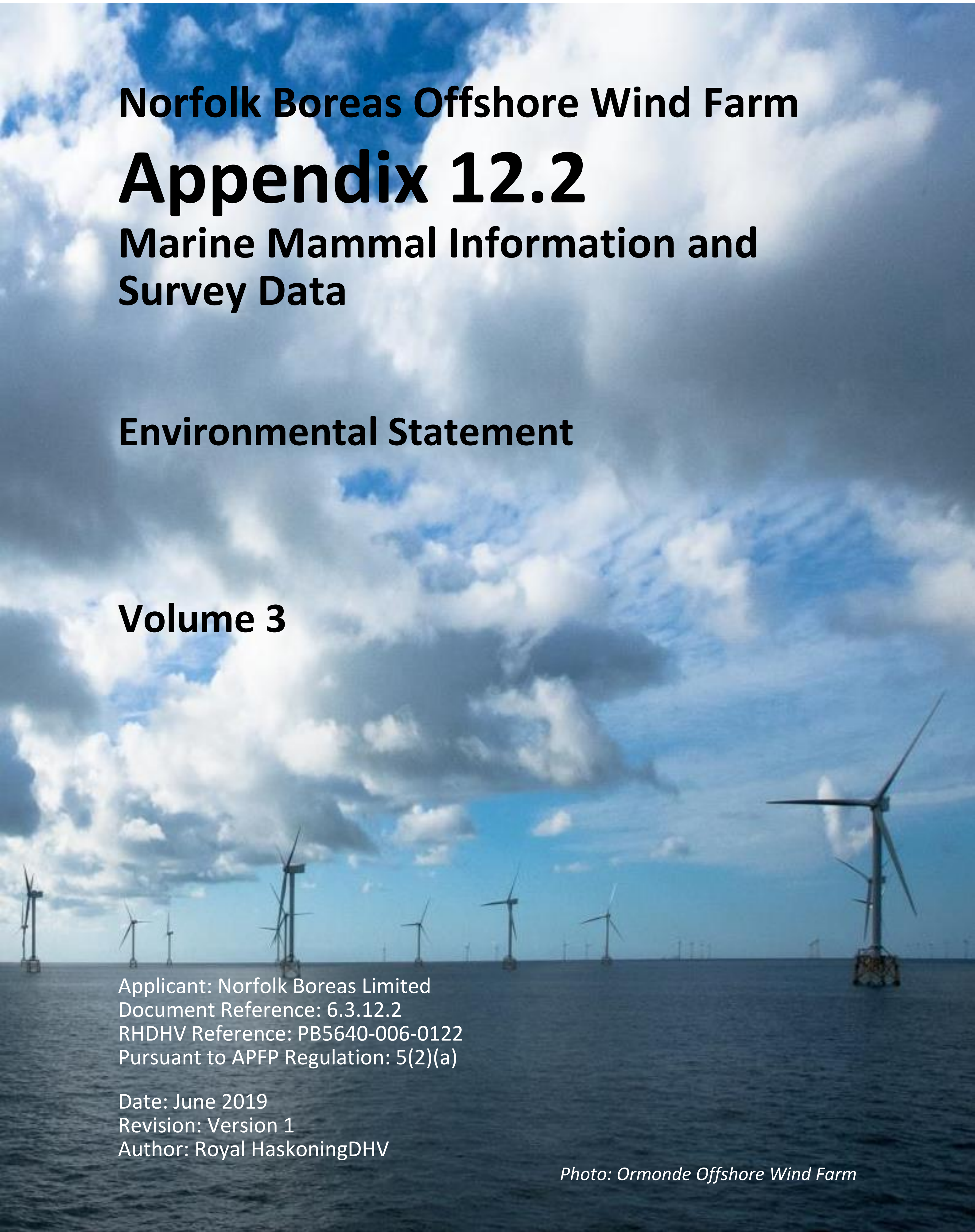


Norfolk Boreas Offshore Wind Farm

Appendix 12.2

Marine Mammal Information and Survey Data

Environmental Statement

Volume 3

Applicant: Norfolk Boreas Limited
Document Reference: 6.3.12.2
RHDHV Reference: PB5640-006-0122
Pursuant to APFP Regulation: 5(2)(a)

Date: June 2019
Revision: Version 1
Author: Royal HaskoningDHV

Photo: Ormonde Offshore Wind Farm

Date	Issue No.	Remarks / Reason for Issue	Author	Checked	Approved
22/02/2019	01D	First draft for Norfolk Boreas Limited review	GS	JL/DT	AD
19/03/2019	02D	Second draft for Norfolk Boreas Limited review	GS	JL/DT	PP
10/04/2019	01F	Final Version for DCO submission	GS	JL/DT/JKL	JL

Table of Contents

Tables

Plates

Glossary of Acronyms

ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
AWAC	Acoustic Wave and Current
CF	Correction Factor
CGNS	Celtic and Greater North Seas
CGNS	Celtic and Greater North Seas
CI	Confidence Intervals
cm	Centimetre
CODA	Cetacean Offshore Distribution and Abundance in the European Atlantic
CS	Continental Shelf
CV	Coefficient of Variation
DECC	Department of Energy and Climate Change
EAOW	East Anglia Offshore Wind
EAOWFL	East Anglia Offshore Wind Farm Limited
EATL	East Anglia THREE Ltd
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPS	European Protected Species
ES	Environmental Statement
ETG	Expert Topic Group
GNS	Greater North Sea
GSD	Ground Sampling Distance
HRA	Habitats Regulation Assessment
IAMMWG	Inter-Agency Marine Mammal Working Group
JCP	Joint Cetacean Protocol
JNCC	Joint Nature and Conservation Committee
km	Kilometre
km^2	Kilometre squared
m	Metre
MATL	Marine Atlantic
mg/l	Milligram per litre
MU	Management Unit
NE	Natural England
nm	Nautical mile
NNR	National Nature Reserve
OWF	Offshore Wind Farm
PEIR	Preliminary Environmental Information Report
QA	Quality Assurance
SAC	Special Area of Conservation
SCANS	Small Cetaceans in European Atlantic waters and the North Sea
SCOS	Special Committee on Seals
SMRU	Sea Mammal Research Unit

SST	for sea surface temperature
WWT	Wildfowl and Wetlands Trust
ZEA	Zonal Environmental Appraisal

Glossary of Terminology

Array cables	Cables which link wind turbine to wind turbine, and wind turbine to offshore electrical platforms.
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to the EIA and information to support HRA.
Interconnector cables	Offshore cables which link offshore electrical platforms within the Norfolk Boreas site
Landfall	Where the offshore cables come ashore at Happisburgh South.
Norfolk Boreas site	The Norfolk Boreas wind farm boundary. Located offshore, this will contain all the wind farm array.
Norfolk Vanguard	Norfolk Vanguard offshore wind farm, sister project of Norfolk Boreas.
Norfolk Vanguard OWF sites	Term used exclusively to refer to the two distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West (also termed NV East and NV West) which will contain the Norfolk Vanguard arrays.
Offshore cable corridor	The corridor of seabed from the Norfolk Boreas site to the landfall site within which the offshore export cables will be located.
Offshore electrical platform	A fixed structure located within the Norfolk Boreas site, containing electrical equipment to aggregate the power from the wind turbines and convert it into a suitable form for export to shore.
Offshore export cables	The cables which transmit electricity from the offshore electrical platform to the landfall.
Offshore project area	The area including the Norfolk Boreas site, project interconnector search area and offshore cable corridor.
Offshore service platform	A platform to house workers offshore and/or provide helicopter refuelling facilities. An accommodation vessel may be used as an alternative for housing workers.
Project interconnector cable	Offshore cables which would link either turbines or an offshore electrical platform in the Norfolk Boreas site with an offshore electrical platform in one of the Norfolk Vanguard sites.
Project interconnector search area	The area within which project interconnector cables would be installed.
Safety zone	An area around a vessel which should be avoided during offshore construction.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.
The Applicant	Norfolk Boreas Limited.
The project	Norfolk Boreas Wind Farm including the onshore and offshore infrastructure.

1 Marine Mammal Information

1.1 Introduction

1. This section of Appendix 12.2 provides information on marine mammals species relevant to the Norfolk Boreas project.

2. In UK waters, two groups of marine mammals occur: cetaceans (whales, dolphins and porpoises) and pinnipeds (seals). The data presented by Reid et al*.* (2003), SCANS-I (Hammond et al*.,* 2002), SCANS-II (Hammond et al., 2013), SCANS-III (Hammond et al*.,* 2017) and the Joint Nature and Conservation Committee (JNCC) (2013) indicate the marine mammal species that occur regularly over large parts of the southern North Sea are harbour porpoise *Phocoena phocoena*, grey seal *Halichoerus grypus*, harbour seal *Phoca vitulina*, white-beaked dolphin *Lagenorhynchus albirostris* and minke whale *Balaenoptera acutorostrata*.

3. Marine mammal species, including Atlantic white-sided dolphin *Lagenorhynchus acutus*, bottlenose dolphin *Tursiops truncatus*, killer whale *Orcinus orca*, sperm whale *Physeter macrocephalus*, long-finned pilot whale *Globicephala melas*, Risso's dolphin *Grampus griseus*, striped dolphin *Stenella coeruleoalba* and other seal species are occasional or rare visitors to the southern North Sea (e.g. Reid et al*.,* 2003; Hammond et al*.,* 2013, 2017; Department of Energy and Climate Change (DECC), 2016; Special Committee on Seals (SCOS), 2017). Species considered as occasional or rare visitors have not been considered further in the description of the existing environment for marine mammals.

1.2 Cetaceans

4. Cetacean populations occurring in UK waters are generally wide-ranging; their distribution and abundance vary considerably over time and space, influenced by both natural and anthropogenic factors (Reid et al*.,* 2003). There may be areas of regular high density for some species, but how important these areas are in comparison to others in their natural range, is still generally unknown (Reid et al*.,* 2003). Given that these species are not constrained to UK waters and are known to travel considerable distances, the assessment is made over a wider geographic context to incorporate potential population impacts throughout their range.

5. Compared to the central and northern North Sea, the southern North Sea has a relatively low abundance of marine mammals, with the exception of the harbour porpoise (DECC, 2016). Ten species of cetacean have been recorded within the southern North Sea, however, only harbour porpoise can be considered to be common to the area throughout the year, with white-beaked dolphin and minke whale occurring as seasonal visitors (DECC, 2016).

6. The Joint Cetacean Protocol (JCP) report (Paxton et al*.,* 2016) indicates that the only cetacean species recorded in significant number within the Norfolk Bank Development Area (which includes the Norfolk Boreas offshore project area) is harbour porpoise, while there are low numbers of minke whale, bottlenose dolphin, common dolphin and white-beaked dolphin and no records of Risso's dolphin or Atlantic white-sided dolphin within the Norfolk Bank Development Area (Paxton et al*.,* 2016).

7. MARINElife (2019), a UK-based charity, record marine mammal and seabird sightings from a variety of platforms, including ferry routes crossing the southern North Sea area. Cetacean species recorded on the ferry route from Rosyth to Zeebrugge, passing near the Norfolk Boreas offshore project area, in 2017 included 67 harbour porpoise (60 in May), 54 grey seal (52 in May), 15 white-beaked dolphin (in May), four minke whale (in May), three common dolphin and one harbour seal. Up to May 2018, the same route has recorded six harbour porpoise, four unidentified dolphin species, three unidentified seal species, two grey seal, one bottlenose dolphin, one common dolphin and one harbour seal. From the 2017 survey data, it is clear that the majority of marine mammal sightings were made in May, although it should be noted that out of all the surveys undertaken, this likely would have had the best environmental conditions for the sighting of marine mammals. The Hull to Zeebrugge route, also passing near the Norfolk Boreas offshore project area, recorded 13 harbour porpoise (one non-effort related), two bottlenose dolphin, two unidentified dolphin or porpoise (non-effort related) and one unidentified whale species (non-effort related) in 2017. The surveys undertaken on this route in 2018 sighted a total of nine harbour porpoise, three grey seal, one harbour seal and one unidentified cetacean. It should be noted that from the sightings reports on the MARINElife (2019) website it is difficult to locate exactly where along the ferry routes the sightings were made, and therefore could have been at any point between the two port locations.

8. Sea Watch volunteer cetacean sightings for the East of England coast in 2017 and 2018 are predominantly harbour porpoise, the other cetacean species that have been recorded include white-beaked dolphin off the Suffolk coast, common dolphin in the river Thames and off the coast of Lincolnshire and Norwich, one beluga off the coast of Kent, and one minke whale off the Norfolk coast (Sea Watch Foundation, 2019).

9. During the 2009-2011 surveys, as part of the former East Anglia Zone, low numbers of cetaceans were recorded, with only 108 individual cetaceans identified from the 17 months of aerial data (East Anglia Offshore Wind (EAOW), 2012c). The majority of the cetaceans positively identified in aerial surveys were harbour porpoise, which accounted for 38% of sightings, with an additional 53% listed as 'small cetaceans'

(which are most likely to be harbour porpoise, but as identification could not be confirmed they are classed as small cetaceans). A further 6% of aerial sightings were identified as 'patterned dolphins' (which are most likely to be white-beaked dolphin) (EAOW, 2012c).

10. During 24 months of aerial surveys covering the East Anglia ONE site, 62 km to the south of Norfolk Boreas, 181 cetaceans in total were recorded, 130 of which (72%) were positively identified as harbour porpoise, 12.5% identified as either a porpoise or small cetacean (which were most likely to be harbour porpoise), 0.5% as a patterned dolphin, and 15% were recorded as unidentified cetacean species (EAOW, 2012b).

11. The boat based survey data from the East Anglia ONE site identified 83% of all cetaceans recorded as being harbour porpoise. The boat based surveys also recorded low numbers of three dolphin species: white-beaked dolphin (8%), bottlenose dolphin (6%) and Risso's dolphin (2%), as well as unidentified dolphin species (2%). On the basis of the boat-based survey results, it was considered likely that the majority of 'small cetaceans' recorded from the former Zone's aerial surveys were harbour porpoise (East Anglia Offshore Wind Farm Limited (EAOWFL), 2012).

12. During the 24 months (September 2011 to August 2013) of East Anglia THREE aerial surveys which were located approximately 14km south of Norfolk Boreas, 341 cetaceans in total were recorded within the East Anglia THREE site and buffer area, 149 of which (44%) were positively identified as harbour porpoise, and a further 188 (55%) identified as either a porpoise or small cetacean. Four white beaked dolphin were also recorded (East Anglia THREE Ltd (EATL), 2015).

13. For the 23 months of available data for the East Anglia ONE North surveys (for September 2016 to July 2018), a total of 232 marine mammals were recorded over the East Anglia ONE North windfarm site and 4km buffer area. Of these, 7.3% were identified as harbour porpoise (n=17), with a further 83.2% identified as small cetaceans (n=193). A total of 2 individuals were identified as dolphin species (but were not identified to species level) and 20 as seal species (SPR, 2019a)

14. The East Anglia TWO surveys covered a period of 21 months (for November 2015 to April 2016, September 2016 to October 2017, and May 2018, and recorded a total of 436 marine mammals. Of these, 15.8% (n=69) were identified as harbour porpoise, 80.7% (n=352) were identified as small cetaceans, and three sightings were made of dolphin species, with a further 12 as seal species (SPR, 2019b).

15. During the Norfolk Vanguard East site surveys, including the East Anglia FOUR surveys, from March 2012 to April 2016 for the offshore wind farm site area and 4km buffer, 636 cetaceans were recorded, with 249 (39% of recorded sightings) identified

as harbour porpoise and 373 (59% of recorded sightings) classed as unidentified small cetacean (which have been included as harbour porpoise for the impact assessment). Three white-beaked dolphin, two common dolphin, two patterned dolphin and seven unidentified dolphin species were also recorded (Norfolk Vanguard Limited, 2018).

16. During Norfolk Vanguard West the site surveys from September 2015 to August 2017 for the site area and 4km buffer, 478 cetaceans were recorded, of which 144 (30% of recorded sightings) were identified as harbour porpoise and 317 (66% of recorded sightings) classed as unidentified small cetacean (which have been included as harbour porpoise for the impact assessment). Thirteen unidentified dolphin and four white-beaked dolphin were also recorded (Norfolk Vanguard Limited, 2018).

17. The Norfolk Boreas site specific surveys for the wind farm area and 4km buffer, identified a total of 930 marine mammals, 708 (76%) of which were unidentified small cetaceans (considered to be harbour porpoise within the impact assessment as a worst-case scenario), 194 (21%) harbour porpoise, 27 unidentified seal species (3%), and one unidentified dolphin species. It should be noted that the area of the Norfolk Boreas site (725km^2) is greater than the Norfolk Vanguard sites (total area for both sites is 592km^2) and East Anglia THREE (301km^2), which is reflected in the higher numbers of marine mammals recorded in the Norfolk Boreas site compared to other offshore wind farms in the former East Anglia Zone.

18. As outlined above, the available data from the Norfolk Boreas site specific survey, surveys within the former Zone, surveys for other offshore wind farms in the southern North Sea and other data sources, including SCANS-II (Hammond et al*.*, 2013), SCANS-III (Hammond et al*.,* 2017), indicate that harbour porpoise is the most abundant cetacean species present within this region, with occasional sightings of dolphin species (most likely white-beaked dolphin), with rare sightings of low numbers of other cetaceans.

19. The data and information sources are outlined in Table 12.11 in section 12.5.2 of Chapter 12 Marine Mammal Ecology.

1.2.1 Harbour porpoise

1.2.1.1 Distribution

20. Harbour porpoise is the most commonly sighted cetacean in the North Sea (Reid et al., 2003; Wildfowl and Wetlands Trust (WWT), 2009; ASCOBANS, 2012; Hammond et al., 2013, 2017; Sea Watch Foundation, 2017) and is the cetacean most likely to be observed in the Norfolk Boreas offshore project area.

21. Harbour porpoise distribution is generally restricted to the temperate and sub-arctic waters of the Northern Hemisphere, mainly on the continental shelf at depths of 20-

200m and primarily within water temperatures ranging from 11 to 14^{o}C (DECC, 2016; Reid et al*.,* 2003).

22. The JNCC Cetacean Atlas (Reid et al*.,* 2003) recorded sightings of harbour porpoise throughout the southern North Sea, although the overall sightings were low in this region compared to the north and central North Sea (Reid et al*.,* 2003).

23. Data on the distribution of marine mammals in UK areas of the North Sea have also been collected opportunistically during aerial surveys for birds conducted by WWT Consulting from 2001-2008 (WWT, 2009). Between 2001 and 2008, a total of 4,588 sightings, comprising 5,439 individual animals, were made of harbour porpoise (WWT, 2009). The results show a similar distribution in occurrence to those presented in Reid et al*.* (2003), with higher relative densities close to shore around the east coast and off the Lincolnshire and Yorkshire coasts, but with much higher relative densities recorded off the coast between Norfolk and Kent. Results for the WWT surveys are also similar to those recorded during SCANS-II, in which higher numbers of harbour porpoise were recorded in the southern North Sea areas than the more northerly survey areas.

24. A series of large scale surveys for cetaceans in European Atlantic waters was initiated in summer 1994 in the North Sea and adjacent waters (SCANS, 1995; Hammond et al*.,* 2002) and continued in summer 2005 in all shelf waters (SCANS-II, 2008; Hammond et al*.,* 2013). Despite no overall change in population size between the SCANS-I and SCANS-II surveys, large scale changes in the distribution of harbour porpoise were observed between 1994 and 2005, with the main concentration shifting from North eastern UK and Denmark to the southern North Sea. Such large scale changes in the distribution of harbour porpoise are likely the result of changes to the availability of principal prey within the North Sea (SCANS-II, 2008).

25. Initial data from the SCANS-III survey also indicates that the occurrence of harbour porpoise is greater in the central and southern areas of the North Sea compared to the northern North Sea (Plate 1.1; Hammond et al*.,* 2017), which is consistent with SCANS-II. Modelling of the new data from 2016 to investigate fine scale distribution and habitat use is in progress.

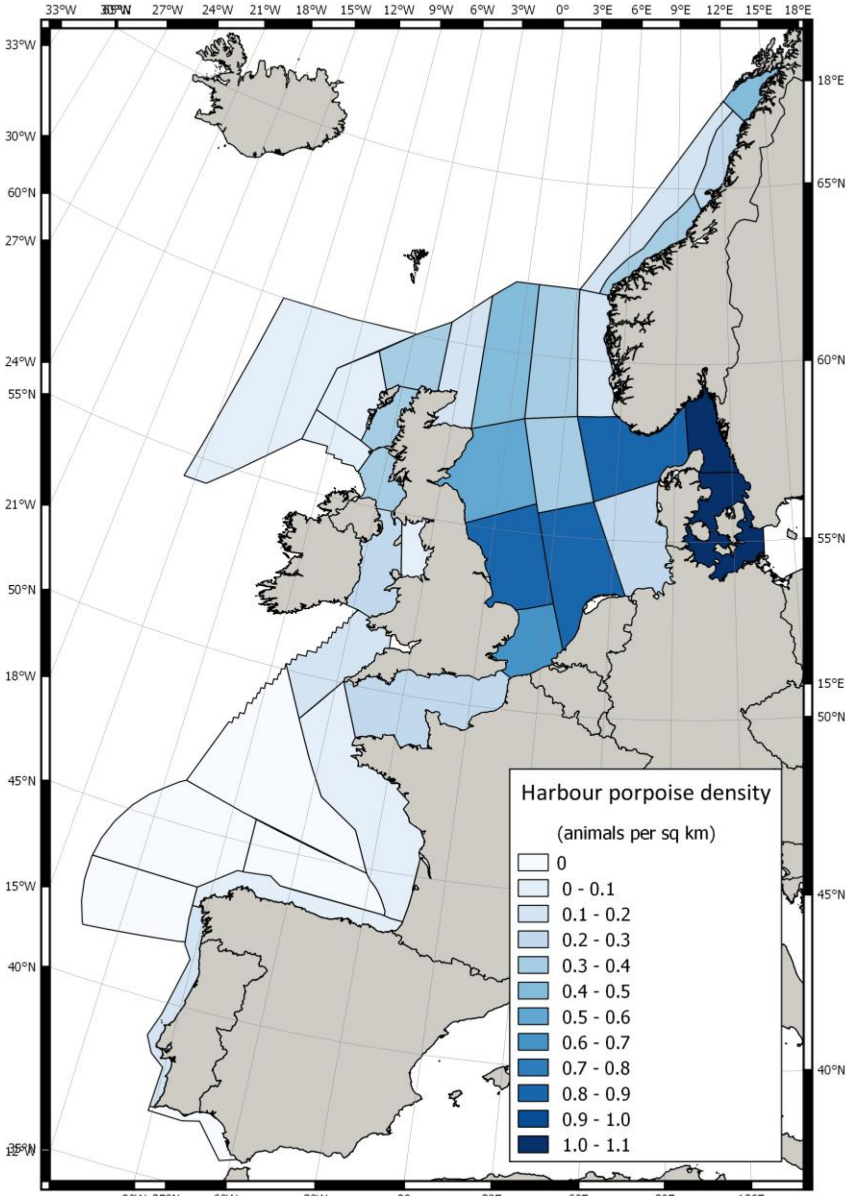


Plate 1.1 Estimated density of harbour porpoise in each SCANS-III survey block (Source: Hammond et al., 2017)

26. Statistical modelling of 18 years of survey data between 1994 and 2011 of the entire UK Exclusive Economic Zone (EEZ) for harbour porpoise using the JCP data together with environmental data (such as water depth, hydrodynamics, sediments and shipping) was undertaken by Heinänen and Skov (2015) to identify discrete and persistent areas of relatively high harbour porpoise density. The model results (Heinänen and Skov, 2015) indicated that the sampled densities of harbour porpoise were influenced by both oceanographic and anthropogenic pressure variables. The coarseness of surface sediments played a major role in the presence and density of porpoises. Water depth and hydrodynamic variables also had an influence on harbour porpoise distribution in the North Sea, with peaks in preferences during

summer at depths of 40m and 200m. Other variables included surface salinity, stability of the water column (described by temperature differences), stratification and eddy activity. The model results also indicated a negative relationship between the number of ships and the distribution of harbour porpoise in the North Sea (Heinänen and Skov, 2015).

27. Within the southern North Sea, Heinänen and Skov (2015) identified one area of high harbour porpoise density; from the western slopes of Dogger Bank south along a 30m depth contour towards an area off the Norfolk coast. This was further split into three areas due to inter-annual variations:

- North-western edge of Dogger Bank (summer);
- Inner Silver Pit; and
- Offshore area east of Norfolk and east of outer Thames estuary (winter).

28. The Heinänen and Skov (2015) analysis was used in the identification of potential SACs for harbour porpoise in UK waters (see section 1.2.4).

29. Gilles et al. (2016) assessed nine years of harbour porpoise survey data (2005 to 2013) collected in the UK (SCANS II, Dogger Bank), Belgium, the Netherlands, Germany, and Denmark, to develop seasonal habitat-based density models for the central and southern North Sea. The models indicated that densities generally increased with day length, with highest densities predicted when day length exceeded 14.5 hours during the months of June through August. The highest harbour porpoise density occurred 150km offshore and at depths between 25 and 40m. Harbour porpoise densities also increased with higher probability for sea surface temperature (SST) fronts and decreased with distance to sandeel grounds.

30. The seasonal maps produced by Gilles et al. (2016) for harbour porpoise density across the central and south-eastern North Sea were consistent with previously described seasonal patterns of harbour porpoise distribution. The spring seasonal density map indicated major hotspots in the southern and south-eastern part of the North Sea, mainly inshore close to the Belgian and Dutch coasts extending toward the German coast off the East Frisian Islands. The model also predicted high densities in the area of the Sylt Outer Reef in the German North Sea as well as north off the coast of Jutland in Denmark. Another potential hotspot in spring was at Dogger Bank and the area north-west of this large sandbank (Gilles et al., 2016). In summer, there was an apparent shift, compared to spring, toward offshore and western areas, with a large hotspot present off the German and Danish west coast that extended toward the Dogger Bank. The seasonal model for autumn indicated lower densities compared to spring and summer, the distribution was spatially heterogeneous and areas with higher densities were predicted north-west of the Dogger Bank and off the German and Danish west coasts (Gilles et al., 2016).

31. The JCP Phase-III report (Paxton et al*.,* 2016) indicated that for the Norfolk Bank development area (an area including the former East Anglia Zone and totalling 14,295km^2), abundances of harbour porpoise ranged from 5,300 (Confidence Interval (CI) = 2,600-15,600) in the spring and 13,700 (CI = 7,000-26,200) in the winter, with numbers in summer and autumn being in between this range. The Norfolk Bank development area covers 2.4% of the North Sea Management Unit (MU), but the abundance estimate of harbour porpoise in this area equates to 13.9% (CI = 8.9-19.2%) of the North Sea MU, indicating a high use of the area (Paxton et al*.,* 2016). Plate 1.2 illustrates the distribution of harbour porpoise, based on modelled densities for summer 2010 from the JCP Phase-III report.

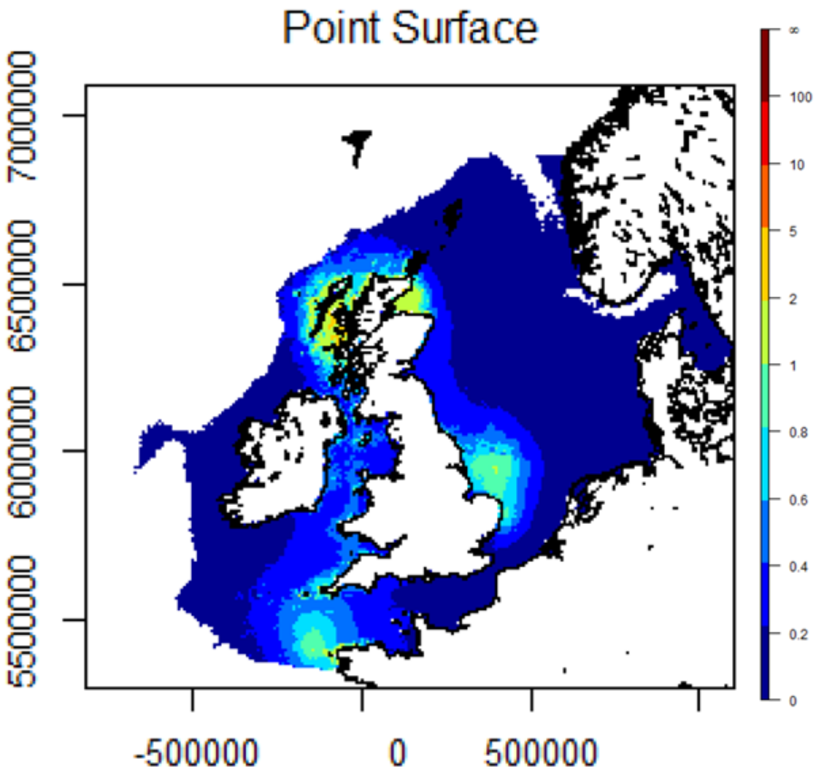


Plate 1.2 Distribution of harbour porpoise based on predicted JCP harbour porpoise densities (animals/km^2) for summer 2010 (Source: Paxton et al*.,* 2016).

1.2.1.2 Diet

32. The main prey fish species of harbour porpoise typically include sandeels, (Ammodytidae spp.), whiting *Merlangius merlangus*, herring *Clupea harengus*, mackerel *Scomber scombrus*, sprat *Sprattus sprattus*, cod *Gadus morhua*, haddock *Melanogrammus aeglefinus*, saithe *Pollachius virens*, pollack *Pollachius pollachius*, Norway pout *Trisopterus esmarkii* as well as flat fish such as flounder *Platichthys flesus* and sole *Solea solea* (Rogan and Berrow, 1996; Reid et al*.,* 2003; Santos and Pierce, 2003; Santos et al., 2004; Evans and Baines, 2010).

33. See Environmental Statement (ES) Chapter 12 for further information on diet.

1.2.1.3 Abundance and density estimates

1.2.1.3.1 North Sea MU

34. Harbour porpoise within the eastern North Atlantic are generally considered to be part of a continuous biological population that extends from the French coastline of the Bay of Biscay to northern Norway and Iceland (Tolley and Rosel, 2006; Fontaine et al., 2007, 2014; IAMMWG, 2015). However, for conservation and management purposes, it is necessary to consider this population as smaller Management Units (MUs). MUs provide an indication of the spatial scales at which effects of plans and projects alone, and in-combination, need to be assessed for the key cetacean species in UK waters, with consistency across the UK (IAMMWG, 2015).

35. The IAMMWG defined three MUs for harbour porpoise: North Sea; West Scotland (WS); and the Celtic and Irish Sea (CIS). Norfolk Boreas is located in the North Sea MU which comprises ICES area IV, VIId and part of Division IIIa (Skagerrak and northern Kattegat (Plate 1.3).

