Hornsea Project Four: Environmental Statement (ES)

PINS Document Reference: A5.4.1
APFP Regulation: 5(2)(a)

Volume A5, Annex 4.1: Marine Mammal Technical Report (Part 1)

Prepared SMRU Consulting, July 2021
Checked GoBe Consultants Ltd., August 2021
Accepted David King, Orsted. August 2021
Approved Julian Carolan, Orsted. September 2021

Doc. no. A5.4.1
Version B

Table of Contents

List of Tables

List of Figures

Glossary

Term	Definition
Acoustic surveys	In this document, acoustic surveys were carried out using a towed hydrophone primarily to detect vocalising harbour porpoise.
Availability bias	Distance sampling assumes that all animals on the trackline (i.e. at zero distance, g(0)) are detected (so that g(0)=1). Availability bias occurs when marine mammals are underwater and not available for detection on the trackline during a survey.
Cetacean	Any member of the group of mammals commonly known as whales, dolphins, and porpoises.
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Statement.
Export cable corridor (ECC)	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Hornsea Four array area to the Creyke Beck National Grid substation, within which the export cables will be located.
High Voltage Alternating Current (HVAC)	High voltage alternating current is the bulk transmission of electricity by alternating current, whereby the flow of electric charge periodically reverses direction.
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Order Limits	The limits within which Hornsea Four (the 'authorised project') may be carried out.
Orsted Hornsea Project Four Ltd	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Perception bias	Distance sampling assumes that all animals on the trackline (i.e. at zero distance, g(0)) are detected (so that g(0)=1). Perception bias occurs when marine mammals are at the surface and available to be detected but may have been missed by the observers.
Sea State	Description of wind-generated ocean wave properties, including their heights, periods and directions. This document refers to the Beaufort Scale.
Telemetry	The study of animal movement where data is obtained from tags attached to individual animals that store and transmit data on their movement patterns.

Acronyms

Acronym	Definition
AfL	Agreement for Lease
BEIS	Department for Business, Energy and Industrial Strategy
BDS	baie de Somme
CGNS	Celtic and Greater North Seas
CI	Confidence Interval
cSAC	candidate SAC
CODA	Cetacean Offshore Distribution and Abundance in the European Atlantic
CV	Coefficient of Variation
DCO	Development Consent Order
DPD	Dolphin Positive Days
ECC	Export Cable Corridor
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EP	Evidence Plan
ES	Environmental Statement
EU	European Union
FCS	Favourable Conservation Status
GAM	Generalised Additive Model
GPS	Global Positioning System
GSD	Ground Sample Distance
HVAC	High Voltage Alternative Current
IAMMWG	Inter-Agency Marine Mammal Working Group
ICES	International Council for the Exploration of the Sea
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
MMO	Marine Management Organisation
MOL	Molene archipelago
MU	Management Unit
NERC	Natural Environment Research Council
O&M	Operation and Maintenance
PEIR	Preliminary Environmental Information Report
pMPA	possible Marine Protected Area
pSAC	possible SAC
PVD	Phocine Distemper Virus
RIAA	Report to Inform Appropriate Assessment
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SCANS	Small Cetaceans in the European Atlantic and North Sea
SCI	Site of Community Importance
SCOS	Special Committee on Seals
SEP	Sept Iles archipelago
SMA	Seal Management Area
SMRU	Sea Mammal Research Unit

Acronym	Definition
SNH	Scottish Natural Heritage
SNS	Southern North Sea
SS	Sea State
TWT	The Wildlife Trusts
UXO	Unexploded Ordnance
WDC	Whale and Dolphin Conservation

Units

Unit	Definition
km	kilometre
m	meter
Sea state (SS)	Beaufort Sea State scale
Animals/km^2	Density of animals per km^2
Animals/km	Sightings or Encounter rate per km travelled on survey
Animals/hour	Sightings or Encounter rate per hour surveyed
Dolphin positive days	Number of surveys days in which a dolphin was sighted
Animals/cell	Density of seals within a grid cell

1 Introduction

1.1 Project background

1.1.1.1 Orsted Hornsea Project Four Ltd (hereafter the 'Applicant') is proposing to develop the Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four'). Hornsea Four will be located approximately 69 km offshore from the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone (please see **Volume A1, Chapter 1: Introduction** for further details on the Hornsea Zone). Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network (please see **Volume A1, Chapter 4: Project Description** for full details on the Project Design). The location of Hornsea Four is illustrated in **Figure 1**. The Order Limits combine the search areas for the onshore and offshore infrastructure.

1.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 846 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project has due consideration to the size and location (within the existing AfL area) of the final project that is being taken forward to Development Consent Order (DCO) application. This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction.

1.1.1.3 The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the array area taken forward at the point of DCO application. Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (468 km^2 – see **Figure 1**) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the Hornsea Four Order Limits is detailed in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**.

1.1.1.4 SMRU Consulting was commissioned by the Applicant to undertake a characterisation of the marine mammal baseline environment of the Hornsea Four array area and surrounding area.

1.1.1.5 The consideration of marine mammals for Hornsea Four has been discussed with consultees through the Hornsea Four Evidence Plan (EP) process; specifically with the Marine Mammal Evidence Plan Technical Panel (hereafter EP Technical Panel) of which Natural England, the Marine Management Organisation (MMO), Cefas, Whale and Dolphin Conservation (WDC); and The Wildlife Trusts (TWT). Agreements made with consultees within the EP process are set out in the topic specific EP Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan**), an annex of the Hornsea Four Consultation Report (**B1.1: Consultation Report**). All agreements within the EP Logs have unique identifier codes which have been used throughout this document to signpost to the specific agreements made (e.g. OFF-MM-1.1).

1.2 Aims and objectives

1.2.1.1 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 Hornsea Four. The baseline data have been compiled through a combination of a literature reviews and data obtained from site-specific surveys (see **Section 2.4** for information on data sources).

2 Methodology

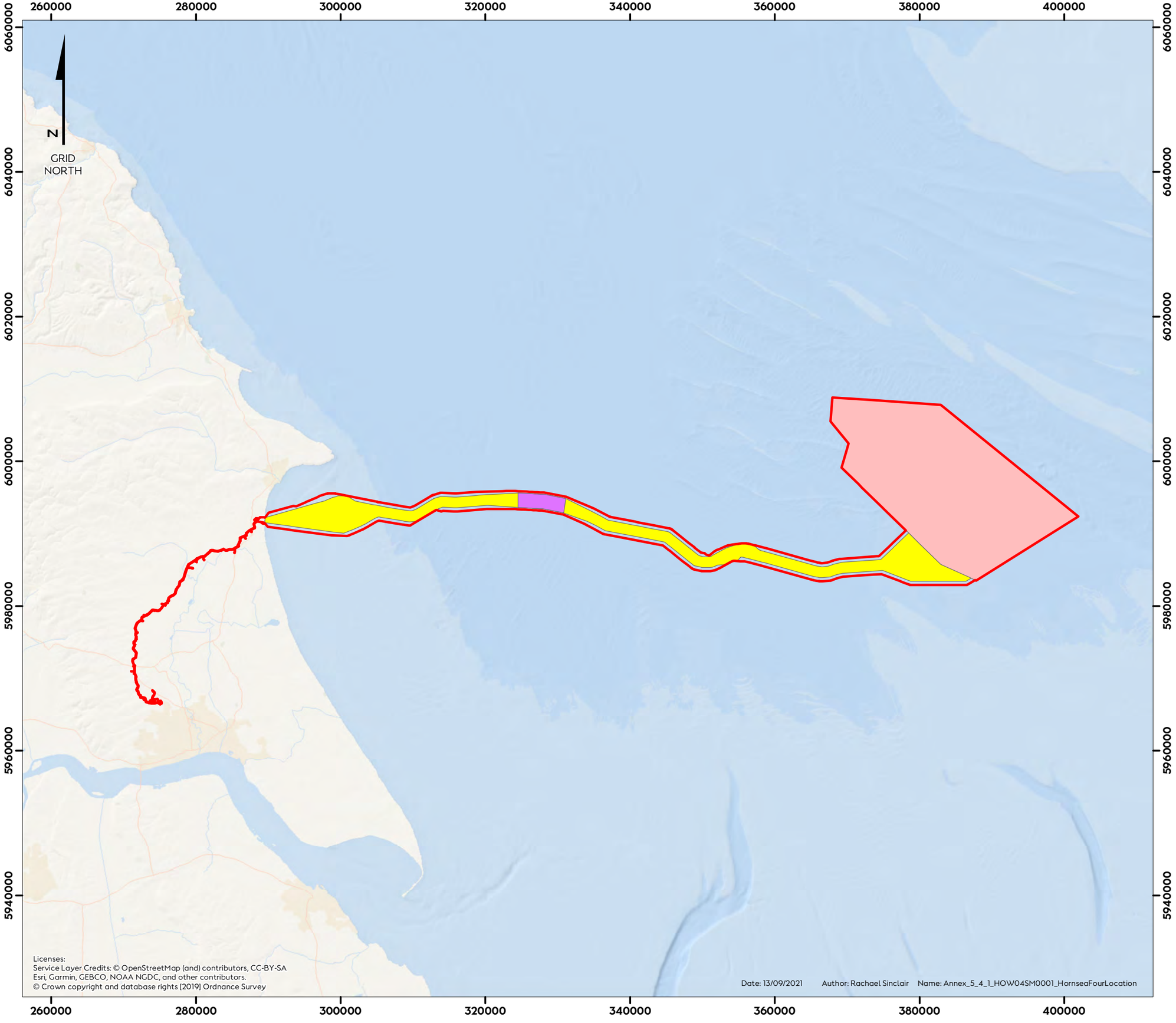
2.1.1.1 Baseline information was gathered by a combination of desk- based review of existing data sources and consideration of site- specific survey data. The existing sources reviewed and the surveys carried out are described in detail below (**Section 2.4**).

2.1.1.2 Hornsea Four is located in the Eastern England Sea Watch Foundation area, within which a total of 12 cetacean species have previously been sighted in nearshore waters. However, of these, only five are considered to be either present throughout the year or recorded annually as seasonal visitors to the region. These include harbour porpoise (*Phocoena phocoena*), minke whales (*Balaenoptera acutorostrata)*, white-beaked dolphins (*Lagenorhynchus albirostris*), Atlantic white-sided dolphins (*Lagenorhynchus acutus*) and killer whales (*Orcinus orca*). While other cetacean species have been recorded at some point in the region since 1980, they are considered to be rare and therefore have not been included in this baseline characterisation. Both the Small Cetaceans in the European Atlantic and North Sea (SCANS) III survey of block O and the HiDef aerial surveys of Hornsea Four recorded sightings of only three cetacean species: harbour porpoise, minke whale and white-beaked dolphin, therefore these are considered to be the most common species in the area of Hornsea Four and are expected to be at risk of impact from Hornsea Four. The Sea Watch Foundation have recorded an increase in the frequency of bottlenose dolphin (*Tursiops truncatus*) sightings along the east England coast, and as such, this species is also included in the baseline characterisation. Therefore, this baseline characterisation report will focus on four cetacean and two seal species (harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*), as agreed with the EP Technical Panel (14 January 2019 and updated 6 November 2019 following PEIR).

Hornsea Four

Figure 1

Hornsea Four Array Area, Offshore ECC and HVAC Area



Order Limits

Array Area

Offshore Export Cable Corridor

HVAC Booster Station Works Area

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:500,000

0 5 10 20 Kilometres

0 3 6 12 Nautical Miles

REV	REMARK	DATE
	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

Hornsea Four Location
Document no: HOW04SM0001
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

2.2 Study area

2.2.1.1 The marine mammal study area varies depending on the species, considering individual species ecology and behaviour. For all species, the study area covers the Hornsea Four array area and offshore Export Cable Corridor (ECC) and is extended over an appropriate area considering the scale of movement and population structure for each species (**Figure 2**). For each species, the area considered in the assessment is largely defined by the appropriate species Management Unit (MU). The study area for marine mammals has been defined at two spatial scales: the MU scale for species specific population units and the marine mammal survey areas for an indication of the local densities of each species.

2.2.1.2 Hornsea Four is located within the International Council for the Exploration of the Sea (ICES) North Sea Assessment Unit for harbour porpoise (ICES 2014) which is equivalent to the North Sea MU as defined in the Inter-Agency Marine Mammal Working Group - IAMMWG (2021) report, the Celtic and Greater North Seas MU (CGNS MU) for white-beaked dolphins and minke whales (IAMMWG 2021) and the South East England Seal MU for both grey and harbour seals (IAMMWG 2013, SCOS 2021). For bottlenose dolphins, the IAMMWG (2021) identified a Greater North Sea MU (represented by ICES Area 4 excluding coastal east Scotland; and ICES Division 3a) as the appropriate MU, however it is noted that animals sighted along the east coast of England are thought to belong to be functionally linked to the Coastal East Scotland MU (see **Section 6**).

2.2.1.3 Previously, surveys of the entire former Hornsea Zone (plus 10 km buffer) were conducted in order to provide detailed density and abundance data within the local Hornsea Zone. However, these data are now between six and nine years old and since then, there may have been changes in the distribution and abundance of marine mammals across the area. Therefore, site-specific aerial surveys were conducted, which encompassed the Hornsea Four AfL plus a 4 km buffer. This baseline characterisation presents the data for the entire site-specific aerial survey area.

Hornsea Four

Figure 2

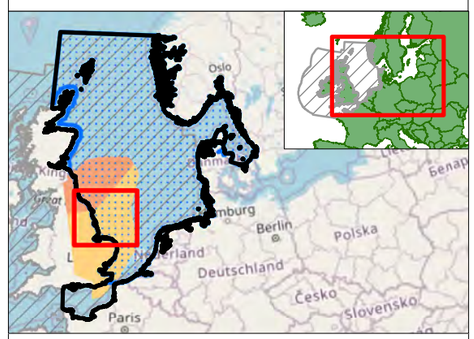
Marine Mammal Study Areas and Management Units

300000 400000 500000

6100000 6000000 5900000

N GRID NORTH

- Order Limits
- Hornsea Four Site-Specific Aerial Survey Area
- Former Hornsea Zone Survey Area
- North Sea Management Unit
- Northeast England Seal Management Area
- Southeast England Seal Management Area
- Greater North Sea Management Unit
- Celtic and Greater North Seas Management Unit



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:1,000,000

0 10 20 40 Kilometres

0 5 10 20 Nautical Miles

REV	REMARK	DATE
--	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

Marine Mammal Study Areas
Document no: HOW04SM0002
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

Date: 13/09/2021 Author: Rachael Sinclair Name: Annex_5_4_1_HOW04SM0002_MarineMammalStudyAreas

2.3 Protected areas

2.3.1.1 In order to conserve biodiversity, by maintaining or restoring Annex II species to a Favourable Conservation Status (FCS), the Habitats Directive requires the designation of Special Areas of Conservation (SACs) for the harbour porpoise, bottlenose dolphins the harbour seal and the grey seal.

2.3.2 Harbour porpoise SAC

2.3.2.1 In 2016, five possible SACs (pSACs) for harbour porpoise were proposed in England, Ireland and Wales, which, following consultation, were then submitted by the UK Government to the European Commission for formal designation in 2017. At this stage these sites became candidate SACs (cSACs). Since then, the Southern North Sea (SNS) area was adopted by the European Commission as a Site of Community Importance (SCI) and in February 2019 became a formally designated SAC. The Hornsea Four array area is located entirely with the northern summer part of the SNS SAC (**Figure 3**) for which conservation objectives and advice on activities were published in March 2019. Full consideration of the potential impact on the draft conservation objectives of the SNS SAC is presented as part of the Report to Inform Appropriate Assessment (RIAA) (see **B2.2: Report to Inform Appropriate Assessment**).

2.3.3 Bottlenose dolphin SAC

2.3.3.1 The Moray Firth SAC in Scotland was designated as an SAC in 2005 and lists bottlenose dolphins as the primary reason for site selection. The site supports the only known resident population of bottlenose dolphins in the North Sea, with individuals being present year round. The boundary of The Moray Firth SAC is approximately a minimum distance of 520 km from the boundary of the Hornsea Four array area (**Figure 3**). Full consideration of the potential impact on the conservation objectives of the SAC is presented as part of the RIAA.

2.3.4 Harbour seal SAC

2.3.4.1 The closest harbour seal SAC to Hornsea Four is The Wash and North Norfolk Coast SAC where harbour seals are listed as the primary reason for site selection. The Wash and North Norfolk Coast SAC supports the largest breeding colony of harbour seals in the UK. The boundary of The Wash and North Norfolk Coast SAC is approximately a minimum distance of 90 km from the boundary of the Hornsea Four array area (**Figure 3**). Full consideration of the potential impact on the conservation objectives of the SAC is presented as part of the RIAA.

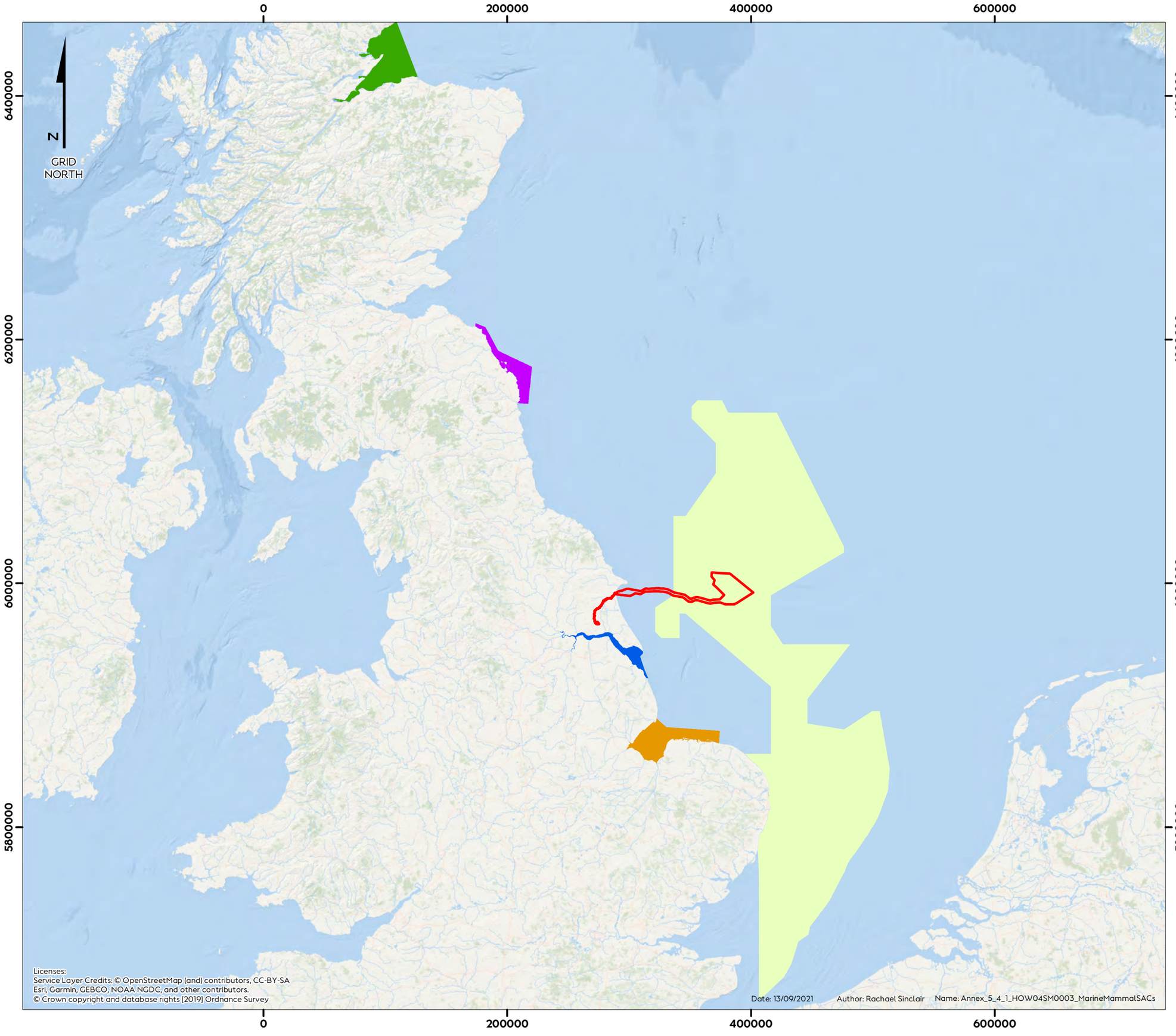
2.3.5 Grey seal SACs

2.3.5.1 The closest grey seal SAC to Hornsea Four is the Humber Estuary SAC where grey seals are listed as a qualifying feature but not the primary reason for site selection. The Humber Estuary SAC is approximately 75 km from the boundary of the Hornsea Four array area and approximately 50 km from the offshore ECC (**Figure 3**). To the north of that is the Berwickshire and North Northumberland Coast SAC where grey seals are listed as the primary reason for site selection. The boundary of the Berwickshire and North Northumberland Coast SAC is approximately 200 km from the boundary of the Hornsea Four array area (**Figure 3**). Full consideration of the potential impact on the conservation objectives of the SACs is presented as part of the RIAA.

Hornsea Four

Figure 3

Locations of Marine Mammal SACs



- Order Limits
- Southern North Sea SAC
- The Wash and North Norfolk Coast SAC
- Berwickshire and North Northumberland Coast SAC
- Humber Estuary SAC
- Moray Firth SAC

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:3,000,000

0 40 80 160 Kilometres

0 15 30 60 Nautical Miles

REV	REMARK	DATE
--	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

Marine Mammal SACs
Document no: HOW04SM0003
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

2.4 Data sources

2.4.1 Hornsea Four site-specific aerial surveys

2.4.1.1 Monthly digital aerial surveys were conducted between April 2016 and March 2018, resulting in 24 surveys. May 2016 was missed due to poor weather and therefore two surveys were conducted in June 2016 to account for this. The EP Technical Panel agreed that these surveys were sufficient to inform the baseline (OFF_MM-1.3). Surveys were undertaken using an aircraft equipped with HiDef Gen II cameras with sensors set to a resolution of 2 cm Ground Sample Distance (GSD). Each camera sampled a strip of 125 m width, separated from the next camera by ~20 m.

2.4.1.2 The survey design consisted of transects 2.5 km apart across the survey area, which included a 4 km buffer around Hornsea Four AfL (**Figure 4**). This resulted in a total transect length of 625.2 km with a transect width of 250 m resulting in a sampled area of 156.3 km^2 which equates to 10.29% coverage of the total survey area.

2.4.1.3 Unlike boat-based surveys, aerial surveys can be carried out in sea states of up to six. The effect of sea state on detection probability of marine mammals has not been as well-explored for aerial surveys as it has for boat-based surveys. The sea state recorded during all Hornsea Four site-specific aerial surveys was between one and six. Very little survey effort was recorded during sea state one (0.2%), sea state five (4.2%) or sea state six (0.1%). Most survey effort was conducted at sea state three (29.7%) and sea state four (51.0%). The proportion of effort in different sea states varied between seasons (**Table 1**, **Table 2** and **Figure 5**). In the summer months (Jun, Jul, Aug) the sea state was predominantly between one and three (66%) with the remaining time at sea state four; while in winter (Dec, Jan, Feb) the predominant sea state was four (75%) with only 22% between sea state one and three. HiDef report that the detection probability of marine mammals does not vary within this level of variation in sea state; however robust analyses have not been carried out to demonstrate this.

360000 380000 400000 420000

6020000 6000000 5980000 5960000

N
GRID NORTH

Hornsea Four

Figure 4
Site-Specific Aerial Survey
Area and Transect Lines

- Order Limits
- Hornsea Four Site Specific Aerial Survey Area
- Survey Transect Lines
- Array Area
- Offshore Export Cable Corridor

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:250,000

0 3 6 12 Kilometres

0 1 2 4 Nautical Miles

REV	REMARK	DATE
--	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

Site Specific Aerial Survey
Document no: HOW04SM0004
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

Date: 13/09/2021 Author: Rachael Sinclair Name: Annex_5_4_1_HOW04SM0004_SiteSpecificAerialSurveyArea

Table 1: Details of the 24 months of Hornsea Four site-specific aerial surveys.

