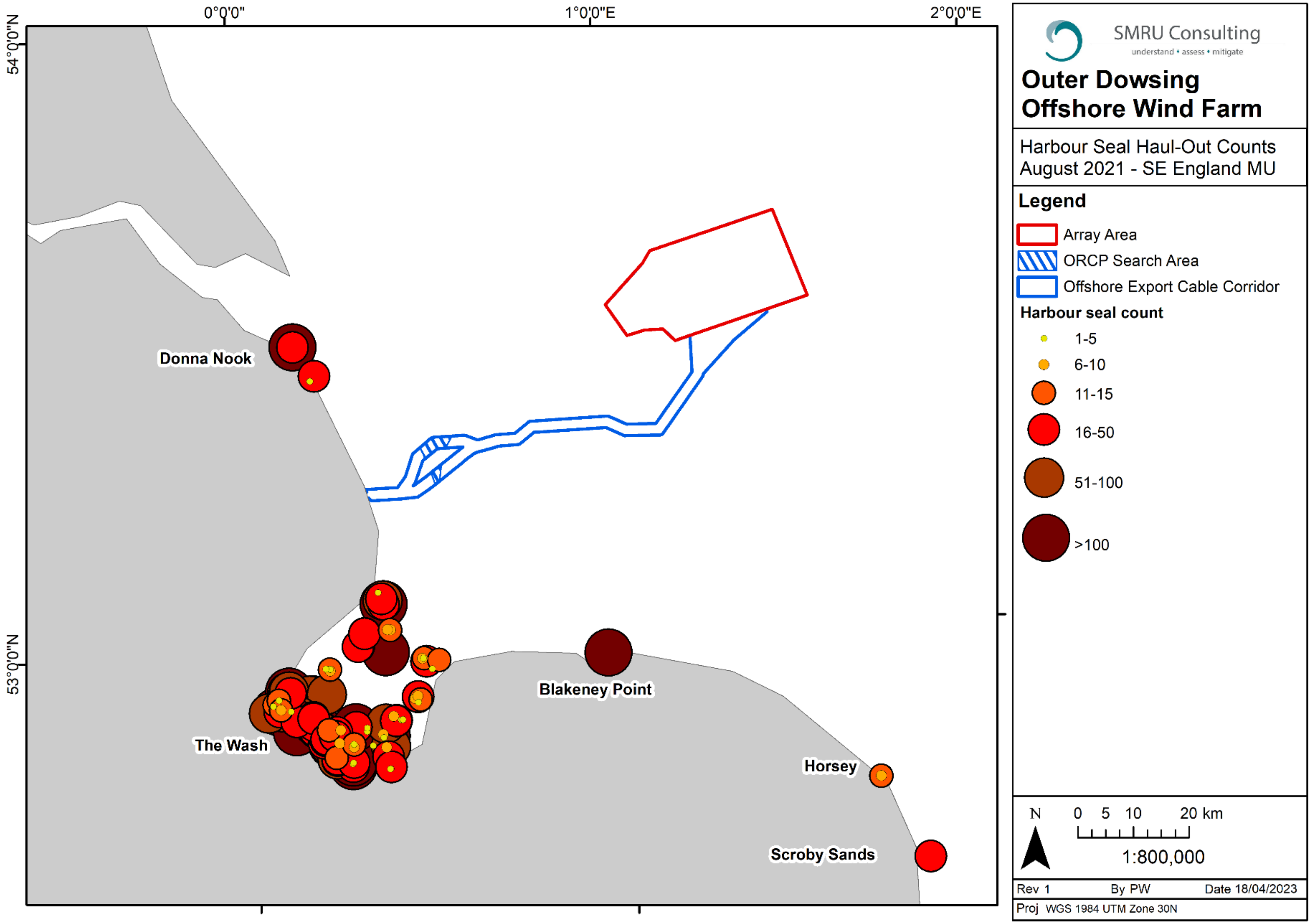

Figure 9.7 Harbour seal haul-out counts from August 2021 (data provided by SMRU).

9.3.2 Donna Nook

Donna Nook is the closest haul-out, located ~5.6 km to the north of the offshore ECC AoS (Figure 9.7), where 146 harbour seals were counted in 2018 and 128 harbour seals were counted in 2019. In 2020, 157 harbour seals were counted at the Donna Nook haul-out and this decreased to 122 in 2021 (SCOS, 2022) (see BP 21/06).

9.3.3 The Wash

The Project is located ~15.7 km north of The Wash haul-out cluster (Figure 9.7). As a collective 3,632 and 2,415 harbour seals were counted in The Wash in 2018 and 2019, respectively. In 2020, the haul-out counts increased to 2,866 and then decreased to 2,667 in 2021 (SCOS, 2022) (see BP 21/06).

9.3.4 Greater Thames Estuary

There are also several haul-outs located within the Greater Thames Estuary Area to the southwest of the Project (within 200 km from the site boundary) (Figure 9.7). As a collective, all haul-out sites in the Greater Thames Estuary Area supported a count of 738 harbour seals in 2018 and 671 harbour seals in 2019. There were no surveys carried out the Greater Thames Estuary during 2020. In 2021, a survey gave a harbour seal count of 498, which equates to a population estimate of 692 (566 – 922) (SCOS, 2022) (see BP 21/07).

While the 2019 August count for harbour seals in the Southeast England MU showed a significant decline across the MU overall, the data for the Greater Thames Estuary area still shows an overall increasing count between 2003 to 2019 at a rate of 8.99% p.a. (Figure 9.8) (Cox *et al.*, 2020). In general, harbour seals haul-out in smaller groups throughout the Greater Thames Estuary area compared to grey seals, with larger group sizes concentrated in the coastal Dengie Flats, Hamford Water, Swale Estuary, Pegwell Bay and outer sandbanks Margate Sands, Goodwin Knoll and Goodwin Sands (Figure 9.9). While harbour seal pups were counted across the Greater Thames Estuary area in 2018, pup counts were highest in Hamford Water and Dengie Flats (Figure 9.9).

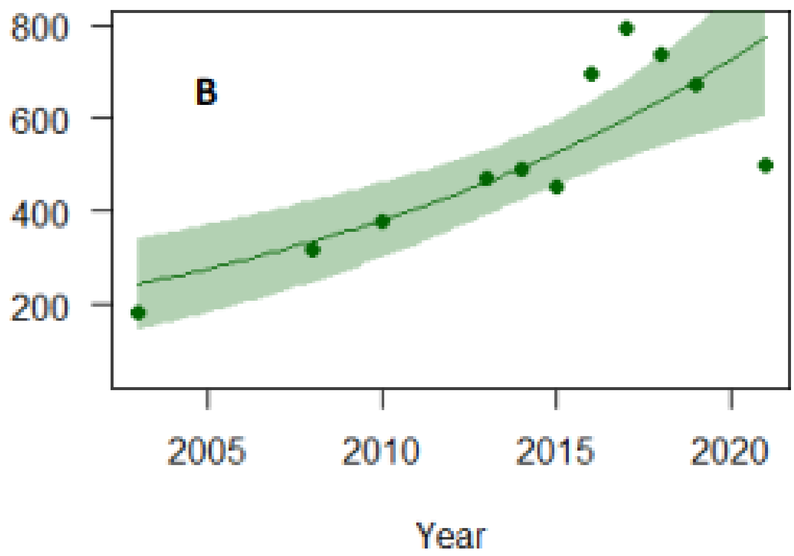

Figure 9.8 2003-2019 counts and fitted trend for the Thames harbour seal population (95% CI shown). Figure taken from SCOS (2022) (see BP 21/07).