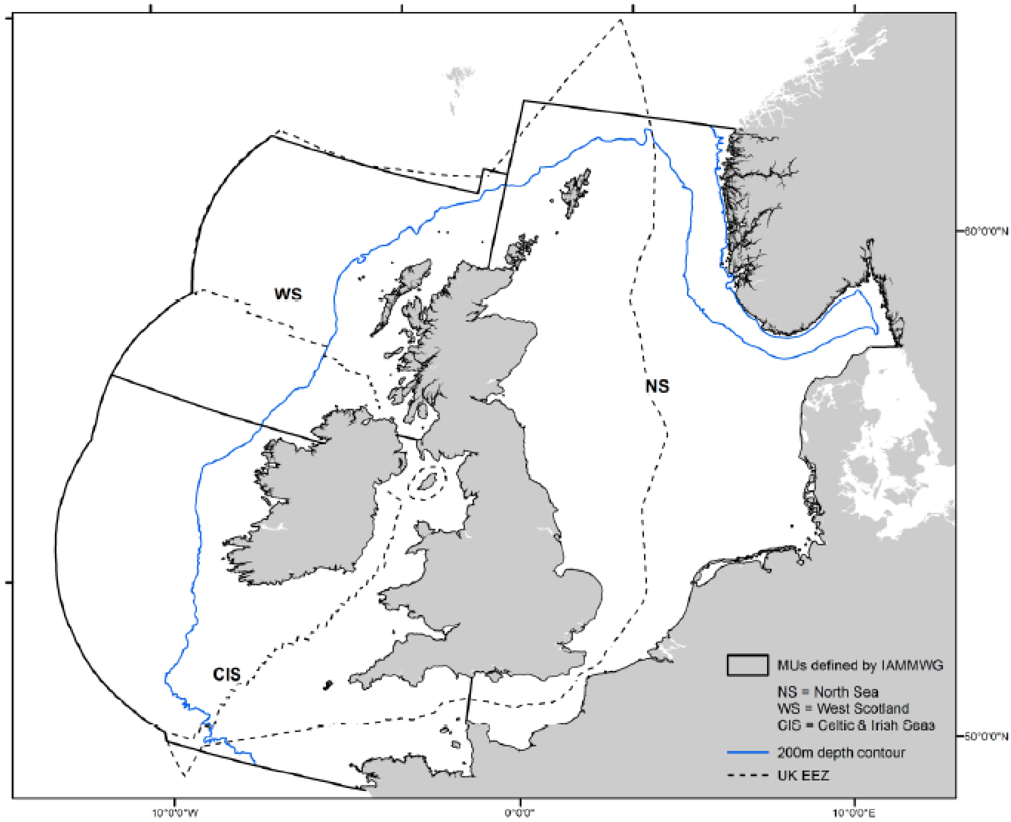


Plate 1.3 Harbour porpoise MUs (Source: IAMMWG, 2015)

36. The SCANS-III estimate of harbour porpoise abundance in the North Sea MU was 345,373 (Coefficient of Variation (CV) = 0.18; 95% CI = 246,526-495,752) with a density estimate of 0.52/km^2 (CV = 0.18; Hammond et al*.,* 2017). This is the reference population for harbour porpoise, as agreed with Natural England as part of

the Norfolk Vanguard EPP (letter dated 03/01/2018) and this approach was agreed for the Norfolk Boreas at the ETG meeting on 12th March 2018.

1.2.1.3.2 SCANS data

37. In July 2005, SCANS-II surveyed the entire EU Atlantic continental shelf to generate robust estimates of abundance for harbour porpoise and other cetacean species. For the entire SCANS-II survey area, harbour porpoise abundance in the summer of 2005 was estimated to be 375,358 (CV = 0.197, 256,304-549,713; Hammond et al., 2013). The Norfolk Boreas site lies both within the SCANS-II survey block B and U. It was estimated that the abundance of harbour porpoise in survey block B (Plate 1.4) was 40,927 (CV = 0.38) with an estimated mean density of 0.331 individuals per km^2 (CV = 0.38) and for block U the abundance was estimated at 93,938 (CV = 0.28) with a density of 0.598 individuals per km^2 (CV = 0.28) (Hammond et al*.,* 2013).

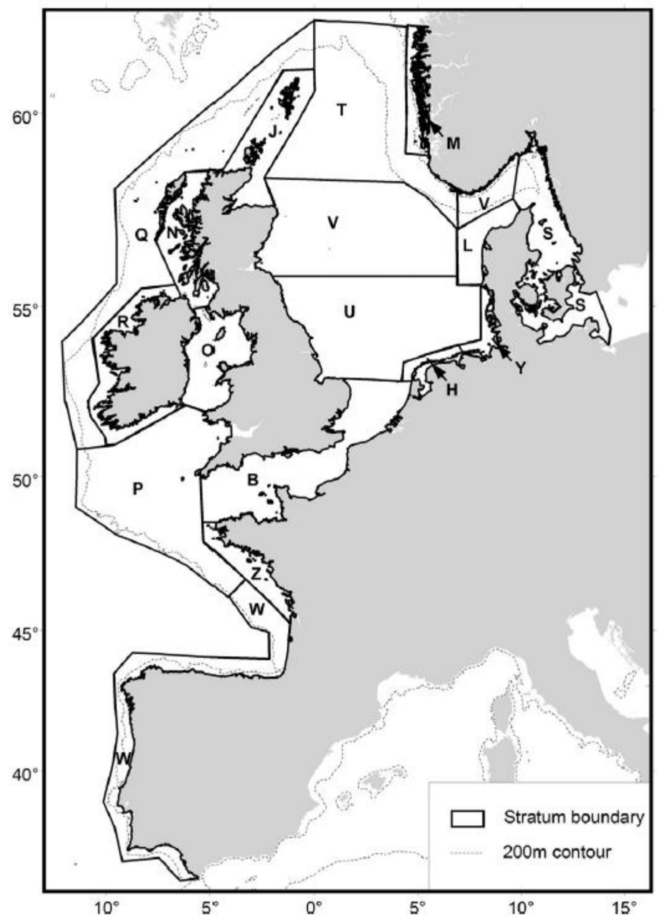


Plate 1.4 Survey blocks for the SCANS-II surveys (Source: Hammond et al., 2013)

38. SCANS-III in the summer of 2016 surveyed all European Atlantic waters from the Strait of Gibraltar in the south to 62°N in the north and extending west to the 200nm limits of all EU Member States (Plate 1.5; Hammond et al., 2017). The survey area was not the same as SCANS-II. For the entire SCANS-III survey area, harbour

porpoise abundance in the summer of 2016 was estimated to be 466,569 with an overall estimated density of 0.381/km^2 (CV = 0.154; 95% CI = 345,306-630,417; Hammond et al*.,* 2017).

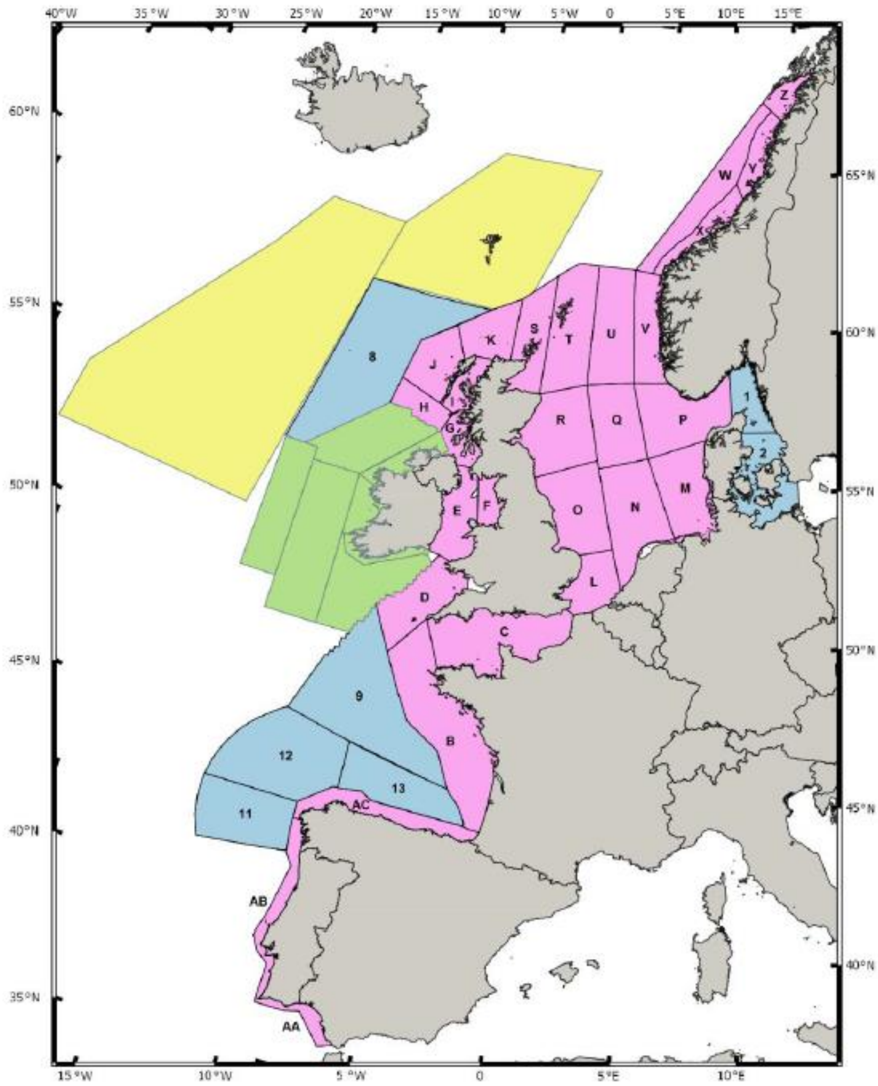


Plate 1.5 Survey blocks covered by SCANS-III and adjacent surveys (Source: Hammond et al*.,* 2017).
SCANS-III = pink lettered blocks surveyed by air; blue numbered blocks were surveyed by ship. Blocks coloured green to the south, west and north of Ireland were surveyed by the Irish ObSERVE project. Blocks coloured yellow were surveyed by the Faroe Islands as part of the North Atlantic Sightings Survey in 2015.

39. The Norfolk Boreas site is located in both SCANS-III survey blocks L and O (Plate 1.5):

- The estimated abundance of harbour porpoise in SCANS-III survey block L is 19,064 harbour porpoise (CV = 0.38; 95% CI = 6,933-35,703), with an estimated density of 0.607 harbour porpoise/km^2 (CV = 0.38; Hammond et al., 2017).

- The estimated abundance of harbour porpoise in SCANS-III survey block O is 53,485 harbour porpoise (CV = 0.21; 95% CI = 37,413-81,695), with an estimated density of 0.888 harbour porpoise/km^2 (CV = 0.21; Hammond et al., 2017).

40. It should be noted that SCANS data is corrected for any animals that might be missed (Hammond et al*.,* 2017) and therefore the application of any further correction factors is not required.

1.2.1.3.3 East Anglia THREE site

41. Aerial surveys were conducted for the East Anglia THREE site plus a 4km buffer between September 2011 and August 2013. The East Anglia THREE aerial surveys indicated harbour porpoise occurred across the East Anglia THREE site plus buffer during both survey years. During the East Anglia THREE aerial surveys high resolution aerial stills capture marine mammals both above and just below the surface. The mean estimates of density were generated from the East Anglia THREE site plus buffer using counts with a correction factor (based on the JCP Phase II report (Paxton et al*.,* 2011)) to take into account animals that were not seen (EATL, 2015). The estimated mean density of harbour porpoise within the East Anglia THREE site plus buffer across the full 24 month survey period was 0.179 individuals per km^2 and for all sightings classified as 'unidentified small cetacean' that were assumed to be harbour porpoise the estimated density was 0.294 individuals per km^2 (EATL, 2015).

1.2.1.3.4 Norfolk Vanguard site specific surveys

42. The Norfolk Vanguard site specific surveys included 32 months of data for Norfolk Vanguard East, and 24 months for Norfolk Vanguard West. The Norfolk Vanguard East survey data included a 4km buffer, with an overlap with the Norfolk Boreas Site. In addition, the two project interconnector cable search areas for Norfolk Boreas are within both the Norfolk Vanguard East and West project boundaries.

43. The Norfolk Vanguard site specific surveys were undertaken using the same methodologies as that of the Norfolk Boreas site specific surveys.

44. At Norfolk Vanguard East (NV East) (without buffer as this provides the worst-case scenario), when unidentified small cetaceans are included with the harbour porpoise data, the highest density estimate was in February 2016, with an uncorrected density estimate of 1.73/km^2 (Confidence Interval (CI) = 1.16-2.32). The corrected density estimates when using the seasonal correction factor is 3.65/km^2 for the offshore wind farm site (without buffer). However, the other monthly density estimates for harbour porpoise, including unidentified small cetaceans, are considerably lower than the February estimate.

45. The annual mean density estimate, when using the seasonal correction factor is 1.26/km^2 for NV East (without buffer).

46. The density estimate during summer (April to September) is 0.73/km^2 and during the winter (October to March) the estimated density is 1.8/km^2 at NV East.

47. At Norfolk Vanguard West (NV West), when unidentified small cetaceans are included with the harbour porpoise data, the highest density estimate was in September 2015, with an uncorrected density estimate of 1.04/km^2 (CI = 0.61-1.29). The corrected density estimate using the seasonal correction factor is 2.29/km^2 for NV West (without buffer). However, the other monthly density estimates for harbour porpoise, including unidentified small cetaceans, are considerably lower than the September estimate.

48. The annual mean density estimate, when using the seasonal correction factor is 0.79/km^2 for the NV West area (without buffer). The density estimate during summer (April to September) is 0.57/km^2 and during the winter (October to March) the estimated density is 1.01/km^2 at NV West.

49. The NV East and NV West density estimates of 1.26/km^2 and 0.79/km^2, respectively, based on the mean annual density and using the seasonal correction factors, will be used to inform any assessment of impacts within the project interconnector search areas. Using the mean annual density allows for seasonal variation in the number of harbour porpoise that could be present. However, it should be noted that the majority of the offshore construction work would occur during summer months when the density estimates are lower, therefore using the annual density estimates is considered a precautionary approach.

Norfolk Boreas site specific surveys

50. High resolution aerial digital still imagery was collected for marine mammals over the Norfolk Boreas site, with a 4km buffer area, covering a total of 1,223km^2. Further information is provided on the analysis and interpretation of the survey results in Section 2.1of this appendix.

51. The information included in this ES is based on 24 months of survey for the Norfolk Boreas site (August 2016 – July 2018).

52. Density estimates were calculated from the raw data counts (see Section 2 of this appendix) for harbour porpoise species and unidentified small cetacean (all assumed to be harbour porpoise to produce a worst-case density and abundance estimate – see below for further information). It should be noted that of the 930 identified marine mammals within the Norfolk Boreas aerial surveys, 65 were outside the 4km buffer zone and so were not included in the analysis of both density estimates and abundances. Correction factors (see section 2.2.2.2 of this appendix) were then

applied to the data to account for the presence of individuals below 2m water depth (the depth at which it is no longer possible to detect marine mammals from aerial imagery).

53. The annual mean density estimate when using the seasonal correction factor is 1.06/km^2 for the Norfolk Boreas site.

54. The density estimate during summer (April to September) is 0.664/km^2 and during the winter (October to March) the estimated density is 1.458/km^2 using the corrected densities.

55. The Norfolk Boreas site density estimate of 1.06/km^2, based on the mean annual density and using the seasonal correction factors, have been used to inform the assessments of impact. Using the mean annual density allows for seasonal variation in the number of harbour porpoise that could be present.

1.2.2 Dolphin species

1.2.2.1 Distribution

56. White-beaked dolphin are widespread across the northern European continental shelf and in the North Sea they tend to be more numerous within 200nm of the Scottish and north-eastern English coasts (Northridge et al*.,* 1995). White-beaked dolphin are present year-round in the North Sea, mainly in waters of 50-100m depth, with most sightings recorded between June and October (Reid et al*.,* 2003). This species is cited as the most abundant cetacean after harbour porpoise in the North Sea (Jansen et al*.,* 2010), and the waters off the coast of Scotland and north east England are one of the four global areas of peak abundance. White-beaked dolphin are widely distributed within the central North Sea, however, very few sightings are recorded along the east coast of England or south of the Humber Estuary, with a small number of sightings in offshore waters within the shallow waters near the North Norfolk Sandbanks and Dogger Bank areas (Gilles et al*.,* 2012; DECC, 2016). The occurrence of white-beaked dolphin in the southern North Sea is relatively low (Reid et al*.,* 2003; Hammond et al*.,* 2013, 2017).

57. The bottlenose dolphin has a worldwide distribution across tropical and temperate seas of both hemispheres and can be found in coastal and continental shelf waters (Reid et al*.,* 2003; DECC, 2016). In most regions, including the UK Continental Shelf (CS), inshore and offshore 'sub-populations' tend to be distinct (DECC, 2016; Oudejans et al*.,* 2015). In UK waters, inshore individuals are frequently reported off north-east and south-west Scotland, in the Irish Sea, and in the western English Channel (DECC, 2016; Inter-Agency Marine Mammal Working Group (IAMMWG), 2015). There are two main areas of UK territorial waters where there are semi-resident groups of bottlenose dolphins: Cardigan Bay in Wales and the Moray Firth

on the north-east coast of Scotland, both of these areas have been designated SACs for bottlenose dolphins. There are also smaller populations of bottlenose dolphins off south Dorset and around Cornwall (Wood, 1998). The occurrence of bottlenose dolphin in the southern North Sea is very low (Reid et al*.,* 2003; Hammond et al*.,* 2013, 2017).

58. The common dolphin is the most numerous offshore cetacean species in the north east Atlantic, most often sighted off the western coast of the UK, in the Celtic Sea, and western approaches to the Channel, it is only occasionally sighted in the North Sea during the summer months (Reid et al*.,* 2003).

59. As outlined in section 1.1, very few dolphin species have been recorded during the Rosyth to Zeebrugge or Hull to Zeebrugge ferry routes in 2017 and 2018 (MARINElife, 2019) and Sea Watch volunteer cetacean sightings for eastern England coast in 2017 and early 2018 (Sea Watch Foundation, 2019).There were also low numbers of dolphin species recorded during the surveys undertaken in the former East Anglia Zone, East Anglia ONE offshore wind farm and East Anglia THREE offshore wind farm (EAOW, 2012c; EAOWFL, 2012; EATL, 2015).

1.2.2.2 Abundance and density estimates

1.2.2.2.1 Management units

60. Scientific evidence supports the assumption that white-beaked dolphin from around the British Isles and North Sea represent one population, with movement between Scottish waters and the Danish North Sea and Skagerrak (Banhuera-Hinestroza et al*.,* 2009; IAMMWG, 2015). The single MU for white-beaked dolphin, the Celtic and Greater North Seas (CGNS) MU, comprises all UK waters and extends to the seaward boundary used by the European Commission for Habitats Directive reporting (area known as Marine Atlantic, termed MATL) (IAMMWG, 2015). However, it is worth noting that this species usually occurs on the continental shelf (Reid et al*.,* 2003; IAMMWG, 2015). The abundance of white-beaked dolphin in the CGNS MU is 15,895 animals (CV=0.29; 95% CI=9,107-27,743; IAMMWG, 2015) and in the UK EEZ white-beaked dolphin abundance is 11,694 (CV = 0.30; 95% CI = 6,578-20,790), which are derived from the SCANS-II abundance estimate for continental shelf waters (Hammond et al*.,* 2013).

61. IAMMWG currently recognise seven MUs for bottlenose dolphin in UK waters. The Norfolk Boreas offshore project area is located in the Greater North Sea (GNS) MU, which is represented by ICES Area IV, excluding coastal east Scotland; and ICES area IIIa. The estimated bottlenose dolphin population size of the GNS MU is zero (IAMMWG, 2015).

62. The single MU for common dolphin, the CGNS MU, comprises all UK waters and extends to the seaward boundary (IAMMWG, 2015). The abundance of common dolphin in the CGNS MU is 56,556 (CV = 0.28; 95% CI = 33,014-96,920) and the UK component (abundance within the UK EEZ) is 13,607 (CV = 0.23; 95% CI = 8,720-21,234). These estimates were derived from SCANS-II (Hammond et al., 2013) and Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA; Macleod et al., 2009) and are likely to be biased low due to perception bias that could not be corrected for in the aerial surveys (IAMMWG, 2015).

1.2.2.2.2 SCANS data

63. The SCANS-II survey provided a wider European population estimate of 16,536 white-beaked dolphin (95% CI = 9,245 – 29,586; Hammond et al*.,* 2013). The Norfolk Boreas site is located within both Blocks B and U of the SCANS-II survey (Plate 1.4; Hammond et al., 2013). No white-beaked dolphin were recorded for the SCANS-II survey block B, and the population estimate for Block U was 501 (CV = 0.97).

64. For the entire SCANS-III survey area (note that it is not the same area as SCANS-II), white-beaked dolphin abundance in the summer of 2016 was estimated to be 36,287 with an overall estimated density of 0.030/km^2 (CV = 0.29; 95% CI = 18,694-61,869; Hammond et al., 2017). As previously discussed, the Norfolk Boreas site is located in both SCANS-III survey block L and survey block O. White-beaked dolphin were not recorded in survey block L during SCANS-III survey. The estimated abundance in SCANS-III survey block O was 143 white-beaked dolphins (CV=0.97; 95% CI = 0-490), with an estimated density of 0.002 white-beaked dolphins per km^2 (CV=0.97; Hammond et al., 2017).

65. During the SCANS-II surveys, two bottlenose dolphin groups were sighted within survey block B, resulting in an estimated density of 0.0032 individuals per km^2 (CV = 0.74) and an abundance estimate of 395 bottlenose dolphin (CV = 0.74; Hammond et al., 2013). No bottlenose dolphin were sighted within block U during the SCANS-II survey. During the SCANS-III surveys no bottlenose dolphin were recorded in survey block O or survey block L (Hammond et al., 2017).

66. Common dolphin were not recorded in the North Sea area during the SCANS-II or SCANS-III surveys (Hammond et al*.,* 2013; 2017).

1.2.2.2.3 Norfolk Vanguard site specific surveys

67. It was not possible to estimate abundance or density estimates based on the very low sightings of dolphin species during the Norfolk Vanguard aerial surveys (Norfolk Vanguard Limited, 2018).

1.2.2.2.4 Norfolk Boreas site specific surveys

68. Only one dolphin was recorded during the aerial surveys for the Norfolk Boreas site surveys, from August 2016 to July 2018, which was not identified to species level (see Annex 1).

69. It was not possible to estimate abundance or density estimates based on the very low sightings of dolphin species during the Norfolk Boreas site aerial surveys.

70. Taking into account the very low numbers and no or infrequent sightings during the site specific surveys at Norfolk Boreas and Norfolk Vanguard, the East Anglia Zone surveys, along with the SCANS-II and SCANS-III surveys, white-beaked dolphin, bottlenose dolphin and common dolphin have not been assessed further or included in the impact assessment as there is a very low risk of having a significant, if any, impact on these species.

1.2.3 Minke whale

1.2.3.1 Distribution

71. Minke whales are widely distributed along the Atlantic seaboard of Britain and Ireland and throughout the North Sea. The JNCC Cetacean Atlas (Reid et al*.,* 2003), indicates that minke whale occur regularly in the North Sea to the north of Humberside, but are comparatively scarce in the southern North Sea. Animals are present throughout the year, but most sightings are between May and September (Reid et al*.,* 2003). DECC (2016) support this, stating that sightings rarely extend past Dogger Bank, but that occasional sightings of minke whale are made as far south as Flamborough Head and the north Humberside coastlines between July and October (DECC, 2016).

72. Higher densities of minke whale have been recorded along the margins of Dogger Bank and adjacent areas in spring and summer (de Boer, 2010; Gilles et al*.,* 2012; Hammond et al*.,* 2013). Few sightings of minke whale have been made further south of these areas and it is thought that they probably enter the North Sea from the north (DECC, 2016). Minke whales appear to move into the North Sea at the beginning of May and are present throughout the summer until October (Northridge et al*.,* 1995).

73. During the Rosyth to Zeebrugge ferry trips in 2017 and 2018 the cetacean species recorded included minke whale in May 2017. On the Felixstowe to Vlaardingen ferry route across the southern North Sea, one minke whale was recorded in May 2016 and on the Hull to Zeebrugge ferry route an unidentified whale was recorded in July 2017 (MARINElife, 2019). It should be noted, that these sightings could have been made be at any point between the two port locations.

74. Aerial surveys undertaken for the former East Anglia Zone did not record any minke whale (EAOW, 2012a). In addition, no minke whale, or large cetaceans (which had the potential to be minke whale) were recorded in the East Anglia THREE site plus buffer during the 24 months of aerial surveys (EATL, 2015). No minke whale were observed within the 24 months of aerial surveys or the 12 months of boat-based surveys for East Anglia ONE (EAOWFL, 2012).

1.2.3.2 Abundance and density estimates

1.2.3.2.1 Celtic and Greater North Seas MU

75. Genetic evidence suggests that the minke whales of the North Atlantic are likely to be a single genetic population (Anderwald et al*.,* 2012). Therefore, IAMMWG (2015) considers a single MU is appropriate for minke whales in European waters.

76. The abundance of minke whales in the CGNS MU is 23,528 animals (CV = 0.27; 95% CI = 13,989-39,572; IAMMWG, 2015). The estimate was derived from SCANS-II (Hammond et al*.,* 2013) and CODA (Macleod et al*.,* 2009) and is likely to be underestimated. The IAMMWG (2015) note the abundance of minke whales is highly seasonal, with abundance peaking during migration south into waters around the UK for summer.

1.2.3.2.2 SCANS data

77. SCANS-I in July 1994, estimated 8,445 minke whale (95% CI = 5,000-13,500) (Hammond et al*.,* 2002). The SCANS-II survey gave an overall estimate of 18,958 minke whale (CV = 0.347); with 10,786 minke whale (CV = 0.29) for the North Sea area; and 13,734 minke whale (CV = 0.41; 95%CI = 9,800 – 36,700) within an area comparable to the 1994 survey (Hammond et al*.,* 2013). Although these estimates were not significantly different, there were noticeable changes in distribution between the two surveys (analogous to those observed in harbour porpoise) which again is most likely to be linked to changes in prey availability.

78. SCANS-II estimated the average minke whale density across survey block B to be 0.01 individuals per km^2 and the estimated abundance was 1,199 individuals (CV = 0.98) and for Block U the estimated population was 3,655 (CV = 0.69) with a density of 0.023 individuals per km^2 (CV = 0.69) Hammond et al*.,* 2013). The high CV value indicates there is a large amount of uncertainty around this estimate, this is a function of the very low sightings rates; only two groups were sighted in block B and four in Block U. Hammond et al*.* (2013) confirms that these two sightings were in the vicinity of the Channel Islands, and not in close proximity to the Norfolk Boreas site.

79. For the entire SCANS-III survey area (not the same area as SCANS-II), minke whale in the summer of 2016 was estimated to be 14,759 with an overall estimated density of 0.008/km^2 (CV = 0.327; 95% CI = 7,908-27,544; Hammond et al*.,* 2017).

80. Norfolk Boreas is located in both SCANS-III survey block L and survey block O. Minke whale were not recorded in survey block L during SCANS-III survey. The estimated abundance in SCANS-III survey block O was 603 minke whale (CV=0.62; 95% CI = 109-1,670), with an estimated density of 0.010 minke whale per km^2 (CV=0.62; Hammond et al., 2017). However, it should be noted that the minke whale sightings in SCANS-III survey block O were to the north of the Norfolk Boreas site.

1.2.3.2.3 Norfolk Vanguard site specific surveys

81. No minke whale or potential minke whale sightings were made in the aerial surveys for either NV East or NV West.

1.2.3.2.4 Norfolk Boreas site specific surveys

82. No minke whale or potential minke whale sightings have been made in the aerial surveys for Norfolk Boreas.

83. As a result of the lack of sightings during the site specific surveys, East Anglia Zone surveys and the lack of sightings in this area of the North Sea during the SCANS-II and SCANS-III surveys, minke whale have not been assessed further or included in the impact assessment as there is a very low risk of having a significant, if any, impact on this species.

1.2.4 Designated sites and conservation importance of cetaceans

84. All cetaceans in UK waters are classed as European Protected Species (EPS) under Annex IV of the Habitats Directive (EU Directive 92/43/EEC) and therefore internationally important. Bottlenose dolphin and harbour porpoise are listed under Annex II of the Habitats Directive and are afforded protection through the designation of Natura 2000 sites.

85. Bottlenose dolphin has not been identified during the Norfolk Boreas or Norfolk Vanguard aerial surveys, and no bottlenose dolphin were positively sighted during the aerial surveys of the East Anglia THREE site (EATL, 2015). During SCANS-III surveys in summer 2016, no bottlenose dolphin were recorded in or around the area of Norfolk Boreas (Hammond et al., 2017). During the SCANS-II surveys, only two bottlenose dolphin groups were sighted within the survey block which encompasses the East Anglia Zone; resulting in an estimated density of 0.0032 (CV = 0.74) individuals per km^2 (Hammond et al., 2013). There are currently seven MUs for bottlenose dolphin in UK waters; the Norfolk Boreas site is located in the GNS MU, which has an estimated population size of zero (IAMMWG, 2015). Taking into

account the very low occurrence of sightings (one sighting) in and around the Norfolk Boreas site and the assessment of the GNS MU population size by the IAMMWG, this species was screened out from further assessment in the Environmental Impact Assessment (EIA) and information for the Habitats Regulation Assessment (HRA).

1.3 Pinnipeds

86. Two seal species live and breed in UK waters: grey seal and harbour (or common) seal (SCOS, 2017). Both species are considered in the EIA and have been considered in the assessments for the HRA.

87. Other seal species that occasionally occur in UK coastal waters, include ringed seals *Phoca hispida*, harp seals *Phoca groenlandica*, bearded seals *Erignathus barbatus* and hooded seals *Cystophora crystata*, all of which are Arctic species and are only rarely encountered in UK water (SCOS, 2017).

88. The seal species included in the assessment has been agreed with the marine mammal ETG.

1.3.1 Grey seal

1.3.1.1 Distribution

89. Grey seals only occur in the North Atlantic, Barents and Baltic Sea with their main concentrations on the east coast of Canada and United States of America and in north-west Europe (SCOS, 2017).

90. Approximately 38% of the worlds grey seals breed in the UK and 88% of these breed at colonies in Scotland with the main concentrations in the Outer Hebrides and in Orkney. There are also breeding colonies in Shetland, on the north and east coasts of mainland Britain and in south-west England and Wales (SCOS, 2017).

91. The Sea Mammal Research Unit (SMRU), in collaboration with others, deployed 269 telemetry tags on grey seals around the UK between 1988 and 2010 (Russell and McConnell, 2014). The telemetry data for grey seal adults (Plate 1.6.a) and pups (Plate 1.6.b) indicate that very few tagged greys seals have been recorded in and around the Norfolk Boreas site, with the tracks of only one grey seal pup tagged at the Isle of May in 2002 and one adult grey seal in the vicinity of the Norfolk Boreas site (Plate 1.6; Russell and McConnell, 2014).