Year	Month	Day	Complete?	# Transects	Total Transect Length (km)	Total Area Surveyed (km^2)	Beaufort Sea State	Predominant Sea State
2016	Apr	27	Y	24	611.54	152.89	2-5	4
2016	Jun	4	Y	24	611.02	152.76	1-3	2
2016	Jun	21	Y	24	610.39	152.60	3-4	3
2016	Jul	4	Y	24	611.28	152.82	3-4	4
2016	Aug	6	Y	24	610.28	152.57	2-4	2
2016	Sep	1	Y	24	608.74	152.18	3-4	4
2016	Oct	25	Y	24	612.01	153.00	2-3	2
2016	Nov	19	Y	24	610.41	152.60	4	4
2016	Dec	11	Y	24	611.57	152.89	4-5	4
2017	Jan	16	Y	24	612.02	153.00	2-3	2
2017	Feb	3	Y	24	611.43	152.86	4	4
2017	Mar	8	Y	24	611.14	152.79	2-4	3
2017	Apr	22	Y	24	611.33	152.83	4	4
2017	May	4	Y	24	599.00	149.52	4	4
2017	Jun	1	Y	24	610.96	152.74	3-4	4
2017	Jul	8	Y	24	610.82	152.70	2-4	3
2017	Aug	6	Y	24	609.98	152.50	3-4	4
2017	Sep	30	Y	24	611.40	152.85	3	3
2017	Oct	26	N	20	485.51	121.38	2-3	3
2017	Nov	25	Y	24	610.45	152.61	4-5	5
2017	Dec	18	Y	24	610.76	152.69	2-5	4
2018	Jan	7	Y	24	610.17	152.54	4-5	4
2018	Feb	7	Y	24	611.28	152.82	4	4
2018	Mar	20	Y	24	611.18	152.79	3-6	3

Table 2: Number of sea state records per survey month by sea state (SS) during the Hornsea Four site-specific aerial surveys. The predominant sea state in each survey month is shaded in light blue.

Year	Month	SS1	SS2	SS3	SS4	SS5	SS6
2016	Apr	0	1	6	136	1	0
2016	Jun	8	98	51	0	0	0
2016	Jun	0	0	151	7	0	0
2016	Jul	0	0	50	113	0	0
2016	Aug	0	81	55	2	0	0
2016	Sep	0	0	58	87	0	0
2016	Oct	0	143	3	0	0	0
2016	Nov	0	0	0	147	0	0
2016	Dec	0	0	0	156	3	0
2017	Jan	0	140	7	0	0	0
2017	Feb	0	0	0	146	0	0
2017	Mar	0	28	116	1	0	0
2017	Apr	0	0	0	148	0	0
2017	May	0	0	0	154	0	0
2017	Jun	0	0	39	107	0	0
2017	Jul	0	27	124	2	0	0
2017	Aug	0	0	16	127	0	0
2017	Sep	0	0	133	0	0	0
2017	Oct	0	3	112	0	0	0
2017	Nov	0	0	0	38	106	0
2017	Dec	0	1	45	70	28	0
2018	Jan	0	0	0	143	1	0
2018	Feb	0	0	0	145	0	0
2018	Mar	0	0	78	60	7	2
% of records		*0.2%*	*14.9%*	*29.7%*	*51.0%*	*4.2%*	*0.1%*

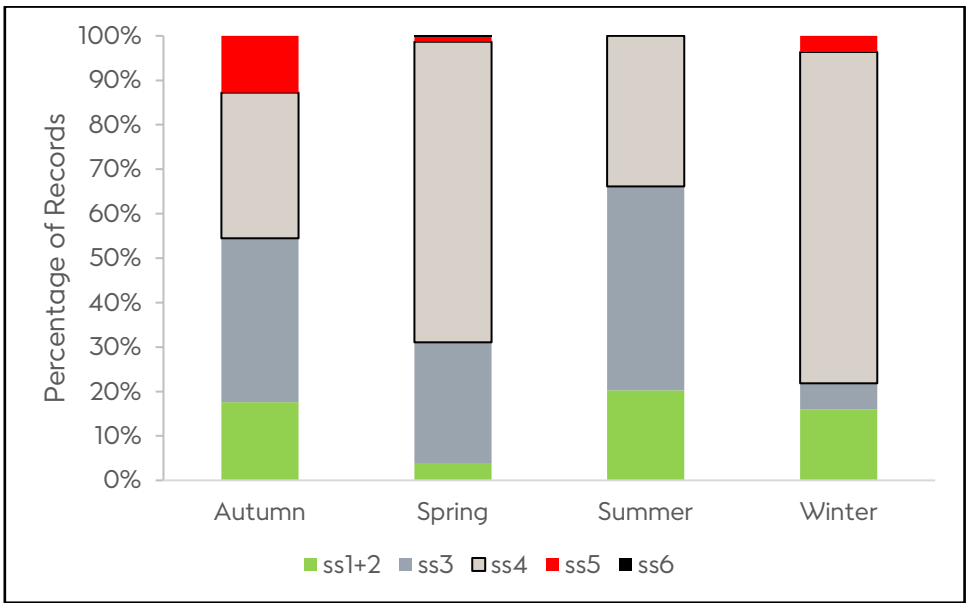


Figure 5: Percentage of effort at each sea state by season during the Hornsea Four site-specific aerial surveys.

2.4.1.4 The number of observations within the surveyed strips was used to calculate a point estimate of the density of animals in the study area. The population size within the survey area was estimated using a non-parametric bootstrap method with replacement in order to obtain abundance with standard deviation, 95% Confidence Intervals (95% CI) and coefficient of variance. For marine mammals, these were relative abundance estimates as they did not correct for the animals underwater (availability bias).

2.4.1.5 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. 2013). 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, in order 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. (2013) 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 sightings rates only.

2.4.1.6 The key limitations of this aerial survey dataset include the effect of sea state on detectability and the availability bias. There is a possibility of uncorrected biases in the aerial survey density estimates as a result of varying detection probabilities related to sea state. As described above, an attempt was made to correct for availability bias for harbour porpoise using correction factors derived from telemetry data; however, these data were obtained from a small sample of porpoise in Danish waters, which may not be representative of the diving and surfacing behaviour of porpoise in the Hornsea Four area.

2.4.2 Former Hornsea Zone vessel surveys

2.4.2.1 Vessel-based surveys of the former Hornsea Zone plus 10 km buffer survey area were conducted on a monthly basis between March 2010 and February 2013. This survey area included the Hornsea Four array area. Line transects were spaced at 6 km apart over the survey area with additional data collection in the Hornsea Project One and Hornsea Project Two areas where transects were spaced 2 km apart. The total transect length for the 6 km spaced transects was 1,457.8 km and for the 2 km transects was 1,141.7 km, resulting in a total transect length of 2,599.6 km across the survey area (**Figure 6**).

2.4.2.2 During the former Hornsea Zone vessel surveys, the visual observation team recorded both seabirds and marine mammals. A dedicated marine mammal observer was used on surveys where suitable weather conditions (i.e. sea state three or less) indicated that conditions would be suitable for marine mammal observations.

2.4.2.3 The visual surveys were augmented with acoustic surveys between July 2011 and February 2013 using a towed hydrophone primarily to detect vocalising harbour porpoise. The entire survey design was surveyed acoustically for a period of nine months with a total of 4,186 acoustic detections of harbour porpoises across the whole survey area over this time. After March 2011, a portion of the southern edge of the survey design (below latitude 53°50'N) was not covered regularly due to concerns about entanglement of the towed hydrophones with fishing gear. However, the un-surveyed area was outside the boundary of the Hornsea Four array area and therefore the absence of acoustic detections in the southern part of the survey area will not have affected the density and abundance estimations for Hornsea Four.

2.4.2.4 In order to estimate the abundance of marine mammals, distance analysis was used. Distance sampling assumes that all animals on the trackline (i.e. at zero distance, g(0)) are detected (so that g(0)=1); however, this assumption is violated in marine mammal surveys as animals may be underwater and not available for detection on the trackline (availability bias). In addition, a proportion of the marine mammals at the surface that were available to be detected may have been missed by the observers (perception bias). In order to correct for these biases a double-platform method was used (visual and acoustic) in order to use capture-mark-recapture methods to estimate the detection probability (g(0)). The detection probability was estimated for both the visual and the acoustic data to obtain density estimates for harbour porpoise.

2.4.2.5 The method of estimation of g(0) for harbour porpoise relies on the ability to reliably match duplicate detections between the visual and acoustic data. The potential sources of error in the estimated time of an animal coming into the detection range of the hydrophone include; errors in sighting time, estimation of distances and angles, and animal movement. In this study, timing was recorded to the nearest minute and therefore there will be some timing errors and associated uncertainty in g(0).

2.4.2.6 In addition to this, there are potential uncertainties relating to the analysis of the acoustic data. For example, cluster size was used as a multiplier to estimate the number of animals detected. The cluster size used to correct the acoustic data was obtained from the mean number of visual detections within a one-minute segment for sightings in sea state 0. However, only 0.9% of the survey effort was conducted at sea state 0 resulting in a small dataset which was not sufficient to obtain a g(0) estimate. In addition, the unusually high

detection ranges recorded (~1,000 m) may indicate potential inaccuracies in the click detector and localiser, introducing uncertainty into the g(0) calculations.

2.4.2.7 This analysis was only carried out for harbour porpoise. There were too few sightings and recordings of other species to conduct the same analysis. The visual sightings data (and the acoustic data for harbour porpoise) were then modelled using a Generalised Additive Model (GAM) incorporating covariates such as Global Positioning System (GPS), time, tide, depth, sediment type, sea state and swell height to create an estimated density surface for each species within the survey area.

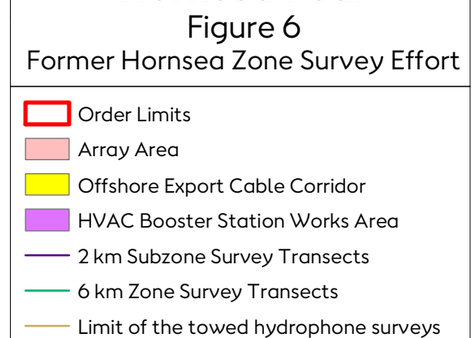
2.4.2.8 The limitations of this vessel-based survey dataset include the effect of sea state on detectability, length of time since surveys were carried out, difficulties in estimating distance of sighting from observer, accurate matching of acoustic and visual detections and potential for presence of survey vessel to affect behaviour of animals and therefore likelihood of detection.

Hornsea Four

Figure 6

Former Hornsea Zone Survey Effort

- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Station Works Area
- 2 km Subzone Survey Transects
- 6 km Zone Survey Transects
- Limit of the towed hydrophone surveys
- Former Hornsea Zone plus 10 km Buffer



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:750,000

0 10 20 40 Kilometres

0 5 10 20 Nautical Miles

REV	REMARK	DATE
--	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

Former Hornsea Zone Survey
Document no: HOW04SM0005
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

Date: 13/09/2021 Author: Rachael Sinclair Name: Annex_5_4_1_HOW04SM0005_FormerHornseaZoneSurvey

300000 350000 400000 450000 500000

6050000 6000000 5950000 5900000

N GRID NORTH

Southwest Patch
Dogger Bank
Outer Well Bank
Haddock Bank
Outer Dowsing
Well Bank
Ower Bank

2.4.3 SCANS Surveys

2.4.3.1 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 of 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. Hornsea Four is located in the SCANS III survey block O, SCANS II survey block U and the SCANS I survey area C.

2.4.3.2 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.

2.4.4 Joint Nature Conservation Committee (JNCC) Report 544: Harbour Porpoise Density

2.4.4.1 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).

2.4.5 JCP Phase III Analysis

2.4.5.1 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 Data Analysis Product has been provided by JNCC to extract abundance estimates averaged for summer 2007-2010 and scaled to the SCANS III estimates for user specified areas. In order to extract data in relation to Hornsea Four, the user specified area encompassed the former Hornsea Zone survey area and extended west to encompass the offshore ECC.

2.4.5.2 It should be noted that there are significant limitations to the estimates provided by the JCP Phase III analysis. 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 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. The data included in the analysis are now between 10 and 26 years old and may not be representative of current cetacean distribution and densities. Finally, the density estimates obtained from the Data Analysis Tool are an averaged density estimate for the summer 2007-2010 and are therefore not representative of densities at other times of the year.

2.4.6 Special Committee on Seals (SCOS)

2.4.6.1 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.

2.4.7 Seal haul-out surveys

2.4.7.1 The most recent publicly available SCOS report is SCOS (2021) which presents the data collected up to 2019. August haul-out count data from 2019 were provided by Chris Morris at SMRU. Grey seal pup count data were also provided by Chris Morris up to and including the 2019 survey (2019 pupping data was not available for the Farne Island in 2019).

Harbour seals

2.4.7.2 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. The counts obtained represent the number of seals that were onshore at the time of the survey and are an estimate of the minimum size of the population. They do not represent the total size of the local population since a number of seals would have been at sea at the time of the survey. However, telemetry data from tagged seals are used to scale this estimate to take account of the proportion of animals at sea at the time of survey. It is noted that these data refer to the numbers of seals found within the surveyed areas only at the time of the survey; numbers and distribution may differ at other times of the year.

Grey seals

2.4.7.3 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. 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 (SNH), The National Trust, Lincolnshire Wildlife Trust and Friends of Horsey Seals.

2.4.8 Seal telemetry

2.4.8.1 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 and more frequent locations. The telemetry data were used to illustrate the distribution of seals at sea and to investigate the degree of connectivity between the Hornsea Four area and seal haul-out sites and SACs.

2.4.9 Seal density maps

2.4.9.1 The seal at-sea usage maps were created in order 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 Programme (MMSS/001/01) and were published in Jones et al. (2015). These have since been 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.

2.4.9.2 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 meant that potential hotspots around these haul-outs will have been missed.

2.4.9.3 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 7). 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 8) 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. It is estimated that grey seals spent 77% of their time at sea on average, therefore, using the current best estimate of the grey seal population size in the British Isles (SCOS 2020), the total at-sea population size for the British Isles is estimated to be ~150,700 individuals (Carter et al. 2020). It is estimated that harbour seals spend 83.4% of their time at sea on average, therefore, using the current best estimate of the harbour seal population size in the British Isles (SCOS 2020), the total at-sea population size for the British Isles is estimated to be ~42,800 individual harbour seals (Carter et al. 2020).

2.4.9.4 The main limitation of this dataset is that only seals tagged in the British Isles were included in the analysis. As a result, 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.

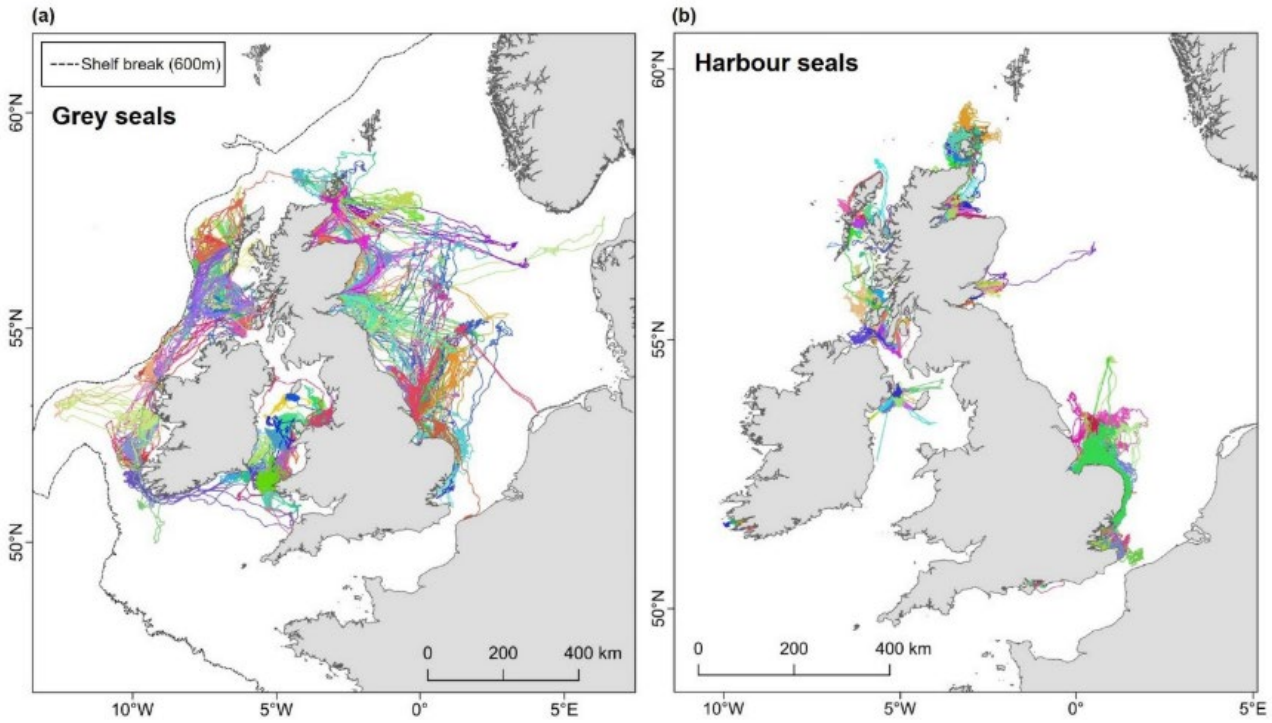


Figure 7: From Carter et al. (2020): GPS tracking data for (a) grey and (b) harbour seals available for habitat preference models.

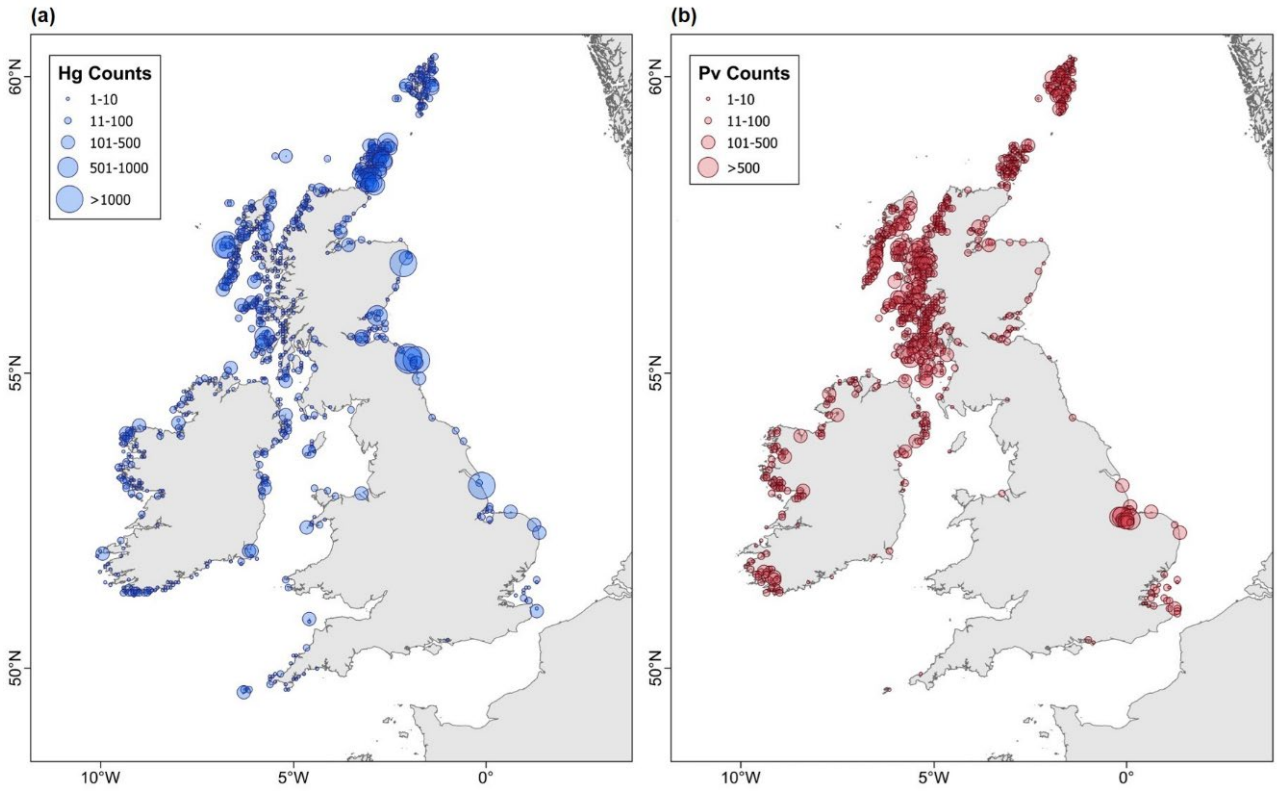


Figure 8: From Carter et al. (2020): Most recent available August count data for (a) grey and (b) harbour seals per 5 km x 5 km haul-out cell used in the distribution analysis.

2.4.10 Sea Watch Foundation bottlenose dolphin sightings data

2.4.10.1 The Sea Watch Foundation provided sightings records (and associated effort data, where available) for bottlenose dolphins along the Yorkshire Coastline between 2003 and 2019. The sightings data were obtained by both Sea Watch Foundation, the Yorkshire Wildlife Trusts and reported sightings by members of the public. Where effort data were available, the data has been used to provide sightings rates per unit of effort (time) or dolphin positive days. Most of the sightings data prior to 2018 did not have associated effort data provided, and therefore the data has only been used to identify periods when dolphins were sighted. A lack of sightings data in any period does not mean an absence of dolphins, as it may reflect an absence or reduction in effort during that time.

3 Harbour porpoise baseline

3.1.1.1 The harbour porpoise is the most widely distributed and most common cetacean species in UK waters. They occur in all parts of the UK continental shelf and are recorded year-round within most of their range. The conservation status of harbour porpoise in UK waters has been assessed as unknown (JNCC 2019b).

3.2 Management Unit

3.2.1.1 The IAMMWG identified the management unit for harbour porpoise as the North Sea. The SCANS III surveys conducted in 2016 resulted in an estimated harbour porpoise abundance estimate of 345,373 (95% CI: 246,526 –495,752) for the ICES North Sea Assessment Unit

(Hammond et al. 2017, Hammond et al. 2021). This was similar to the estimate in 2005 (355,000, revised from Hammond et al. 2013) and 1994 (289,000, revised from Hammond et al. 2002). This trend analysis indicates that the harbour porpoise abundance in the North Sea is stable and has not changed since 1994 (Figure 9), although the associated confidence intervals are quite wide.

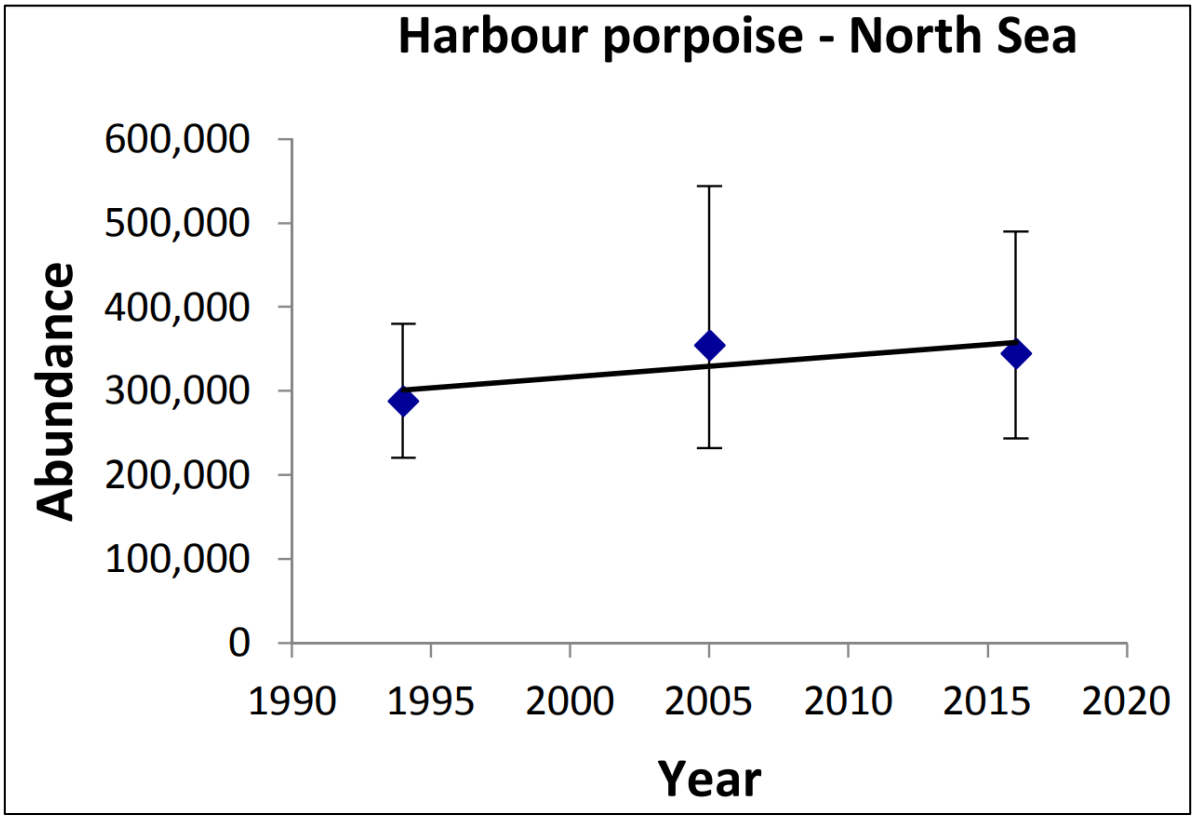


Figure 9: Harbour porpoise abundance in the North Sea (Hammond et al. 2017). Estimated rate of annual change = 0.8% (95%CI: -6.8; 9.0%), p = 0.18. Error bars are log-normal 95% confidence intervals.