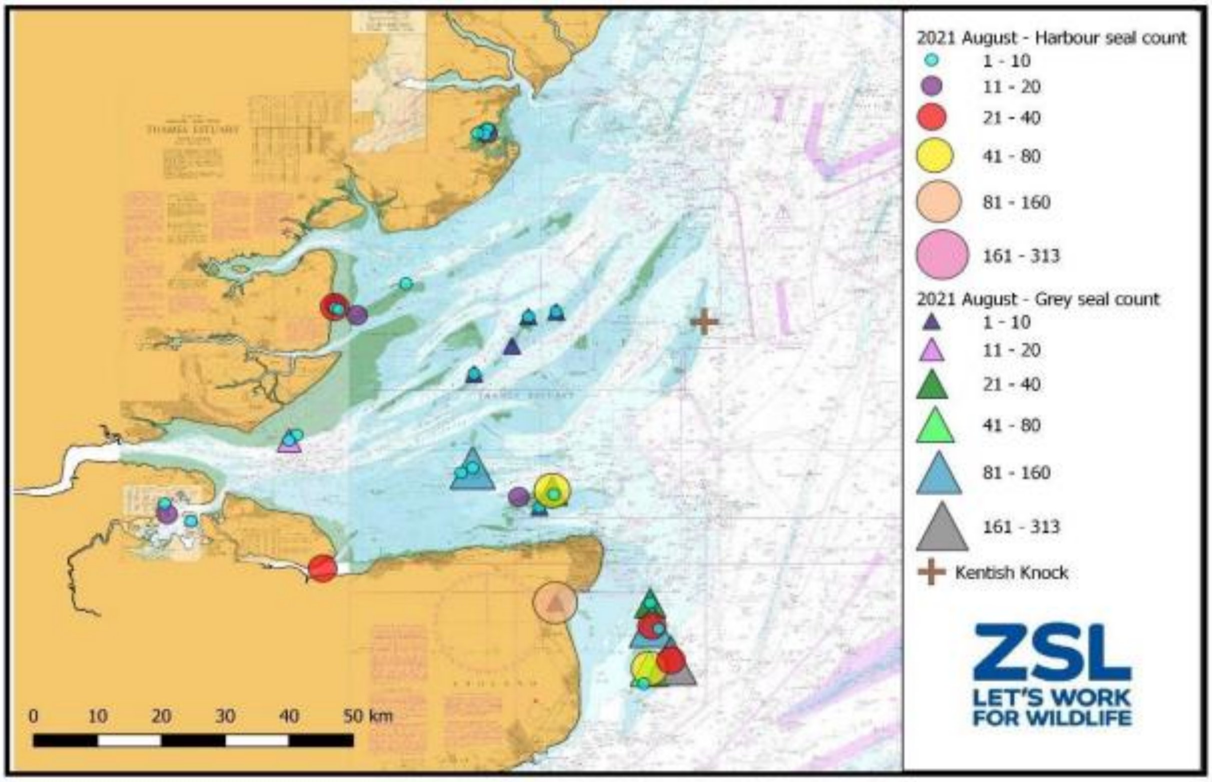

Figure 9.9 The harbour seal and grey seal counts from 2021. Figure taken from (SCOS, 2022) (see BP 21/07).

9.4 At-sea density

As expected, given the location of the main haul-out sites and the limited foraging ranges of harbour seals, the areas of highest at-sea density within the Southeast England MU are concentrated in the waters within and extending out of The Wash and the Greater Thames Estuary. The predicted densities within the Project site boundary (array area) are low with average densities of 0.04 harbour seals/km^2 and a maximum density of 0.21 harbour seals/km^2 (Figure 9.10). Harbour seal densities are significantly higher within the offshore ECC, with a maximum of 0.86 harbour seals/km^2. Within the 50 km buffer of ODOW, there are predicted to be ~1,670 harbour seals at any one time, which equates to an average density of 0.13 harbour seals/km^2. There is a predicted maximum density of 2.10 harbour seals/km^2 in the southwest of the 50 km, extending out of The Wash SAC. In general, harbour seal hotspots extend offshore 50 km from the associated SAC (Carter *et al.*, 2022), and therefore, usage in the area is not expected to be uniform. The density estimate from the habitat usage maps is considered to be the most reliable, and therefore will be taken forward to be used in the impact assessment.

9.5 Telemetry

In total, there have been 86 harbour seals tagged in the Southeast England MU, 67 of which were tagged in The Wash and 19 were tagged in the Thames area (Margate and Hadley Sands). Data from these 86 harbour seals indicate high use of the Project site, the Site Boundary and Offshore ECC AoS (Figure 9.11). Within the 50 km buffer of the Site Boundary, there are telemetry track data recorded from 69 harbour seals. All 69 of the seals within the 50 km buffer showed connectivity with The Wash SAC. This connectivity between the harbour seals in the vicinity of the Project and The Wash SAC will need to be considered in the HRA.

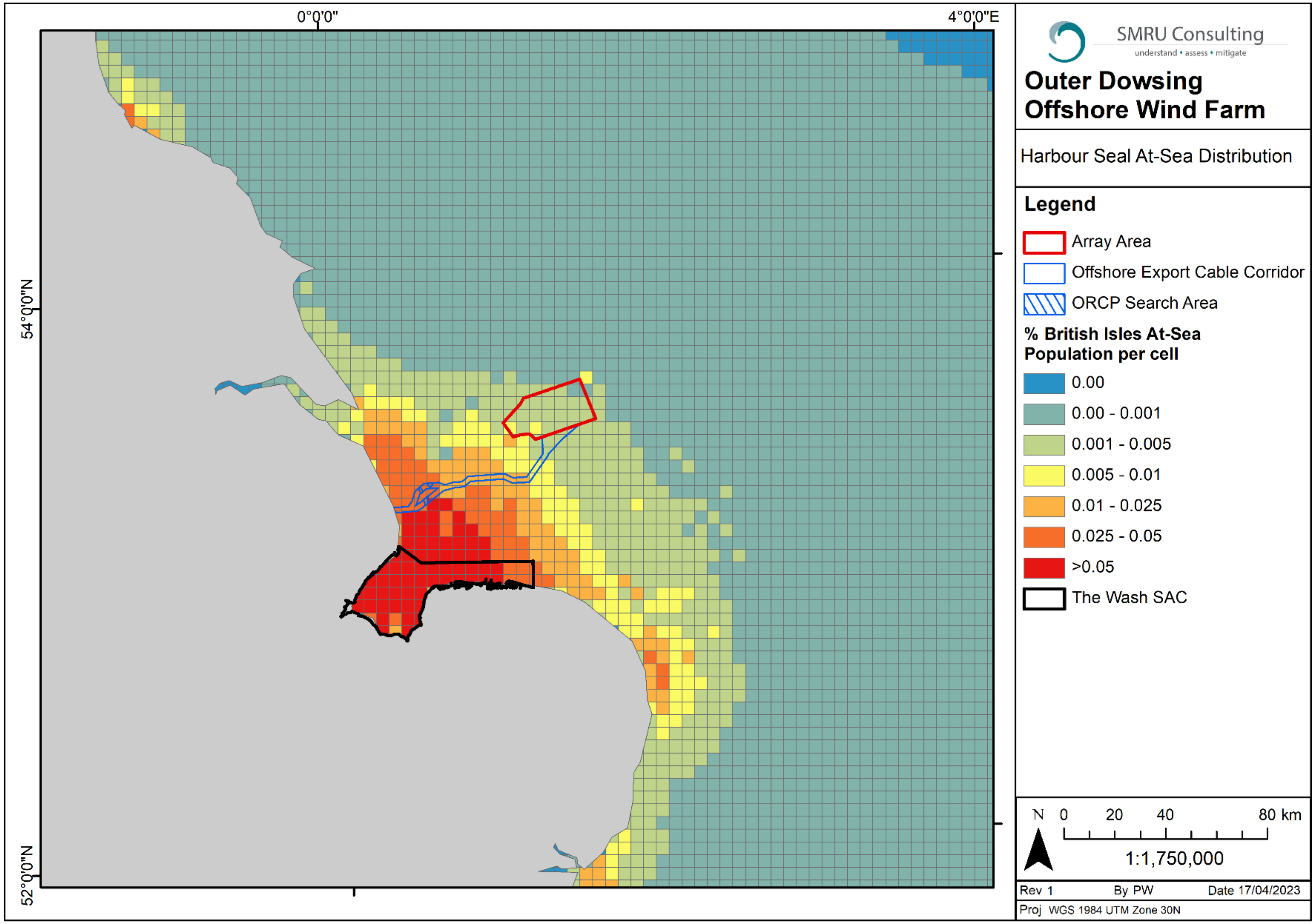

Figure 9.10 Harbour seal at-sea distributions (Carter *et al.*, 2020, Carter *et al.*, 2022).

