Hornsea 4

Ørsted

Hornsea Project Four: Preliminary Environmental Information Report (PEIR)

Volume 5, Annex 3.1: Fish and Shellfish Ecology Technical Report

Prepared	GoBe Consultants Ltd, 26 April 2019
Checked	GoBe Consultants Ltd, 27 April 2019
Accepted	David King, Ørsted. 28 May 2019
Approved	Julian Carolan, Ørsted. 28 May 2019

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Glossary

Term	Definition
Beam trawl	The simplest method of bottom trawling where the mouth of the net is held open by a solid metal beam, attached to two "shoes", which are solid metal plates, welded to the ends of the beam, which slide over and disturb the seabed.
Benthic ecology	Benthic ecology encompasses the study of the organisms living in and on the sea floor, the interactions between them and impacts on the surrounding environment.
Crustacea	Arthropod of the large, mainly aquatic group Crustacea, such as a crab, lobster, shrimp, or barnacle
Demersal	Relating to the seabed and area close to it. Demersal spawning species are those which deposit eggs onto the seabed.
Elasmobranchs	Cartilaginous fishes such as sharks, rays, and skates.
Epibenthic	Organisms living on the surface of the seabed
Fish larvae	The developmental stage of fish which have hatched from the egg and receive nutrients from the yolk sac until the yolk is completely absorbed.
Nursery habitat	Habitats where high numbers of juveniles of a species occur, having a greater level of productivity per unit area than other juvenile habitats.
Otter trawl	A trawl net fitted with a pair of otter boards which are used to keep the mouth of the trawl open.
Pelagic	Any part of the water column (i.e. the sea from surface to bottom sediments) that is not close to the seabed. Pelagic spawning species release their eggs into the upper layers of the sea.
Semi-pelagic (or benthopelagic)	Partially living their life on the seabed (benthic) and partially living their life in the water column above (pelagic).
Spawning	The release or deposition of eggs and sperm, usually into water, by aquatic animals.
Trammel netting	A rectangular net made of multiple layers of mesh that is held vertically in the water by weights and floats.

Acronyms

Acronym	Definition
BAP	Biodiversity Action Plan
BGS	British Geological Society
CIEEM	Chartered Institute of Ecology and Environmental Management
CPA	Coast Protection Act 1949
DCO	Development Consent Order
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
ES	Environmental Statement
FEPA	Food and Environment Protection Act 1985
GSI	Gonadal Somatic Index
HRA	Habitats Regulations Assessment
HVAC	High Voltage Alternating Current
IBTS	International Bottom Trawl Surveys
ICES	International Council for the Exploration of the Sea
IHLS	International Herring Larval Survey
IUCN	International Union for the Conservation of Nature
JNCC	Joint Nature Conservation Committee
MCZ	Marine Conservation Zone
MMO	Marine Management Organisation
NERC	Natural Environment and Rural Communities
NIMF	Nationally Important Marine Features
NPS	National Policy Statement
ORJIP	Offshore Wind, Offshore Renewable Joint Industry Project
OSPAR	Oslo Paris Convention (also known as Convention for the Protection of the Marine Environment of the North-East Atlantic)
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
PSA	Particle Size Analysis
SAC	Special Area of Conservation
VER	Valued Ecological Receptor

Units

Unit	Definition
m	metre
m^2	square metre
mm	millimetre
km	kilometre

1 Introduction

1.1 Introduction

1.1.1 Project background

1.1.1.1 Ørsted Hornsea Project Four Ltd (hereafter the Applicant) is proposing to develop the Hornsea Project Four Offshore Wind Farm (hereafter Hornsea Four). Hornsea Four will be located approximately 65 km offshore the East Riding of Yorkshire in the southern North Sea and will be the fourth project to be developed in the former Hornsea Zone (please see **Volume 1, Chapter 1: Introduction** for further details on the Hornsea Zone). Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network. The location of Hornsea Four is illustrated in (**Figure 1**). The Preliminary Environmental Information Report (PEIR) boundary combines the search areas for the offshore infrastructure.

1.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 848 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate EIA, the project is currently giving due consideration to the size and location (within the existing AfL area) of the final project that will be taken forward to consent application (DCO). This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction. The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the AfL taken forward at the point of PEIR (see **Figure 1**). The evolution of the AfL is detailed in **Volume 1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume 4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**. The final developable area taken forward to consent may differ from that presented in **Figure 1** due to the results of the EIA, technical considerations and stakeholder feedback.

1.1.1.3 GoBe Consultants was commissioned to undertake a fish and shellfish study of the Hornsea Four site and surrounding area. The characterisation of the existing marine environment has been derived using data and information from a number of sources, including the scientific literature, fisheries statistical datasets, fish and shellfish surveys undertaken within the former Hornsea Zone and site-specific characterisation surveys undertaken for Hornsea Four.

1.1.1.4 This report has been produced following a full review of the Scoping Opinion provided by the Planning Inspectorate.

1.1.2 Aims and Objectives

1.1.2.1 The aim of this study was to provide an up to date characterisation of fish and shellfish ecological resources within a defined study area, which incorporates the offshore components of Hornsea Four and the zone of potential impact.

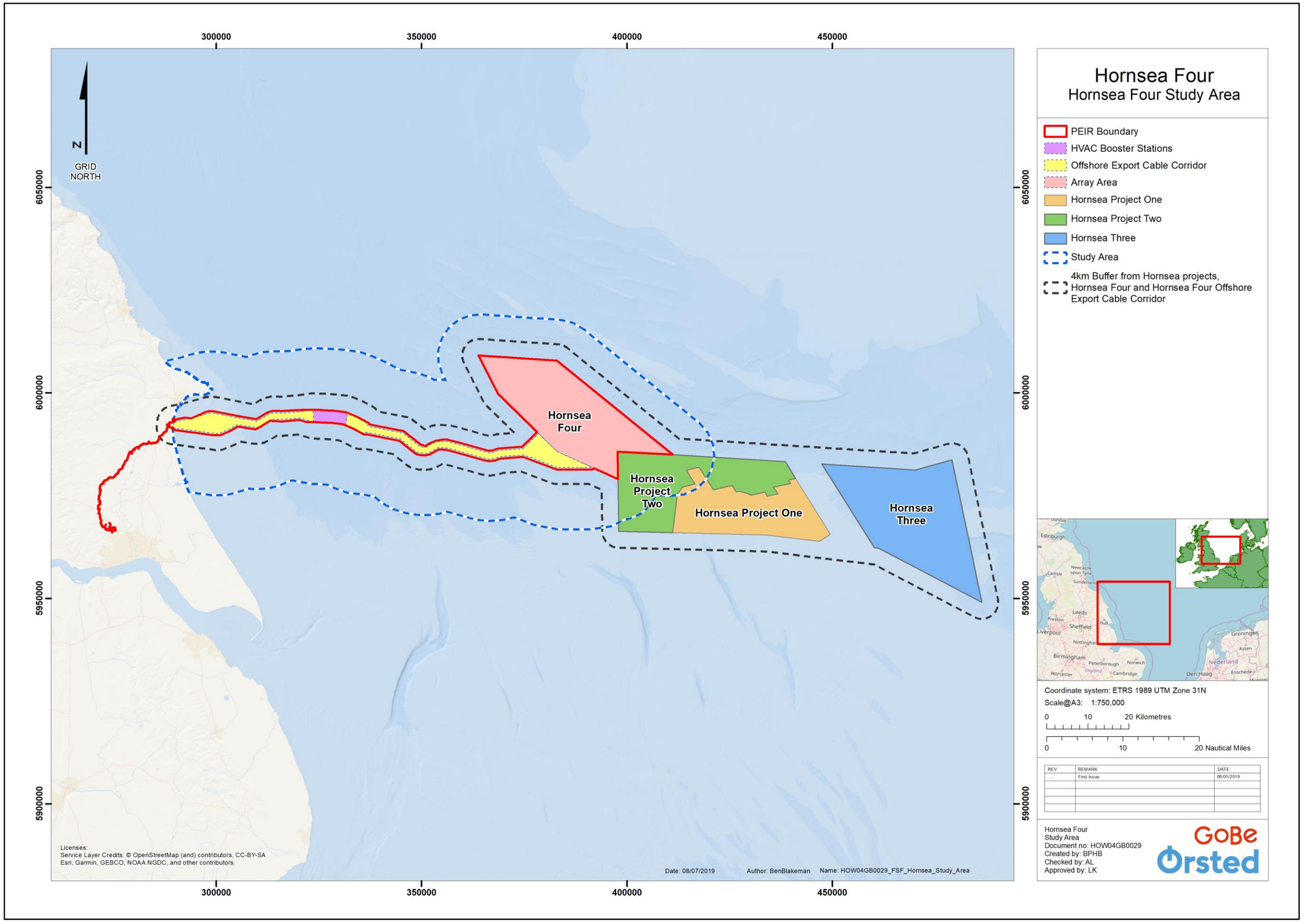


Figure 1: Hornsea Four study area (not to scale).

1.1.2.2 Using existing data (including trawl data from Hornsea Project One Offshore Wind Farm (Hornsea Project One), Hornsea Project Two Offshore Wind Farm (Hornsea Project Two) and Hornsea Project Three Offshore Wind Farm (Hornsea Three), and Dogger Bank Creyke Beck Offshore Wind Farm (Creyke Beck), together with new data collected specifically for Hornsea Four, the objective was to give a general description of the fish and shellfish assemblages within the defined study area (**Figure 1**).

2 Methodology

2.1 Fish and shellfish study area

2.1.1.1 For the purposes of this report, the fish and shellfish study area has been defined at the following two spatial scales:

- The fish and shellfish study area is defined as the area encompassing the Hornsea Four array area including much of the wider former Hornsea Zone encompassing the Hornsea Project One, Hornsea Project Two and Hornsea Three areas plus a 4 km buffer which was surveyed as part of previous Hornsea survey campaigns from 2010 to 2017; and
- A 10 km buffer surrounding the array area, and a 15 km buffer around the offshore ECC, to represent the tidal ellipse distance, in order to incorporate the maximum distance sediments will travel in one tidal cycle.

2.1.1.2 A wider study area will be considered for noise impacts which will be confirmed within the PEIR assessment based on the results of the noise modelling.

2.2 Evidence Plan

2.2.1.1 The purpose of the Hornsea Four Evidence Plan process is to agree the environmental information the Applicant needs to supply to the Planning Inspectorate, as part of a Development Consent Order (DCO) application for Hornsea Four. The Evidence Plan seeks to ensure compliance with the EIA and HRA requirements.

2.2.1.2 As part of the Evidence Plan process, the Marine Ecology and Processes Evidence Plan Technical Panel was established with representatives from the key regulatory bodies and their advisors and statutory nature conservation bodies, including the Marine Management Organisation (MMO), Cefas and Natural England. Marine Ecology and Processes Evidence Plan Technical Panel meetings have been taking place since September 2018 and will continue as required throughout the PEIR and Environmental Statement (ES) drafting process. The purposes of these meetings are to discuss, and gain agreement on, the characterisation of the baseline environment and the impacts to be considered within the impact assessment.

2.2.1.3 Hornsea Four is located within the former Hornsea Zone, for which extensive data and knowledge regarding fish and shellfish ecology is already available. This data/knowledge has been acquired through zonal studies and from the surveys and characterisations undertaken for Hornsea Project One, Hornsea Project Two and Hornsea Three. It has been

proposed that the Hornsea Four fish and shellfish characterisation be completed using a combination of desktop data and information sources, and survey data collected as part of the characterisations of the Hornsea Project One, Hornsea Project Two and Hornsea Three offshore wind farms and the former Hornsea Zone. Additional survey data from the Dogger Bank Creyke Beck baseline characterisation, and BGS (2015) PSA data has also been proposed to be used to inform this report. This is under discussion within the Marine Ecology and Processes Evidence Plan Technical Panel.

2.2.1.4 No additional site-specific survey data has been collected for fish and shellfish ecology. However, data collected as part of the benthic ecology surveys of the Hornsea Four array area, specifically the Particle Size Analysis (PSA) data to characterise the suitability of sediments as sandeel (*Ammodytes* sp.) and herring (*Clupea harengus*) spawning habitats has been incorporated into the baseline characterisation assessment.

2.3 Desktop Review

2.3.1 Overview

2.3.1.1 A detailed desktop review was carried out to establish the baseline of information available on fish and shellfish populations in the fish study area for Hornsea Four (as shown in). Information was sought on fish and shellfish ecology in general and on spawning and nursery activity. Species of commercial importance were identified through reference to the **Volume 5, Annex 7.1: Commercial Fisheries Technical Report**, and the individual species accounts detail whether or not the species assessed are of commercial importance.

2.3.2 Data Sources

2.3.2.1 Data to support the baseline characterisation of the Hornsea Four study area was utilised from the sources listed in **Table 1** below.

Table 1: Data sources used to inform the Hornsea Four baseline characterisation.

Data Source	Data utilisation
Hornsea Project One baseline characterisation study	Used to provide information regarding the fish and shellfish ecology of the site. The surveys also provided PSA data to provide an indication on the location of suitable habitat and spawning grounds for sandeel and herring.
Hornsea Project Two baseline characterisation study	
Hornsea Three baseline characterisation study	
Creyke Beck baseline characterisation study	
Hornsea Four Habitat Classification Report (Gardline, 2019	Provided site specific PSA data presented to provide an indication on the location of suitable habitat and spawning grounds for sandeel and herring.
BGS Marine Sediment Particle Size dataset sourced from the BGS GeoIndex Offshore portal[1]	

[1] https://www.bgs.ac.uk/GeoIndex/offshore.htm#BGSOffMar

Data Source	Data utilisation
Coull *et al.* (1998) Fisheries Sensitivity Maps in British Waters.[2]	Used to provide information on likely spawning or nursery areas for commercial species.
Ellis *et al.* (2010) Mapping spawning and nursery areas of species to be considered in Marine Protected Areas (Marine Conservation Zones).	Provided information on fish spawning and nursery grounds.
Ellis *et al.* (2012) Spawning and nursery grounds of selected fish species in UK waters. Scientific Series Technical Report	
The International Herring Larval Survey (IHLS) data (ICES, 2007–2017)[3]	Provided a quantitative estimate of herring larval abundance within potential and historic spawning grounds.
The International Bottom Trawl Surveys (IBTS) (2017)	Provided a fish sample database of target species.
Cefas 2015 full coverage Folk and EUNIS map (Stephens and Diesing 2015)	Provided an indication of the likelihood of suitable sandeel and herring spawning or nursery habitats within the study area.
Boyle and New (2018) ORJIP Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options.	Provided guidance on the methodology used to determine herring spawning grounds.

2.3.3 Survey methodology

2.3.3.1 Baseline characterisation surveys conducted in the former Hornsea Zone for Hornsea Project One, Hornsea Project Two and Hornsea Three were used to inform this technical report on the fish and shellfish ecology of the Hornsea Four site. Despite these survey locations not being within Hornsea Four, the data from these trawls are presented within this characterisation to provide further background information on the fish and shellfish communities in the southern North Sea.

2.3.3.2 As part of the baseline characterisation surveys for Hornsea Project One and Hornsea Project Two, seasonal otter trawl surveys were undertaken in spring and autumn 2011, within the sites' array area. A high-opening 5 m otter trawl with a 40 mm cod-end was used, to catch both semi-pelagic and demersal species. During the survey, high abundances of actively spawning herring were caught, and categorised depending on their development stage and spawning condition using the International Council for the Exploration of the Sea (ICES) Gonadal Somatic Index (GSI) criteria.

2.3.3.3 Epibenthic beam trawls were also undertaken as part of the baseline benthic ecology characterisation of the Hornsea Project One, Hornsea Project Two and Hornsea Three within the array and ECC boundaries. The surveys were undertaken using a standard 2 m Cefas 'Jennings' beam trawl fitted with a 5 mm cod-end:

[2] https://www.cefas.co.uk/media/52612/sensi_maps.pdf
[3] http://www.ices.dk/marine-data/data-portals/pages/eggs-and-larvae.aspx).

- 40 trawls within the former Hornsea Zone (including ten in the Hornsea Four array area) undertaken in November and December 2010;
- 21 trawls within the Hornsea Project Two array area undertaken in July 2012;
- 41 trawls within the Hornsea Project One array area undertaken in July 2010; and
- 28 trawls within the Hornsea Project One and Hornsea Project Two offshore cable corridors undertaken in June and October 2011.

2.3.3.4 For a detailed description of the methodologies followed, refer to the Hornsea Three Fish and Shellfish Technical Report (2018).[4]

2.3.3.5 Data from baseline characterisation surveys undertaken prior to the Creyke Beck development were also used to inform this technical report within the offshore Export Cable Corridor (ECC), as the landfall location of Creyke Beck overlaps with that proposed for Hornsea Four.

2.3.3.6 As part of the baseline characterisation surveys for Creyke Beck, various surveys were conducted along the proposed ECC. These included adult and juvenile fish surveys in April 2012, consisting of demersal otter trawling in the offshore region of the export cable, and scientific 2 m beam trawl surveys in both the inshore and offshore regions. Pelagic fish surveys were undertaken along the ECC in September 2011, and shellfish trammel netting and potting within the inshore region in August 2011. For a detailed breakdown of the methodologies followed, refer to the Dogger Bank Creyke Beck Fish and Shellfish Technical Report (2013)[5].

2.3.4 Spawning and nursery grounds

2.3.4.1 Data from Coull *et al.* (1998) and Ellis *et al.* (2010; 2012) were used to inform the baseline characterisation for this report on the locations of spawning and nursery habitats of species reviewed. Spawning and nursery habitat locations for the species are shown in **Section 3** of this report.

2.3.4.2 Herring and sandeel were highlighted as key species of relevance in the Scoping Report (Ørsted, 2018) when considering impacts to spawning areas as they are demersal spawners, with specific sediment requirements for spawning. A baseline characterisation of herring and sandeel spawning grounds within the study area is undertaken using the annual IHLS data from the last ten years (ICES, 2007–2017). An overview of the methodologies used are given below.

