FIVE ESTUARIES OFFSHORE WIND FARM

PRELIMINARY ENVIRONMENTAL INFORMATION REPORT

VOLUME 4, ANNEX 7.1: MARINE MAMMALS BASELINE CHARACTERISATION

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understand ♦ assess ♦ mitigate

Five Estuaries Offshore Wind Farm

Marine Mammal Baseline Characterisation

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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 and the abundance and density of marine mammals that could potentially be impacted by the Five Estuaries Offshore Wind Farm (VE). The baseline data have been compiled through a combination of literature review 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 two years of site-specific surveys at VE) are harbour porpoise (*Phocoena phocoena*), harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*). Other marine mammals that have been sighted in the southeast of England but are considered to be only occasionally or rarely present include: bottlenose dolphins (*Tursiops truncatus*), white-beaked dolphins (*Lagenorhynchus albirostris*), common dolphins (*Delphinus delphis*), minke whales (*Balaenoptera acutorostrata*), fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*) (Reid *et al.*, 2003). None of these other marine mammal species were identified during the two years of site-specific aerial surveys at VE (HiDef Aerial Surveying Ltd, 2021); therefore, it is proposed that these species are scoped out of assessment for VE.

2 Study Area

The VE 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 (Figure 1): 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);
    - Harbour seals: Southeast England MU; and
    - Grey seals: combined Southeast and Northeast England MUs.
- The VE study area (Figure 2) includes the survey area for the VE site-specific surveys to provide an indication of the local densities of each species.

The marine mammal study area (MUs and survey area) is shown in Figure 1.

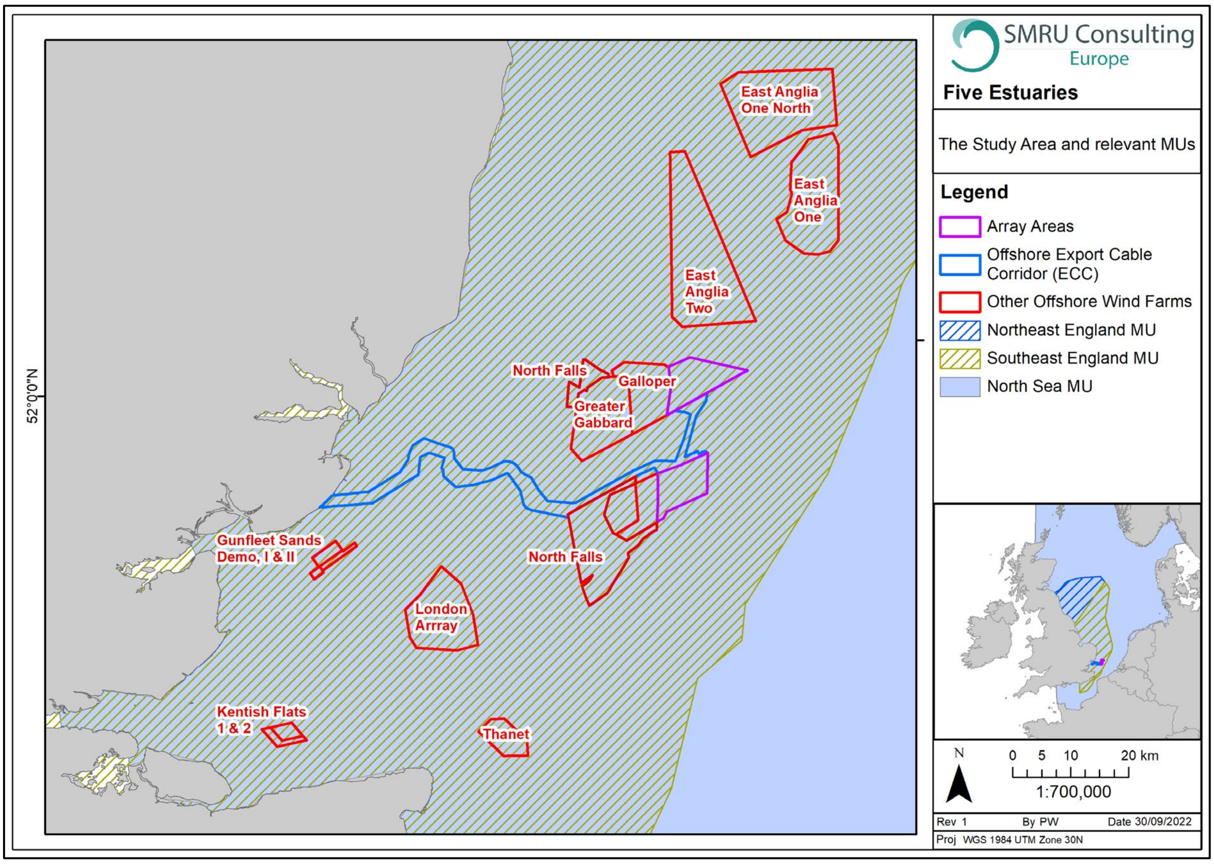

Figure 1 Marine mammal study area (MUs).

3 Data Sources

Table 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 VE. 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): site-specific surveys, SCANS, JCP, MERP distribution maps, SCOS, seal habitat preference maps, seal haul-out counts.

Table 1 Marine mammal baseline datasets

SOURCE	DESCRIPTION
Site-specific aerial surveys for VE (HiDef Aerial Surveying Ltd, 2020, 2021)	Site-specific baseline characterisation digital video aerial surveys (March 2019 – February 2021). The survey area consists of the VE array areas with a 4 km buffer.
Additional Offshore Wind Farm (OWF) surveys	• Galloper OWF baseline and post-construction surveys (vessel-based); • Greater Gabbard OWF baseline, construction and post-construction surveys (vessel-based); and

SOURCE	DESCRIPTION
	• North Falls (Greater Gabbard Extension) OWF baseline surveys (aerial).
SCANS III (Hammond *et al.*, 2021)	Combination of vessel and aerial surveys of the North Sea and European Atlantic continental shelf waters conducted in July 2016.
JCP Phase III (Paxton *et al.*, 2016)	38 data sources between 1994-2010. Species abundance estimates provided for each season for various areas of commercial interest for offshore development.
JCP Data Analysis Tool	The JCP Phase III Data Analysis Product will be used to extract abundance estimates for cetaceans averaged for summer 2007-2010 and scaled to the SCANS III estimates for user specified areas.
MERP (Waggitt *et al.*, 2020)	Predicted distribution maps available at monthly and 10 km^2 density scale for multiple cetacean species.
SCOS reports (SCOS, 2021, 2022)	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.
Seal haul-out data (SMRU, 2020)	August haul-out surveys of harbour and grey seals.
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.
Porpoise presence in the Thames Estuary (Cucknell *et al.*, 2020)	Visual and acoustic vessel surveys conducted in March 2015, augmented by opportunistic sightings records and strandings data.
Grey seal pup counts (SMRU, 2020)	Surveys of the main UK grey seal breeding colonies annually between mid-September and late-November to estimate the numbers of pups born at the main breeding colonies.
Telemetry data (SMRU, 2019)	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.
Seal habitat preference maps (Carter *et al.*, 2020)	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

SOURCE	DESCRIPTION
	population (excluding hauled-out animals) estimated to be present in each grid cell at any one time during the main foraging season.
EU 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.
Seawatch Foundation Sightings[1]	Sightings recorded from the Eastern England region.

3.0 Site-specific surveys

The site-specific baseline characterisation surveys for VE consisted of monthly digital video aerial surveys conducted by HiDef Aerial Surveying Limited (HiDef) from March 2019 to February 2021. The aim of the surveys was to collect data on the abundance and distribution of marine mammals to characterise the baseline environment to inform Environmental Impact Assessment (EIA). Full details of the site-specific surveys can be found in the year 1 and year 2 survey reports: HiDef Aerial Surveying Ltd (2020), and HiDef Aerial Surveying Ltd (2021) (Volume 4, Annexes 4.4 and 4.5 respectively).

Surveys were designed to cover an area of 606 km^2, including a 4 km buffer around the proposed array areas (Figure 2). Aircraft were flown at a height of 550 m along transects of variable length with 2.5 km spacing, providing coverage of 10-15.2% of the survey area (Table 2). Data collected were 2 cm Ground Sampling Distance (GSD) digital video.

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 the 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.

The World Meteorological Organization (WMO) sea state (definitions provided in Table 3) varied across surveys, with average WMO sea states across each survey ranging between 1.00 and 5.91 (Table 2). The HiDef survey reports state that "*Sea state is scored based on the WMO Sea State code, in which score 6 or more is a high degree of sea state in which the data should not be used as it would affect detection rates*" (HiDef Aerial Surveying Ltd, 2020, 2021). The relationships between environmental conditions and marine mammal detection probability are not well understood, therefore it is difficult to account for any potential biases in the resulting outcomes. Current limits for aerial surveys of cetaceans are based on the abilities of visual of observers and these have largely been informed from the SCANS surveys (Hammond et al. 2002, 2013 2021); shipboard and aerial surveys are conducted up to Beaufort sea state 4. This sea state limit acknowledges the fact that some species (e.g. the larger or more gregarious ones) are easier to detect than others. HiDef state that the use of video for HiDef surveys allows them to use data for all species up to sea state 4.

[1] Sightings data taken from https://seawatchfoundation.org.uk/legacy_tools/region.php?output_region=6

For this reason (in addition to the fact that the spatial extent of the surveys did not cover the full extent of expected marine mammal disturbance impact ranges), it was considered necessary to examine other data sources in order to determine the best abundance and density estimates to take forward to the quantitative impact assessment for VE. These data sources are described in the sections below, with their resulting density estimates presented in species-specific baseline section from Section 5 onwards.

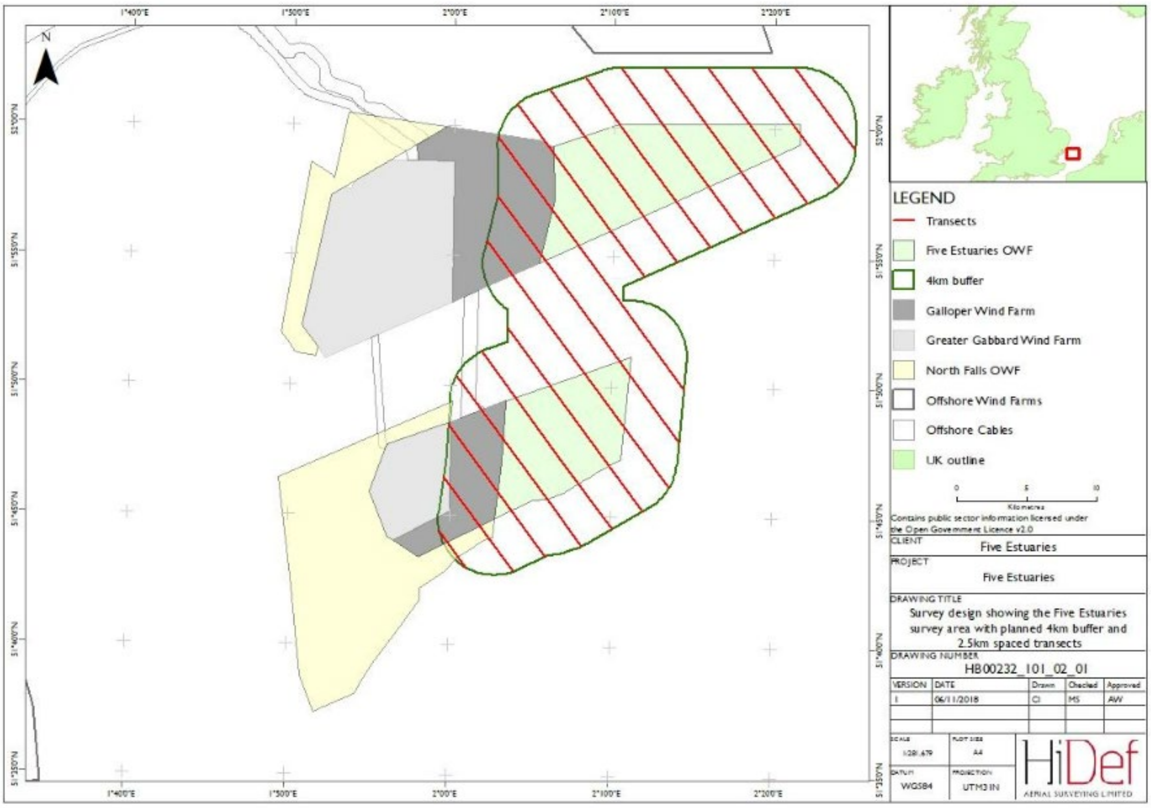

Figure 2 Survey design showing the VE survey area with 4 km buffer and 2.5 km spaced transects (HiDef Aerial Surveying Ltd, 2020, 2021).

Table 2 Survey effort across the 24 surveys of VE site from March 2019 to February 2021 (HiDef Aerial Surveying Ltd 2020, 2021).

Month	Total length of transects analysed (km)	Area covered (km^2)	% covered	WMO Sea state (average)
26 Mar-19	240.20	90.07	14.87	3.00
5 Apr-19	245.75	92.16	15.22	3.02
11 May-19	243.91	91.47	15.10	3.03
6 Jun-19	240.12	90.04	14.87	3.83
1 Jul-19	240.90	90.34	14.92	2.98
28 Aug-19	240.14	90.05	14.87	1.05

Month	Total length of transects analysed (km)	Area covered (km^2)	% covered	WMO Sea state (average)
10 Sep-19	240.42	90.16	14.89	2.00
5 Oct-19	240.43	60.71	10.02	2.12
6 Nov-19	242.01	66.31	10.94	1.99
23 Dec-19	239.48	89.80	14.83	4.99
18 Jan-20	265.16	66.29	10.94	3.97
14 Feb-20	241.35	90.50	14.94	3.00
11 Mar-20	240.59	90.22	14.90	3.85
09 Apr-20	240.68	90.25	14.90	2.87
03 May-20	234.27	87.85	14.50	1.88
20 Jun-20	240.27	90.10	14.88	2.79
21 Jul-20	240.04	90.01	14.86	2.38
05 Aug-20	239.93	89.97	14.85	3.02
02 Sep-20	240.73	90.27	14.90	1.00
09 Oct-20	240.12	64.31	10.61	2.96
05 Nov-20	240.20	64.38	10.62	2.98
15 Dec-20	240.38	90.14	14.88	2.34
22 Jan-21	240.26	62.86	10.37	3.00
13 Feb-21	240.50	90.19	14.89	5.91

Table 3 WMO Sea state codes (HiDef Aerial Surveying Ltd 2020, 2021) and Beaufort Sea State[2].

WMO Sea State	Wave height	Sea Description
0	0.0 m	Calm (glassy)
1	0.0 – 0.1 m	Calm (rippled)
2	0.1 – 0.5 m	Smooth (wavelets)
3	0.5 – 1.25 m	Slight (first whitecaps)
4	1.25 – 2.5 m	Moderate (many whitecaps)
5	2.5 – 4.0 m	Rough (some spray)

[2] https://www.metoffice.gov.uk/weather/guides/coast-and-sea/beaufort-scale

6	4.0 – 6.0 m	Very rough (large waves, many whitecaps, much spray)
Beaufort Sea State	**Wave height**	**Sea Description**
0	0 m	Calm (glass)
1	0.1	Calm (rippled)
2	0.2 – 0.3	Smooth (wavelets)
3	0.6 – 1.0	Slight
4	1.0 – 1.5	Slight - Moderate
5	2.0 – 2.5	Moderate
6	3.0 – 4.0	Rough

3.1 Other OWF surveys

There are a high number of offshore wind farm developments in the area, and previous survey work has been conducted for each of these wind farms. Given the close proximity of Galloper, Greater Gabbard and North Falls to VE, marine mammal data from these offshore wind farms were considered to be relevant to characterising the general area and as such, they have been examined and summarised in this baseline characterisation.

Monthly ornithological boat-based surveys for Galloper and Greater Gabbard were previously conducted for the area of the VE site in which incidental sightings of marine mammals were recorded (Royal Haskoning, 2011). Between 2004 and 2006, boat-based surveys were carried out for the Greater Gabbard Offshore Wind Farm (GGOWF) site, plus a 4 km buffer. From June 2008 to May 2011, the survey area was then extended to include the 222 km^2 Galloper Wind Farm (GWF) site (Figure 3). The boat-based surveys were undertaken by Ecological Consulting (February and March 2004), the British Trust for Ornithology (BTO) (2004 to 2006) and Environmentally Sustainable Systems Limited (ESS) (2008 to 2010). Survey transects conducted by BTO ran parallel to the coast at 1.8 km intervals for the first three surveys and then subsequently 2 km apart perpendicular to the coast. During ESS surveys, transect spacing was set at 2 km intervals throughout. Across the 16 GGOWF surveys, harbour porpoise were the most frequently sighted marine mammal species, with low sightings of harbour seals, grey seals, unidentified seals and one unidentified dolphin species (North Falls, 2021). During the GWF surveys harbour porpoise were the most frequently sighted marine mammal species with low sightings of grey seals and a single sighting of white-beaked dolphins (North Falls, 2021).

From March 2019 to February 2021, aerial surveys were conducted to determine the baseline for the proposed North Falls Offshore Wind Farm. The survey design covered the area of the 150 km^2 North Fall array sites, with the addition of a 4 km buffer (North Falls, 2021). During these surveys, harbour porpoise were the most frequently sighted marine mammal species with low sightings of grey seals and a single sighting of a minke whale.

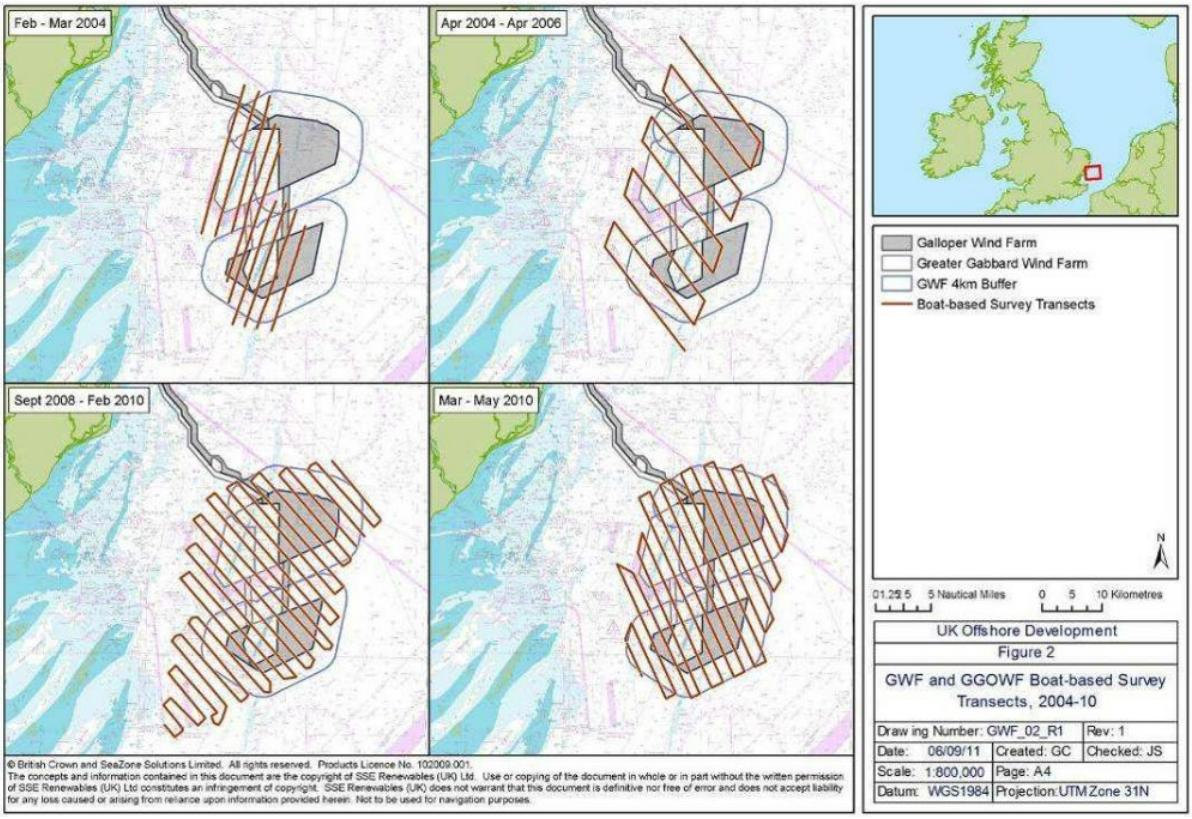

Figure 3 GWF and GGOWF boat-based survey transects (2004-2010) (Royal Haskoning, 2011).