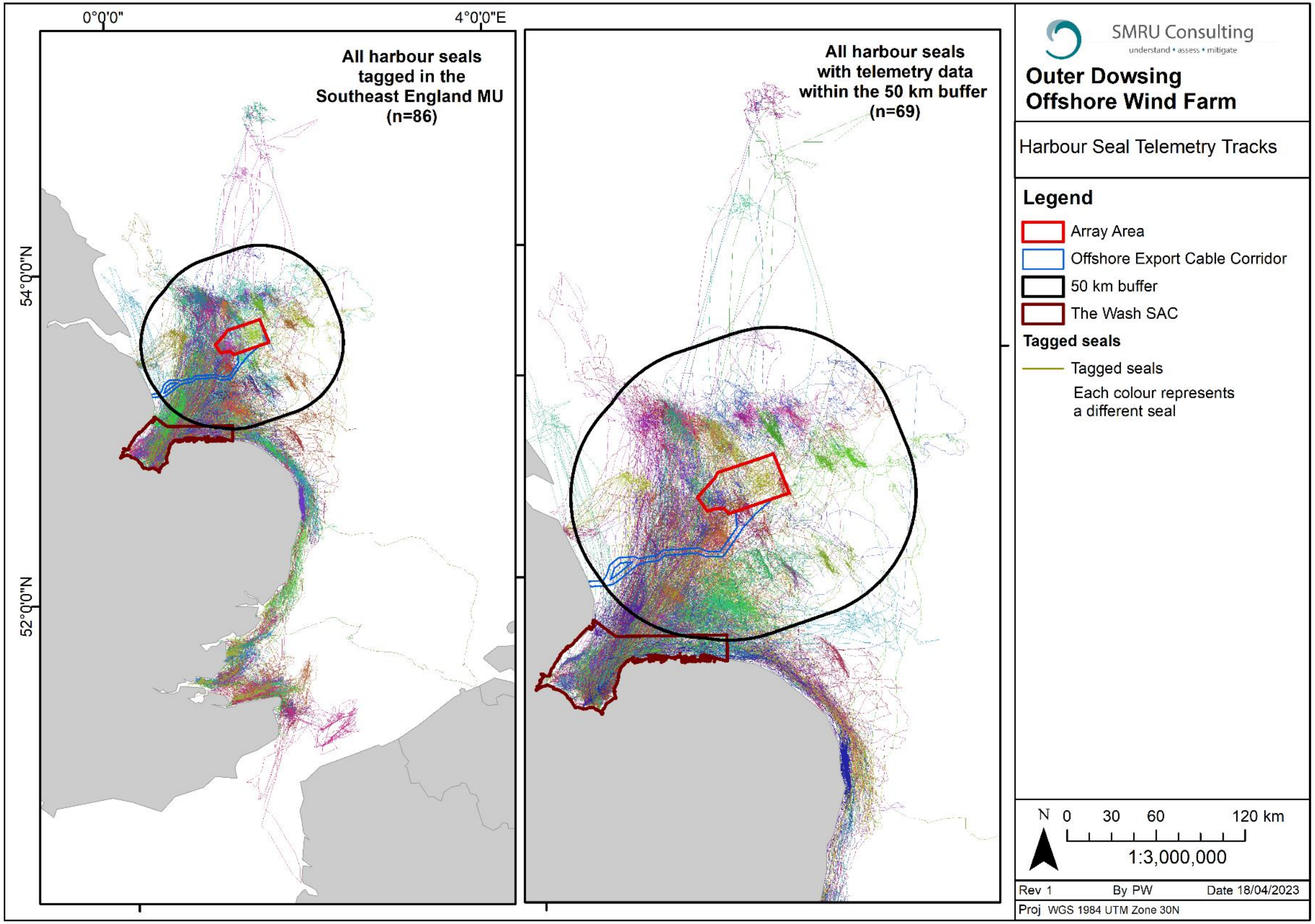

Figure 9.11 Harbour seal telemetry tracks in the vicinity of the Project and connectivity with The Wash SAC

10 Grey seals

The overall assessment of conservation status of grey seals in UK waters has been assessed as Favourable with an overall improving trend in conservation status (JNCC, 2019b) and population modelling for regularly monitored grey seal breeding colonies across the UK show an increasing trend of <1.5% p.a.(SCOS, 2022). The most recent UK wide abundance estimate for grey seals was 157,300 individuals (approx. 95% CI: 144,600 – 169,400) at the start of the 2020 breeding season, based on the 2019 pup production estimates from surveyed colonies (SCOS, 2022). In the UK, grey seal August counts between 2016 and 2019 were highest in Southeast England (8,667), the North Coast and Orkney (8,599) and Northeast England (6,501) (Figure 10.1).

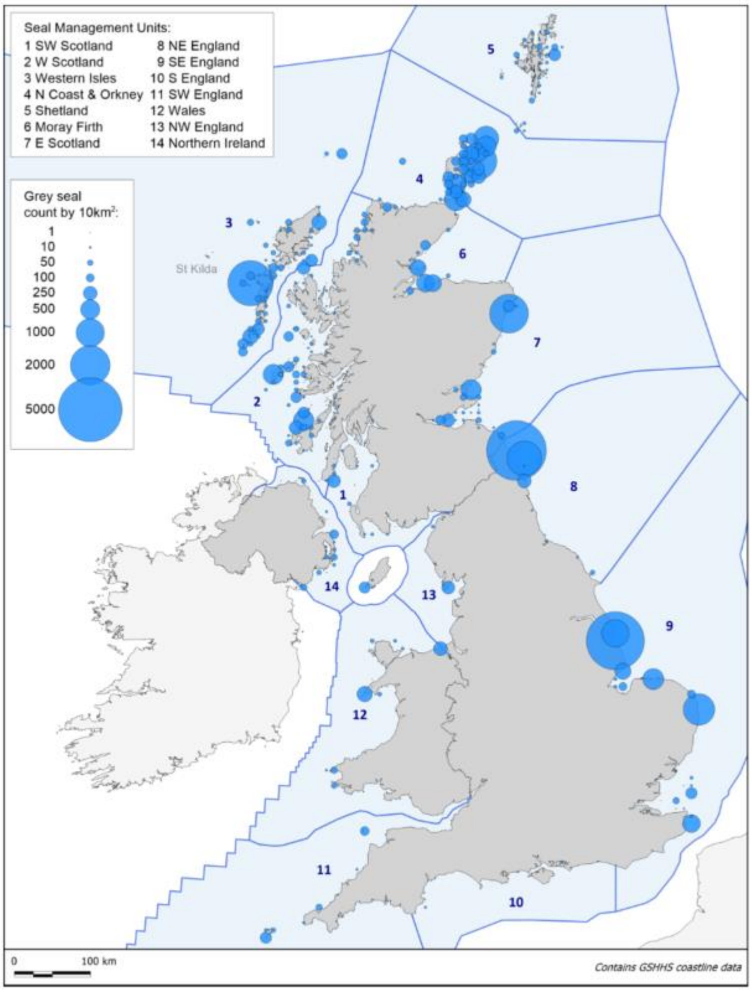

Figure 10.1 August distribution of grey seals around the British Isles by 10km squares based on the most recent available haul-out count data collected up until 2019. Figure taken from (SCOS, 2021).

10.1 Breeding sites

The grey seal pup production in the North Sea shows an annual increase of 7.5% p.a. between 2014 and 2018, which is a slightly lower rate of increase than the 11.5% p.a. between 2010 and 2016 (Figure 10.2) (SCOS, 2021). The nearest key breeding region for grey seals to the Project is the Donna Nook and East Anglia area of the North Sea region which encompasses the breeding colonies at Donna Nook, Blakeney Point and Horsey. The latest pup production estimate in 2019 for the Donna Nook and East Anglia area is 7,902 pups (an annual increase of 10.1 % since 2016), and for the Farne Islands is 2,823 pups (an annual increase of 7.1 % since 2016) (SCOS, 2022) (Figure 10.3).

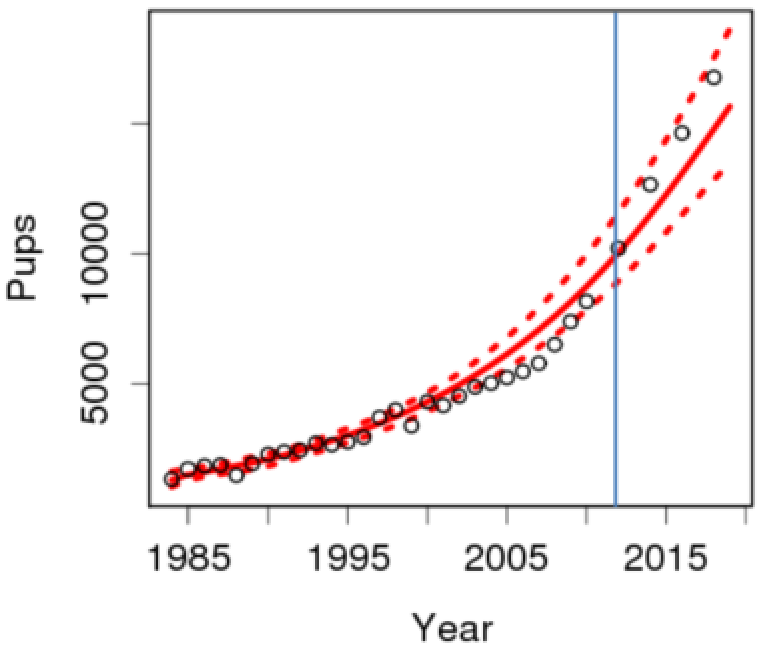

Figure 10.2 Posterior mean estimates of pup production (solid lines) and 95% confidence intervals (dashed lines) from the model grey seal population dynamics, fit to pup production estimates for regularly monitored colonies in the North Sea. The vertical blue line at 2012 indicates the change to a new camera system. Figure taken from SCOS (2021).