Herring

2.3.4.3 The method used to determine herring spawning grounds has utilised the data on historical spawning locations (Coull *et al*, 1998) and known habitat preferences, alongside the IHLS

[4] Hornsea Project Three. Fish and Shellfish Technical Report (2018) https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010080/EN010080-000575-HOW03_6.5.3.1_Volume%205%20-%203.1%20-%20Fish%20and%20Shellfish%20Ecology%20Technical%20Report.pdf

[5] Dogger Bank Creyke Beck Fish and Shellfish Technical Report (2013) https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010021/EN010021-000521-6.13.1%20Chapter%2013%20Appendix%20A%20Fish%20and%20Shellfish%20Technical%20Report%20Part%201%20-%20Application%20Submission_F-OFC-CH-013.pdf

data to refine these areas and provide a more nuanced view of the spawning trends of herring over the previous decade.

2.3.4.4 The methodology used follows that of Boyle and New (2018); for a detailed breakdown of the methodology, refer to the full Offshore Wind, Offshore Renewable Joint Industry Project (ORJIP) report[6].

2.3.4.5 IHLS data was first downloaded from the ICES Eggs and Larvae data pages[7] for the last ten available years (2007 to 2016 autumn data; note that no data is currently available for 2017 or 2018 autumn surveys from the IHLS website) for all larval size classes <11 mm, to provide an updated analysis of herring larvae distribution. The time range of data utilised provides an up-to-date distribution, whilst also reducing any skewing of the data which could occur for data covering a shorter period of time. The data were categorised by spawning season (August to October) (**Table 6**), imported into a database, where queries were run to extract the total amount of larvae per m^2 by spawning season, and as the whole ten-year dataset (with trawl replicates removed).

2.3.4.6 The query outputs were separate annual spawning season datasets, and a dataset for the full ten-year period (2007-2017) which contained single records for each trawl showing the total larvae per m^2 caught in the trawl. The data were then represented as point data on a map in ArcGIS, with each point retaining the larval counts per m^2; the data were then used to create heat maps in QGIS, reflecting this parameter. A radius of 50 km was used to allow sufficient overlap between the points, so that the extrapolation of the heat maps covers the full IHLS survey area.

2.3.4.7 The rasters produced were then categorised in ArcGIS, using the methodology summarised in **Figure 2**.

[6] ORJIP (2018) https://www.carbontrust.com/media/676435/orjip-piling-study-final-report-aug-2018.pdf
[7] ICES Eggs and Larvae data pages (http://www.ices.dk/marine-data/data-portals/Pages/Eggs-and-larvae.aspx

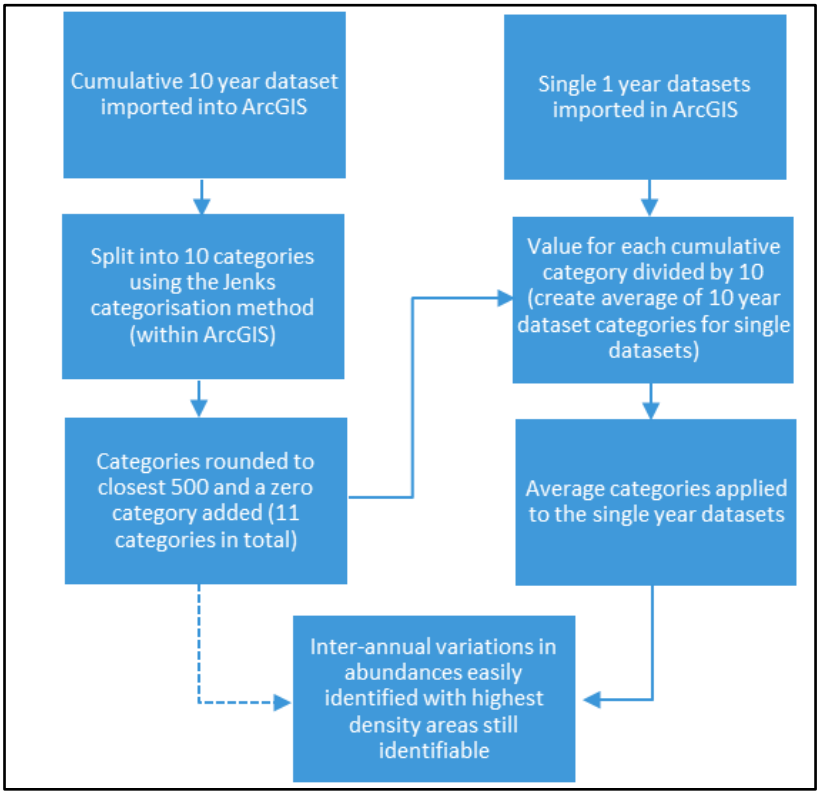


Figure 2: Data categorisation methodology (reproduced from the ORJIP report (2018)).

2.3.4.8 The categorisation of the raster data in this way allows the comparison of relative abundance between the annual larvae abundances, and the determination of any variation in the relative importance of each spawning area in any one year.

2.3.4.9 The heat maps produced for this desktop study have taken the best available up to date data and present the herring larvae data to show 'hot spots' for particular stocks of herring within the study area, to assist in identifying spawning grounds. The data were then presented alongside Coull *et al.* (1998) fish sensitivity maps, that show historic and potential spawning sites and nursery areas. The Hornsea Four ECC and the array area are also presented, to enable the spatial relationship to important herring spawning areas to be determined and as a basis for the impact assessment process. The results of this analysis are summarised in **Section 3** below.

2.3.4.10 In addition, PSA data from the baseline characterisation surveys for the former Hornsea Zone, Hornsea Project One, Hornsea Project Two, Hornsea Three, and data from the British Geological Survey (BGS) were presented alongside site-specific PSA data (presented in the Hornsea Four Offshore Wind Farm Habitat Classification Report (Gardline, 2019)) and broadscale marine habitat data generated from EUNIS and Folk (1954) (Stephens and Diesing 2015). The PSA data were processed in accordance to the methodologies described in Reach *et al.* (2013), and classified using the categories in **Table 2** to identify the preferred, marginal and unsuitable herring spawning habitats within the Hornsea Four

fish and shellfish study area, replicating the tidal ellipse distance, and therefore the furthest distance travelled by sediment in one tidal cycle.

Table 2: Herring potential spawning habitat sediment classifications (Sources adapted from Reach *et al*, 2013).

Folk Class (Folk, 1954)	Habitat sediment preference	Habitat sediment classification
Gravel and part sandy Gravel	Prime	Preferred
Part sandy Gravel and part gravelly Sand	Sub-prime	Preferred
Part gravelly Sand	Suitable	Marginal
Everything excluding Gravel, sandy Gravel and part gravelly Sand	Unsuitable	Unsuitable

2.3.4.11 The results of these analyses are summarised in Section 3 below.

Sandeel

2.3.4.12 PSA data from the baseline characterisation surveys for the former Hornsea Zone, Hornsea Project One, Hornsea Project Two, Hornsea Three, and data from the British Geological Survey (BGS) were presented alongside site-specific PSA data (presented in the Hornsea Four Offshore Wind Farm Habitat Classification Report (Gardline, 2019)) and broadscale marine habitat data generated from EUNIS and Folk (1954) (Stephens and Diesing 2015). The PSA data were processed in accordance to the methodologies described in Latto *et al.* (2013), and classified using the categories in Table 3 to identify the preferred, marginal and unsuitable herring spawning habitats within the Hornsea Four fish and shellfish study area, replicating the tidal ellipse distance, and therefore the furthest distance travelled by sediment in one tidal cycle.

Table 3: Sandeel habitat sediment classifications (Sources adapted from Latto *et al*, 2013).

Folk Class (Folk, 1954)	Habitat sediment preference	Habitat sediment classification
Part Sand, Part slightly gravelly Sand and part gravelly Sand (< 1% muds, > 85% sand)	Prime	Preferred
Part Sand, Part slightly gravelly Sand and part gravelly Sand (< 4% muds, > 70% sand)	Sub-prime	Preferred
Sandy Gravel	Suitable	Marginal
All others (including part muddy Sand, part slightly gravelly muddy sand, part gravelly muddy Sand, part muddy sandy Gravel and part sandy Gravel.	Unsuitable	Unsuitable

2.4 Data Limitations and sensitivities

2.4.1 Fish and Shellfish Ecology

2.4.1.1 Mobile species such as fish, exhibit varying spatial and temporal patterns. All surveys from across the former Hornsea Zone (i.e. otter and epibenthic beam trawls) were undertaken to provide a semi-seasonal description of the fish and shellfish assemblages within the fish and shellfish study area. It should be noted, however, that the data collected during these surveys represent snapshots of the fish and shellfish assemblage within the study area at the time of sampling and the fish and shellfish assemblages may vary considerably both seasonally and annually.

2.4.1.2 Furthermore, the efficiency of the survey methods employed at collecting species will vary depending on the nature of the survey methods used and the species recorded. For example, the semi-pelagic otter trawl would not collect pelagic species (e.g. herring and sprat (*Sprattus sprattus*)) as efficiently as a pelagic trawl and the 2 m scientific beam trawl would not be as efficient at collecting sandeel and shellfish species as other methods used commercially in the study area (e.g. sandeel or shrimp trawls and shellfish potting).

2.4.2 Spawning and nursery grounds

2.4.2.1 Coull *et al.* (1998) and Ellis *et al.* (2010, 2012) are considered the key references for providing broad scale overviews of the potential spatial extent of spawning grounds and the relative intensity and duration of spawning. Both Coull *et al.* (1998) and Ellis *et al.* (2010, 2012) are based on a collection of various data sources. Many of the conclusions drawn by Coull *et al.* (1998), are based on historic research and may fail to account for more recent changes in fish distributions and spawning behaviour. Ellis *et al.* (2010, 2012) also face limitations due to the wide scale distribution of sampling sites used for the annual international larval survey data, consequently resulting in broad scale grids of spawning and nursery grounds.

2.4.2.2 The spatial extent of the spawning grounds and the duration of spawning periods indicated in these studies are therefore considered likely to represent the maximum theoretical extent of the areas and periods within which spawning will occur. Spawning grounds may therefore be smaller in extent and display shorter spawning periods. In some cases, spawning grounds may no longer be active, for example the Dogger Bank spawning ground.

2.4.2.3 The EUNIS and Folk (1954) (Stephens and Diesing 2015) broadscale marine habitat data used to identify preferred sandeel and herring spawning habitats is limited by the broadscale nature of the data, since it does not account for small scale, localised differences in seabed sediments, unlike the data obtained from site-specific grab sampling. In this case it is important to review all datasets presented, to develop a clear overview of preferred sandeel and herring habitat.

2.4.2.4 It should also be noted that the use of PSA data and broadscale habitat mapping only provides a proxy for the presence of sandeels and herring in these locations (based on suitability of habitats; i.e. the potential for spawning rather than actual contemporary spawning activity); therefore, this data should be reviewed alongside other datasets presented in this chapter in determining the location and relative importance of spawning habitats.

3 Results

3.1 Fish ecology

3.1.1.1 Historic surveys have recorded the presence of a number of species of conservation importance within the former Hornsea Zone, including: Atlantic salmon, cod, whiting, plaice, common sole, herring, mackerel, lesser sandeel, spotted ray and thornback ray (Table 9). Sprat, dab, lemon sole and solenette were also recorded in the historic former Hornsea Zone data.

3.1.1.2 A total of 84 species were recorded in the otter and epibenthic beam trawls undertaken within the study area (as part of the Hornsea Three baseline characterisation); several species were recorded frequently with dab occurring in 93.2% of trawls.

3.1.1.3 Fish species recorded in the epibenthic beam trawls in the study area were dominated in abundance by solenette. Additional flatfish species recorded included scaldfish, dab, plaice and lemon sole. Dragonettes, gobies, lesser weever, whiting and sandeels were also recorded in the area (as recorded in the Hornsea Three baseline characterisation surveys).

3.1.1.4 The otter trawls were dominated by whiting, dab and sprat, with herring recorded at high abundances during the spring. Dab and plaice were recorded, with moderate (plaice) to high abundances (dab), with brill, sole and lemon sole recorded at much lower abundances in the area. Additional species recorded within the trawls include grey gurnard, lesser weaver, and the European common squid. Limited seasonal variation is reflected in species abundances, with a slightly higher abundance in spring, likely due to differences in clupeid species.

3.1.1.5 Within the baseline characterisation surveys conducted within the inshore section of the ECC of Creyke Beck (where it overlaps with the proposed landfall for the Hornsea Four ECC) the most dominant species caught in trammel net surveys were the small spotted catshark, whiting, and dab. Dab had the highest catch rate observed in beam trawls conducted in October; plaice in comparison, were absent during otter trawl surveys in the inshore section of the ECC.

3.1.2 Species by species distribution and abundance

3.1.2.1 Figure 3 to Figure 22 show the distributions of key species (those with the highest recorded abundances in the Hornsea Three baseline characterisation report (RPS, 2018), and those of commercial importance (see Volume 5, Annex 7.1: Commercial Fisheries Technical

Report) recorded in the study area, during the otter and epibenthic beam trawls. Key species recorded along the inshore section of the ECC are also discussed in further detail in this section.

Whiting

3.1.2.2 Whiting (*Merlangius merlangus* , a species of conservation importance (UK Biodiversity Action Plan (BAP), and Natural Environment and Rural Communities (NERC) Act, 2006), was the most abundant species recorded throughout the former Hornsea Zone and the fish and shellfish study area during otter and epibenthic beam trawls. Figure 3 shows the distribution of whiting across the former Hornsea Zone, with abundances up to 800 per 500 m recorded in within the Hornsea Four array area, and to the south east of the array area during sampling conducted in the autumn. Abundances recorded during epibenthic beam trawling were lower than those recorded from the otter trawl samples (as recorded in the Hornsea Three surveys). Whiting were also recorded in relatively high abundances in trammel net surveys conducted in the nearshore section of the Hornsea Four ECC (as recorded in the Creyke Beck surveys). High intensity nursery grounds are located across the array area and EEC of Hornsea Four, with low intensity spawning grounds also present across the array area (Figure 3 and Figure 4) (Ellis *et al*, 2010).

3.1.2.3 In a broader context, whiting are largely distributed throughout the North Sea, with high densities found almost everywhere except surrounding Dogger Bank, which generally shows a marked hole in distribution (ICES, 2005g), proximal to the Hornsea Four array area. Data from the IBTS supports this, showing that whiting are widely distributed throughout the North Sea, with consistently high abundances recorded in most areas, although variable abundances have been recorded nearshore (ICES, 2017a), within the Hornsea Four ECC area.

Dab

3.1.2.4 As can be seen in Figure 5, dab (*Limanda limanda*) was consistently recorded at high abundances throughout the study area, with highest abundances in offshore areas, within the proposed Hornsea Four array area (as observed in Hornsea Three baseline characterisation surveys).

3.1.2.5 Dab were also recorded in high numbers in the inshore trammel net surveys and with a high catch rate in beam trawl surveys (in October) carried out in the nearshore section of the Hornsea Four ECC (Figure 6) (as observed in the Crekye Beck baseline characterisation surveys).

3.1.2.6 Dab spawning areas were identified by van der Land (1990) and Lelievre *et al*. (2012) (as cited in Sundby *et al*, 2017) across the Hornsea Four study area, with a high intensity spawning area located off Flamborough and along the southern edge of Dogger Bank, off the offshore section of the Hornsea Four ECC, and the array area (Sundby *et al*, 2017).

3.1.2.7 In a broader context, spawning occurs throughout the southern North Sea, off Brittany and southern England, with areas of high intensity spawning also located in the German Bight

northwest of Helgoland and along the northern Dutch coast, with peak egg densities found along Dutch and German coasts (Sundby *et al*, 2017).

Plaice

3.1.2.8 Plaice were identified as a species of commercial importance in **Volume 5, Annex 7.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

3.1.2.9 As shown in **Figure 7**, plaice (*Pleuronectes plates*) were recorded throughout the array area in epibenthic and otter trawls (as observed in Hornsea Three baseline characterisation surveys). Otter trawl surveys undertaken in the nearshore section of the Hornsea Four ECC, also recorded low catch rates of plaice (in the Creyke Beck surveys) (**Figure 8**).

3.1.2.10 High intensity plaice spawning grounds are located across the Hornsea Four fish and shellfish study area (Ellis *et al*,2010) as shown in **Figure 7** and **Figure 8**, with a low intensity nursery ground is also located to the west of the array area, across the nearshore section of the Hornsea Four ECC.

3.1.2.11 In a broader context, in the North Sea juvenile plaice are concentrated in the Southern and German Bights, and also occur along the east coast of Britain, and in the Skagerrak and Kattegat. Juveniles are typically of low densities in the central North Sea, and almost absent for the north eastern part. Coastal and inshore waters of the North Sea represent essential nursery grounds, with areas of high egg production located within the eastern channel and Southern Bight (ICES, 2005h)

Cod

3.1.2.12 Cod (*Gadus Morhua*) were reviewed in this technical report due to their commercial importance (as well as being a species of conservation importance (UK BAP and NERC Act, 2006).

3.1.2.13 Historic trawl survey data for cod presence across the former Hornsea Zone showed distribution patterns consistent with those observed in the IBTS data, with high abundances occurring in the central and northern North Sea, around Dogger Bank and in the Southern Bight (ICES, 2005c). Cod were consistently recorded in otter and epibenthic trawls to the east of the Hornsea Four array area (as observed in Hornsea Three baseline characterisation surveys) and was not found to be one of the main characterising species of the fish assemblage. Trammel net surveys (Creyke Beck surveys) undertaken in the nearshore section of the Hornsea Four ECC showed relatively moderate abundances of cod, with a peak in abundance observed in January (**Figure 10**).

3.1.2.14 Cod spawning grounds are typically widespread and not restricted to specific areas, found offshore in all areas of the North Sea. However, a survey in 2004 showed important concentrations to the north-west of the Dogger Bank (ICES, 2005c). Low intensity cod spawning grounds are located within the array area of the Hornsea Four (Ellis *et al*, 2010), with low intensity nursery grounds located across the study area (Ellis *et al*, 2010) (**Figure 9**).