3.3 SCANS III

3.3.1.1 The SCANS III survey of block O consisted of a total of 3,242.8 km of effort. The main species sighted was harbour porpoise with an estimated block-wide abundance of 53,485 porpoise (95% CI: 37,413 –81,695) and an estimated density of 0.888 porpoise/km^2 (CV: 0.209, 95% CI: 0.621 – 1.357) (Hammond et al. 2017, Hammond et al. 2021). The SCANS surveys of the whole of the North Sea show a southwards shift in distribution of the North Sea population between the survey years of 1994 and 2005; this pattern of higher densities in the southern North Sea persisted in the most recent 2016 surveys (Figure 10).

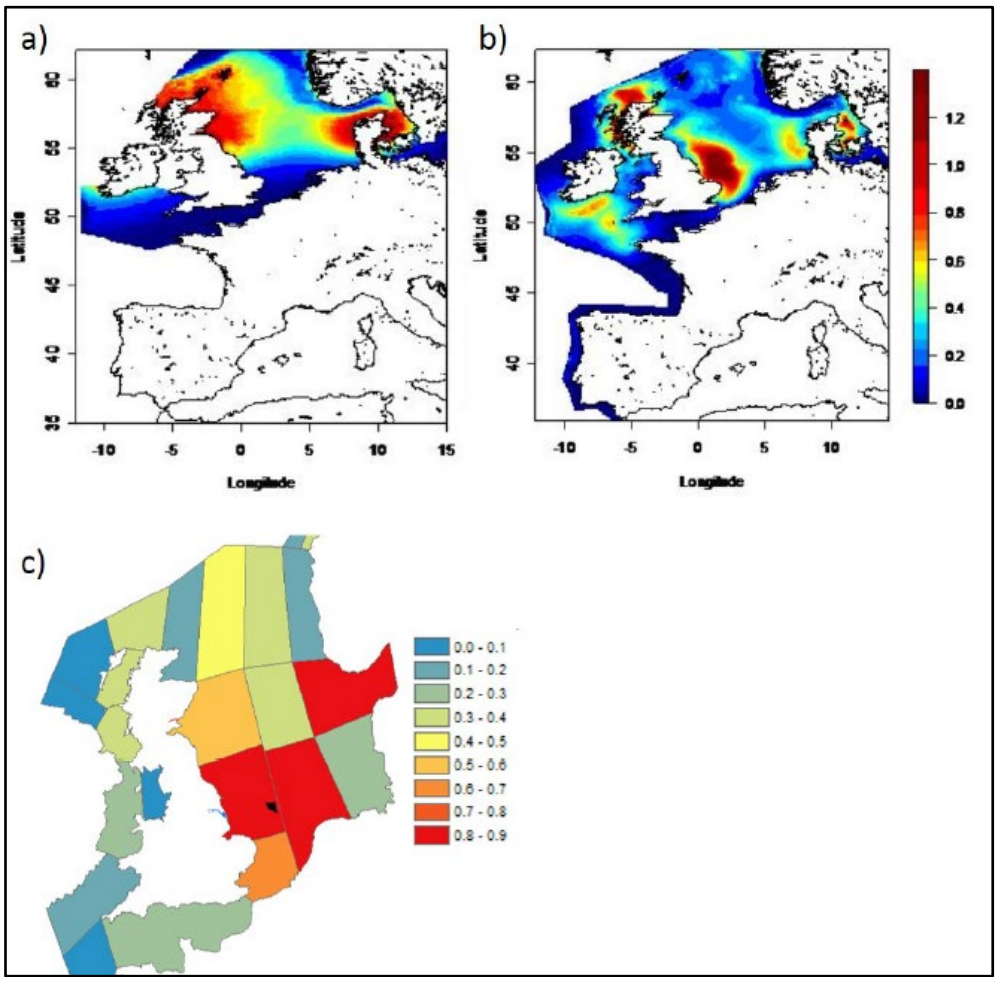


Figure 10: Harbour porpoise density estimates a) modelled density surface for SCANS-I 1994 data, b) modelled density surface for SCANS-II 2005 data, c) block wide density estimates for SCANS-III 2016 data.

3.4 Hornsea Four site-specific aerial surveys

3.4.1.1 The 24 months of Hornsea Four site-specific aerial surveys resulted in 1,327 sightings of harbour porpoise, which occurred throughout the survey area (HiDef Aerial Surveying Ltd 2018). The average adjusted density estimate (accounting for animals underwater and not available for detection) across the survey site across all 24 surveys was 1.74 porpoise/km^2, although there was inter-annual variation in density estimates with considerably higher density across the survey area in year one of the surveys (Apr 2016 - Mar 2017 with 862 sightings resulting in an average adjusted density of 2.24 porpoise/km^2) compared to year two of the surveys (Apr 2017 – Mar 2018 with 465 sightings resulting in an average adjusted density of 1.26 porpoise/km^2) (Table 3).

3.4.1.2 There was a clear seasonal pattern to the sightings of harbour porpoise. Sightings rates were highest in summer (Jun, Jul, Aug: 0.846 porpoise/km^2) and lowest in winter (Dec, Jan, Feb: 0.094 porpoise/km^2) (Table 4). When adjusted for availability this results in an average summer adjusted density across the survey area of 3.8 porpoise/km^2 and an average winter adjusted density of 0.49 porpoise/km^2 (Table 4). The monthly density plots also illustrate this seasonal pattern in the data with higher densities in the summer months (Figure 11).

However, these seasonal patterns should be considered with some caution since the sea state also varied between seasons (Table 4). There are currently insufficient data on how sightings rates from aerial surveys differ with sea state and, while there is evidence of a seasonal pattern to the sightings data, it is possible that is partly explained by differences in sea state. However, it is unlikely that given the observed pattern of sea state distribution across the seasons that this would fully explain the seasonal variation in density estimates.

3.4.1.3 While the total sightings maps (Figure 12) illustrates that there were more sightings in the southern part of the survey area, the month to month sightings showed large variation in spatial usage (HiDef Aerial Surveying Ltd 2018) (Figure 14), therefore it was not possible to clearly define a spatial pattern in the sightings data. It is therefore important to highlight that porpoise usage of the survey area varies both temporally between months and between years, and spatially within the survey area.

Table 3: Details of the number of harbour porpoise sighted within the Hornsea Four site-specific aerial survey area (Hornsea Four AfL + 4 km buffer) for each of the 24 months of aerial surveys. Presented are the non-adjusted abundance estimates and the abundance estimates adjusted to account to availability bias.

Year	Month	Day	Porpoise Sightings	Non-adjusted abundance estimates				Adjusted abundance estimates for availability bias			
				Density (#/km²)	Popn Estimate	95% CI		Density (#/km²)	Popn Estimate	95% CI	
2016	Apr	27	27	0.17	258	69	486	0.64	971	260	1829
2016	Jun	4	205	1.26	1909	1584	2238	6.09	9223	7653	10812
2016	Jun	21	166	0.92	1394	925	1932	4.44	6735	4469	9334
2016	Jul	4	146	0.77	1171	838	1529	3.91	5941	4252	7757
2016	Aug	6	89	0.56	850	572	1156	2.64	4003	2694	5444
2016	Sep	1	26	0.17	260	148	383	1.02	1557	886	2293
2016	Oct	25	130	0.85	1290	1057	1540	5	7591	6220	9062
2016	Nov	19	7	0.05	71	20	125	0.3	425	120	749
2016	Dec	11	2	0.01	10	0	30	0.06	57	0	170
2017	Jan	16	31	0.16	249	126	405	0.79	1235	625	2009
2017	Feb	3	18	0.12	180	89	287	0.73	1099	544	1753
2017	Mar	8	15	0.1	148	58	264	0.45	663	260	1182
2017	Apr	22	5	0.03	50	10	99	0.12	193	39	381
2017	May	4	13	0.08	123	50	207	0.35	545	222	917
2017	Jun	1	80	0.51	770	475	1086	2.46	3720	2295	5247
2017	Jul	8	156	1.01	1539	1219	1868	5.12	7808	6185	9477
2017	Aug	6	62	0.41	619	358	904	1.93	2916	1686	4258
2017	Sep	30	48	0.31	476	197	831	1.79	2754	1140	4808
2017	Oct	26	37	0.29	437	234	665	1.71	2572	1377	3913
2017	Nov	25	3	0.02	30	0	69	0.12	180	0	413
2017	Dec	18	11	0.07	110	30	206	0.4	624	170	1167
2018	Jan	7	3	0.02	30	10	59	0.1	149	50	293
2018	Feb	7	21	0.14	210	89	352	0.85	1283	544	2150
2018	Mar	20	26	0.16	250	157	348	0.72	1119	703	1558

Year	Month	Day	Porpoise Sightings	Non-adjusted abundance estimates				Adjusted abundance estimates for availability bias			
				Density (#/km²)	Popn Estimate	95% CI		Density (#/km²)	Popn Estimate	95% CI	
Year 1: April 2016 - March 2017			*862*	*0.43*	*649*	*578*	*723*	*2.24*	*3377*	*3008*	*3762*
Year 2: April 2017 - March 2018			*465*	*0.25*	*387*	*307*	*473*	*1.26*	*1951*	*1548*	*2385*
Average (all 24 surveys)				*0.34*	*518*			*1.74*	*2640*		
Spring Average (Mar, Apr, May)				*0.11*				*0.46*			
Summer Average (Jun, Jul, Aug)				*0.78*				*3.80*			
Autumn Average (Sep, Oct, Nov)				*0.28*				*1.66*			
Winter Average (Dec, Jan, Feb)				*0.09*				*0.49*			

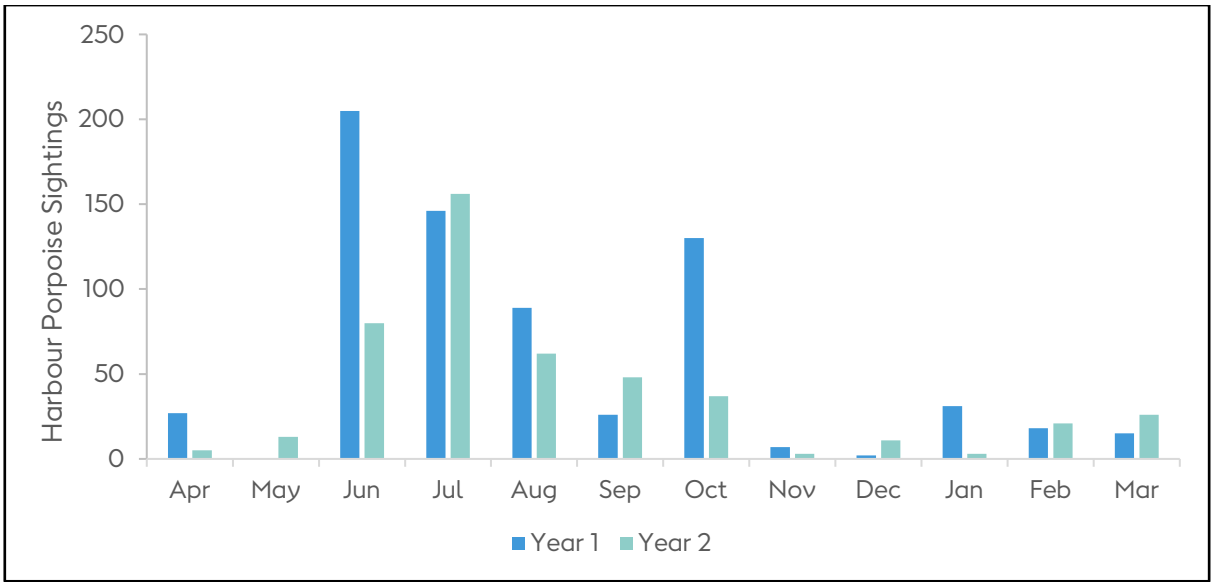


Figure 11: Monthly sightings counts for harbour porpoise within the Hornsea Four site-specific aerial survey area between April 2016 and March 2018.

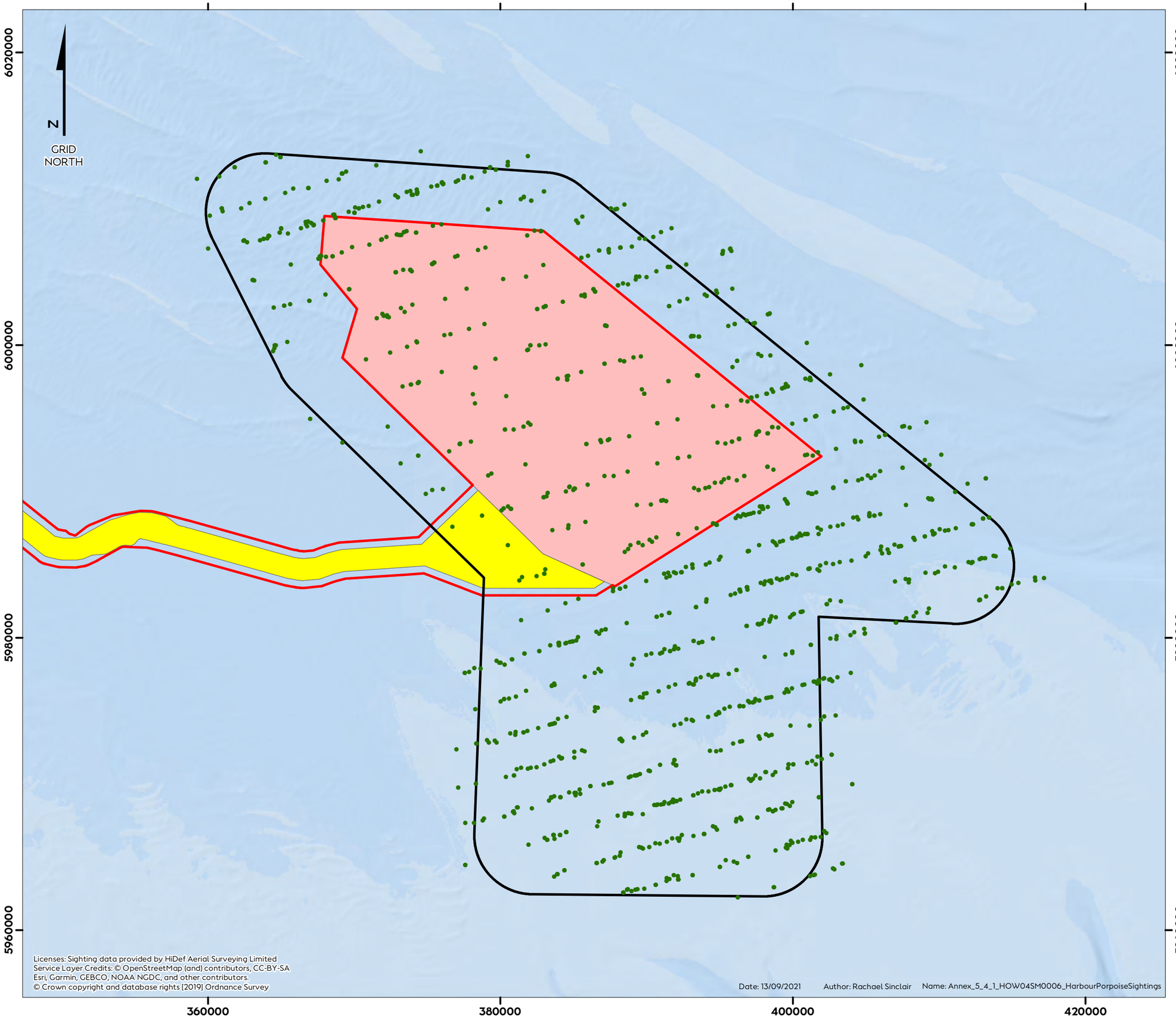
Table 4: Percentage of effort at each sea state (SS) alongside average sightings rate and average adjusted density by season for the Hornsea Four site-specific aerial survey.

Season	SS1-2	SS3	SS4	SS5	SS6	Average Sightings Rate (#/km²)	Average Adjusted Density (#/km²)
Spring	3.9%	27.1%	67.6%	1.1%	0.3%	0.11	0.46
Summer	20.2%	45.9%	33.8%	0.0%	0.0%	0.85	3.80
Autumn	17.6%	36.9%	32.8%	12.8%	0.0%	0.28	1.66
Winter	15.9%	5.9%	74.6%	3.6%	0.0%	0.09	0.49

Hornsea Four

Figure 12

Harbour Porpoise Sightings Across the Hornsea Four Site-Specific Aerial Survey Area



- Order Limits
- Array Area
- Offshore Export Cable Corridor
- Hornsea Four Site-Specific Aerial Survey Area
- Harbour Porpoise

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:250,000

0 3 6 12 Kilometres

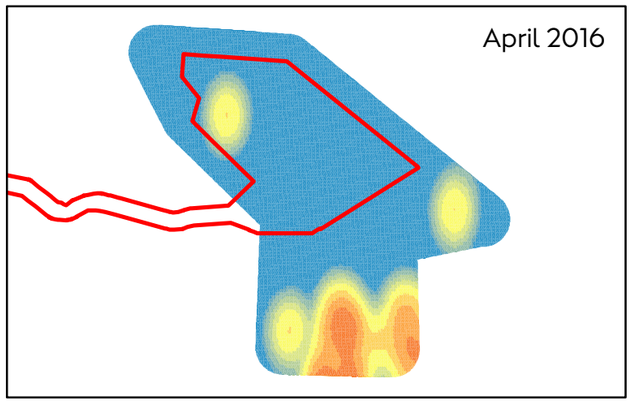
0 1 2 4 Nautical Miles

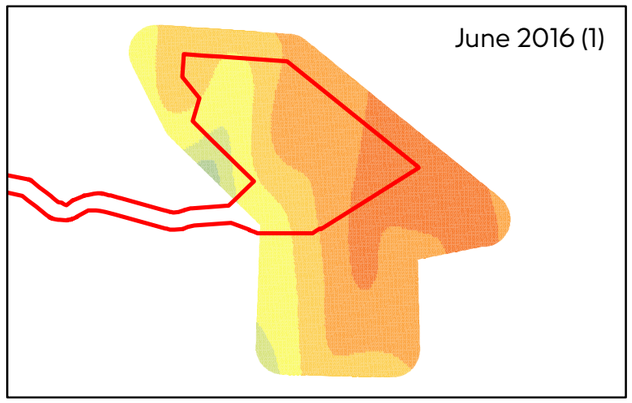
REV	REMARK	DATE
-	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

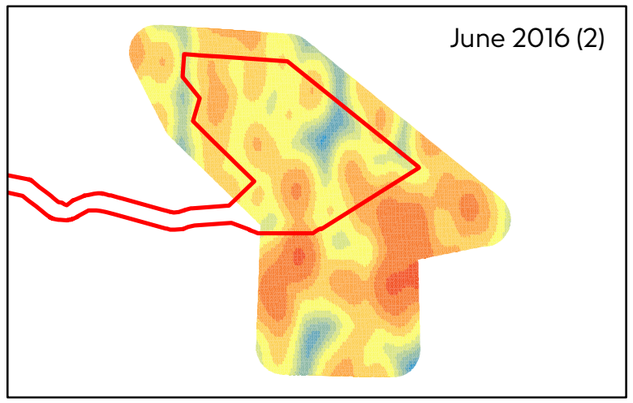
Harbour Porpoise Aerial Sightings
Document no: HOW04SM0006
Created by: RRS
Checked by: BPHB
Approved by: LK

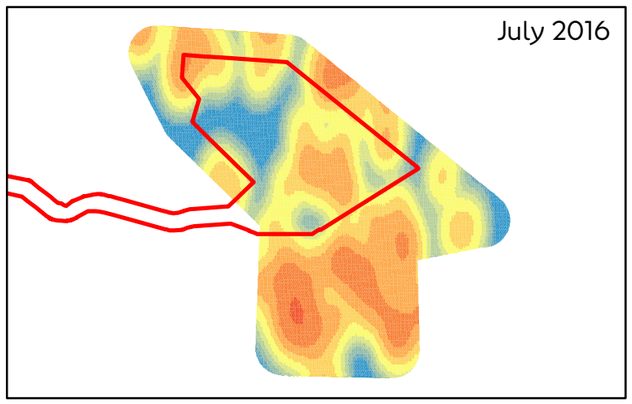
Ørsted

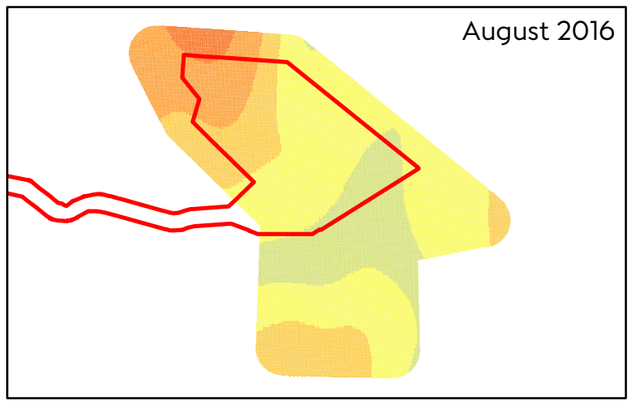
Date: 13/09/2021 Author: Rachael Sinclair Name: Annex_5_4_1_HOW04SM0006_HarbourPorpoiseSightings

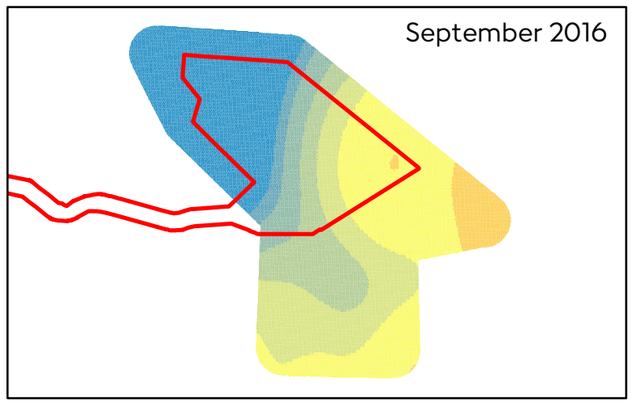


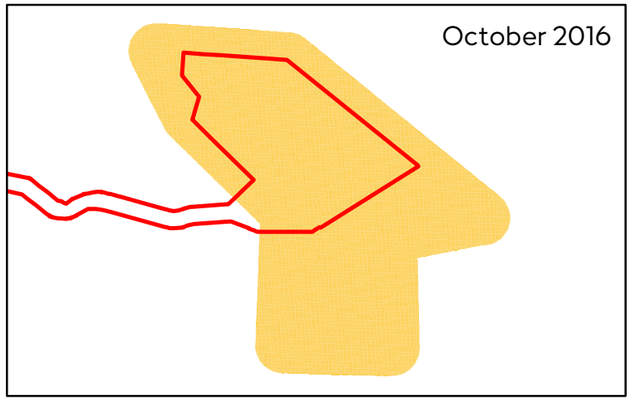


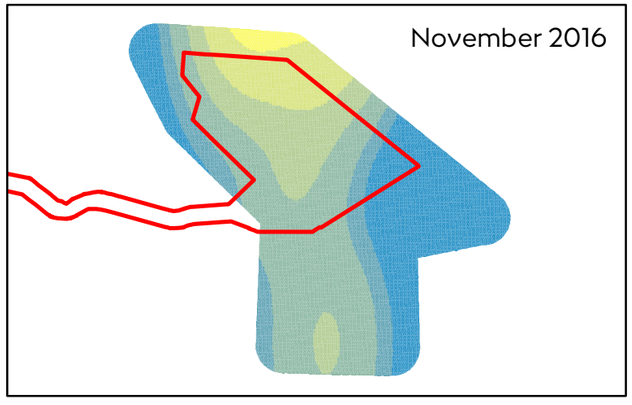


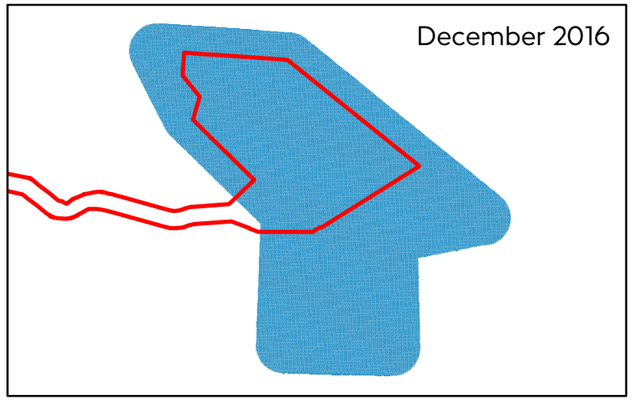


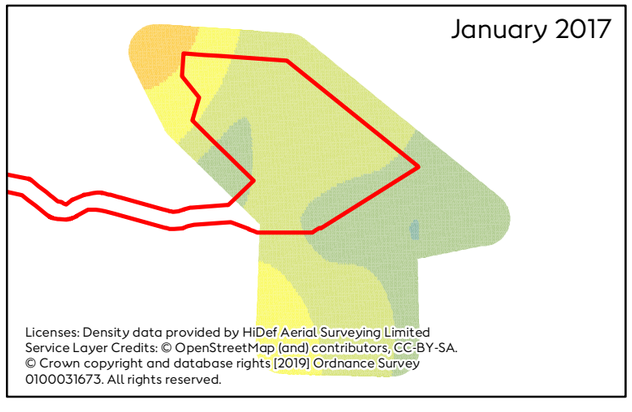


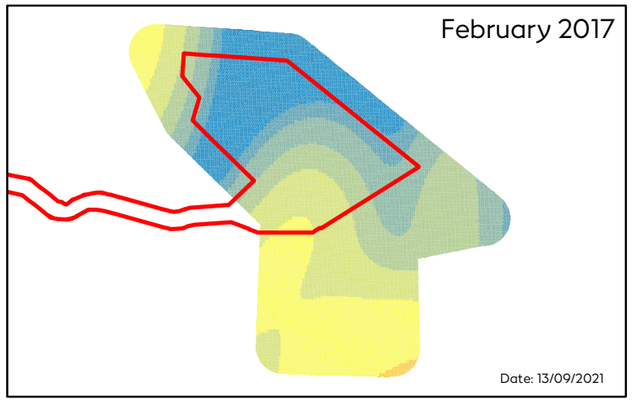




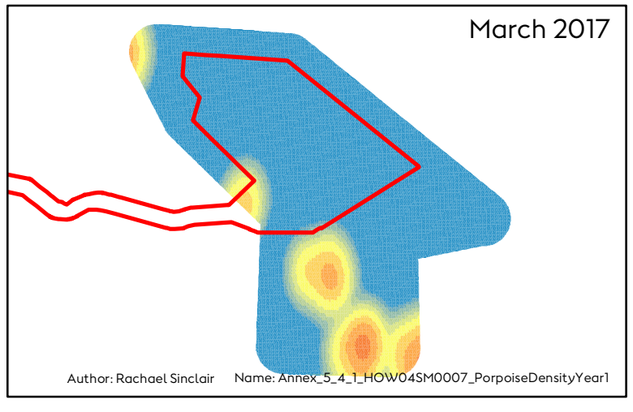








Date: 13/09/2021



Author: Rachael Sinclair Name: Annex_5_4_1_HOW04SM0007_PorpoiseDensityYear1

Hornsea Four

Figure 13

Harbour Porpoise Estimated Density Surfaces for Year 1

Order Limits

Harbour Porpoise Density (#/km²)