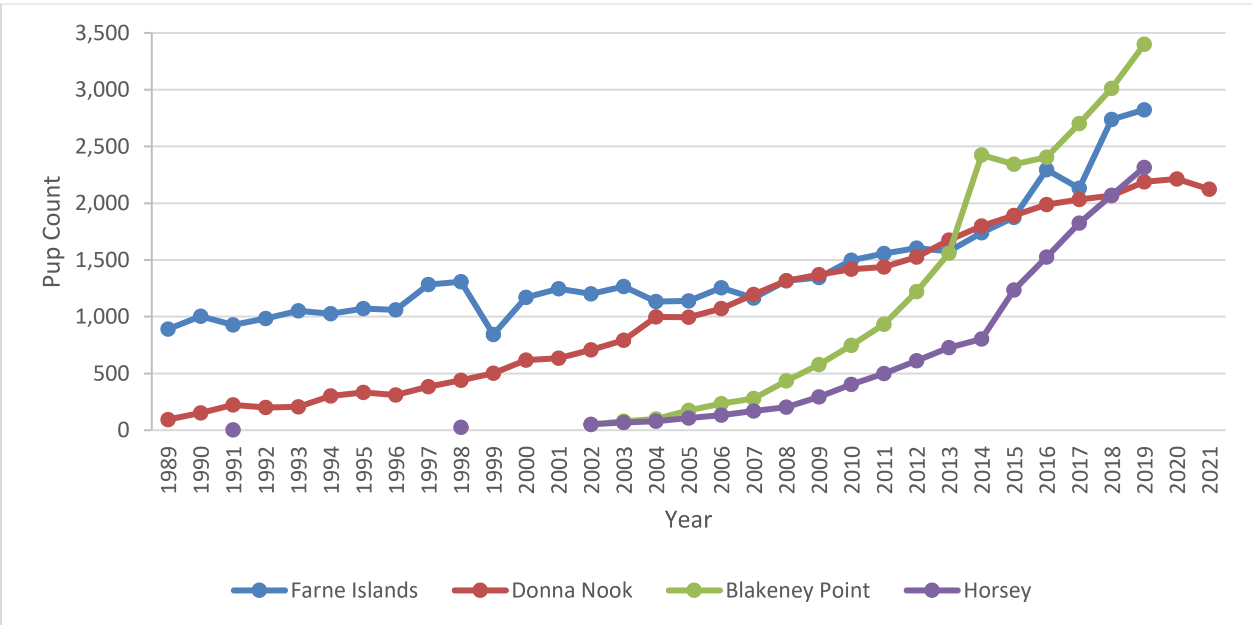

Figure 10.3 Grey seal pup counts at breeding colonies in the Southeast and Northeast England MUs. Data from SMRU.

10.2 Site-specific surveys

To date, a total of 40 grey seals have been recorded in during the site-specific surveys (March 2021 – February 2022). Sightings were recorded throughout the survey area and peaked at 10 recorded grey seals in October 2021. In addition, there were several unidentified seal species and seal/small cetacean species throughout the survey period, some of which could have been grey seals.

Similarly, to harbour seals, during surveys of nearby wind farms (including Triton Knoll, Lincs, Dudgeon and Sheringham Shoal Extensions) grey seals have been observed from surveys at all sites. However, density estimates could not be reliably calculated to the lack of recorded sightings and dedicated surveys.

10.3 The Project geophysical surveys

Throughout the 2021 geophysical surveys, there were low numbers of grey seal sightings and unidentified seal sightings, which could have been grey seals. During the 2022 surveys, 19 grey seals were sighted and 16 unidentified seals were recorded, which could have been grey seals (Seiche, 2022a). However, due to the low number of recorded sightings, a density estimate could not be reliably calculated.

10.4 Haul outs

10.4.1 MU

Given the wide-ranging nature of grey seals (frequently travelling over 100 km between haul-out sites) (SCOS, 2021), and the large degree of movement between the north east and south east of England, it is not appropriate to consider the Southeast England MU as a discrete population unit in isolation, therefore the relevant population against which to assess impacts should be the combined Southeast and Northeast England MUs. The latest August haul-out count for grey seals in Southeast England MU is from the 2019 survey where 8,667 grey seals were counted (SCOS, 2021). The latest August haul-out count data for grey seals in Northeast England is from the 2020 survey where 4,660 grey seals were counted (SCOS, 2022) (see BP 21/03). The 2019 August haul-out count for the Southeast England MU combined with the 2020 count for the Northeast England MU (13,327 combined total) can be scaled by the estimated proportion hauled-out (0.2515; 95% CI 0.2145 – 0.2907) (SCOS, 2022) to produce an estimate of 52,990 grey seals in the Southeast and Northeast England MUs combined (95% CI: 45,845 – 62,131).

Overall, the grey seal population in the Northeast England MU has shown a continuing increase (Figure 10.4). However, there is uncertainty associated with the trends as shown by the large 95% confidence intervals. It is unclear as to whether the most recent counts show the continuing trend or a step increase (SCOS, 2022). In the Southeast England MU, there has been a notable increase since 2002 (the PDV outbreak for which grey seal mortality is not associated) (Figure 10.5). However, during the past four years, this increase has slowed and began to level off (SCOS, 2022).

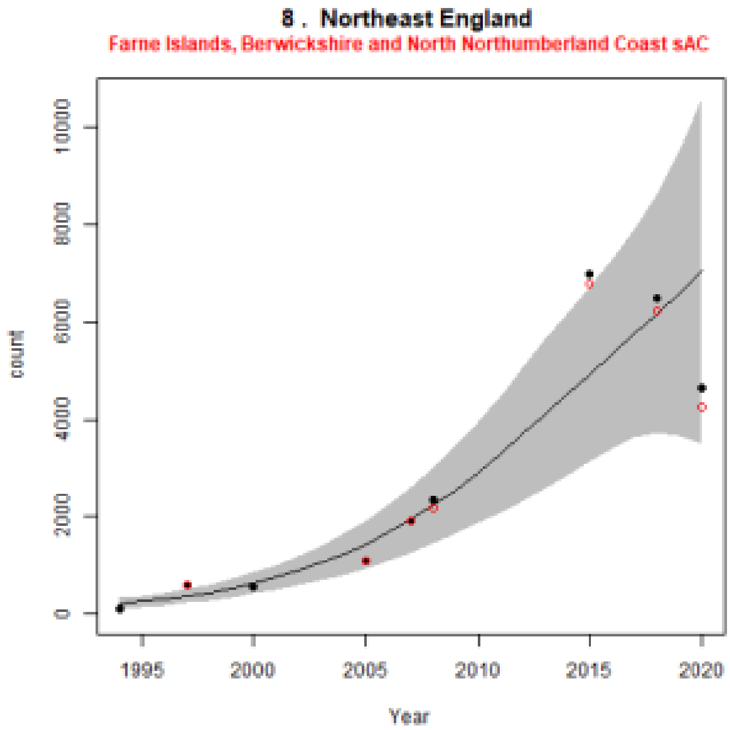

Figure 10.4 The predicted trend and associated 95% confidence intervals for the grey seal August haul-out counts in the Northeast England MU. The red circles indicate the SAC counts, the filled black circles indicate the values used to fit the trends and the open black circles illustrate the MU wide counts (SCOS, 2022) (see BP 21/03).