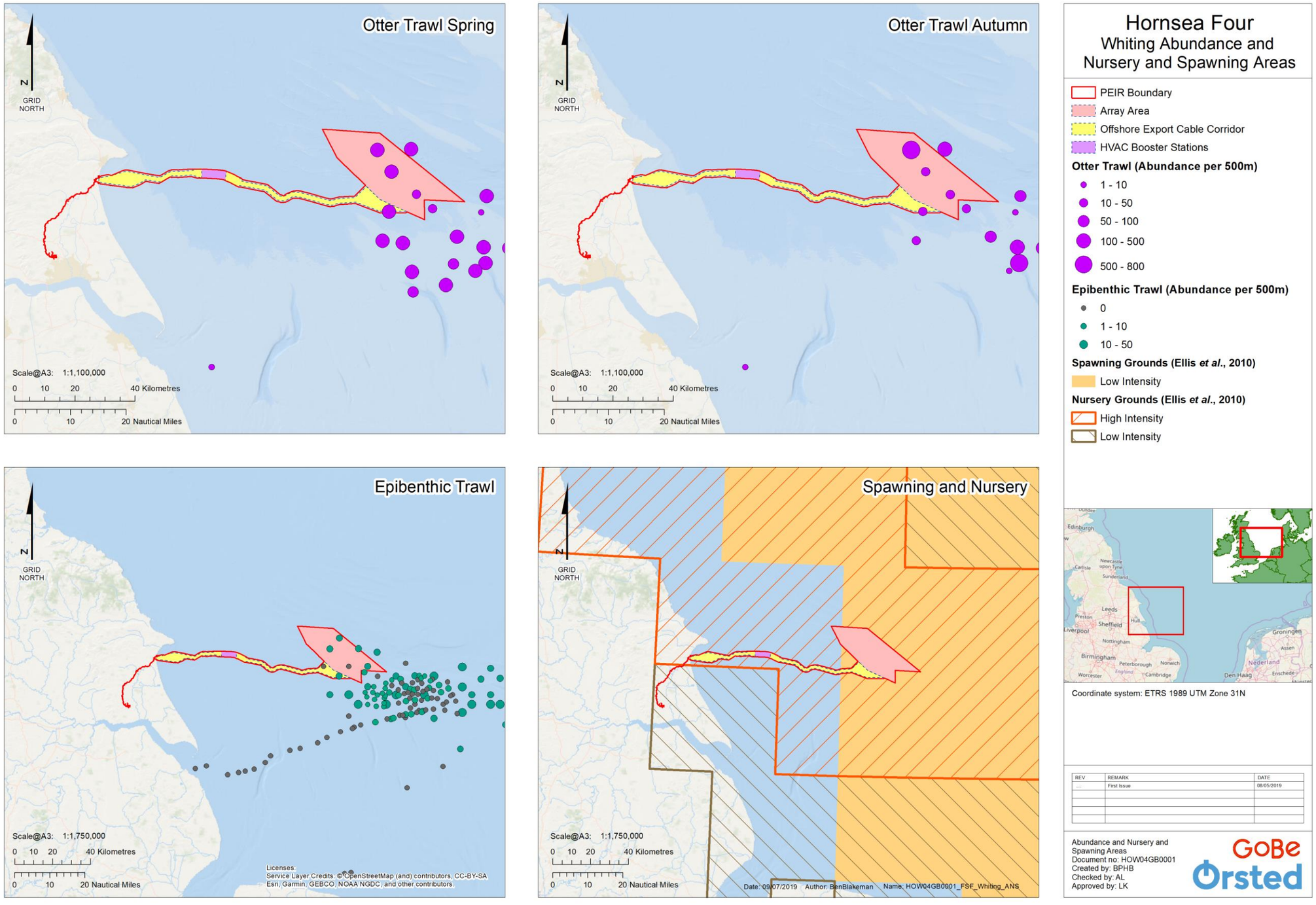


Figure 3: Whiting abundances within the Hornsea Four array area, with data from Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).

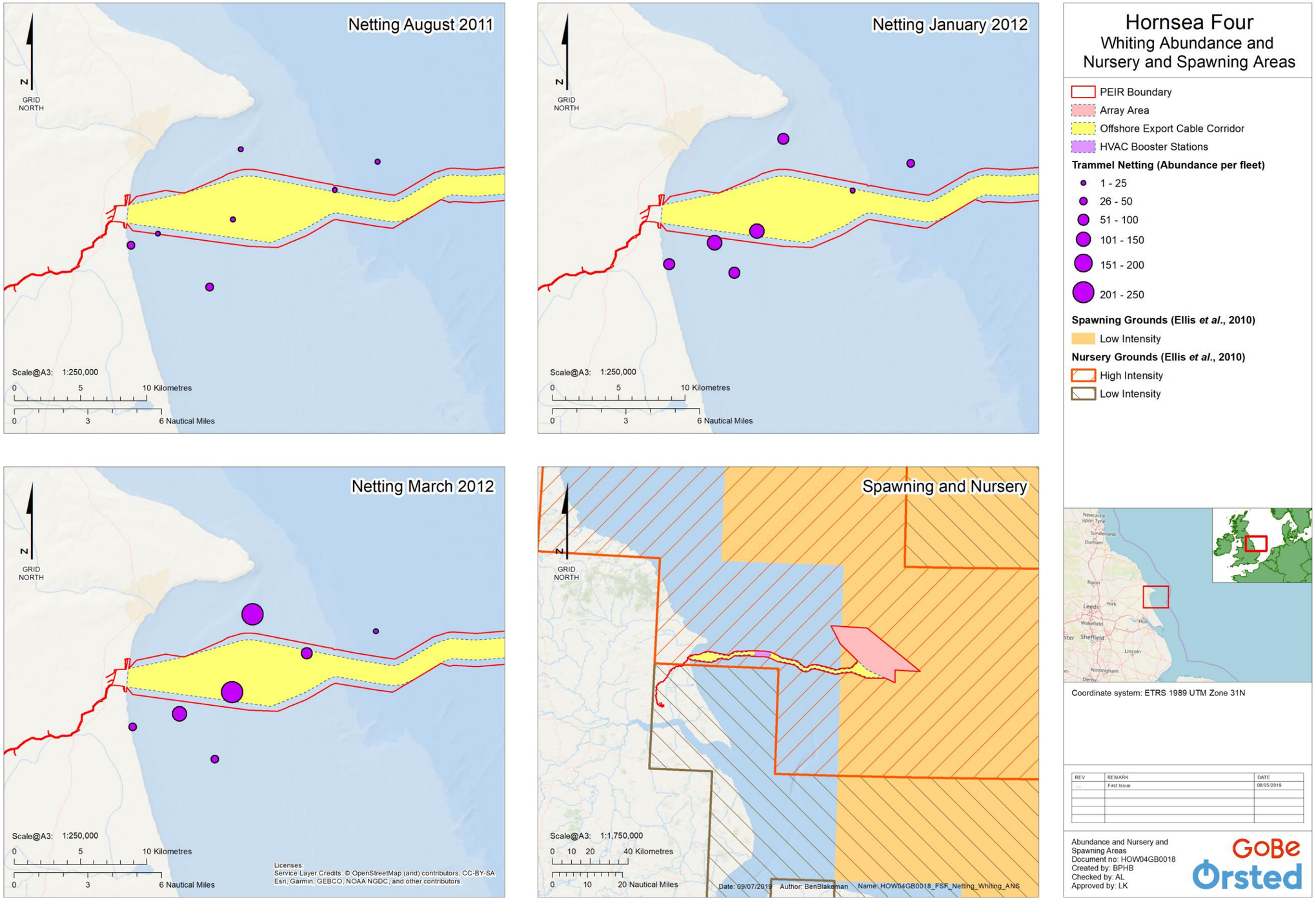
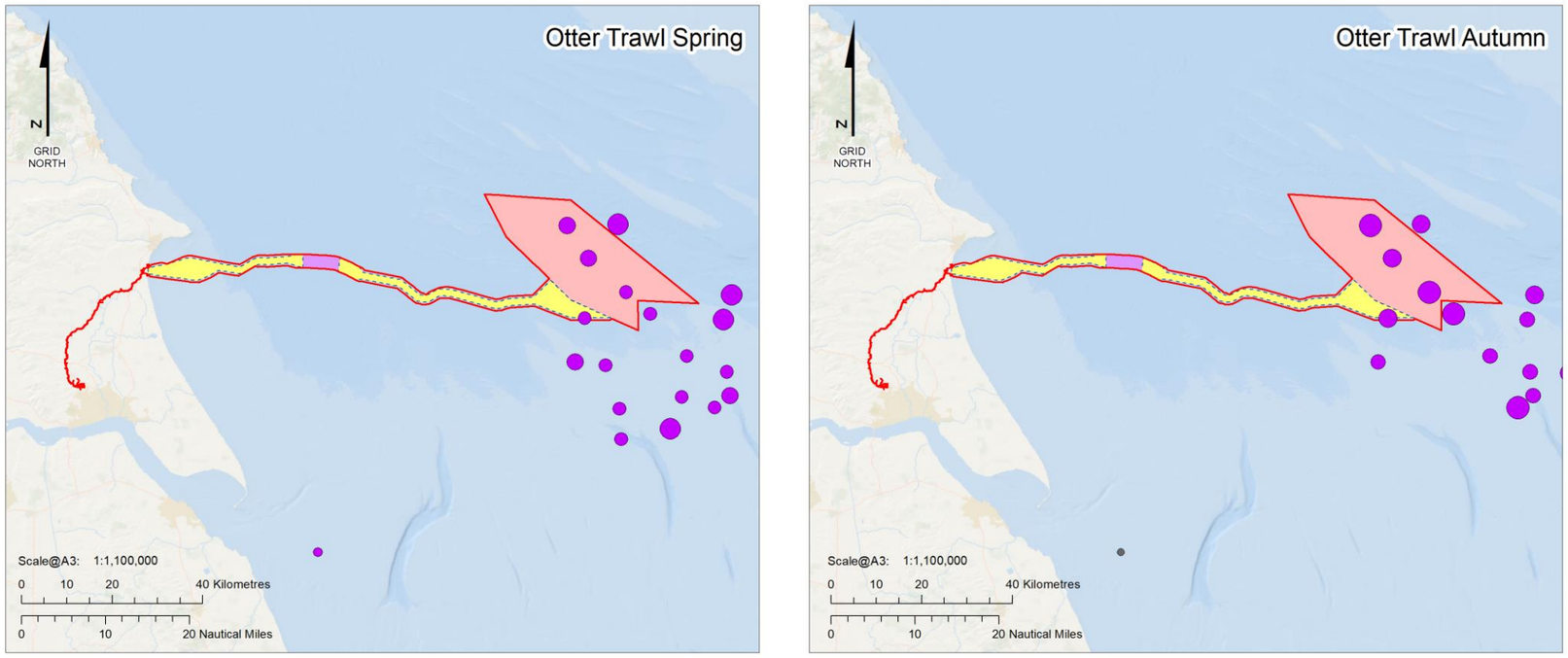
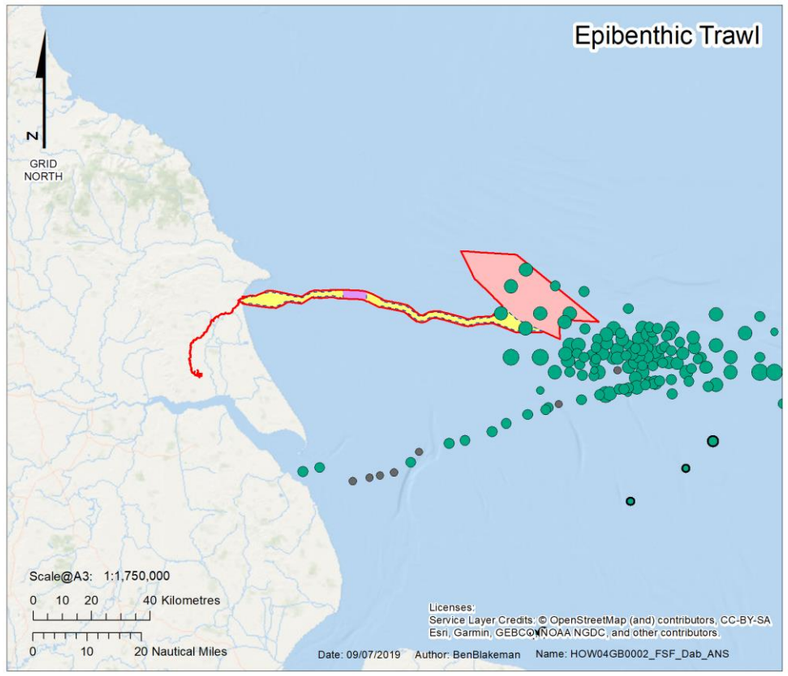


Figure 4: Whiting abundances within the Hornsea Four ECC, with data from Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).





Hornsea Four
Dab Abundance

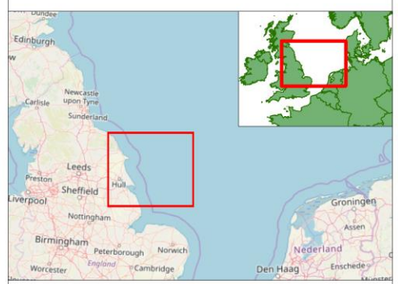
PEIR Boundary
Array Area
Offshore Export Cable Corridor
HVAC Booster Stations

Otter Trawl (Abundance per 500m)

- 0
- 1 - 10
- 10 - 50
- 50 - 100
- 100 - 200
- 200 - 250

Epibenthic Trawl (Abundance per 500m)

- 0
- 1 - 10
- 10 - 50
- 50 - 100



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Abundance and Nursery and Spawning Areas
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Figure 5: Dab abundances within the Hornsea Four array area (not to scale).

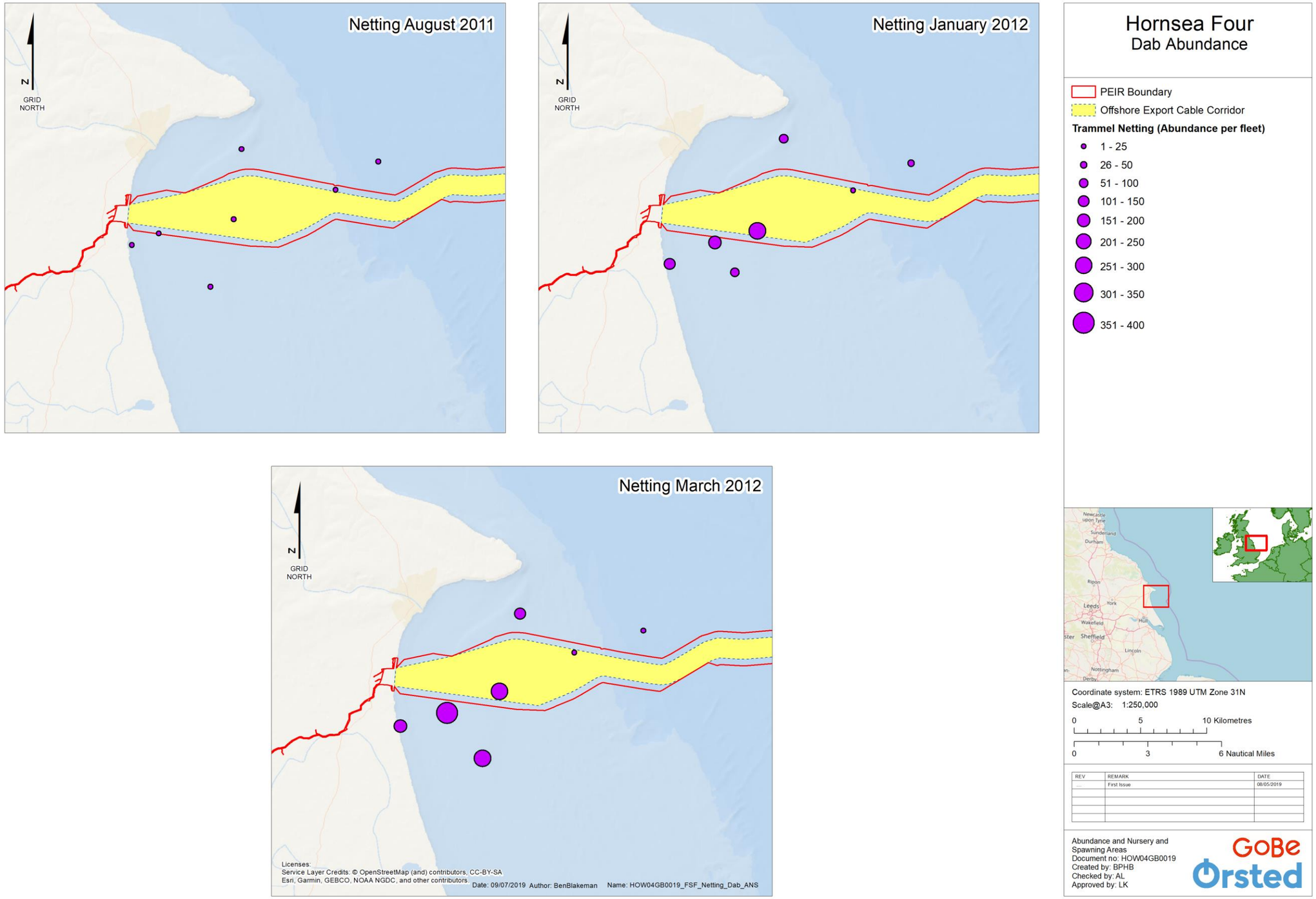


Figure 6: Dab abundances within the Hornsea Four ECC (not to scale).