3.2 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). 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.

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.

The VE project is located in the SCANS I and SCANS II survey block B (Figure 4). In SCANS I, the surveys were boat-based and had a search effort of 1,470 km, covering an area of 105,233 km^2 in sea states of 4 or less. In SCANS II, block B was surveyed using aircraft, with a search effort of 3,674 km in an area of 123,825 km^2. All aerial surveys were conducted in July 2005, and therefore these data are not representative of densities at other times of the year.

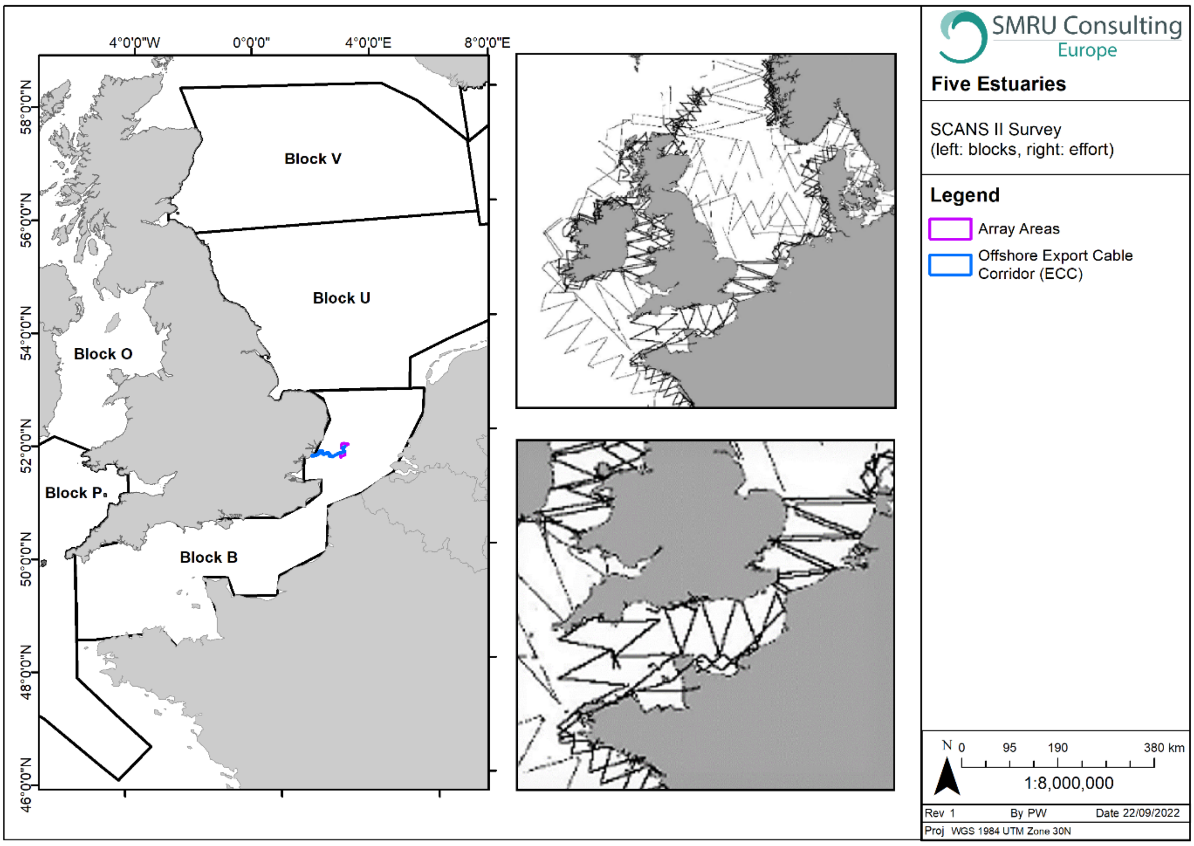

Figure 4 SCANS II survey blocks (left), effort (right) in relation to the VE project (Hammond et al. 2006)

The survey blocks in which the VE is located in SCANS I and SCANS II differ from that of SCANS III, and so direct comparisons between the surveys is not possible. In SCANS III, the VE is located within block L, which was surveyed using aircraft in June and July 2016, and therefore not representative of densities at other times of the year (Figure **5**). A key limitation of the SCANS III data is the low spatial and temporal coverage. Block L has a surface area of 12,322 km^2 and only 1,949 km was surveyed under primary effort. This limitation is also reflected within the SCANS II data.

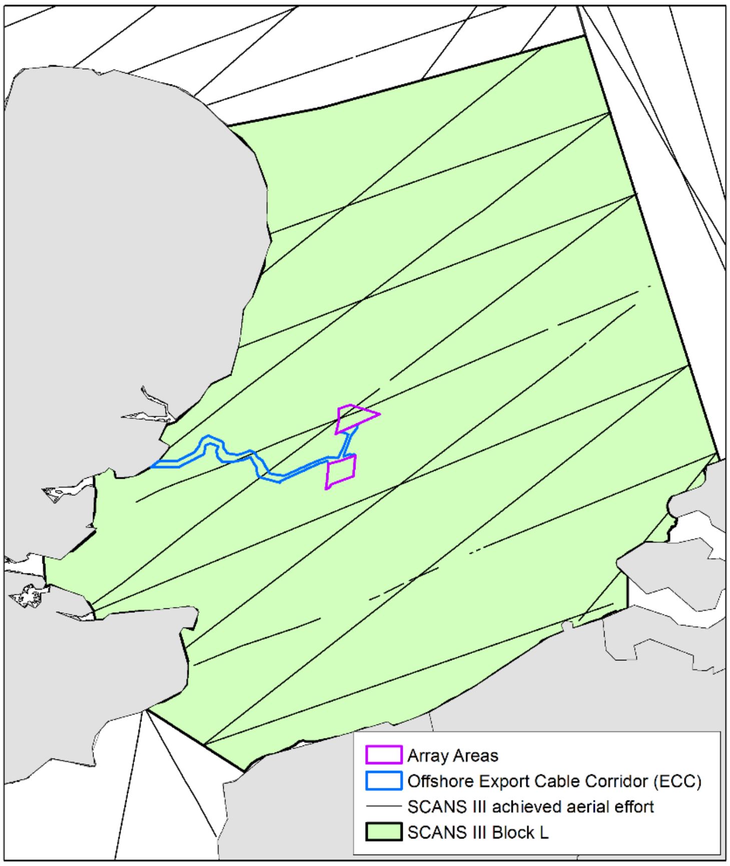

Figure 5 SCANS III survey block L and aerial survey transect effort in relation to the VE project. Joint Cetacean Protocol (JCP)

3.2.1 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 areas of commercial interest of most relevance to the VE is Norfolk Bank (a region to the east of East Anglia) with an area of 14,295 km^2 (Figure 6).

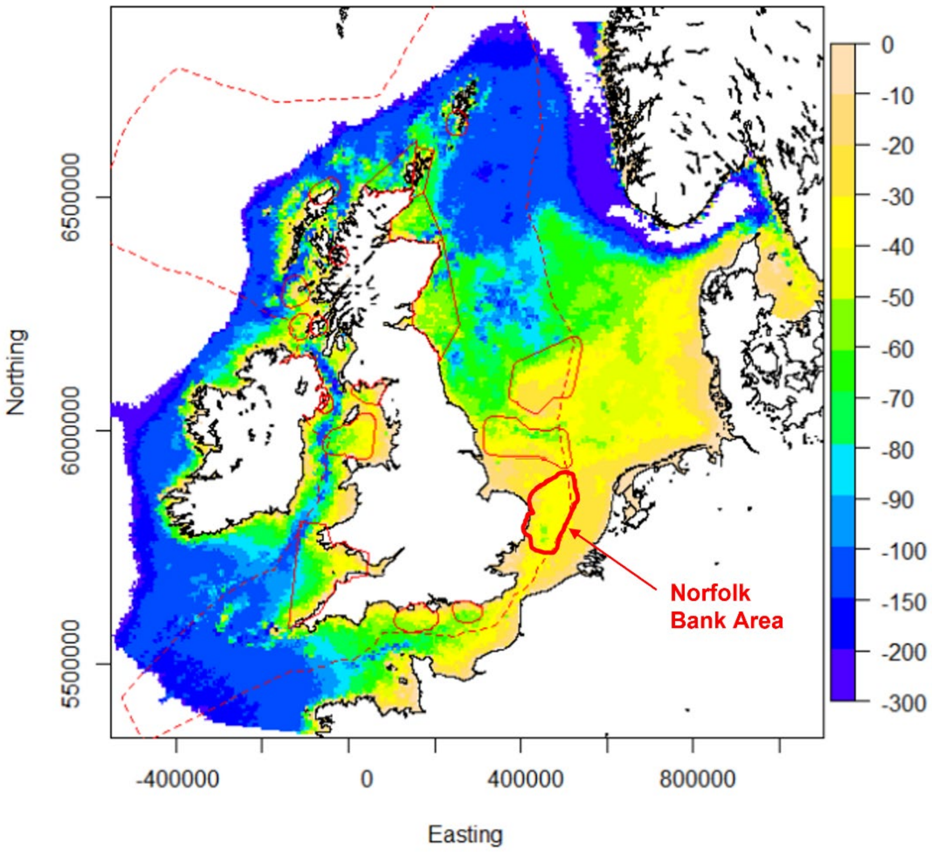

Figure 6 The Phase III region showing (red) areas of interest for offshore development where estimates of abundance are of special commercial interest (red dashed line = British exclusive economic zone, colour = depth in m) (Paxton et al. 2016).

In 2017, JNCC released the JCP Phase III Data Analysis Product[3] that can be used to extract the cetacean abundance estimates for summer 2007-2010 (average) for a user specified area (Figure 7). 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.

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 is therefore not representative of densities at other times of the year.

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

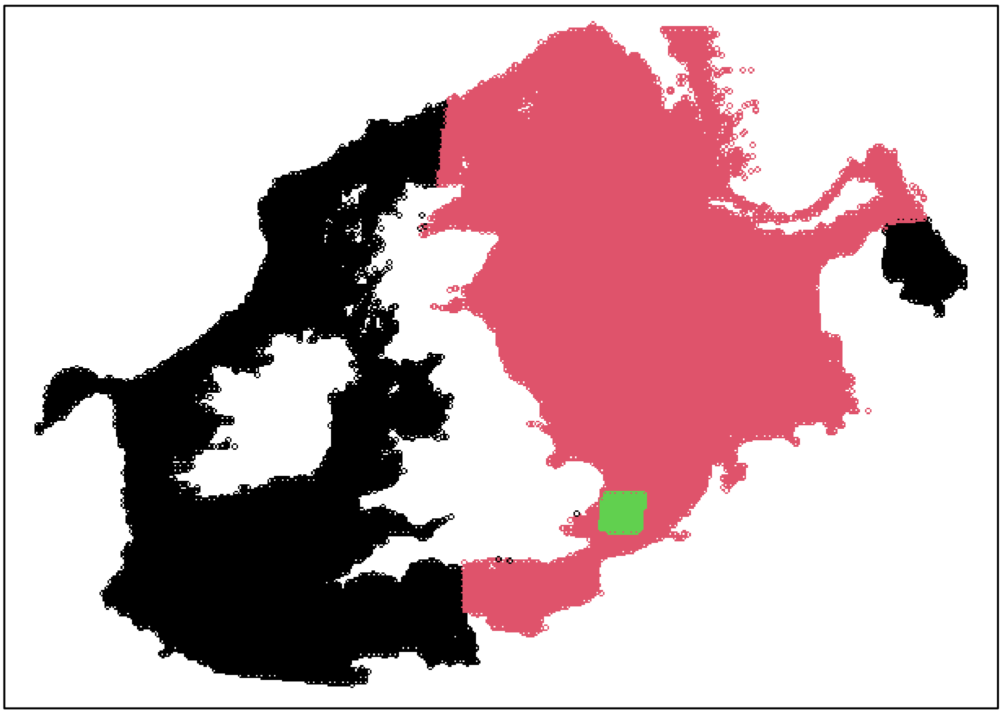

Figure 7 The user specified area used to extract cetacean abundance and density estimates from the JCP III R code. The map shows the whole area under consideration (black + pink + green), the harbour porpoise North Sea MU (pink) and the specific area of interest (green).

3.2.2 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 Special Areas of Conservation (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, 2015).

3.2.3 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. 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. Therefore, while the density estimates obtained from these maps for harbour porpoise may be 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.

3.3 Special Committee on Seals (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 the Special Committee on Seals (SCOS). The Sea Mammal Research Unit (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.

3.3.1 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.

Within the Greater Thames Estuary Area (defined as the body of water between the counties of Kent and Essex delineated by Gravesend in the west, Felixstowe in the north and Deal in the south, and contains several constituent estuaries including the Medway and Swale), surveys are conducted by a combination of SMRU, the Zoological Society of London (ZSL) and Bramley Associates (Cox *et al.*, 2020). 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 are 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).

3.3.2 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.

3.4 Seal habitat preference

The 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 a 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 telemetry and haul-out count data and modifications were 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 side 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 means 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, the Department for Business, Energy and Industrial Strategy (BEIS) 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). Telemetry data from 114 grey seals and 239 harbour seals were included in the analysis (Figure 8). 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 9) 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 Southeast England

MU, and therefore the predicted at-sea distributions in this MU may not be representative of the true at-sea distribution.

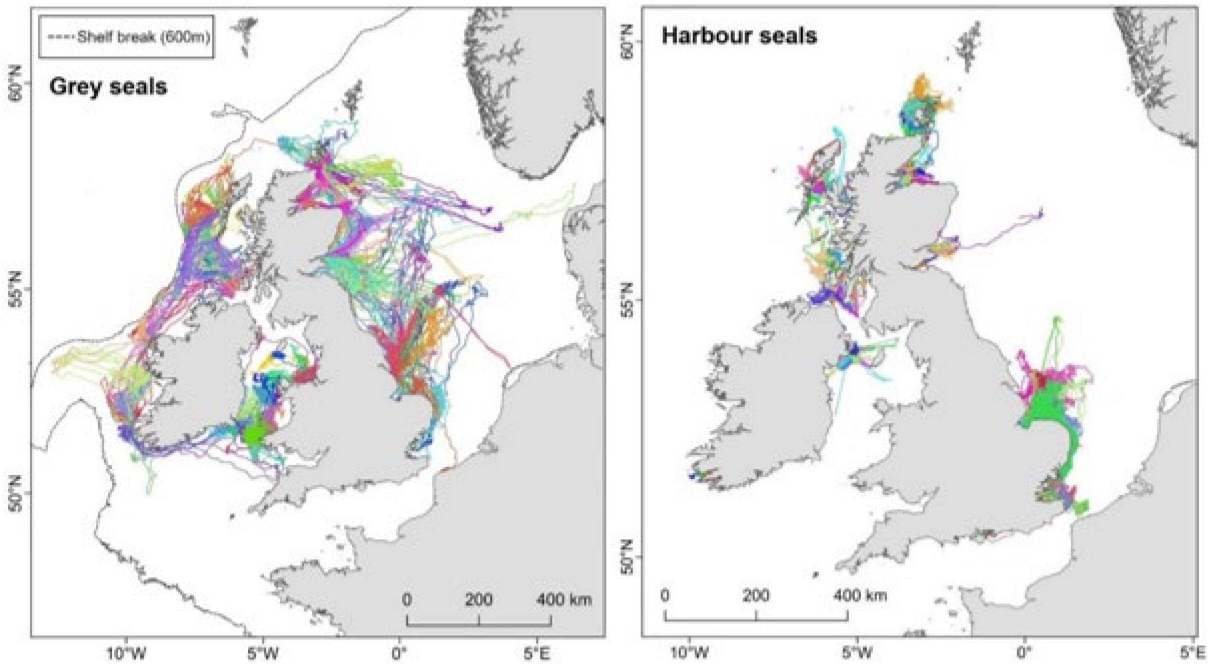

Figure 8 GPS tracking data for grey and harbour seals available for habitat preference models (Carter *et al.*, 2020).

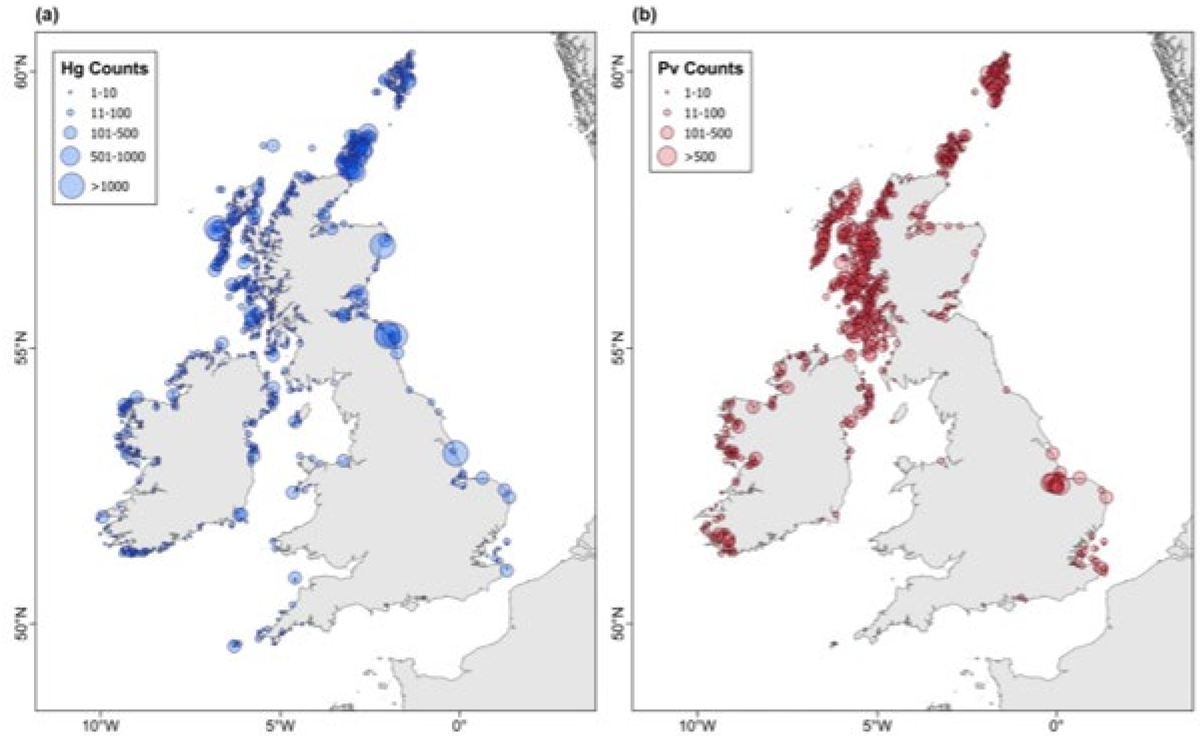

Figure 9 Most recent available August count data for (a) grey and (b) harbour seals per 5 km x 5 km haul-out cell used in the distribution analysis (Carter et al. 2020).

3.5 Seal telemetry

SMRU has deployed 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. 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 the degree of connectivity among the VE, seal haul-out sites and SACs.

In addition to the UK seal telemetry data, 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 10). Maps were generated using the at-sea distribution of individuals, with interpolated locations within 0.1° grids which encompassed both the entire English Channel area and the southern Celtic Sea. All 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.