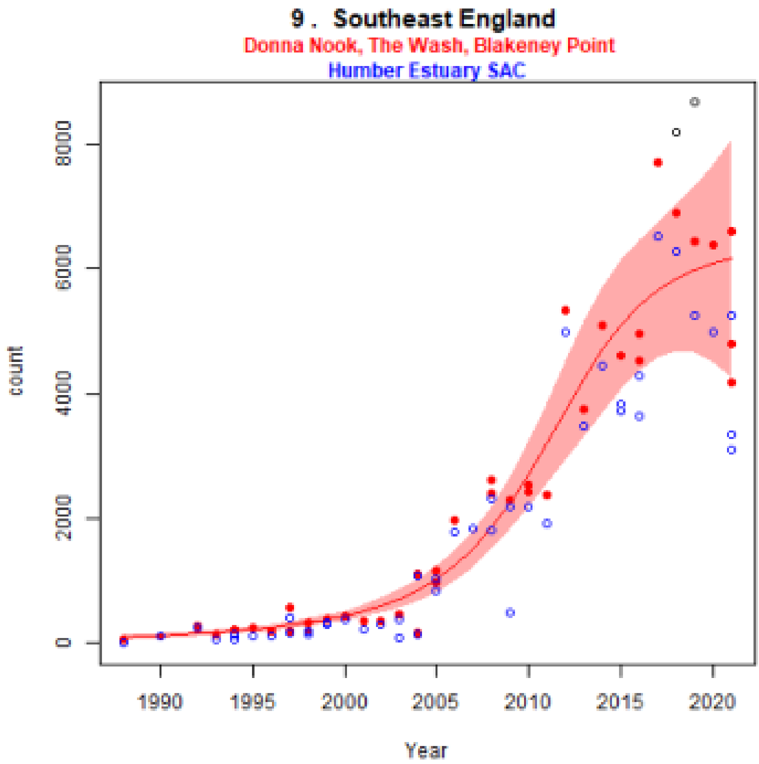

Figure 10.5 August counts of grey seals on the coast between Donna Nook (blue) and along the coast between Donna Nook and Blakeney (red) between 1988 and 2021. The red line and associated 95% confidence intervals represent the counts from Donna Nook to Blakeney (SCOS, 2022) (see BP 21/03).

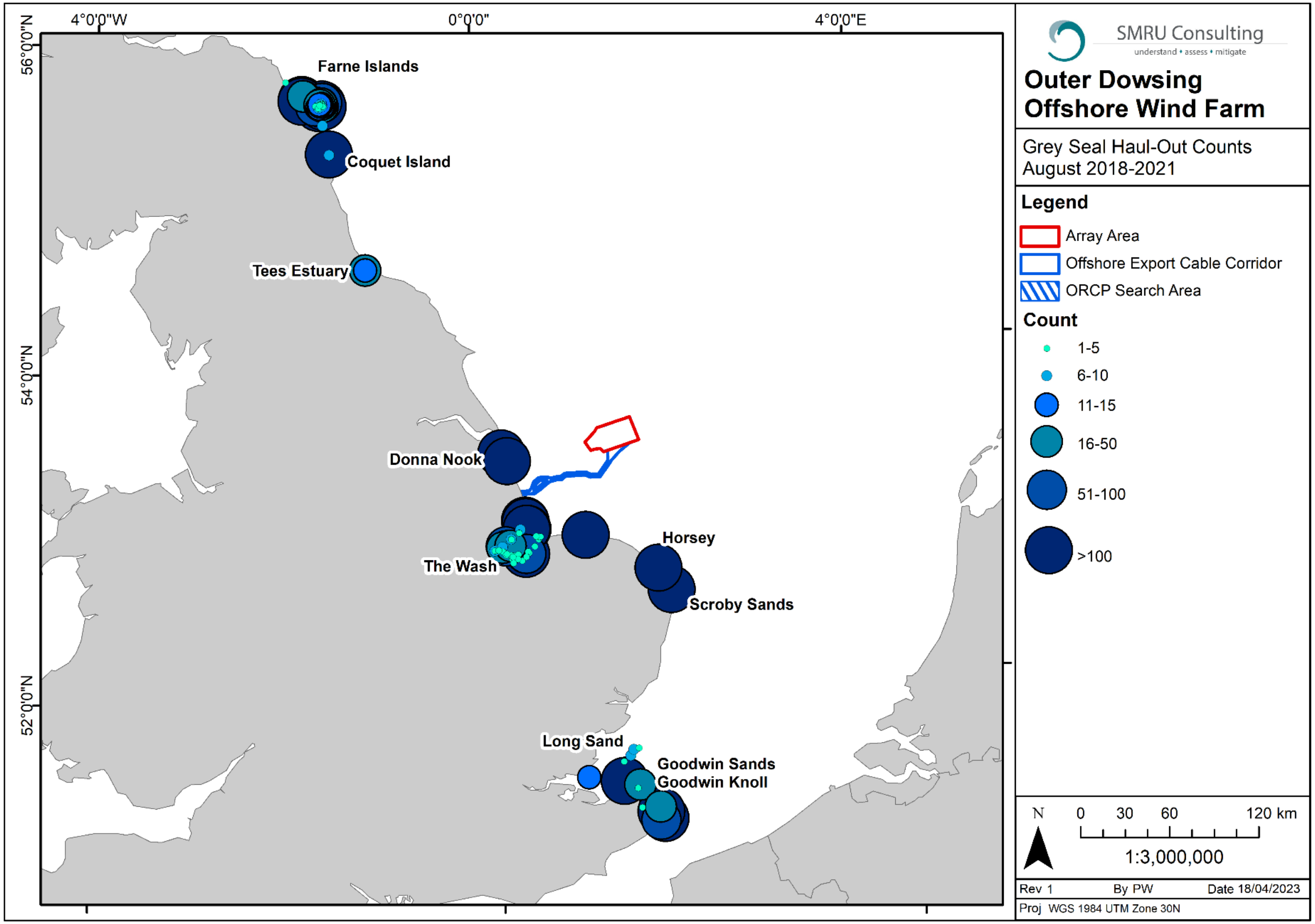

Figure 10.6 Grey seal haul-out counts in the Southeast and Northeast England MUs from 2018 to 2021 (data provided by SMRU).

10.4.2 Farne Islands

In the Northeast England MU, most grey seal haul-outs are located within the Farne Islands (1,608 in 2018 (SCOS, 2021)), located ~ 265 km north of the Project (Figure 10.6).

10.4.3 Donna Nook

Most grey seal haul-outs in the Southeast England MU are located in Donna Nook (6,288 in 2018 and 5,265 in 2019), which is ~9.9 km north of the Project offshore ECC AoS (Figure 10.6). In 2020, Donna Nook held 60% of the grey seal counts in the Southeast England MU but has shown a decline in recent years (4,982 in 2020 and 3,897 in 2021) (SCOS, 2022) (see BP 21/06).

10.4.4 Scroby Sands

Scroby Sands is the second largest haul-out site (497 in 2018 and 1,333 in 2019), located ~87.6 km to the southeast of the Project offshore ECC AoS (Figure 10.6). In recent years, the counts in this area have increased from 1,191 in 2020 to 1,377 in 2021 (SCOS, 2022) (see BP 21/06).

10.4.5 The Wash

There are also several haul-outs located within The Wash ~15.3 km south of the Project (Figure 10.6). As a collective, the haul-outs counts within The Wash were 253 grey seals in 2018 and 540 in 2019. Grey seal counts in The Wash have increased in recent years with 644 grey seals counted in 2020 and 799 counted in 2021. In addition, grey seal distribution within The Wash has expanded with grey seals now identified on 21 sites, including sheltered creeks known to be used by harbour seals (Figure 10.7) (SCOS, 2022) (see BP 21/06).