92. Tags deployed on grey seals at Donna Nook and Blakeney Point in May 2015, indicated that they used multiple haul-out sites; with one grey seal hauling out in the Netherlands and one in Northern France (Russell, 2016). Plate 1.7 shows the tagged seal movements along the east coast of England and indicates that grey seal travel between haul-out sites along the east coast of England, as well as to the north of

France and up to the Firth of Forth and across Fladden Ground and Dogger Bank (Russell, 2016). Russell et al. (2013) found that between 21% and 58% of female grey seals used different regions for breeding and foraging.

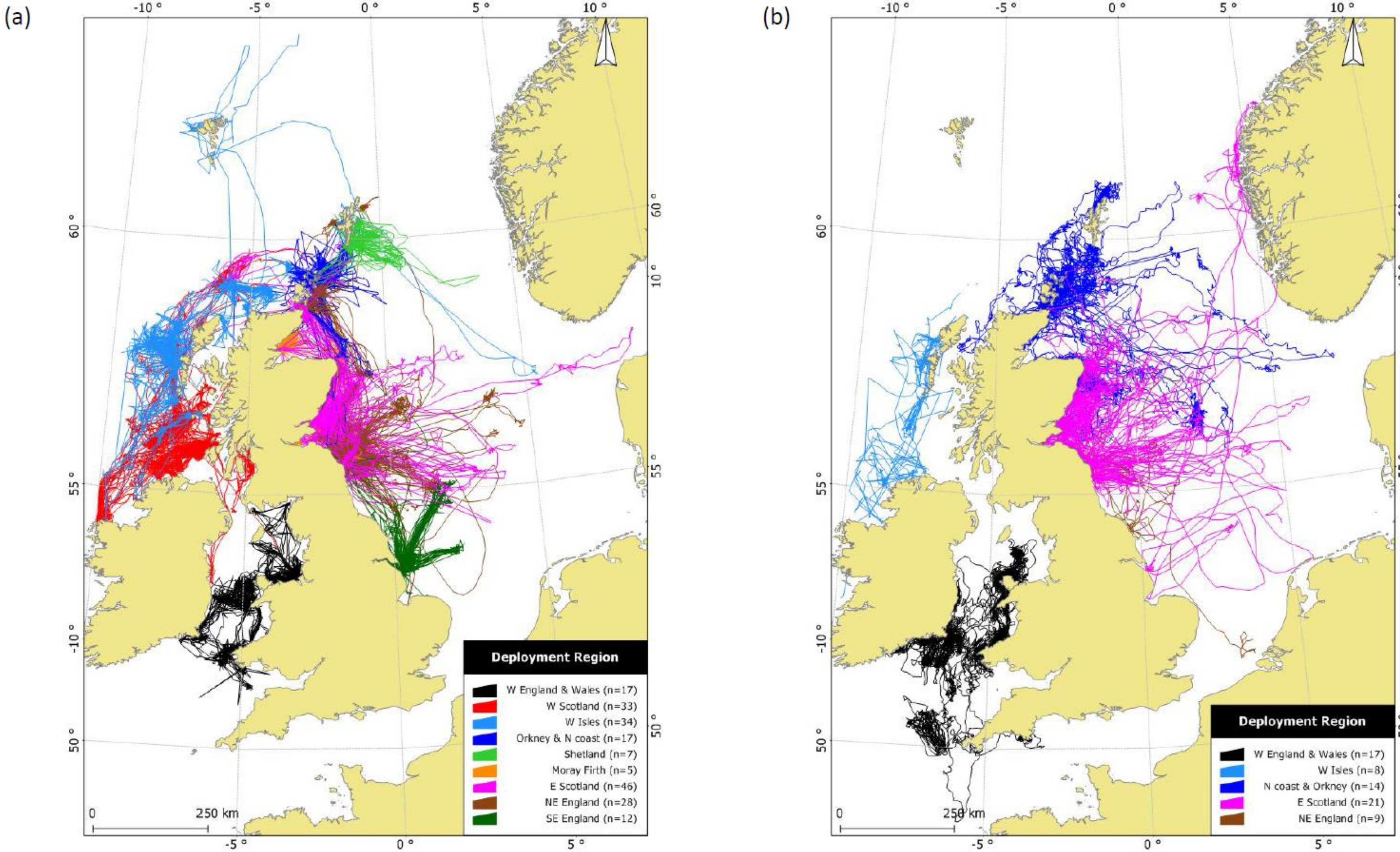


Plate 1.6 Telemetry tracks by deployment region for grey seals aged (a) one year or over and (b) pups (Source: Russell and McConnell, 2014)

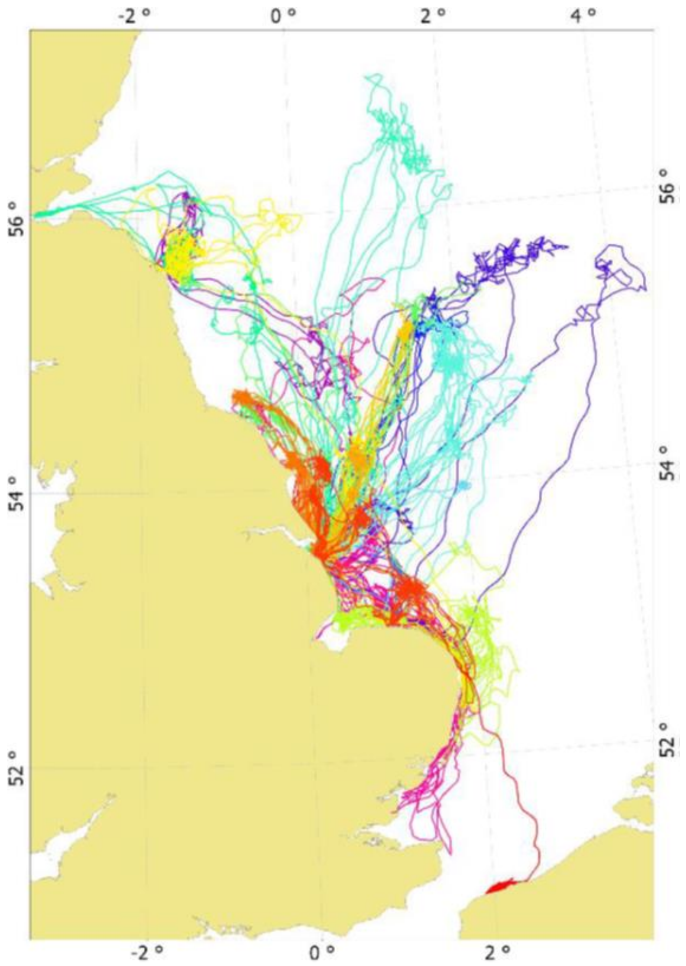


Plate 1.7 Tagged grey seal movements along the East coast of England (Source: Russell, 2016)

93. Aerial surveys conducted for the former East Anglia Zone from November 2009 to April 2011, did not record any observations of seals (EAOW, 2012c).

94. During aerial surveys at the East Anglia ONE site (EAOWFL, 2012) no observations of grey seal were made. Grey seals were also not recorded during boat based surveys at the East Anglia ONE site, suggesting that there is low usage of the East Anglia ONE site (EAOWFL, 2012).

95. During East Anglia THREE surveys (September 2011 to August 2013) only two seals were recorded, observations of seals were not classified to a particular species (EATL, 2015). The results of the East Anglia THREE aerial surveys support the tagging data and suggest that there is low usage of the former East Anglia Zone.

96. For the East Anglia THREE EIA (EATL, 2015), EATL commissioned SMRU Marine Ltd and IMARES to investigate the connectivity between tagged grey seal and the East Anglia THREE site plus a 20km buffer area (EATL, 2015). The SMRU study was based on their database of telemetry data of tagged grey seal pups and adults from important breeding locations in UK, including the Farne Islands, Donna Nook,

Abertay Sands and the Isle of May from 1988 to 2008. The study indicated that none of the 92 tagged grey seals aged one year or over entered the East Anglia THREE site plus a 20km buffer area or surrounding area. However, the tracks did indicate the movement of grey seals between MUs on the east coast of England and Scotland. From the Dutch telemetry studies a total of 77 grey seal were tagged at haul-out sites in the Netherlands between 2005 and 2013. Of these seals, six were found to travel within 20km of the East Anglia THREE site. Of these six seals, three entered the offshore cable corridor and two were within the East Anglia THREE site. Although, it is likely all grey seals from Dutch sites spent less than 2% of their 'time-at-sea' within the East Anglia THREE site. However, the study did indicate the movement of grey seal between the UK and Dutch sites.

97. The north Dutch coastline is an important foraging zone and migration route for grey seal (Brasseur et al*.,* 2010). A study on the grey seal development in the Dutch part of the Wadden Sea shows that the growth of the breeding population is fuelled by the annual immigration of grey seals from the UK (Brasseur et al*.* 2014).

98. There is a considerable amount of movement of grey seals that occurs (as observed from telemetry data) among the different areas and regional subunits of the North Sea and no evidence to suggest that grey seals on the North Sea coasts of Denmark, Germany, the Netherlands or France are independent from those in the UK (SCOS, 2017).

99. Spatial distributions indicate that grey seals have homogeneous usage near-shore, that they typically range widely and frequently travel over 100km between haul-out sites, and that they tend to spend approximately 15% of their time far-offshore, e.g. more than 50km from the coast (Russell and McConnell, 2014; SCOS, 2017).

100. Marine Scotland commissioned SMRU to produce maps of grey seal distribution in UK waters (Russell et al*.,* 2017). These maps were produced by combining information about the movement patterns of electronically tagged seals with survey counts of seals at haul-out sites. The resulting maps show estimates of mean seal usage (seals per 5 km x 5 km grid cell) within UK waters. The maps indicate that grey seal usage is relatively low in and around the Norfolk Boreas site and higher along the coast and cable corridor (Figure 12.2 in ES chapter; Russell et al*.,* 2017).

1.3.1.2 Haul-out sites

101. Compared with other times of the year, grey seals in the UK spend longer hauled out during their annual moult (between December and April) and during their breeding season (SCOS, 2017).

102. In eastern England, pupping occurs mainly between early November and mid-December (SCOS, 2017). Pups are typically weaned 17 to 23 days after birth, when

they moult their white natal coat, and then remain on the breeding colony for up to two or three weeks before going to sea. Mating occurs at the end of lactation and then adult females depart to sea and provide no further parental care (SCOS, 2017).

103. In the UK, grey seals typically breed on remote uninhabited islands or coasts and in small numbers in sea caves, where they can avoid busy beaches and storm surges, although they are also known to breed on some exposed beaches. For example, at Donna Nook in Lincolnshire, grey seals have become habituated to human disturbance and over 70,000 people visit this colony during the breeding season with no apparent impact on the breeding seals (SCOS, 2016).

104. The Norfolk Boreas site is located approximately 73km offshore (at the closest point). Principal grey seal haul-out sites at Scroby Sands are approximately 67km from the site, the distance to Blakeney Point haul-out site is approximately 121km, the distance to The Wash is approximately 168km and Donna Nook is located approximately 180km from the Norfolk Boreas site (Figure 12.4 in ES Chapter 12).

105. Historically, Donna Nook has been the most important breeding site for grey seals on the east coast of England, however, there has been a considerable increase in the number of pups born at Blakeney Point, with this site now the biggest grey seal breeding colony in England, overtaking Donna Nook (SCOS, 2016).

106. The main breeding and haul-out sites for grey seal on the east coast of England are located at Blakeney Point (within the Wash and North Norfolk Coast SAC which is designated for harbour seal), at Horsey (located in the Winterton-Horsey Dunes SAC, although grey seal are not currently listed as a qualifying feature) and at Donna Nook in the Humber Estuary Special Area of Conservation (SAC) (Figure 12.4 in ES Chapter 12).

107. While grey seal are not currently a qualifying feature at the North Norfolk SAC (which includes Blakeney Point) or Winterton-Horsey Dunes SAC, it is recognised that these sites are important for the population, as breeding, moulting and haul-out sites. Therefore, consideration will be given to grey seal as part of the North Norfolk SAC and Winterton-Horsey Dunes SAC in the assessments for the HRA, to determine if there is the potential for any disturbance to grey seals hauled out at these sites.

108. At Horsey on the Norfolk coastline from Winterton to Waxham, grey seal use the haul-out sites for breeding and moulting. Counts undertaken by the Friends of Horsey Seals wardens in the 2016-17 breeding season indicated that the overall numbers of births increased from 1,236 in 2015-2016 to 1,487. The first births were recorded in early November and birth rate peaked on the 2nd December 2016 (Rothney, 2017). Counts undertaken in the 2017-18 breeding season (from October 2017 to January 2018) indicated that the total pups born this season were 1,825

(Friends of Horsey, 2018). The most recent grey seal count for the 2018-19 breeding season revealed a further increase in the total pups born over the season, with an increase of 245 over the previous year, with a total grey seal pup count of 2,069 (Friends of Horsey, 2019). Counts in 2015-16, during a 15 week period from 15th October 2015 to 21st January 2016, indicated that the number of adult grey seals recorded varied with the stage in the breeding cycle. The recent counts indicate that the breeding colony of grey seals at Horsey-Winterton is continuing to increase in numbers and expand its distribution (Rothney, 2016).

109. The landfall for the Norfolk Boreas offshore export cables will be at Happisburgh South, approximately 9km from the Horsey seal haul-out sites to the south and 44km from the Blakeney Point haul-out site to the north (Figure 12.4 in ES Chapter 12).

1.3.1.3 Diet and foraging

110. Grey seals are generalist feeders, foraging mainly on the sea bed at depths of up to 100m although they are probably capable of feeding at all the depths found across the UK continental shelf (SCOS, 2017).

111. In the North Sea, principal prey items are sandeel, whitefish (such as cod, haddock, whiting and ling *Molva molva*) and flatfish (plaice *Pleuronectes platessa*, sole, flounder, dab *Limanda limanda*) (Hammond and Grellier, 2006). Amongst these, sandeels are typically the predominant prey species. Diet varies seasonally and from region to region (SCOS, 2016).

112. Food requirements depend on the size of the seal and fat content (oiliness) of the prey, but an average consumption estimate of an adult is 4 to 7 kg per seal per day depending on the prey species (SCOS, 2017).

113. Grey seals typically forage in the open sea and return regularly to haul out on land where they rest, moult and breed. They may range widely to forage and frequently travel. Foraging trips can last anywhere between one and 30 days (SCOS, 2017).

114. Tracking of individual seals has shown that most foraging probably occurs within 100km of a haul-out site, with ranges of approximately 145km (Thompson et al., 1996), although they can feed up to several hundred kilometres offshore, with ranges of 1,088 to 6,400km recorded (Dietz et al., 2003). Individual grey seals based at a specific haul-out site often make repeated trips to the same region offshore, but will occasionally move to a new haul-out site and begin foraging in a new region (SCOS, 2017). Movements have been recorded between haul-out sites on the east coast of England and the Outer Hebrides (SCOS, 2017). Studies of regular foraging and dispersal between winter breeding sites, and summer foraging and haul out sites indicates ranges of 1,000km (e.g. McConnell et al., 1992).

115. Telemetry studies of grey seal in the UK have identified a highly heterogeneous spatial distribution with a small number of offshore 'hot spots' continually utilised (Matthiopolous et al*.,* 2004; Russell et al*.,* 2017).

116. Data analyses of tagged seals indicate that foraging distribution is related to their breeding distribution (Russell and McConnell, 2014). Female grey seal do not forage while suckling their pups. Therefore, the movement of female grey seals differs between the foraging and breeding seasons. Russell et al*.* (2013) found that between 21 and 58% of females used different regions for foraging and breeding.

117. The resulting tracks from the tags also show grey seals range far from land and pups may have more long ranging movements than adults (Plate 1.6; Russell and McConnell, 2014).

1.3.1.4 Abundance and density estimates

118. See ES Chapter 12 Marine Mammals.

1.3.1.5 Reference population for assessment

119. See ES Chapter 12 Marine Mammals.

1.3.2 Harbour seal

1.3.2.1 Distribution

120. Harbour seals have a circumpolar distribution in the Northern Hemisphere and are divided into five sub-species. The population in European waters represents one subspecies *Phoca vitulina vitulina* (SCOS, 2017).

121. On the east coast of Britain harbour seal distribution is generally restricted, with concentrations in the major estuaries of the Thames, The Wash and the Moray Firth (SCOS, 2017).

122. SMRU, in collaboration with others, has deployed around 344 telemetry tags on harbour seals around the UK between 2001 and 2012 (Russell and McConnell, 2014). The tracks indicate that very few tagged harbour seals have been recorded in the immediate vicinity of the Norfolk Boreas offshore project area, with tracks moving along the coast between The Wash and the Thames estuaries (Plate 1.8). This is reflected in the harbour seal density estimates for the Norfolk Boreas site compared to the offshore cable corridor, although harbour seal numbers in the Norfolk Boreas site and the offshore cable corridor are very low. Most tracks of seals tagged in The Wash appear to move directly out to sea or to the north of The Wash (Plate 1.8).

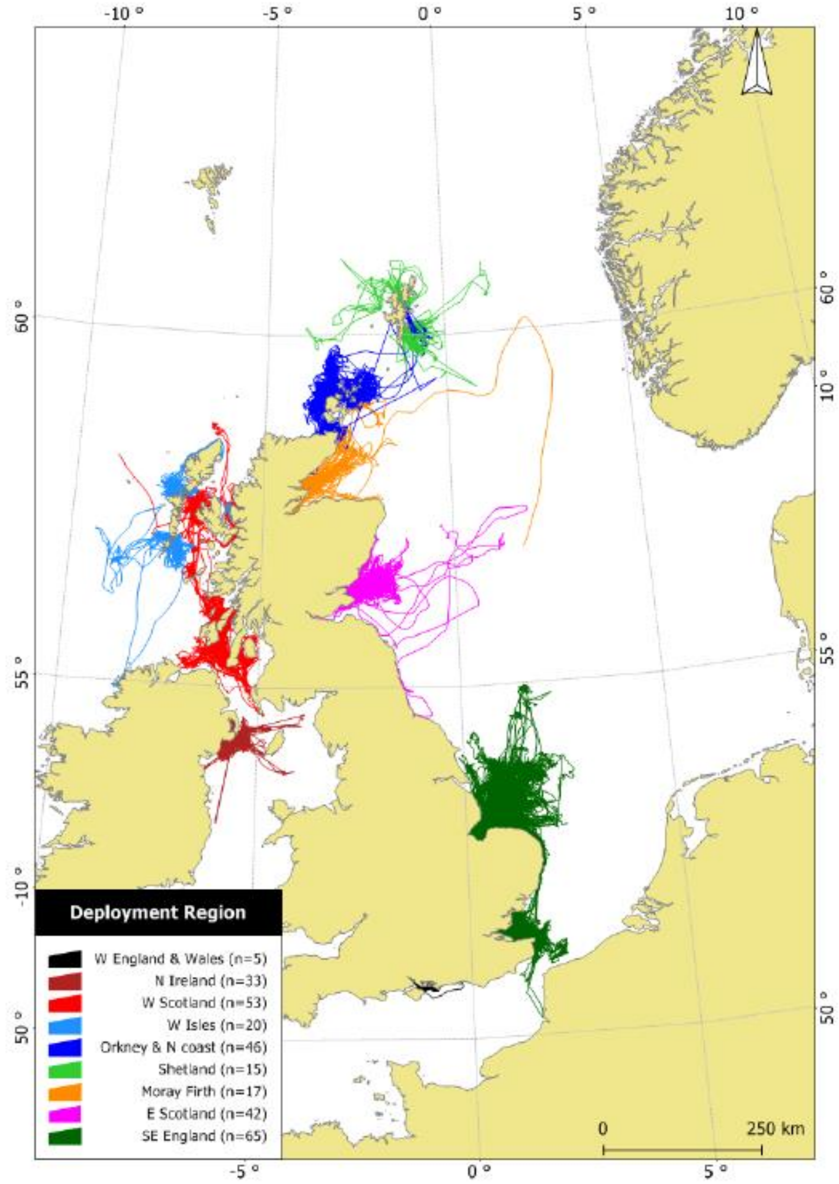


Plate 1.8 Telemetry tracks by deployment region for harbour seals aged one year or over (Source: Russell and McConnell, 2014)

123. Aerial surveys conducted for the East Anglia Zone, did not record any observations of seals (EAOW, 2012c) neither did aerial surveys at the East Anglia ONE site. However, during boat based surveys, three harbour seal were recorded at the East Anglia ONE site, suggesting that there is low usage of the East Anglia ONE site (EAOWFL, 2012). As outlined for grey seal, only two unidentified seals were recorded during East Anglia THREE surveys (EATL, 2015). The results of the surveys support the tagging data and suggest that there is low usage of the former East Anglia Zone.

124. For the East Anglia THREE EIA (EATL, 2015), EATL commissioned SMRU Marine Ltd and IMARES to investigate the connectivity between tagged harbour seal and the East Anglia THREE site plus a 20km buffer area (EATL, 2015). The SMRU study was

based on their database of telemetry data of harbour seal juveniles and adults from tagging locations including the Wash and the Thames Estuary from 2003 to 2012, including data from the Zoological Society of London seal tagging study. The SMRU study indicated that none of the 43 tagged harbour seals aged one or above entered the East Anglia THREE site plus a 20km buffer area or surrounding area. For the Dutch telemetry studies, a total of 273 harbour seal were tagged at sites in the Netherlands between 1997 and 2013. Of these seals, 10 were found to travel within 20km of the EA3 site. Of these 10 seals, six entered the offshore cable corridor and two were within the East Anglia THREE site. Although, it is likely all but one harbour seal spent less than 2% of their 'time-at-sea' within the area, with an exception being a harbour seal tagged in 2007 which spent at least 2% and up to 17% of its 'time-at-sea' within the offshore cable corridor. The Dutch tagging data illustrate the long ranging movements of harbour seal and levels of connectivity between Dutch haul out sites and those on the east coast of England (EATL, 2015).

125. The SMRU maps of harbour seal distribution in UK waters (Russell et al*.,* 2017), based on the movement patterns of electronically tagged seals with survey counts of seals at haul-out sites, indicate that harbour seal usage is relatively low in and around the Norfolk Boreas offshore project area, and is higher along the coast and cable corridor (Russell et al*.,* 2017).

126. Spatial distributions indicate harbour seals persist in discrete regional populations, display heterogeneous usage and generally stay within 50km of the coast (Russell and McConnell, 2014).

1.3.2.2 Haul-out sites

127. See ES Chapter.

1.3.2.3 Diet and foraging

128. Harbour seals normally feed within 40-50 km around their haul out sites. Tracking studies have shown that harbour seal typically travel 50-100km offshore and can travel 200km between haul-out sites (Lowry et al*.,* 2001; Sharples et al*.,* 2012). Harbour seal exhibit relative short foraging trips from their haul out sites. The range of these trips does vary depending on the surrounding marine habitat (e.g. 25km on the west of Scotland (Cunningham et al*.,* 2009); 30km-45km in the Moray Firth (Tollit et al*.,* 1998; Thompson and Miller, 1990). However, data from The Wash (from 2003 - 2005) suggest that harbour seal in this area travel further, and repeatedly forage between 75km and 120km offshore (with one seal travelling 220km; Sharples et al*.,* 2008). Telemetry studies indicate that the tracks of tagged harbour seals have a more coastal distribution than grey seals and do not travel as far from haul-outs (Plate 1.8; Russell and McConnell, 2014).

129. Harbour seal take a wide variety of prey including sandeels, gadoids, herring and sprat, flatfish and cephalopods. Diet varies seasonally and regionally, prey diversity and diet quality also showed some regional and seasonal variation (SCOS, 2017). It is estimated harbour seals eat 3-5 kg per adult seal per day depending on the prey species (SCOS, 2017).

1.3.2.4 Abundance and density estimates

130. See ES Chapter 12.

1.3.2.5 Reference population for assessment

131. See ES Chapter 12.

2 Marine Mammal Survey Data

2.1 Introduction

132. This part of Appendix 12.2 summarises the marine mammal data collected during the marine mammal site specific surveys within the Norfolk Boreas site with a 4km buffer area (Plate 2.1). The purpose of these surveys is to assess the temporal and spatial variation in marine mammal abundance and distribution in and around the Norfolk Boreas site.

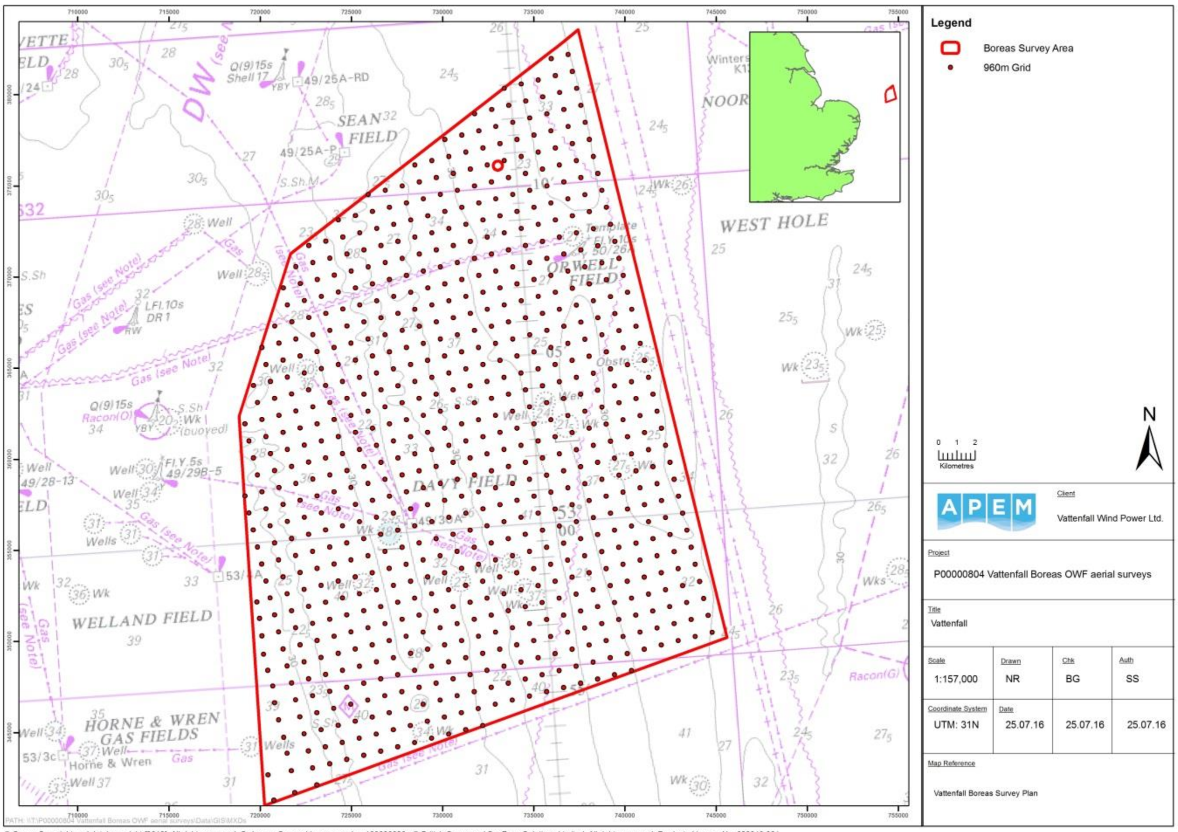


Plate 2.1 Location of the Norfolk Boreas aerial surveys and 4km buffer zones with basic survey design and estimated image collection points (image nodes).

133. The following monthly aerial surveys have been undertaken for the Norfolk Boreas site to characterise the area for marine mammals, the results of which are included in this Appendix and have been used to inform the assessment within ES Chapter 12:

- Aerial survey data of the Norfolk Boreas site with a 4km buffer from August 2016 to July 2018.

134. The aerial surveys were designed specifically to collect adequate and robust data on both marine mammals and birds across the Norfolk Boreas site with a 4km buffer.

Aerial surveys have been used in the SCANS surveys, including the SCANS-III surveys to estimate cetacean abundance (Hammond et al., 2017).

135. The technology underlining aerial digital methods for surveying marine mammals has evolved considerably in recent years and several independent studies have justified the growing confidence in the emerging use of digital survey methods (Voet et al., 2017; Lowry, 1999; Koski et al., 2013; Stewart et al., 2013). The improvement of digital sensors and enhancement of imagery resolution now allows for the monitoring of large areas at a small ground sampling distance (Voet et al., 2017). Additionally, perception or detection bias can be minimised and the production of permanent records allows species identification, group size and behaviour to be re-analysed. During aerial surveys, marine mammals can be seen not only when breaking the surface, but when below the surface as well. Under normal conditions, harbour porpoises are available for detection during aerial surveys when in the top two metres of the water column (Teilmann et al., 2007, 2013). Therefore, correction factors have been applied to take into account the animals that are submerged, so that robust density estimates can be calculated (see section 2.2.2.2 of this Appendix).

136. The digital aerial survey approach has many advantages over alternative methods. It is performed from an altitude at which disturbance to target species is minimal, and is not subject to the bias of repulsion (i.e. inducing flee responses in marine mammals, such as harbour porpoise, that can influence the numbers recorded and affect their apparent distribution) or attraction (i.e. some marine mammal species, such as bottlenose dolphin may be attracted to boats and ride the bow wave formed by the vessel). The aerial survey approach also provides very accurate positioning data, and can be interpreted to provide information on swimming direction and the distance between animals in a pod. Furthermore, owing to the speed of the aircraft, it is possible to cover large areas in a single day of survey, meaning within-survey temporal variance is minimised. Images collected can be scrutinised post hoc, are subject to Quality Assurance (QA), and provide a permanent record for future interpretation.

137. A major advantage of collecting many digital still images is the resulting statistical power. Each image is a representative sample of marine mammal distribution and abundance, and can be considered independent from every other image due to the 500m separation between image centres. In this way, a systematic grid of many independent estimates of the abundance is formed, resulting in increased precision of abundance estimates.

138. It is also necessary to understand certain restrictions and limitations associated with aerial survey for marine mammals. For example, it is often difficult to identify individuals to species level from the imagery and higher level groupings are

frequently used for classification, which influences the information available for individual species that can be taken forward for further assessment (see section 2.2.2.1). Although submerged individuals near the surface can be observed, water clarity could introduce bias in the results with more individuals likely to be recorded during calm weather with greater water clarity than e.g. following a storm when water is potentially more turbid. Marine mammals spend a large proportion of time underwater and individuals present which are too deep to be captured by the imagery will not be recorded, requiring the application of a correction factor (see section 2.2.2.2).