- 0.00 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- 5.00 - 10.00
- >10

Coordinate system: ETRS 1989 UTM Zone 31N

0 10 20 40 Kilometres

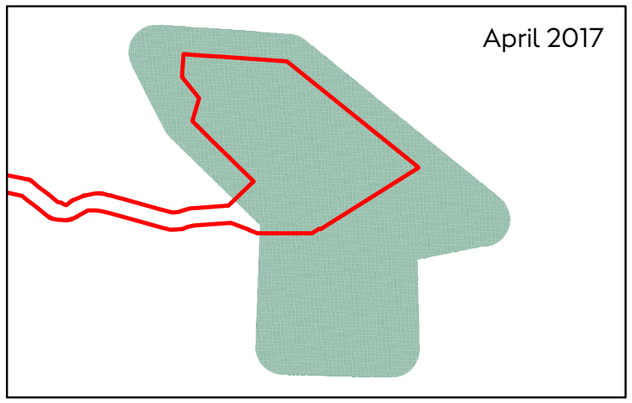
0 5 10 20 Nautical Miles

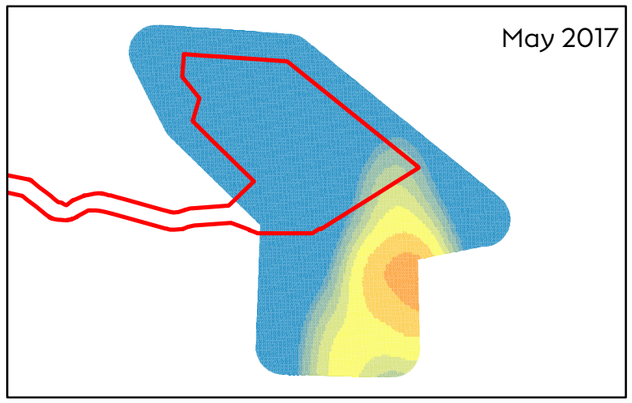
N GRID NORTH

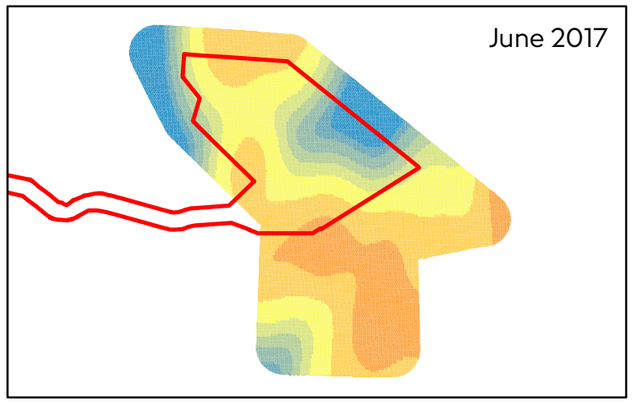
REV	REMARK	DATE
--	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

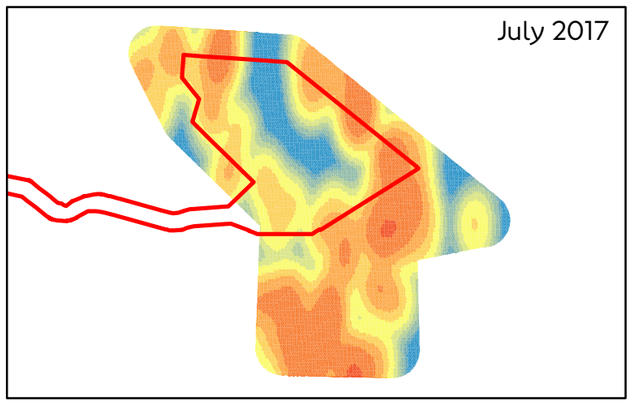
Harbour Porpoise Density Year 1
Document no: HOW04SM0007
Created by: RRS
Checked by: BPHB
Approved by: LK

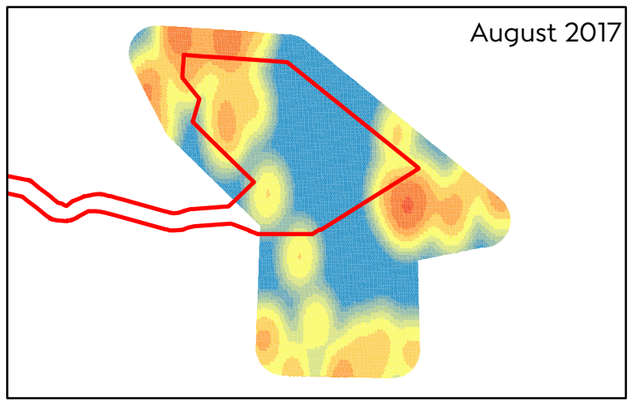
Ørsted

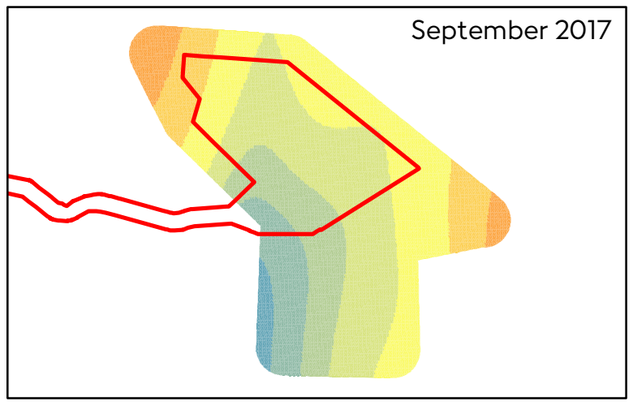


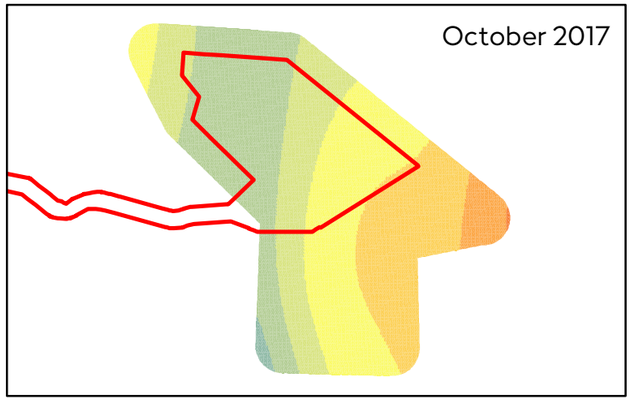


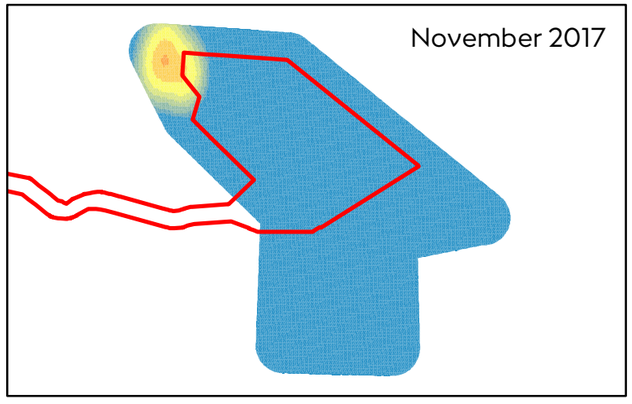


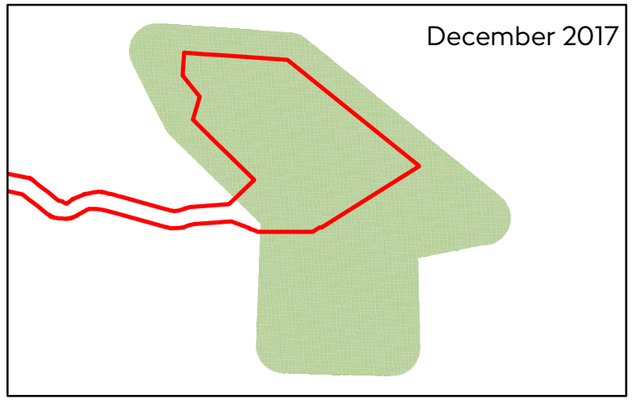


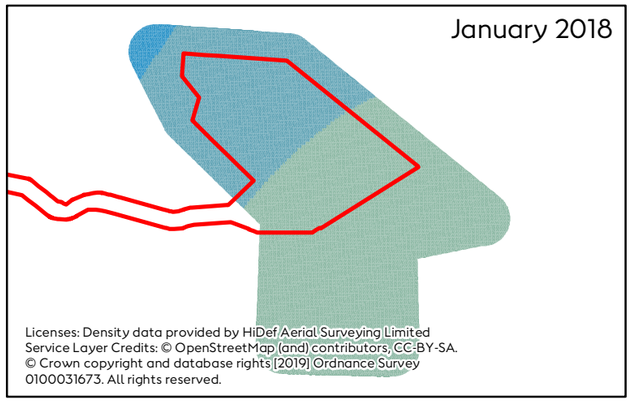


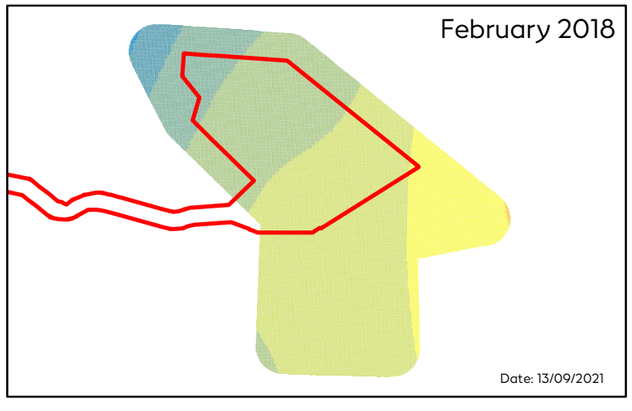




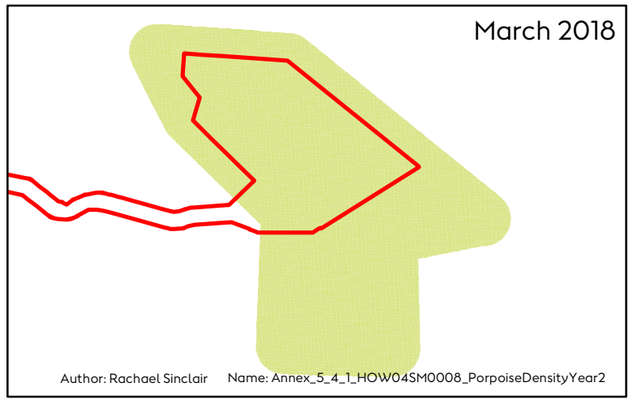








Date: 13/09/2021



Author: Rachael Sinclair Name: Annex_5_4_1_HOW04SM0008_PorpoiseDensityYear2

Hornsea Four

Figure 14

Harbour Porpoise Estimated Density Surfaces for Year 2

Order Limits

Harbour Porpoise Density (#/km²)

- 0.00 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- 5.00 - 10.00
- >10

Coordinate system: ETRS 1989 UTM Zone 31N

0 10 20 40 Kilometres

0 5 10 20 Nautical Miles

N GRID NORTH

REV	REMARK	DATE
--	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

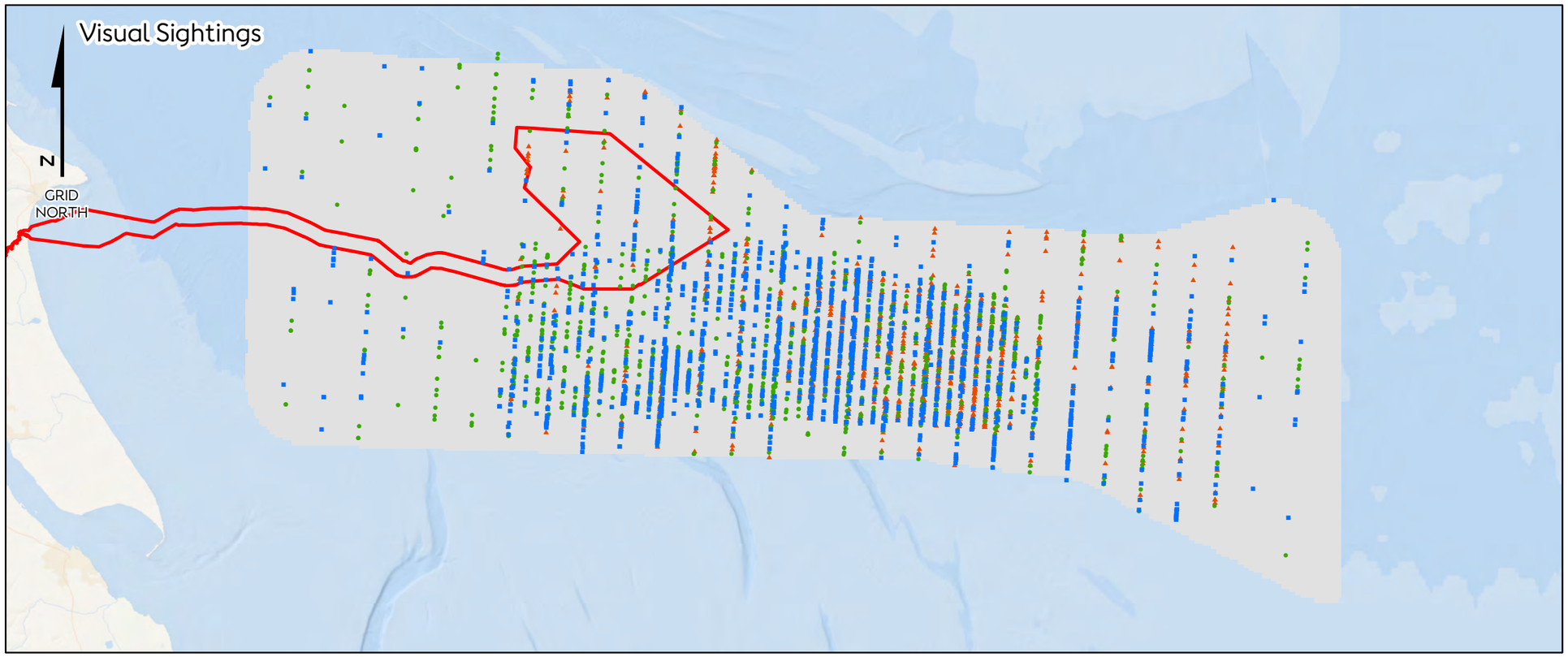
Harbour Porpoise Density Year 2
Document no: HOW04SM0008
Created by: RRS
Checked by: BPHB
Approved by: LK

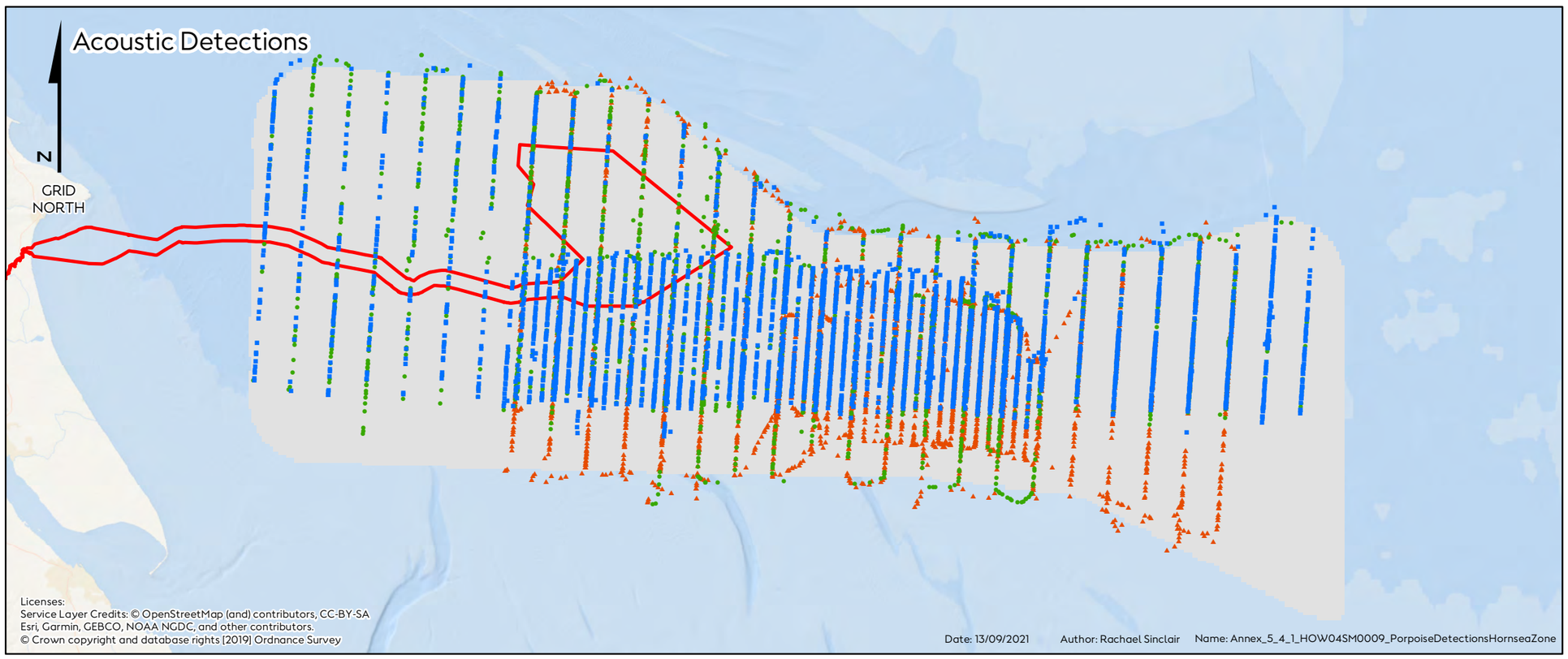
Ørsted

3.5 Former Hornsea Zone vessel surveys: visual and acoustic

3.5.1.1 A total of 6,504 harbour porpoise sightings occurred during the three years of visual vessel-based surveys of the former Hornsea Zone plus 10 km buffer (**Figure 15**). The visual sightings data confirm that harbour porpoise are present throughout the entire former Hornsea Zone. Note, the area in the centre of the survey area with a higher number of sightings is where the survey design differed (transects spaced closer together) and so does not necessarily represent a higher density of porpoise in the area.

3.5.1.2 The modelled density surfaces for harbour porpoise (based on both the visual sightings data and the acoustic detection data) indicate patchy areas of higher density within the former Hornsea Zone plus 10 km buffer. Compared to the modelled density estimates across the rest of the former Hornsea Zone, the densities estimated within the Hornsea Four array area are lower, with average modelled local densities of 1.2 porpoise/km^2 (visual data) and 1.6 porpoise/km^2 (acoustic data) (**Figure 16**).