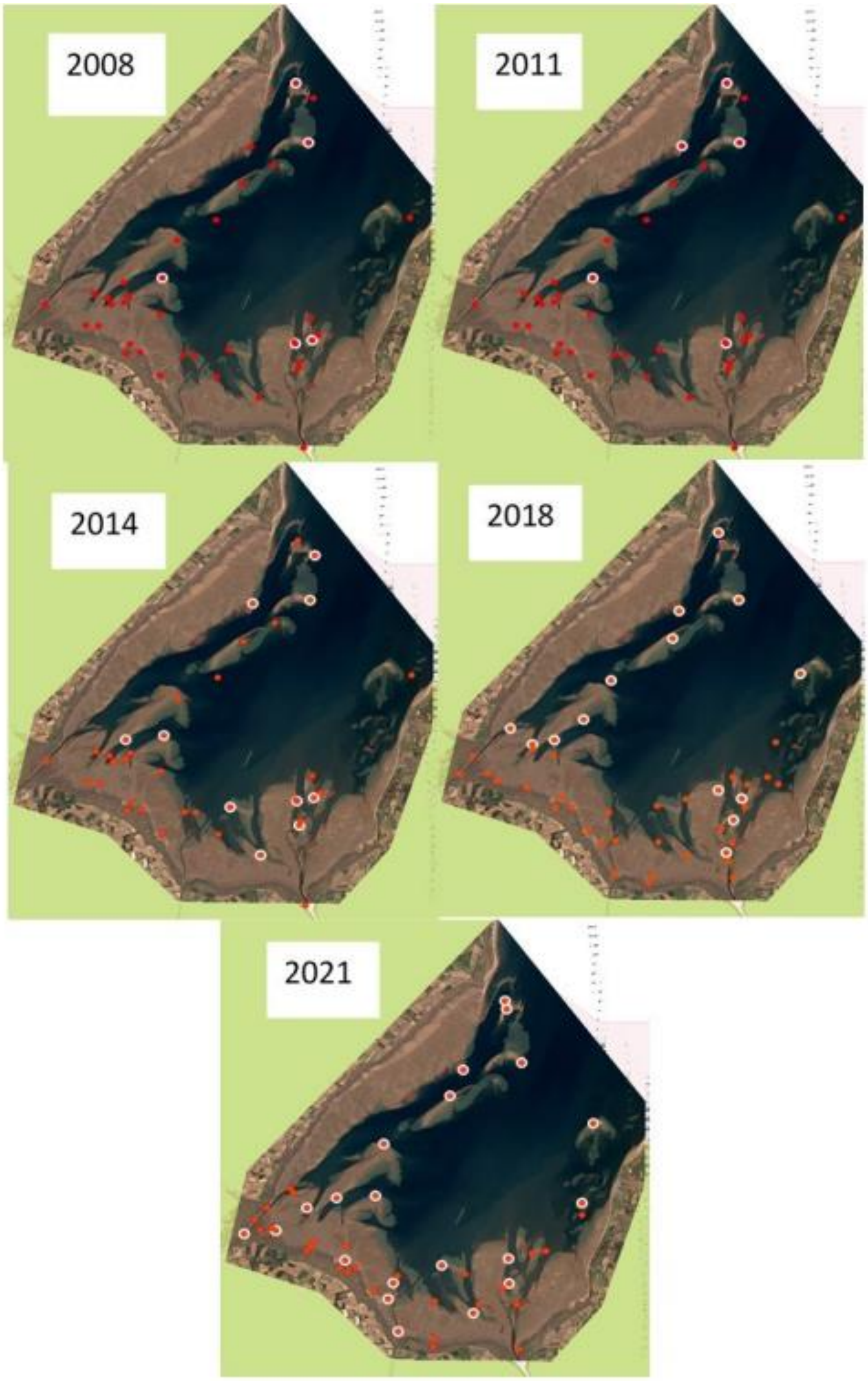

Figure 10.7 The distribution of harbour (red) and grey (white) seals in the Wash from 2008 to 2021 (SCOS, 2022) (see BP 21/06).

10.4.6 Greater Thames Estuary Area

Within the Greater Thames Estuary Area to the southwest of the development (within around 200 km from the PEIR Boundary) there are several haul-outs (Figure 10.6). As a collective, all haul-out sites in the Greater Thames Estuary Area (Long Sand to Goodwin Sands/Knoll) supported a count of 596 grey seals in 2018 and 772 grey seals in 2019. Overall, there has been an increase in counts in the Greater Thames Estuary area (Figure 10.8), specifically between 2003 to 2019 at a rate of 12.62% p.a. (Cox *et al.*, 2020). In this area, grey seals have been counted in highest numbers at offshore sandbanks such as Kentish Knock and Goodwin Sands (Figure 9.9, Figure 10.9). The most recent count in this area was undertaken in 2021, where 749 grey seals were counted, which equates to a population estimate of 2,978 (2,577 – 3,492) grey seals (SCOS, 2022) (see BP 21/07). However, during 2021, the Kentish Knock sandbanks were excluded due to the proximity to surrounding wind farms, and therefore, this is suggested to be the reason for the decline in counts rather than a population decline (SCOS, 2022).

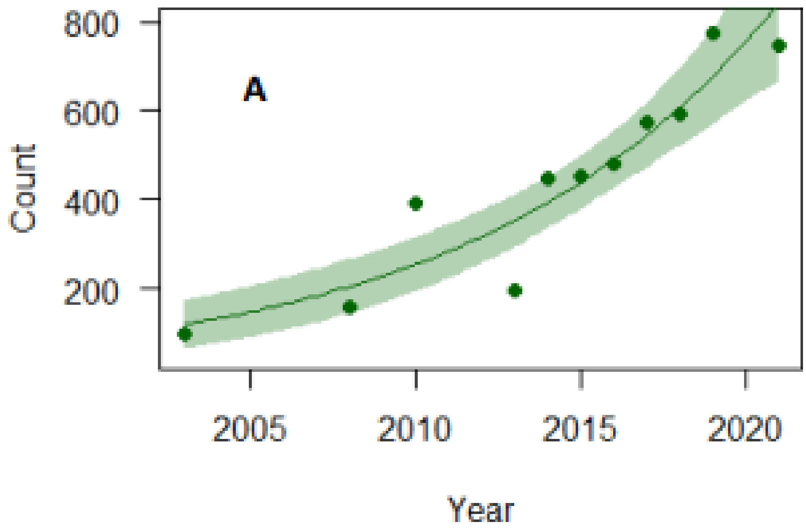

Figure 10.8 2003-2019 counts and fitted trend for the Thames grey seal population (95% CI shown). Figure taken from SCOS (2022) (see BP 21/07).

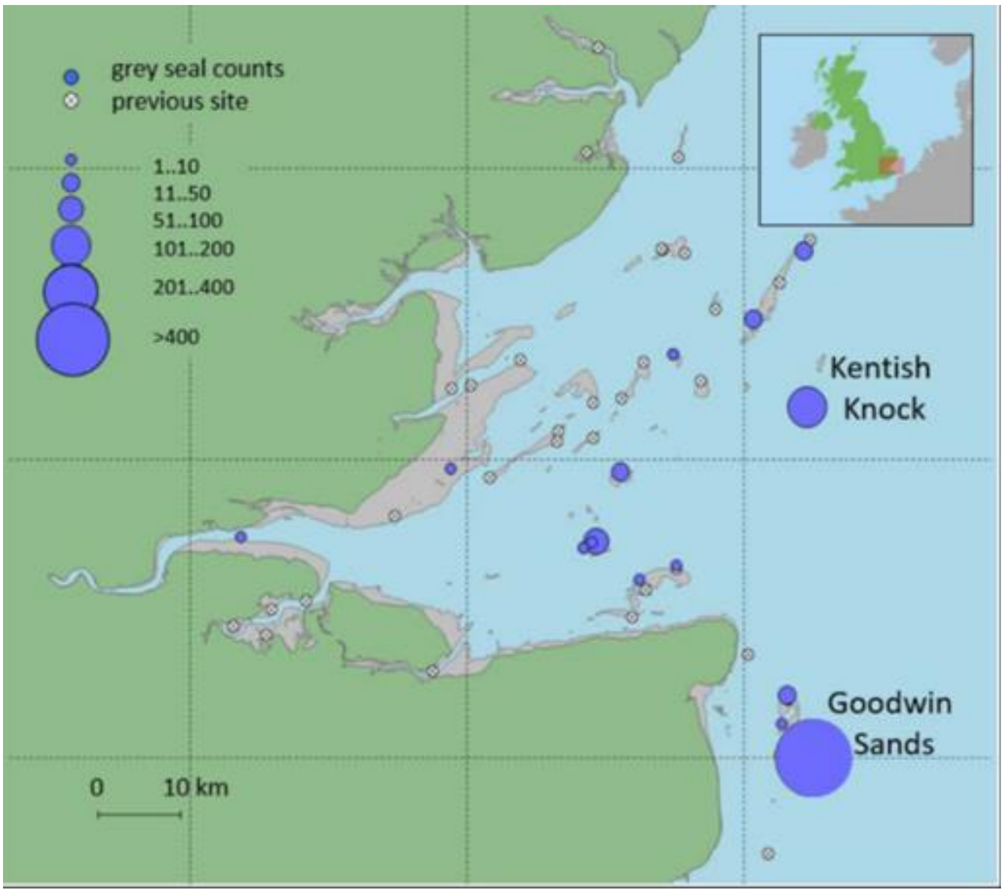

Figure 10.9 Count of grey seals and other sites occupied by grey seals in previous surveys. Figure taken from Cox *et al.* (2020).