2.2 Methodology

2.2.1 Data collection

139. APEM collected high resolution aerial digital still imagery over the Norfolk Boreas site and 4km buffer, covering a total of 1,223km^2. The monthly surveys collected imagery data at 2cm Ground Sampling Distance (GSD) with the image nodes (estimated image collection points) being spaced 960m apart in order to achieve a minimum of 8% coverage for each survey period (each month). Coverage of the Norfolk Boreas site and 4km buffer was between approximately 8.72% and 9.49% per month. Plate 2.1 shows the survey area for the Norfolk Boreas site.

140. The aerial surveys were completed using a Vulcanair P68 C Observer or Britten-Norman Islander twin-engine survey aircraft using a bespoke GPS-linked flight management system to ensure the survey tracks were completed with high accuracy.

141. All images were analysed to enumerate marine mammals to species level, where possible. Internal QA was carried out by APEM on each survey. Images were assessed in batches with a different staff member responsible for each batch. Each image containing marine mammals was reviewed and checked by APEM's dedicated QA Manager, ensuring that 100% of marine mammals recorded were subject to internal QA to ensure the species identification is correct. Images containing no marine mammals were removed and kept separately for further internal QA. Of these 'blank' images, 10% were randomly selected for internal QA by a different staff member to that which initially analysed the imagery. If there was less than 90% agreement, the entire batch would be re-analysed as part of the QA procedures. Following internal QA, external QA was carried out by SMRU, who provided an independent third party assessment of the marine mammals recorded in each survey.

2.2.2 Data analysis

142. APEM supplied the raw data and MacArthur Green conducted the initial data analysis. It should be noted that the aerial surveys included marine mammals that were recorded outside of the 4km buffer area (total of 65 marine mammal sightings were outwith the 4km buffer zone), and were not included within the following density and abundance estimates.

143. Raw data were supplied to MacArthur Green as plane GPS track logs, containing details for each image location and observation logs, containing details of all objects (seabird, marine mammal, vessel, etc.) recorded. The datasets were merged using the image ID to obtain a single dataset. All non-marine mammal records were removed prior to analysis of marine mammal density and abundance estimates. Analysis was conducted for each survey separately. Marine mammal locations were assigned to the following sub-zones; wind farm, wind farm plus 2km buffer and wind farm plus 4km buffer (note that each buffer width also included the wind farm data).

144. Density and abundance can be estimated in two ways using these data, referred to as design based and model based methods. Design based methods apply a straightforward extrapolation, with density estimated for the surveyed area (i.e. the sum of all the image footprints) and multiplied up to the total area to obtain abundance. This makes the assumption that the surveyed sample is representative of the un-surveyed region, thus the design of survey is important (hence 'design based'). A design based estimate has no spatial variation in the estimated density or abundance.

145. Model based methods use explanatory data (e.g. spatial coordinates, sea depth, etc.) fitted to observations to estimate the expected number of observation in un-surveyed regions. Model based estimates can therefore generate variable density surfaces reflecting the relationships between data and covariates. However, to obtain reliable model based estimates it is necessary to have a reasonably large number of observations to permit robust parameter estimation. Thus, this can only be conducted for more numerous species.

146. For the current preliminary assessment, only design based methods have been used. Model based methods will also be undertaken for species-survey combinations which meet the minimum sample size requirements (as an approx. guide a minimum of 50 observations per survey is typically required).

147. Design based confidence intervals for each species were obtained using a bootstrap resampling method. For each survey, images were drawn randomly (with replacement) from the dataset until the same number of images as the original sample was obtained (e.g. if the survey comprised 350 images, each resampled

dataset also contained 350 images, drawn from the original dataset). This process was repeated 1,000 times and the density and abundance calculated for each resampled dataset. The upper and lower 95% confidence limits were calculated across the 1,000 samples to estimate sampling variation.

2.2.2.1 Species identification

148. In some instances, an image had sufficient clarity to identify an individual to species level, whereas for other individuals the clarity may not have been sufficient to identify to species levels and it was necessary instead to categorise the individual at a lower identification level e.g. unidentified patterned dolphin species (see Table 2.1 for the different levels of identification of individuals).

149. Sightings were assigned to a specific species where possible, or to one of the following categories:

- Unidentified cetacean species;
- Phocid species (seals);
- Unidentified dolphin or porpoise (small cetacean);
- Unidentified dolphin; and
- Unidentified patterned dolphin.

Table 2.1 Marine mammals identification levels according to species and species groups used within baseline report

<table>
<tr><th>Identification level 1</th><th>Identification level 2</th><th>Identification level 3</th><th>Identification level 4</th><th>Identification level 5</th></tr>
<tr><td rowspan="7">Unidentified cetacean species</td><td rowspan="7">Unidentified dolphin / porpoise</td><td colspan="3">Harbour porpoise Phocoena phocoena</td></tr>
<tr><td rowspan="6">Unidentified dolphin species</td><td colspan="2">Risso’s dolphin Grampus griseus</td></tr>
<tr><td colspan="2">Bottlenose dolphin Tursiops truncatus</td></tr>
<tr><td rowspan="4">Unidentified patterned dolphin species</td><td>White-beaked dolphin Lagenorhynchus albirostris</td></tr>
<tr><td>Atlantic white-sided dolphin Lagenorhynchus acutus</td></tr>
<tr><td>Common dolphin Delphinus delphis</td></tr>
<tr><td>Striped dolphin Stenella coeruleoalba</td></tr>
<tr><td rowspan="2">Phocid species</td><td colspan="4">Grey seal Halichoerus grypus</td></tr>
<tr><td colspan="4">Harbour seal Phoca vitulina</td></tr>
</table>

150. The surveys within the Norfolk Boreas site indicate that harbour porpoise is the most abundant marine mammal species. It is therefore assumed that a large number of unidentified small cetaceans are likely to be harbour porpoise. As a worst-case

scenario (i.e. maximum possible density estimate) for harbour porpoise, the density has been obtained by adding the number of harbour porpoise recorded to the number of unidentified small cetaceans. For this reason, two estimates for harbour porpoise were obtained:

- Identified harbour porpoise; and
- Identified harbour porpoise plus unidentified small cetacean (dolphin or porpoise).

151. The maximum estimate based on identified harbour porpoise plus unidentified small cetacean is used in the impact assessment as the worst-case scenario.

2.2.2.2 Correction factors

152. It is possible for aerial imagery to capture marine mammals at the sea surface and just below, therefore correction factors (CF) must be applied to the raw data counts for each species to account for individuals that could be below the sea surface.

2.2.2.2.1 Harbour porpoise

153. The colour and size of harbour porpoise (small in comparison to other marine mammal species) make them relatively easy to identify from aerial imaging. They can be seen on the waters surface and within the top 2m of the water column (Teilmann et al*.,* 2007, 2013; Williamson et al*.,* 2016). Correction factors are used to account for the probability of harbour porpoise being below the water surface or detection zone (i.e. below 2m for harbour porpoise) and being undetectable by aerial surveys.

154. Voet et al*.* (2017) determined correction factors for harbour porpoise in the North Sea is based on published marine mammal dive profile data. Teilmann et al*.* (2013) tagged 35 harbour porpoise in the waters around Denmark using satellite transmitters. The satellite transmitters recorded data for a period of on average 135 days, the minimum and maximum days of contact were 25 days and 349 days, respectively (Teilmann et al*.,* 2013).

155. The percentage of time that each harbour porpoise spent between 0 and 2m water depth (including the time that the dorsal fin was above the water surface) was analysed, with no significant differences being found between male and female porpoise, the size of the individual (used as a proxy for age) or in the location that the individual was tagged.

156. There were, however, significant differences in the time of year, with the spring and summer having a higher average time spent between 0 and 2m compared to autumn and winter. These seasonal average surface times are based on documented dive profile data of a large number of animals covering a wide range of ages and both

sexes. Therefore, to take this into account, Teilmann et al. (2013) suggest that aerial survey data should be corrected for time submerged as well as for seasonal effects.

157. Taking into account the seasonal average surface times presented in Teilmann et al. (2013), Voet et al. (2017) established seasonal correction factors for harbour porpoise to use to determine abundance and density estimates obtained from aerial digital surveys (Table 2.2).

Table 2.2 Harbour porpoise seasonal correction factors

Season	Correction Factor
Spring (Mar – May)	0.571
Summer (Jun – Aug)	0.547
Autumn (Sept – Nov)	0.455
Winter (Dec - Feb)	0.472

158. The seasonal correction factors in Table 2.2 were applied to the monthly data to take into account for the probability of harbour porpoise being below the water surface or detection zone (i.e. below 2m for harbour porpoise) and being undetectable by aerial surveys.

159. Turbidity can affect the ability to detect marine mammals in the 2m detection zone below the surface. As outlined in Chapter 8 Marine Geology, Oceanography and Physical Processes sediment concentrations across the Norfolk Boreas site could range from 1 to 35mg/l. Measurements from the nearby Norfolk Vanguard East site (which determined the baseline for part of the project interconnector search area) recorded sediment concentrations were between 0.3 and 108mg/l throughout that year. Concentrations were less than 30mg/l for 95% of the time and less than 10mg/l for 70% of the time.

160. Water clarity (Secchi depth) in the North Sea varies with water depth and distance from the coast (Dupont and Aksnes, 2013). Long-term overall measurements of Secchi depth for the southern and central North Sea in the area of Norfolk Boreas indicate means of between 5.52m-1 (SD = 1.06) and 3.27m-1 (SD=2.22) in summer, 2.70m-1 (SD = 2.41) in spring / autumn and 1.66m-1 (SD = 0.93) in winter (Capuzzo et al., 2015).

161. Therefore, there is no indication of any limitations in observing marine mammals up to 2m below the surface. The correction factors take into account the number of animals that could be below 2m from the surface and not detected during the aerial surveys.

162. Correction factors are based on individual species and typically cannot be applied to species groups (such as unidentified small cetaceans). However, as it is assumed that all individuals in the 'harbour porpoise and unidentified small cetacean' group

are harbour porpoise, the correction factor for harbour porpoise was applied to this group.

163. Previously the acceptance of digital survey methods has been queried owing to uncertainty over their ability to provide reliable estimates of spatial and temporal variation in absolute abundance or density as corrected from relative measures. However, correcting the density estimates for availability bias increases the confidence levels in these estimates. Therefore, it is believed that the harbour porpoise aerial digital counts corrected using the seasonal correction factors deliver realistic density estimates.

164. The density estimates from the site specific aerial surveys using the correction factors are comparable to those from the SCANS-III survey, although as expected are slightly higher for the site specific survey areas compared to the larger SCANS-III survey blocks. For example, the SCANS-III density estimate for survey block O (0.888 harbour porpoise per km^2) is relatively similar to the Norfolk Boreas density estimate average annual of 1.061 harbour porpoise per km^2.

2.2.2.2.2 Other marine mammal species

165. The average time spent at the water surface is not as well studied for other marine mammal species as it is for harbour porpoise.

166. For grey and harbour seal, SMRU used tagging studies of 44 grey seals (1997) and 17 harbour seals (2003-2004) in the Pentland Firth and Orkney (SMRU, 2011). For grey seal, data collected from 22,012 dives found an average of 27.09% time spent at the waters surface, and for harbour seal, data collected from 44,156 dives found an average of 18.32% if time spent at the waters surface. This did not account for the time that the seals would be just below the waters surface and so would still be detectable in aerial surveys.

167. A study into the dive profiles of white-beaked dolphin (Rasmussen et al*.,* 2013) found that of the two tagged free-ranging individuals (tagged in Icelandic waters in 2006), the female spent 18% of its time close to the waters surface (0-2m). A study in the Gulf of Maine (Mate et al*.,* 1994) found that one tagged Atlantic white-sided dolphin male individual was found to spend 11% of its time at the waters surface. A study conducted for bottlenose dolphin in Tampa Bay, Florida found that one female individual spent 12.9% of its time at the water surface (Mate et al*.,* 1995).

168. Table 2.3 describes the mean time spent at the water surface for the other marine mammal species determined by the limited studies described above.

Table 2.3 Mean time other marine mammal species spend at the water surface (derived from SMRU, 2011, Rasmussen et al., 2013 and Mate et al. 1994 and 1995).

Species	Mean time spent at surface (%)
Grey seal	27.09
Harbour seal	18.32
White-beaked dolphin	18
Bottlenose dolphin	12.9
Atlantic white-sided dolphin	11

2.2.3 Survey Effort

169. The next sections summarise the monthly survey effort the Norfolk Boreas site and 4km buffer. Monthly coverage was between 8.72 and 9.49% of the Norfolk Boreas site and 4km buffer area, covering 36 transects per month (Table 2.4).

Table 2.4 Monthly survey coverage and effort for Norfolk Boreas

Month of Survey	Number of Transects	Coverage	Number of Images	Weather Conditions
August 2016	36	8.72%	1,441	Clear Visibility >10km Wind speeds 10-20 knots Wind Direction south south-westerly Sea state 1
September 2016	36	9.49%	1,441	Clear Visibility >10km Wind speeds 10-40 knots Wind Direction varying (north, east, west, south south-westerly) Sea state 2
October 2016	36	9.49%	1,441	Clear Visibility >10km Wind speeds 8-28 knots Wind Direction east Sea state 3
November 2016	36	9.49%	1,442	Partially overcast Visibility >10km Wind speeds 20-45 knots Wind Direction south-westerly Sea state 3-4
December 2016	36	9.49%	1,441	Clear to overcast Visibility 8-10km Wind speeds 5-14 knots Wind Direction south and westerly Sea state 1-3
January 2017	36	9.49%	1,441	Overcast Visibility >10km Wind speeds 7-15 knots Wind Direction South westerly Sea state 2-3
February 2017	36	9.49%	1,441	Overcast Visibility >10km Wind speeds 7-40 knots

Month of Survey	Number of Transects	Coverage	Number of Images	Weather Conditions
				Wind Direction westerly and west-north-westerly Sea state 2-4
March 2017	36	9.49%	1,441	Clear - overcast Visibility >10km Wind speeds 20-40 knots Wind Direction west-south-westerly, south-westerly and westerly Sea state 3
April 2017	36	9.49%	1,441	Overcast Visibility >10km Wind speeds 14-25 knots Wind Direction westerly and north-westerly Sea state 1-4
May 2017	36	9.49%	1,441	Clear Visibility >10km Wind speeds 10-24 knots Wind Direction south-westerly and southerly Sea state 2-4
June 2017	36	9.49%	1,441	Cloudy Visibility >10km Wind speeds 15-35 knots Wind Direction south-westerly Sea state 1-2
July 2017	36	9.49%	1,441	Cloudy Visibility >10km Wind speeds 5-10 knots Wind Direction variable Sea state 1-2
August 2017	36	9.49%	1,441	Mostly clear Visibility >10km Wind speeds 12-15 knots Wind Direction north-westerly Sea state 1
September 2017	36	9.49%	1,441	Cloudy Visibility >10km Wind speeds 15-40 knots Wind Direction south-westerly to westerly Sea state 2-3
October 2017	36	9.49%	1,441	Cloudy Visibility >10km Wind speeds 20-40 knots Wind Direction westerly Sea state 3-4
November 2017	36	9.31%	1,414.5	Overcast Visibility >10km Wind speeds 30 knots Wind Direction north-westerly and westerly Sea state 2-4
December	36	9.49%	1,441	Overcast – clear

Month of Survey	Number of Transects	Coverage	Number of Images	Weather Conditions
2017				Visibility >10km Wind speeds 7-15 knots Wind Direction northerly and westerly Sea state 2-4
January 2018	36	9.48%	1,441	Overcast Visibility >10km Wind speeds 20-30 knots Wind Direction westerly Sea state 2-4
February 2018	36	9.49%	1,441	Broken cloud - overcast Visibility >7km Wind speeds 14-43 knots Wind Direction westerly and southerly Sea state 3-4
March 2018	36	9.48%	1,441	Cloudy Visibility >10km Wind speeds 13-22 knots Wind Direction north-westerly and south-easterly Sea state 1-2
April 2018	36	9.48%	1,441	Cloudy – mostly clear Visibility >8km Wind speeds 7-35 knots Wind Direction south-westerly, north-westerly and westerly Sea state 2-4
May 2018	36	9.49%	1,441	Clear Visibility >10km Wind speeds 0-15 knots Wind Direction variable Sea state 0
June 2018	36	9.49%	1,442	Mostly clear – partially cloudy Visibility >10km Wind speeds 10-20 knots Wind Direction south-westerly and north-westerly Sea state 3-4
July 2018	36	9.49%	1,441	Clear Visibility >10km Wind speeds 5-7 knots Wind Direction southerly Sea state 0-1

2.2.4 Results

170. Table A1.1 in Annex 1 - Raw Data shows the full raw data count for surveys completed for the Norfolk Boreas site specific surveys, with harbour porpoise counts and harbour porpoise and unidentified small cetacean counts. The data is split

between the Norfolk Boreas site only, the Norfolk Boreas site and 2km buffer and the Norfolk Boreas site and 4km buffer area.

2.2.4.1 Raw data counts

171. Table 2.5 summarises the raw data count for the Norfolk Boreas site area and 4km buffer.

Table 2.5 Norfolk Boreas raw data count for all surveys, including the Norfolk Boreas site area and 4km buffer

Date	Harbour porpoise	Dolphin / porpoise	Dolphin species	Seal species
August 2016	10	18	0	1
September 2016	30	66	0	0
October 2016	3	12	0	0
November 2016	2	7	0	0
December 2016	13	154	1	0
January 2017	7	62	0	0
February 2017	2	65	0	0
March 2017	1	33	0	0
April 2017	5	12	0	0
May 2017	7	3	0	2
June 2017	7	4	0	0
July 2017	26	2	0	0
August 2017	3	5	0	1
September 2017	3	11	0	0
October 2017	0	9	0	1
November 2017	11	66	0	3
December 2017	8	49	0	0
January 2018	9	31	0	1
February 2018	3	35	0	5
March 2018	5	19	0	0
April 2018	0	2	0	0
May 2018	26	20	0	5
June 2018	0	1	0	0
July 2018	13	22	0	8
Total	**194**	**708**	**1**	**27**

2.2.4.2 Corrected data

172. To correct the final counts to account for the availability bias for individuals at the water's surface, the count is divided by the correction factor (mean time spent at surface). The updated seasonal correction factors as outlined in Table 2.2 have been used. See Table 2.6 for the corrected data for the Norfolk Boreas site and 4km buffer.

Table 2.6 Correction Factors applied to the Norfolk Boreas site and 4km buffer

Date	Harbour porpoise		Dolphin / porpoise		Dolphin species		Seal species	
	Raw data count	With Seasonal CF	Raw data count	With Seasonal CF	Raw data count	With dolphin sp CF (0.11)	Raw data count	With seal sp CF (0.1832)
August 2016	10	18.28	18	32.91	0	0.00	1	5.46
September 2016	30	65.93	66	145.05	0	0.00	0	0.00
October 2016	3	6.59	12	26.37	0	0.00	0	0.00
November 2016	2	4.40	7	15.38	0	0.00	0	0.00
December 2016	13	27.54	154	326.27	1	9.09	0	0.00
January 2017	7	14.83	62	131.36	0	0.00	0	0.00
February 2017	2	4.24	65	137.71	0	0.00	0	0.00
March 2017	1	1.75	33	57.79	0	0.00	0	0.00
April 2017	5	8.76	12	21.02	0	0.00	0	0.00
May 2017	7	12.26	3	5.25	0	0.00	2	10.92
June 2017	7	12.80	4	7.31	0	0.00	0	0.00
July 2017	26	47.53	2	3.66	0	0.00	0	0.00
August 2017	3	5.48	5	9.14	0	0.00	1	5.46
September 2017	3	6.59	11	24.18	0	0.00	0	0.00
October 2017	0	0.00	9	19.78	0	0.00	1	5.46
November 2017	11	24.18	66	145.05	0	0.00	3	16.38
December 2017	8	16.95	49	103.81	0	0.00	0	0.00
January 2018	9	19.07	31	65.68	0	0.00	1	5.46
February 2018	3	6.36	35	74.15	0	0.00	5	27.29
March 2018	5	8.76	19	33.27	0	0.00	0	0.00

Date	Harbour porpoise		Dolphin / porpoise		Dolphin species		Seal species	
	Raw data count	With Seasonal CF	Raw data count	With Seasonal CF	Raw data count	With dolphin sp CF (0.11)	Raw data count	With seal sp CF (0.1832)
April 2018	0	0.00	2	3.50	0	0.00	0	0.00
May 2018	26	45.53	20	35.03	0	0.00	5	27.29
June 2018	0	0.00	1	1.83	0	0.00	0	0.00
July 2018	13	23.77	22	40.22	0	0.00	8	43.67
Total	**194**	**381.59**	**708**	**1,465.74**	**1**	**9.09**	**27**	**147.38**

2.2.4.3 Abundance estimates

173. The abundance of harbour porpoise and unidentified small cetaceans were estimated from the raw data counts. Correction factors were then applied to the data to account for the presence of individuals below 2m water depth (the depth at which it is no longer possible to detect marine mammals from aerial imagery). Plate 2.2 and Plate 2.3 show the abundance estimates for harbour porpoise and harbour porpoise and unidentified dolphin / porpoise across the Norfolk Boreas site with 4km buffer.

174. Section 2.2.2 outlines the approach used for the abundance estimates.

175. The highest number of harbour porpoise for the Norfolk Boreas site with 4km buffer was recorded in September 2016, with an estimated abundance of 287 individuals, resulting in an abundance estimate of 630 with the seasonal correction factor (Plate 2.2). When unidentified small cetaceans are included, the highest abundance estimate was in December 2016 with an abundance of 1,883 individuals, resulting in an abundance of 3,990 with the seasonal correction factor (Plate 2.3).

176. There is a clear seasonal pattern of abundances for the harbour porpoise only data, with the highest abundance being in the summer months (September 2016, July 2017 and May and July 2018) as well as smaller peaks in the winter (in December 2016 and November 2017 (Plate 2.2).

177. For the abundancies including unidentified small cetaceans (dolphins or porpoises), there is again a seasonal pattern. However, there are higher abundancies in the winter period (December 2016 and January 2017, and November and December in 2017) with a smaller peak in the summer of 2016 (September). There area smaller peaks in July 2017 and May and July 2018, indicating that higher than normal numbers are seen in these summer months, but the highest peaks are seen in winter (Plate 2.3).

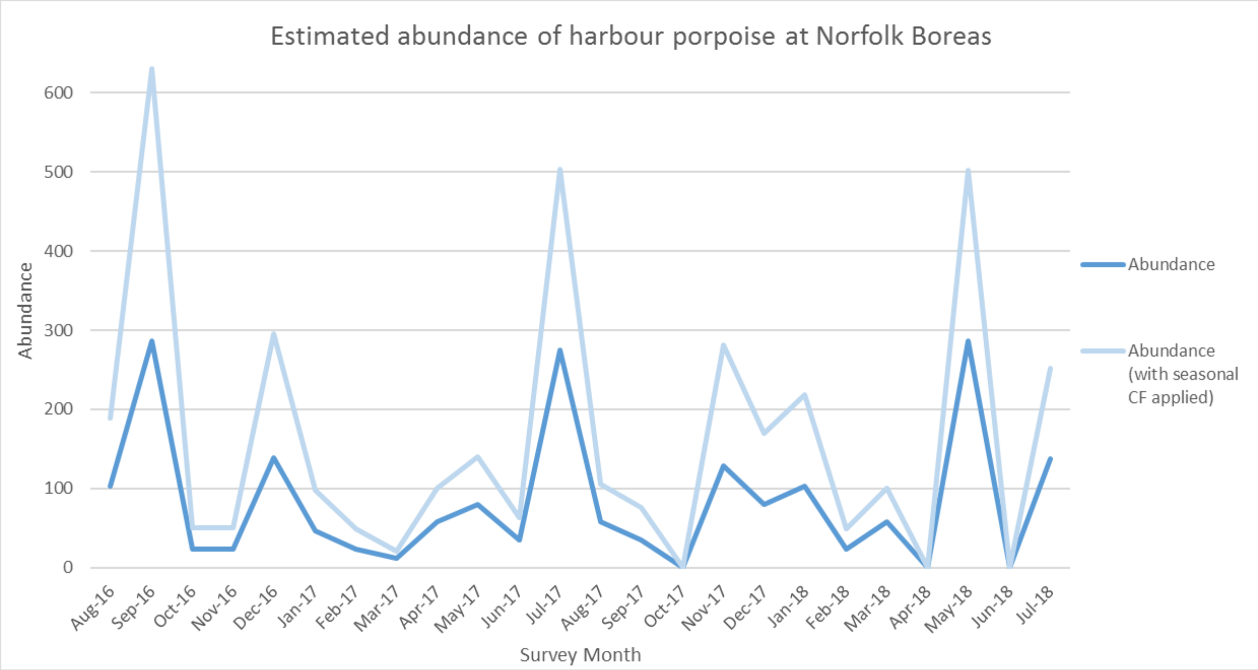


Plate 2.2 The estimated abundance of harbour porpoise across the Norfolk Boreas site and 4km buffer with seasonal correction factor applied.

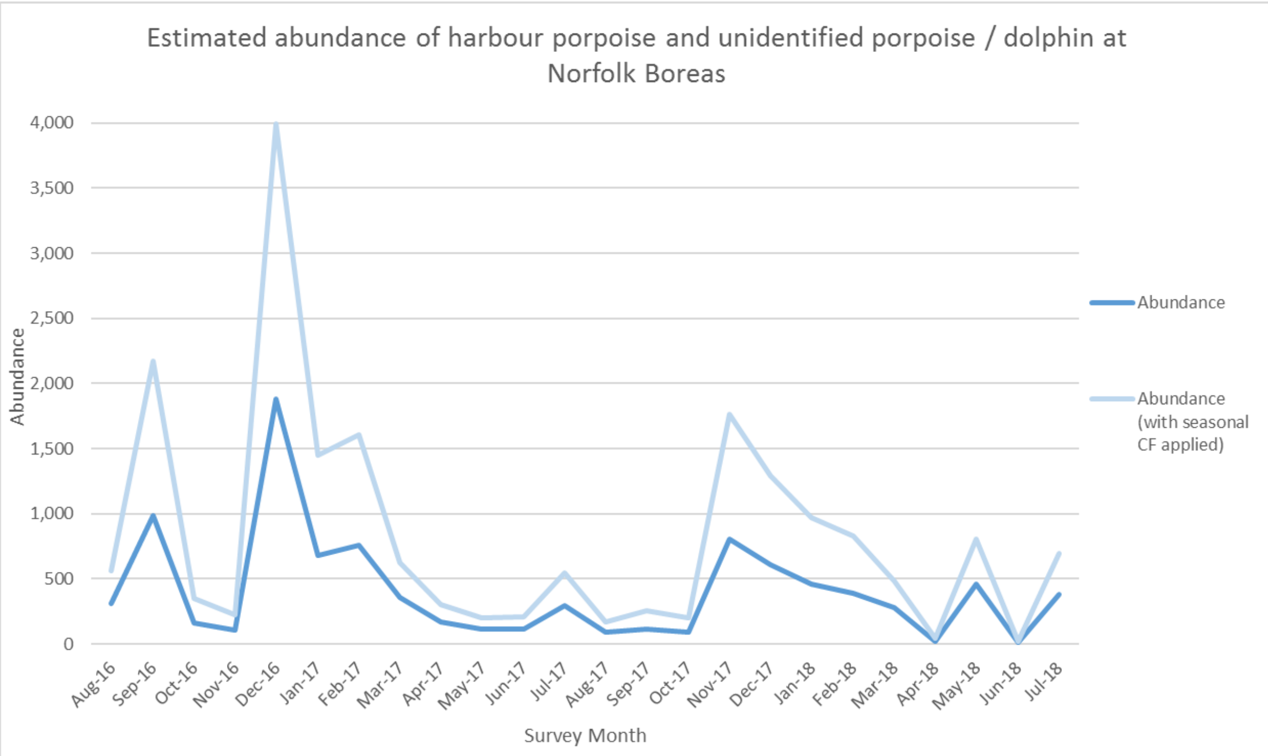


Plate 2.3 The estimated abundance of harbour porpoise and unidentified small cetaceans across Norfolk Boreas site and 4km buffer with seasonal correction factor applied.

2.2.4.4 Density estimates

178. Table 2.7 presents the estimated densities for harbour porpoise only at the Norfolk Boreas site. The density estimates are calculated using the maximum density for each month over the survey period, which is averaged to produce an overall density estimate over a year. This then takes into account seasonal variability to produce a worst-case likely density, of which impacts can be measured against.

179. When unidentified small cetaceans are included with the harbour porpoise data (Table 2.8), the highest density estimate was in December, with an uncorrected density estimate of 1.63/km^2 (97.5% CI = 1.274-2.033/km^2); the corrected density estimates when using the seasonal correction factor is 3.453/km^2 for the Norfolk Boreas site. However, the other monthly density estimates for harbour porpoise, including unidentified small cetaceans, are considerably lower than the December estimate (Table 2.8).

180. The annual mean density estimate when using the seasonal correction factor is 1.06/km^2 for the Norfolk Boreas site.

181. The density estimate during summer (April to September) is 0.664/km^2 and during the winter (October to March) the estimated density is 1.458/km^2 using the corrected densities.