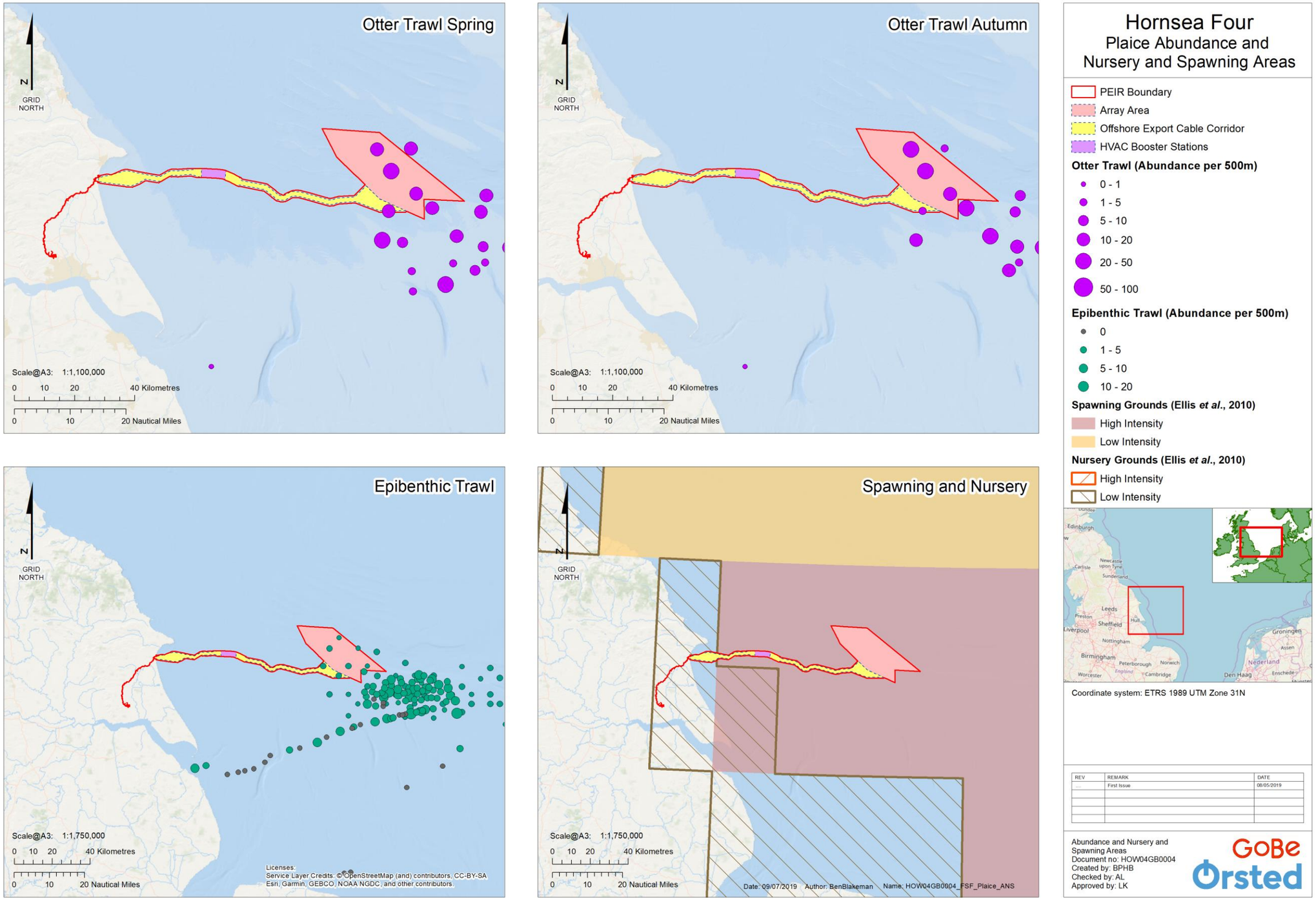
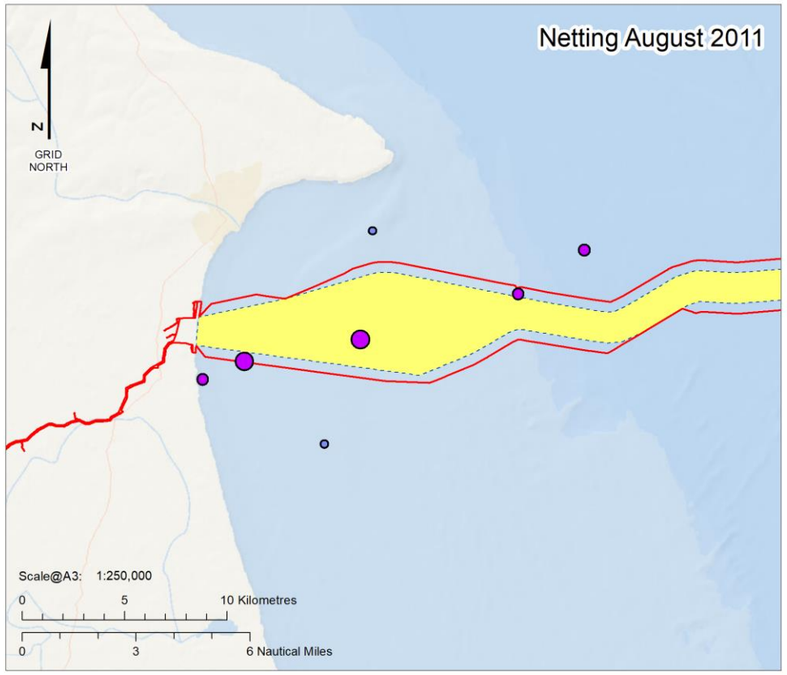
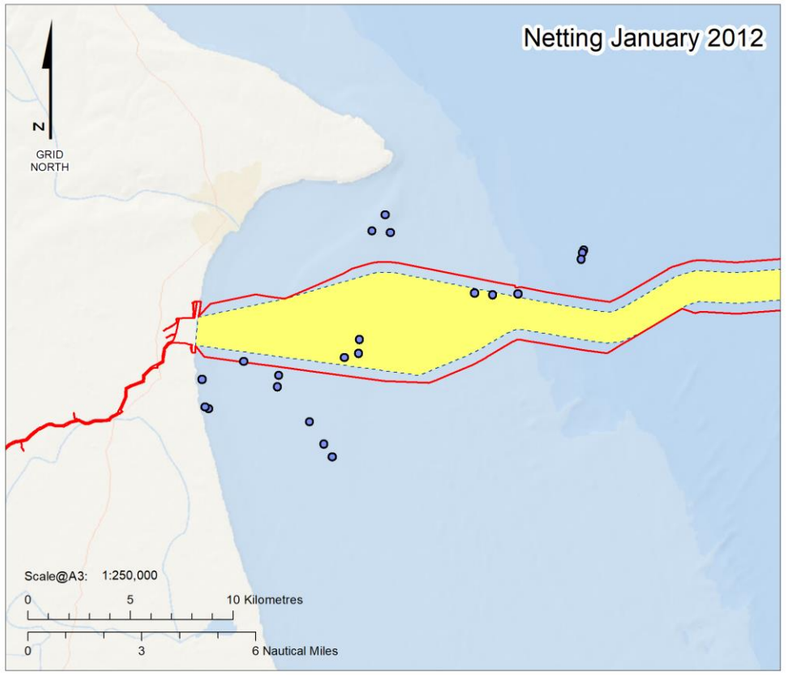
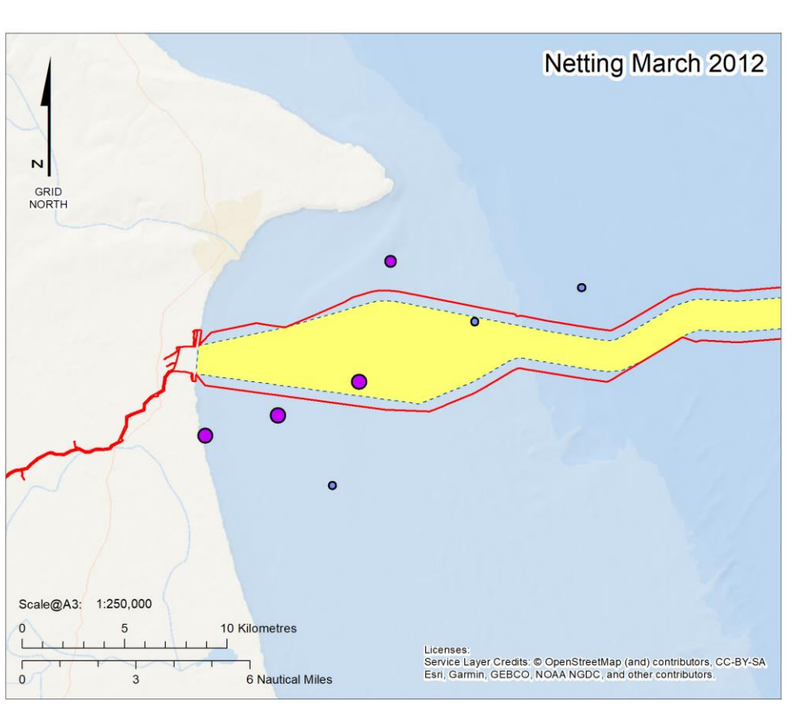
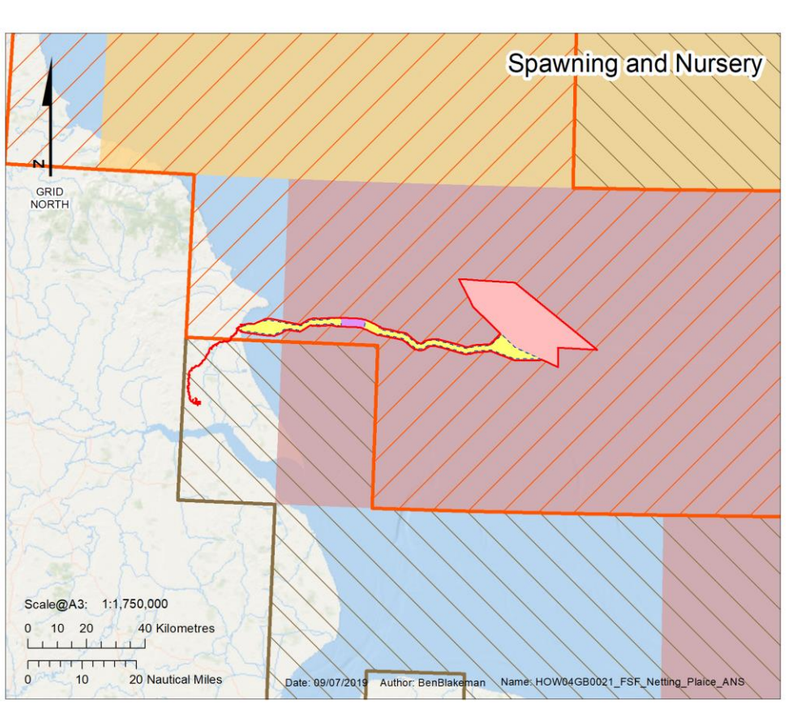


Figure 7: Plaice abundances within the Hornsea Four array area, with data from Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).









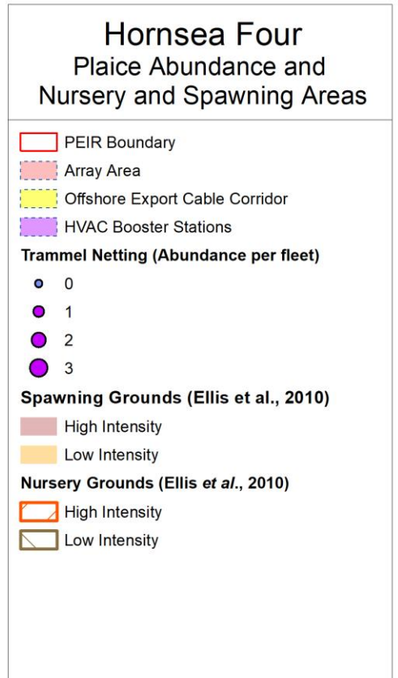
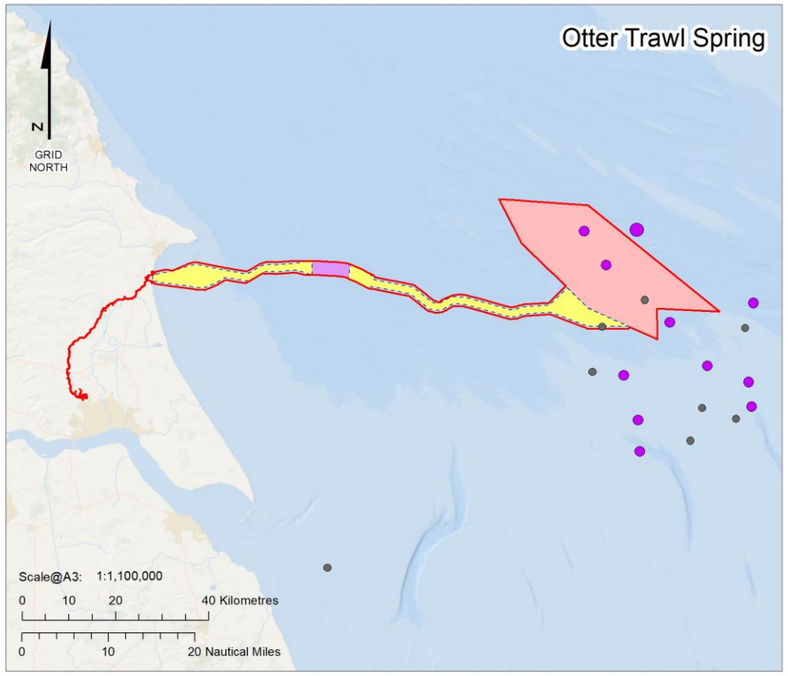
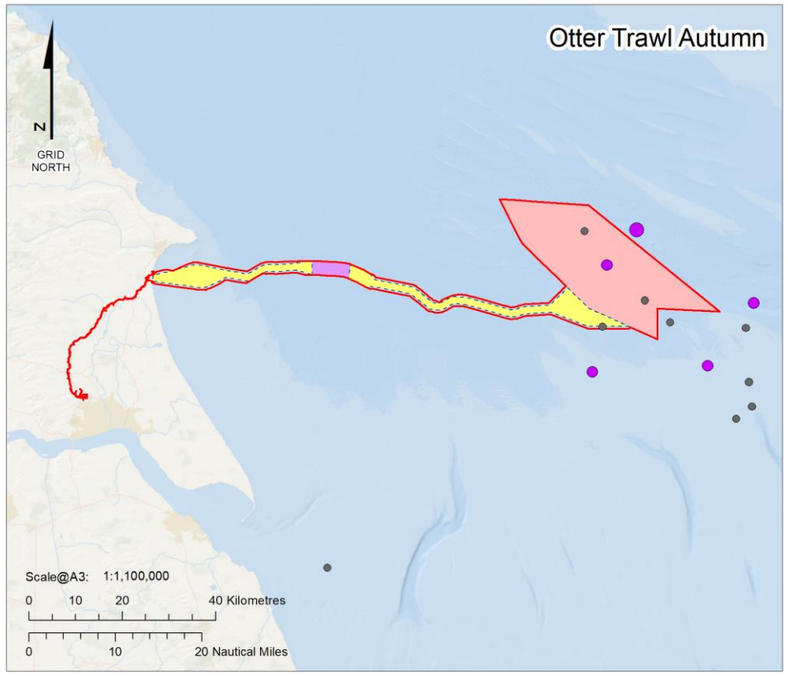
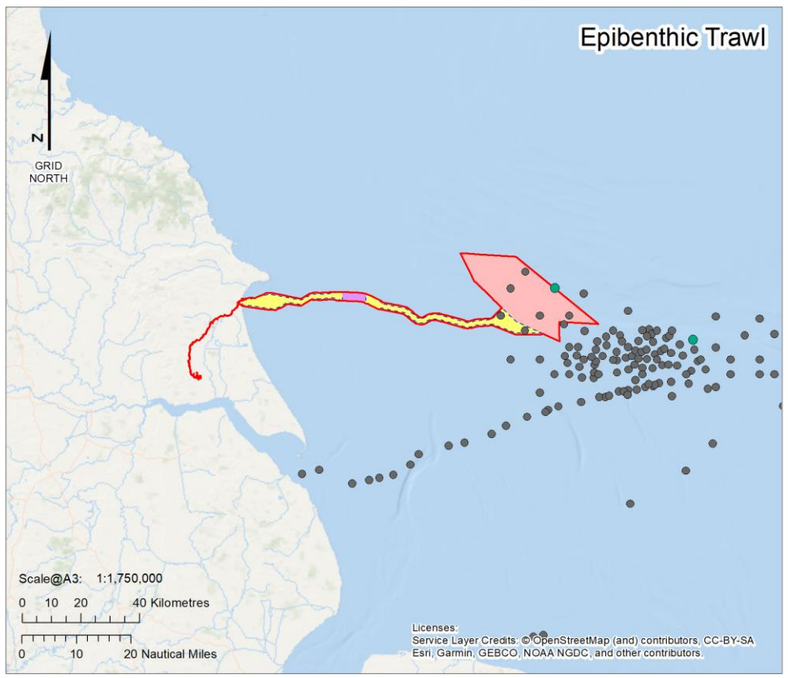
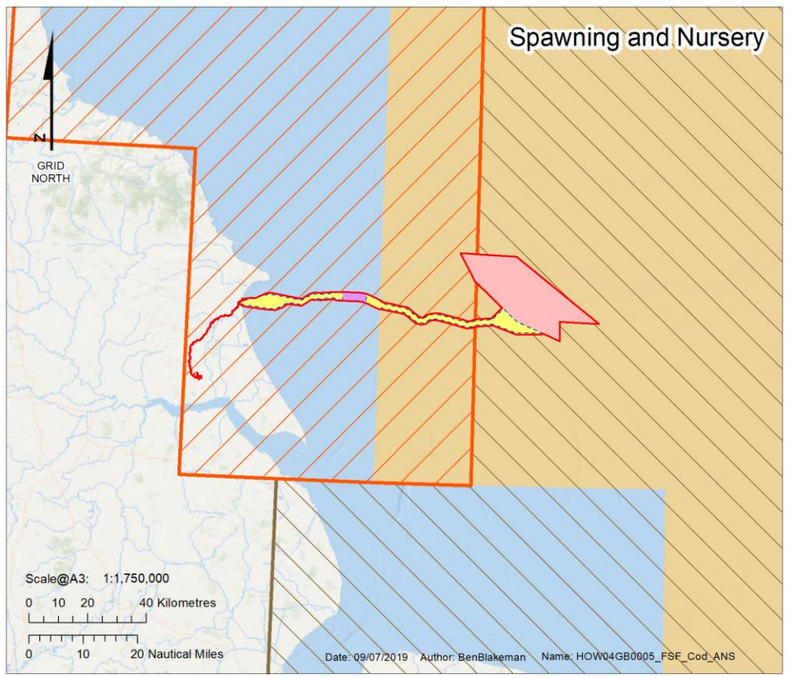


Figure 8: Plaice abundances within the Hornsea Four ECC, with data from Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).