10.5 At-sea density

In the Southeast and Northeast England MUs, grey seal at-sea distribution is primarily located in the waters extending out of the Humber Estuary and the Farne Islands. Specifically, there are hotspots in grey seal density >150 km offshore from the Humber Estuary SAC (Carter *et al.*, 2022). There are high densities of grey seals between the Humber Estuary and The Wash SAC, and in the vicinity of the Project (Figure 10.10). Grey seal density estimates within the Project site boundary are on average 0.76 grey seals/km^2 and reach a maximum of 1.25 grey seals/km^2. Maximum grey seal densities within the ECC AoS are much higher at 4.92 grey seals/km^2. Within the 50 km buffer of the Project, there are predicted to be ~11,018 grey seals at any one time, which equates to an average density of 0.85 grey seals/km^2. Usage within the 50 km buffer is not expected to be uniform, with higher densities towards the coast and the Humber Estuary SAC. At present, the density estimate from the habitat preference map is the most reliable, and therefore will be taken forward to be used in the impact assessment.

10.6 Telemetry

In total, there have been 64 grey seals tagged in the east England MUs (33 from the Southeast England MU and 31 from the Northeast England MU). These seals were tagged at the Farne Island, Donna Nook and Blakeney between 1988 and 2015. Data from these 64 tagged grey seals indicate high use of the Project Offshore ECC and moderate use of the Site Boundary (array area) (Figure 10.11 Left).

Of these 64 tagged grey seals, 32 had telemetry data within the 50 km buffer of the array area (Figure 10.11 Right). The telemetry track data indicates high connectivity between the 50 km buffer and the Humber Estuary SAC (n=29) and less connectivity with the Berwickshire and North Northumberland Coast SAC (n=10). This connectivity between the grey seals in the vicinity of the Project and the SACs will be considered in the HRA.

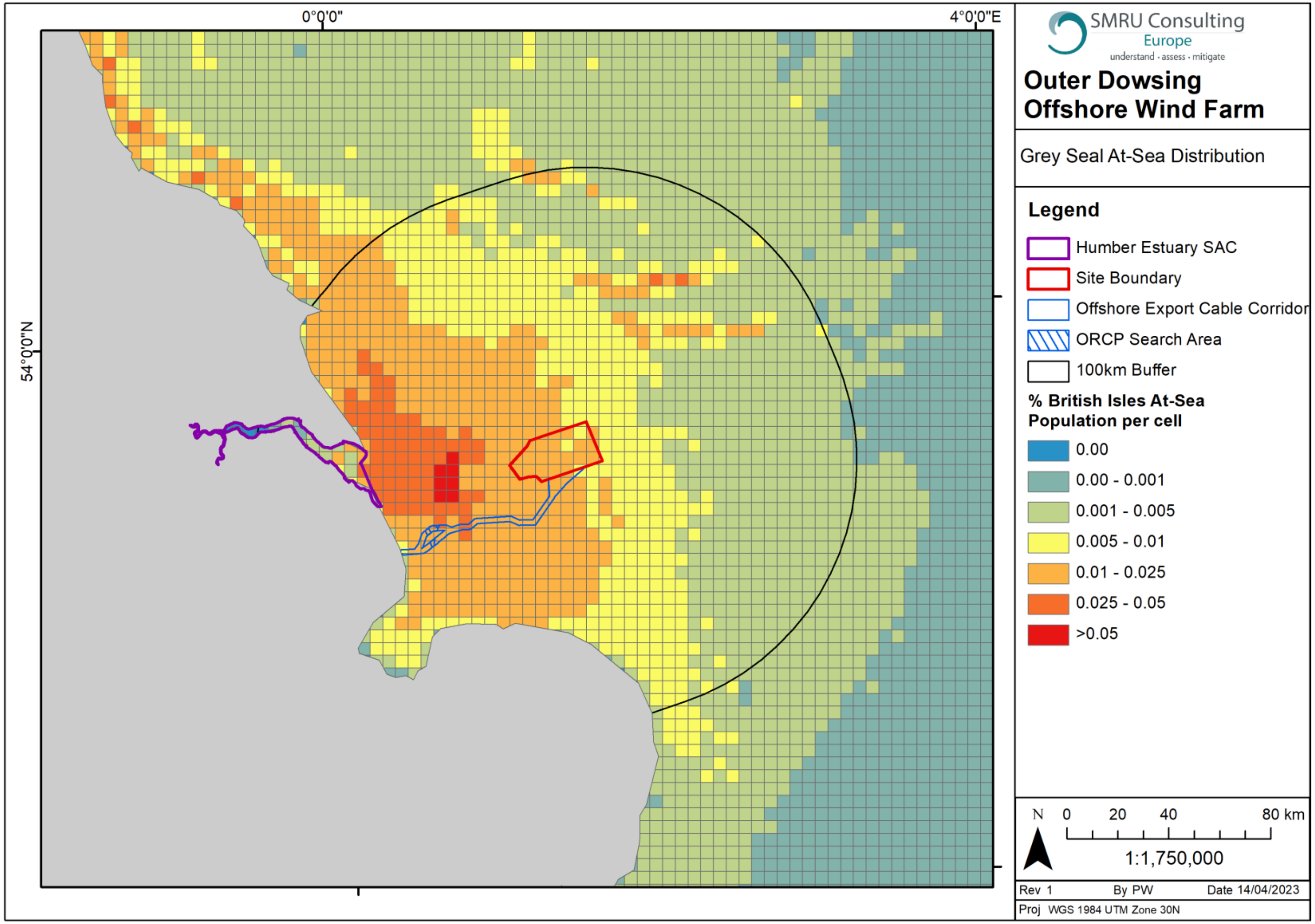

Figure 10.10 Grey seal at-sea distributions (Carter *et al.*, 2020, Carter *et al.*, 2022).

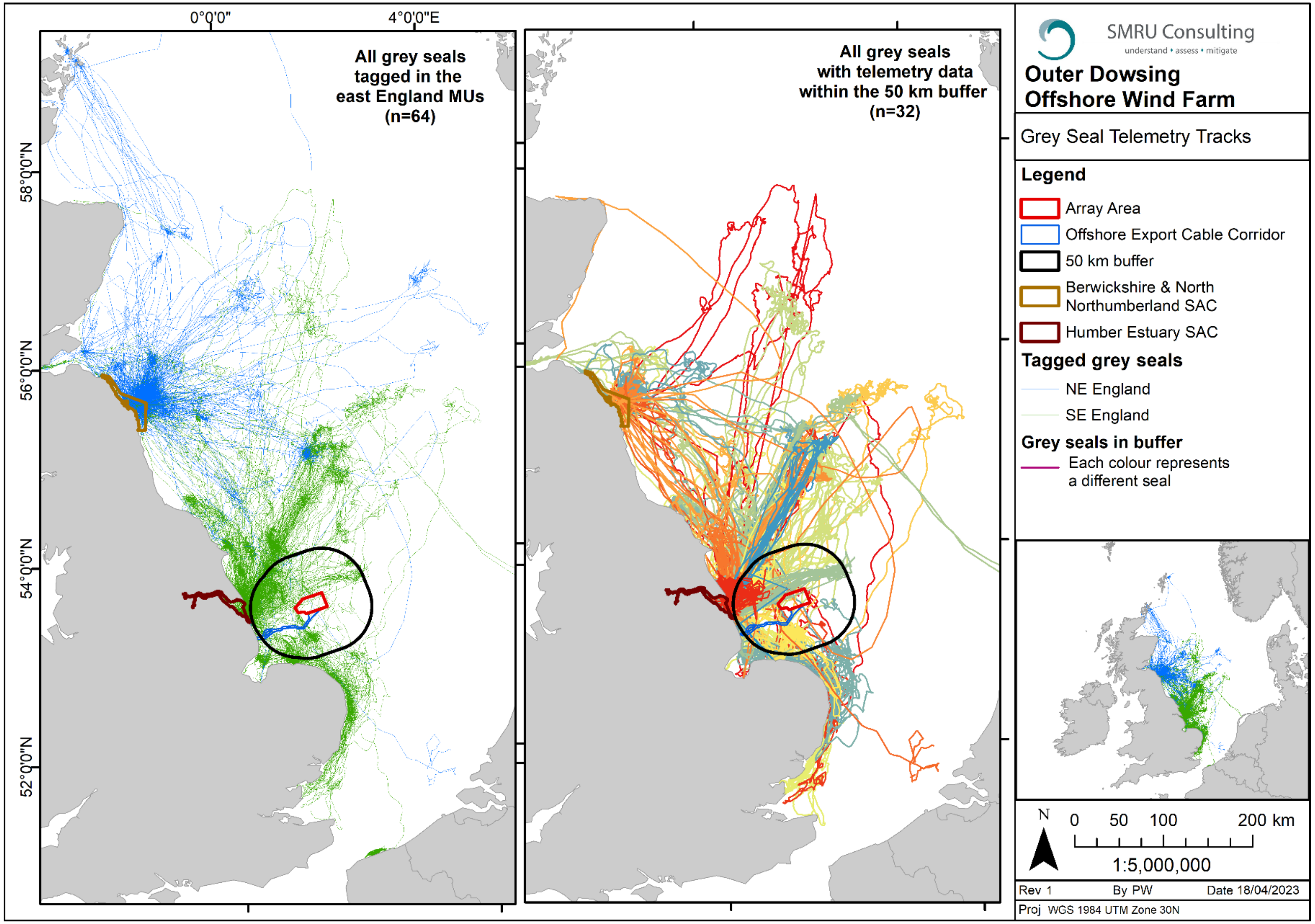

Figure 10.11 Grey seal telemetry tracks in the vicinity of the Project and connectivity with grey seal SACs.