Table 2.7 The highest density estimates for Norfolk Boreas for harbour porpoise only

By Month	Density Estimate (individuals / km^2) based on raw data (CI)	Density Estimate (individuals / km^2) with seasonal CF
Jan	0.111 (0.032-0.207)	**0.236**
Feb	0.019 (0-0.047)	**0.040**
Mar	0.08 (0.016-0.159)	**0.139**
Apr	0.064 (0.016-0.143)	**0.112**
May	0.235 (0.15-0.329)	**0.411**
Jun	0.028 (0-0.066)	**0.052**
Jul	0.225 (0.131-0.31)	**0.412**
Aug	0.084 (0.037-0.141)	**0.154**
Sep	0.271 (0.144-0.399)	**0.596**
Oct	0.024 (0-0.06)	**0.052**
Nov	0.132 (0.06-0.216)	**0.290**
Dec	0.129 (0.048-0.226)	**0.273**
Annual	**0.117 (0.053-0.192)**	**0.231**

Table 2.8 The highest density estimates for Norfolk Boreas for harbour porpoise and unidentified small cetaceans

By Month	Density Estimate (individuals / km^2) based on raw data (97.5% CI)	Density Estimate (individuals / km^2) with seasonal CF
Jan	0.566 (0.385-0.783)	**1.200**
Feb	0.75 (0.543-0.974)	**1.590**
Mar	0.302 (0.127-0.509)	**0.529**
Apr	0.167 (0.06-0.299)	**0.293**
May	0.376 (0.225-0.545)	**0.658**
Jun	0.094 (0.019-0.179)	**0.172**
Jul	0.334 (0.159-0.54)	**0.610**
Aug	0.263 (0.119-0.43)	**0.480**
Sep	0.807 (0.581-1.051)	**1.773**
Oct	0.155 (0.06-0.274)	**0.341**
Nov	0.745 (0.516-0.997)	**1.637**
Dec	1.63 (1.274-2.001)	**3.453**
Annual	**0.516 (0.339-0.715)**	**1.061**

3 References

Anderwald, P., Evans, P.G., Dyer, R., Dale, A., Wright, P.J. and Hoelzel, A.R. (2012). Spatial scale and environmental determinants in minke whale habitat use and foraging. Marine Ecology Progress Series, 450, pp.259-274.
ASCOBANS (2012). Convention on Migratory Species. Available at: <http://www.cms.int/species/ascobans/asc_bkrd.htm>
Banhuera-Hinestroza, E., Galatius Jørgensen, G., Kinze, C., Rasmussen M., and Evan, P. (2009). White-beaked dolphin. In Report of ASCOBANS/HELCOM Small Cetacean population structure workshop Held 8-10 October 2007. ASCOBANS, Bonn, Germany.
Brasseur, S., van Polanen Petel, T., Aarts, G., Meesters, E., Dijkman, E., and Reijnders, P., (2010). Grey seals (*Halichoerus grypus*) in the Dutch North Sea: population ecology and effects of windfarms. In: we@sea (Ed.), IMARES Report number C137/10. Available at: <http://www.we-at-sea.org/leden/docs/reports/RL2-2 2005-006 Effect of windfarms on grey seals in the Dutch North Sea.pdf>
Brasseur, S.M.J.M., van Polanen Petel, T.D., Gerrodette, T., Meesters, E.H.W.G., Reijnders, P.J.H. and Aarts, G. (2014). Rapid recovery of Dutch grey seal colonies fuelled by immigration. Marine Mammal Science. doi: 10.1111/mms.12160.
Capuzzo, E., Stephens, D., Silva, T., Barry, J. and Forster, R.M. (2015). Decrease in water clarity of the southern and central North Sea during the 20th century. Global Change Biology, 21: 2206–2214, doi: 10.1111/gcb.12854.
Cunningham, L., Baxter, J.M., Boyd., I.L., Duck, C.D., Lonergan, M., Moss, S.E. and McConnell, B. (2009). Harbour seal movements and haul-out patterns: implications for monitoring and management. Aquatic Conservation: Marine and Freshwater Ecosystems, 19 398-407.
de Boer, M.N. (2010). Spring distribution and density of minke whale Balaenoptera acutorostrata along an offshore bank in the central North Sea. Marine Ecology Progress Series 408: 265-274.
DECC (now Department for Business, Energy and Industrial Strategy) (2016), UK Offshore Energy Strategic Environmental Assessment 3 (OESEA3)
Dietz, R., Teilmann, J., Henrisksen, O.D. and Laidre. K. (2003). Movements of seals from Rodsand sanctuary monitored by satellite telemetry. Relative importance of the Nysted Offshore Wind Farm to seals. NERI, Denmark. Report No. 429: Page 44.
Dupont, N. and Aksnes, D.L. (2013). Centennial changes in water clarity of the Baltic Sea and the North Sea. Estuarine, Coastal and Shelf Science, 131: 282-289.
EAOW (East Anglia Offshore Wind Limited) (2012a). East Anglia THREE Offshore Windfarm, Environmental Impact Assessment Scoping Report. November 2012.
EAOW (East Anglia Offshore Wind Limited) (2012b). Zonal Environmental Appraisal Report (ZEA).
EAOWFL (East Anglia Offshore Wind Farm Limited) (2012). EA 1 Environmental Statement. Chapter 11 Marine Mammals.

EATL (East Anglia THREE Limited) (2015). East Anglia THREE Environmental Statement.

Evans, P.G.H. and Baines, M.E. (2010). Abundance and Behaviour of Cetaceans and Basking Sharks in the Pentland Firth and Orkney waters. Report by Hebog Environmental Ltd and Sea Watch Foundation. Scottish Natural Heritage Commissioned Report No. (iBids and Projects ID 1052). 41 pp.

Friends of Horsey (2018). Seal Pup Count 2017-2018. Dated 18th January 2018. http://friendsofhorseyseals.co.uk/wp-content/uploads/2018/01/Seal_count_18th_January_2018.pdf

Friends of Horsey (2019). Seal Pup Count 2018-2019. Dated 18th January 2018.

Gilles, A., Peschko, V., Scheidat, M. and Siebert, U. (2012). Survey for small cetaceans over the Dogger Bank and adjacent areas in summer 2011. Document submitted by Germany to 19th ASCOBANS Advisory Committee Meeting in Galway, Ireland, 20-22 March 2012. AC19/Doc.5-08(P). 16pp.

Gilles, A., Viquerat, S., Becker, E. A., Forney, K. A., Geelhoed, S. C. V., Haelters, J., Nabe-Nielsen, J., Scheidat, M., Siebert, U., Sveegaard, S., van Beest, F. M., van Bemmelen, R.and Aarts, G. (2016). Seasonal habitat-based density models for a marine top predator, the harbor porpoise, in a dynamic environment. Ecosphere 7(6):e01367. 10.1002/ecs2.1367

Hammond P.S., Macleod K., Berggren P., Borchers D.L., Burt L., Cañadas A., Desportes G., Donovan G.P., Gilles A., Gillespie D., Gordon J., Hiby L., Kuklik I., Leaper R., Lehnert K, Leopold M., Lovell P., Øien N., Paxton C.G.M., Ridoux V., Rogano E., Samarraa F., Scheidatg M., Sequeirap M., Siebertg U., Skovq H., Swifta R., Tasker M.L., Teilmann J., Canneyt O.V. and Vázquez J.A. (2013). Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. Biological Conservation 164, 107-122.

Hammond, P. S., Benke, H., Borchers, D.L., Buckand, S.T., Collet, A., Heide-Jørgensen, M-P., Heimlich-Boran, S., Hiby, A.R., Leopold, M. F., and Øien, N. (2002). Distribution and abundance of the harbour porpoise and other small cetaceans in the North Sea and Adjacent Waters. Journal of Applied Ecology, 39(2); 361-376.

Hammond, P.S., Lacey, C., Gilles, A., Viquerat, S., Boerjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M., Scheidat, M. and Teilmann, J. (2017). Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. Wageningen Marine Research.

Heinänen, S. and Skov, H. (2015). The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area, JNCC Report No.544 JNCC, Peterborough.

IAMMWG (2015). Management Units for cetaceans in UK waters (January 2015). JNCC Report No. 547, JNCC Peterborough.

Jansen, O.E., Leopold, M.F., Meesters, E.H.W.G. and Smeenk C. (2010). Are white-beaked dolphins Lagenorhynchus albirostris food specialists? Their diet in the southern North Sea. Journal of the Marine Biological Association of the United Kingdom 90, 1501–1508.

Koski, W.R., Thomas, T.A., Funk, D.W. and Macrander, A.M. (2013). Marine mammals sightings by analysts of digital imagery versus aerial surveyors: a preliminary comparison.

Journal of Unmanned Vehicle Systems 1: 25-40.

Lowry, L.F., Frost, K.J., Hoep, J.M. and Delong, R.A. (2001). Movements of satellite-tagged subadult and adult harbor seals in Prince William Sound, Alaska. Marine Mammal Science 17(4): 835−861.

Lowry, M.S. (1999). Counts of California sea lion (Zalophus californianus) pups from aerial color photographs and from the ground: a comparison of two methods. Marine Mammal Science 15(1): 143–158.

Macleod,K., Burt, M.L., Cañadas, A., Rogan, E., Santos, B., Uriarte, A., Van Canneyt, O., Vázquez, J. A. and Hammond, P. S. (2009). Design-based estimates of cetacean abundance in offshore European Atlantic waters. Appendix I in the Final Report of the Cetacean Offshore Distribution and Abundance in the European Atlantic. 16pp.

MARINElife (2018). Marine mammal sightings from southern North Sea ferry routes: http://www.marine-life.org.uk/sightings

Mate BR, Rossbach KA, Nieukirk SL, Wells RS, Irvine AB, Scott MD and Read AJ (1995). Satellite-monitored movements and dive behaviour of a bottlenose dolphin (*Tursiops truncates*) in Tampa Bay, Florida. Marine Mammal Science 11: 452–463.

Mate BR, Stafford KM, Nawojchik R and Dunn LJ (1994). Movements and dive behaviour of a satellite-monitored Atlantic white-sided dolphin (*Lagenorhynchus acutus*) in the gulf of Maine. Marine Mammal Science 10: 116–121.

Matthiopoulos, J., McConnell, B.J., Duck, C. and Fedak, M.A. (2004). Using satellite telemetry and aerial counts to estimate space use by grey seals around the British Isles. Journal of Applied Ecology. 41(3):476-491.

McConnell, B.J., Chambers, C., Nicholas, K.S. and Fedak, M.A. (1992). Satellite tracking of grey seals (Halichoerus grypus). Journal of Zoology, 226(2), pp.271-282.

Norfolk Vanguard Limited (2018) Norfolk Vanguard Offshore Wind Farm Chapter 12 Marine Mammals: Environmental Statement Volume 1.

Northridge, S.P., Tasker, M.L., Webb, A. and Williams, J.M. (1995). Distribution and relative abundance of harbour porpoises (Phocoena phocoena L.), white-beaked dolphins (Lagenorhynchus albirostris Gray), and minke whales (Balaenoptera acutorostrata Lacepède) around the British Isles. ICES Journal of Marine Science: Journal du Conseil, 52(1), pp.55-66.

Oudejans, M.G., Visser, F., Englund, A., Rogan, E. and Ingram, S.N. (2015). Evidence for distinct coastal and offshore communities of bottlenose dolphins in the North East Atlantic. PLoS ONE 10(4): e0122668.

Paxton, C.G.M., Scott-Hayward, L., Mackenzie, M., Rexstad, E. and Thomas, L. (2016). Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resources with Advisory Note, JNCC Report 517, ISSN 0963-8091: http://jncc.defra.gov.uk/page-7201

Rasmussen MH, Akamatsu T, Teilmann J, Vikinsson G and Miller LA (2013). Biosonar, diving and movements of two tagged white-beaked dolphin in Icelandic waters. Deep-Sea Research II 88-89: 97-105.

Reid, J.B, Evans, P.G.H. and Northridge, S.P. (2003). Atlas of cetacean Distribution in North west European waters. JNCC, Peterborough.

Rogan, E. and Berrow, S.D. (1996). A review of harbour porpoises. Phocoena phocoena, in Irish waters. Report to International Whaling Commission, 46, pp.595-606.
Rothney, E. (2016). Grey Seal breeding colony report winter season 2015-16. Friends of Horsey Seals.
Rothney, E. (2017). Horsey Grey Seal breeding colony report 2016-17. Friends of Horsey Seals.
Russell, D.J.F (2016). Movements of grey seal that haul out on the UK coast of the southern North Sea. Report for the Department of Energy and Climate Change (OESEA-14-47).
Russell, D.J.F. and McConnell, B.J. (2014). Seal at-sea distribution, movements and behaviour. Report to DECC. URN: 14D/085. March 2014 (final revision).
Russell, D.J.F., McConnell, B.J., Thompson, D., Duck, C.D., Morris, C., Harwood, J. and Matthiopoulos, J. (2013). Uncovering the links between foraging and breeding regions in a highly mobile mammal. Journal of Applied Ecology, Vol 50, no. 2, pp. 499-509.
Santos, M.B. and Pierce, G.J. (2003). The diet of harbour porpoise (*Phoceona phoceona*) in the North east Atlantic. Oceanography and Marine Biology: an Annual Review 2003, 41, 355–390.
Santos, M.B., Pierce, G.J., Learmonth, J.A., Reid, R.J., Ross, H.M., Patterson, I.A.P., Reid, D.G. and Beare, D. (2004). Variability in the diet of harbor porpoises (*Phocoena phocoena*) in Scottish waters 1992–2003. Marine Mammal Science, 20(1), pp.1-27.
SCOS (2016). SCOS Report. Scientific Advice on Matters Related to the Management of Seal Populations: 2016. http://www.smru.st-andrews.ac.uk/files/2017/04/SCOS-2016.pdf
SCOS (2017). Scientific Advice on Matters Related to the Management of Seal Populations: 2017. Available at: http://www.smru.st-andrews.ac.uk
ScottishPower Renewables (2019a) East Anglia ONE North Offshore Wind Farm Preliminary Environmental Information: Chapter 11 Marine Mammals.
ScottishPower Renewables (2019b) East Anglia TWO Offshore Wind Farm Preliminary Environmental Information: Chapter 11 Marine Mammals.
Sea Watch Foundation (2018). Reports of cetacean sightings eastern England: http://www.seawatchfoundation.org.uk/recentsightings/
Sharples R.J., Matthiopoulos, J. and Hammond, P.S. (2008). Distribution and movements of harbour seals around the coast of Britain: Outer Hebrides, Shetland, Orkney, the Moray Firth, St Andrews Bay, The Wash and the Thames Report to DTI July 2008.
Sharples, R.J., Moss, S.E., Patterson, T.A. and Hammond, P.S. (2012). Spatial Variation in Foraging Behaviour of a Marine Top Predator (*Phoca vitulina*) Determined by a Large-Scale Satellite Tagging Program. PLoS ONE 7(5): e37216.
SMRU (2011). Utilisation of space by grey and harbour seals in the Pentland Firth and Orkney waters. Scottish Natural Heritage Commissioned Report No. 441.
Stewart, R.E.A., Born, E.W., Dunn, J.B., Koski, W.R. and Ryan, A.K. (2013). Use of multiple methods to estimate walrus (Odobenus rosmarus rosmarus) abundance in the Penny

Strait-Lancaster Sound and West Jones Sound stocks, Canada. NAMMCO Sci. Publ. 9: Online Early, doi: 10.7557/3.2608.

Teilmann J, Christiansen CT, Kjellerup S, Dietz R and Nachman G (2013). Geographic, seasonal and diurnal surface behaviour of harbour porpoise. Marine Mammal Science 29(2): E60-E76.

Teilmann J, Larsen F and Desportes G (2007). Time allocation and diving behaviour of harbour porpoises (Phocoena phocoena) in Danish and adjacent waters. Journal of Cetacean Research and Management 9(3): 201-210.

Thompson, P. M. and Miller, D. (1990). Summer foraging activity movements of radio-tagged common seals (Phoca vitulina L.) in the Moray Firth, Scotland. J. Appl. Ecol. 27: 492±501.

Thompson, P.M., McConnell, B.J., Tollit, D.J., Mackay, A., Hunter, C. and Racey, P.A. (1996). Comparative distribution, movements and diet of harbour and grey seals from the Moray Firth, N.E. Scotland. Journal of Applied Ecology. 33: 1572-1584.

Tollit, D.J., Black, A.D., Thompson, P.M., Mackay, A., Corpe, H.M., Wilson, B., Parijs, S.M., Grellier, K. and Parlane, S. (1998). Variations in harbour seal Phoca vitulina diet and dive-depths in relation to foraging habitat. Journal of Zoology, 244(2), pp.209-222.

Voet H., Rehfisch M., McGovern S. and Sweeney S. (2017). Marine Mammal Correction Factor for Availability Bias in Aerial Digital Still surveys. Case Study: Harbour porpoise (*Phocoena phocoena*) in the Southern North Sea. APEM Ltd.

Wildfowl and Wetland Trust (WWT). (2009). Distributions of Cetaceans, Seals, Turtles, Sharks and Ocean Sunfish recorded from Aerial Surveys 2001-2008. WWT Consulting. Report to Department of Energy and Climate Change.

Williamson LD, Brookes KL, Scott BE, Graham IM, Bradbury G, Hammond PS and Thompson PM (2016). Echolocation detections and digital video surveys provide reliable estimates of the relative density of harbour porpoises. Methods in Ecology and Evolution 7(7): 762–769.

Wood, C.J. (1998). Movement of bottlenose dolphins around the south-west coast of Britain. Journal of Zoology London 246: 155-163.

3.1.1 APEM Monthly Survey Reports

APEM (2017). Norfolk Boreas: August 2016 Monthly Report - Aerial Bird & Marine Mammal Survey 01, Year 01. APEM Scientific Report P804 – NB01. Vattenfall Wind Power Limited, December 2017, 21 pp.

APEM (2017). Norfolk Boreas: September 2016 Monthly Report - Aerial Bird & Marine Mammal Survey 02, Year 01. APEM Scientific Report P804 – NB02. Vattenfall Wind Power Limited, December 2017, 22 pp.

APEM (2017). Norfolk Boreas: October 2016 Monthly Report - Aerial Bird & Marine Mammal Survey 03, Year 01. APEM Scientific Report P804 – NB03. Vattenfall Wind Power Limited, December 2017, 23 pp.

APEM (2017). Norfolk Boreas: November 2016 Monthly Report - Aerial Bird & Marine

Mammal Survey 04, Year 01. APEM Scientific Report P804 – NB04. Vattenfall Wind Power Limited, December 2017, 22 pp.
APEM (2017). Norfolk Boreas: December 2016 Monthly Report - Aerial Bird & Marine Mammal Survey 05, Year 01. APEM Scientific Report P804 – NB05. Vattenfall Wind Power Limited, December 2017, 23 pp.
APEM (2017). Norfolk Boreas: January 2017 Monthly Report - Aerial Bird & Marine Mammal Survey 06, Year 01. APEM Scientific Report P804 – NB06. Vattenfall Wind Power Limited, December 2017, 22 pp.
APEM (2017). Norfolk Boreas: February 2017 Monthly Report - Aerial Bird & Marine Mammal Survey 07, Year 01. APEM Scientific Report P804 – NB07. Vattenfall Wind Power Limited, December 2017, 22 pp.
APEM (2017). Norfolk Boreas: March 2017 Monthly Report - Aerial Bird & Marine Mammal Survey 08, Year 01. APEM Scientific Report P804 – NB08. Vattenfall Wind Power Limited, December 2017, 24 pp.
APEM (2017). Norfolk Boreas: April 2017 Monthly Report - Aerial Bird & Marine Mammal Survey 09, Year 01. APEM Scientific Report P804 – NB09. Vattenfall Wind Power Limited, December 2017, 23 pp.
APEM (2017). Norfolk Boreas: May 2017 Monthly Report - Aerial Bird & Marine Mammal Survey 10, Year 01. APEM Scientific Report P804 – NB10. Vattenfall Wind Power Limited, December 2017, 22 pp.
APEM (2017). Norfolk Boreas: June 2017 Monthly Report - Aerial Bird & Marine Mammal Survey 11, Year 01. APEM Scientific Report P804 – NB11. Vattenfall Wind Power Limited, December 2017, 22 pp.
APEM (2017). Norfolk Boreas: July 2017 Monthly Report - Aerial Bird & Marine Mammal Survey 12, Year 01. APEM Scientific Report P804 – NB12. Vattenfall Wind Power Limited, December 2017, 21 pp.
APEM (2018). Norfolk Boreas: August 2017 Monthly Report - Aerial Bird & Marine Mammal Survey 01, Year 02. APEM Scientific Report P1785 – NB13. Vattenfall Wind Power Limited, October 2018, 21 pp.
APEM (2018). Norfolk Boreas: September 2017 Monthly Report - Aerial Bird & Marine Mammal Survey 02, Year 02. APEM Scientific Report P1785 – NB14. Vattenfall Wind Power Limited, October 2018, 24 pp.
APEM (2018). Norfolk Boreas: October 2017 Monthly Report - Aerial Bird & Marine Mammal Survey 03, Year 02. APEM Scientific Report P1785 – NB15. Vattenfall Wind Power Limited, October 2018, 22 pp.
APEM (2018). Norfolk Boreas: November 2017 Monthly Report - Aerial Bird & Marine Mammal Survey 04, Year 02. APEM Scientific Report P1785 – NB16. Vattenfall Wind Power Limited, October 2018, 22 pp.
APEM (2018). Norfolk Boreas: December 2017 Monthly Report - Aerial Bird & Marine Mammal Survey 05, Year 02. APEM Scientific Report P1785 – NB17. Vattenfall Wind Power Limited, October 2018, 21 pp.
APEM (2018). Norfolk Boreas: January 2018 Monthly Report - Aerial Bird & Marine

Mammal Survey 06, Year 02. APEM Scientific Report P1785 – NB18. Vattenfall Wind Power Limited, October 2018, 22 pp.
APEM (2018). Norfolk Boreas: February 2018 Monthly Report - Aerial Bird & Marine Mammal Survey 07, Year 02. APEM Scientific Report P1785 – NB19. Vattenfall Wind Power Limited, October 2018, 21 pp.
APEM (2018). Norfolk Boreas: March 2018 Monthly Report - Aerial Bird & Marine Mammal Survey 08, Year 02. APEM Scientific Report P1785 – NB20. Vattenfall Wind Power Limited, October 2018, 22 pp.
APEM (2018). Norfolk Boreas: April 2018 Monthly Report - Aerial Bird & Marine Mammal Survey 09, Year 02. APEM Scientific Report P1785 – NB21. Vattenfall Wind Power Limited, October 2018, 21 pp.
APEM (2018). Norfolk Boreas: May 2018 Monthly Report - Aerial Bird & Marine Mammal Survey 10, Year 02. APEM Scientific Report P1785 – NB22. Vattenfall Wind Power Limited, October 2018, 22 pp.
APEM (2018). Norfolk Boreas: June 2018 Monthly Report - Aerial Bird & Marine Mammal Survey 11, Year 02. APEM Scientific Report P1785 – NB23. Vattenfall Wind Power Limited, October 2018, 20 pp.
APEM (2018). Norfolk Boreas: July 2018 Monthly Report - Aerial Bird & Marine Mammal Survey 12, Year 02. APEM Scientific Report P1785 – NB24. Vattenfall Wind Power Limited, October 2018, 22 pp.

Annex 1 - Raw Data

Table A1.1 Raw count for the marine mammal surveys undertaken for the Norfolk Boreas site and 4km buffer.

Species	Area	Month	Year	Count	Density	Lower 97.5%	Upper 97.5%	Abundance
Harbour porpoise	Norfolk Boreas site only	August	2016	4	0.064	0.000	0.128	46.312
Harbour porpoise	Norfolk Boreas site only	September	2016	17	0.271	0.144	0.399	196.828
Harbour porpoise	Norfolk Boreas site only	October	2016	1	0.016	0.000	0.048	11.578
Harbour porpoise	Norfolk Boreas site only	November	2016	1	0.016	0.000	0.048	11.578
Harbour porpoise	Norfolk Boreas site only	December	2016	8	0.129	0.048	0.226	93.617
Harbour porpoise	Norfolk Boreas site only	January	2017	3	0.048	0.000	0.113	35.095
Harbour porpoise	Norfolk Boreas site only	February	2017	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site only	March	2017	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site only	April	2017	4	0.064	0.016	0.143	46.253
Harbour porpoise	Norfolk Boreas site only	May	2017	6	0.096	0.032	0.176	69.469
Harbour porpoise	Norfolk Boreas site only	June	2017	1	0.016	0.000	0.064	11.548
Harbour porpoise	Norfolk Boreas site only	July	2017	8	0.128	0.048	0.223	92.506
Harbour porpoise	Norfolk Boreas site only	August	2017	4	0.064	0.016	0.127	46.194
Harbour porpoise	Norfolk Boreas site only	September	2017	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site only	October	2017	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site only	November	2017	7	0.112	0.032	0.209	81.492
Harbour porpoise	Norfolk Boreas site only	December	2017	2	0.032	0.000	0.080	23.126
Harbour porpoise	Norfolk Boreas site only	January	2018	7	0.111	0.032	0.207	80.839
Harbour porpoise	Norfolk Boreas site only	February	2018	1	0.016	0.000	0.048	11.548
Harbour porpoise	Norfolk Boreas site only	March	2018	5	0.080	0.016	0.159	57.668

Species	Area	Month	Year	Count	Density	Lower 97.5%	Upper 97.5%	Abundance
Harbour porpoise	Norfolk Boreas site only	April	2018	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site only	May	2018	12	0.192	0.096	0.303	138.937
Harbour porpoise	Norfolk Boreas site only	June	2018	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site only	July	2018	9	0.143	0.064	0.239	103.670
Harbour porpoise	Norfolk Boreas site + 2km buffer	August	2016	7	0.084	0.024	0.155	80.385
Harbour porpoise	Norfolk Boreas site + 2km buffer	September	2016	22	0.264	0.156	0.372	253.858
Harbour porpoise	Norfolk Boreas site + 2km buffer	October	2016	2	0.024	0.000	0.060	22.923
Harbour porpoise	Norfolk Boreas site + 2km buffer	November	2016	1	0.012	0.000	0.036	11.506
Harbour porpoise	Norfolk Boreas site + 2km buffer	December	2016	8	0.097	0.036	0.169	92.805
Harbour porpoise	Norfolk Boreas site + 2km buffer	January	2017	3	0.036	0.000	0.084	34.768
Harbour porpoise	Norfolk Boreas site + 2km buffer	February	2017	1	0.012	0.000	0.036	11.484
Harbour porpoise	Norfolk Boreas site + 2km buffer	March	2017	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site + 2km buffer	April	2017	5	0.060	0.012	0.119	57.418
Harbour porpoise	Norfolk Boreas site + 2km buffer	May	2017	7	0.083	0.036	0.143	80.230
Harbour porpoise	Norfolk Boreas site + 2km buffer	June	2017	2	0.024	0.000	0.060	22.967

Species	Area	Month	Year	Count	Density	Lower 97.5%	Upper 97.5%	Abundance
Harbour porpoise	Norfolk Boreas site + 2km buffer	July	2017	13	0.155	0.072	0.239	149.286
Harbour porpoise	Norfolk Boreas site + 2km buffer	August	2017	4	0.048	0.012	0.096	45.934
Harbour porpoise	Norfolk Boreas site + 2km buffer	September	2017	2	0.024	0.000	0.060	22.945
Harbour porpoise	Norfolk Boreas site + 2km buffer	October	2017	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site + 2km buffer	November	2017	11	0.132	0.060	0.216	127.083
Harbour porpoise	Norfolk Boreas site + 2km buffer	December	2017	4	0.048	0.012	0.096	46.023
Harbour porpoise	Norfolk Boreas site + 2km buffer	January	2018	8	0.096	0.036	0.167	91.868
Harbour porpoise	Norfolk Boreas site + 2km buffer	February	2018	1	0.012	0.000	0.036	11.461
Harbour porpoise	Norfolk Boreas site + 2km buffer	March	2018	5	0.060	0.012	0.119	57.418
Harbour porpoise	Norfolk Boreas site + 2km buffer	April	2018	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site + 2km buffer	May	2018	18	0.215	0.131	0.323	206.903
Harbour porpoise	Norfolk Boreas site + 2km buffer	June	2018	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site + 2km buffer	July	2018	9	0.107	0.047	0.191	103.153
Harbour porpoise	Norfolk Boreas site +	August	2016	9	0.084	0.037	0.141	103.180

Species	Area	Month	Year	Count	Density	Lower 97.5%	Upper 97.5%	Abundance
	4km buffer							
Harbour porpoise	Norfolk Boreas site + 4km buffer	September	2016	25	0.235	0.141	0.329	286.828
Harbour porpoise	Norfolk Boreas site + 4km buffer	October	2016	2	0.019	0.000	0.047	22.894
Harbour porpoise	Norfolk Boreas site + 4km buffer	November	2016	2	0.019	0.000	0.047	22.899
Harbour porpoise	Norfolk Boreas site + 4km buffer	December	2016	12	0.114	0.057	0.181	139.495
Harbour porpoise	Norfolk Boreas site + 4km buffer	January	2017	4	0.038	0.009	0.085	46.268
Harbour porpoise	Norfolk Boreas site + 4km buffer	February	2017	2	0.019	0.000	0.047	22.998
Harbour porpoise	Norfolk Boreas site + 4km buffer	March	2017	1	0.009	0.000	0.028	11.482
Harbour porpoise	Norfolk Boreas site + 4km buffer	April	2017	5	0.047	0.009	0.094	57.366
Harbour porpoise	Norfolk Boreas site + 4km buffer	May	2017	7	0.066	0.019	0.113	80.312
Harbour porpoise	Norfolk Boreas site + 4km buffer	June	2017	3	0.028	0.000	0.066	34.471
Harbour porpoise	Norfolk Boreas site + 4km buffer	July	2017	24	0.225	0.131	0.310	275.563
Harbour porpoise	Norfolk Boreas site + 4km buffer	August	2017	5	0.047	0.009	0.094	57.452
Harbour porpoise	Norfolk Boreas site + 4km buffer	September	2017	3	0.028	0.000	0.066	34.393

Species	Area	Month	Year	Count	Density	Lower 97.5%	Upper 97.5%	Abundance
Harbour porpoise	Norfolk Boreas site + 4km buffer	October	2017	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site + 4km buffer	November	2017	11	0.105	0.048	0.171	127.993
Harbour porpoise	Norfolk Boreas site + 4km buffer	December	2017	7	0.066	0.019	0.113	80.372
Harbour porpoise	Norfolk Boreas site + 4km buffer	January	2018	9	0.084	0.038	0.141	103.336
Harbour porpoise	Norfolk Boreas site + 4km buffer	February	2018	2	0.019	0.000	0.047	22.912
Harbour porpoise	Norfolk Boreas site + 4km buffer	March	2018	5	0.047	0.009	0.094	57.539
Harbour porpoise	Norfolk Boreas site + 4km buffer	April	2018	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site + 4km buffer	May	2018	25	0.235	0.150	0.329	287.044
Harbour porpoise	Norfolk Boreas site + 4km buffer	June	2018	0	0.000	0.000	0.000	0.000
Harbour porpoise	Norfolk Boreas site + 4km buffer	July	2018	12	0.113	0.056	0.178	137.677
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	August	2016	13	0.208	0.064	0.367	150.515
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	September	2016	49	0.782	0.495	1.086	567.327
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	October	2016	7	0.112	0.032	0.224	81.047
Harbour porpoise and unid.	Norfolk Boreas site only	November	2016	5	0.080	0.016	0.176	57.890

Species	Area	Month	Year	Count	Density	Lower 97.5%	Upper 97.5%	Abundance
Porpoise or dolphin								
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	December	2016	101	1.630	1.274	2.001	1,181.921
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	January	2017	34	0.548	0.339	0.807	397.745
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	February	2017	47	0.750	0.543	0.974	544.170
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	March	2017	13	0.207	0.096	0.335	150.322
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	April	2017	10	0.159	0.048	0.319	115.632
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	May	2017	6	0.096	0.032	0.176	69.469
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	June	2017	5	0.080	0.016	0.191	57.742
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	July	2017	8	0.128	0.048	0.223	92.506
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	August	2017	5	0.080	0.016	0.175	57.742
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	September	2017	3	0.048	0.000	0.112	34.734
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	October	2017	3	0.048	0.000	0.112	34.824
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	November	2017	46	0.738	0.482	1.059	535.518
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	December	2017	18	0.287	0.143	0.478	208.138