Hornsea Four
Cod Abundance and Nursery and Spawning Areas

- PEIR Boundary
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

Otter Trawl (Abundance per 500m)

- 0
- 0 - 1
- 1 - 10
- 10 - 20
- 20 - 30

Epibenthic Trawl (Abundance per 500m)

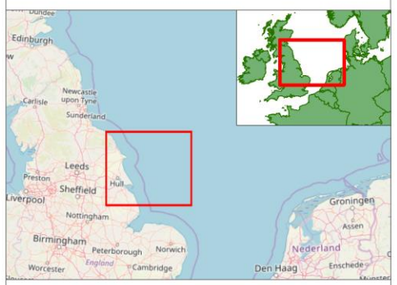
- 0
- 0 - 1

Spawning Grounds (Ellis *et al.*, 2010)

- Low Intensity

Nursery Grounds (Ellis *et al.*, 2010)

- High Intensity
- Low Intensity



Coordinate system: ETRS 1989 UTM Zone 31N

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Figure 9: Cod abundances within the Hornsea Four array area, with data from Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).

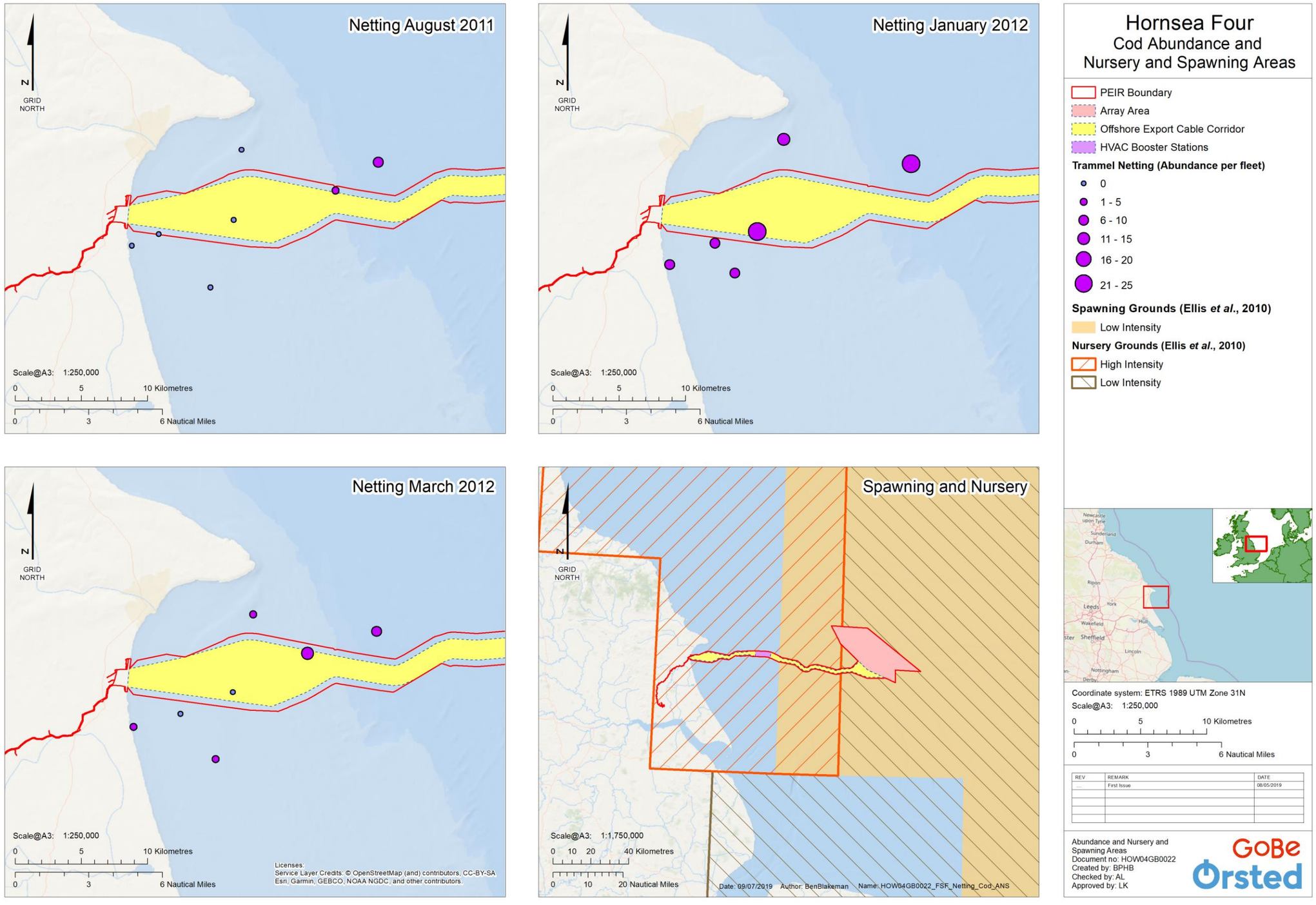


Figure 10: Cod abundances within the Hornsea Four EEC, with data from Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).

Lemon sole

3.1.2.15 Lemon sole (*Microstomus kitt*) was recorded at low abundances throughout the fish and shellfish study area (**Figure 11**) during otter and epibenthic trawls, with relatively higher abundances, compared to the overall low-density population, recorded in otter trawls to the north of the former Hornsea Zone, within the deeper waters of Outer Silver Pit. The Hornsea Four array area and ECC is within the mapped spawning and nursery habitats for this species (**Figure 11**, and **Figure 12**), however these are identified as low intensity spawning and nursery areas. Lemon sole spawning areas within the North Sea are located within the English Channel and along the eastern coast, although spawning grounds are absent in the central North Sea (Coull *et al*, 1998).

Common sole

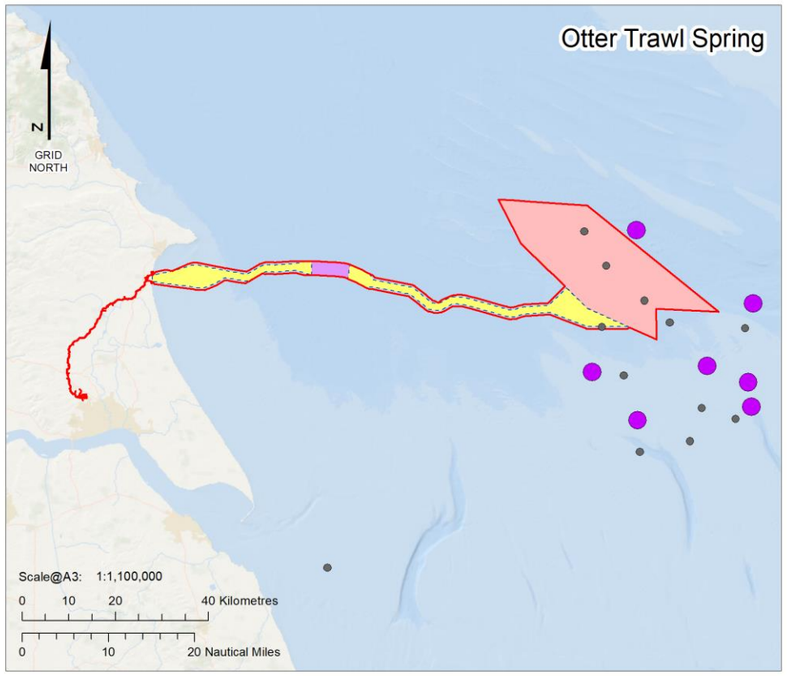
3.1.2.16 Common sole (*Solea solea*), a species of conservation importance (UK BAP and NERC Act, 2006), was recorded at high abundances in the northwest of the former Hornsea Zone and were repeatedly recorded at low abundances across the study area during otter and epibenthic trawls, with the highest abundances (i.e. <4 individuals per 500 m) recorded in the study area (as part of the Hornsea Three baseline characterisation). These are not plotted due to the low abundances of the species.

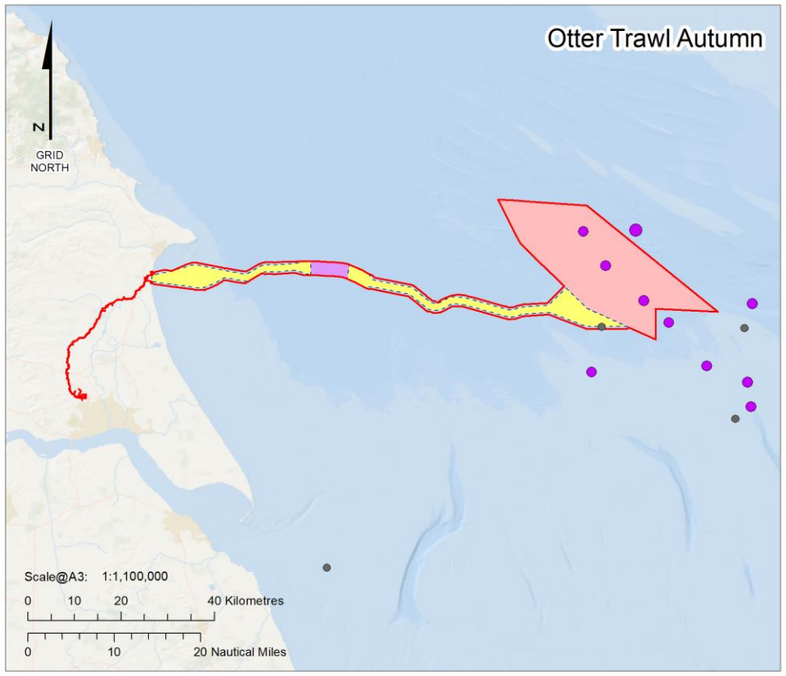
3.1.2.17 Spawning grounds for common sole typically occur all along the southern coasts, with IBTS data indicating high intensity spawning grounds located within the Wash. Moderate intensity spawning grounds are located in the Humber estuary and along the coast to south of Flamborough Head (ICES, 2005f), indicating the presence of common sole spawning grounds in the inshore section of the Hornsea Four ECC. However, in a broader context, the primary spawning areas of common sole in the southern North Sea appear to be situated within the English Channel and along the continental coast (ICES, 205f).

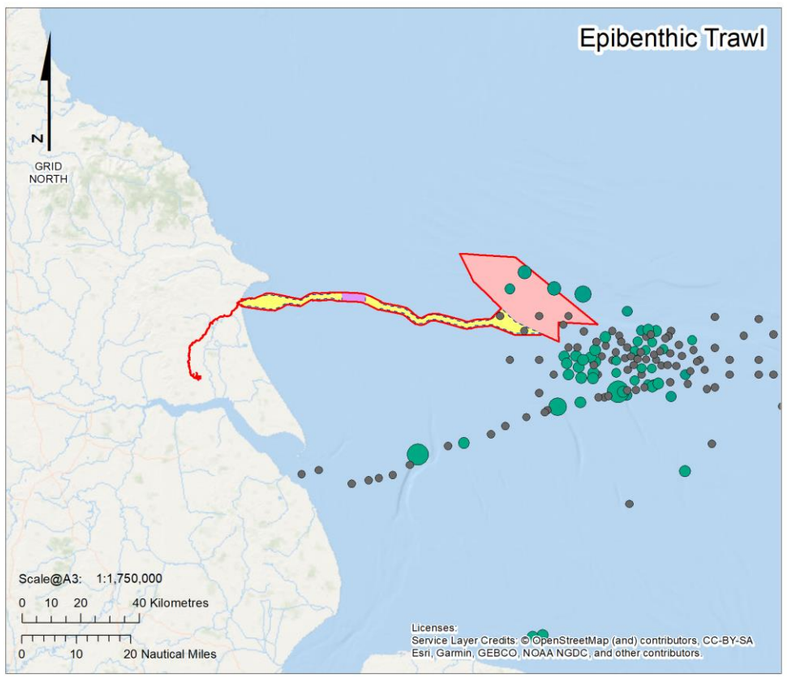
Solenette

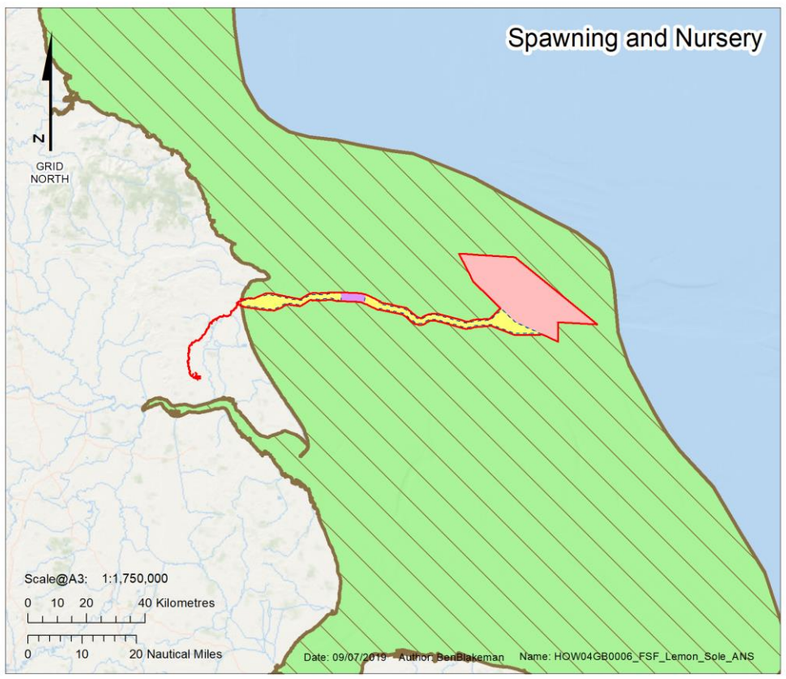
3.1.2.18 Solenette (*Buglossidium luteum*) was recorded at high abundances in the offshore areas of the former Hornsea Zone and was the main characterising species recorded during epibenthic beam trawl sampling in the study area. Solenette were recorded with highest abundances within the mid and eastern sections of the study area, although the species was not recorded within the Hornsea Four array area. This species was recorded in otter trawls though at considerably lower abundances due to the small size of this species (otter trawl mesh size at cod end = 40 mm, with most solenette measuring less than 100 mm length). Despite this, seasonal variation in the species can be observed within the otter trawl records, with increased abundance recorded in autumn (as recorded in the Hornsea Three baseline characterisation surveys).

3.1.2.19 Solenette spawning areas in the North Sea were mapped by van der Land (1990) and Lelievre *et al*. (2012); spawning areas were found to be located to across the south-eastern North Sea (Sundby *et al*, 2017), with no spawning areas located within the study area









Hornsea Four
Lemon Sole Abundance and Nursery and Spawning Areas

- PEIR Boundary
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

Otter Trawl (Abundance per 500m)

- 0
- 1 - 5
- 5 - 7

Epibenthic Trawl (Abundance per 500m)

- 0
- 1 - 5
- 5 -10
- 10 - 15
- 15 - 20

Spawning Grounds (Coull *et al.*,1998)

- Spawning

Nursery Grounds (Coull *et al.*, 1998)

- Nursery

Coordinate system: ETRS 1989 UTM Zone 31N

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Figure 11: Lemon sole abundances within the Hornsea Four array area, with data from Coull *et al.* (1998) showing spawning and nursery habitats (not to scale).

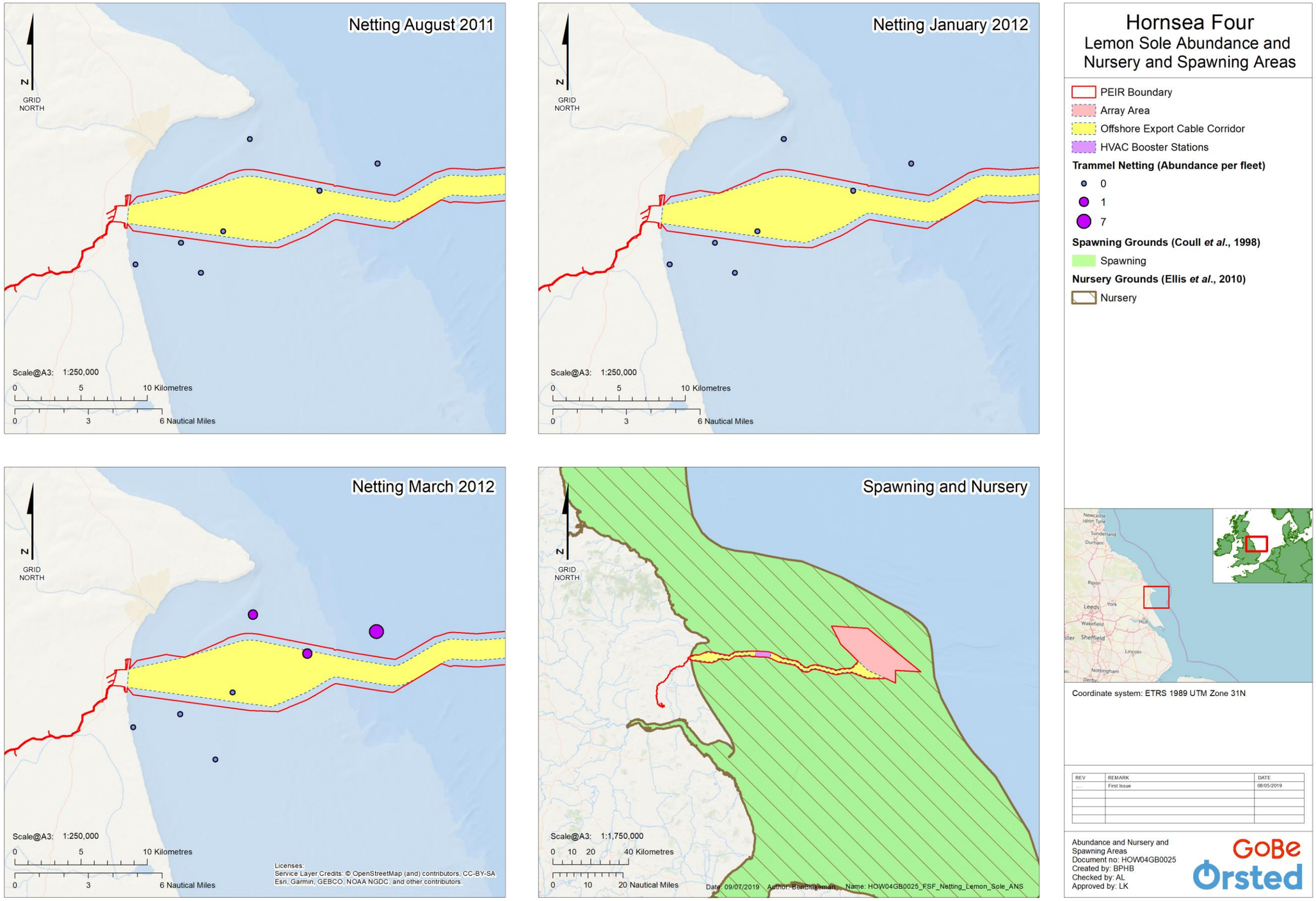


Figure 12: Lemon sole abundances within the Hornsea Four EEC, with data from Coull *et al.* (1998) and Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).