Hornsea Four

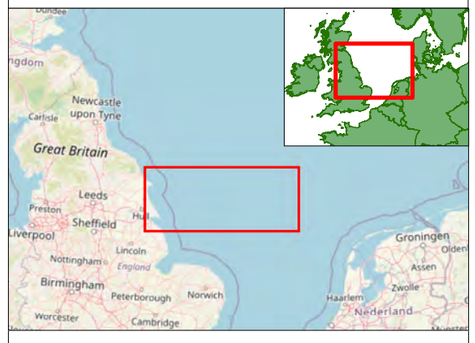
Figure 15

Harbour Porpoise Sightings and Detections Across the Former Hornsea Zone

- Order Limits
- Former Hornsea Zone plus 10 km buffer

Harbour Porpoise Detections

- March 2010 - Feb 2011
- March 2011 - Feb 2012
- March 2012 - Feb 2013



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:800,000

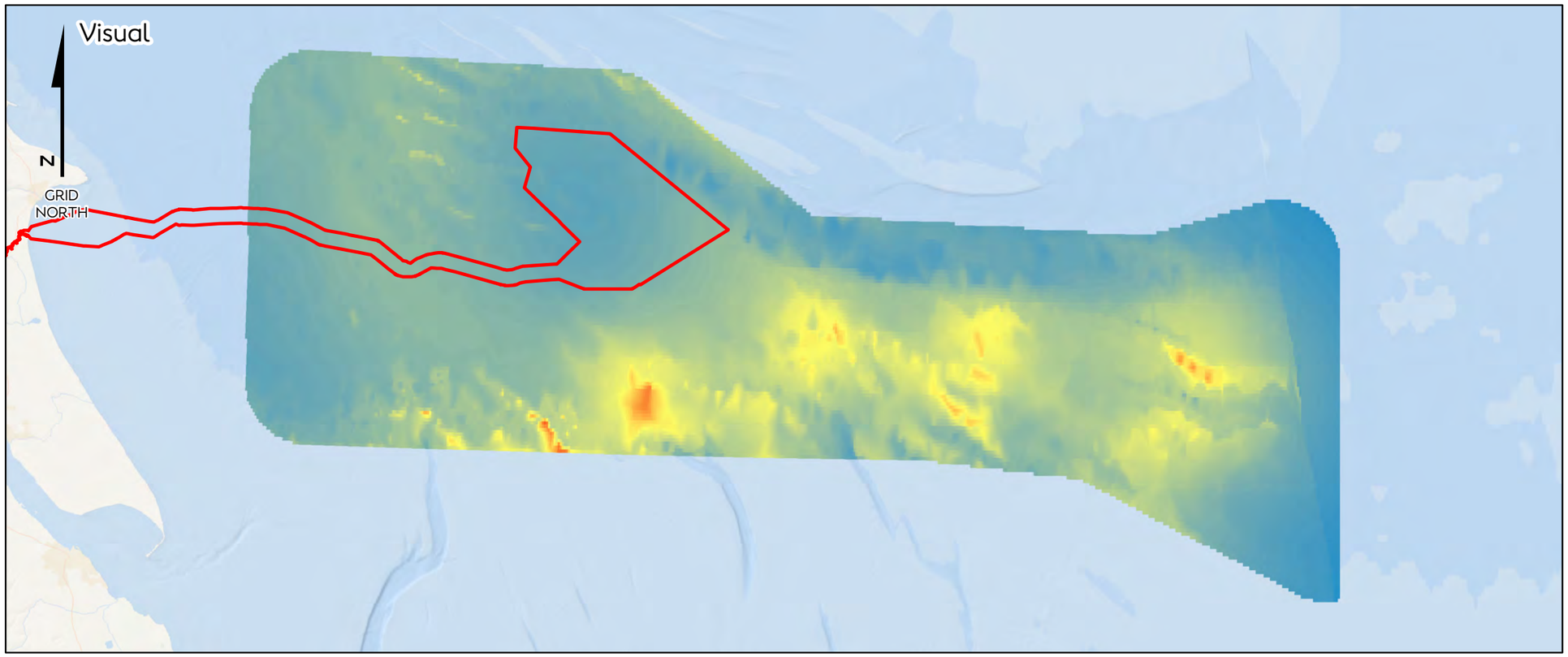
0 10 20 40 Kilometres

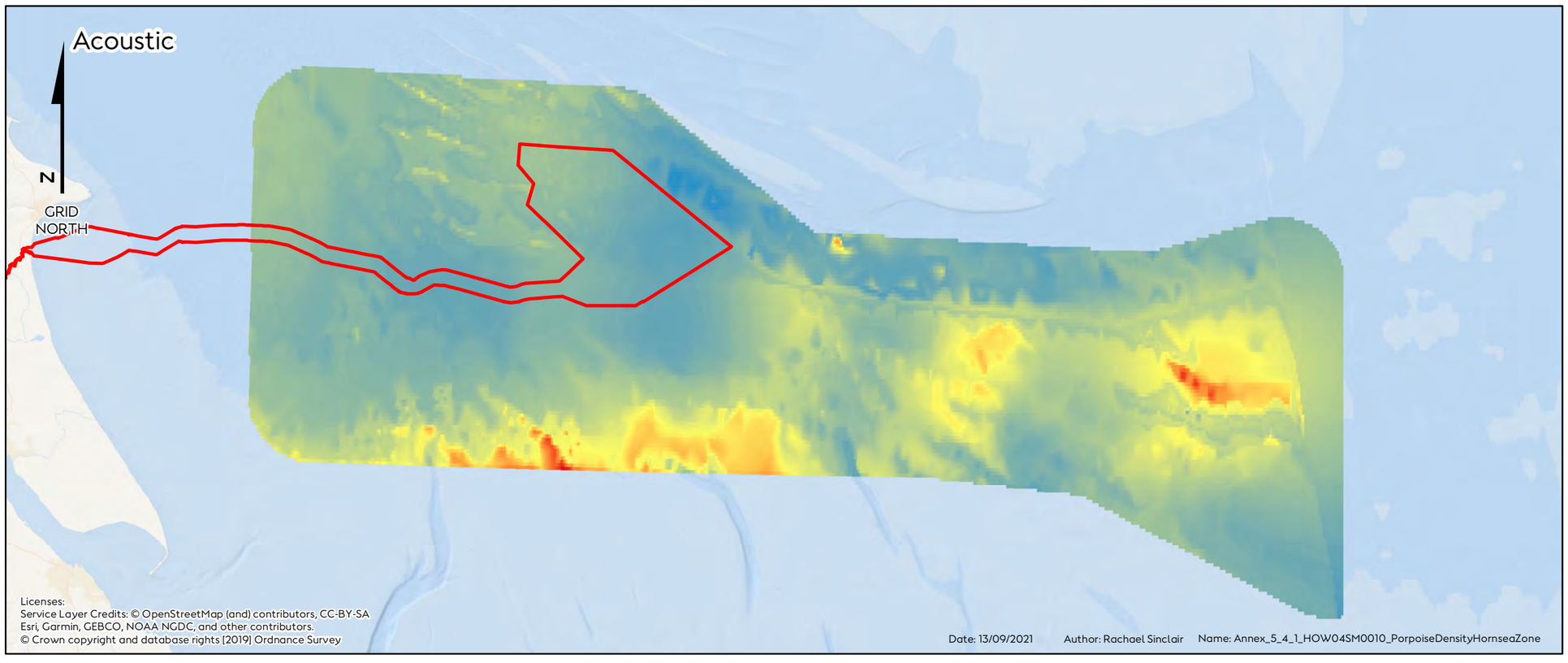
0 5 10 20 Nautical Miles

REV	REMARK	DATE
--	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

Harbour Porpoise Detections
Document no: HOW04SM0009
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted





Hornsea Four

Figure 16

Harbour Porpoise Density

Order Limits

Harbour Porpoise Density (visual) (#/km²)

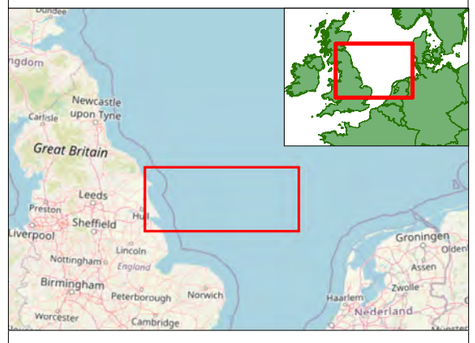
High : 6.91733

Low : 0.281666

Harbour Porpoise Density (acoustic) (#/km²)

High : 6.91733

Low : 0.627502



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:800,000

0 5 10 20 Kilometres

0 5 10 20 Nautical Miles

REV	REMARK	DATE
--	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	09/02/2020

Harbour Porpoise Density
Document no: HOW04SM0010
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

3.6 JCP Phase III

3.6.1.1 The JCP Phase III Data Resource was used to obtain the abundance and density of harbour porpoise (averaged for summer 2007-2010) within the area that encompassed the former Hornsea Zone survey area and extended west to the coast to include the offshore ECC (Figure 17). This resulted in a scaled density estimate across the user specified area of 3.12 porpoise/km^2 which is very similar to the average summer density from the Hornsea Four aerial surveys (3.8 porpoise/km^2). However, it would be inappropriate to use the JCP Phase III summer density estimate in the quantitative impact assessment as this density is not representative of other times of the year. The quantitative impact assessment is intended to illustrate the potential for impact across the construction period; since the Hornsea Four construction period extends over a 12 month period, a summer only density estimate is inappropriate and would vastly overpredict the impacts to harbour porpoise. This approach was discussed and agreed with stakeholders through the EP process (OFF-MM-1.4).

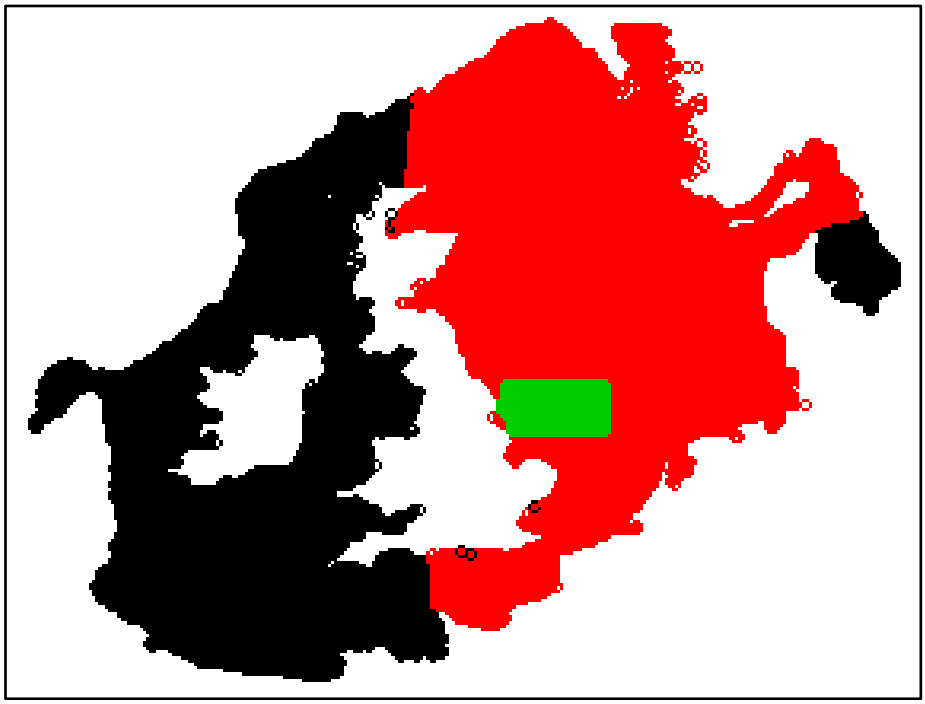


Figure 17: User specified area (green), North Sea MU (red) and full extent of JCP Phase III dataset (black) used to extract abundance and density estimates.

Table 5: JCP Phase III scaled abundance and density estimates for the user specified area in Figure 17.

	Point Estimate	Lower	Upper
Scaled abundance (user area)	63,424	37,387	83,452
Scaled density (user area) (#/km^2)	3.12	1.84	4.11

3.7 JNCC Report 544: Harbour Porpoise Density

3.7.1.1 The Heinänen and Skov (2015) analysis concluded that in the summer months, harbour porpoise presence in the North Sea MU was best predicted by water depth, surface salinity and eddy potential, while the density was best predicted by the water depth and the vertical temperature gradient. For the summer months the modelling showed a peak in densities at the inner shelf waters (30-50 m depth) and that animals seemed to avoid well mixed areas and waters with high current speeds as well as avoiding areas with muddy or hard bottom substrates. In the winter months the presence of harbour porpoise was best predicted by water depth, eddy potential and the surface sediments. For the winter months the modelling showed a peak in presence was observed at water depths of 30-40 m and that animals seemed to avoid waters with high current speeds as well as avoiding areas with muddy bottom substrates.

3.7.1.2 Overall, this analysis predicted varying densities in both the summer and winter months in the central part of the North Sea MU. The analysis predicted density estimates for the Hornsea Four array area of up to >3 porpoise/km^2 in the summer of 2010[1] but with high levels of spatial and temporal variation (**Figure 18**).

3.7.1.3 It is worth highlighting that the analysis presented in Heinänen and Skov (2015) relies on extensive extrapolation of survey data over space and time. Any such extrapolation is sensitive to the covariates used in models, as opposed to predictions within the support of the data. Subjective decisions in the retention of covariates in Heinänen and Skov (2015) calls into question the validity of such extrapolation. The survey effort on which the analysis is based was particularly patchy in time in the southern North Sea area which may limit the degree of confidence that can be placed in the model predictions. Despite the noted uncertainties in the data, the areas that were subsequently identified as cSACs for harbour porpoise had relatively high survey effort associated with them (IAMMWG 2015b).

3.7.1.4 The Hornsea Four array area is located within the persistent high-density area identified and selected in the southern North Sea during the summer; which has since been formally designated as an SAC as a result of these data and the analyses presented in Heinänen and Skov (2015).

[1] Note, the density surface is not available for use and so the value of >3 was read off the figures presented in the Heinänen and Skov (2015) report.

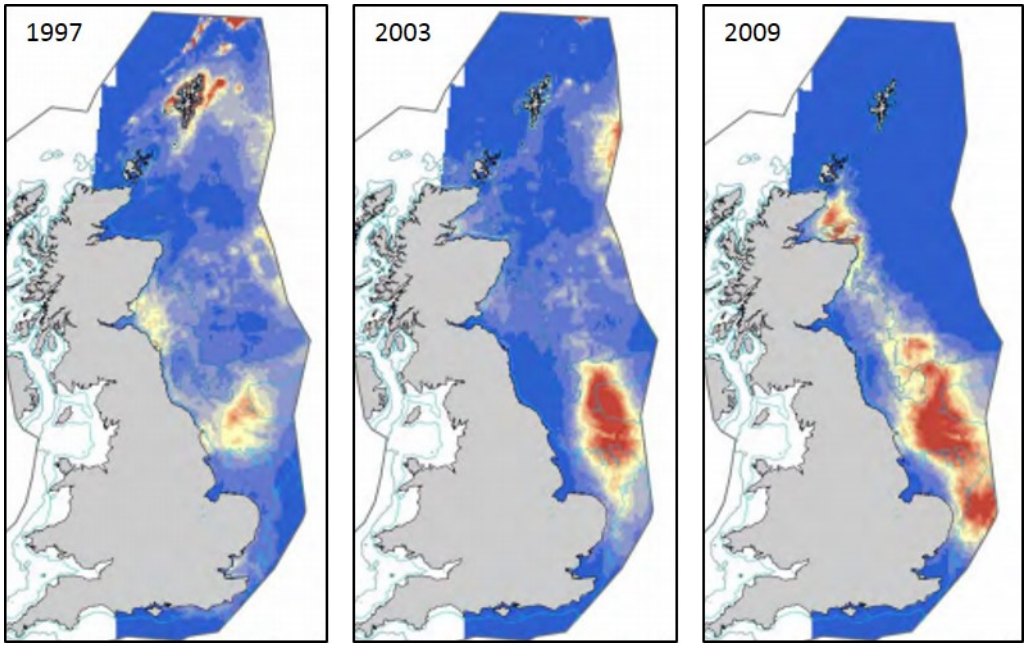


Figure 18: Harbour porpoise summer density surface for 1997 (left), 2003 (middle) and 2009 (right) (Heinänen and Skov 2015).

3.8 Harbour porpoise summary

3.8.1.1 In summary, there have been several studies that have produced density estimates for harbour porpoise in the vicinity of Hornsea Four, using a variety of survey methods and resulting in a wide range of density estimates from 0.888 (SCANS III survey block O) to 3.80 porpoise/km^2 (Hornsea Four aerial survey summer average) (**Table 6**). Each of these surveys have been conducted differently and different data analysis methods have been applied to the data, each of which differ in terms of assumptions such as cluster size, g(0) estimates etc. None of the density estimates can be considered to accurately reflect "true density" and the assumptions behind the density estimates and the level of confidence in those estimates should be considered. The most recent data available are the HiDef aerial survey data (2016-2018) which showed a seasonal pattern in the density estimates with an average adjusted density estimate across 24 months of survey of 1.74 porpoise/km^2.

3.8.1.2 Harbour porpoise sightings rates are known to vary greatly at fine scale temporal and spatial levels. This is clearly evident in the large difference in sightings rates between consecutive months obtained by the Hornsea Four aerial surveys (**Table 3**). Given the uncertainties in each of the available datasets, a range of density estimates are taken forward into the quantitative impact assessment. As agreed with stakeholders through the EP process, the density sources taken forward to assessment are the Hornsea Four site-specific aerial survey 2-year average (uniform density), the former Hornsea Zone acoustic estimates (spatially varying density surface) and the SCANS III density estimate for the portions of impact areas that extend beyond the aerial and acoustic survey areas (OFF-MM-1.4).

Table 6: Range of density estimates available for harbour porpoise in relation to the Hornsea Four area.

Dataset	Density Estimate (porpoise/km^2)
Hornsea Four site-specific aerial surveys (Year 1 average)	2.24
Hornsea Four site-specific aerial surveys (Year 2 average)	1.26
Hornsea Four site-specific aerial surveys (overall 2-year average)	1.74
Hornsea Four site-specific aerial surveys (summer average)	3.80
Scaled JCP Phase III (user specified area – summer 2007-2010 averaged)	3.12
Former Hornsea Zone vessel surveys (visual density surface average within Hornsea Four array area)	1.2
Former Hornsea Zone vessel surveys (acoustic density surface average within Hornsea Four array area)	1.6
SCANS III (survey block O)	0.888
Heinänen & Skov (summer 2010)	>3

4 Minke whale baseline

4.1.1.1 Minke whales are mainly observed in continental shelf waters around the UK, in waters depths <200 m. They are most commonly sighted in the summer months when they are located in more inshore waters to feed on herring and mackerel. The conservation status of minke whales in UK waters has been assessed as unknown (JNCC 2019f). There are currently no designated European sites with minke whales as a notified interest feature, however there are two Marine Protected Areas (MPAs) proposed for minke whales in Scottish waters (Southern Trench MPA in the Moray Firth and The Sea of the Hebrides MPA).

4.2 Management Unit

4.2.1.1 The IAMMWG (2021) recommends the use of the Celtic and Greater North Sea MU, which has an estimated minke whale abundance of 20,118 (CV:0.18, 95% CI: 14,061 – 28,786) based on the data collected by SCANS III in 2016 and ObSERVE in 2015-17 (Hammond et al. 2017, Rogan et al. 2018, Hammond et al. 2021).

4.2.1.2 For the North Sea alone (a sub-section of the entire CGNS MU), the 2016 SCANS III abundance estimate was 8,900 (CV=0.24) which is in the range of the estimates obtained from SCANS I, SCANS II, SCANS III and the Norwegian Independent Line Transect Surveys (Schweder 1997, Skaug et al. 2004, Bøthun et al. 2009, Solvang et al. 2015) (**Figure 19**). Therefore, the time series data show no support for a change in minke whale abundance in the North Sea since 1989.

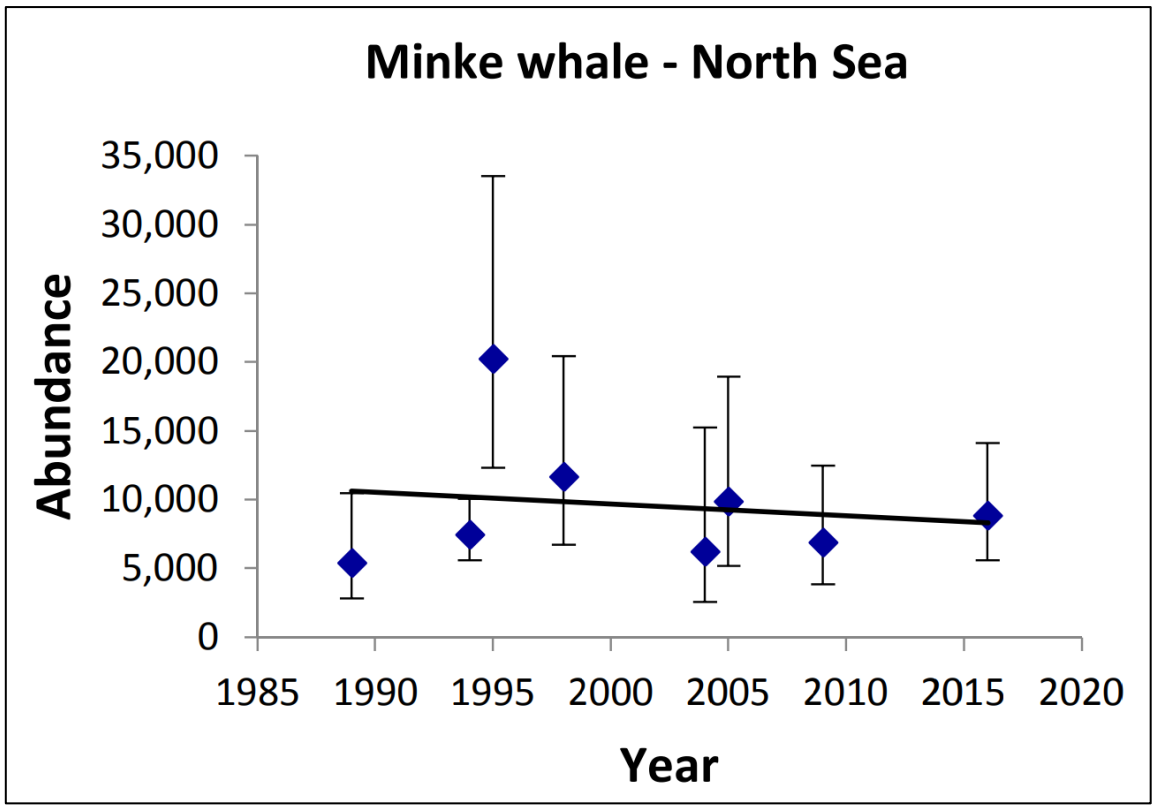


Figure 19: Minke whale abundance in the North Sea (Hammond et al. 2017). Estimated rate of annual change = -0.25% (95%CI: -4.8; 4.6%), p = 0.90. Error bars are log-normal 95% confidence intervals.

4.3 SCANS III – block O

4.3.1.1 The SCANS III survey of block O 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) with an estimated density of 0.010 whales/km^2 (CV: 0.621) 95% CI: 0.002 – 0.028) (Hammond et al. 2017, Hammond et al. 2021). 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 20**).

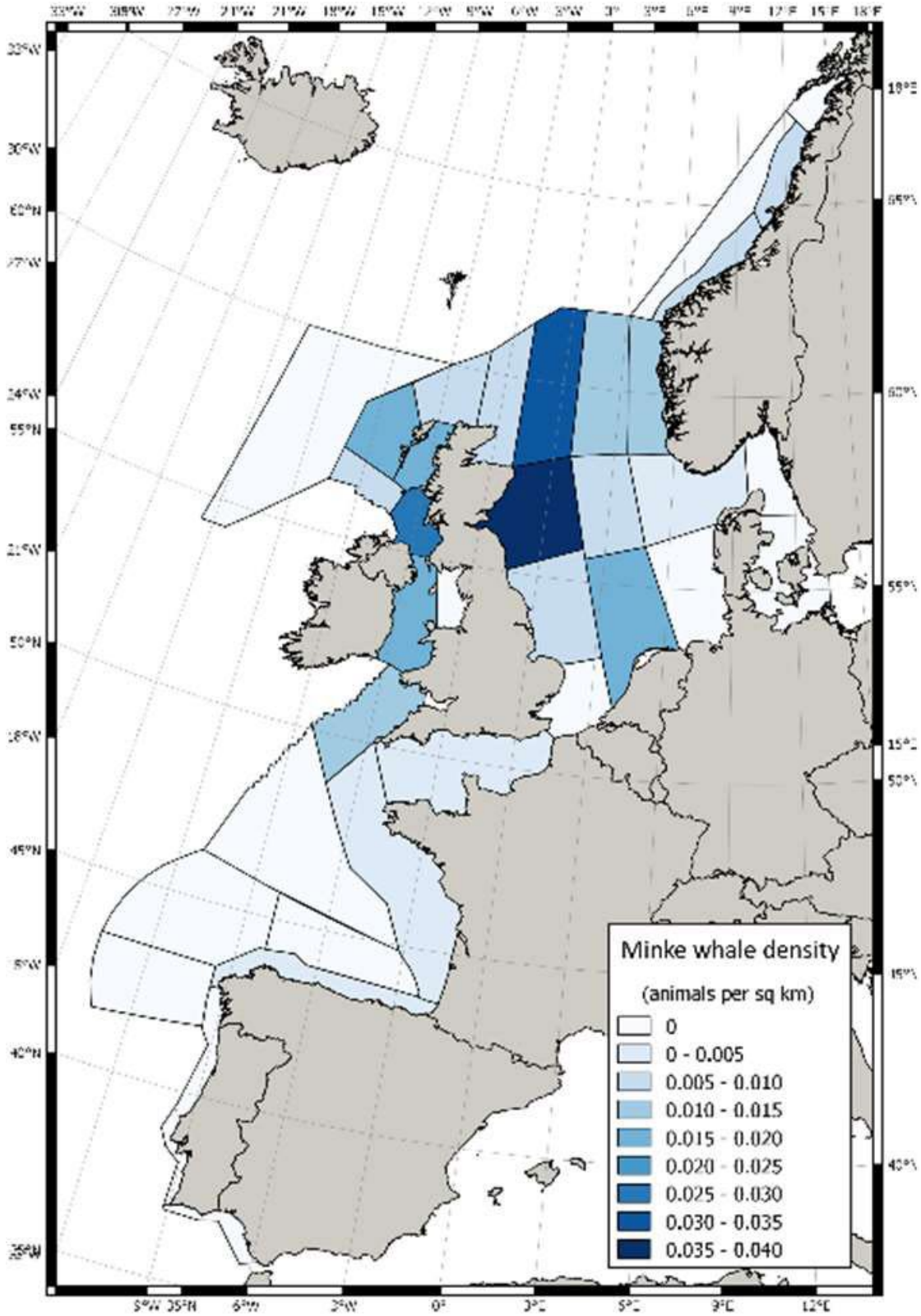


Figure 20: Minke whale density estimates in SCANS III blocks.

4.4 Hornsea Four site-specific aerial surveys

4.4.1.1 The 24 months of site-specific aerial surveys resulted in sightings of 12 individual minke whales, which occurred throughout the survey area. More sightings were recorded in the southern part of the survey area (Figure 22), however there were insufficient data to draw any conclusions regarding spatial patterns. There was however, a clear seasonal pattern to the sightings of minke whales, with this species only being sighted in the summer months between May and August (Figure 21).