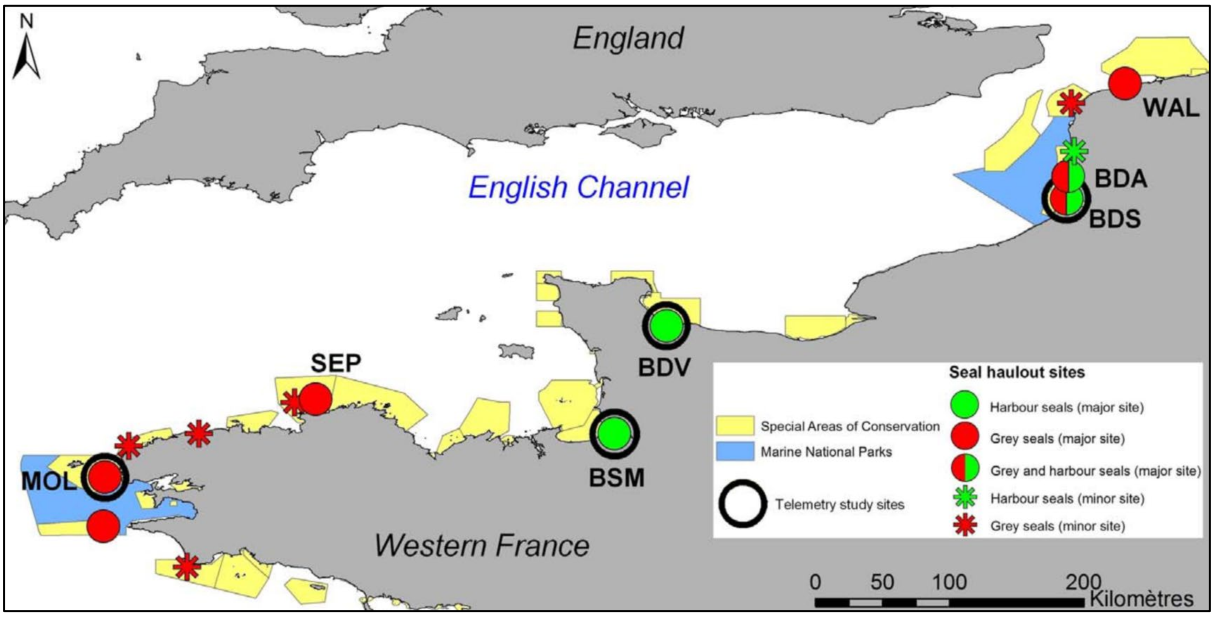

Figure 10 Map of all grey (red) and harbour seal (green) haul-out sites in metropolitan France (Vincent et al 2017). Circles indicate haulout sites where the seasonal maximum number of seals exceeds 50 individuals. Stars indicate smaller haul-out sites used by fewer seals, not detailed in this study. 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 iles archipelago (SEP), baie du Mont-Saint-Michel (BSM), baie des Veys (BDV), baie de Somme (BDS), baie d'Authie (BDA) and Walde (WAL).

3.6 River Thames & Estuary

In March 2015 a visual and acoustic vessel survey for harbour porpoises was conducted from R/V Song of the Whale, using randomised survey lines covering the major channel within the River Thames and Estuary, resulting in 676 km of visual and acoustic effort (Cucknell *et al.*, 2020) (Figure 11). Data on harbour porpoise sightings and acoustic detections were combined with other local data sources between 1990 and 2015, including: public sightings, strandings, shore watch data, sightings from ferry routes and other survey-based sightings and detections (from a combination of sources including ZSL, Essex Wildlife Trust Biodiversity Records, MARINElife, CSIP, Kent Wildlife Trust, Kent Mammal Group and Marine Conservation Research) (see Cucknell *et al.*, 2020 for full details). These collated data were used to describe harbour porpoise presence in the River Thames and Estuary area.

Figure 11 Thames Estuary survey area. Solid black lines represent the survey track-lines with the hull and towed hydrophones, grey line represents survey track-lines with the towed hydrophone only. Map shows porpoise sightings (white triangles) and acoustic detections from the towed hydrophone (black circles) and hull-mounted hydrophone (white circles) arrays. Dark grey polygons represent operational wind farms. Figure taken from (Cucknell *et al.*, 2020).

3.7 Sea Watch Foundation

The Sea Watch Foundation maintains a national sightings database of marine mammals around the UK. VE is located in Sea Watch Foundation Eastern England Area, including Lincolnshire, East Anglia, Suffolk and Essex and North Kent. In the Eastern England area between 28th July 2021 and 1st June 2022, a total of 216 marine mammal sightings were reported[4], consisting of the following:

- Harbour porpoise (177);
- Grey seals (15);
- Harbour seals (9);
- Bottlenose dolphin (8);
- Minke whale (3);
- White-beaked dolphin (3); and
- Large whale (species unidentified) (1).

[4] Sightings data taken from https://seawatchfoundation.org.uk/legacy_tools/region.php?output_region=6 14/06/2022

4 SACs

Table 4 details the SACs for marine mammals located within the relevant species MUs. There is one UK designated site for harbour porpoise in the North Sea MU: the Southern North Sea SAC (Figure 12). The VE array areas and most of the Offshore ECC are located within the winter area of the Southern North Sea SAC. Given the overlap with the Southern North Sea SAC, the potential for impacts to the SAC will require full assessment as part of the Habitats Regulation Assessment (HRA) (Volume 8, Report 2).

There is one harbour seal designated site in the Southeast England MU: The Wash and North Norfolk Coast SAC. There is no direct overlap between the VE project boundaries and the Wash and North Norfolk Coast SAC; however, the potential for connectivity with the SAC is considered within this baseline.

There are two designated sites for grey seals within the Southeast and Northeast England MUs: the Humber Estuary SAC (SE England MU) and the Berwickshire and North Northumberland Coast SAC (NE England MU). There is no direct overlap between the VE project boundaries and the two grey seal SACs; however, the potential for connectivity with the SACs is considered within this baseline.

Table 4 Special Areas of Conservation (SACs) with relevance to marine mammals and VE

Site	Closest distance to VE	Features or description
Southern North Sea SAC	Coincident with the VE array areas and Offshore Export Cable Corridor (ECC)	Primary reason for site selection - harbour porpoise
The Wash and North Norfolk Coast SAC	~140 km swimming distance from the VE array areas	Primary reason for site selection - harbour seal
Humber Estuary SAC	~215 km swimming distance from the VE array areas	Qualifying feature – grey seal
Berwickshire and North Northumberland Coast SAC	~450 km swimming distance from the VE array areas	Primary reason for site selection – grey seal

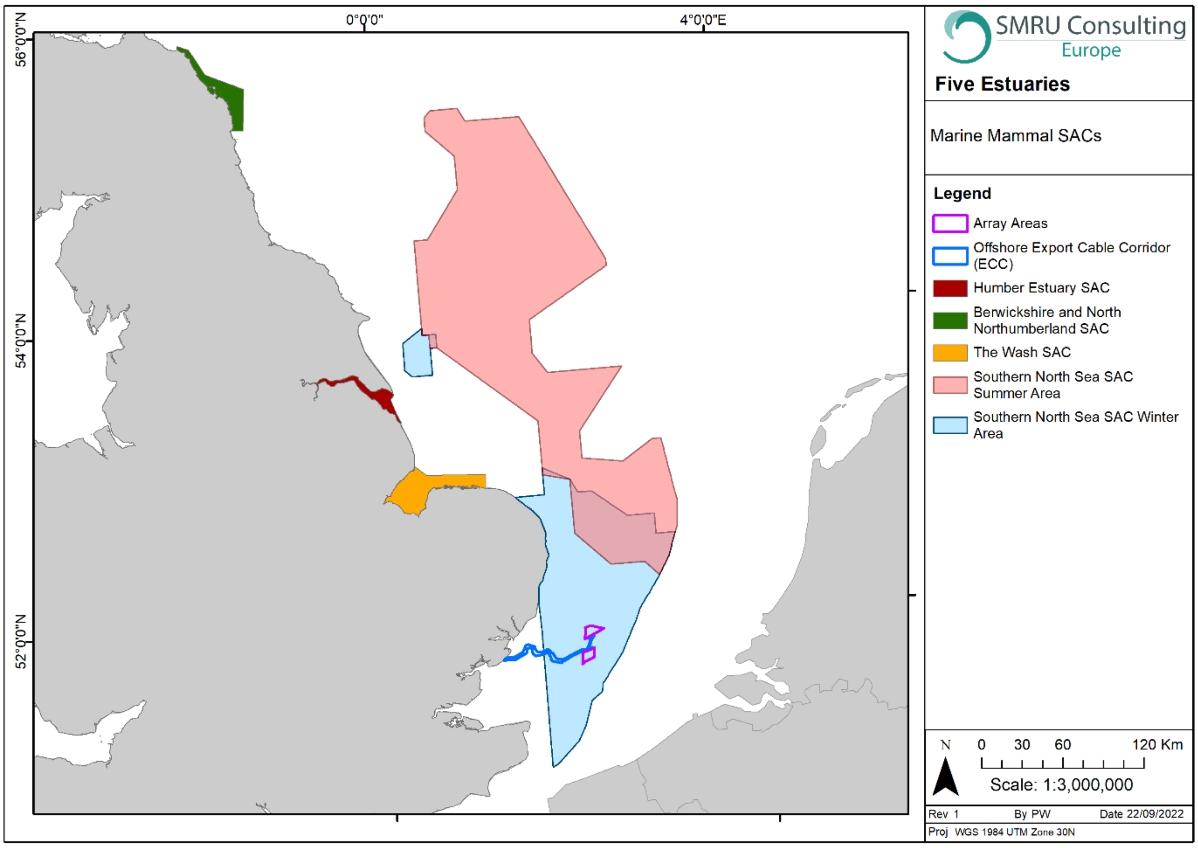

Figure 12 Special Areas of Conservation for marine mammals.

5 Harbour porpoise

5.0 MU

Harbour porpoise are distributed globally and can be found throughout UK in shallow waters (<200 m). 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 was 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". Across the three SCANS abundance estimates for harbour porpoise in the North Sea MU (1994, 205 and 2016) there is no evidence of a trend in abundance, although confidence intervals are large and data have limited power to detect trends (power analysis indicates a minimum annual rate of change of 1.8% that could be detected with a high (80%) statistical power) (Hammond *et al.*, 2021).

5.1 Site-specific surveys

Harbour porpoise were the most abundant marine mammal sighted in the VE site-specific surveys (HiDef Aerial Surveying Ltd, 2020, 2021). They were sighted in every survey month throughout the two survey years, totalling 575 sightings across the 24 months (Table 5). Sightings occurred in sea states 1-5, with most sightings occurring in sea states 1 (16.6%), 2 (37.5%) or 3 (37.5%). A correction factor was applied to the data to account for the proportion of animals submerged and not available for detection, with the assumption that animals were visible and available to detection to a depth of 2 m below the surface. 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 which primarily used Danish waters with some animals moving through the wider North Sea (Teilmann *et al.*, 2013). This resulted in corrected harbour porpoise density estimates for the VE site (Table 6), with a maximum density estimate of 8.48 porpoise/km^2 and an average monthly density estimate of 1.82 porpoise/km^2 throughout the two years.

Despite VE being located in the winter portion of the Southern North Sea SAC, the harbour porpoise density estimates were relatively stable across winter, spring and summer, with a peak in the autumn months (Table 6, Figure 13). Given how variable porpoise detection rates were from survey to survey, and the fact that seasonality in pile driving activities at VE is currently unknown, the average density estimate across all 24 surveys is considered the best density estimate to take forward to the quantitative impact assessment.

Spatial distribution of harbour porpoise within the survey area differed between surveys, with no clear pattern other than that porpoise use the entire survey area (Figure 14, Figure 15). In the north-east of the survey area, high densities of harbour porpoise were observed in March 2019 and May 2020, contrasting to the widespread presence in March, April and September 2020.

Table 5 Number of harbour porpoise recorded from the HiDef surveys between March 2019 and February 2021 (HiDef Aerial Surveying Ltd, 2020, 2021).

Year 1	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
Harbour porpoise	23	6	3	13	10	46	43	10	77	12	4	15	262
Year 2	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Total**
Harbour porpoise	32	25	96	17	26	4	32	12	28	10	15	16	313

Table 6 Adjusted density and population estimates for harbour porpoise in the VE survey area from the HiDef surveys between March 2019 and February 2021, taking into account the number of animals that are estimated as being unavaliable for detection (HiDef Aerial Surveying Ltd, 2020, 2021).

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
26 Mar-19	0.26	155	60	279	1.52	905	350	1629
5 Apr-19	0.06	40	7	77	0.29	196	34	378
11 May-19	0.03	20	0	51	0.17	113	0	287
6 Jun-19	0.15	89	27	154	0.92	545	165	942
1 Jul-19	0.11	67	27	115	0.71	431	174	739
28 Aug-19	0.51	312	174	494	3.05	1866	1041	2955
10 Sep-19	0.48	289	219	363	3.62	2181	1653	2740
5 Oct-19	0.17	101	49	159	1.30	775	376	1220
6 Nov-19	1.27	773	512	1042	8.48	5160	3418	6955
23 Dec-19	0.13	81	32	140	0.96	599	236	1034
18 Jan-20	0.06	37	0	90	0.33	205	0	498

Harbour porpoise	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (#/km²)	Population estimate	Lower 95% CI	Upper 95% CI	Density estimate (#/km²)	Population estimate	Lower 95% CI	Upper 95% CI
14 Feb-20	0.17	102	40	178	1.35	812	319	1418
11 Mar-20	0.36	216	148	285	1.80	1078	739	1422
09 Apr-20	0.28	169	85	269	1.17	709	357	1128
03 May-20	1.08	654	375	981	5.20	3148	1805	4722
20 Jun-20	0.19	115	67	166	0.99	602	351	868
21 Jul-20	0.29	176	114	241	1.59	967	627	1325
05 Aug-20	0.04	27	0	60	0.20	138	0	307
02 Sep-20	0.36	216	127	307	2.32	1394	819	1981
09 Oct-20	0.20	122	50	204	1.31	801	328	1339
05 Nov-20	0.46	282	180	379	3.07	1882	1201	2530
15 Dec-20	0.11	69	7	145	0.69	436	44	916
22 Jan-21	0.27	162	40	340	1.49	896	221	1880
13 Feb-21	0.18	108	39	192	1.23	735	266	1307
Adjusted (absolute) density estimate across all months					**Maximum: 8.48 Average: 1.82**			
Average adjusted (absolute) density estimate across seasons (Spring: M, A, M; Summer: J, J A; Autumn: S, O, N; Winter: D, J, F)					**Spring 1.69**	**Summer 1.24**	**Autumn 3.35**	**Winter 1.01**

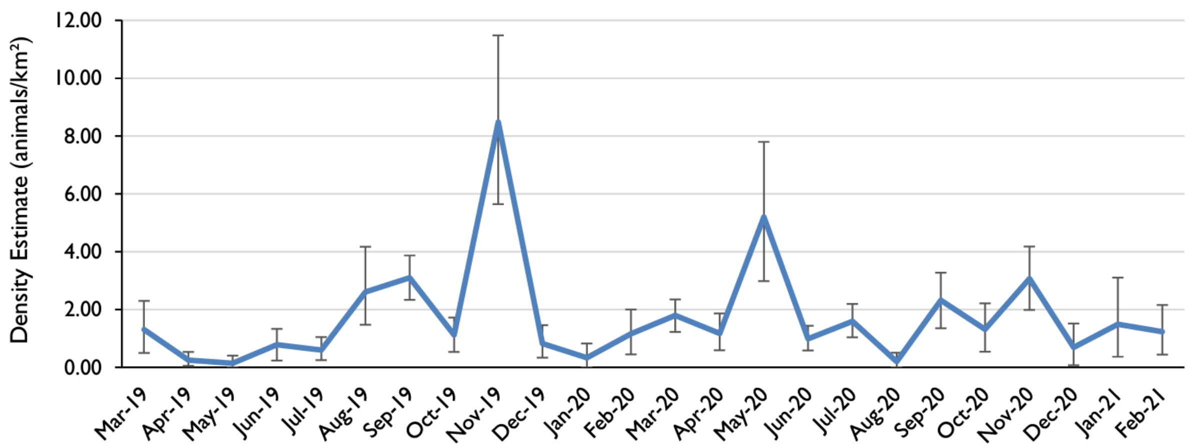

Figure 13 Density of harbour porpoise (number/km²) and number of detections per segment between March 2019 and February 2020 (HiDef Aerial Surveying Ltd 2020, 2021).

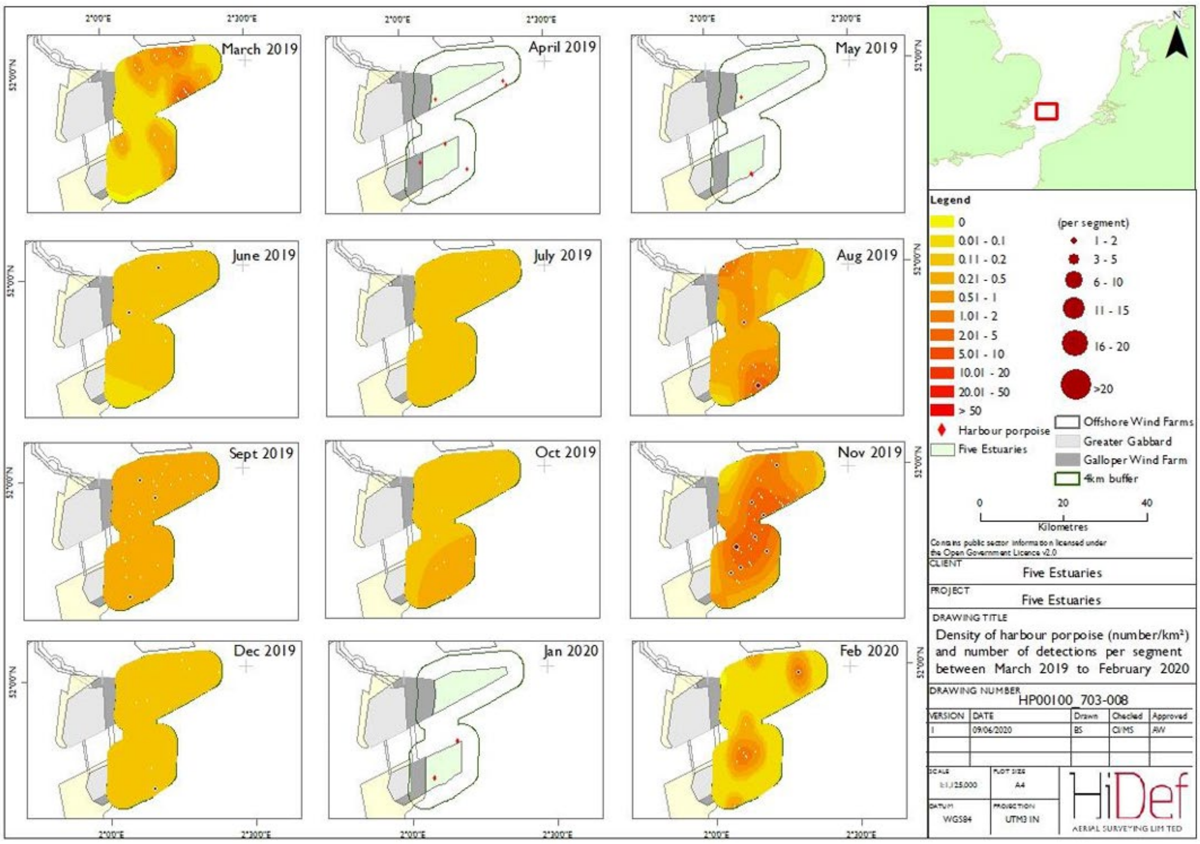

Figure 14 Density of harbour porpoise (number/km²) and number of detections per segment between March 2019 and February 2020 (HiDef Aerial Surveying Ltd 2020)[5].