Grey Gurnard

3.1.2.20 Grey gurnard (*Eutrigla* gurnardus) was one of the key characterising species in the fish assemblage recorded in otter trawls within the study area, with highest abundances generally recorded in the west and northwest of the study area (as recorded in the Hornsea Three baseline characterisation). Abundances of grey gurnard were much lower in the epibenthic beam trawls. Grey gurnard were not recorded within the proposed Hornsea Four array area. No seasonal differences were observed in the survey data, although distribution and abundances reportedly vary throughout the year, with winter populations occurring in the central North Sea at depths of 50-100 m, and dense spring populations in the southern North Sea (ICES, 2005d). Quarterly IBTS surveys of grey gurnard abundance show a shift in distribution in the spring, with the area south of 56°N becoming densely populated, this may be a result of spawning behaviours, suggesting the potential for grey gurnard spawning areas within the study area (ICES, 2005d).

Sprat

3.1.2.21 Sprat (*Sprattus* sprattus) are widely distributed within the North Sea and are an important prey resource for a number of piscivorous fish, marine mammals and sea birds. IBTS data show that that the highest concentrations of sprat generally occur to the east and northwest of the former Hornsea Zone. Data from the IBTS also show that sprat largely occur within the 50 m depth contour throughout the southern North Sea (including the former Hornsea Zone).

3.1.2.22 Sprat was one of the main characterising species in otter trawls conducted within the study area (as part of the Hornsea Three baseline characterisation surveys). **Figure 13** shows that there was a strong seasonal difference in the abundances of this species, with notably higher abundances in spring than autumn. Sprat was only recorded at low abundances in epibenthic beam trawls, though as a pelagic species sampled with a demersal/benthic trawl, this result was to be expected. Beam trawl surveys undertaken in the nearshore section of the Hornsea Four ECC, showed a peak in the abundance of sprat in October, although low abundances of the species were observed in trammel net surveys in the same area (as recorded in the Creyke Beck surveys).

3.1.2.23 Within the North Sea, spawning occurs in both coastal and offshore waters, with IBTS data indicating important spawning areas located in the inner German Bight, off Jutland, along the English coast, and in areas west and north of Scotland (ICES, 2005e). The Hornsea Four array area and offshore section of the ECC are located within both spawning and nursery grounds for sprat (Coull *et al*, 1998) (**Figure 13**).

Herring

3.1.2.24 Herring were identified as a species of commercial importance in **Volume 5, Annex 7.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

3.1.2.25 High abundances of herring (*Clupea harengus*), a species of conservation importance (UK BAP and NERC Act, 2006), were recorded immediately to the south of the central section of the former Hornsea Zone, and in the inshore sections of the mouth of the Humber Estuary area (as observed in Hornsea Three baseline characterisation surveys). IBTS data show that herring occur throughout the North Sea, although juvenile herring are restricted

to within the 100 m depth contour and are most abundant in the south-eastern North Sea. Mature herring (i.e. 3+ years) occur primarily along a westerly bank running from the Southern Bight to the northern North Sea (encompassing the former Hornsea Zone), with limited records in the eastern North Sea (ICES, 2005a).

3.1.2.26 Herring were recorded primarily during otter trawl surveys in the study area, though small numbers of this species were also recorded in epibenthic beam trawls (in Hornsea Three baseline characterisation surveys). As with sprat, there was a strong seasonal pattern in the data for this species, with highest abundances recorded within the fish and shellfish study area during spring and lower abundances in autumn (**Figure 14**).

3.1.2.27 The Hornsea Four array area and offshore ECC coincide with low intensity nursery habitat for herring, with some discrete spawning habitats also shown in **Figure 14**. These are discussed in more detail in **Section 3.2.2**. On a broader scale, within the North Sea herring spawning sites are located along the eastern coast of England and Scotland, with smaller sites within the English Channel, and one site within the central North Sea (ICES, 2005a).

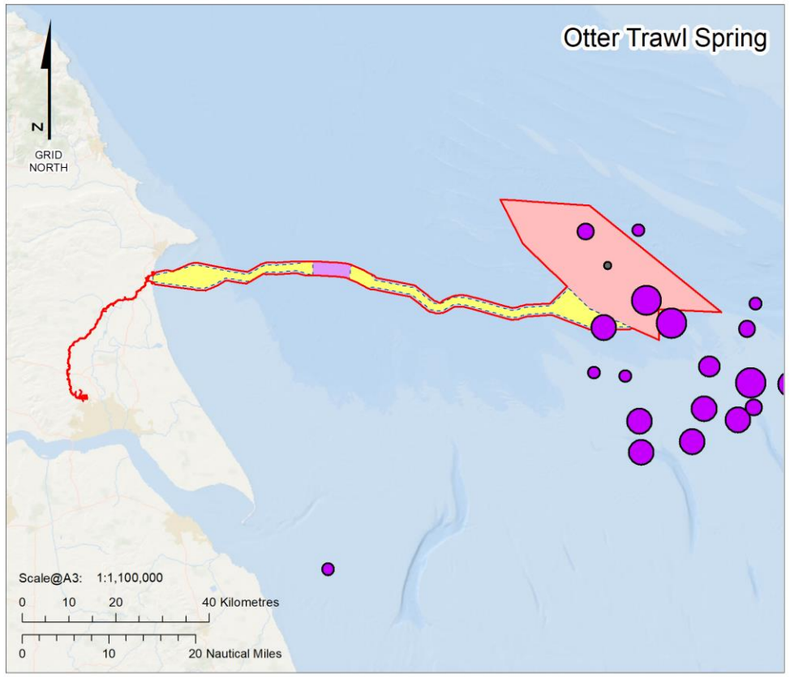
Mackerel

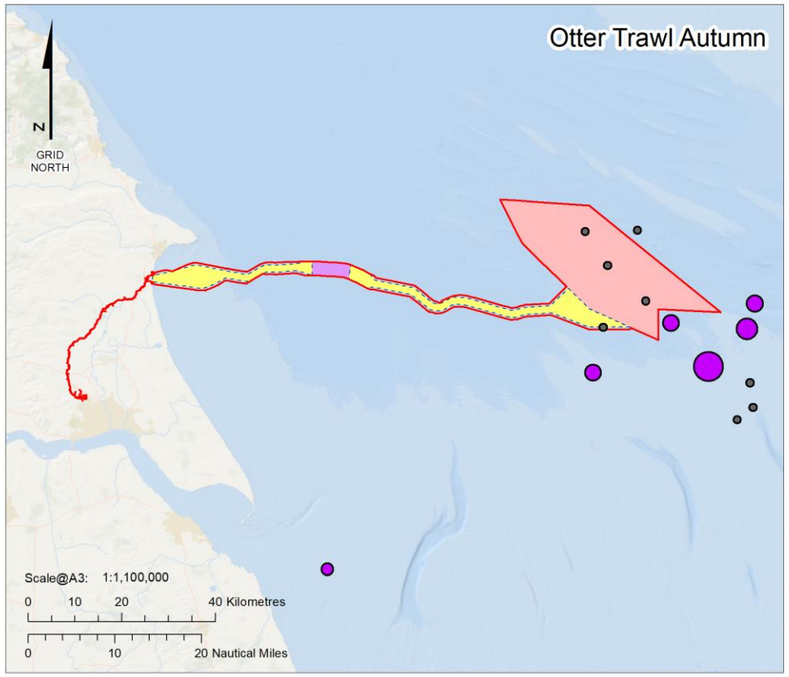
3.1.2.28 Mackerel were identified as a species of commercial importance in **Volume 5, Annex 7.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

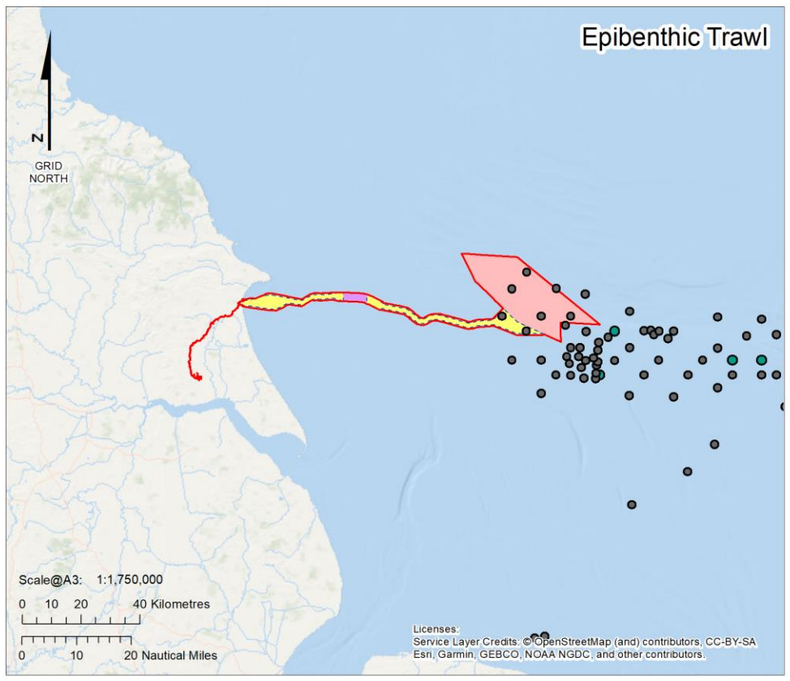
3.1.2.29 Mackerel (*Scomber scombus*) typically have a wide spread distribution across the North Sea; they are of importance as a food resource for larger pelagic predators including sharks and marine mammals. They are also consumed by seabirds (ICES 2005e).

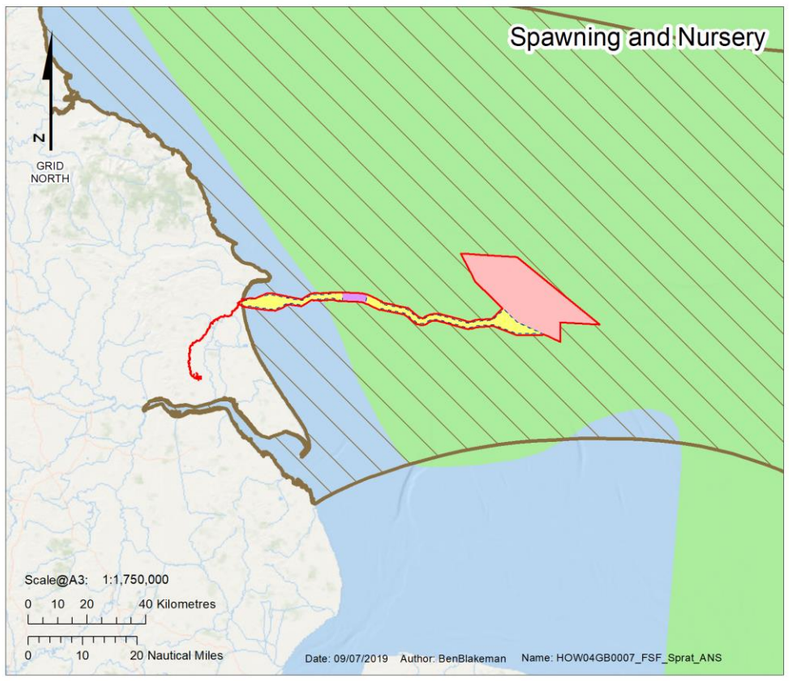
3.1.2.30 Historic data from the former Hornsea Zone shows the presence of mackerel, a species of conservation importance (UK BAP and NERC Act, 2006), within the area. Mackerel were also recorded throughout the fish and shellfish study area during the autumn otter trawl surveys within the study area, with only very low abundances recorded during spring (**Figure 15**) (as recorded in the Hornsea Three baseline characterisation surveys). Mackerel is a pelagic species and as a result this species was not recorded in epibenthic beam trawls. Mackerel also caught in moderate abundances in the August trammel net surveys within the inshore section of the Hornsea Four ECC (as recorded in Creyke Beck surveys) (**Figure 16**).

3.1.2.31 Spatial distributions of mackerel are known to vary seasonally in the North Sea, with increased abundances occurring in summer in the Southern Bight (from the Channel) and the northern North Sea (around Scotland; ICES, 2005b). IBTS data indicate that mackerel spawning habitats have been variable in the past, but are mainly located in the central North Sea, with extensions along the southern coast of Norway and in the Skagerrak. In 2005, mackerel eggs were reportedly distributed in a broad band running obliquely from the north English coast to the Norwegian Deeps (ICES, 2005b). Mackerel spawning habitat coincides with the Hornsea Four study area and in proximity to the eastern side of the Hornsea Four array area. Low intensity mackerel nursery habitats occur across the array area and EEC (**Figure 15**). The seasonal variation in abundances is not thought to be directly related to spawning behaviour (the spawning period for this species is March to July (Coull *et al*, 1998).