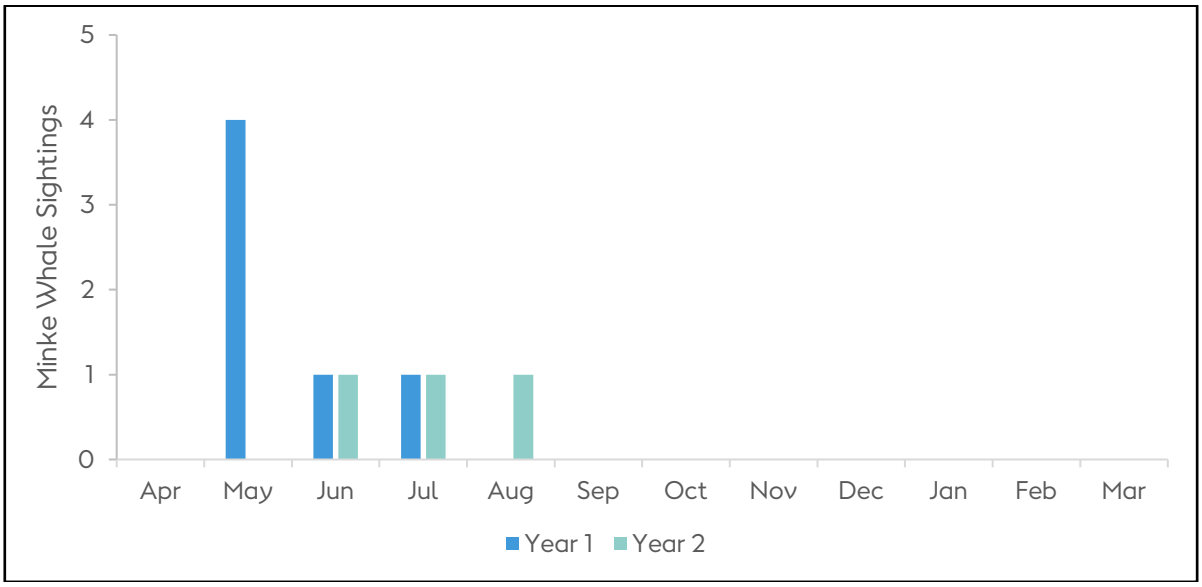


Figure 21: Monthly sightings counts for minke whales within the Hornsea Four site-specific aerial survey area between April 2016 and March 2018.

Hornsea Four

Figure 22

Minke Whale Sightings

360000 380000 400000 420000

6020000 6000000 5980000 5960000

N

GRID NORTH

- Order Limits
- Array Area
- Offshore Export Cable Corridor
- Hornsea Four Site-Specific Aerial Survey Area
- Minke Whale

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:250,000

0 3 6 12 Kilometres

0 1 2 4 Nautical Miles

REV	REMARK	DATE
...	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

Minke Whale Aerial Sightings
Document no: HOW04SM0012
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

Date: 13/09/2021 Author: Rachael Sinclair Name: Annex_5_4_1_HOW04SM0012_MinkeWhaleSightings

4.5 Former Hornsea Zone vessel surveys: visual

4.5.1.1 A total of 158 minke whales were observed in the former Hornsea Zone plus a 10 km buffer survey area over the three-year survey period, with a mean cluster size of 1.07 animals. The relative abundance of minke whale was calculated by multiplying the average density estimate across the former Hornsea Zone plus a 10 km buffer survey site by the area (9,276 km^2). The resulting relative abundance for the former Hornsea Zone plus a 10 km buffer survey area was calculated as 56 individuals.

4.5.1.2 **Figure 23** shows the monthly encounter rate within the former Hornsea Zone plus a 10 km buffer survey area, for sea states zero to three only, across 2010 to 2013. The mean encounter rate in the survey area was 0.003 minke whales/km^2. The encounter rate fluctuated over the months across the survey area, with a peak in sightings in July, particularly in 2012/2013. Minke whales were notably absent from the survey area during the winter months.

4.5.1.3 The density surface map obtained from the GAM modelling estimated a gradient in density across the former Hornsea Zone survey area, with higher densities of minke whales in the north-west (up to 0.02 whales/km^2) and lower densities in the south-east (0 whales/km^2) (**Figure 24**). However, it is important to note that the size of the density estimate is between only 0.00 and 0.02 whales/km^2 which highlights that, as there is actually very little change in the density across the survey area, there may not be sufficient data to comment meaningfully on any spatial pattern within the survey area. The average density across the entire survey area obtained from the density surface was 0.006 whales/km^2. Within the Hornsea Four array area, estimated obtained from the density surface reached a maximum of 0.013 whales/km^2 in the north-west and had an average estimated density across the array area of 0.009 whales/km^2.

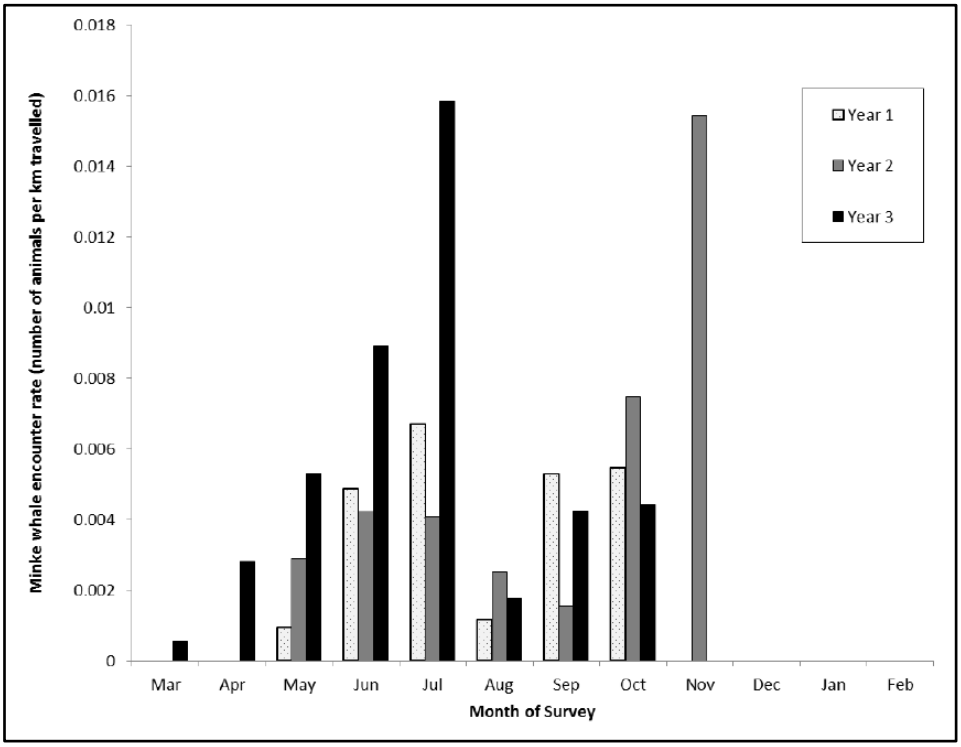
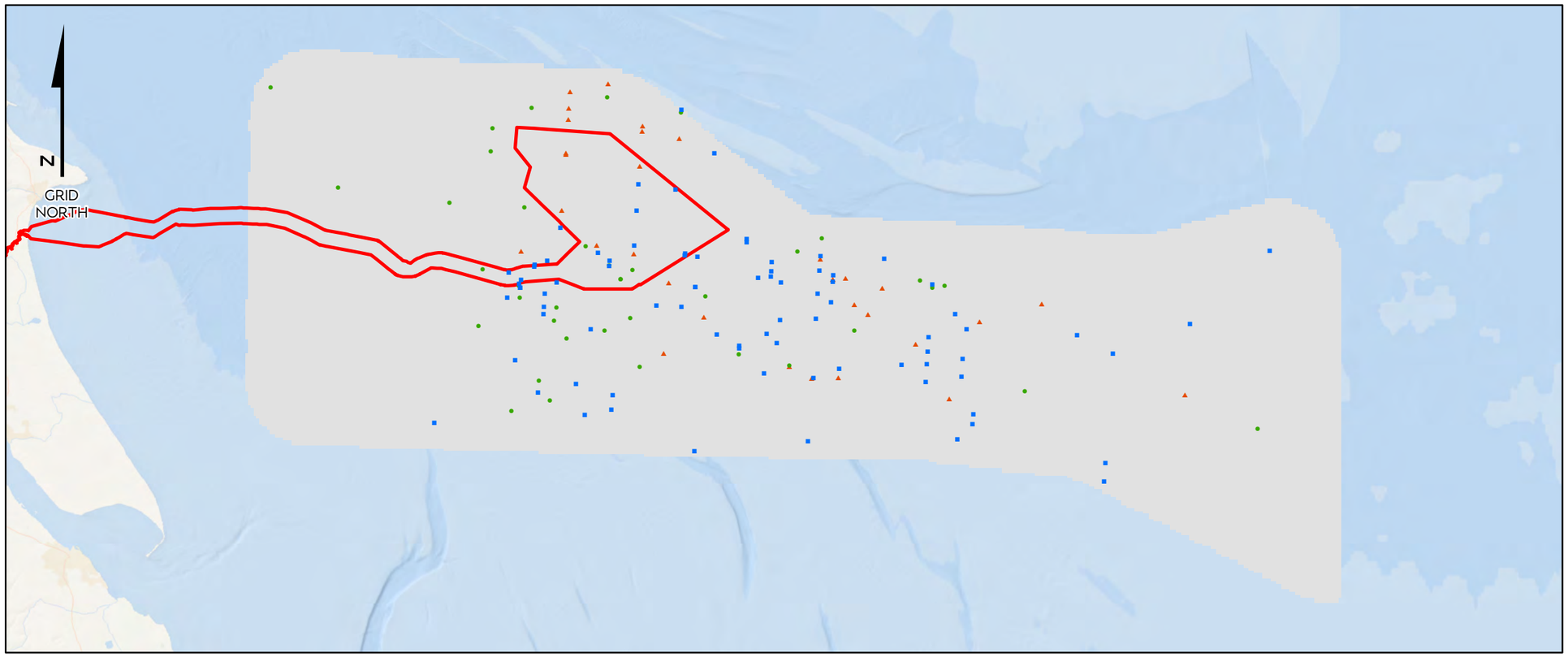


Figure 23: Monthly mean encounter rate of minke whale in the former Hornsea Zone plus 10 km buffer in Year 1 (2010/2011), Year 2 (2011/2012) and Year 3 (2012/2013). Data presented are for sightings in Beaufort sea states of zero to three.

Hornsea Four

Figure 24

Minke Whale Sightings and Estimated Density Across the former Hornsea Zone



Order Limits

Former Hornsea Zone plus 10 km buffer

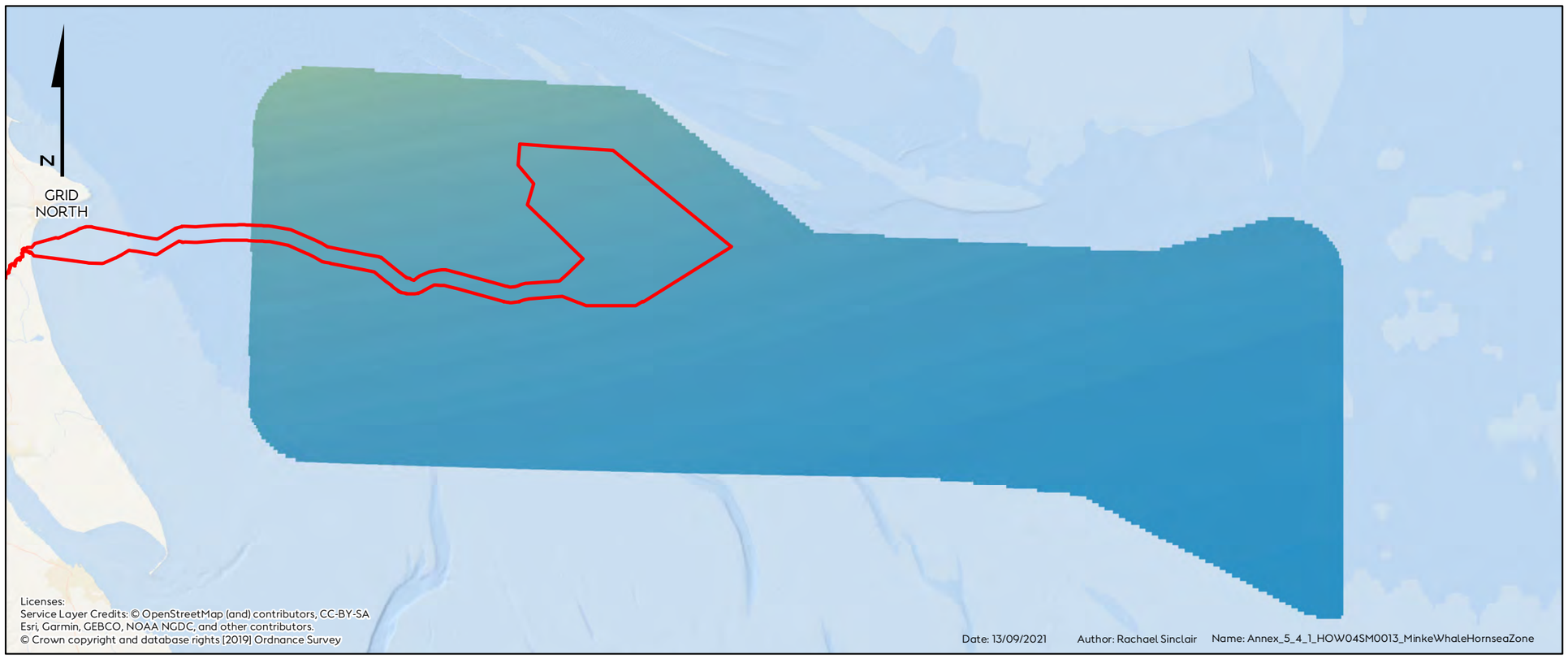
Minke Whale Detections

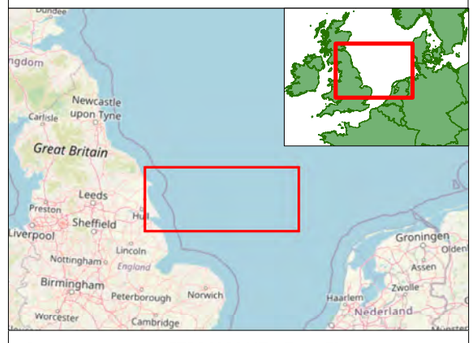
- March 2010 - Feb 2011
- March 2011 - Feb 2012
- March 2012 - Feb 2013

Minke Whale Density (#/km²)

High : 0.1

Low : 0





Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:800,000

0 10 20 40 Kilometres

0 5 10 20 Nautical Miles

REV	REMARK	DATE
--	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

Minke Whale Sightings
Document no: HOW04SM0013
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

Date: 13/09/2021 Author: Rachael Sinclair Name: Annex_5_4_1_HOW04SM0013_MinkeWhaleHornseaZone

4.6 Minke whale summary

4.6.1.1 The most appropriate unit to assess impacts against is updated CGNS MU (combined SCANS III and Irish ObSERVE data), which estimated a total minke whale abundance of 20,118 animals (IAMMWG 2021). The modelled density surface for the former Hornsea Zone (and the SCANS III block wide density estimate where impacts extend beyond the modelled Hornsea Zone surface) is considered to be the most appropriate density estimates to take forward to quantitative impact assessment (Table 7).

Table 7: Range of density estimates available for minke whales in relation to the Hornsea Four area.

Dataset	Density (# whales/km^2)
SCANS III Block O	0.010
Former Hornsea Zone vessel surveys (average across entire zone)	0.006
Former Hornsea Zone vessel surveys (average across the Hornsea Four array area)	0.009

5 White-beaked dolphin baseline

5.1.1.1 The white-beaked dolphin has a somewhat limited range, being found predominantly in the cool temperate and subarctic waters of the north Atlantic (Reid et al. 2003). They are abundant on the continental shelf around west and north Scotland and in the northern North Sea and are less common in the southern North Sea, the English Channel and Irish Sea. The conservation status of white-beaked dolphins in UK waters has been assessed as unknown (JNCC 2019e).

5.2 Management Unit

5.2.1.1 The IAMMWG identified the management unit for white-beaked dolphins as the CGNS area. There is an abundance estimate for this entire MU presented in (IAMMWG 2021) of 43,951 animals (CV: 0.22, 95% CI: 28,439 – 67,924). The time series data for the North Sea alone (a sub-section of the entire CGNS MU) show no support for a change in white-beaked dolphin abundance in the North Sea since 1994 (Figure 25) (Hammond et al. 2017), although confidence intervals are wide.

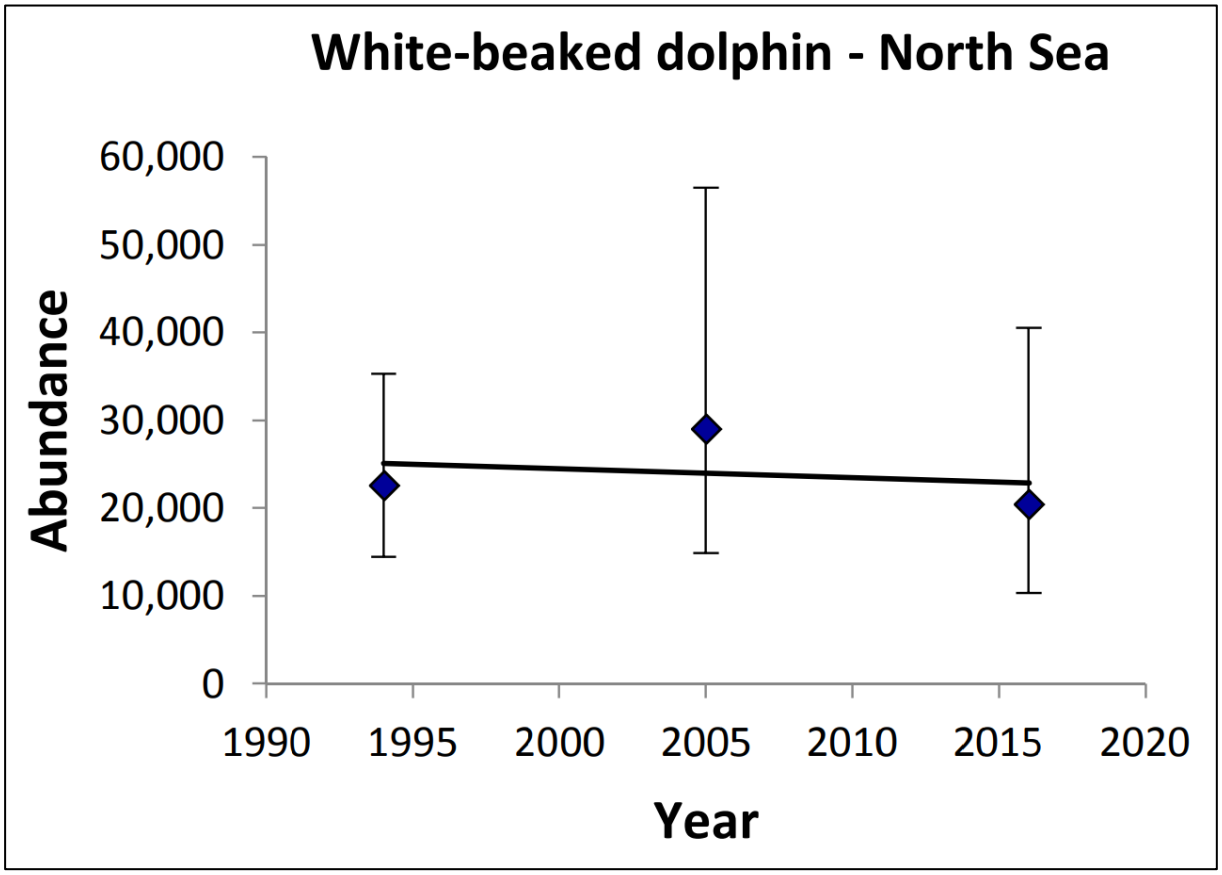


Figure 25: White-beaked dolphin abundance in the North Sea (Hammond et al. 2017). Estimated rate of annual change = -0.5% (95%CI: -18; 22%), p = 0.36. Error bars are log-normal 95% confidence intervals.

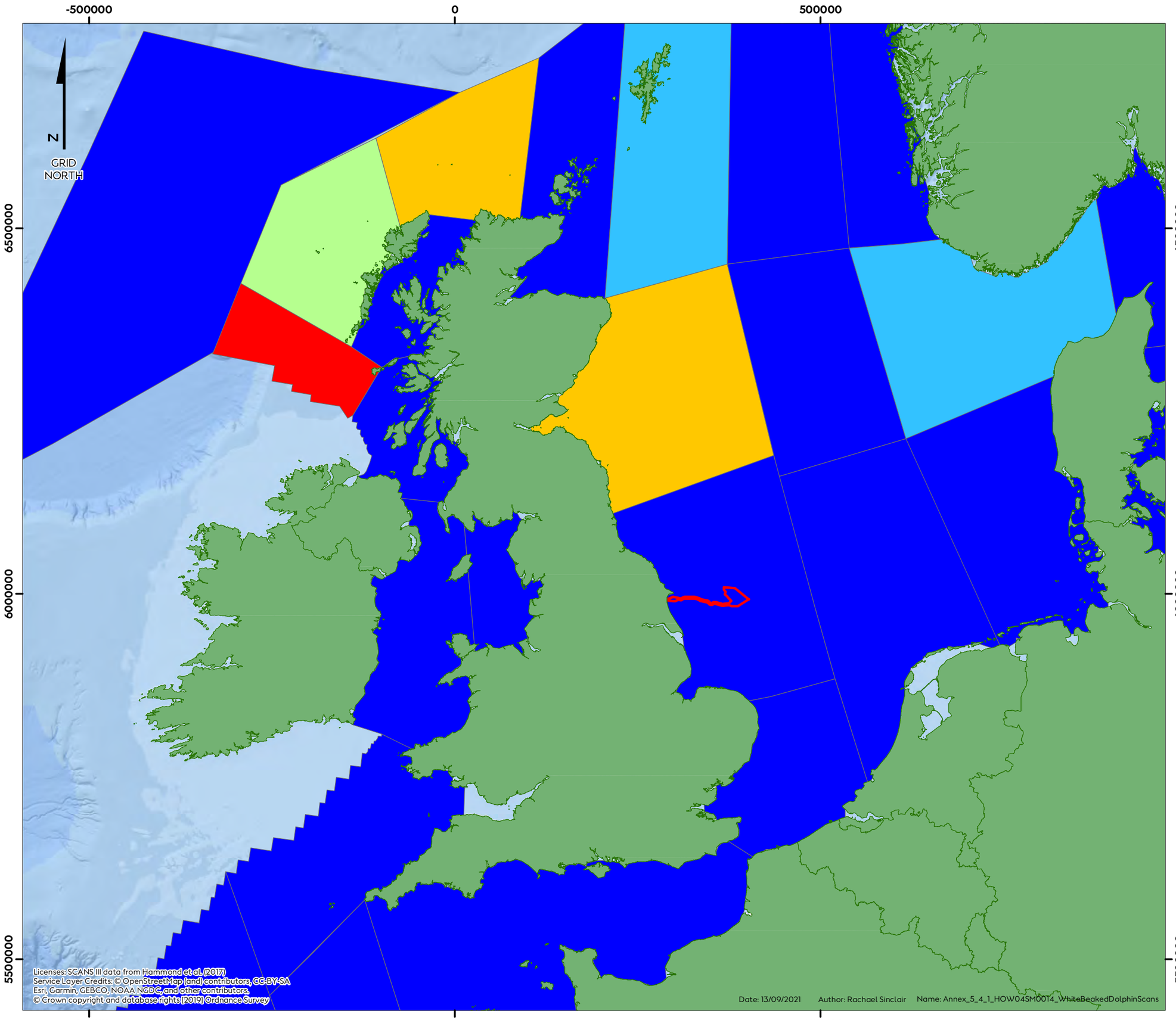
5.3 SCANS III – block O

5.3.1.1 The SCANS III survey of block O consisted of a total of 3,242.8 km of effort. A total of 143 white-beaked dolphins were estimated to be located within survey block O (95% CI: 0 - 490) with an estimated density of 0.002 dolphins/km^2 (CV: 0.970, 95% CI: 0.000 – 0.008). 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 (Figure 26).

Hornsea Four

Figure 26

White-beaked Dolphin SCANS III



REV	REMARK	DATE
--	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

White-beaked Dolphin SCANS III
Document no: HOW04SM0014
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

Date: 13/09/2021 Author: Rachael Sinclair Name: Annex_5_4_1_HOW04SM0014_WhiteBeakedDolphinScans

5.4 Hornsea Four site-specific aerial surveys

5.4.1.1 The 24 months of site-specific aerial surveys resulted in sightings of 82 white-beaked dolphins, which occurred mostly in the northern part of the survey area (Figure 28), however there were insufficient data to draw any conclusions regarding spatial patterns. There was a clear seasonal pattern to the sightings of white-beaked dolphins, with this species being sighted more in the autumn and winter months (Figure 27), however there was also a large amount of annual variation with 78% of the total sightings being recorded in year 1 of the surveys.