Species	Area	Month	Year	Count	Density	Lower 97.5%	Upper 97.5%	Abundance
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	January	2018	20	0.318	0.143	0.541	230.968
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	February	2018	14	0.223	0.111	0.366	161.678
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	March	2018	19	0.302	0.127	0.509	219.139
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	April	2018	2	0.032	0.000	0.080	23.097
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	May	2018	18	0.287	0.128	0.495	208.406
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	June	2018	0	0.000	0.000	0.000	0.000
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site only	July	2018	21	0.334	0.159	0.540	241.896
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	August	2016	22	0.263	0.119	0.430	252.638
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	September	2016	59	0.708	0.456	0.960	680.802
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	October	2016	13	0.155	0.060	0.274	148.999
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	November	2016	7	0.084	0.024	0.168	80.540
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	December	2016	132	1.592	1.291	1.918	1,531.286
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	January	2017	47	0.566	0.385	0.783	544.702
Harbour porpoise and unid.	Norfolk Boreas site +	February	2017	53	0.633	0.454	0.836	608.627

Species	Area	Month	Year	Count	Density	Lower 97.5%	Upper 97.5%	Abundance
Porpoise or dolphin	2km buffer							
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	March	2017	25	0.298	0.191	0.417	286.537
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	April	2017	14	0.167	0.060	0.299	160.769
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	May	2017	8	0.095	0.036	0.179	91.692
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	June	2017	6	0.072	0.012	0.155	68.901
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	July	2017	14	0.167	0.072	0.275	160.769
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	August	2017	5	0.060	0.012	0.131	57.418
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	September	2017	7	0.084	0.012	0.179	80.308
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	October	2017	5	0.060	0.012	0.119	57.418
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	November	2017	62	0.745	0.516	0.997	716.284
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	December	2017	34	0.407	0.251	0.586	391.192
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	January	2018	32	0.382	0.203	0.585	367.473
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	February	2018	21	0.250	0.143	0.381	240.691
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	March	2018	22	0.263	0.119	0.418	252.638

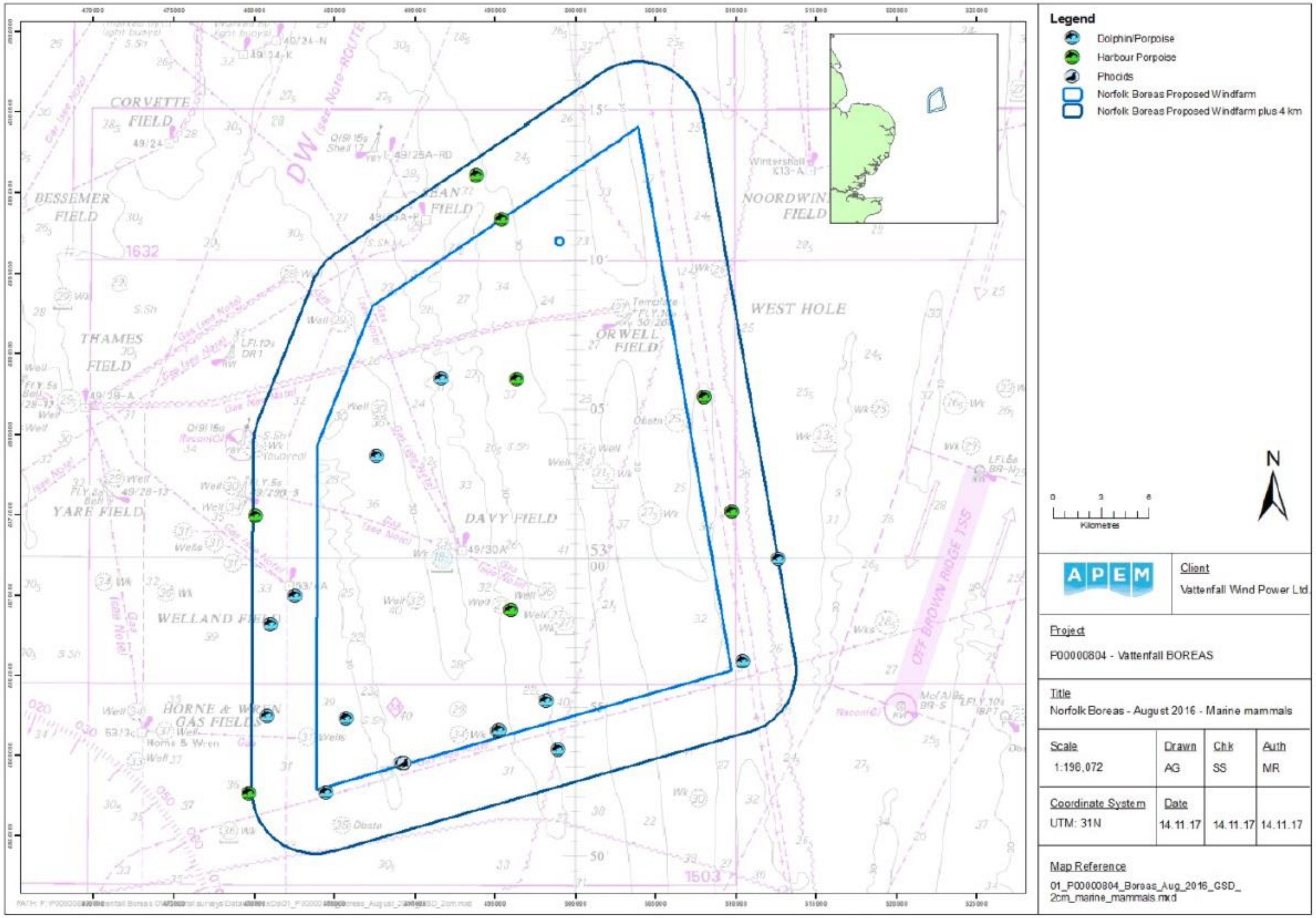
Species	Area	Month	Year	Count	Density	Lower 97.5%	Upper 97.5%	Abundance
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	April	2018	2	0.024	0.000	0.060	22.967
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	May	2018	26	0.311	0.167	0.490	298.859
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	June	2018	0	0.000	0.000	0.000	0.000
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 2km buffer	July	2018	28	0.334	0.178	0.524	320.922
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	August	2016	27	0.253	0.131	0.394	309.540
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	September	2016	86	0.807	0.581	1.051	986.687
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	October	2016	14	0.131	0.056	0.225	160.260
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	November	2016	9	0.084	0.019	0.169	103.044
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	December	2016	162	1.540	1.273	1.853	1,883.178
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	January	2017	59	0.558	0.397	0.738	682.454
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	February	2017	66	0.621	0.461	0.799	758.945
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	March	2017	31	0.291	0.178	0.413	355.935
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	April	2017	15	0.141	0.047	0.253	172.097
Harbour porpoise and unid.	Norfolk Boreas site +	May	2017	10	0.094	0.019	0.178	114.731

Species	Area	Month	Year	Count	Density	Lower 97.5%	Upper 97.5%	Abundance
Porpoise or dolphin	4km buffer							
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	June	2017	10	0.094	0.019	0.179	114.905
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	July	2017	26	0.244	0.131	0.357	298.526
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	August	2017	8	0.075	0.009	0.160	91.924
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	September	2017	10	0.094	0.019	0.178	114.644
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	October	2017	8	0.075	0.028	0.131	91.785
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	November	2017	69	0.656	0.457	0.866	802.863
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	December	2017	53	0.498	0.329	0.676	608.534
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	January	2018	40	0.376	0.235	0.535	459.271
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	February	2018	34	0.318	0.206	0.450	389.497
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	March	2018	24	0.226	0.113	0.348	276.189
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	April	2018	2	0.019	0.000	0.047	22.981
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	May	2018	40	0.376	0.225	0.545	459.271
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	June	2018	1	0.009	0.000	0.028	11.508

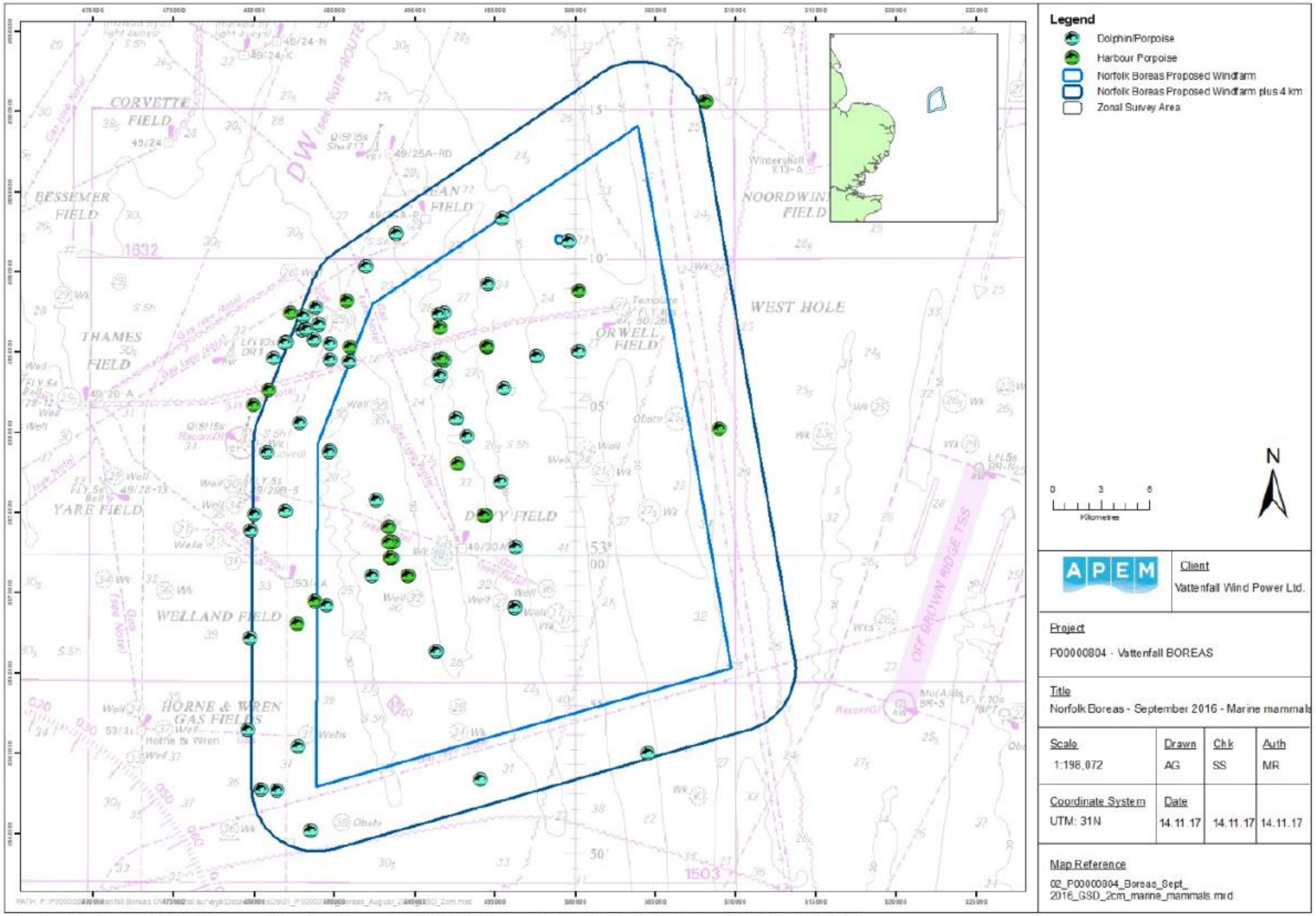
Species	Area	Month	Year	Count	Density	Lower 97.5%	Upper 97.5%	Abundance
Harbour porpoise and unid. Porpoise or dolphin	Norfolk Boreas site + 4km buffer	July	2018	33	0.310	0.169	0.460	378.612