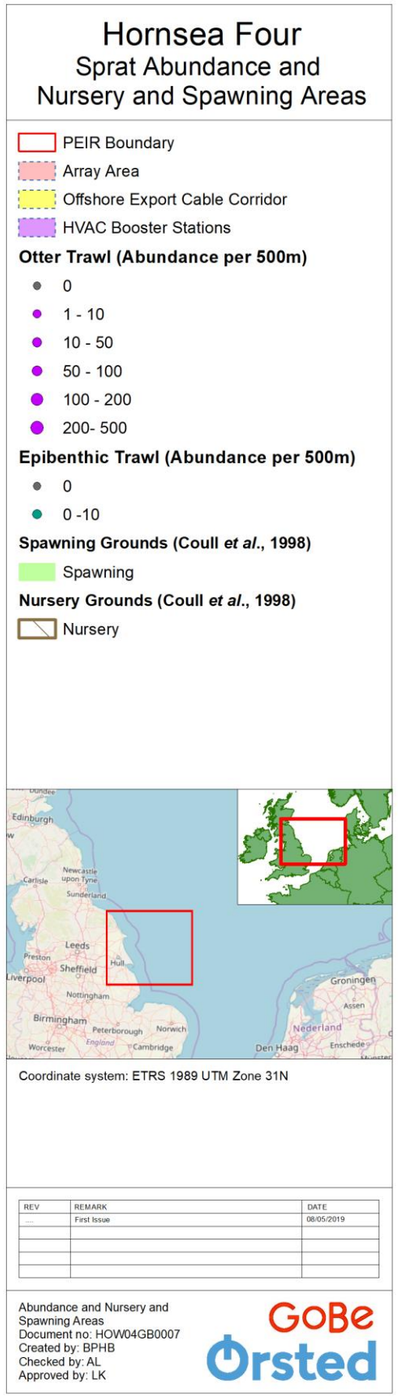
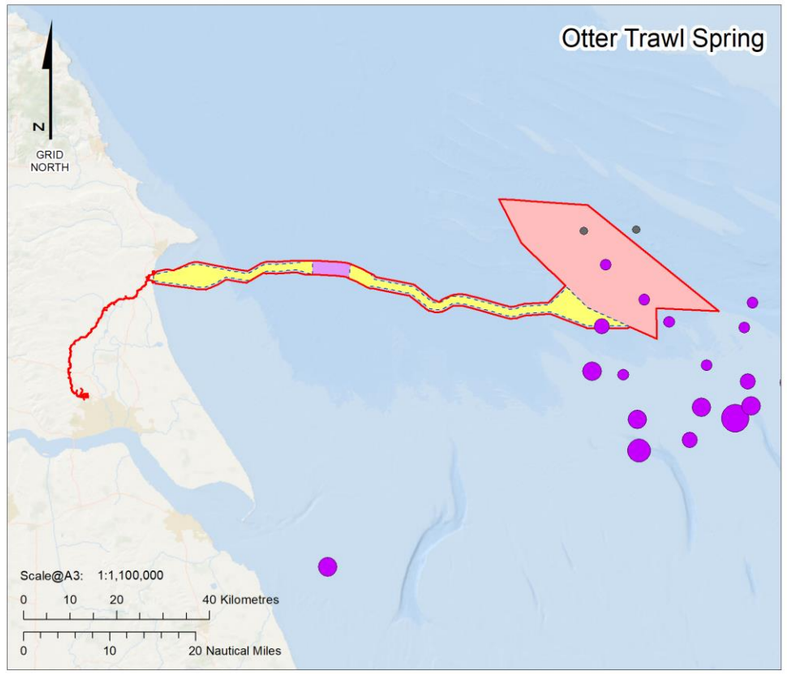
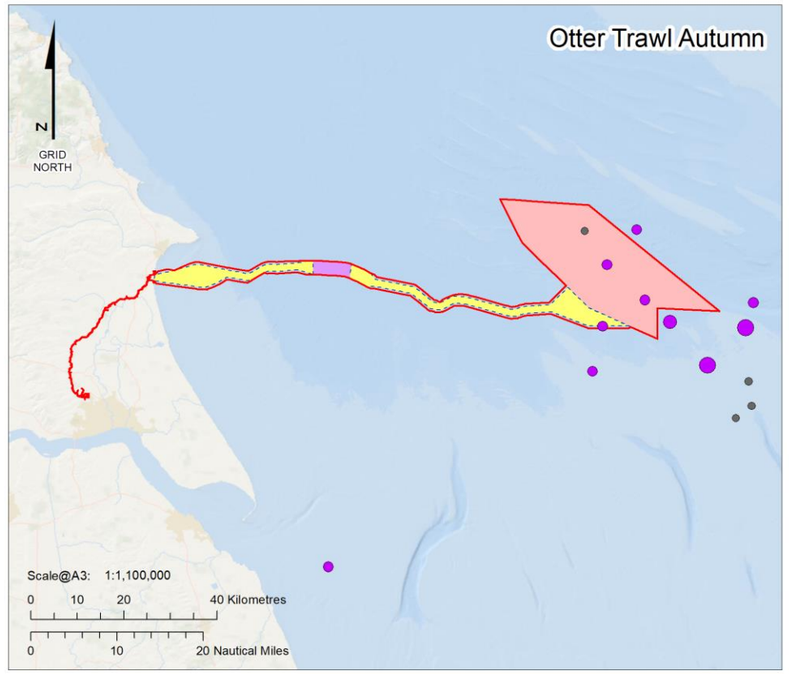
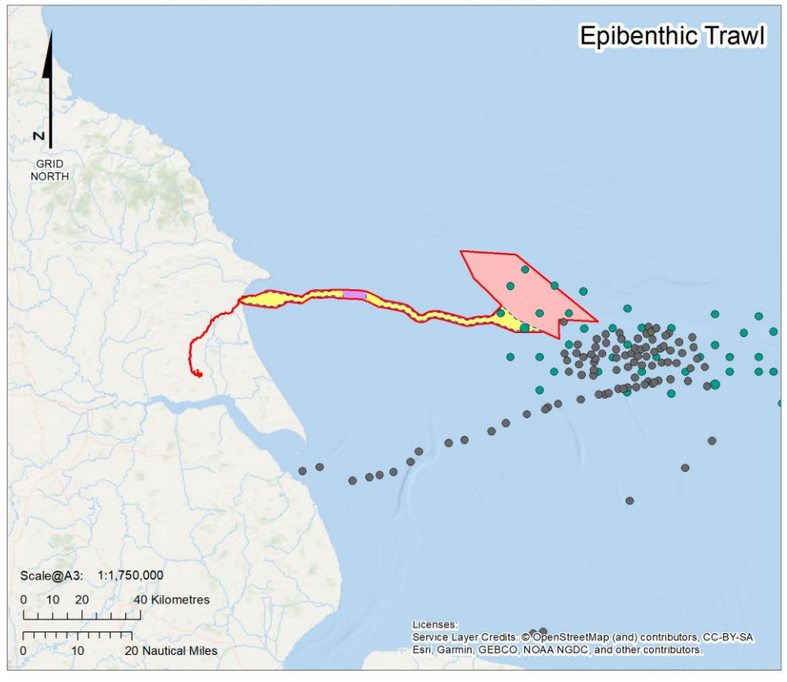
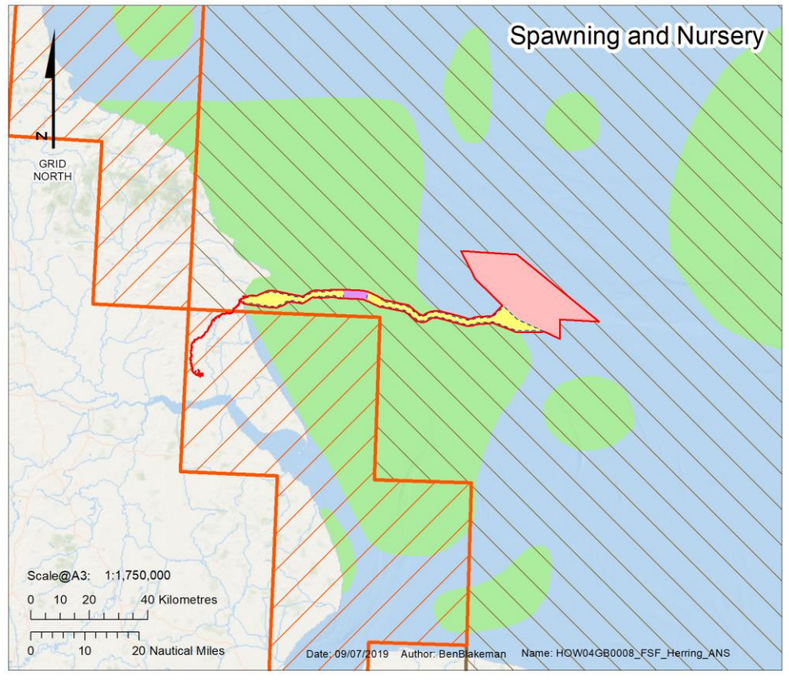


Figure 13: Sprat abundances within the Hornsea Four array area with data from Coull *et al.* (1998) showing spawning and nursery habitats (not to scale).









Hornsea Four
Herring Abundance and Nursery and Spawning Areas

- PEIR Boundary
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

Otter Trawl (Abundance per 500m)

- 0
- 1 - 10
- 10 - 50
- 50 - 100
- 100 - 200
- 200 - 900

Epibenthic Trawl (Abundance per 500m)

- 0
- 0 - 1

Spawning Grounds (Coull *et al.*, 1998)

- Spawning

Coordinate system: ETRS 1989 UTM Zone 31N

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Abundance and Nursery and Spawning Areas
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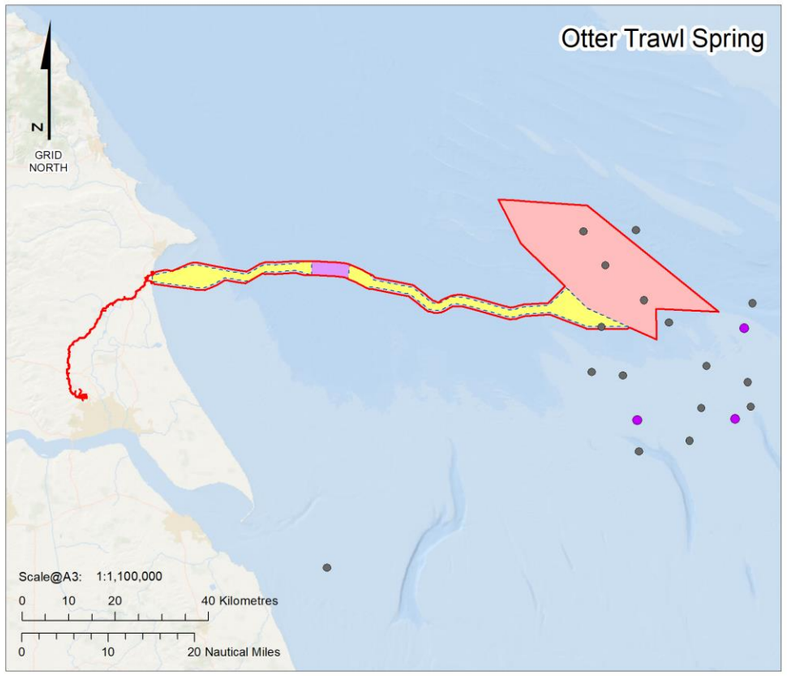
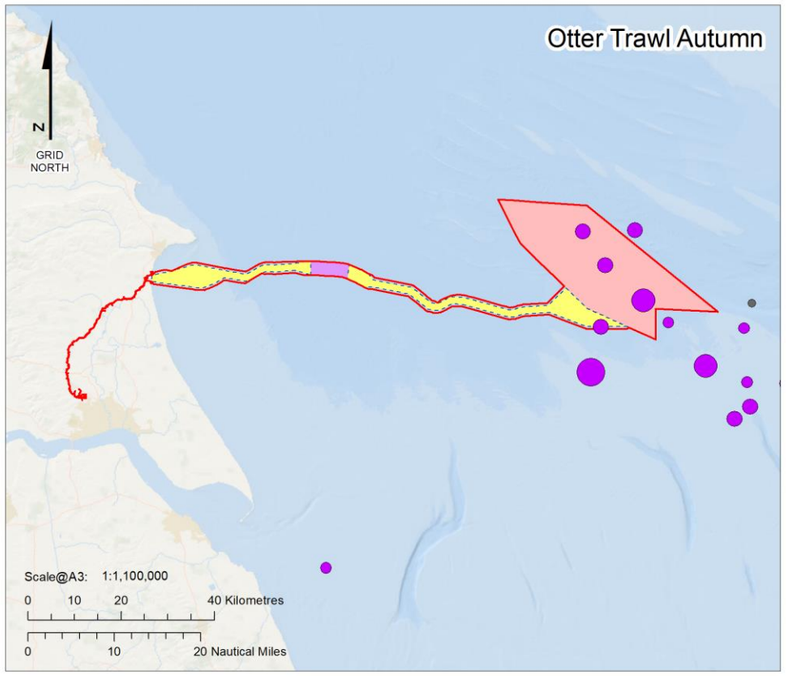
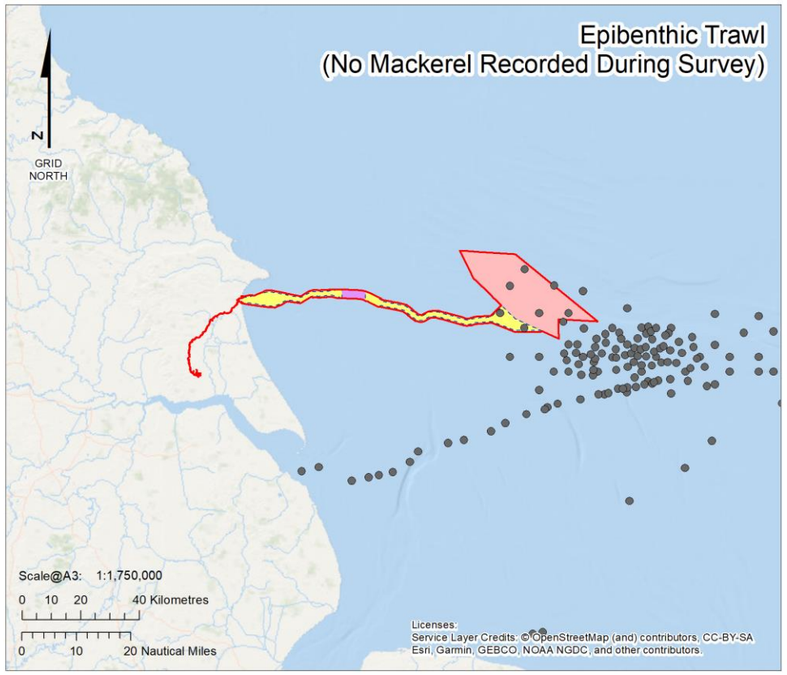
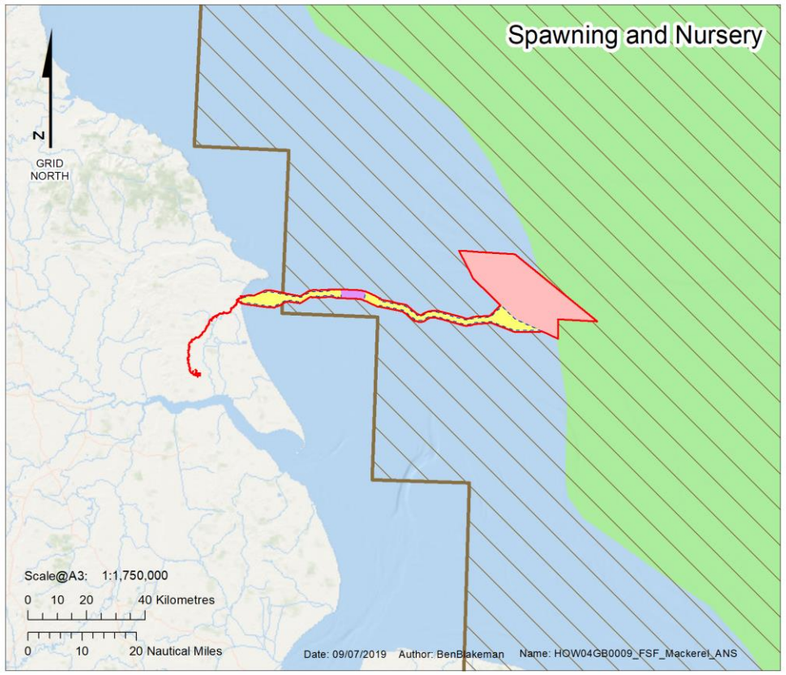
Figure 14: Herring abundances within the fish and shellfish study area, with data from Coull *et al.* (1998) and Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).









Hornsea Four
Mackerel Abundance and Nursery and Spawning Areas

- PEIR Boundary
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

Otter Trawl (Abundance per 500m)

- 0.0
- 0.1 - 1.0
- 1.0 - 10.0
- 10.0 - 20.0
- 20.0 - 40.0
- 40.0 - 60.0

Spawning Grounds (Coull *et al.*, 1998)

- Spawning

Nursery Grounds (Ellis *et al.*, 2010)

- Low Intensity

Coordinate system: ETRS 1989 UTM Zone 31N

REV	REMARK	DATE
	First Issue	08/05/2019

Abundance and Nursery and Spawning Areas
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Figure 15: Mackerel abundances within the Hornsea Four array area, with data from Coull *et al.* (1998) and Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).

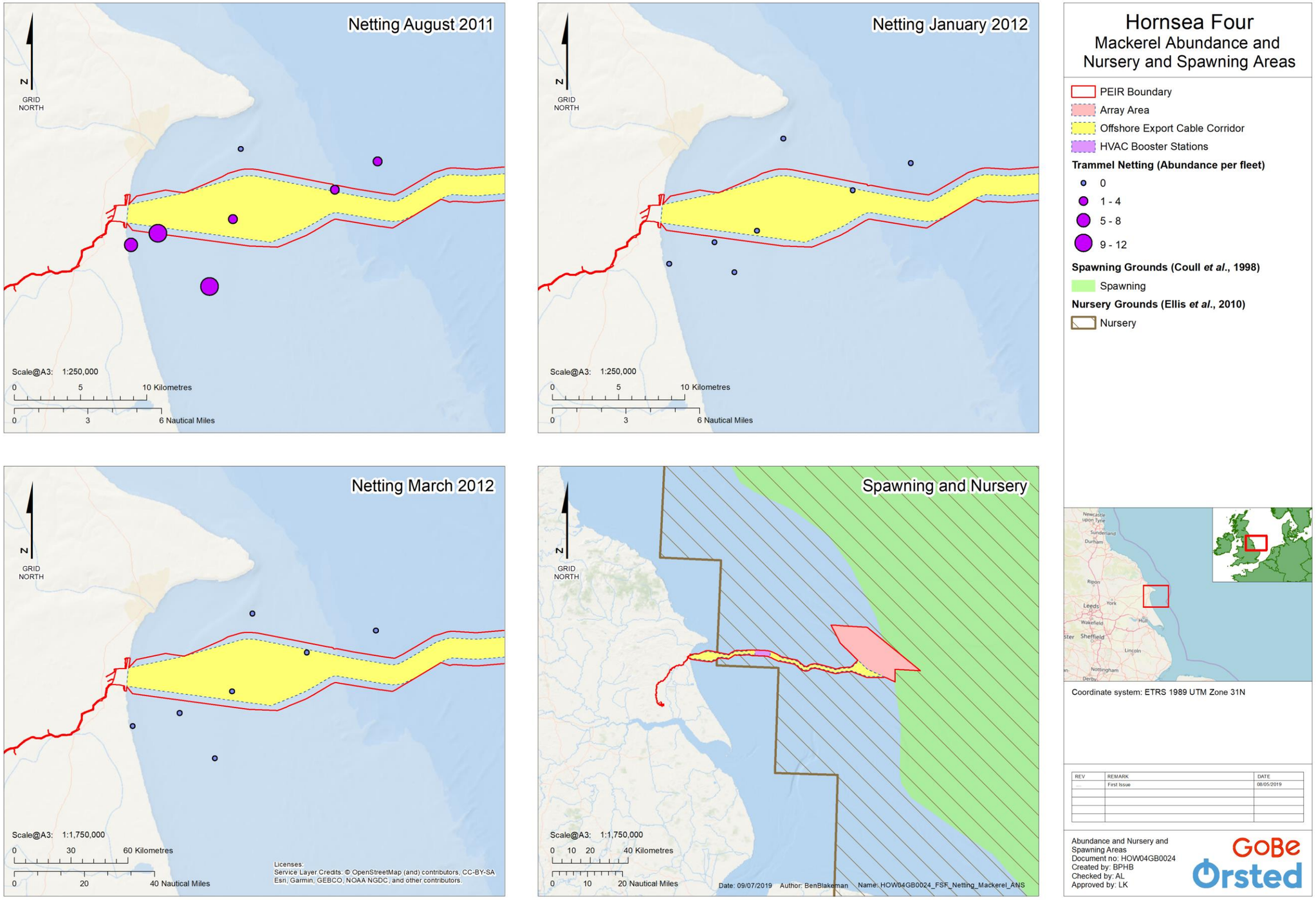


Figure 16: Mackerel abundances within the Hornsea Four ECC with data from Coull *et al.* (1998) and Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).

Sandeel

3.1.2.32 Sandeel are of particular commercial importance as identified in **Volume 5, Annex 7.1: Commercial Fisheries Technical Report**, particularly to the Danish commercial fishing fleet in the Dogger Bank area. In addition to this, sandeels are of importance in the food web being a key prey species for several other species including piscivorous fish, seabirds and marine mammals.