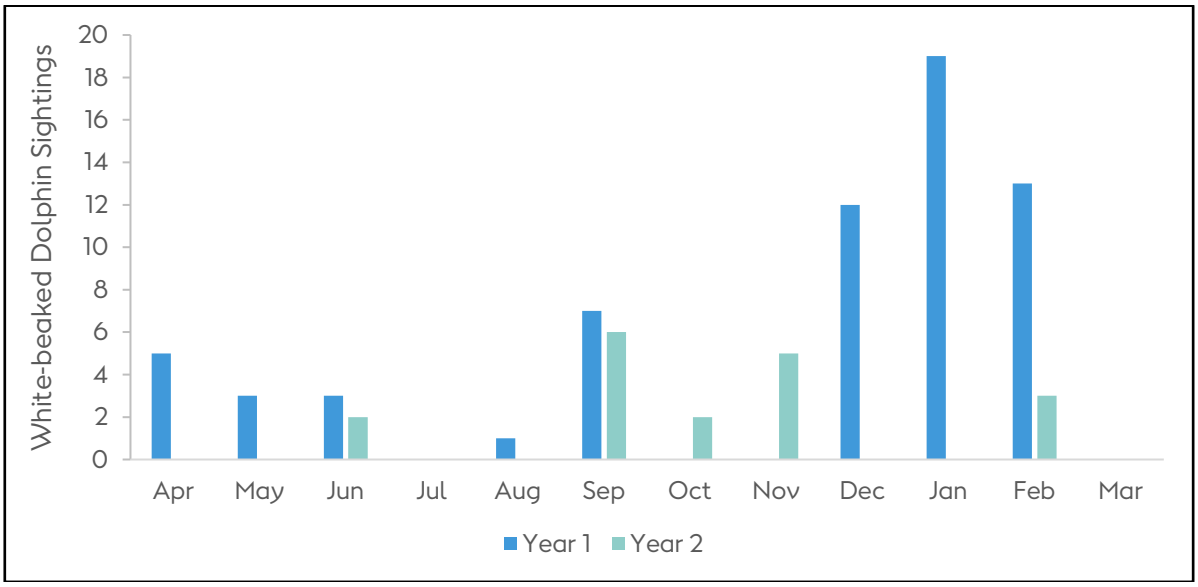
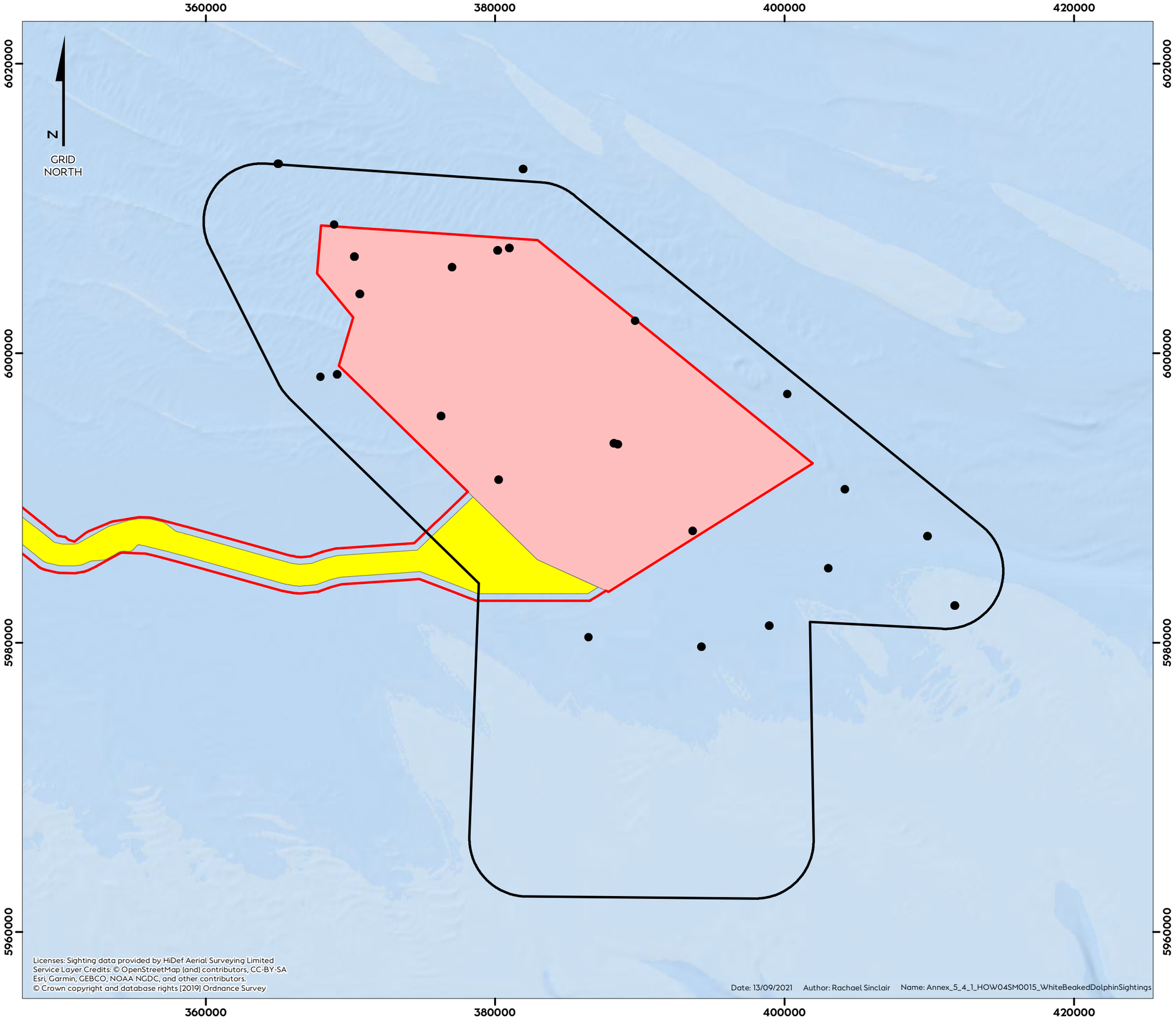


Figure 27: Monthly sightings counts for white-beaked dolphins within the Hornsea Four site-specific aerial survey area between April 2016 and March 2018.

Hornsea Four

Figure 28

White-beaked Dolphin Sightings



- Order Limits
- Array Area
- Offshore Export Cable Corridor
- Hornsea Four Site-Specific Aerial Survey Area
- White-beaked Dolphin

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:250,000

0 3 6 12 Kilometres

0 1 2 4 Nautical Miles

REV	REMARK	DATE
...	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

White-beaked Dolphin Sightings
Document no: HOW04SM0015
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

Date: 13/09/2021 Author: Rachael Sinclair Name: Annex_5_4_1_HOW04SM0015_WhiteBeakedDolphinSightings

5.5 Former Hornsea Zone vessel surveys: visual

5.5.1.1 A total of 298 white-beaked dolphins were observed in the former Hornsea Zone plus 10 km buffer survey area over the three-year survey period, with a mean cluster size of 2.9 animals. The relative abundance of white-beaked dolphins was calculated by multiplying the average density estimate across the former Hornsea Zone plus a 10 km buffer survey site by the area (9,276 km^2). The resulting relative abundance for the former Hornsea Zone plus a 10 km buffer was calculated as 149 individuals. The average relative density of white-beaked dolphins within the former Hornsea Zone plus 10 km buffer survey area across all three years of data was therefore 0.16 dolphins/km^2. However, there was a clear seasonal pattern to the sightings with white-beaked dolphins being sighted predominantly in the winter months between November and January (Figure 29). This seasonal pattern of sightings occurring predominantly in the winter months matches that obtained from the Hornsea Four aerial surveys described above.

5.5.1.2 The density surface map obtained from the GAM modelling estimated a gradient in density across the former Hornsea Zone survey area, with higher densities of white-beaked dolphins in the north-west (up to 0.12 dolphins/km^2) and lower densities in the south-east (0 dolphins/km^2) (Figure 30). The average estimated density across the whole Former Hornsea Zone survey area was 0.016 dolphins/km^2. Within the Hornsea Four array area, estimated densities obtained from the density surface reached a maximum of 0.04 dolphins/km^2 in the north-west with an average estimated density across the array area of 0.02 dolphins/km^2.

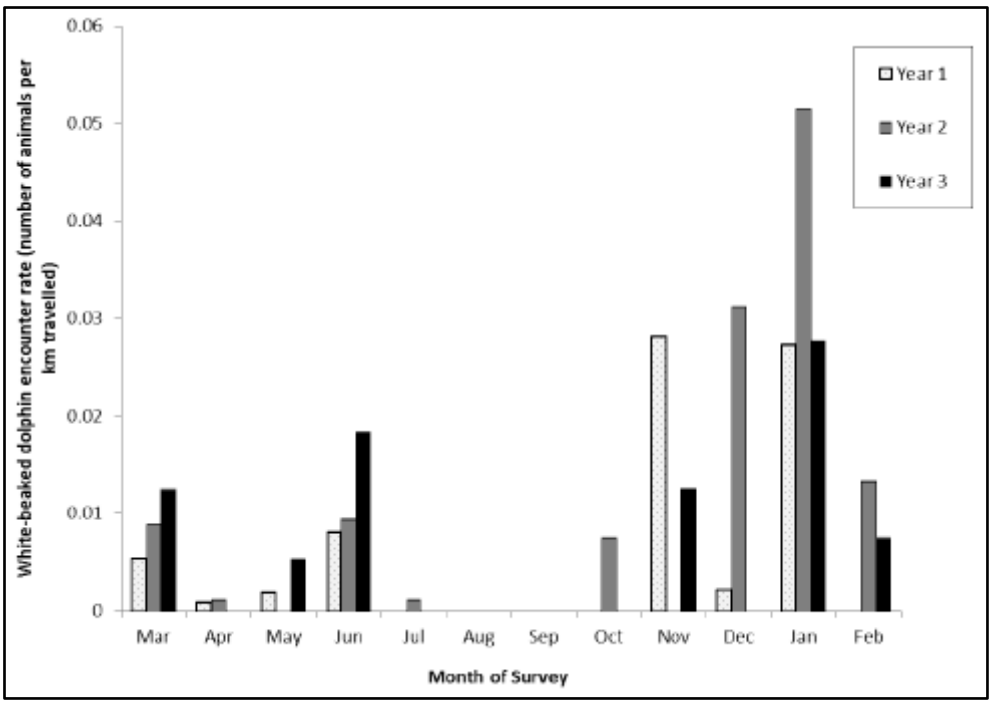
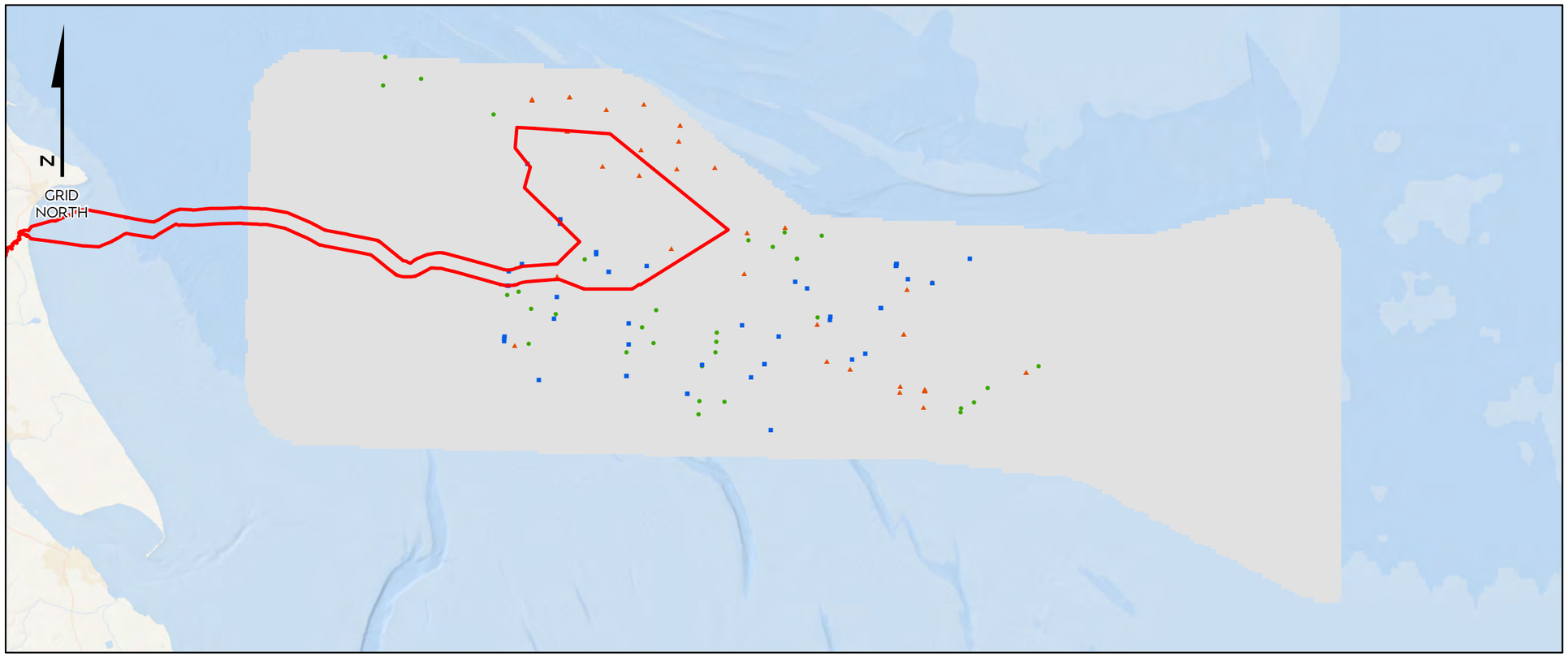
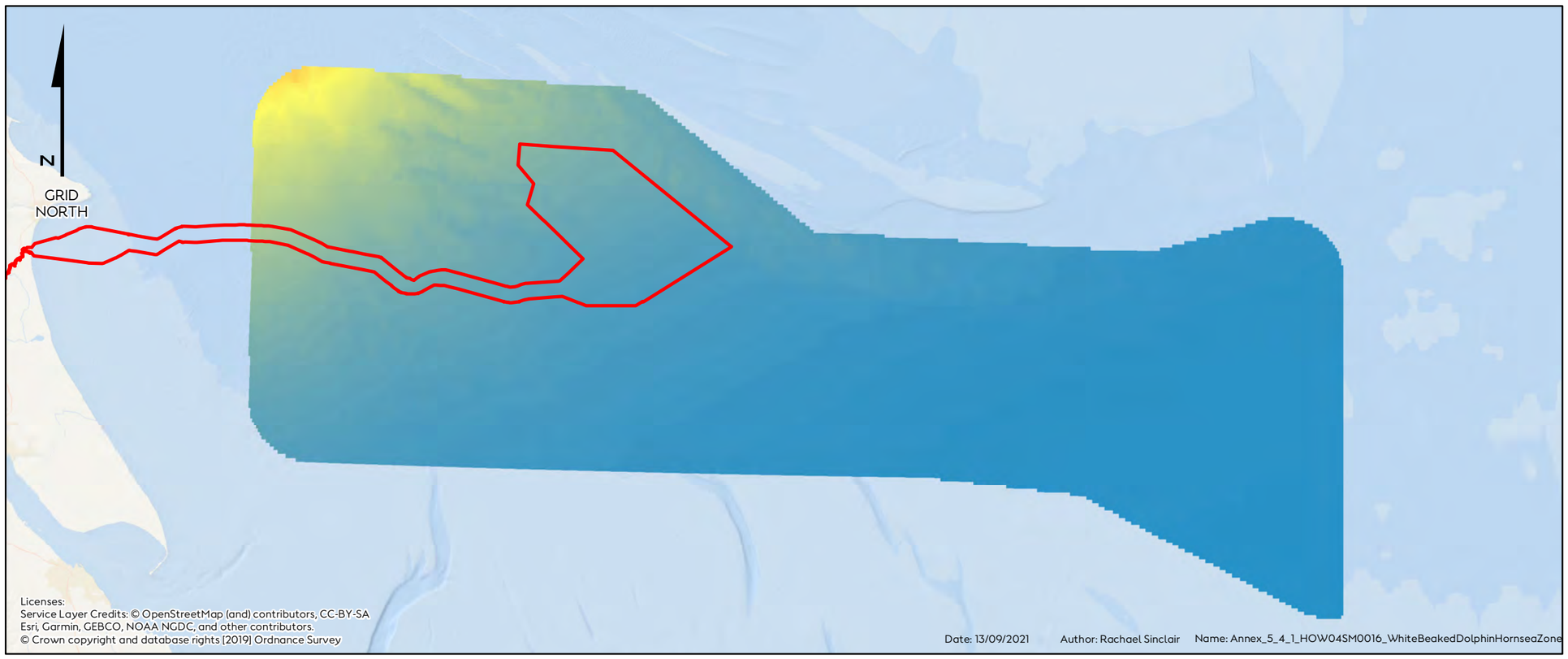


Figure 29: Monthly mean encounter rate of white-beaked dolphins in the former Hornsea Zone plus 10 km buffer in Year 1 (2010/2011), Year 2 (2011/2012) and Year 3 (2012/2013). Data presented are for sightings in Beaufort sea states of zero to three.





Licenses:
Service Layer Credits: © OpenStreetMap (and) contributors, CC-BY-SA
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors.
© Crown copyright and database rights [2019] Ordnance Survey

Date: 13/09/2021 Author: Rachael Sinclair Name: Annex_5_4_1_HOW04SM0016_WhiteBeakedDolphinHornseaZone

Hornsea Four

Figure 30

White-Beaked Dolphin Sightings and Estimated Density Across the Former Hornsea Zone

Order Limits

Former Hornsea Zone plus 10 km buffer

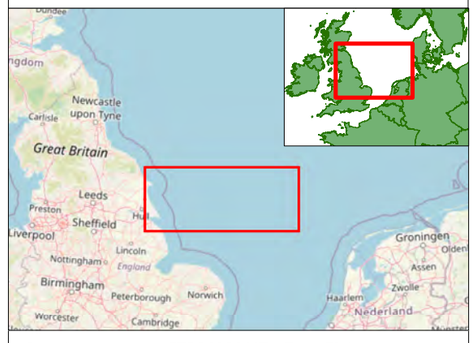
White-beaked Dolphin Detections

- March 2010 - Feb 2011
- March 2011 - Feb 2012
- March 2012 - Feb 2013

White-beaked Dolphin Density (#/km²)

High : 0.2

Low : 0



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:800,000

0 10 20 40 Kilometres

0 5 10 20 Nautical Miles

REV	REMARK	DATE
--	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	29/07/2021

White-beaked Dolphin Sightings
Document no: HOW04SM0016
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

5.6 White-beaked dolphin summary

5.6.1.1 The most appropriate unit to assess impacts against is updated abundance estimate for the CGNS MU (combined SCANS III and Irish ObSERVE data), which estimated a total white-beaked dolphin abundance of 43,951 animals. The modelled density surface for the former Hornsea Zone (and the SCANS III block wide density estimate for impacts which extend beyond the Hornsea Zone area) is considered to be the most appropriate density estimates to take forward to impact assessment (Table 8).

Table 8: Range of density estimates available for white-beaked dolphins in relation to the Hornsea Four area.

Dataset	Density (# dolphins/km^2)
SCANS III Block O	0.002
Former Hornsea Zone vessel surveys (average across entire zone)	0.016
Former Hornsea Zone vessel surveys (average across the Hornsea Four array area)	0.020

6 Bottlenose dolphin baseline

6.1.1.1 Bottlenose dolphins in the UK have been assessed as having an unknown conservation status (JNCC 2019a). Previously, the IAMMWG (2015a) have assigned bottlenose dolphins on the east coast of England as belonging to the greater North Sea MU (ICES Area IV, excluding coastal east Scotland; and ICES area IIIa), however they did not assign an abundance estimate for this MU. The IAMMWG (2015a) did however note that bottlenose dolphins sighted along the east coast of England are thought to belong to the Coastal East Scotland MU. The recent update to the cetacean MU estimates (IAMMWG 2021) identifies a new MU for bottlenose dolphins: the Greater North Sea MU within which Hornsea Four is located. This Greater North Sea MU has an estimated abundance of 2,022 (CV: 0.75, 95% CI: 548 – 7,453).

6.1.1.2 Previous photo ID data have shown that the Coastal East Scotland population expanded its range in the St Andrews Bay and the Tay estuary, and in 2015 52.5% of the population was estimated to be using the St Andrews Bay and the Tay estuary area during the summer (Arso Civil et al. 2019). New photo ID data have confirmed that individuals from this population have been sighted in the Netherlands and in Ireland in 2019[2] which had never previously been recorded. The knowledge of bottlenose dolphin movement along the east coast of Scotland in the 1990s beyond the Moray Firth SAC (which was considered to be their core area of distribution), further south and northeast England is currently developing, for example, the new Citizen Fins project[3] has received public photos from the east coast of England (off Scarborough) that have been identified by photo-ID as Coastal East Scotland bottlenose dolphins. This highlights the potential for the Coastal East Scotland population to have a much wider range than previously assumed, or that the population has continued to expand its range over time. Therefore, it is considered that the bottlenose dolphins present along the east coast of England and in relation to Hornsea Four are likely to be functionally linked to the Coastal East Scotland MU and as such, the Moray Firth SAC needs

[2] https://www.abdn.ac.uk/lighthouse/blog/international-sightings/

[3] https://synergy.st-andrews.ac.uk/citizenfins/

to be considered in the RIAA. The current abundance estimate for the Coastal East Scotland MU is 189 (155 – 216)[4] (IAMMWG 2021).

6.1.1.3 Therefore, the most appropriate MU against which to assess the impacts from Hornsea Four is the combined Greater North Sea and Coastal East Scotland MUs which results in a reference population size of 2,211 bottlenose dolphins.

6.1.1.4 No bottlenose dolphins were sighted during the site-specific aerial surveys at Hornsea Four, though there were sightings of marine mammals that could not be categorised beyond 'seal/small cetacean species'. No bottlenose dolphins were sighted within SCANS III survey block O.

6.1.1.5 The Sea Watch Foundation consider bottlenose dolphins to be uncommon in the east of England; however, they do highlight that increased sightings have occurred in recent years[5]. The Sea Watch Foundation and the Yorkshire Wildlife Trust have conducted land-based surveys of marine mammals since 2003, however most of the data for the years 2003 to 2017 do not have associated effort data and therefore trends in sightings rates cannot be determined. Since 2018, more regular effort-based watches have occurred along the Yorkshire coast. In 2018, two main sites were surveyed: Marine Drive and Royal Society for the Protection of Birds (RSPB) Bempton Cliffs, with watches occurring on 42 days, totalling 60 hours of effort between February and December (**Table 9**). In 2019, data watches occurred on 83 days, totalling 101 hours of effort between February and September (**Table 10**). In 2019, more sites were surveyed; the primary site was still Marine Drive, however other surveyed sites included Old Nab, Filey Brigg, Flamborough and Hornsea North and South (**Figure 31**). No bottlenose dolphins were sighted during the watches in 2018. In comparison, a total of 53 bottlenose dolphins were sighted in 2019 during nine encounters between April and September. The average monthly sightings rate in 2019 varied between 0 and 1.63 dolphins/hour with highest sightings rates in August (**Table 10**).

6.1.1.6 No reliable density estimate exists for bottlenose dolphins in the east of England, and therefore it is challenging to predict the number of animals that could potentially be impacted by Hornsea Four. There are four density estimates that can be obtained from the literature: based on SCANS III, IAMMWG MU, JCP Phase III and MERP maps:

- SCANS III (Hammond et al. 2021) survey Block O (within which Hornsea Four is located) = **0.00 dolphins/km^2**
- Assuming a uniform density throughout the Greater North Sea MU (2,022 dolphins in 639,886 km^2) = **0.003 dolphins/km^2**
- JCP Phase III (Paxton et al. 2016) South Dogger Bank commercial area of interest (30 dolphins in area of 14,265 km^2) = **0.002 dolphins/km^2**
- MERP (Waggitt et al. 2020) July maximum density within Hornsea Four Order Limits = **0.002 dolphins/km^2**

6.1.1.7 Of these available density estimates, the most precautionary density estimate to take forward to impact assessment is 0.003 dolphins/km^2.