[5] Note: kernel density mapping was not conducted for surveys with fewer than 5 observations

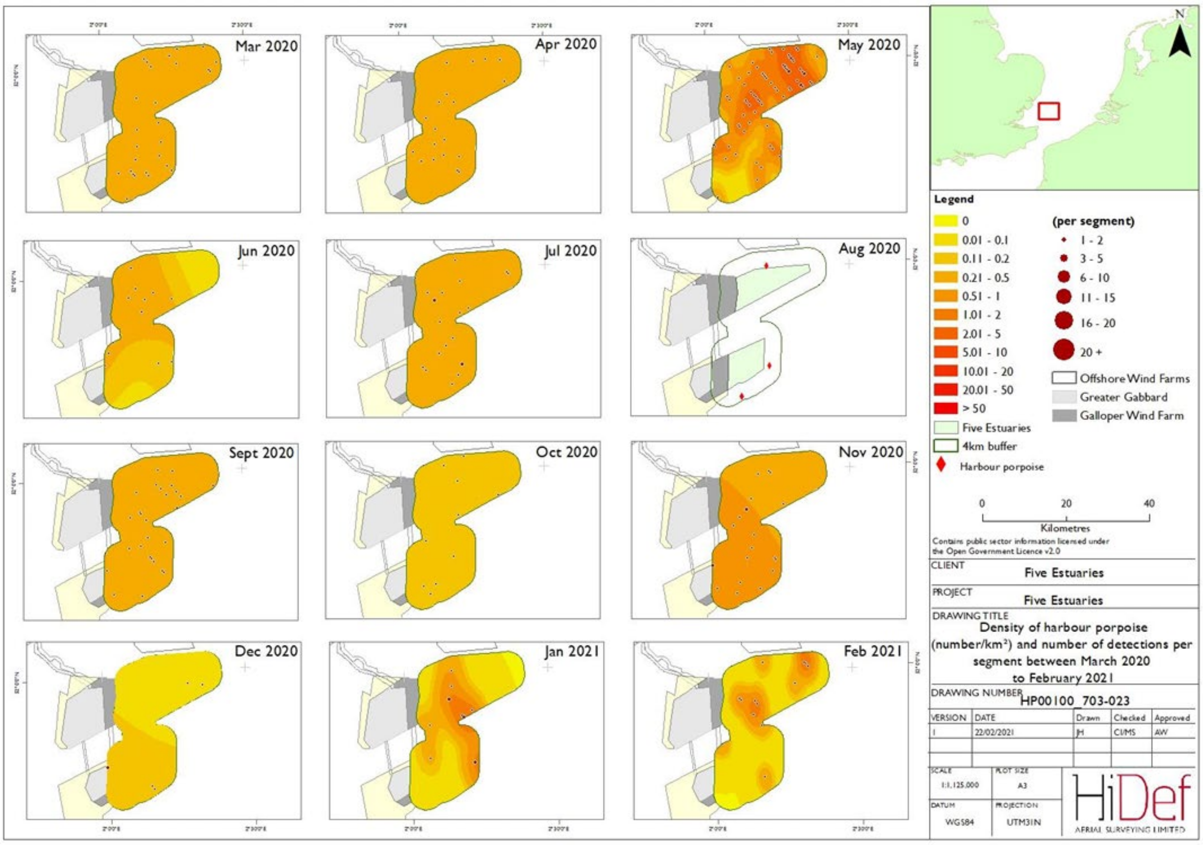

Figure 15 Density of harbour porpoise (number/km²) and number of detections per segment between March 2020 and February 2021 (HiDef Aerial Surveying Ltd, 2021)[6].

5.2 SCANS

VE is located within the SCANS III survey block L, where there was an estimated block-wide abundance of 19,064 harbour porpoise (95% CI: 6,933 - 35,703) and an estimated density of 0.607 harbour porpoise/km^2 in July 2016 (Hammond *et al.*, 2021) (Table 7). Densities in the neighbouring block O were higher than that of block L (location of the VE) with estimated densities of 0.888 porpoise/km^2. The SCANS surveys of the whole of the North Sea show a southwards shift in distribution of the North Sea harbour porpoise population between the survey years of 1994 (SCANS I) and 2005 (SCANS II) (Figure 16); this pattern of higher densities in the southern North Sea persisted in the most recent 2016 surveys. 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.

Table 7 Harbour porpoise density estimates from SCANS surveys with respective surface area and search effort.

Survey	Year	Block	Area (km^2)	Effort (km)	Density (#/km^2)
SCANS I	1994	B	105,223	1,470	0
SCANS II	2005	B	123,825	3,674	0.331
SCANS III	2016	L	31,404	1,949.3	0.607

[6] Note: kernel density mapping was not conducted for surveys with fewer than 5 observations

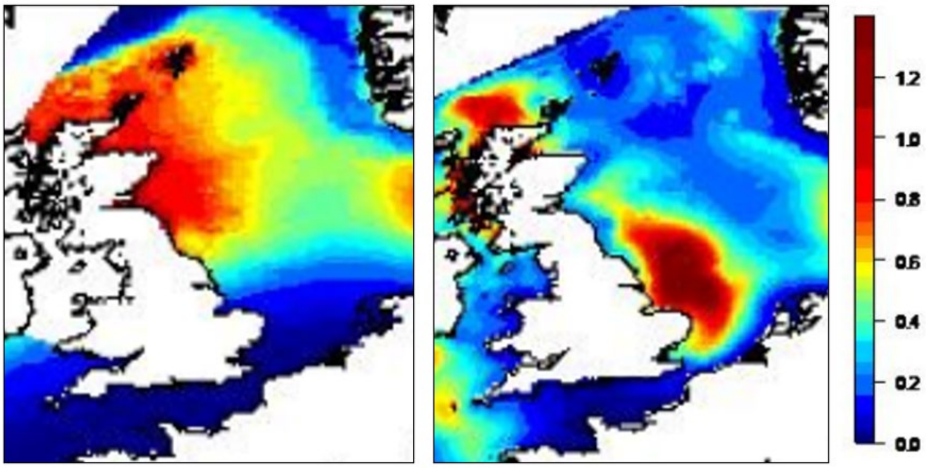

Figure 16 Harbour porpoise estimated density surface (animals per km^2) for SCANS I 1994 data (left), and for SCANS II 2005 data (right) (Hammond et al. 2006).

5.3 JCP

5.3.1 JCP Phase III

Paxton *et al.* (2016) produced predicted harbour porpoise densities for summer 2010 (Figure 17). Density estimates for Norfolk Bank, a 14,295 km^2 region to the east of East Anglia in which VE is located, showed that harbour porpoise abundance was higher in winter months compared to the rest of the year and reached a maximum of 0.96 harbour porpoise/km^2 and an average of 0.53 porpoise/km over the year (Table 8).

The JCP Phase III Data Analysis Product provided a high estimate of 1.88 harbour porpoise/km^2 in the vicinity of the VE, averaged for the summer 2007-2010. This estimate is for the summer months only and is not representative of densities at other times of the year. This estimate is higher than that obtained for the Norfolk Bank area by the JCP Phase III analysis (summer 2010 estimate 0.50 harbour porpoise/km^2). However, there is large inter-annual variation in the JCP dataset and as such, the density estimate averaged across 2007 - 2020 is expected to differ to that from 2010 alone.

Table 8 JCP Phase III abundance and density estimates for harbour porpoise in 2010 for the Norfolk Bank region (Paxton et al. 2016).

Season	Abundance point estimate	95% CI	Density (#/km^2)
Winter	13,700	7,000 – 26,200	0.96
Spring	5,300	2,600 – 15,600	0.37
Summer	7,100	3,600 – 12,700	0.50
Autumn	4,000	1,800 – 8,500	0.28
Average	7,525	-	0.53

Table 9 JCP Phase III Data Analysis Product abundance and density estimates for harbour porpoise for the user specified area (see Figure 7) averaged for the summer 2007-2010.

	Abundance	Density (#/km^2)
Point estimate	12,351	1.88

Lower confidence interval	7,010	1.07
Upper confidence interval	18,693	2.84

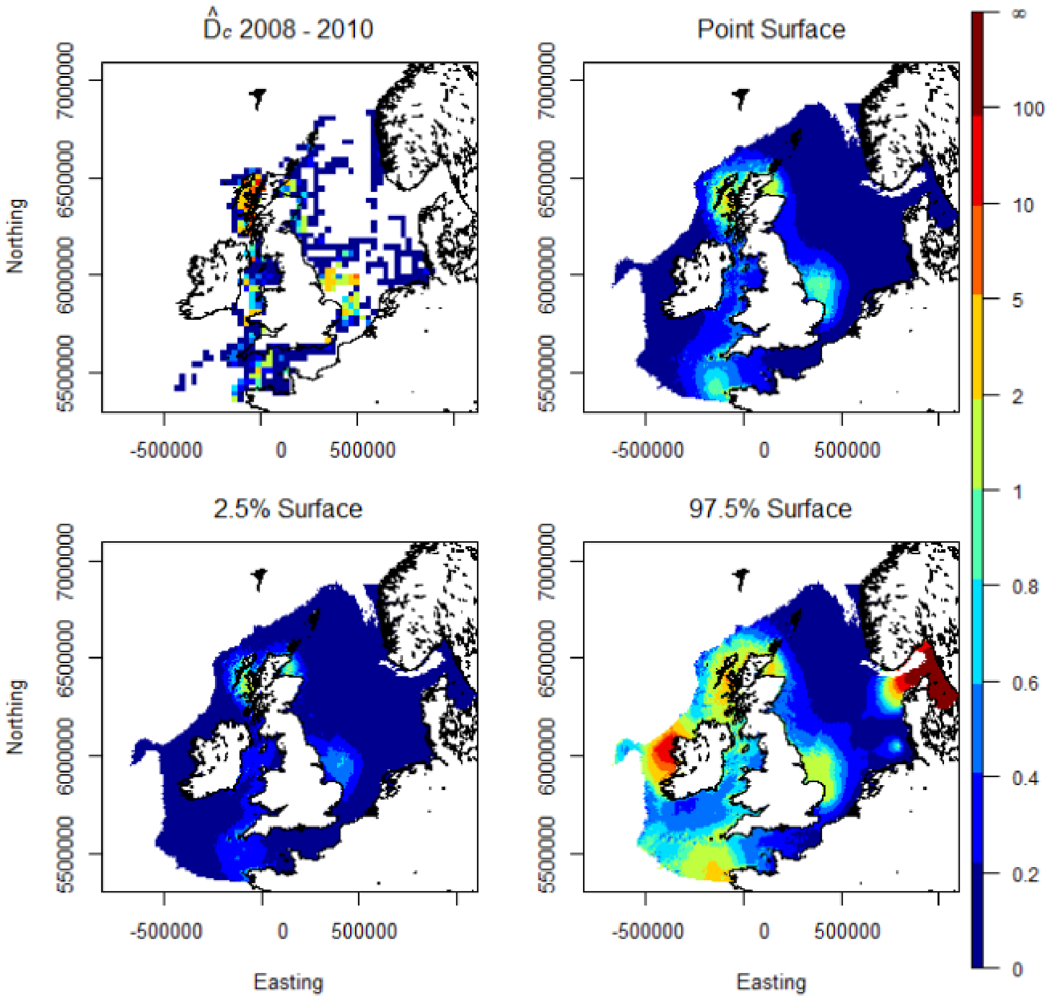

Figure 17 Predicted harbour porpoise densities for summer 2010 (Paxton *et al.*, 2016). Top left; input densities (summer all years), top right; point estimate of cell densities, bottom left; lower (2.5%) confidence limit on cell densities, bottom right; upper (97.5%) confidence limit on cell densities (dolphins/km^2). Note that the top left plot exaggerates the spatial coverage of the relevant effort.

5.3.2 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 years of survey data as part of the JCP. The analysis 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 and the outer Thames Estuary (Figure 18), in which VE is located. During winter, harbour porpoise were predicted to be present in high densities at the VE site with a result of >3.0 harbour porpoise/km^2. In contrast, during summer the predicted densities were lower at a maximum of 1.5 – 1.8 harbour porpoise/km^2, suggesting seasonal variation at the VE site.

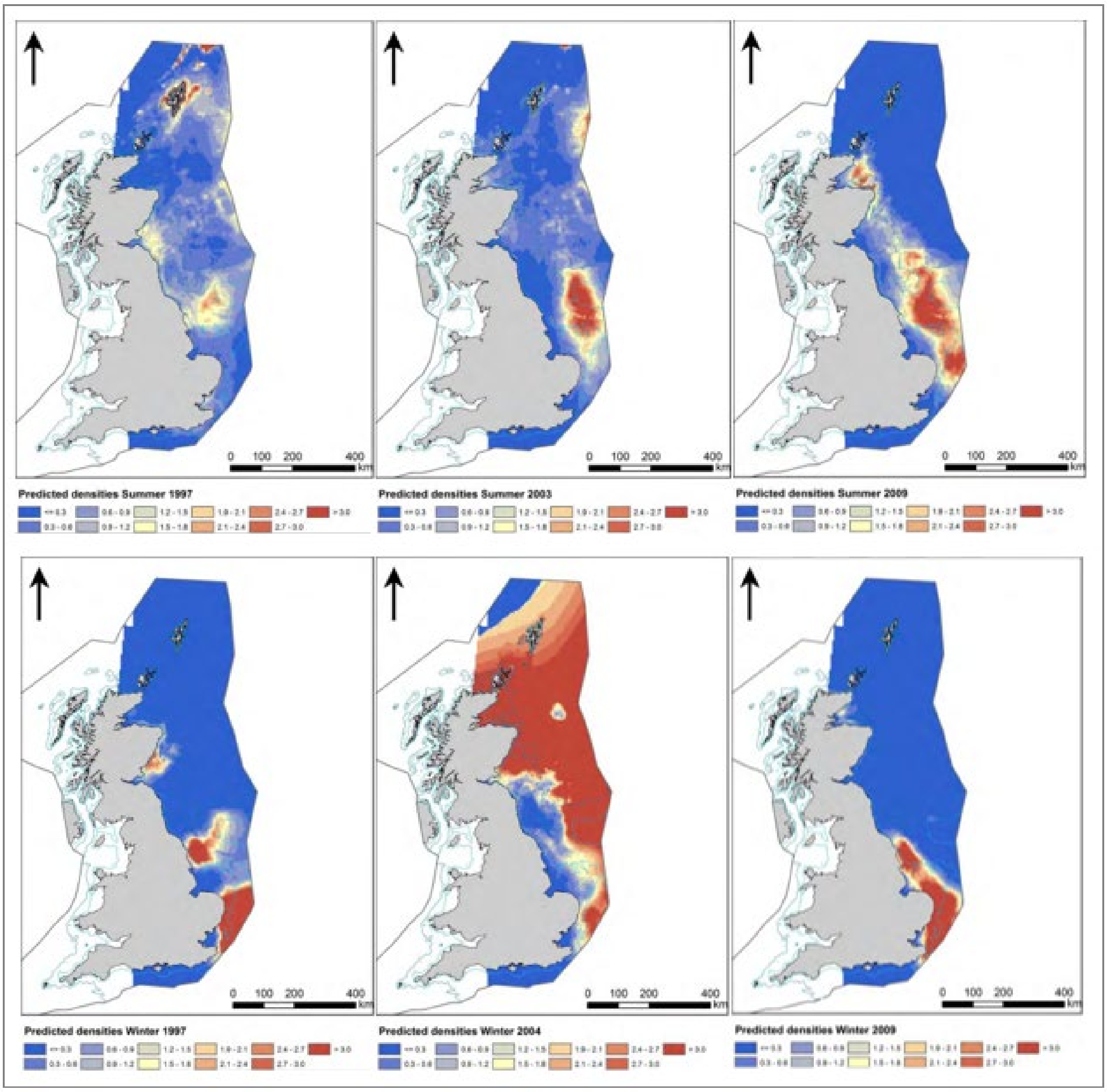

Figure 18 Predicted densities (#/km^2) during summer (top panel) and winter (bottom panel) in management unit 1 for three different years in each model period (Heinänen and Skov 2015).

5.3.3 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; however, these maps are not considered to be suitable for quantitative impact assessments and are provided in this baseline characterisation for illustrative purposes only. Harbour porpoise densities were predicted to be high year-round in the North Sea region, specifically in the southern North Sea SAC area (Figure 19).

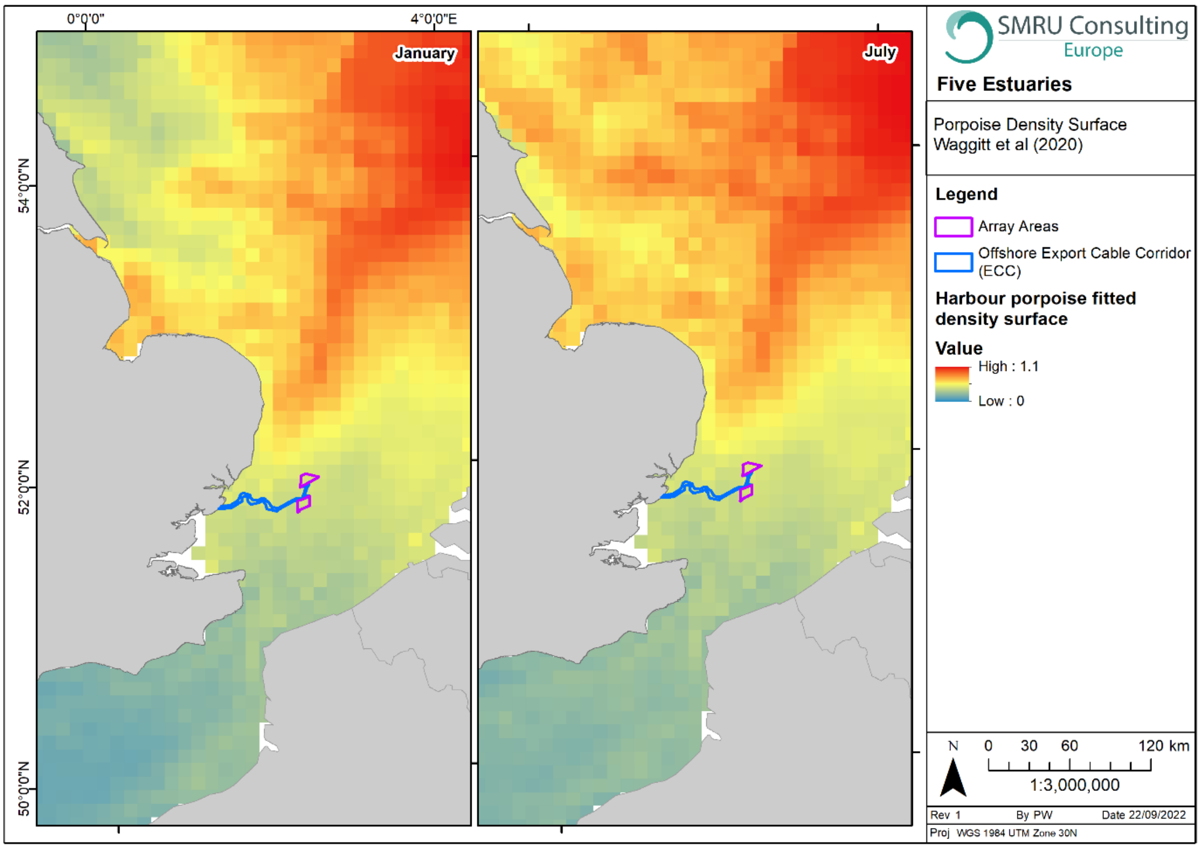

Figure 19 Harbour porpoise density surfaces (#/km^2) (January and July). Data from Waggitt et al. (2020)

5.4 Other OWF surveys

Harbour porpoise were the main species incidentally sighted during the site-specific boat-based baseline ornithology surveys conducted at GGOWF and GWF (Royal Haskoning, 2011). During the GGOWF surveys, 166 harbour porpoise were sighted from 2004 to 2006 and for the GWF surveys, 570 harbour porpoise were sighted from 2008 to 2011. These data highlight that harbour porpoise are present year-round, with the highest incidental sightings rate recorded between February-May (Figure 20). Sightings were lower during the spring of 2011; however, it is suggested that this could be due to construction activities at GGOWF being underway. Sightings of harbour porpoise were mainly individual adults, with a maximum of six individuals seen in one group. During the spring months it was noted that individuals of differing sizes were sighted travelling, suggesting mother and calf pairs in the survey area. Encounter rates were calculated for the survey areas which showed a maximum rate of 0.9 animals/km and a mean maximum encounter rate of 0.55 animals/km. It was highlighted that compared to broad scale survey data in the North Sea, the encounter rates within the survey area were lower. A key limitation of these surveys is there is no record of effort or detection probability with incidental sightings, and therefore we can only confirm the species presence and cannot calculate density estimates for the survey area.