Data collected by Vincent *et al.* (2017) shows clear evidence that grey seals exhibit wide-ranging movement behaviours. Grey seals tagged in France and the Netherlands recorded telemetry data throughout the Wadden Sea and Southeast England MU, with fewer tracks extending into the vicinity of the Project and the Northeast England MU indicating there are limited transboundary effects (Figure 10.12).

Given that the data presented in Vincent *et al.* (2017) show connectivity between France, the Netherlands and the Southeast England MU, this highlights a limitation of the current seal habitat preference maps. These current maps include grey seals only tagged in the UK, and therefore do not account for the presence of grey seals from France or the Wadden Sea. Therefore, the seal habitat preference maps may potentially underestimate the true density of grey seals present in the vicinity of the Project; though these remain the best density data source currently available.

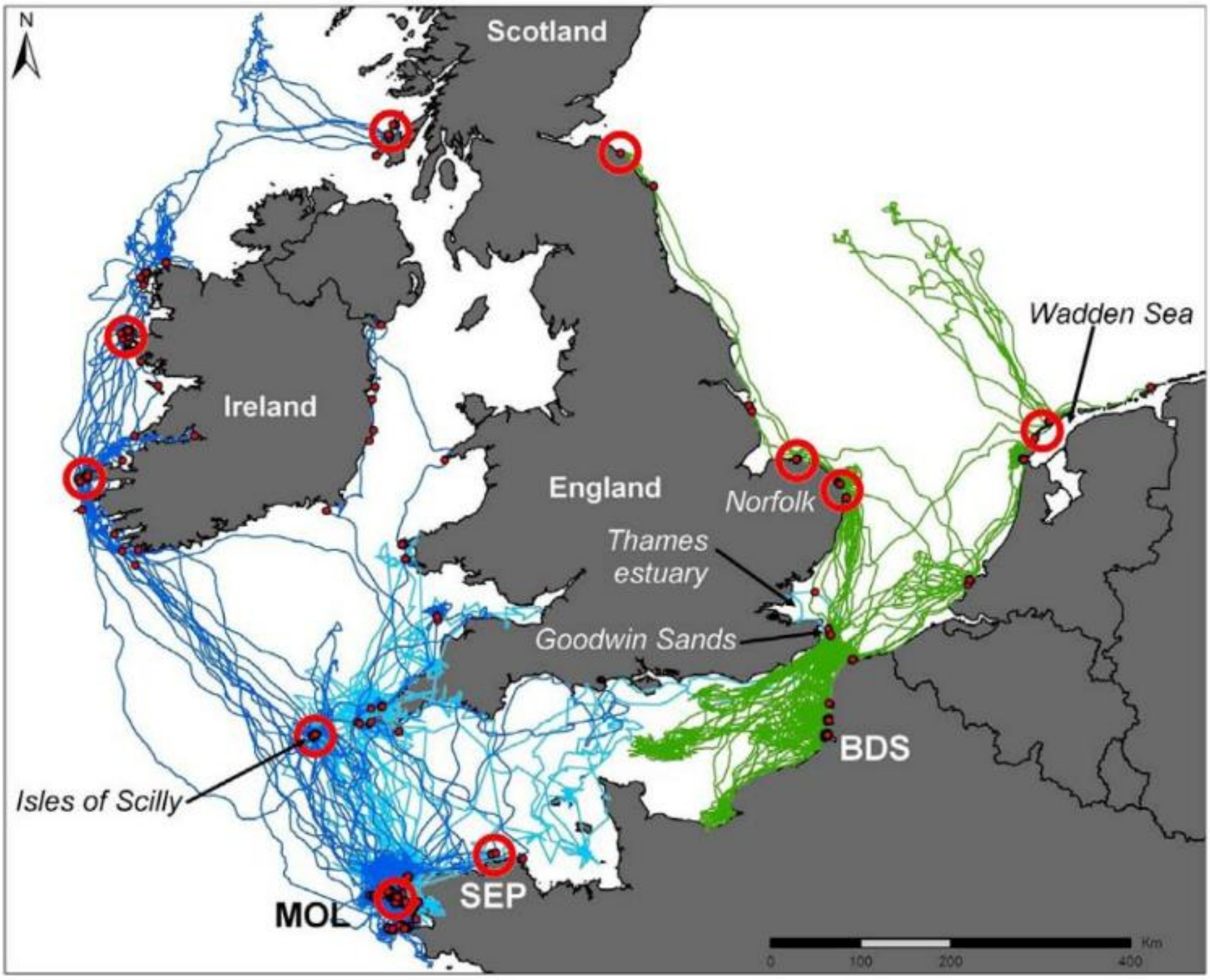

Figure 10.12 Telemetry tracks for grey seals tagged in France (Vincent *et al.*, 2017). Tracks from MOL (15 individuals tracked by Argos tags from 1999 to 2003, in light blue, and 19 individuals tracked by GPS/GSM tags from 2010 to 2013, in dark blue) and BDS (11 individuals tracked in 2012, in green). Red dots indicate haul-out locations of the seals. Thick, red circles indicate breeding locations, as suggested from the activity budget of the seals.

11 Conclusions

The Project site-specific surveys alongside the literature review of other data sources confirmed the presence of six marine mammal species regularly present in the Project area (Table 11.1). These six species will be taken forward to the quantitative impact assessment at PEIR. It is noted that the HiDef (2022) site-specific survey density estimates are valid for year 1 of the surveys only, as sightings from year 2 had not been processed in time for the PEIR. Therefore, depending on the results of the year 2 surveys, the density estimates used in the quantitative impact assessment at EIA may differ to those presented here at PEIR. In addition to identifying the MU and density estimate to take forward to quantitative impact assessment (Table 11.1), this baseline has also identified various marine mammal protected areas that will be given further consideration in the HRA:

- Southern North Sea SAC (harbour porpoise)
- Moray Firth SAC (bottlenose dolphins)
- Southern Trench MPA(NC) (minke whale)
- Wash and North Norfolk SAC (harbour seal)
- Humber Estuary SAC and Berwickshire and North Northumberland Coast SAC (grey seal).

Table 11.1 Species, MU size and density estimates recommended for the use in the Project quantitative assessment.

Species	MU	MU Size	MU Ref	Density (#/km^2)	Density ref
Harbour porpoise	North Sea	346,601	IAMMWG (2022)	2.375	HiDef (2022) site-specific surveys
Bottlenose dolphin	Greater North Sea	2,022	IAMMWG (2022)	0.002 0.110[3]	SCANS III & JCP III Assumed 2 km from coast
White-beaked dolphin	Celtic and Greater North Seas	43,951	IAMMWG (2022)	0.002	HiDef (2022) site-specific surveys & Hammond *et al.* (2021) SCANS III
Minke whale	Celtic and Greater North Seas	20,118	IAMMWG (2022)	0.010	SCANS III & Royal HaskoningDHV (2021)
Harbour seal	Southeast England	4,852	SCOS (2022) counts scaled to account for seals at sea using Lonergan *et al.* (2013)	Grid cell specific	Habitat preference (Carter *et al.*, 2020, Carter *et al.*, 2022)
Grey seal	Southeast & Northeast England	52,990	SCOS (2022) counts scaled to account for seals at sea using SCOS (2022) BP 21/03	Grid cell specific	Habitat preference (Carter *et al.*, 2020, Carter *et al.*, 2022)

[3] Only present within 2 km of the coastline

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