Annex 2 – Marine Mammal Sighting Locations

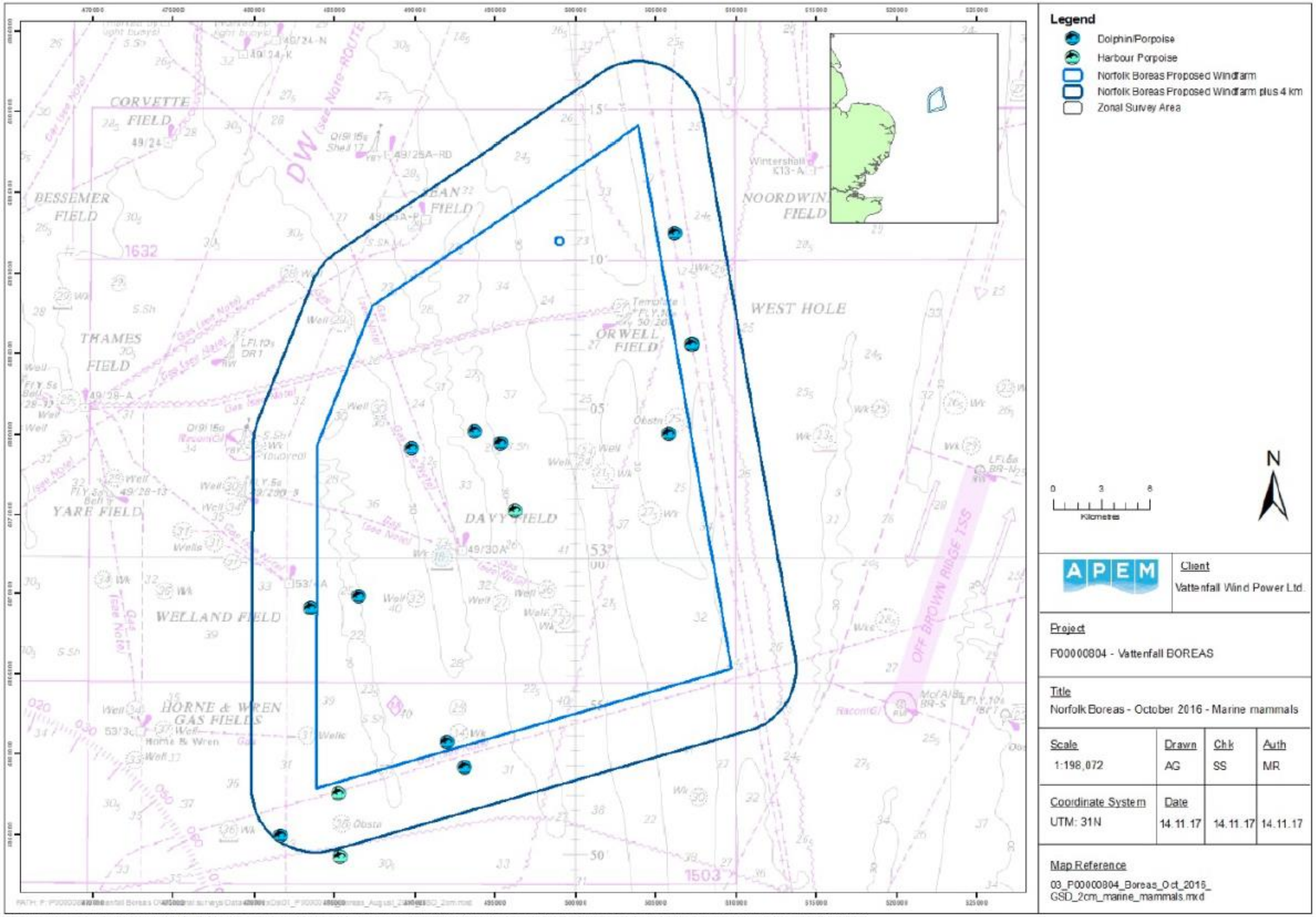
3.1 August 2016



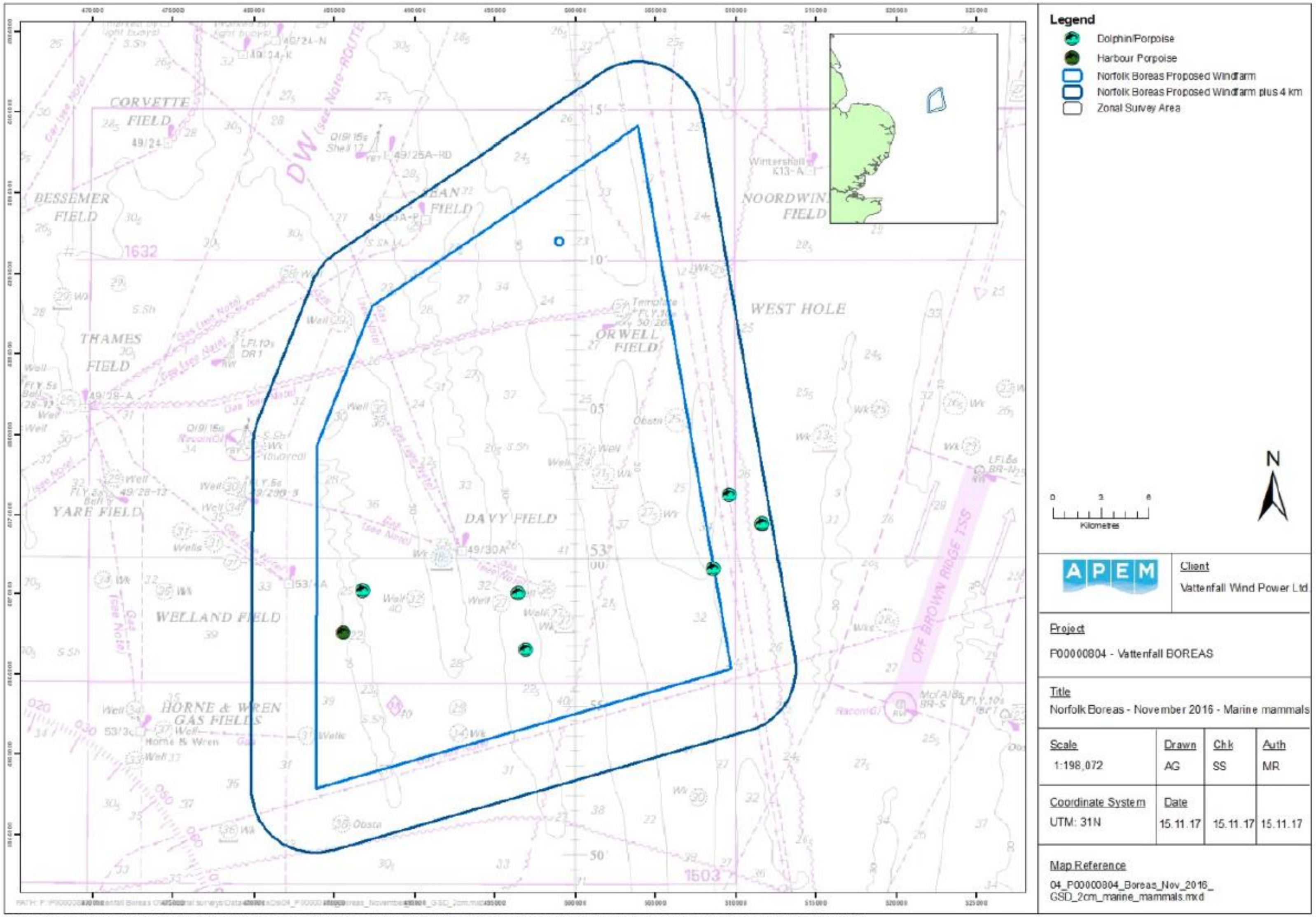
3.2 September 2016



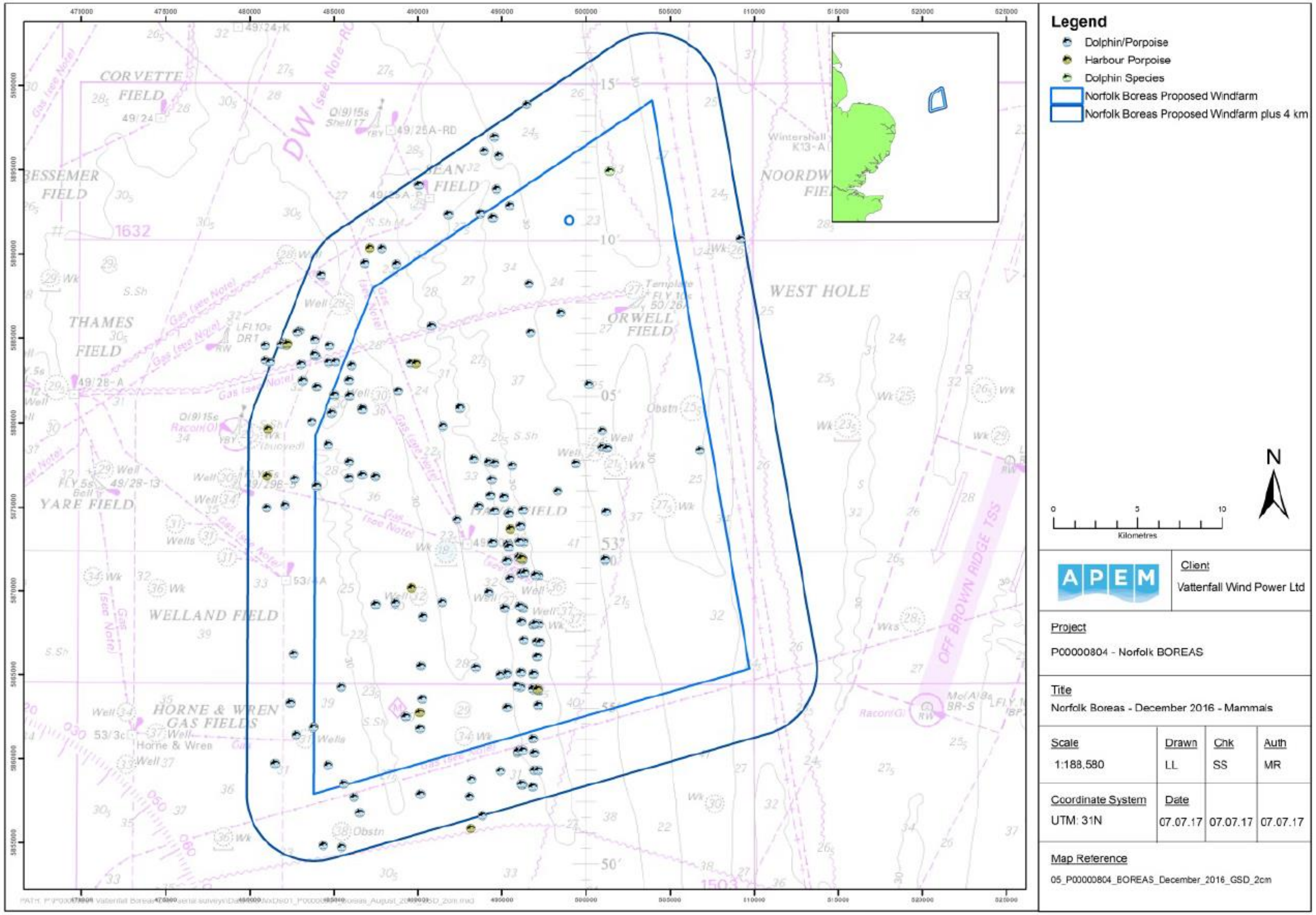
3.3 October 2016



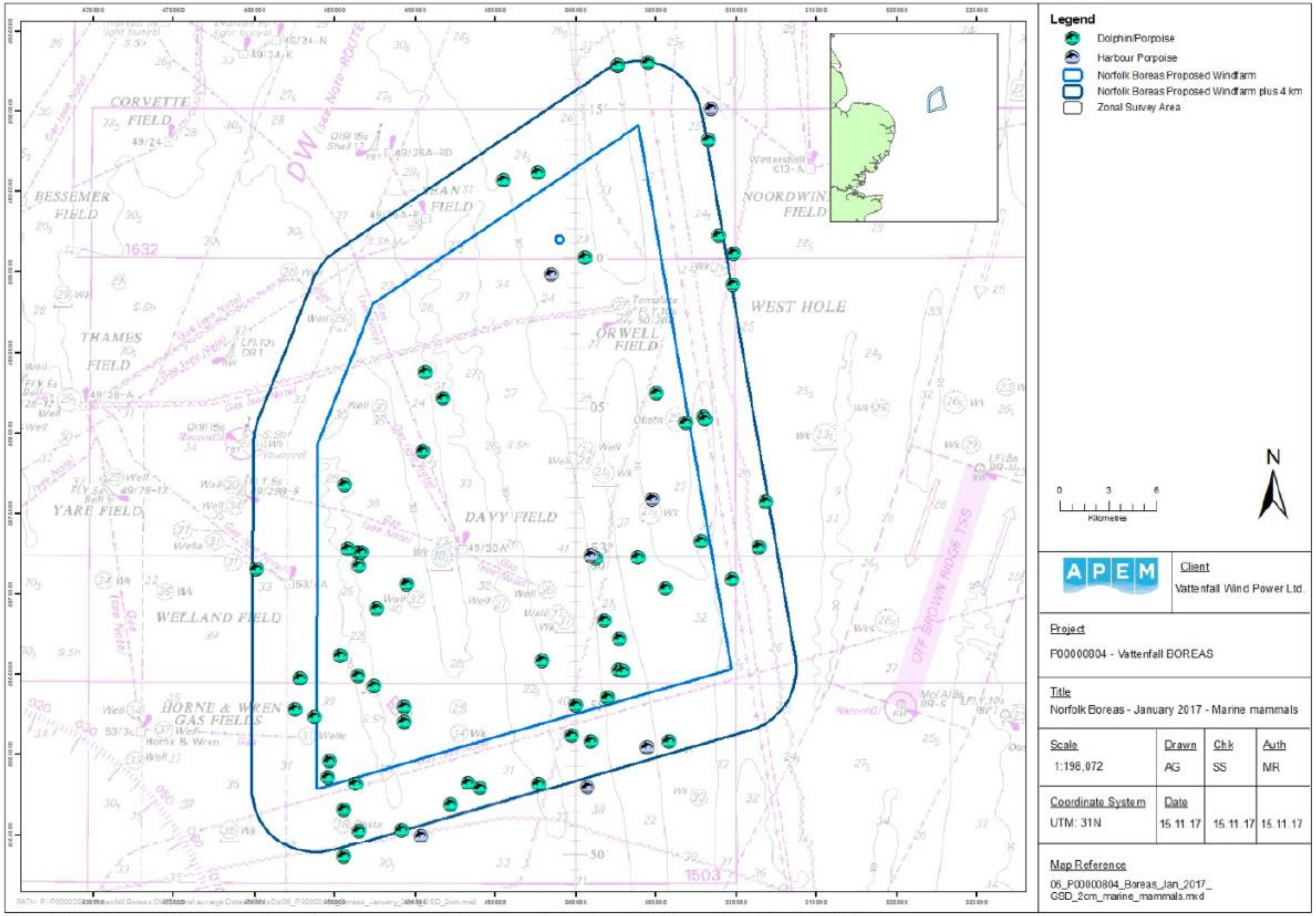
3.4 November 2016



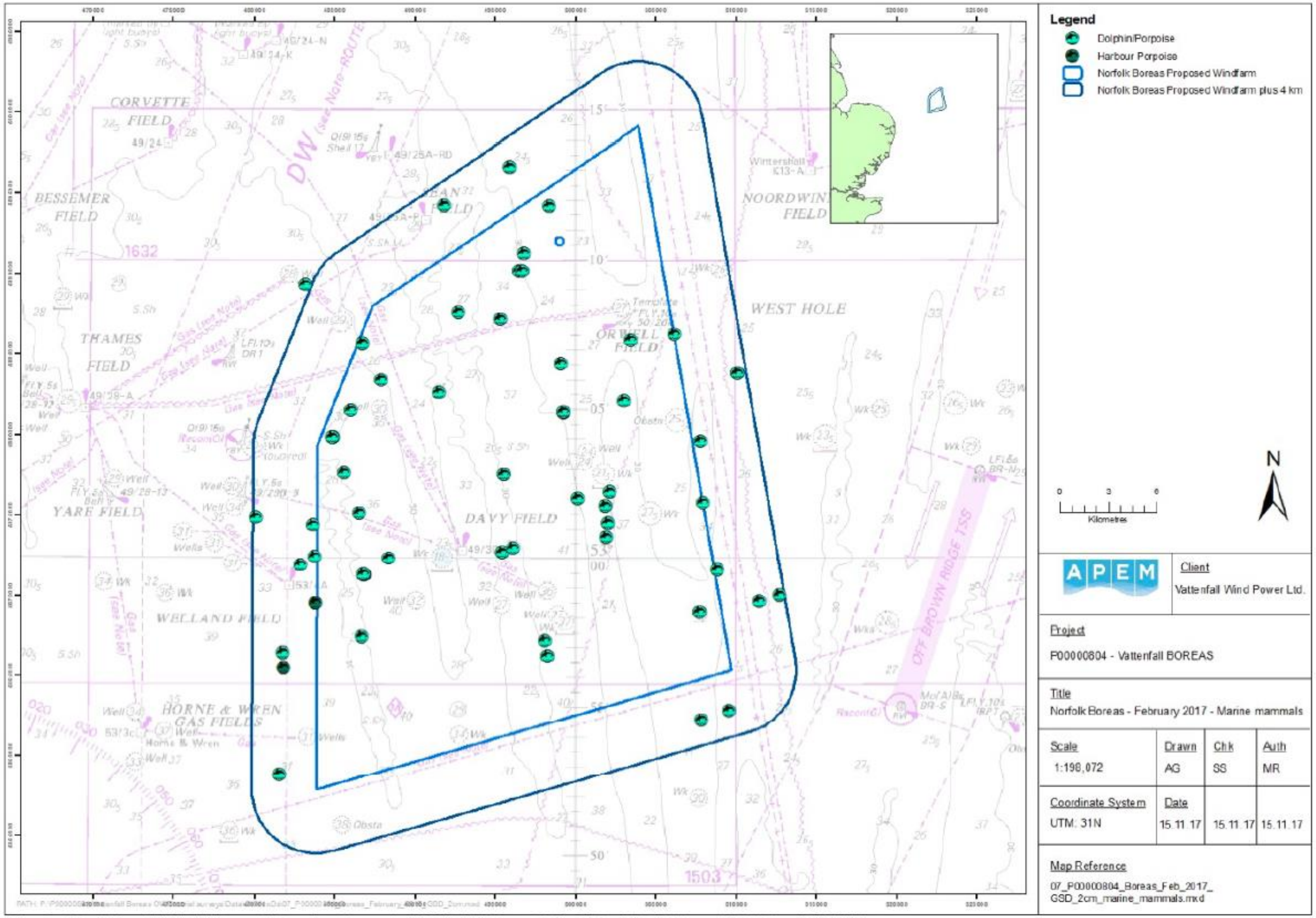
3.5 December 2016



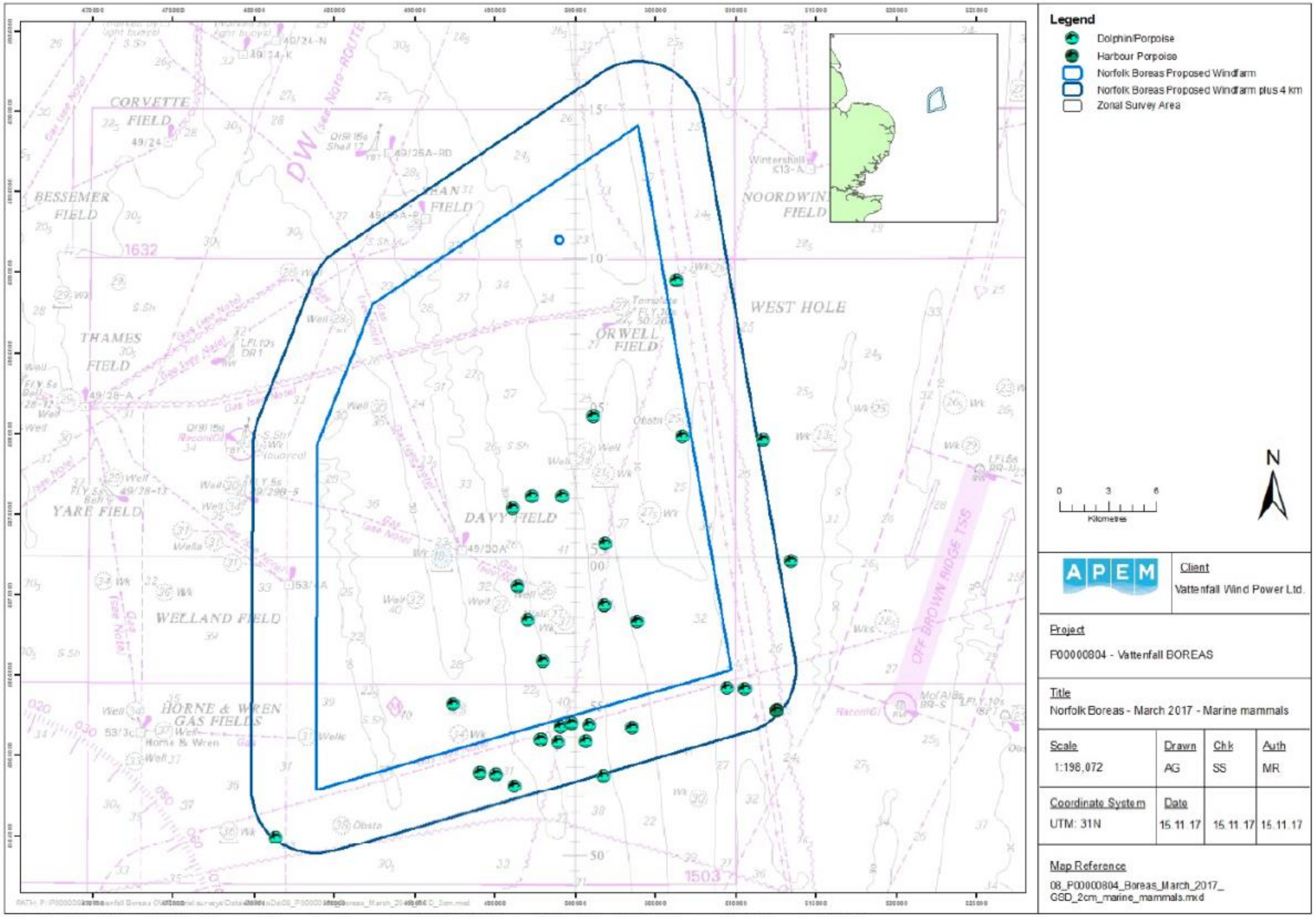
3.6 January 2017



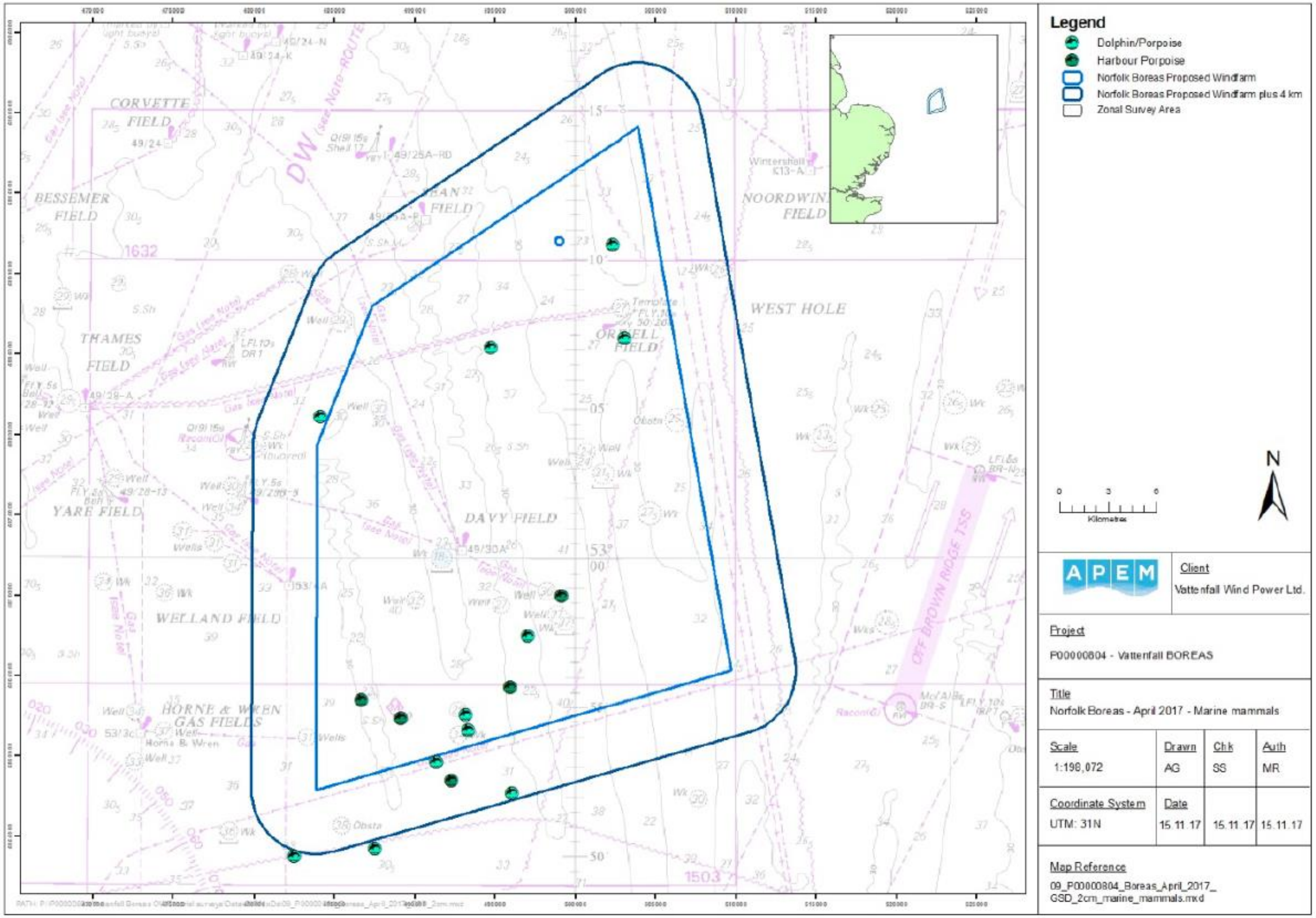
3.7 February 2017



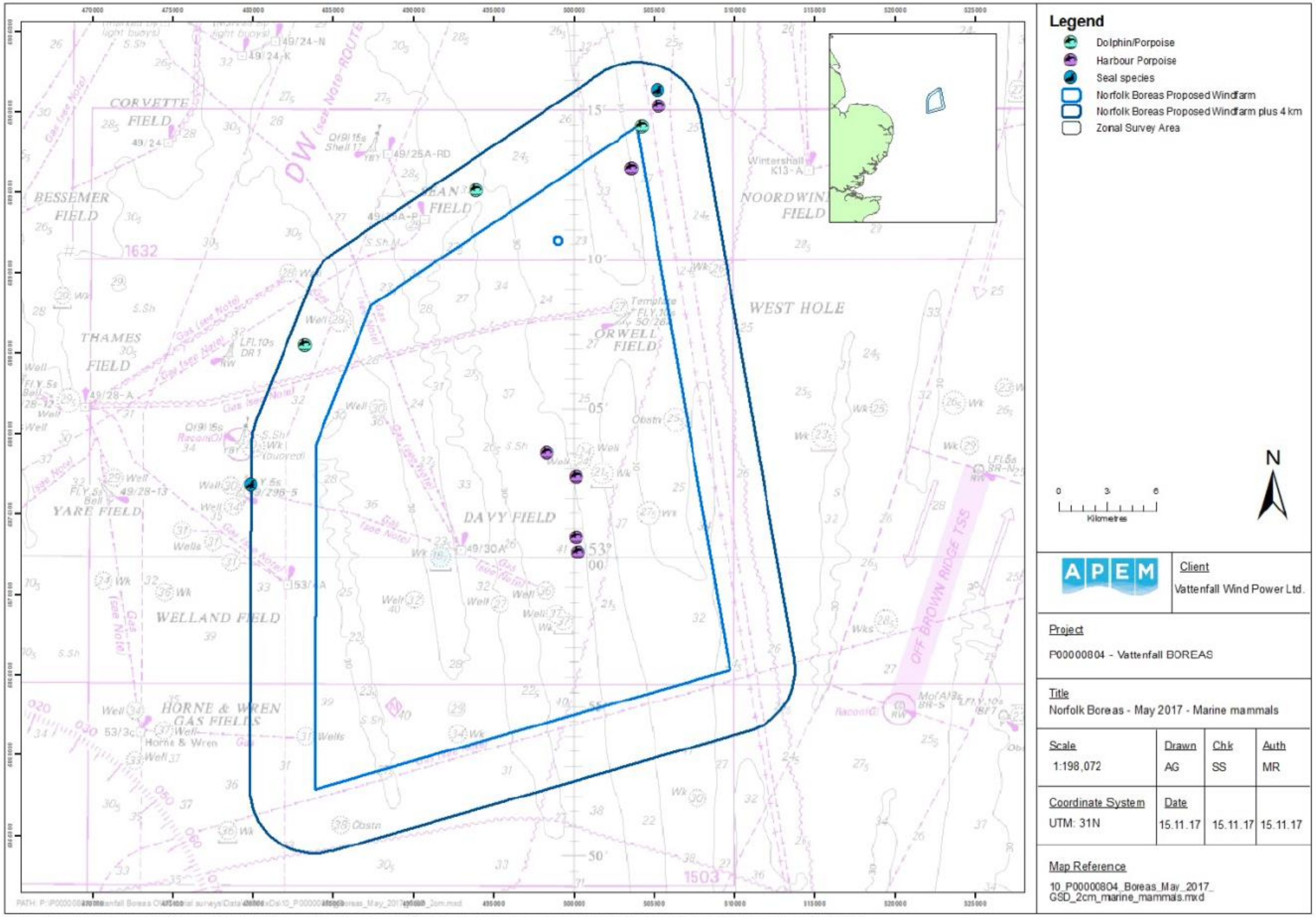
3.8 March 2017



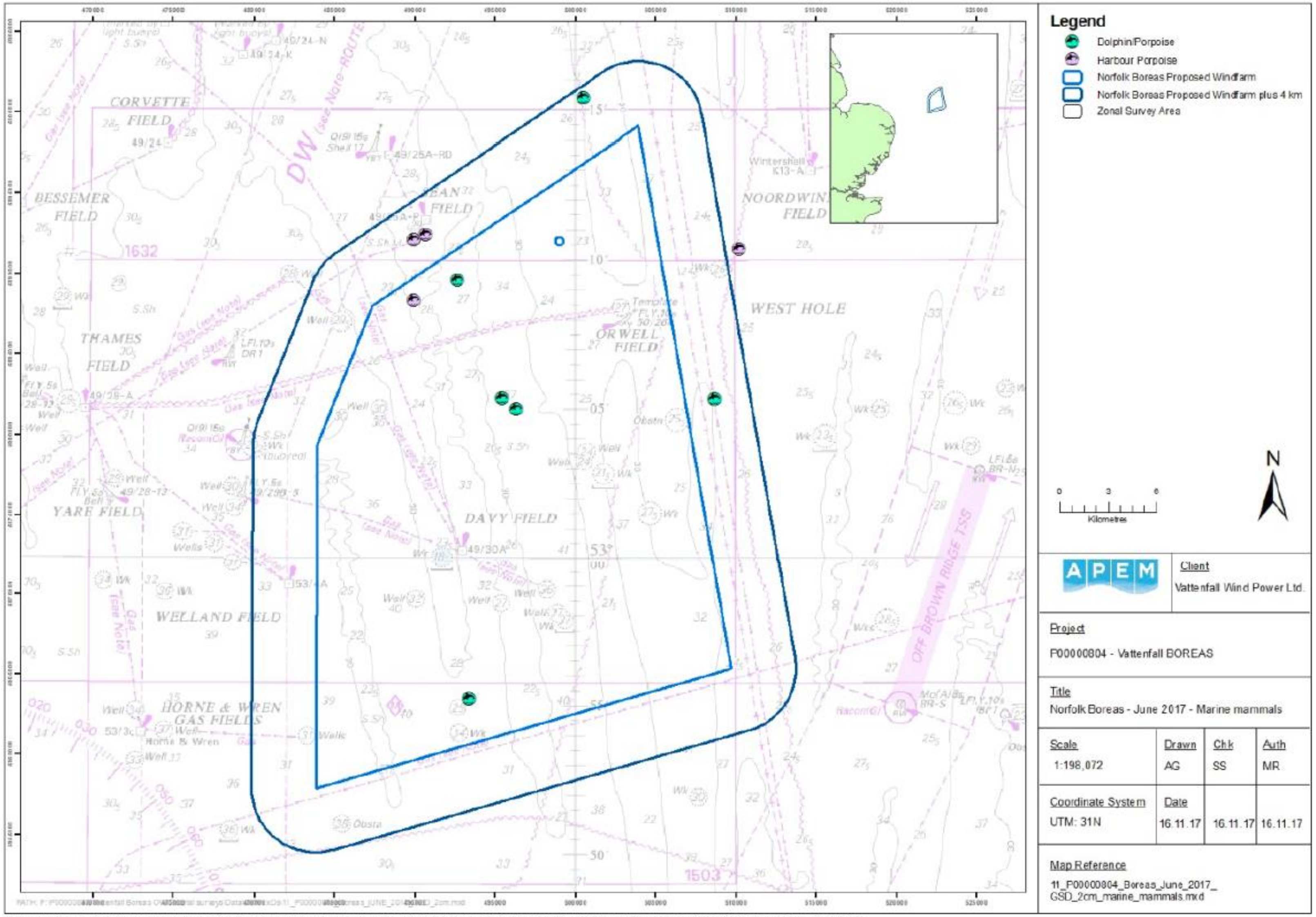
3.9 April 2017



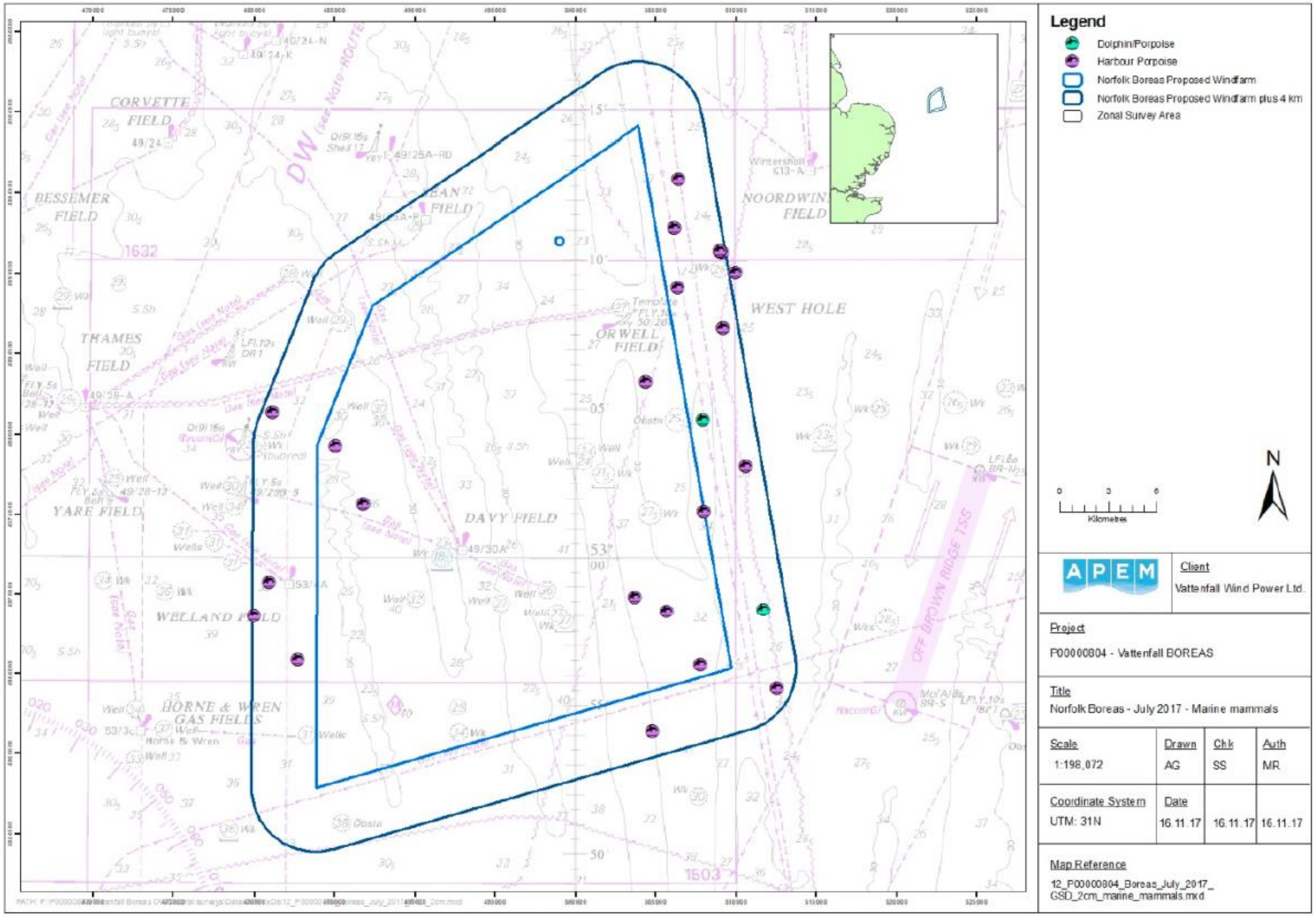
3.10 May 2017


Legend
Dolphin/Porpoise
Harbour Porpoise
Seal species
Norfolk Boreas Proposed Windfarm
Norfolk Boreas Proposed Windfarm plus 4 km
Zonal Survey Area
N
0 3 6
Kilometres
APEM
Client
Vattenfall Wind Power Ltd.
Project
P00000804 - Vattenfall BOREAS
Title
Norfolk Boreas - May 2017 - Marine mammals
Scale
1:198,072
Drawn
AG
Chk
SS
Auth
MR
Coordinate System
UTM: 31N
Date
15.11.17
15.11.17
15.11.17
Map Reference
10_P00000804_Boreas_May_2017_GSD_2cm_marine_mammals.mxd
DAVY FIELD
WEST HOLE
THAMES FIELD
YARE FIELD
WELLAND FIELD
HORNE & WREN GAS FIELDS
BESSEMER FIELD
CORVETTE FIELD
ORWELL FIELD
NOORDWIND FIELD
OFF BROWN RIDGE TSS