[4] Estimate of the Scottish east coast bottlenose dolphin population based on CMR and calculated using a Bayesian model with 95% HPDI for 2015 (Cheney et al. 2018)
[5] https://seawatchfoundation.org.uk/wp-content/uploads/2012/07/EasternEngland.pdf

6.1.1.8 Previous data have shown that bottlenose dolphins in the Tayside and Fife area are mainly encountered in waters less than 20 m deep and within 2 km from the coast (Quick et al. 2014). Assuming that the dolphins sighted in the east of England are connected to the Coastal East Scotland population, and assuming that they would display similar distributions throughout their range, it could be expected that any impacts to dolphins associated with the Moray Firth MU population would be limited to the more nearshore impacts of cable laying, Unexploded Ordnance (UXO) clearance and piling associated with the HVAC, rather than offshore piling of the WTG foundations.

Table 9: Effort and bottlenose encounter data for land-based watches in 2018 and 2019.

Year	Site	Months surveyed	Days Surveyed	Hours Surveyed	# Encounters	# Dolphins Sighted	Dolphin Positive Days (DPD)	Sightings Rate (bnd/hr)	Sightings Rate (Encounters/hr)	% DPD
			#	sum	sum	sum	sum	mean	mean	
2019	**ALL**	**2-9**	**83**	**101.0**	**9**	**53**	**8**	**0.4**	**0.1**	**10%**
2019	Marine Drive	2-9	71	69.1	5	26	4	11.7	2.2	6%
2019	Filey Brigg	6	1	1.5	1	15	1	10.0	0.7	100%
2019	Esplanade	5	1	1.0	1	5	1	5.0	1.0	100%
2019	Flamborough	7	1	1.0	0	0	0	0.0	0.0	0%
2019	Hornsea North	6, 8	2	2.3	0	0	0	0.0	0.0	0%
2019	Hornsea South	5, 6	5	4.8	1	3	1	3.0	1.0	20%
2019	Old Nab	4,5,7	7	21.4	1	4	1	1.5	0.4	14%
2018	**ALL**	**2-3 7-12**	**42**	**60**	**0**	**0**	**0**	**0**	**0**	**0%**
2018	Marine Drive	7-12	33	32.3	0	0	0	0	0	0%
2018	RSPB Bempton Cliffs	2-3 7-8	9	27.7	0	0	0	0	0	0%

Table 10: Monthly effort and sightings data from land-based watches in 2018 and 2019.

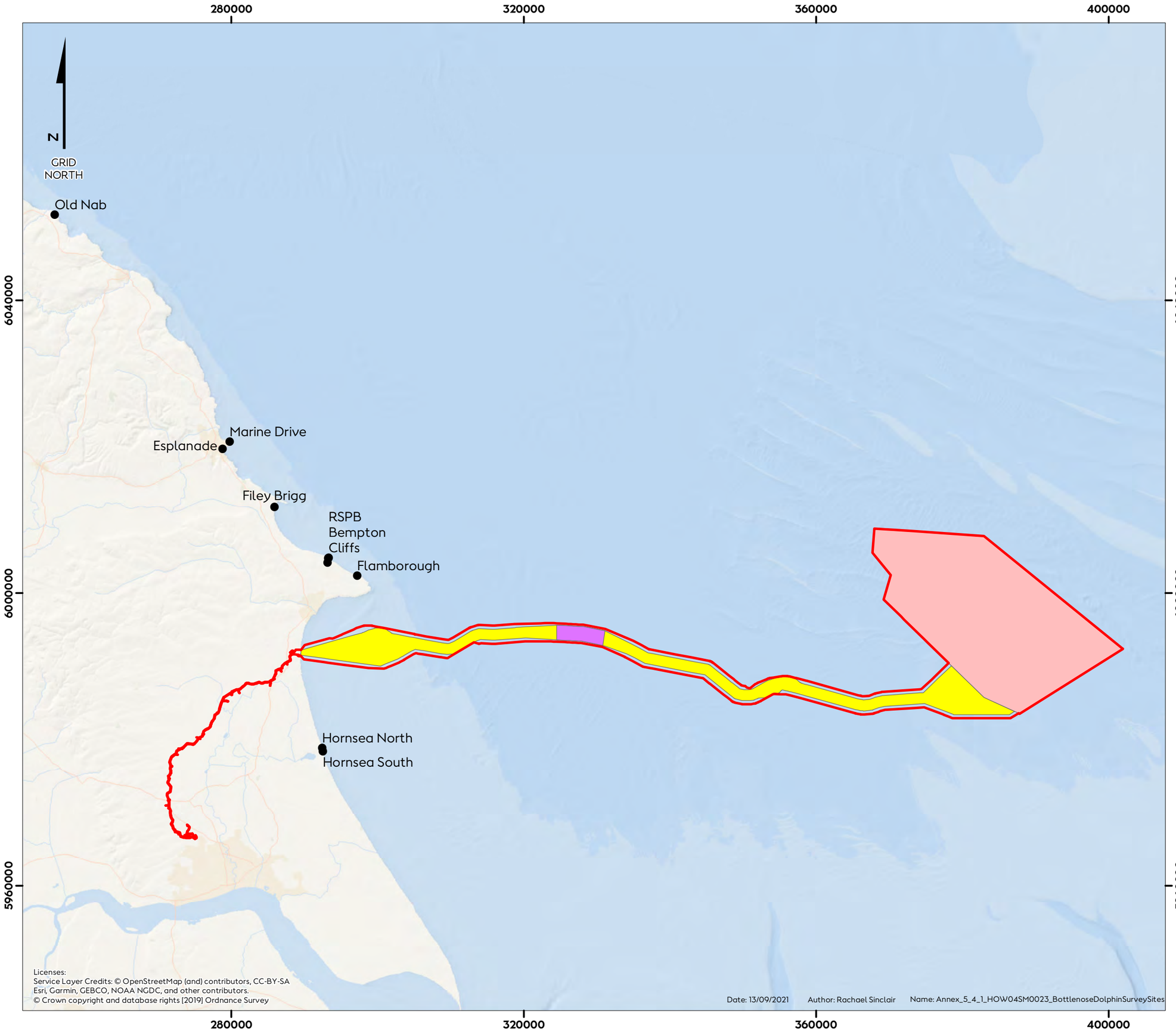
Year	Month	# Days Surveyed	# Hours Surveyed	# Dolphins Sighted	Average Sightings Rate (#/hour)	Dolphin Positive Days	
2019	Jan	-	-	-	-	-	-
	Feb	22	19.0	0	0.00	0	0%
	Mar	7	4.0	0	0.00	0	0%
	Apr	3	4.8	4	0.52	1	33%
	May	15	21.2	13	0.45	3	20%
	Jun	13	14.4	15	0.42	1	8%
	Jul	15	25.2	0	0.00	0	0%
	Aug	4	6.5	12	1.63	2	50%
	Sep	4	5.9	9	0.69	1	25%
	Oct	-	-	-	-	-	-
	Nov	-	-	-	-	-	-
	Dec	-	-	-	-	-	-
2018	Jan	-	-	-	-	-	-

Year	Month	# Days Surveyed	# Hours Surveyed	# Dolphins Sighted	Average Sightings Rate (#/hour)	Dolphin Positive Days	
	Feb	3	7.2	0	0.00	0	0%
	Mar	4	22.8	0	0.00	0	0%
	Apr	-	-	-	-	-	-
	May	-	-	-	-	-	-
	Jun	-	-	-	-	-	-
	Jul	12	14.2	0	0	0	0%
	Aug	2	1.6	0	0	0	0%
	Sep	4	2.75	0	0	0	0%
	Oct	9	5.75	0	0	0	0%
	Nov	2	1.4	0	0	0	0%
	Dec	6	4.4	0	0	0	0%

Hornsea Four

Figure 31

Bottlenose Dolphin Survey Sites



- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Station Works Area
- SeaWatch Foundation Land Based Survey Sites

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:500,000

0 5 10 20 Kilometres

0 3 6 12 Nautical Miles

REV	REMARK	DATE
	First Issue for DCO	29/07/2021

Bottlenose Dolphin Survey Sites
Document no: HOW04SM0023
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

7 Harbour seal baseline

7.1.1.1 Harbour seals are the smaller of the two UK seal species, weigh 80-100 kg at adulthood and live for 20-30 years. They mainly forage within 40-50 km from their haul-out site (SCOS 2021) (though recent analysis of telemetry data shows that the maximum distance travelled from a haul-out by harbour seal was 273 km (Carter et al. 2020)), and are generalist feeders that consume a wide range of prey including sandeels, gadoids, herring, sprat, flatfish, octopus and squid (SCOS 2018, 2021). Harbour seals give birth to a single pup in June/July and moult in August, during which times they haul-out on land, usually in sheltered areas such as sandbanks and in estuaries.

7.1.1.2 The UK supports approximately 30% of all European harbour seals and they are mainly found along the west coast of Scotland, in the Moray Firth, Orkney, Shetland, The Wash, the greater Thames Estuary and along the Irish coast. Approximately 16% of the UK population are found in England, with approximately 90% of this total being located along the Lincolnshire and Norfolk coast including The Wash SAC. The Wash harbour seal population declined drastically following both the 1988 and 2002 Phocine Distemper Virus (PVD) epidemics; however, the population size had recovered to pre-2002-epidemic levels by 2012. Unlike many harbour seal populations around the UK that are declining, the population along the east coast of England increased since 2002, however the 2019 August count was lower than expected and could be the first indicator of a decline in the population (SCOS 2021). Overall, the UK harbour seal population has an Unfavourable-Inadequate Conservation Status due to the general decline of most harbour seal colonies along the east coast of Britain (JNCC 2019d).

7.2 August haul-out counts

7.2.1 UK count

7.2.1.1 Not all seal MUs are surveyed every year, therefore the most recent counts from each MU are combined to provide the most up to date UK count. The most recent count across Scotland and England was the period between 2016 and 2019, where a total of 26,846 harbour seals were counted across Scottish MUs and 3,831 harbour seals were counted in the Northeast and Southeast England MUs. Therefore, the total count across Scotland and east England was 30,677 harbour seals (**Table 11**). This can be scaled by the estimated proportion hauled-out at the time of the survey (0.72, 95% CI 0.54 –0.88) (Lonergan et al. 2013) to produce a harbour seal population estimate of 42,607 harbour seals (34,860 – 56,809) (note: this does not include counts for south and west of England, Wales or Northern Ireland). Carter et al. (2020) estimated the at-sea harbour seal population size in the British Isles to be ~42,800 seals.

Table 11: August haul-out counts of harbour seals by MU for the count period 2016-2019 (SCOS 2021).

Seal MU	Count
East Scotland	343
Moray Firth	1,077
North Coast & Orkney	1,405
Northeast England	79
Shetland	3,180
Southeast England	3,752
Southwest Scotland	1,709
West Scotland	15,600
Western Isles	3,532

7.2.2 Southeast England MU count

7.2.2.1 Hornsea Four is located in the Southeast England MU. The most recent August haul-out counts for the Southeast England MU is from 2019, which was surveyed by both SMRU (the Wash area) and the Zoological Society London (the greater Thames area). In 2019 a total of 3,752 harbour seals were counted in the Southeast England MU (SCOS 2021). This scales to an estimated SMA population size of 5,211 (95% CI: 4,264 – 6,948). Within the Southeast England SMA there are five key haul-out areas: The Wash, Essex and Kent, Blakeney Point, Donna Nook and Scroby Sands. By far the largest of these haul-out areas is The Wash where 2,415 harbour seals were counted in August 2019 (Figure 32). 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).

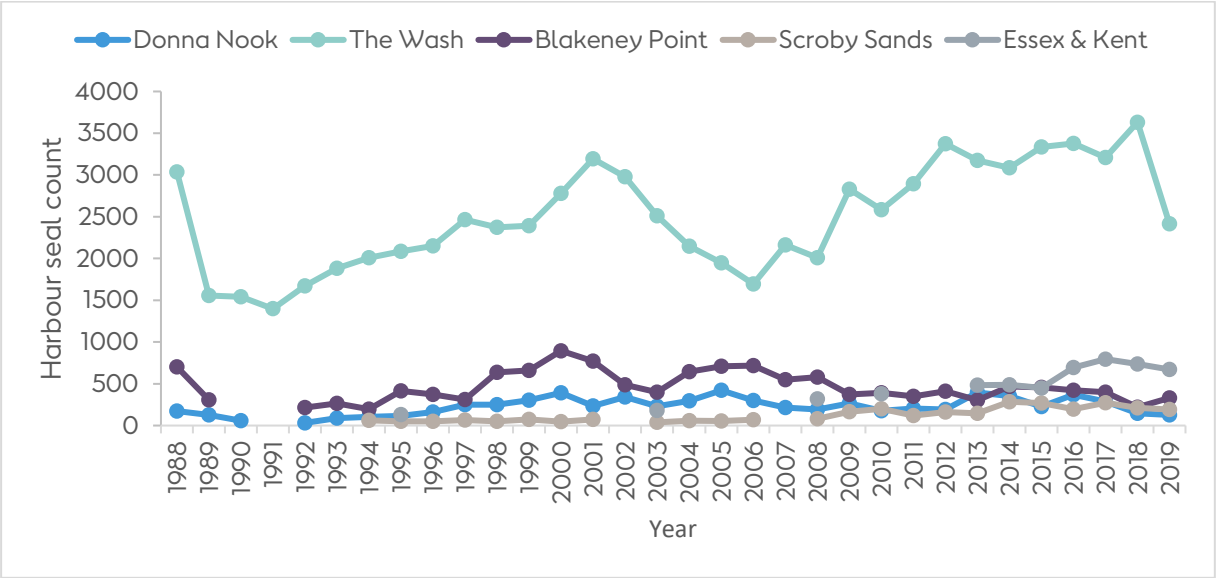


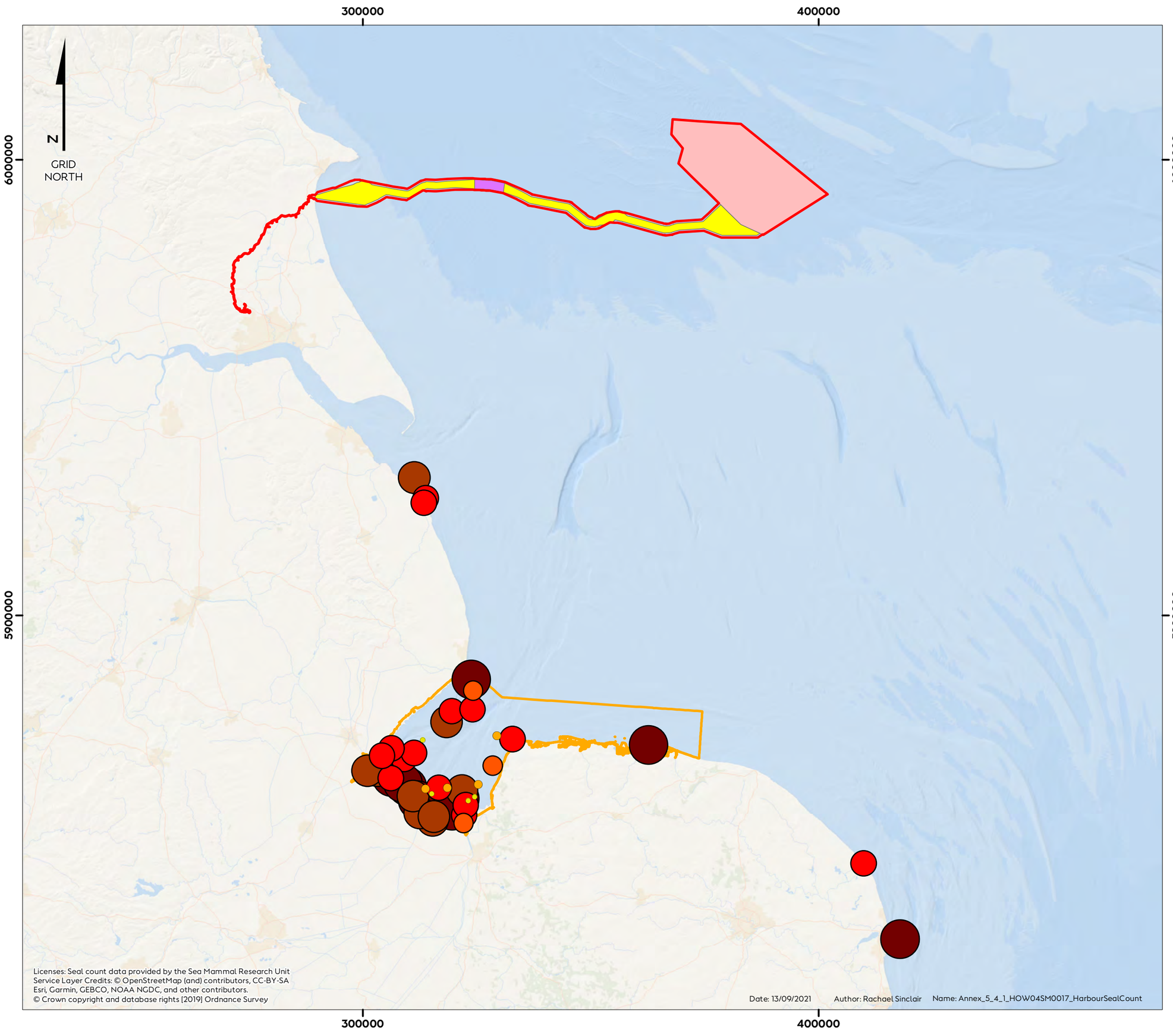
Figure 32: Harbour seal August moult haul-out counts at the five main areas in the Southeast England Seal MU (SCOS 2021).

7.2.2.2 The main harbour seal haul-out location in the Southeast England SMA is The Wash SAC which is located approximately ~103 km swimming distance to the south of the proposed landfall location and approximately ~97 km swimming distance to the southeast of the Hornsea Four array area (**Figure 33**). The closest harbour seal haul-out location to the offshore ECC is located at Donna Nook which is approximately ~60 km swimming distance to the south.

Hornsea Four

Figure 33

Harbour Seal Haul-out Count



- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Station Works Area

Harbour Seal Haul-out Count 2019

- 1-5
- 6-10
- 11-15
- 16-50
- 51-100
- >100

- The Wash SAC

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:800,000

0 5 10 20 Kilometres

0 5 10 20 Nautical Miles

REV	REMARK	DATE
--	First Issue	16/05/2019
A	Updated following PEIR consultations, for DCO	05/02/2020

Harbour Seal Count
Document no: HOW04SM0017
Created by: RRS
Checked by: BPHB
Approved by: LK

Ørsted

Date: 13/09/2021 Author: Rachael Sinclair Name: Annex_5_4_1_HOW04SM0017_HarbourSealCount

7.2.2.3 The telemetry dataset for harbour seals tagged in the Southeast England SMA consists of 86 animals tagged between 2003 and 2016:

- 5 animals tagged at the Wash in 2003;
- 11 animals tagged at the Wash in 2004;
- 8 animals tagged at the Wash in 2005;
- 9 animals tagged at the Thames in 2006;
- 10 animals tagged at the Thames in 2012;
- 23 animals tagged at the Wash in 2012; and
- 20 animals tagged at the Wash in 2016.

7.2.2.4 These telemetry data indicate a small amount of overlap between seal tracks and the Hornsea Four array area (**Figure 35**). Of the 86 animals tagged in the Southeast England SMA (mainly within the Wash SAC), only six seals recorded GPS locations within the Hornsea Four array area. There appears to be limited connectivity between the Hornsea Four array area and the Wash SAC for harbour seals; which is as expected since the Wash SAC is ~103 km swimming distance from the Hornsea Four array area, and is therefore outside of the typical harbour seal foraging ranges of 40-50 km from a haul-out (SCOS 2018).

7.3 At-sea density

7.3.1.1 For comparative reasons, both the older seal at-sea usage maps (Russell et al. 2017) and the new seal habitat preference maps (Carter et al. 2020) are discussed here. However it should be noted that the new habitat preference maps are considered to be the better data source for estimates of at-sea densities since they a) use more recent data b) use better quality data, and c) remove the null usage assumptions.

7.3.1.2 Both maps predict patchy use of UK waters by harbour seals, with hotspots of usage in the west coast of Scotland, Orkney, Shetland, the Moray Firth, The Wash and the Greater Thames Estuary (**Figure 34** –please note the different scales used in the two maps). The harbour seal at-sea usage map does not estimate high densities of harbour seals within the Hornsea Four array area or the offshore ECC. The grid cell with the highest at-sea usage density within the Hornsea Four array area estimated 2.98 harbour seals per cell (0.12 seals/km^2). Almost all of the grid cells located within the Hornsea Four array area have an estimated at-sea usage density of <1 seal/cell. As with the at-sea usage map, the harbour seal habitat preference map does not predict high densities of harbour seals within the Hornsea Four array area or the offshore ECC. The grid cell with the highest habitat preference density within the Hornsea Four Order Limits is 0.018 seals/km^2. All cells within the array area and the offshore ECC are predicted to have a habitat preference density of <1 seal/cell. For both the at-sea usage and the habitat preference map, the area of higher predicted density within and surrounding The Wash does not extend as far as Hornsea Four.

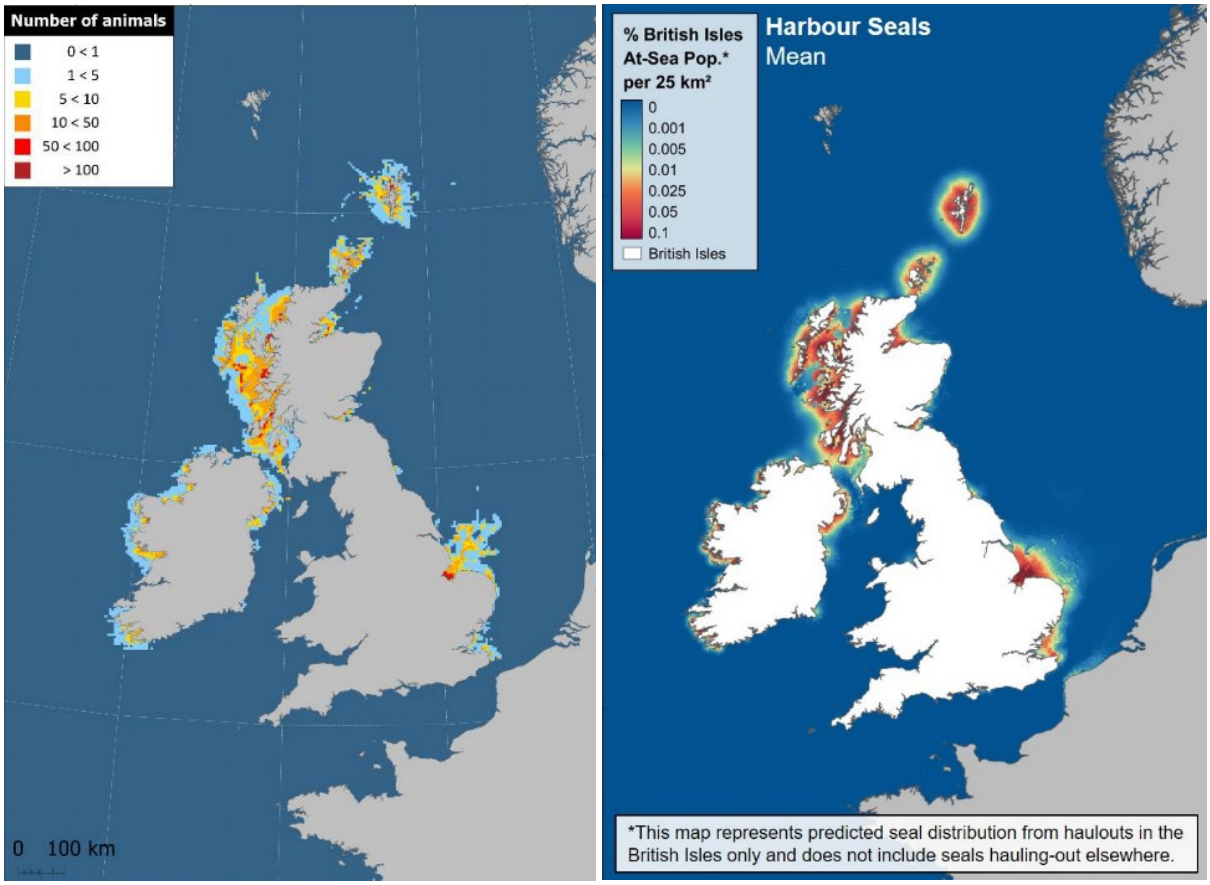


Figure 34 Harbour seal at-sea distributions. Left = Mean at-sea usage from Russell et al. (2017). Right = Updated mean at-sea population from Carter et al. (2020) (note difference in scale, Russell et al., 2017 is number of seals per grid cell, Carter et al., 2020 is % of British Isles at-sea population per grid cell).