From March 2019 to February 2021, monthly aerial surveys were conducted for the North Falls site. Harbour porpoise was again the most frequently sighted marine mammal with 330 and 406 sightings in Year 1 and Year 2, respectively (North Falls, 2021).

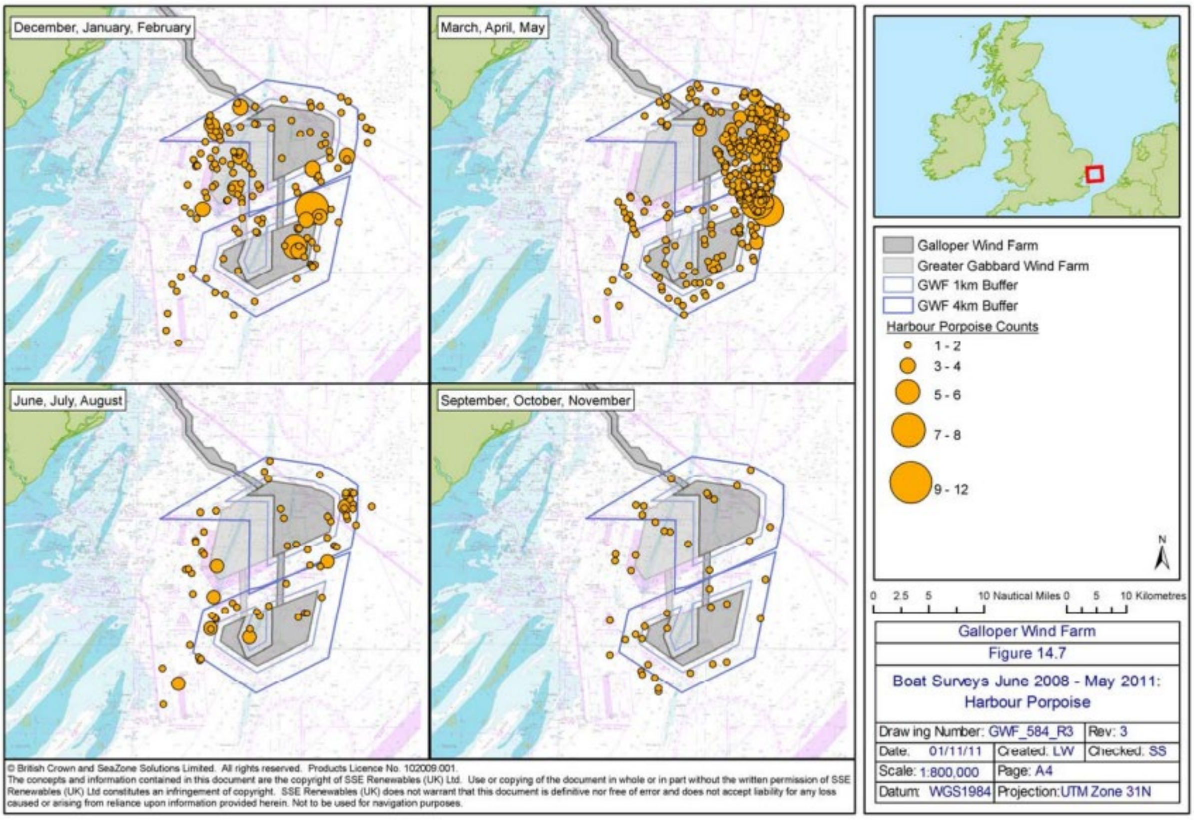

Figure 20 Harbour porpoise sightings across the wider GWF and GGOWF survey area from June 2008 to May 2011 (Royal Haskoning 2011).

5.5 River Thames & Estuary

During the R/V Song of the Whale surveys in March 2015, 17 harbour porpoise sightings (average group size = 2) and 45 unique acoustic detections of harbour porpoise groups were reported (n = 24 hull-mounted array, n = 21 towed array) (Figure 21) (Cucknell *et al.*, 2020). This resulted in an acoustic encounter rate of 4.2 porpoise groups/100 km surveyed, with highest encounter rates in the outer Thames Estuary. Data from the shore watches, public sightings and strandings between 1990 and 2015 recorded over 2,000 sightings, 161 strandings and 45 acoustic detections of porpoise throughout the tidal Thames area. Sightings were reported year-round, with peak sightings in April and August, and peak strandings in March and April. While these data provide evidence on harbour porpoise year-round presence in the area, they are unable to provide density estimates for the River Thames and Estuary area.

Figure 21 River Thames and Estuary displaying public sightings from onshore and offshore effort (grey triangles) where latitude and longitude data were provided, strandings (white squares) and MCR sightings (white triangles), towed (black circles) and hull-mounted (white circles). Figure taken from Cucknell *et al.* (2020).

5.6 Summary

Density estimates obtained for harbour porpoise vary considerably from 0.28 harbour porpoise/km^2 to >3.0 harbour porpoise/km^2 (Table 10). 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) and hence the southern part of the Southern North Sea SAC is winter only. The harbour porpoise sightings across the site-specific surveys, with relatively stable density estimates across the two years of surveys, with the exception of peaks in November 2019 and May 2020 (Figure 13). Given how variable porpoise detection rates were from survey to survey, and the fact that no seasonal pattern to the sightings was evident, the average density estimate across all 24 surveys is considered the best density estimate to take forward to the quantitative impact assessment.

The adjusted average density estimate obtained from the site-specific surveys (1.82 porpoise/km^2) is considered to be the best density estimate to take forward to the quantitative impact assessment. While the spatial range of the surveys were limited, other data sources such as the JCP Data Analysis Tool suggest that this density estimate is also appropriate for use over a wider impact area since the density estimate was almost identical to the average site-specific estimate (1.82 vs 1.88 porpoise/km^2).

Table 10 Harbour porpoise density estimates.

Source	Area	Temporal	Density (#/km^2)
HiDef site-specific surveys	**Project survey area**	**Monthly 2019-2021**	**1.82 (average)**
SCANS III	Southern North Sea	Summer 2016	0.607

Source	Area	Temporal	Density (#/km^2)
Norfolk Bank area	East of East Anglia	Winter 2010	0.96
Norfolk Bank area	East of East Anglia	Spring 2010	0.37
Norfolk Bank area	East of East Anglia	Summer 2010	0.50
Norfolk Bank area	East of East Anglia	Autumn 2010	0.28
Norfolk Bank area	East of East Anglia	Average 2010	0.53
Heinanen & Skov	VE area	Summer	1.5-1.8
Heinanen & Skov	VE area	Winter	>3.0
JCP Data Tool	User specified area	Summer 2010	1.88
GGOWF	Greater Gabbard OWF + 4 km buffer	2004-2006	Confirmed presence but no density estimates available
GWF	Galloper OWF	2004-2006	
River Thames & Estuary	River Thames & Estuary	March 2015 surveys & 1990-2015 year-round opportunistic data	

6 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 20).

There are significant differences in harbour seal population size and dynamics across the various seal MUs in the UK. The MUs with the largest August haul-out counts in the 2016-2019 count period were West Scotland (15,600), Southeast England (3,752), the Western Isles (3,532) and Shetland (3,180) (Figure 22). In general, the east England MUs have shown increases in counts (broken by phocine distemper virus (PDV) epidemics in 1988 and 2002), the north east MUs (East Scotland, Moray Firth, North Coast and Orkney, and Shetland) have shown declines since the 1990s and the northwest MUs (West Scotland, Western Isles, and South-West Scotland) have remained stable or increased since 1990s (Thompson *et al.*, 2019).

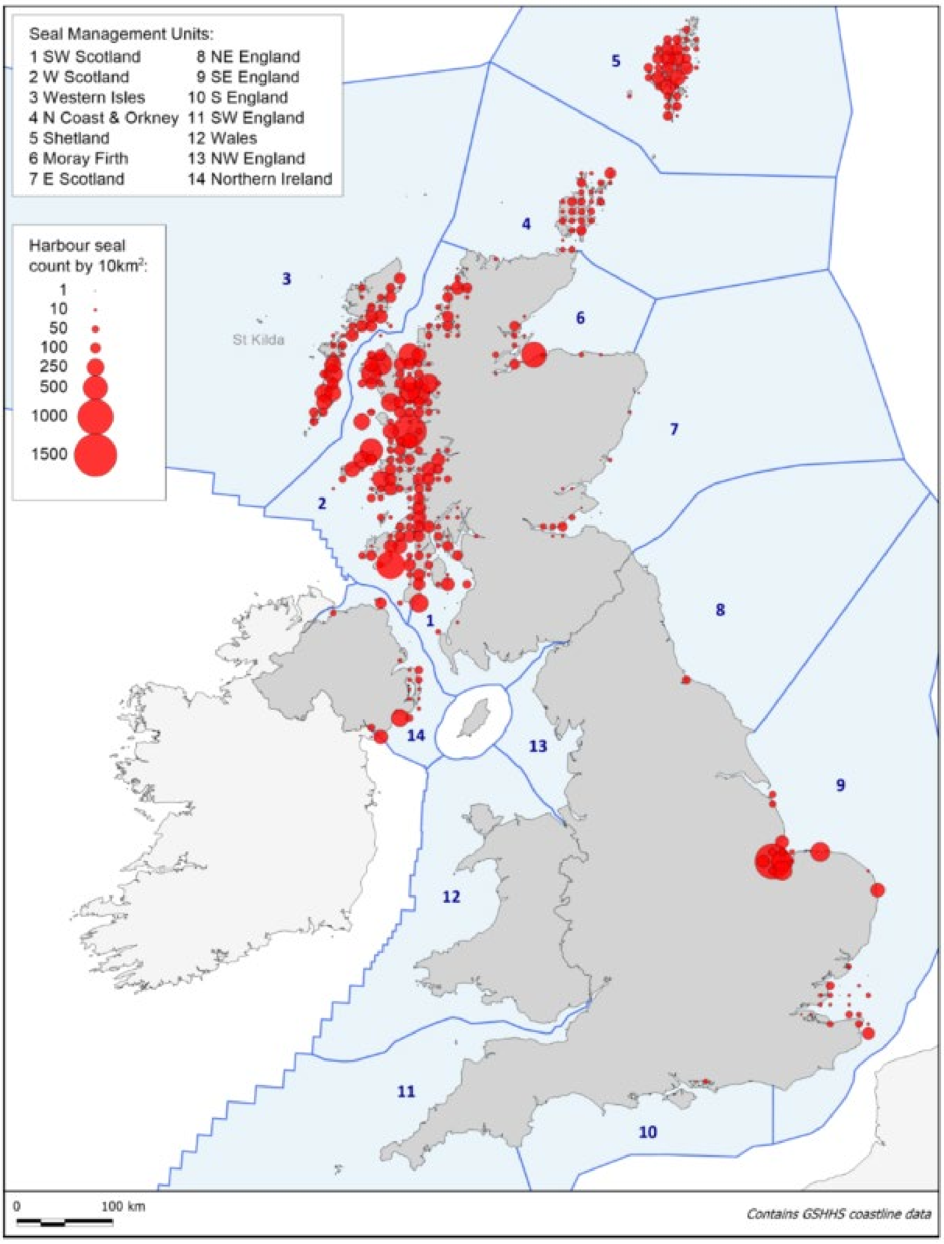

Figure 22 August distribution of harbour seals around the British Isles by 10km squares based on the most recent available haul-out count data collected up until 2019. Figure taken from (SCOS, 2022).

6.0 Site-specific surveys

No harbour seals were sighted during the two years of site-specific surveys; however, there were several sightings of unidentified seal species (n=9) and unidentified seal/small cetacean species (n=28) recorded year-round, some of which could have been harbour seals (Figure 23) (HiDef Aerial Surveying Ltd, 2020, 2021).

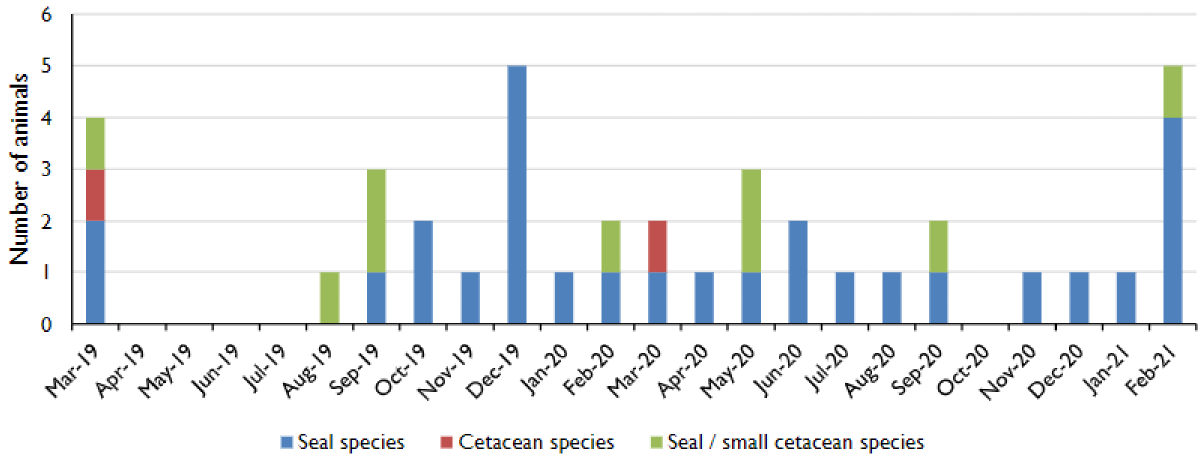

Figure 23 Number of partially identified non-avian animals recorded in HiDef surveys from March 2019 to February 2021 (HiDef Aerial Surveying Ltd, 2020, 2021).

6.1 Haul outs

6.1.1 MU

The Southeast England MU harbour seal count has varied considerably over time (Figure 24). There was a 50% lower count in 1989 compared to 1988 as a result of the PDV epizootic. 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, the 2019 count for the Southeast England MU was 27.6% lower than the mean count between 2012-2018, which may represent the first indication of a population decline and SCOS recommend that research is required to determine the time course and potential causes of this reduction (SCOS, 2021). The 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 2016-2019 dataset where 3,752 harbour seals were counted (SCOS, 2021). 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).

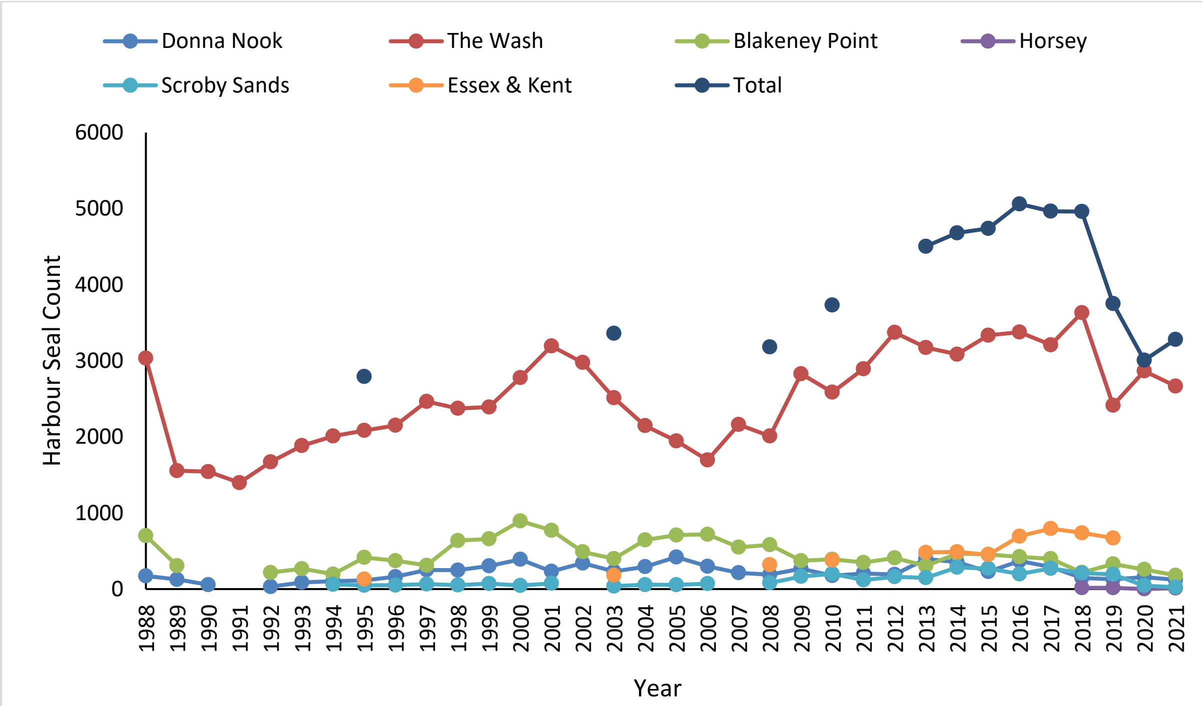

Figure 24 Harbour seal haul-out counts across the Southeast England MU over time. Data from SMRU.

As shown in Figure 25, 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 26). 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).

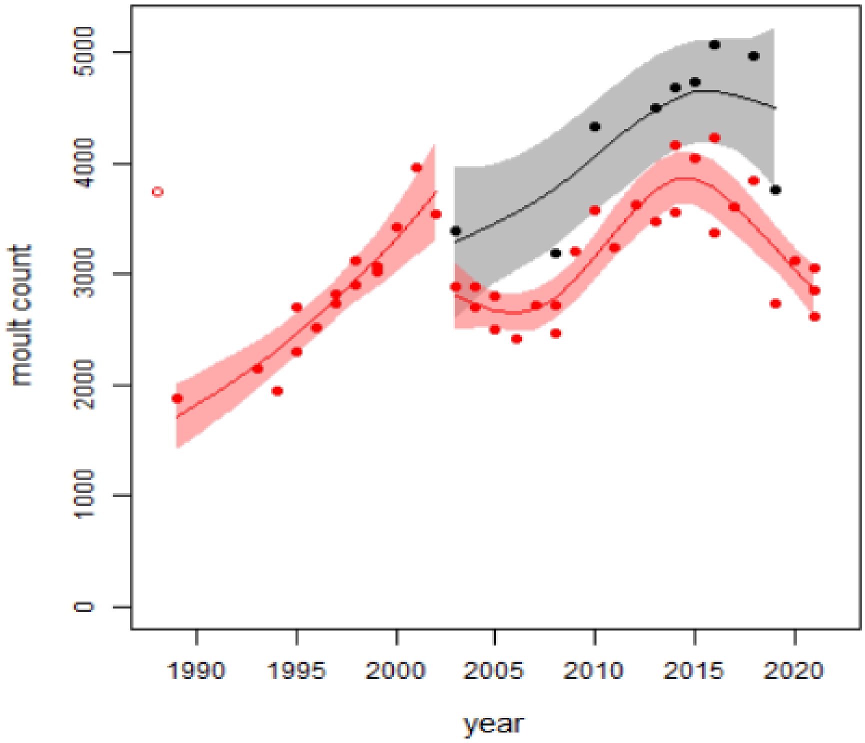

Figure 25 The August counts of harbour seals in the Wash and North Norfolk SAC (red) and the total for the Southeast England MU (grey) between 1988 and 2021 (SCOS, 2022) (see BP 21/06).