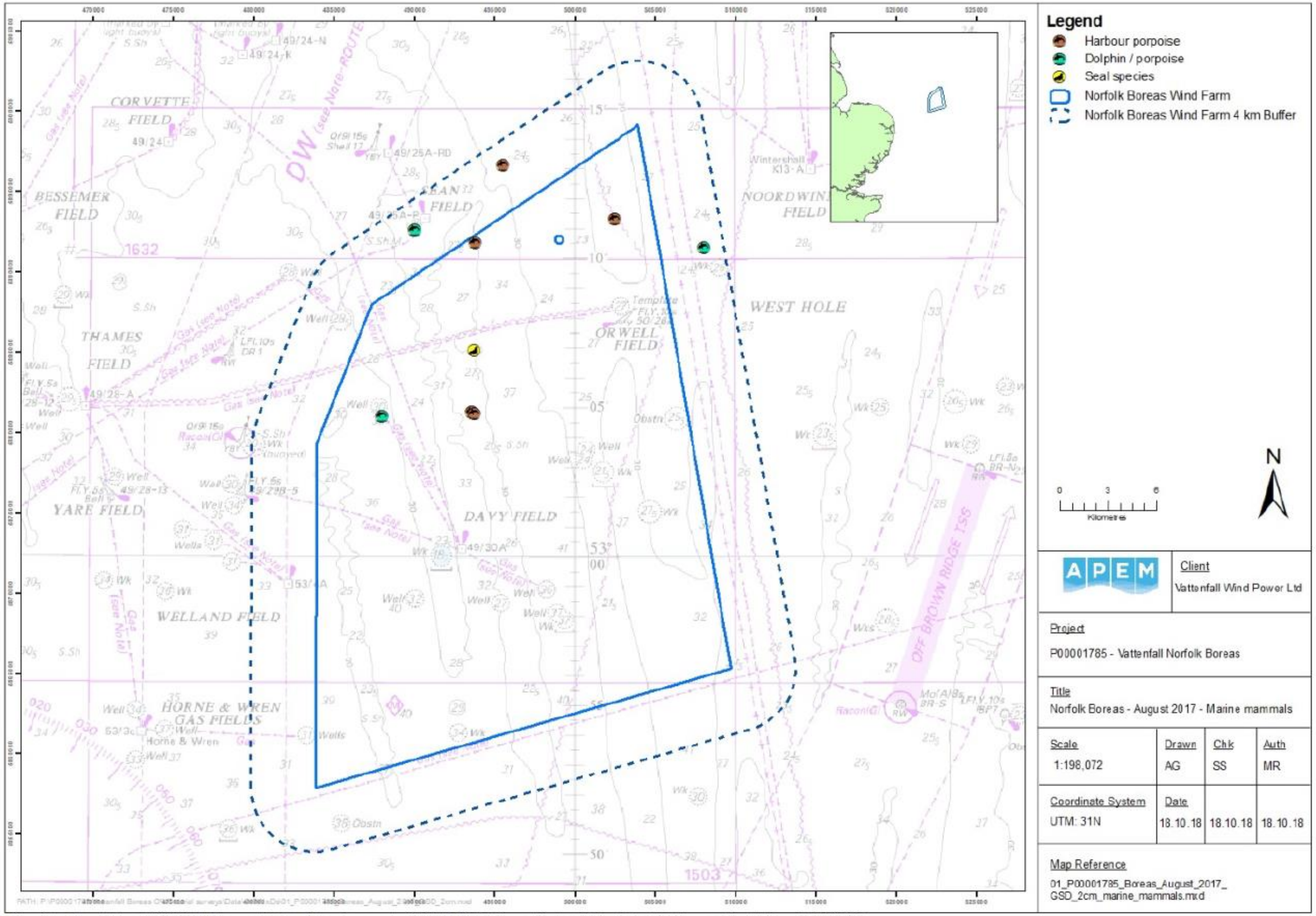
3.11 June 2017



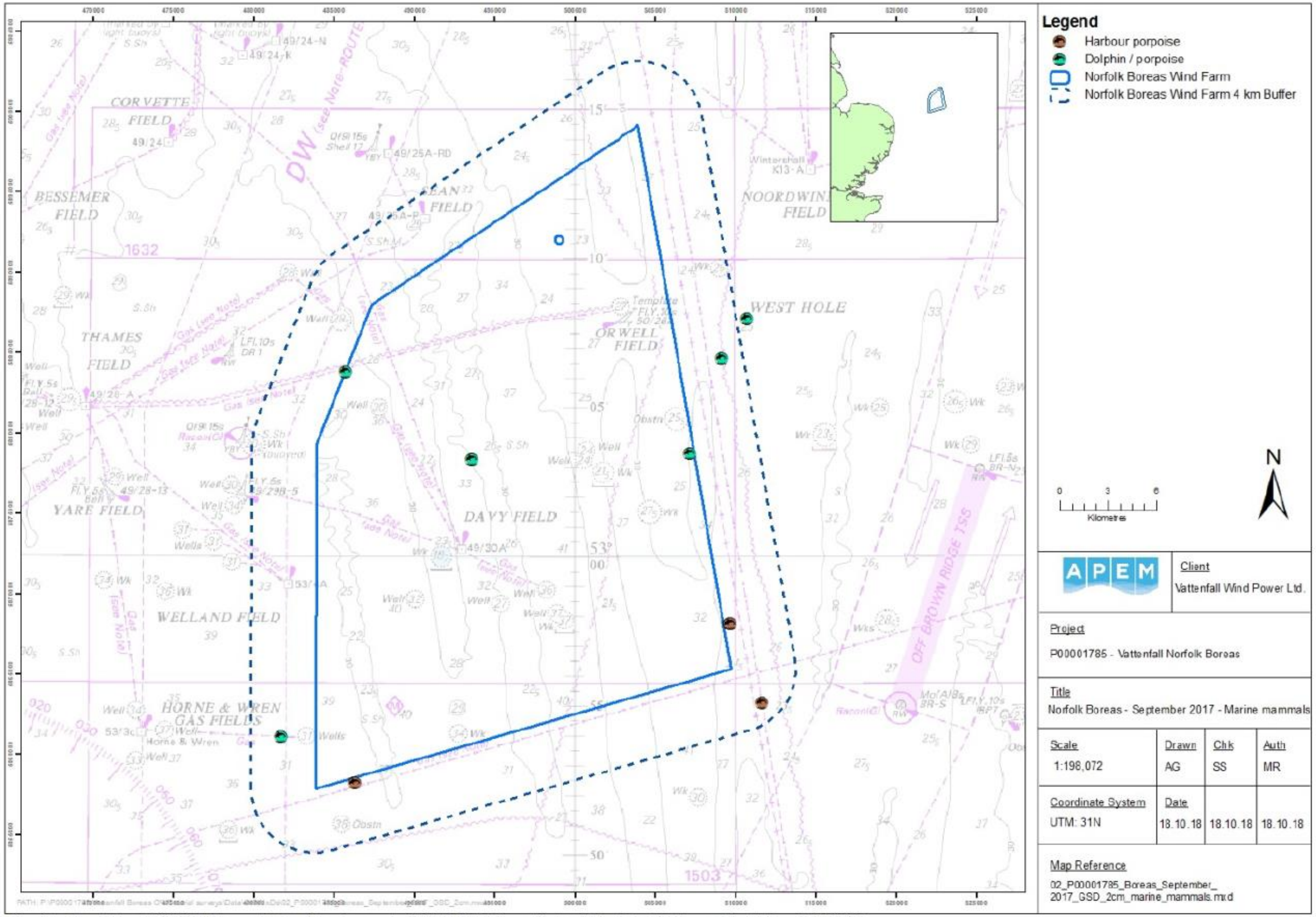
3.12 July 2017



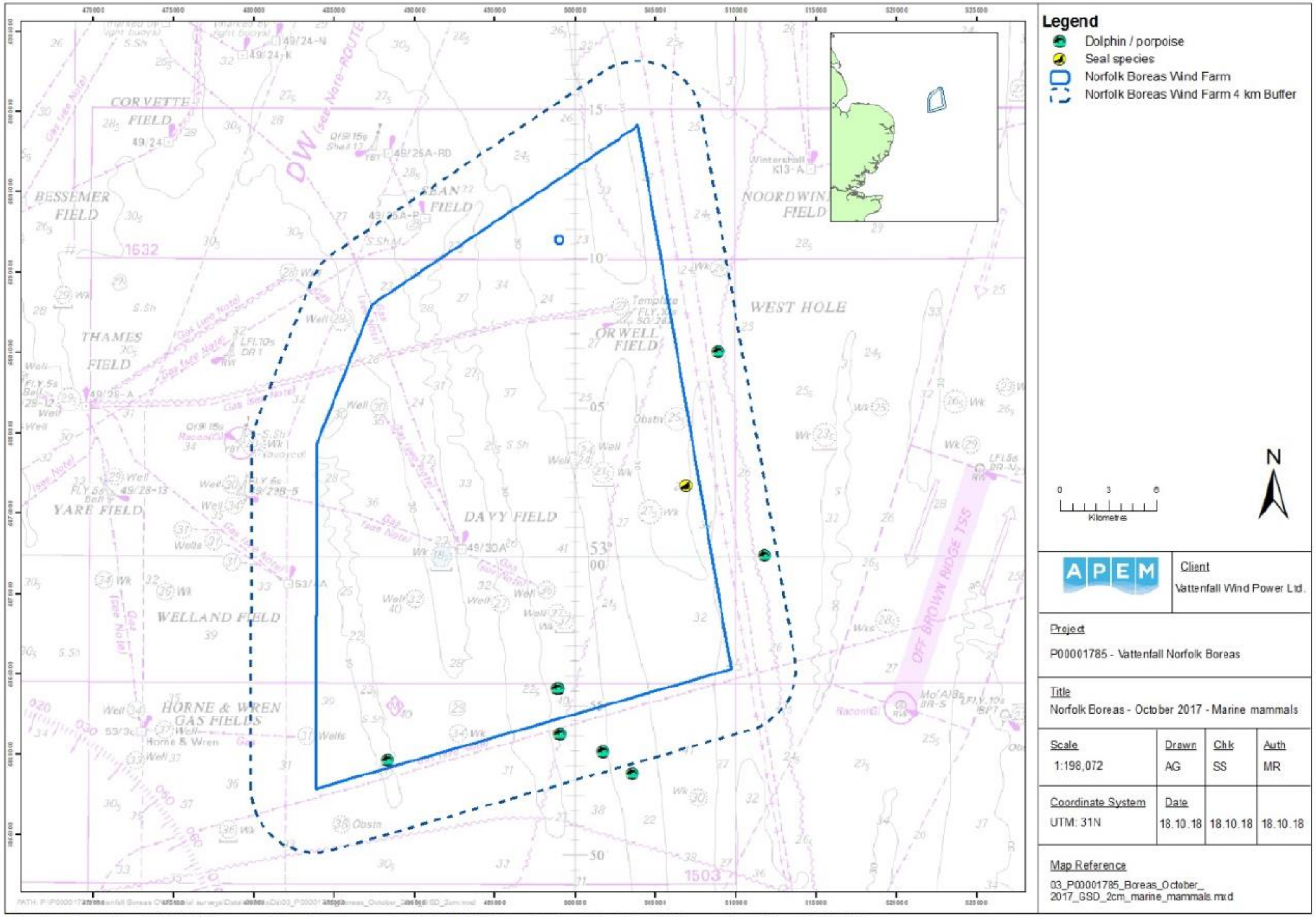
3.13 August 2017



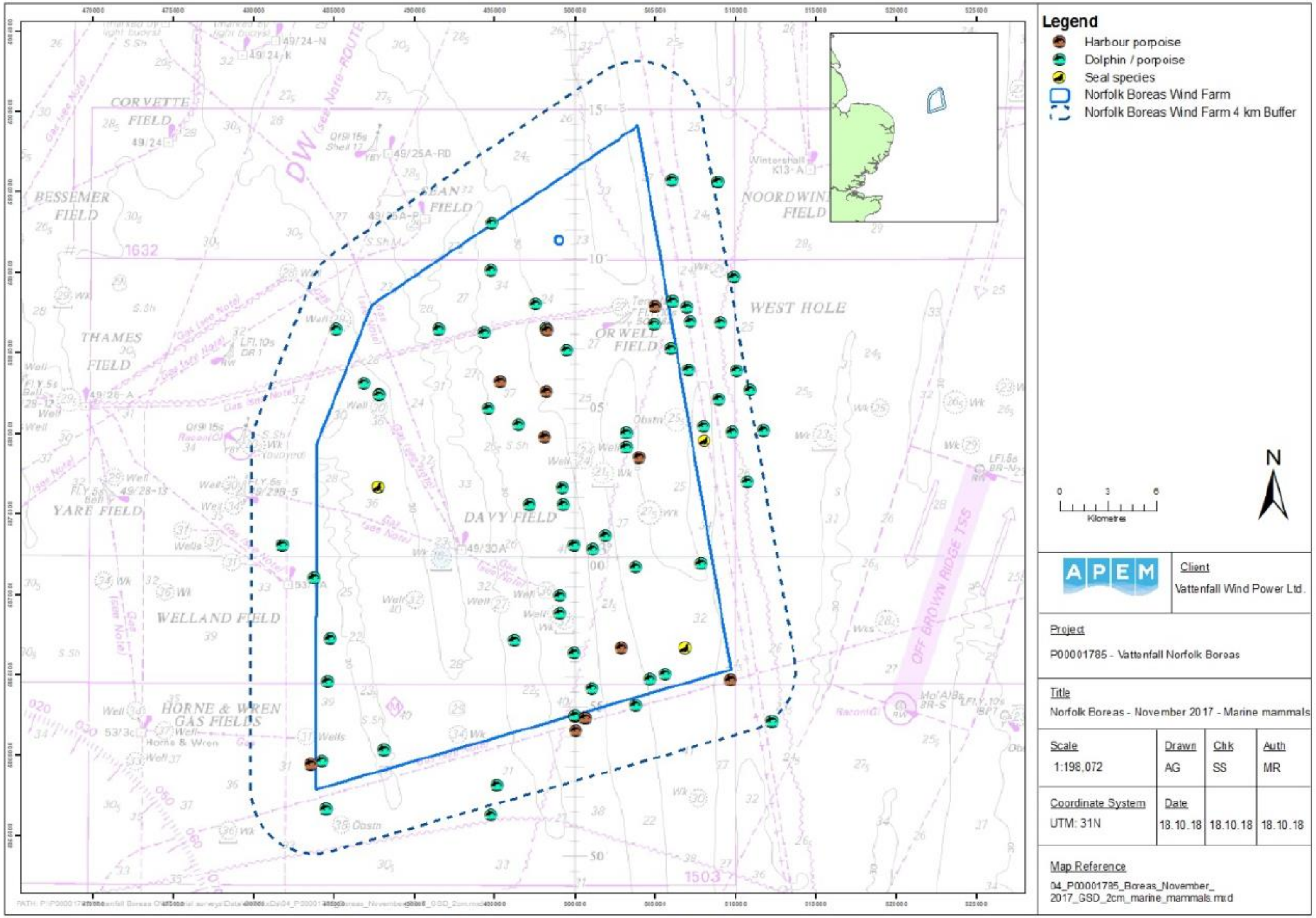
3.14 September 2017



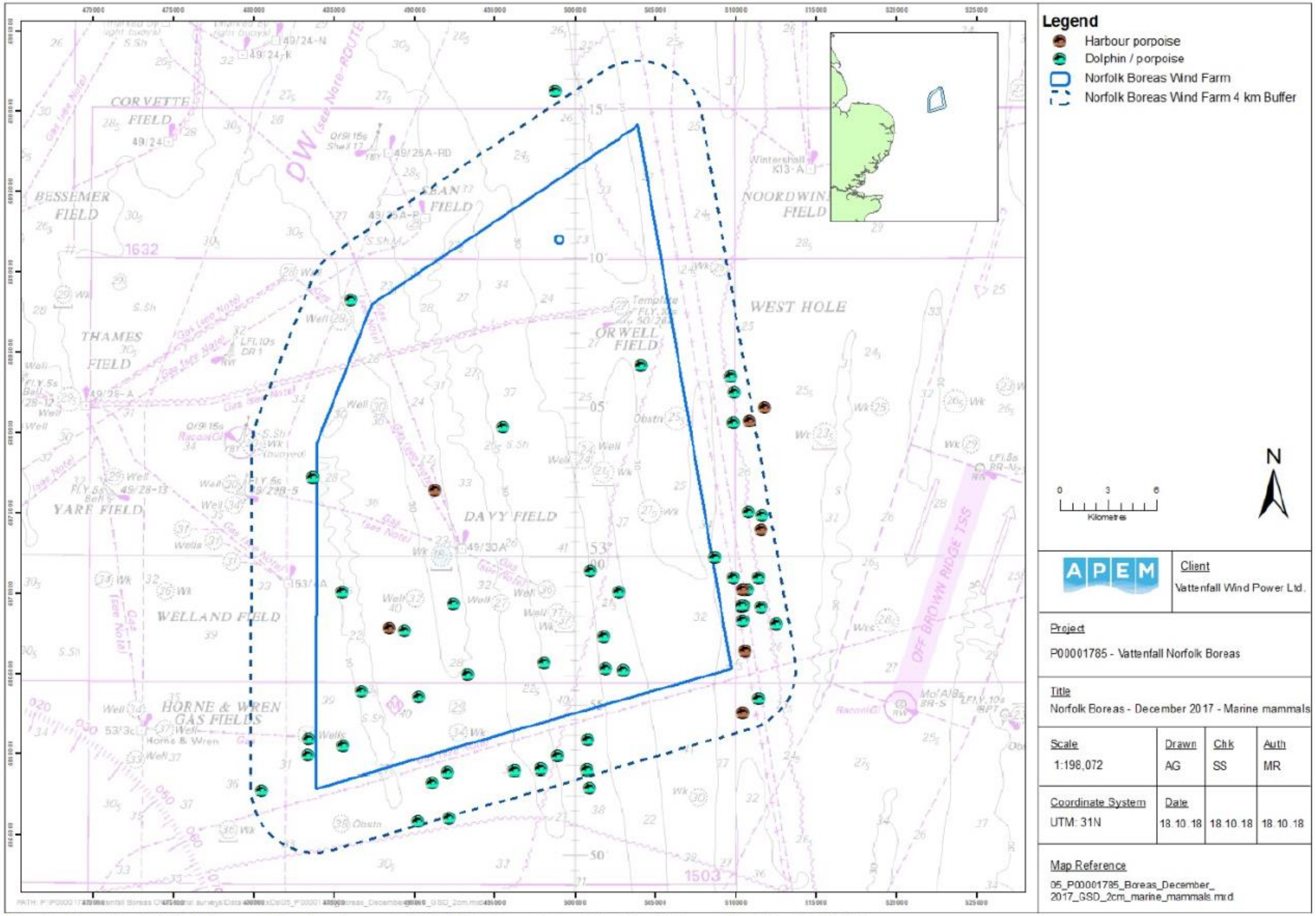
3.15 October 2017



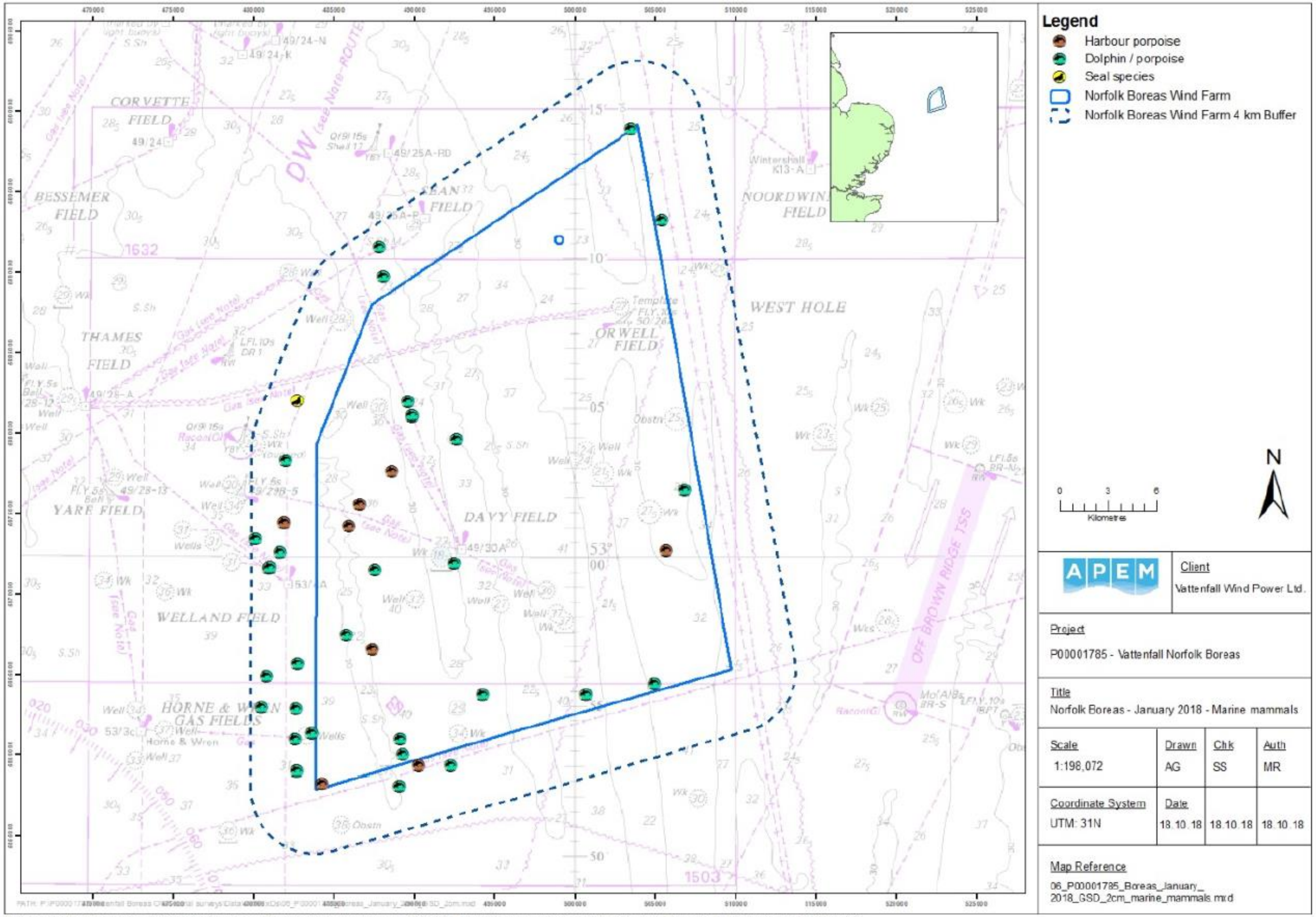
3.16 November 2017



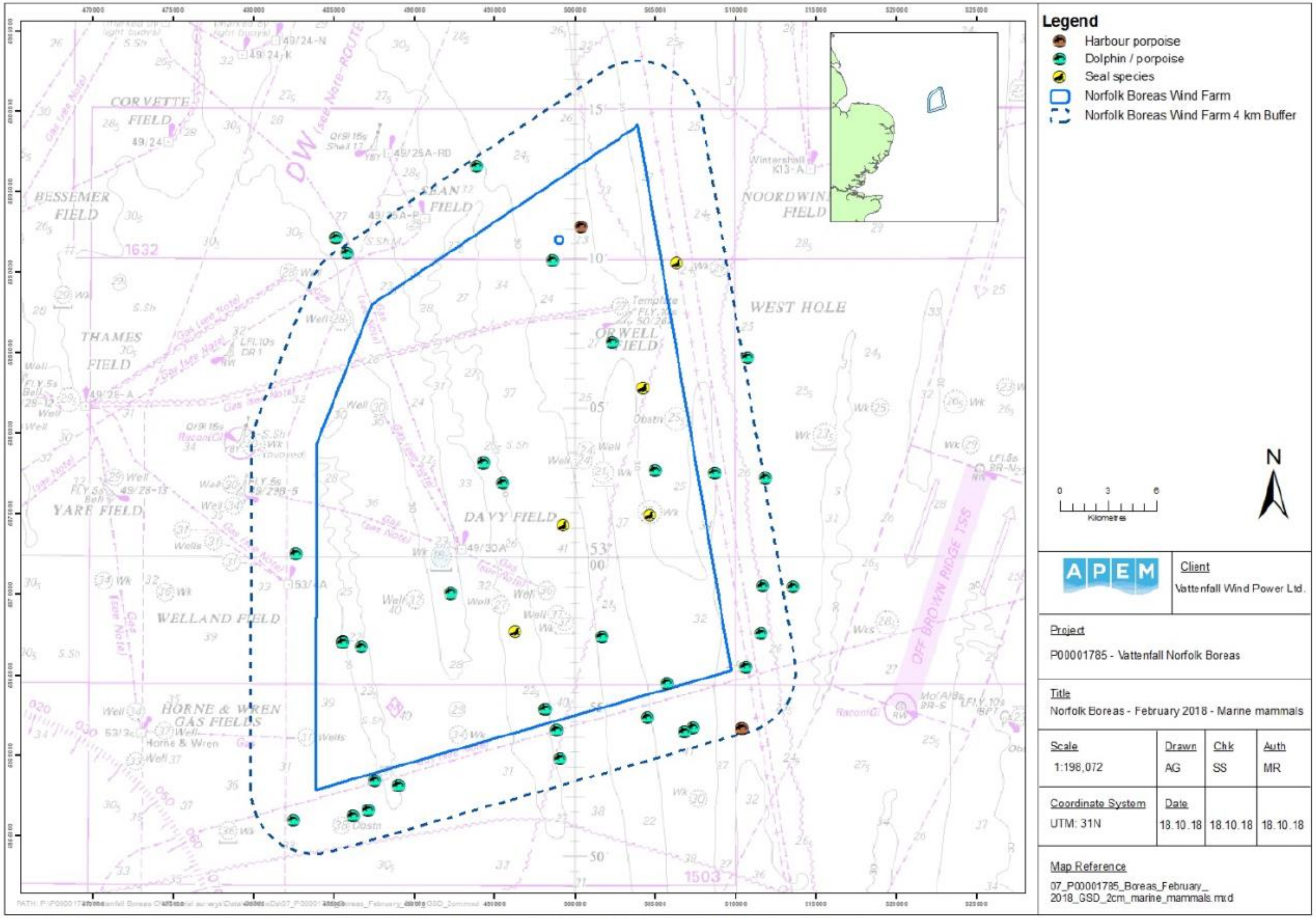
3.17 December 2017



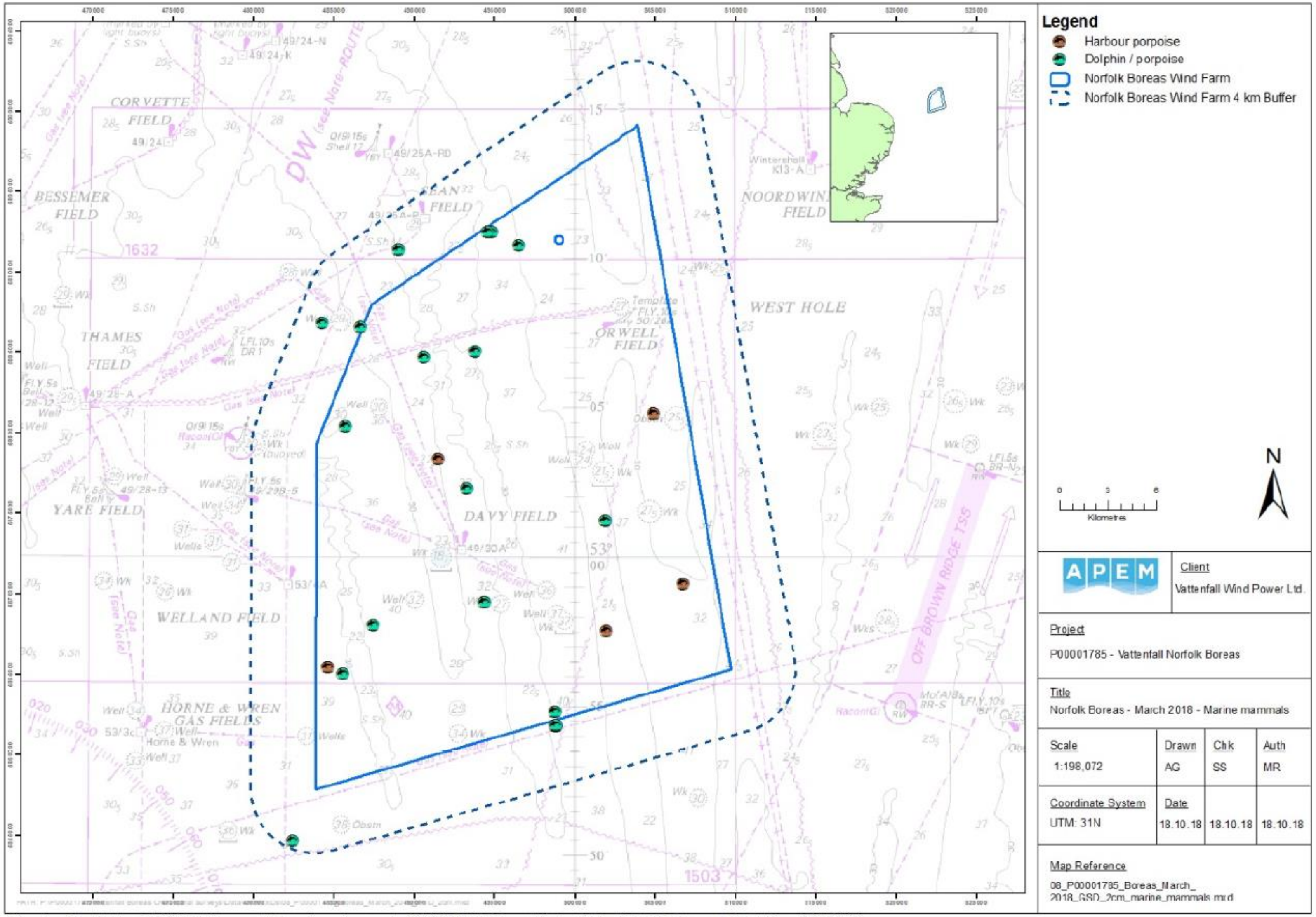
3.18 January 2018



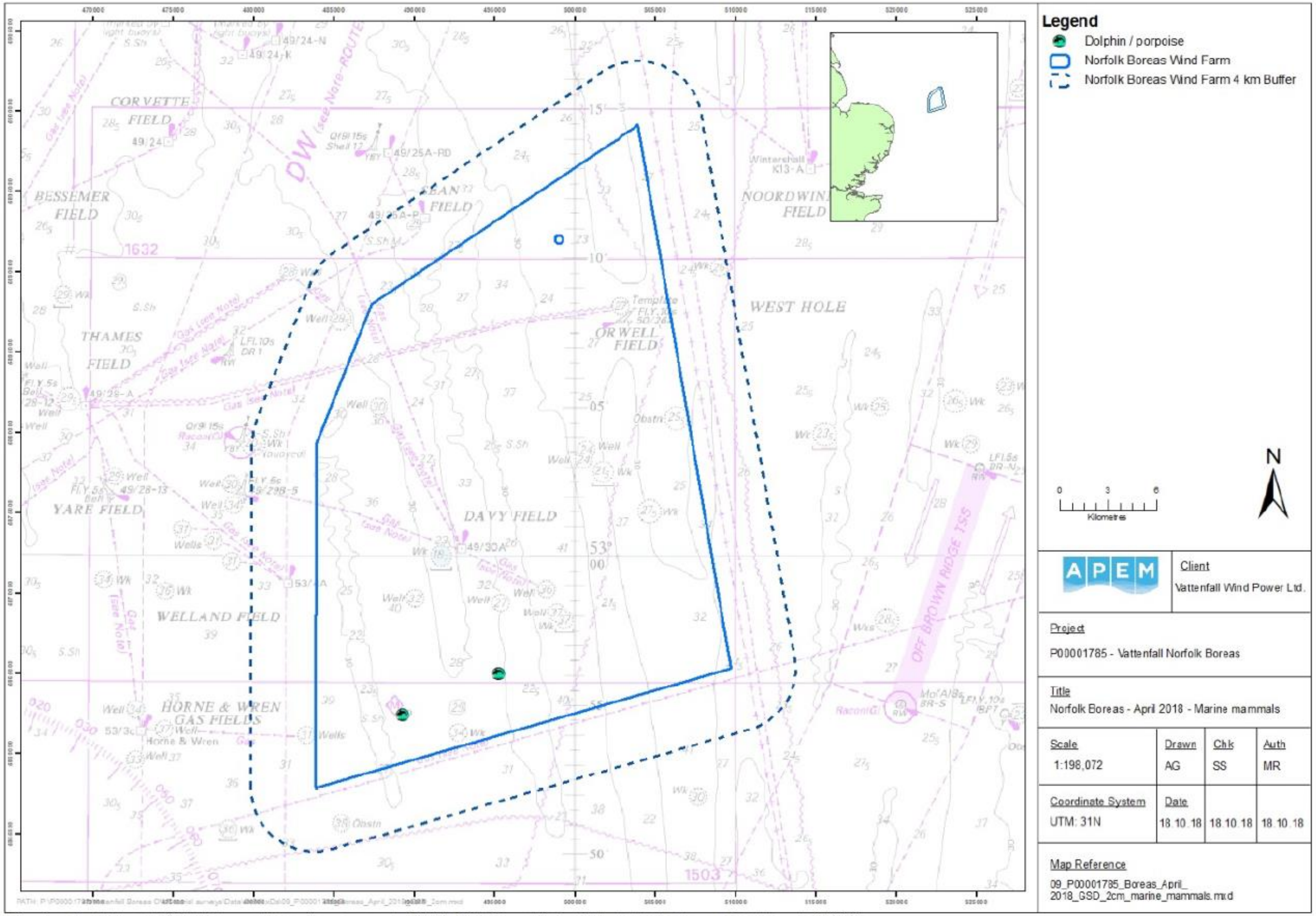
3.19 February 2018



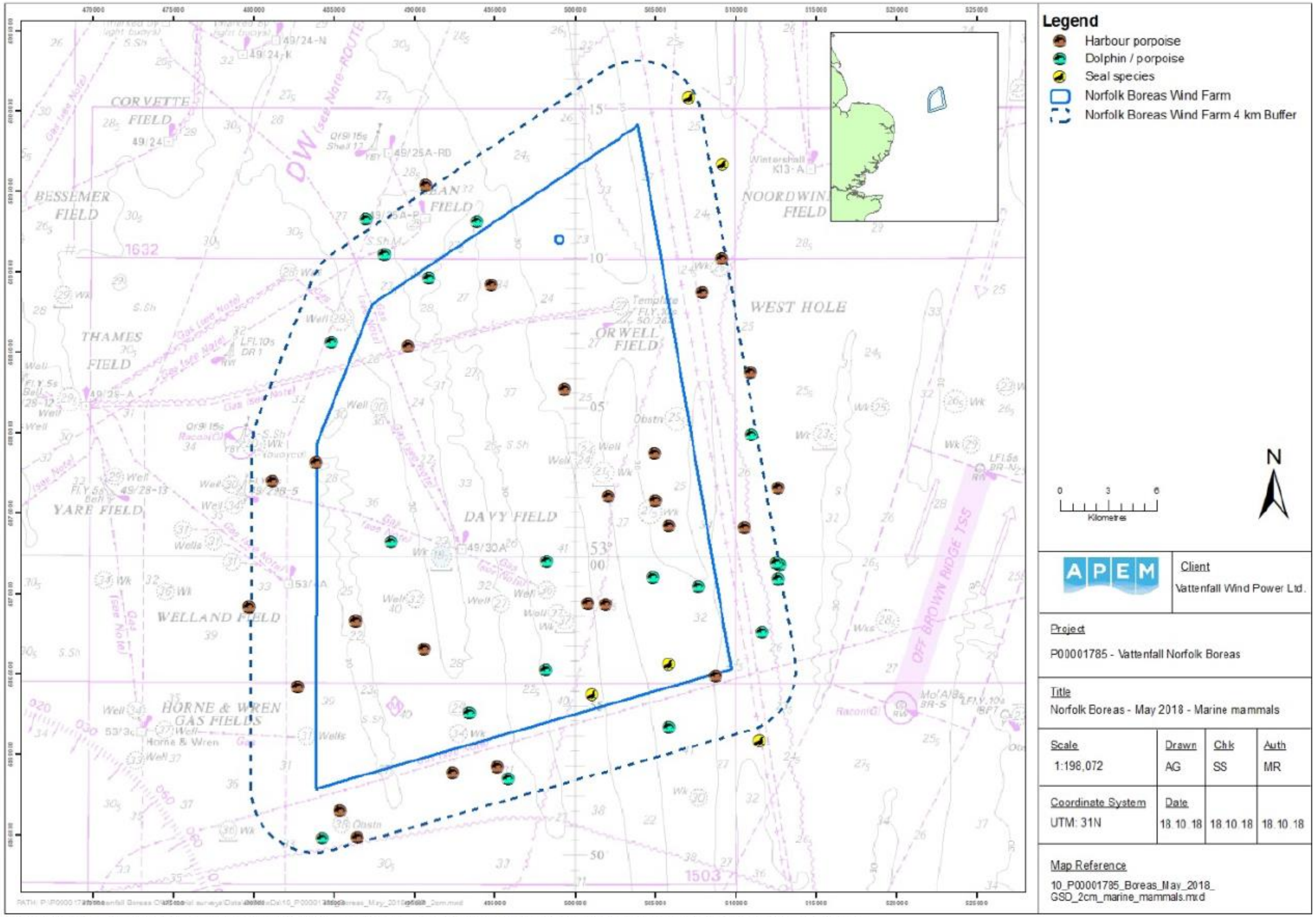
3.20 March 2018



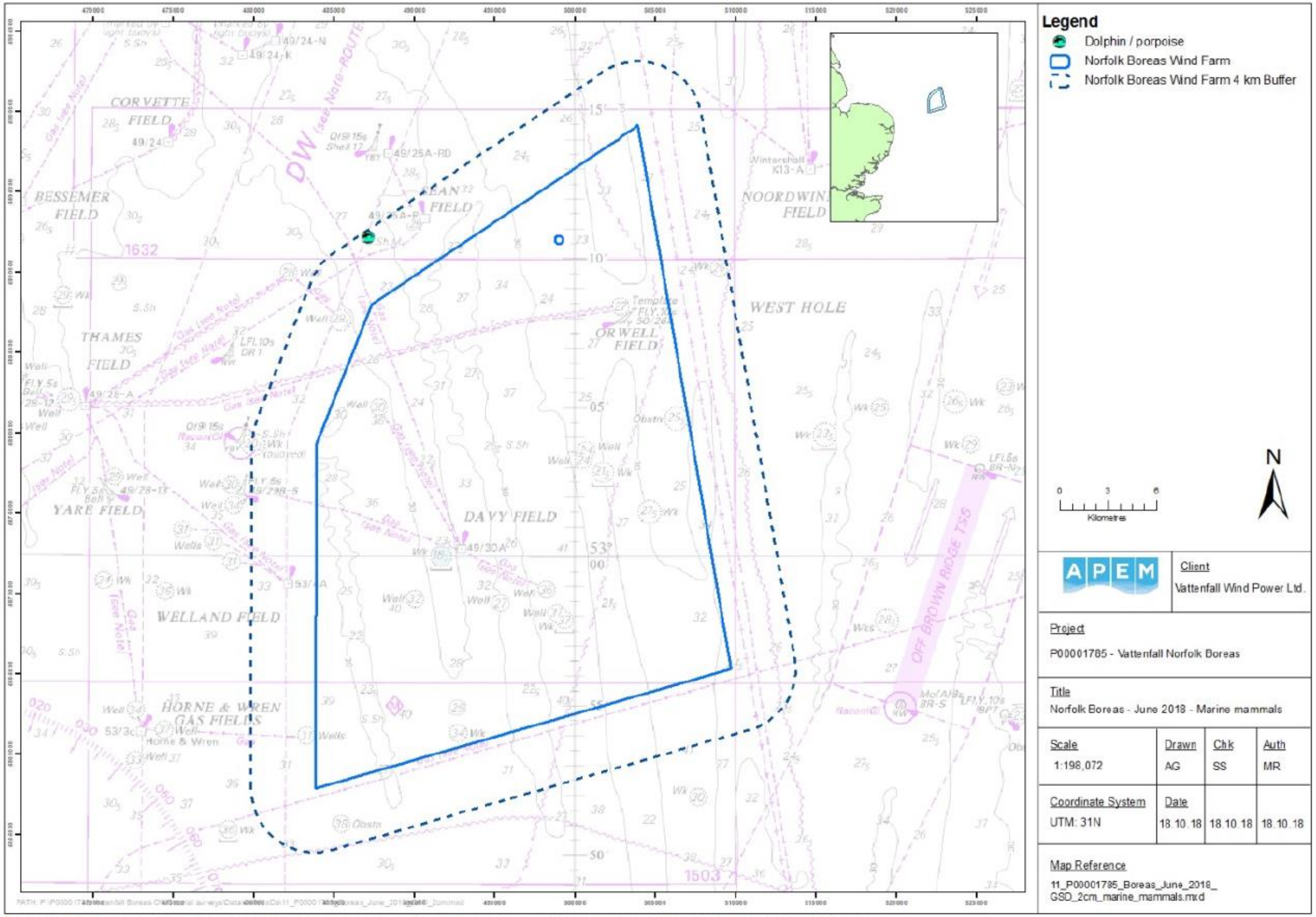
3.21 April 2018



3.22 May 2018


Legend
Harbour porpoise
Dolphin / porpoise
Seal species
Norfolk Boreas Wind Farm
Norfolk Boreas Wind Farm 4 km Buffer
N
Kilometres
APEM
Client
Vattenfall Wind Power Ltd.
Project
P00001785 - Vattenfall Norfolk Boreas
Title
Norfolk Boreas - May 2018 - Marine mammals
Scale
1:198,072
Drawn
AG
Chk
SS
Auth
MR
Coordinate System
UTM: 31N
Date
18.10.18
18.10.18
18.10.18
Map Reference
10_P00001785_Boreas_May_2018_GSD_2cm_marine_mammals.mxd

3.23 June 2018



3.24 July 2018