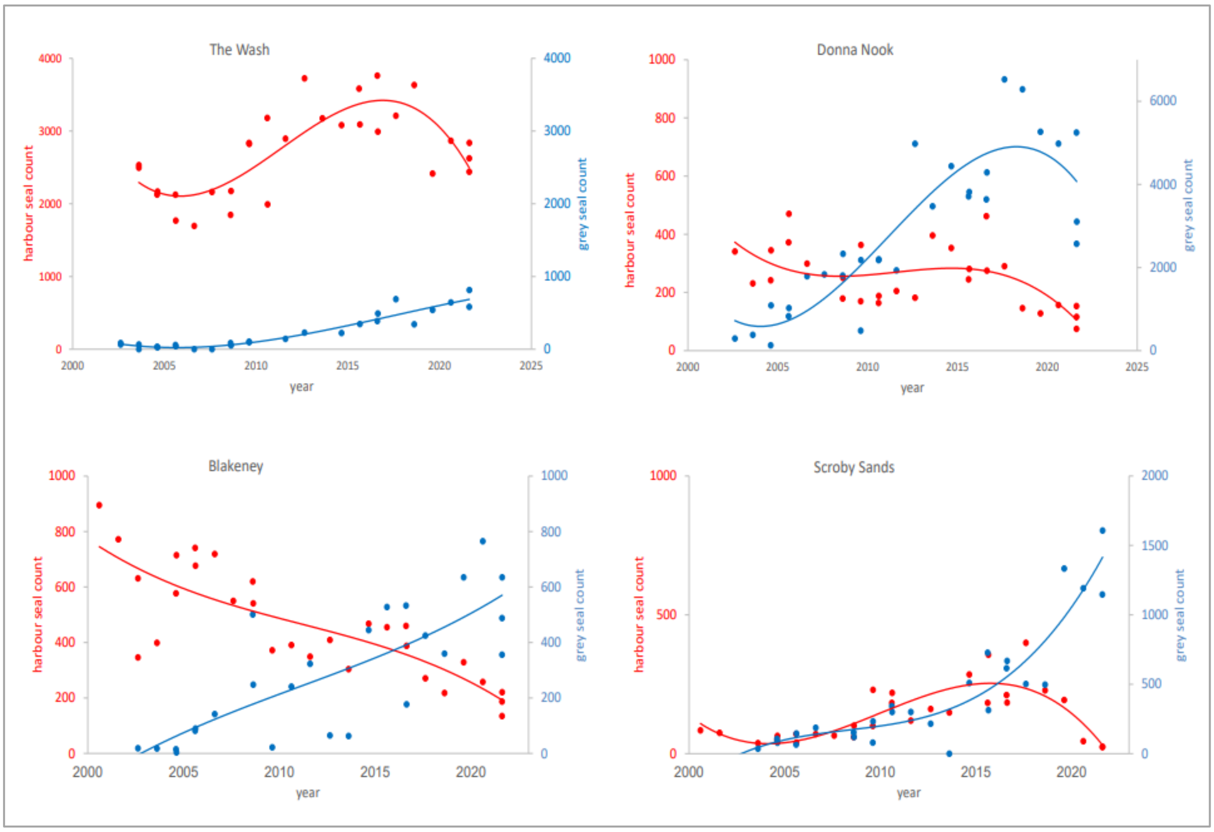

Figure 26 The counts of harbour seals (red) and grey seals (blue) from 2002 to 2021 in the Wash, Donna Nook, Blakeney Point and Scroby Sands (SCOS, 2022) (see BP 21/06).

Within the Southeast England MU, most harbour seal haul-out sites are located either in The Wash or in the Greater Thames Estuary area. There are no harbour seal haul-outs located within the VE Offshore ECC (Figure 27).

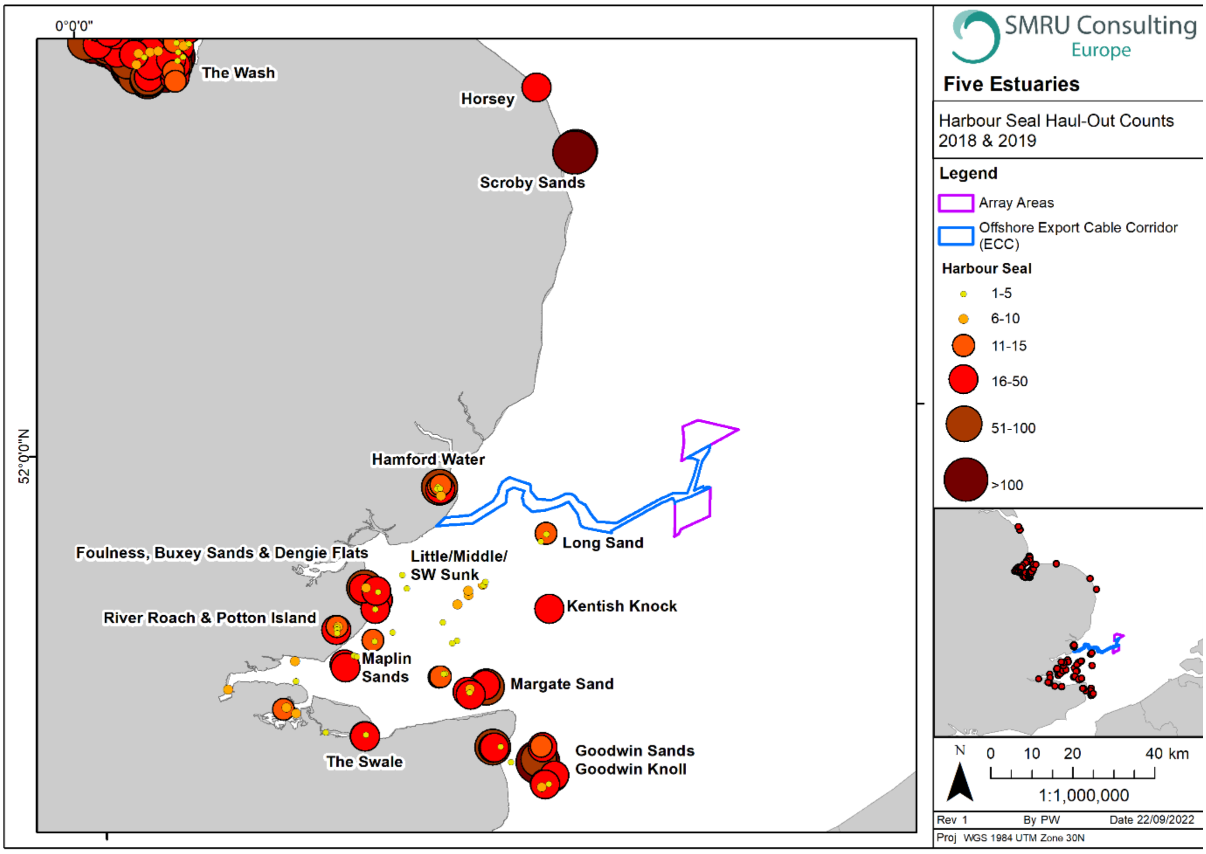

Figure 27 Harbour seal haul-out counts from 2018 and 2019 (data provided by SMRU).

6.1.2 Hamford Water

The nearest cluster of haul-out sites to VE landfall is at Hamford Water (~10 km from the Offshore ECC) where 98 harbour seals were counted in 2018 and 33 were counted in 2019 (data from SMRU).

6.1.3 Long Sand

Long Sand haul out site, where 18 harbour seals were counted in 2018 and only 2 in 2019 (data from SMRU), is located ~5 km from the Offshore ECC.

6.1.4 The Wash

The VE is located ~182 km south of The Wash haul-out cluster (Figure 27). 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).

6.1.5 Greater Thames Estuary Area

There are also several haul-out sites located within the Greater Thames Estuary Area to the southwest of the development (within around 100 km from the Offshore ECC) (Figure 27). As a collective, all haul-out sites in the Greater Thames Estuary Area (Hamford Water to Goodwin Sands/Knoll, including

Kentish Knock) supported a count of 738 harbour seals in 2018 and 671 harbour seals in 2019. Specifically, at the Kentish Knock sandbank, 37 harbour seals were counted in 2019 (Cox *et al.*, 2020). There were no surveys carried out in the Greater Thames Estuary during 2020. In 2021, 498 harbour seals were counted, which equates to a population estimate of 692 (566 – 922) (SCOS, 2022) (see BP 21/07). It should be noted that during the 2021 survey, Kentish Knock sandbanks were missed excluded due to the proximity to the surrounding wind farms (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 29) (Cox *et al.*, 2020). In general, harbour seals hauled-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 28 top). 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 28 bottom). In the 2021 survey, harbour seal counts were highest in Goodwin Sands area (Figure 30) (SCOS, 2022) (see BP 21/07).

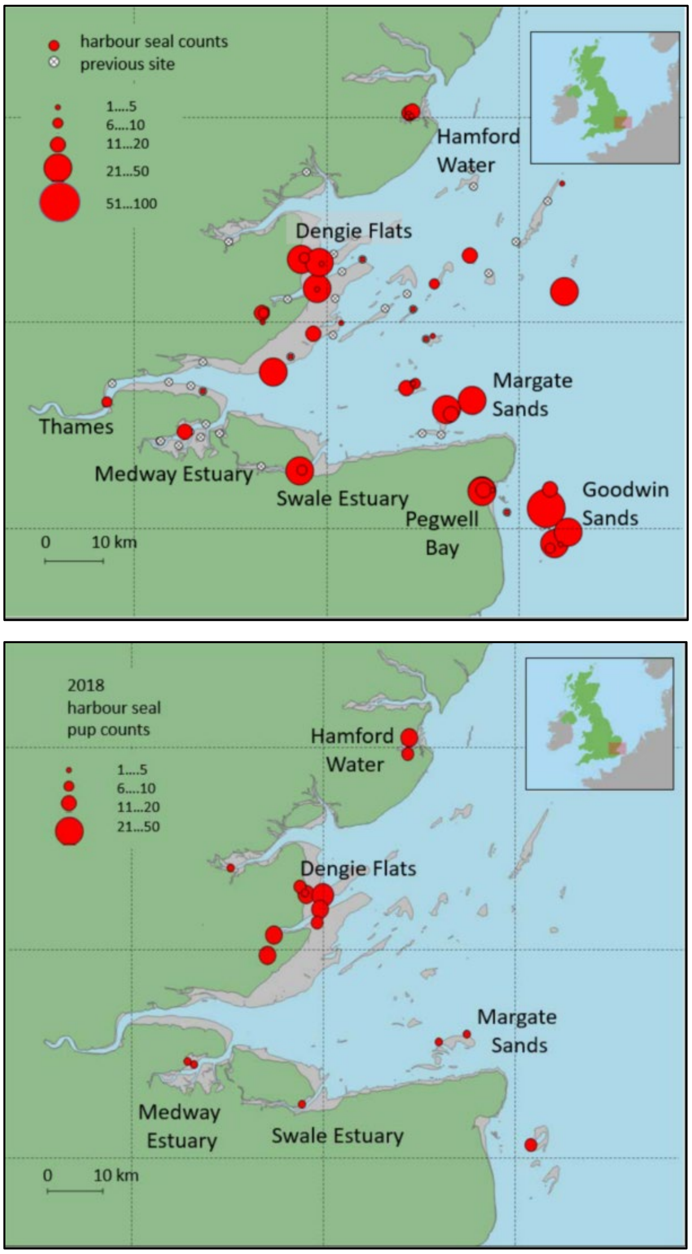

Figure 28 Figures taken from Cox *et al.* (2020). Top: 2019 count of harbour seals and other sites occupied by harbour seals in previous survey. Bottom: Distribution and count of harbour seal pups (2018).

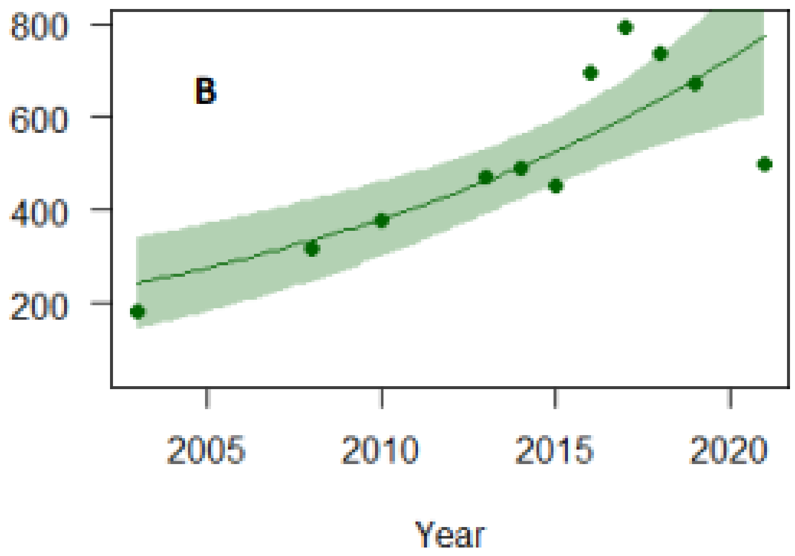

Figure 29 2003-2019 counts and fitted trend for Thames harbour seal population (95% CI shown).). Figure taken from SCOS (2022) (see BP 21/07).

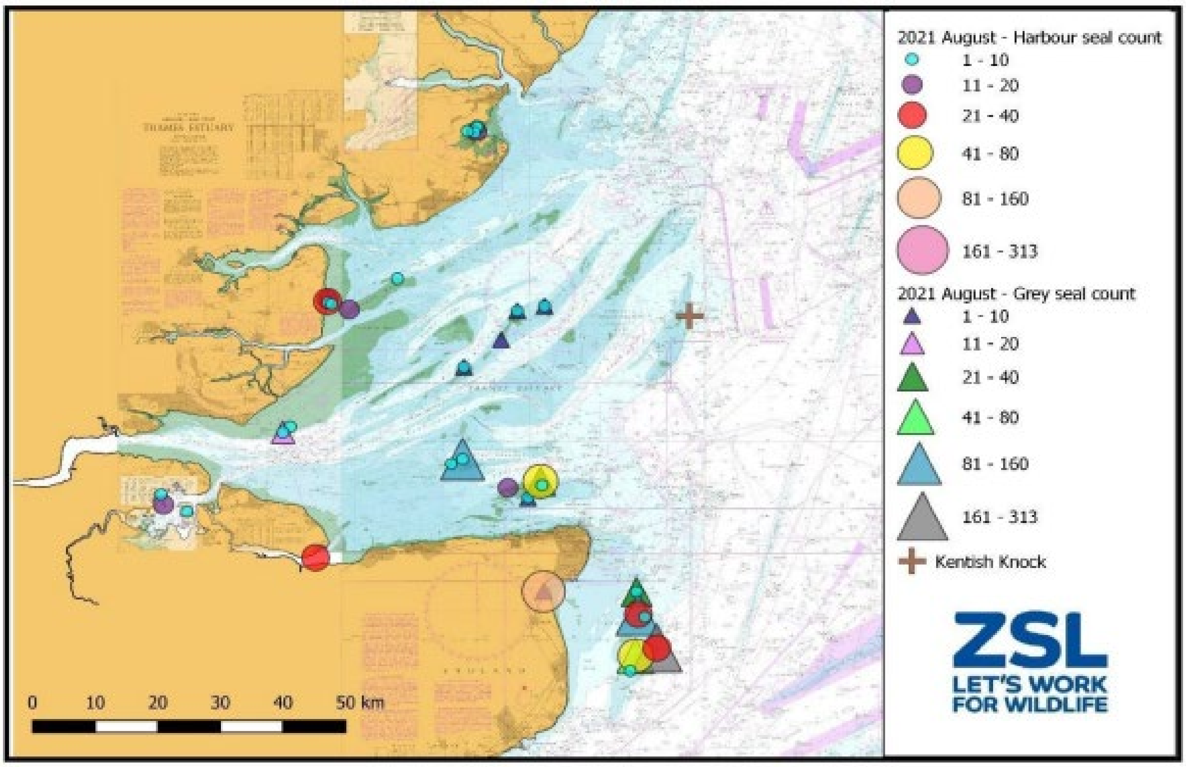

Figure 30 The harbour seal and grey seal counts from 2021. Figure taken from (SCOS, 2022) (see BP 21/07).

6.2 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. Harbour seal at-sea density estimates within the VE array areas are low at 0.007 harbour seals/km^2. However, densities are much higher along the Offshore ECC and towards the coast, where densities within the Offshore

ECC reach up to 0.36 harbour seals/km^2 (Figure 31). Within a 50 km buffer of the VE array areas, there are predicted to be ~194 harbour seals at any one time, which equates to an average density of 0.018 harbour seals/km^2.

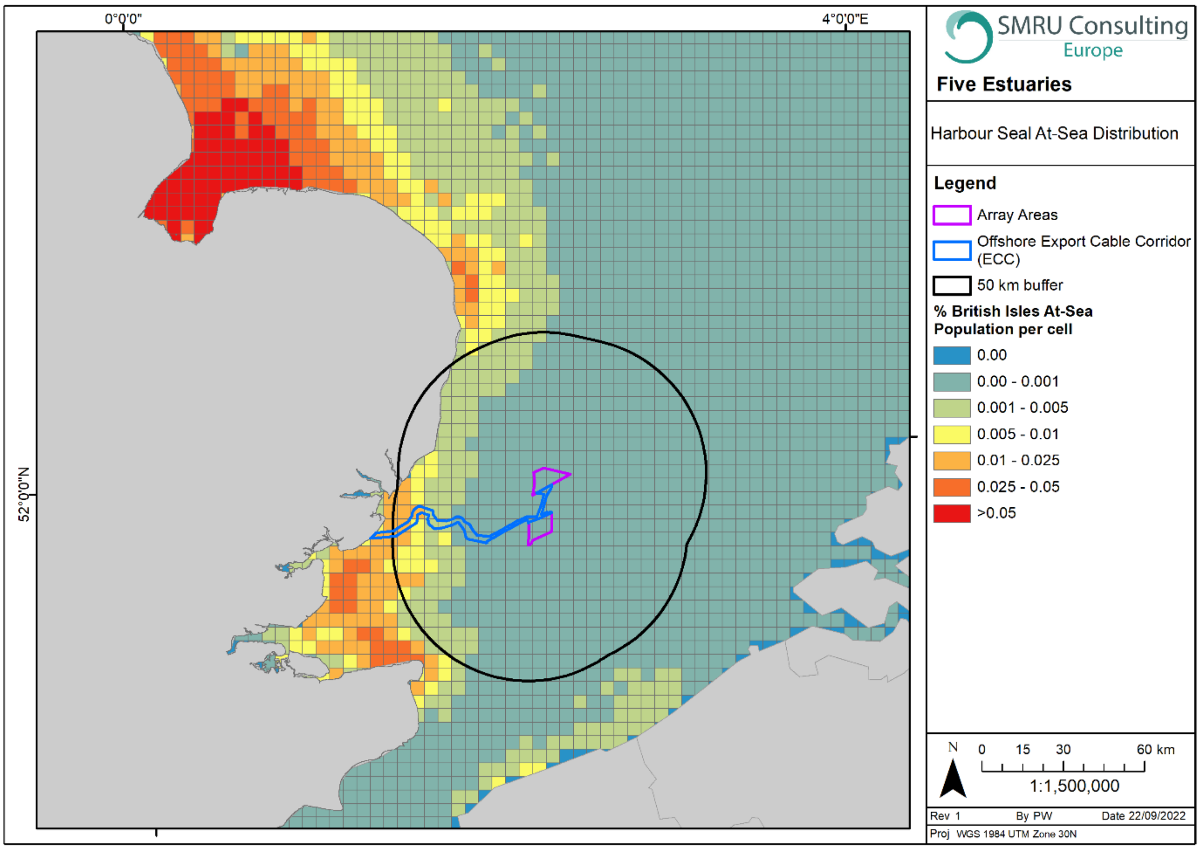

Figure 31 Harbour seal at-sea distributions (Carter *et al.*, 2020)

6.3 Telemetry

Telemetry data from 86 harbour seals tagged in the Thames Estuary and The Wash indicate little use of the VE array areas, with most of the tagged harbour seal activity being concentrated along the coastal part of the Offshore ECC (Figure 32). Harbour seals typically feed within 40 to 50 km from their haul-out sites (SCOS, 2022). Within a 50 km buffer of the VE site, there are telemetry tracks from 26 harbour seals, 17 of which showed connectivity with The Wash SAC. This connectivity between seals in the vicinity of VE and The Wash SAC will need to be considered in the HRA.

A study conducted by Vincent *et al.* (2017) on the abundance and at-sea distribution of harbour seals in France, showed that the harbour seals remained coastal and in close proximity to their respective haul-outs. This suggests that harbour seals tagged at French haul-out sites do not show connectivity with the Southeast England MU and other EU sites in the Netherlands, France and the Wadden Sea (Figure 33).

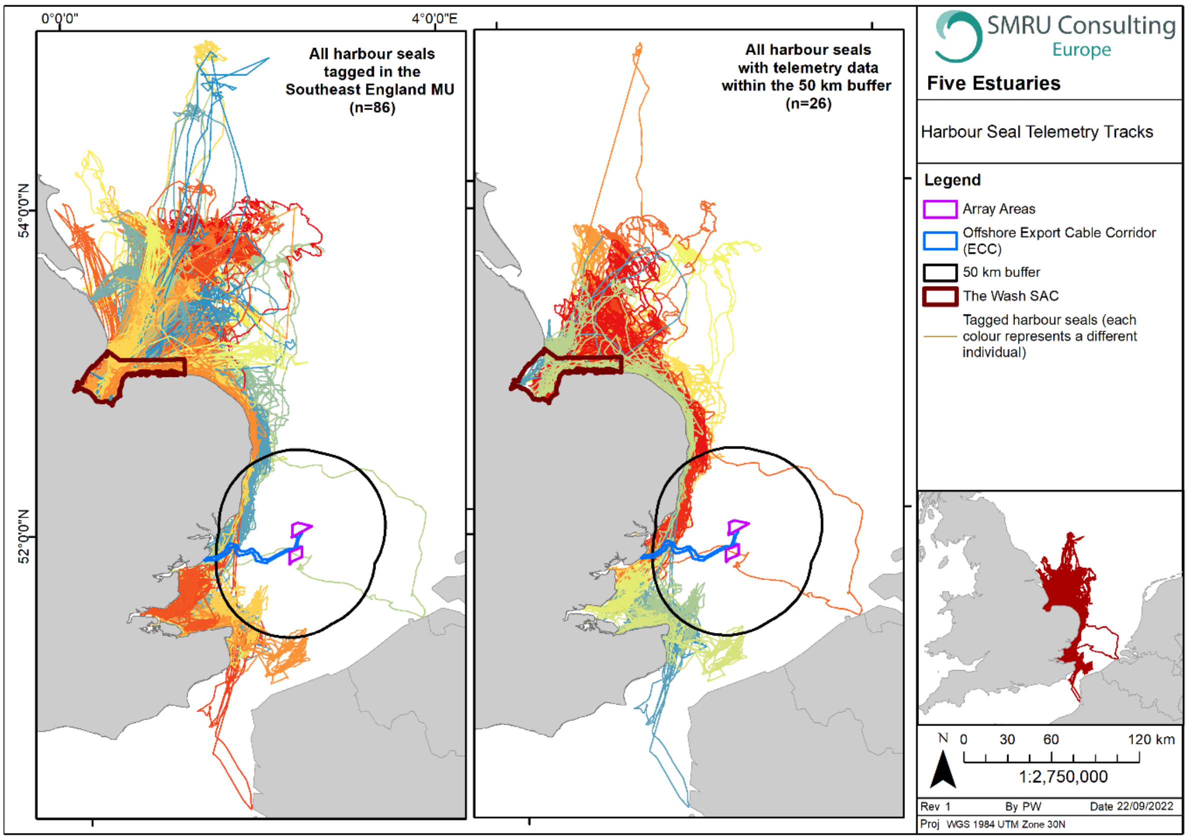

Figure 32 Harbour seal telemetry tracks (data from SMRU).

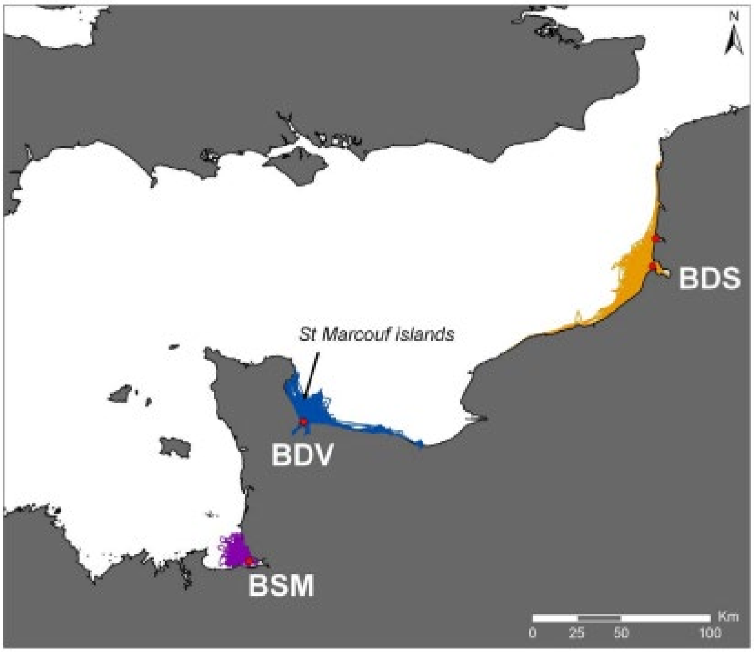

Figure 33 Harbour seal telemetry tracks obtained from 2006 to 2010. BSM = 6 individuals tracked in 2006 and 2007, in purple. BDV = 12 individuals tracked in 2007 and 2008, in blue. BDS = 10 individuals tracked in 2010, in orange. Red dots indicate haul-out locations of the seals. Seals tracked for less than a month are not shown here. Figure obtained from (Vincent *et al.*, 2017).

7 Grey seals

The overall Conservation Status of grey seals in UK waters has been assessed as Favourable with an overall improving trend (JNCC, 2019b). Population modelling for regularly monitored grey seal breeding colonies across the UK show an increasing trend of <1.5% p.a. between 2016-2019 (SCOS, 2021). 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 34). 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).

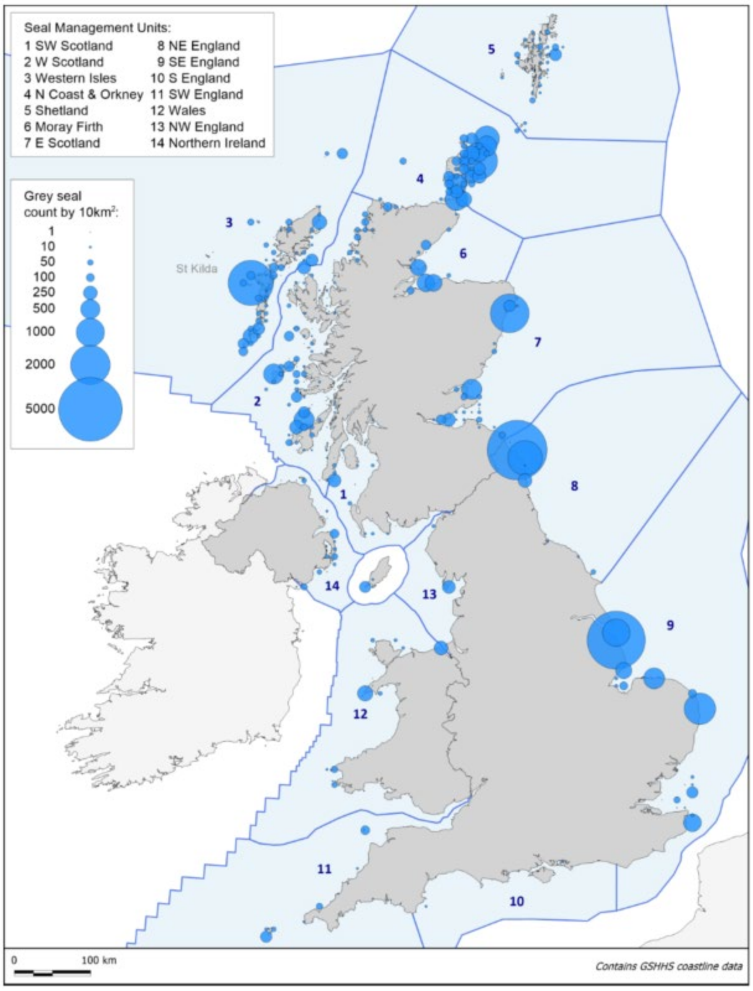

Figure 34 August distribution of grey seals around the British Isles by 10 km squares based on the most recent available haul-out count data collected up until 2019. Figure taken from SCOS (2022).

7.0 Breeding sites

The grey seal pup production in the North Sea showed 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 35). The nearest key breeding region for grey seals to VE 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 36).

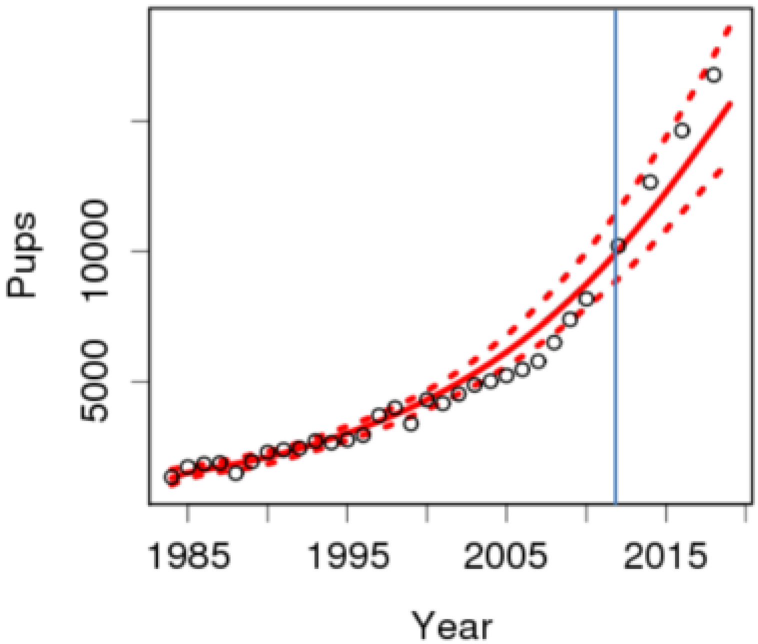

Figure 35 Posterior mean estimates of pup production (solid line) and 95% Confidence Intervals (dashed lines) from the model of grey seal population dynamics, fit to pup production estimates for regularly monitored colonies in the North Sea. The vertical blue line at 2012 indicates the change to a new camera system. Figure taken from (SCOS, 2021)

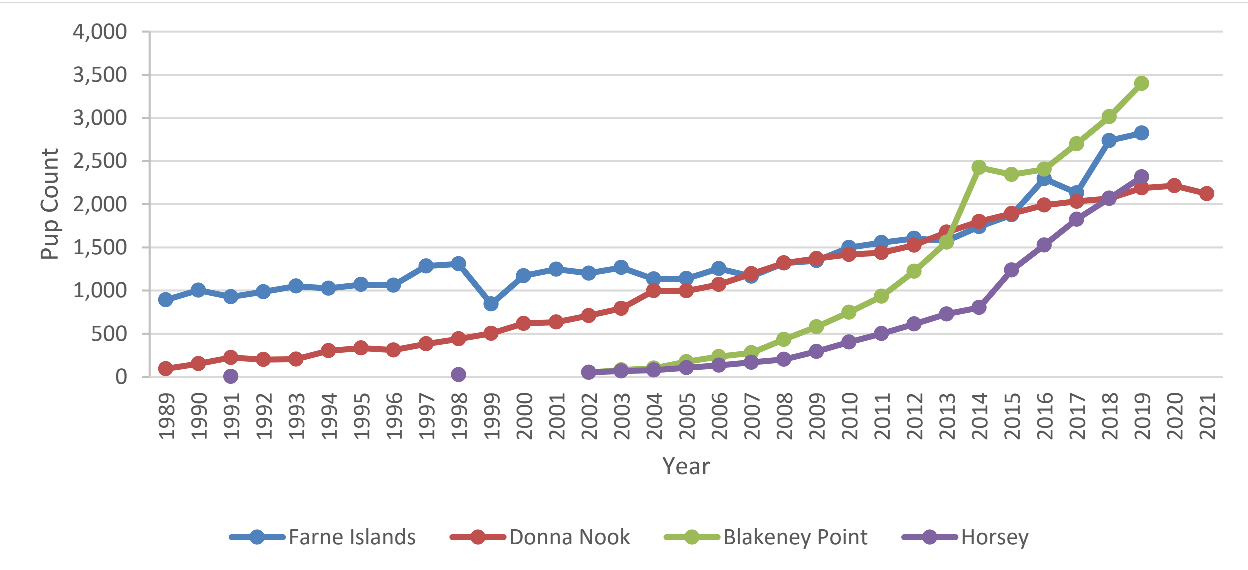

Figure 36 Grey seal pup counts at breeding colonies in the Southeast and Northeast England MUs (data from SMRU).

7.1 Site-specific surveys

Grey seals were sighted only occasionally during the two years of site-specific surveys with a total of 8 sightings over the 24 surveys (Table 11). However, there were several sightings of unidentified seal species (n=28) and unidentified seal/small cetacean species (n=9), recorded year round, some of which could have been grey seals (HiDef Aerial Surveying Ltd, 2020, 2021). Consequently, there were not enough sightings to calculate a density estimate for grey seals in the survey area.

The low number of sightings from the HiDef VE surveys is consistent with previous OWF site surveys in the area. During surveys conducted for the GGOWF, 6 grey seals (and 1 unidentified seal species, which could have been a grey seal) were sighted between 2004 and 2006. Similarly, during the GWF surveys, 6 grey seals were recorded within the study area from June 2008 to May 2011, with a maximum density estimate of 0.016 grey seals/km^2 during April 2010 (Royal Haskoning, 2011). Two years of aerial surveys (March 2019 - February 2021) for the North Falls OWF showed a total of 23 grey seal sightings, 6 in Year 1 and 17 in Year 2 (North Falls, 2021). These similar results are expected given the close proximity of the North Falls, GGOW and GWF to VE.

Table 11 Number of grey seals recorded from the HiDef surveys between March 2019 and February 2021 (HiDef Aerial Surveying Ltd, 2020, 2021).

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
Grey seal	1	0	0	0	0	2	0	0	0	0	0	1	4
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Total**
Grey seal	0	1	0	0	0	1	0	0	0	1	0	1	4

7.2 Haul outs

7.2.1 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 37). 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 38). However, during the past four years, this increase has slowed and began to level off (SCOS, 2022).

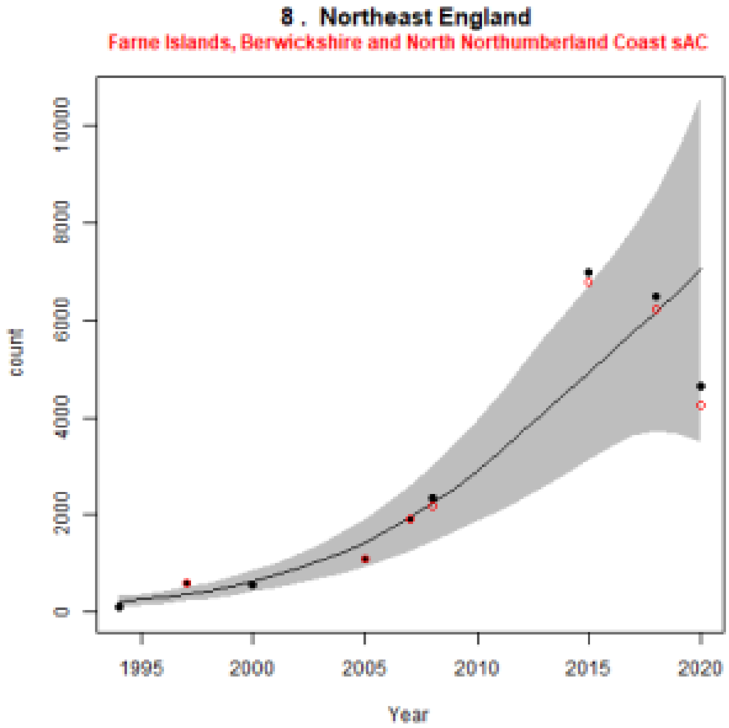

Figure 37 The predicted trend and associated 95% confidence intervals for the grey seal August haul-out counts in the Northeast England MU. The red circles indicate the SAC counts, the filled black circles indicate the values used to fit the trends and the open black circles illustrate the MU wide counts (SCOS, 2022) (see BP 21/03).

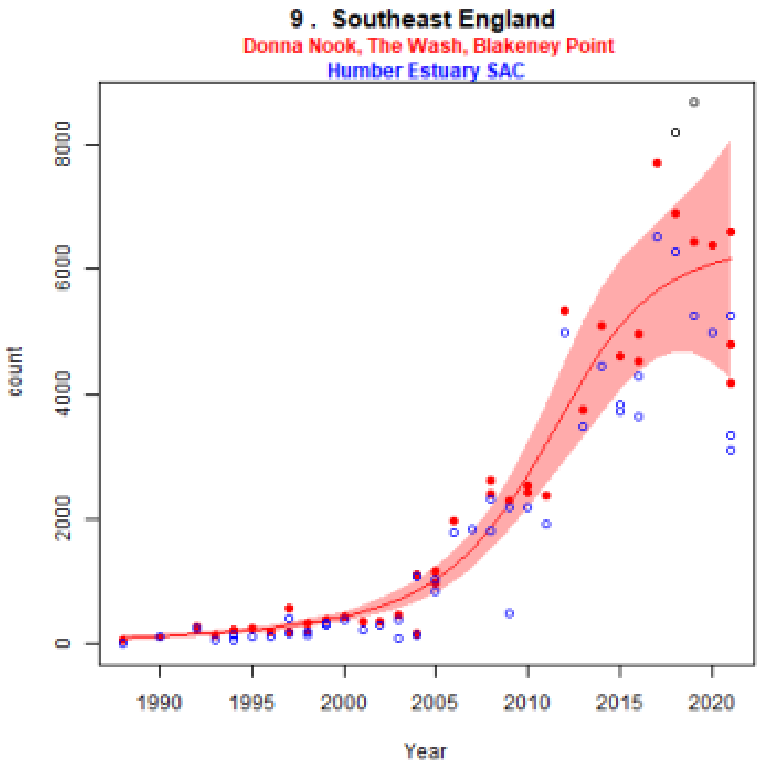

Figure 38 August counts of grey seals on the coast between Donna Nook (blue) and along the coast between Donna Nook and Blakeney (red) between 1988 and 2021. The red line and associated 95% confidence intervals represent the counts from Donna Nook to Blakeney (SCOS, 2022) (see BP 21/03).

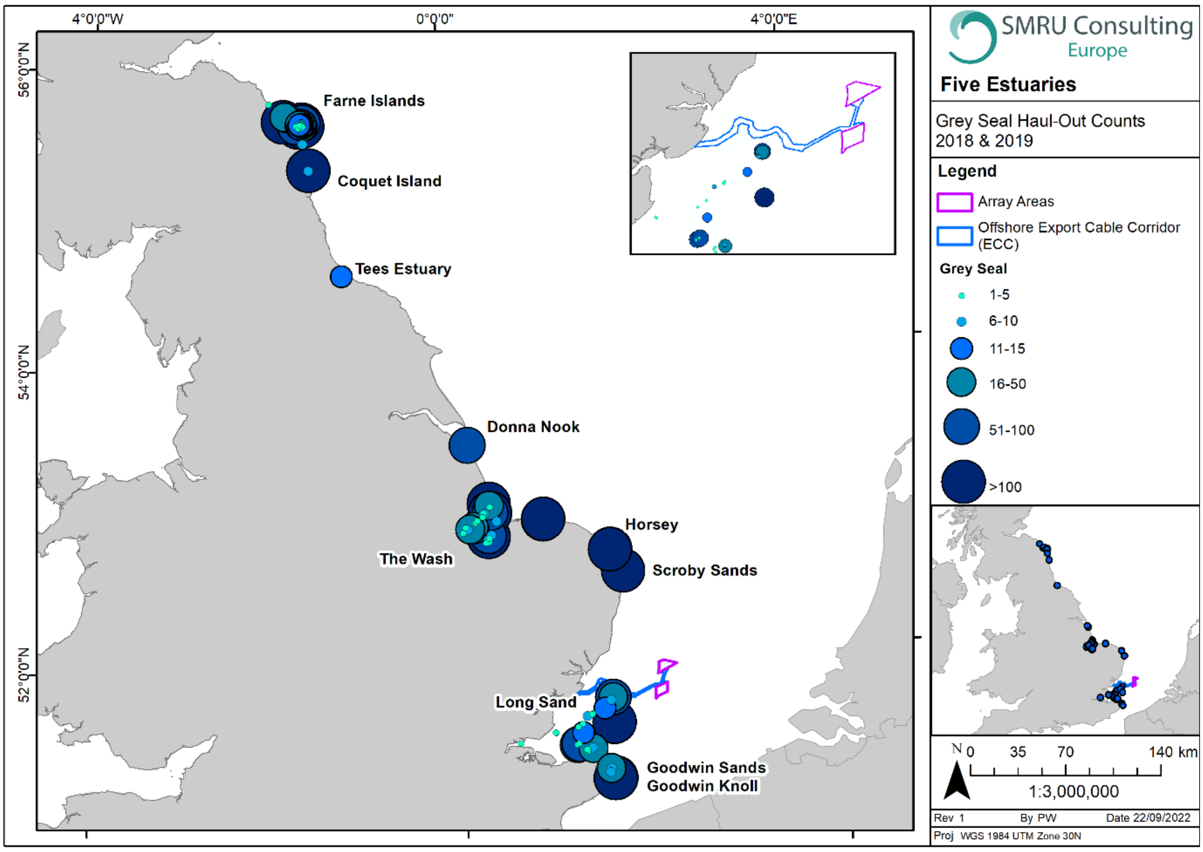

Figure 39 Grey seal haul-out counts in the Southeast and Northeast England MUs from 2018 to 2019 (data provided by SMRU).

7.2.2 Farne Islands

In the Northeast England MU, most grey seal haul-outs are located within the Farne Islands (1,608 hauled out in August 2018 (SCOS, 2021)), located ~ 480 km north of VE (Figure 39).

7.2.3 Donna Nook

Most grey seal haul-outs in the Southeast England MU are located in Donna Nook (6,288 hauled-out in August 2018 and 5,265 in August 2019), which is ~216 km north of the Offshore ECC (Figure 39). 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 hauled-out in August 2020 and 3,897 hauled-out in August 2021) (SCOS, 2022) (see BP 21/06).

7.2.4 Greater Thames Estuary Area

Within the Greater Thames Estuary Area to the southwest of the development (within around 100 km from the Offshore ECC) there are several haul-outs (Figure 39). As a collective, all haul-out sites in the Greater Thames Estuary Area (Long Sand to Goodwin Sands/Knoll, including Kentish Knock) supported a count of 596 grey seals in 2018 and 772 grey seals in 2019. Specifically, at the Kentish Knock sandbank, 195 grey seals were counted in 2019. The closest haul-out to the Offshore ECC is Long sands (~5 km), where 77 grey seals were counted in 2018 and 22 in 2019 (Cox *et al.*, 2020).

Overall, there has been an increase in counts in the Greater Thames Estuary area (Figure 40), 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 41). 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) (see BP 21/07).

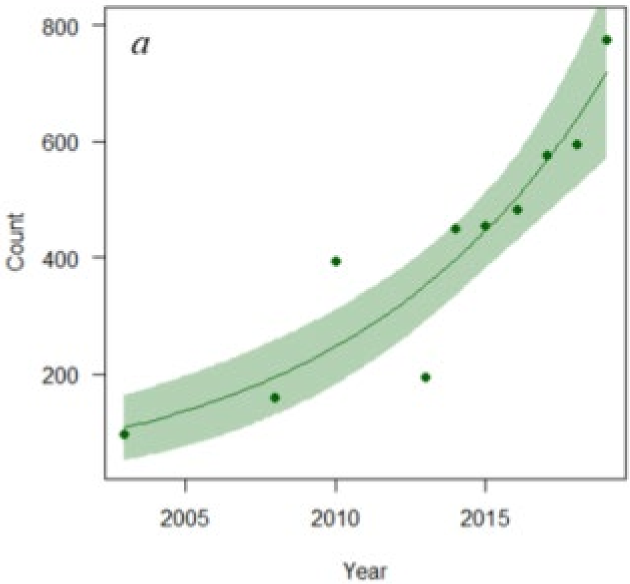

Figure 40 2003-2019 counts and fitted trend for Thames grey seal population (95% CI shown). Figure taken from Cox *et al.* (2020).

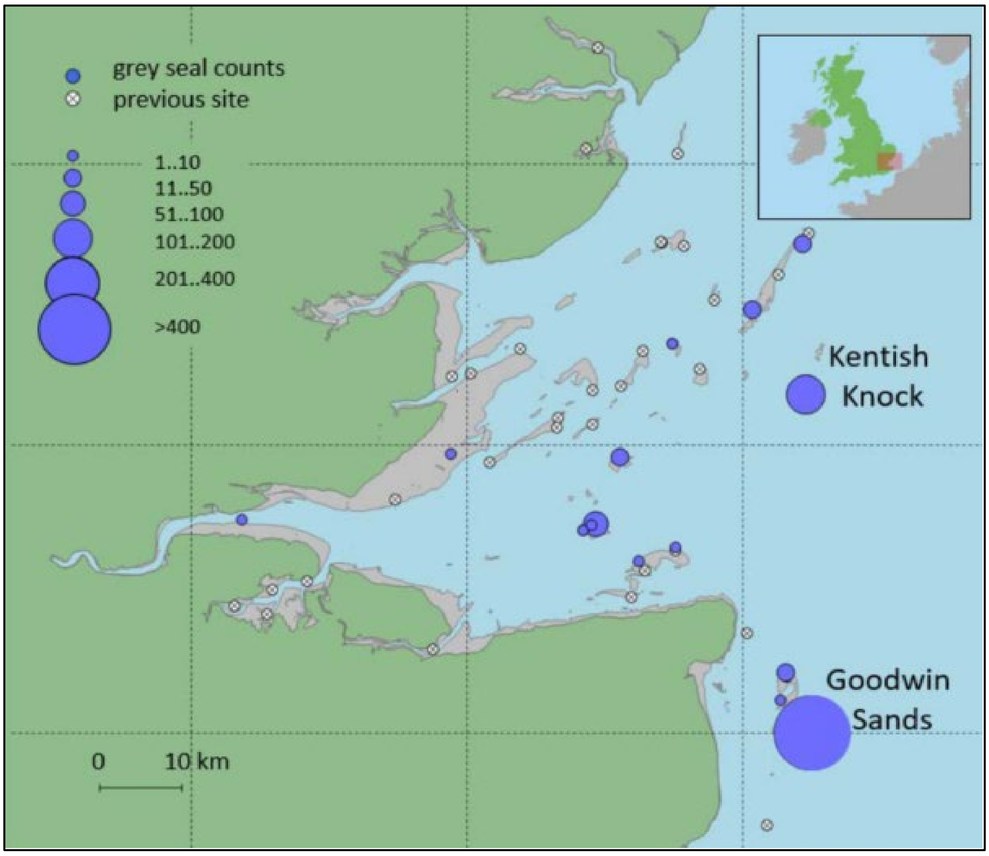

Figure 41 2019 count of grey seals at other sites occupied by grey seals in previous surveys. Figure taken from Cox *et al.* (2020).

7.3 At-sea density

In the Southeast and Northeast England MUs, grey seal at-sea distribution is primarily in the waters extending out of the Humber Estuary and the Farne Islands. The at-sea densities in the southern Southeast England MU and in the vicinity of VE are relatively low compared to other areas within the MUs. Grey seal at-sea density estimates within the VE array areas are low, with a maximum of 0.08 grey seals/km^2, and maximum densities within the Offshore ECC of 0.27 grey seals/km^2 (Figure 42). Within the 50 km buffer of the VE array areas, there are predicted to be ~1,281 grey seals at any one time, which equates to an average density of 0.106 grey seals/km^2. However, seal usage of this area is not expected to be uniform, with slightly higher densities towards the coast.

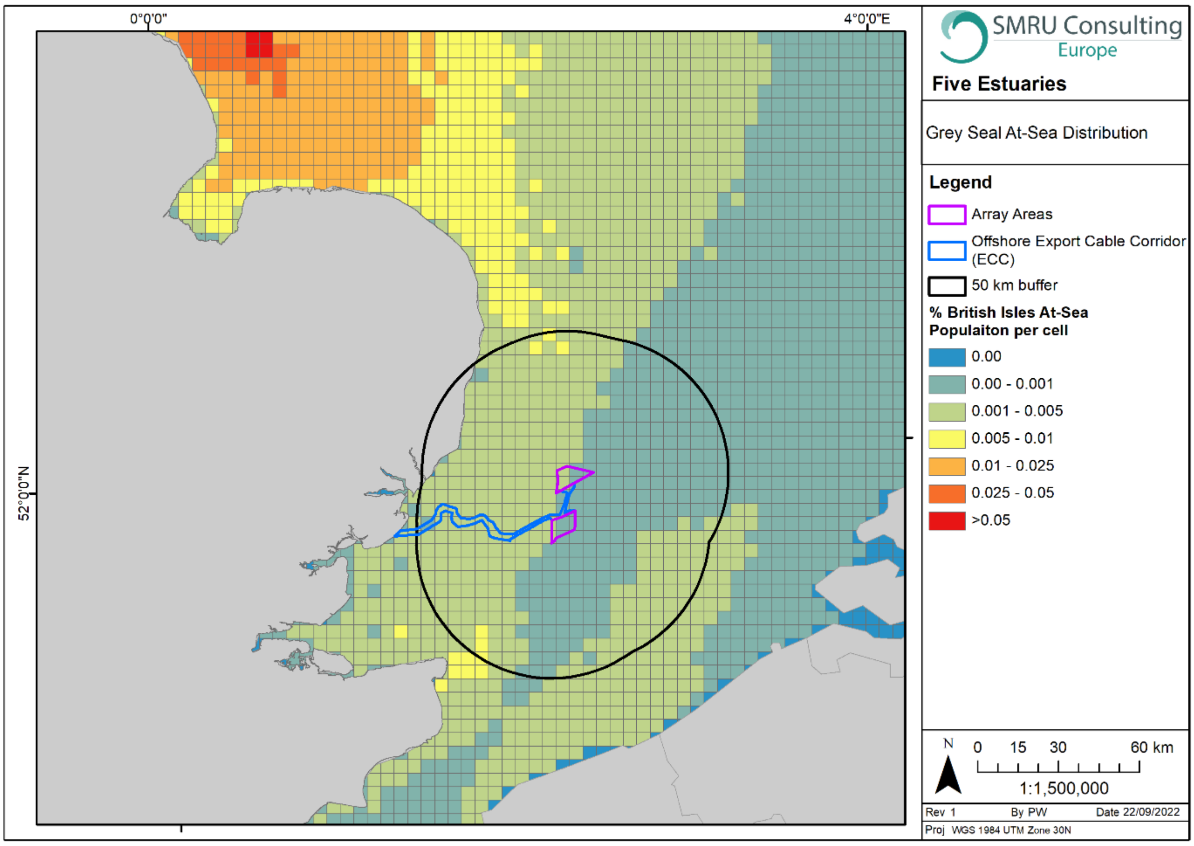

Figure 42 Grey seal at-sea distributions (Carter *et al.*, 2020)

7.4 Telemetry

In total, 64 grey seals have been 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 the 64 seals indicate low use of the VE array areas, with most of the tagged grey seal activity being concentrated along the coastal part of the Offshore ECC (Figure 43). Note, no grey seals have been tagged in the Thames Estuary and thus connectivity between the VE area and the Thames Estuary may be under-represented.

Within a 50 km buffer of the VE array areas, telemetry tracks of seven grey seals were recorded, of which one was tagged at the Farnes, one at Donna Nook and five at Blakeney. The telemetry track data indicate connectivity between the 50 km buffer of the VE array areas and the Humber Estuary SAC (4 seals) and the Berwickshire and North Northumberland Coast SAC (2 seals). This connectivity between the seals in the vicinity of VE and the SACs will need to be considered in the HRA (Volume 8, Report 2).

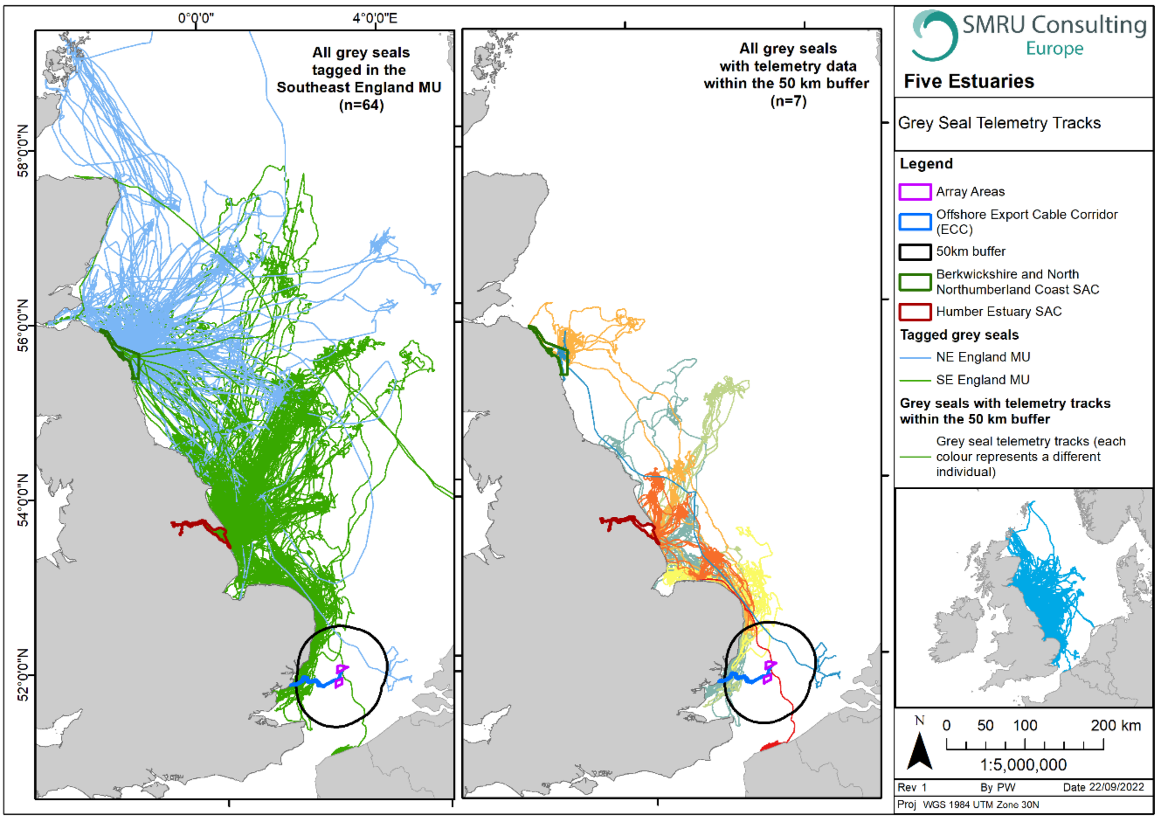

Figure 43 Grey seal telemetry tracks in the vicinity of the VE and connectivity with grey seal SACs (data from SMRU).

Data collected by Vincent *et al.* (2017), show clear evidence that grey seals exhibit wide-ranging movements. Grey seals tagged in France and the Netherlands moved throughout the Wadden Sea and Southeast England MU, including the vicinity of the VE (Figure 44). This large-scale movement needs to be considered in the transboundary effects assessment for grey seals.

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. The current maps only include grey seals tagged in the UK, and do not account for the presence of grey seals from France or the Wadden Sea. Therefore, it is likely that the seal habitat preference maps underestimate the true density of grey seals present in the vicinity of VE.

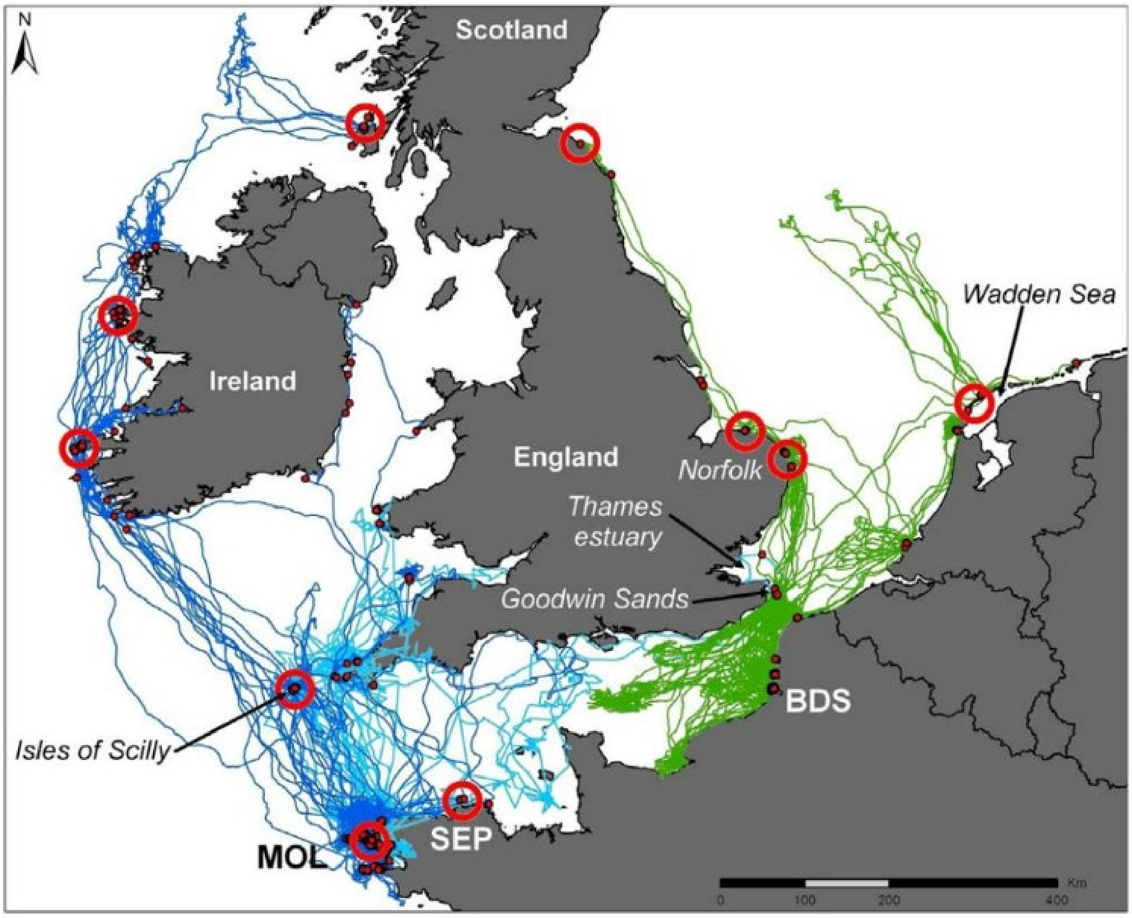

Figure 44 Telemetry tracks for grey seals tagged in France (Vincent *et al.*, 2017). Tracks from MOL (15 individuals tracked by Argos tags from 1999 to 2003, in light blue, and 19 individuals tracked by GPS/GSM tags from 2010 to 2013, in dark blue) and BDS (11 individuals tracked in 2012, in green). Red dots indicate haul-out locations of the seals. Thick, red circles indicate breeding locations, as suggested from the activity budget of the seals.

8 Conclusions

The data available for this baseline characterisation have confirmed that harbour porpoise, harbour seals and grey seals are likely to be present in the vicinity of the VE site year-round and should be considered within the quantitative impact assessment. There are a range of density estimates available from various surveys and data sources for harbour porpoise. The most robust and relevant density estimates for all three species have been outlined in Table 12 and are the ones recommended to be used in the quantitative impact assessment.

Table 12 Species, MU size and density estimate recommended for use in the VE quantitative assessment.

Species	MU	MU Size	MU Ref	Density (#/km^2)	Density ref
Harbour porpoise	North Sea	346,601	IAMMWG (2022)	1.82 (24-month average)	HiDef site-specific surveys
Harbour seal	Southeast England	5,211	Latest August counts scaled to account for seals at-sea	Grid-cell specific	Habitat preference (Carter *et al.*, 2020, Carter *et al.*, 2022)
Grey seal	Southeast & Northeast England	63,464			

9 References

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