3.1.2.33 The presence of lesser sandeel (*Ammodytes tobianus*), a species of conservation importance (UK BAP and NERC Act, 2006), has been recorded in historic surveys of the former Hornsea Zone. Lesser sandeel abundances were generally highest in epibenthic beam trawl sampling in the study area compared to abundances recorded in otter trawls. This is likely to be due to the narrow body shape and small size of these species (adults typically less than 20 cm in length; (Rowley, 2008)) and the relatively large mesh size (40 mm cod end) used during otter trawling. Sandeels (*Ammodytes tobianus* and *Hyperoplus lanceolatus*) were generally recorded at highest abundances along the eastern boundary of the Hornsea Four array area and also in the central part of the former Hornsea Zone (**Figure 17** and **Figure 18**) (as recorded in Hornsea Three baseline characterisation surveys).

3.1.2.34 Surveys undertaken within the nearshore section of the Hornsea Four ECC, showed relatively high abundances of sandeel *Ammodytes marinus*, with a peak in abundance observed in August; this is likely due to the seasonal cycle of the species, with the August data collected at the end of the feeding season, likely best representing the distribution of sandeels in the sediment (as recorded in Creyke Beck surveys).

3.1.2.35 Sandeel spawning habitats are known to occur throughout the southern North Sea, with habitats occurring to the north and north west of the former Hornsea Zone, and further north of Dogger Bank. Low intensity lesser and greater sandeel spawning and nursery habitats are located within the Hornsea Four array area. High intensity lesser and greater sandeel spawning habitats are located on the eastern boundary of the Hornsea Four array area ((**Figure 17** and **Figure 18**) (as recorded in the Hornsea Three baseline characterisation).

3.1.2.36 Suitable sandeel habitats have been mapped out using data from EUNIS and Folk (1954) (Stephens and Diesing 2015), and site specific PSA data from the Hornsea Four Habitat Classification report (Gardline, 2019), and from the former Hornsea Zone from BGS (2015) were presented in **Section 3.2.3** (sandeel preferred habitats being contiguous with sandeel spawning habitat).

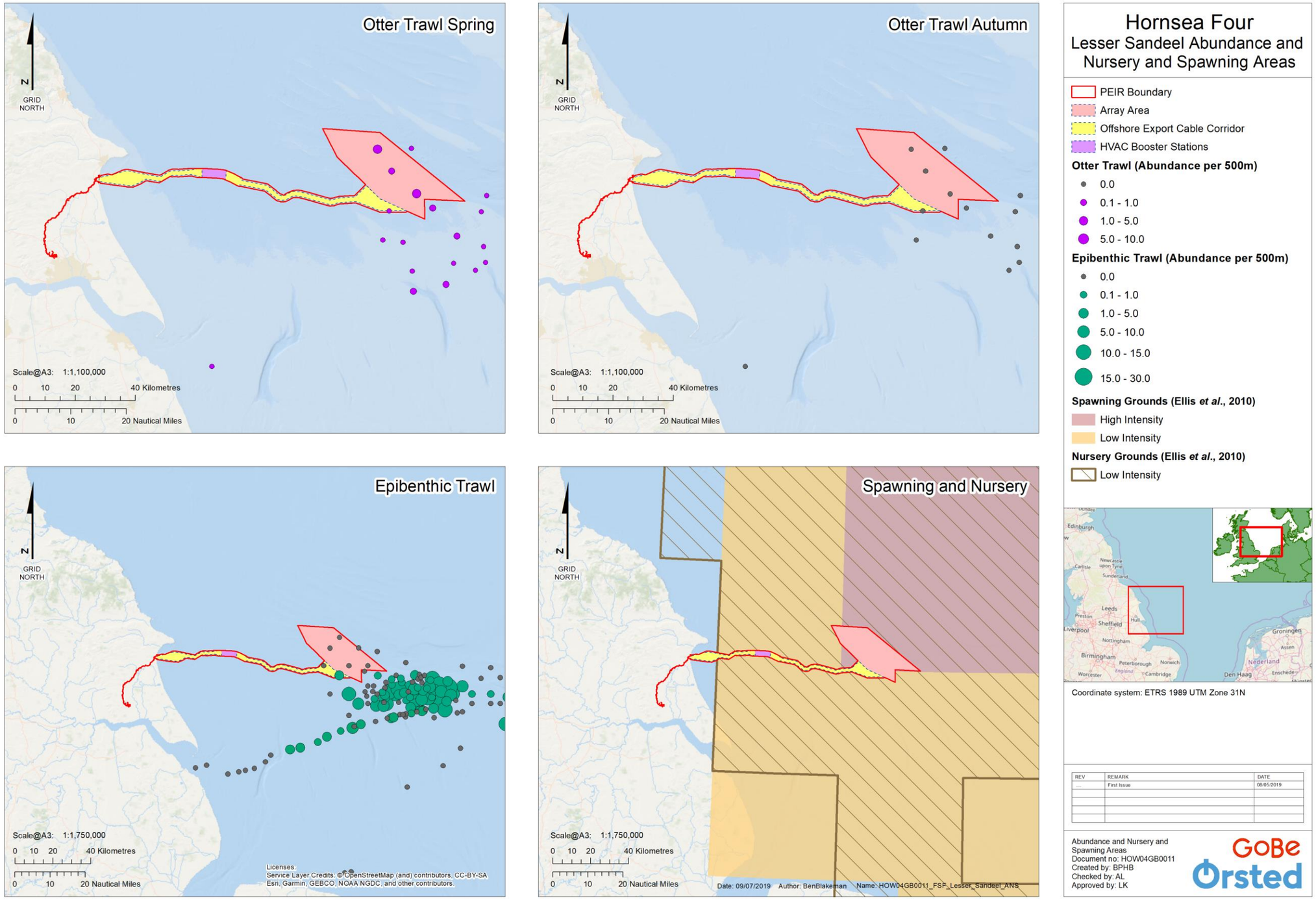
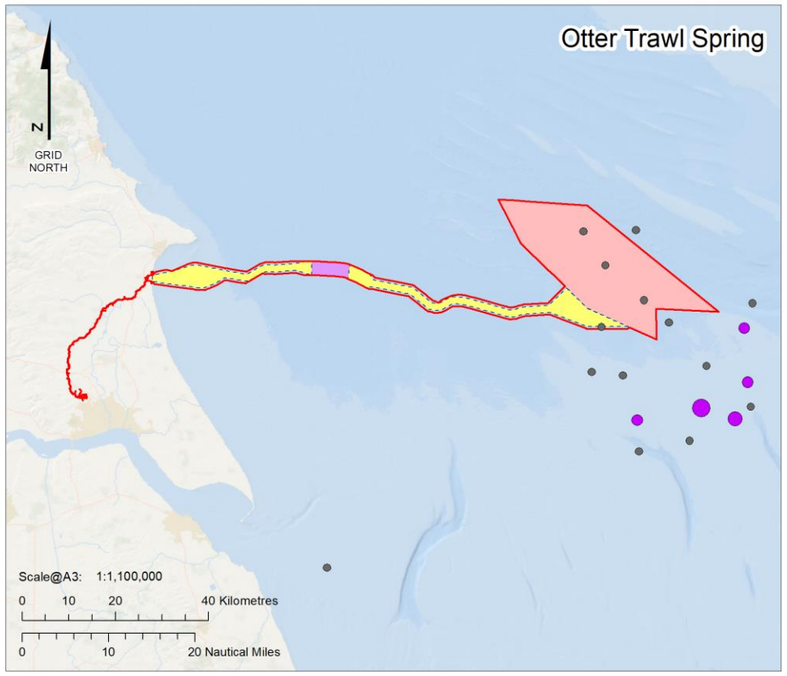
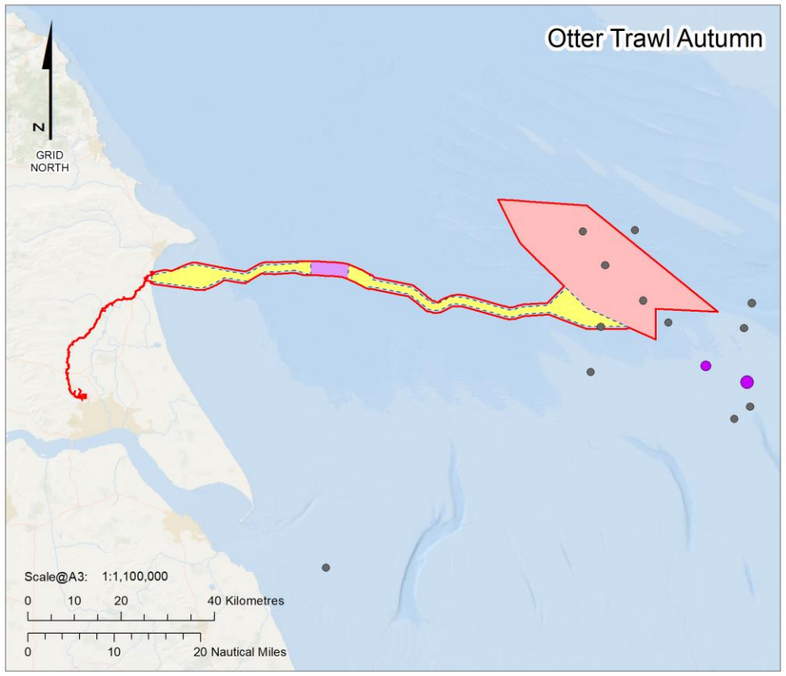
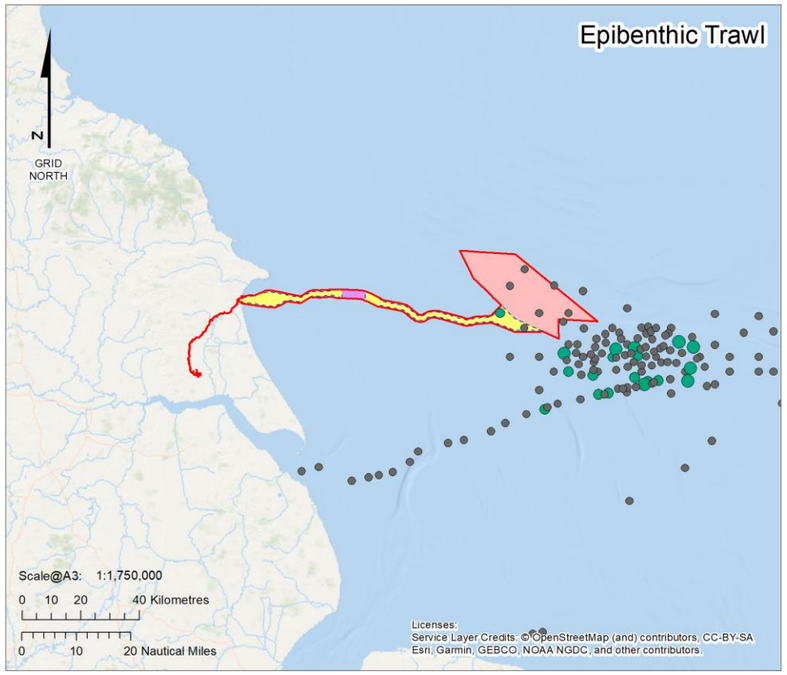
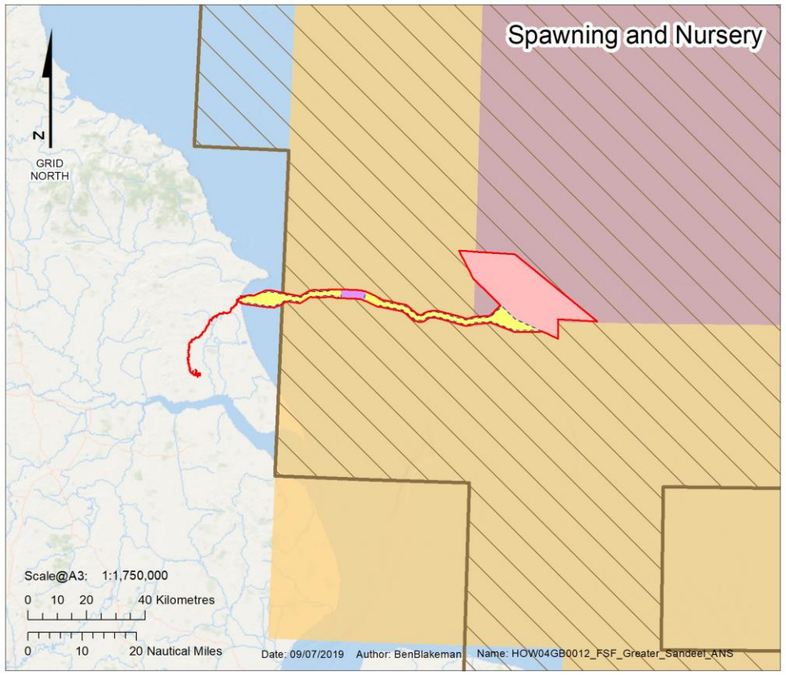


Figure 17: Lesser sandeel abundances within the fish and shellfish study area, with data from Ellis *et al* (2010) showing spawning and nursery habitats (not to scale).









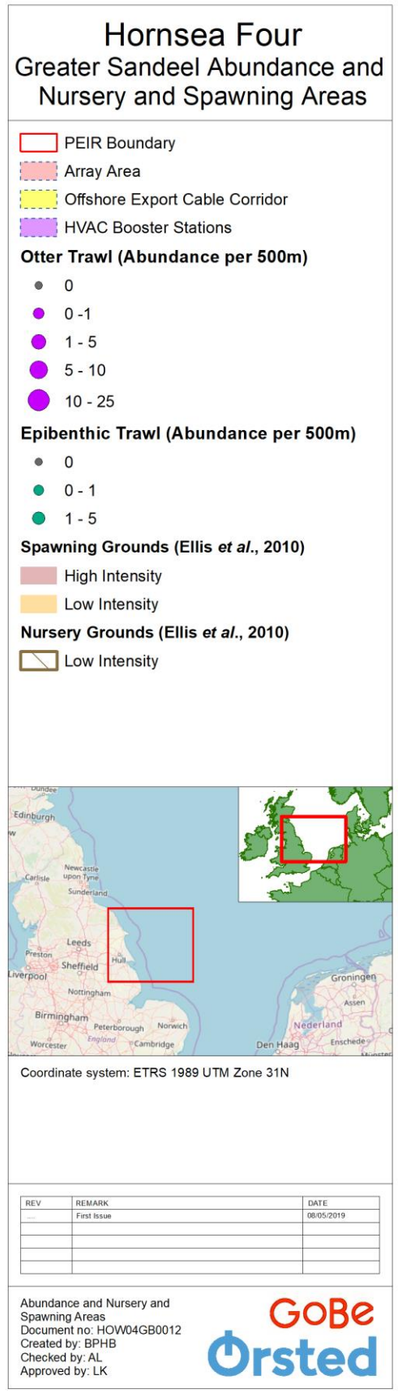


Figure 18: Greater sandeel abundances within the fish and shellfish study area, with data from Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).

Elasmobranchs

3.1.2.37 Thornback ray (*Raja clavate*) and spotted ray (*Raja montagui*), both species of conservation importance (Oslo Paris Convention (OSPAR)), have been recorded in historic surveys of the former Hornsea Zone. The species have also been recorded sporadically during both otter and epibenthic beam trawl surveys undertaken within the study area (**Figure 19**, **Figure 20**, **Figure 21** and **Figure 22**) (as part of the Hornsea three baseline characterisation surveys). No spawning or nursery habitats have been mapped in the vicinity of the Hornsea Four study area. In a broader context, thornback ray are typically the most abundant in the south-western North Sea, especially in the Outer Thames Estuary and the Wash, with these areas also including the primary spawning and nursery grounds (ICES, 2005i), indicating likely low abundances of the species within the proximity of Hornsea Four. Spotted ray distributions are focussed within the south-western North Sea, particularly near outer parts of estuaries, and low presence over the northern and eastern parts of the basin (Sguotti *et al*, 2016), this was supported by catch rate data, which indicated concentrations around southern England, but also Scotland (Daan, Heessen and ter Hofstede, 2005). Blonde ray (*Raja brachyura*) were not recorded within the study area, or the inshore section of the Hornsea Four ECC. Trammel net surveys undertaken within the nearshore section of the Hornsea Four ECC showed increased abundance of lesser spotted dogfish, with peaks in August (as recorded in Creyke Beck surveys).

3.1.2.38 Additional elasmobranchs recorded at low abundances throughout the study area included cuckoo ray (*Raja naevus)*, starry smooth hound (*Mustelus asterias*), lesser spotted dogfish (*Scyliorhinus canicular*) and spurdog (*Squalus acanthias).* Evidence suggests cuckoo ray are largely abundant off the coast of Scotland, with surveys showing high abundances of the species off the west coast of Scotland (ICES, 2017b)and the east coast of Scotland (Walker and Heesen, 1996), indicating the main distributions of the species are located in the northern North Sea. Modelled spatial distributions of lesser-spotted dogfish and spurdog showed lesser spotted dogfish populations concentrated within the southernmost parts of the North Sea, primarily in the Thames and Humber regions (Sguotti *et al*, 2016). Spurdog were widely distrcibuted within the North Sea, with concentrations varying between the northern and Southern North Sea (Sguotti *et al*, 2016).

3.1.2.39 Starry smoothhound (*Mustelus asterias)* were observed in relatively low abundances in trammel net surveys conducted in the nearshore section of the Hornsea Four ECC (as observed in Creyke Beck surveys). Modelled spatial distributions of smoothhound in the North Sea show concentrations primarily in the southern North Sea, within the Thames region, and off the continental coast (Sguotti *et al*, 2016).

3.1.2.40 Whilst tope (*Galeorhinus galeus*) have been recorded within the southern North Sea area, they were not recorded in any of the surveys undertaken in the study area, although they do have low intensity nursery grounds within the study area, to the east of the Hornsea Four array area. Modelled spatial distributions of tope show population concentrations within the eastern part of the North Sea, off the continental coast (Sguotti *et al*, 2016).

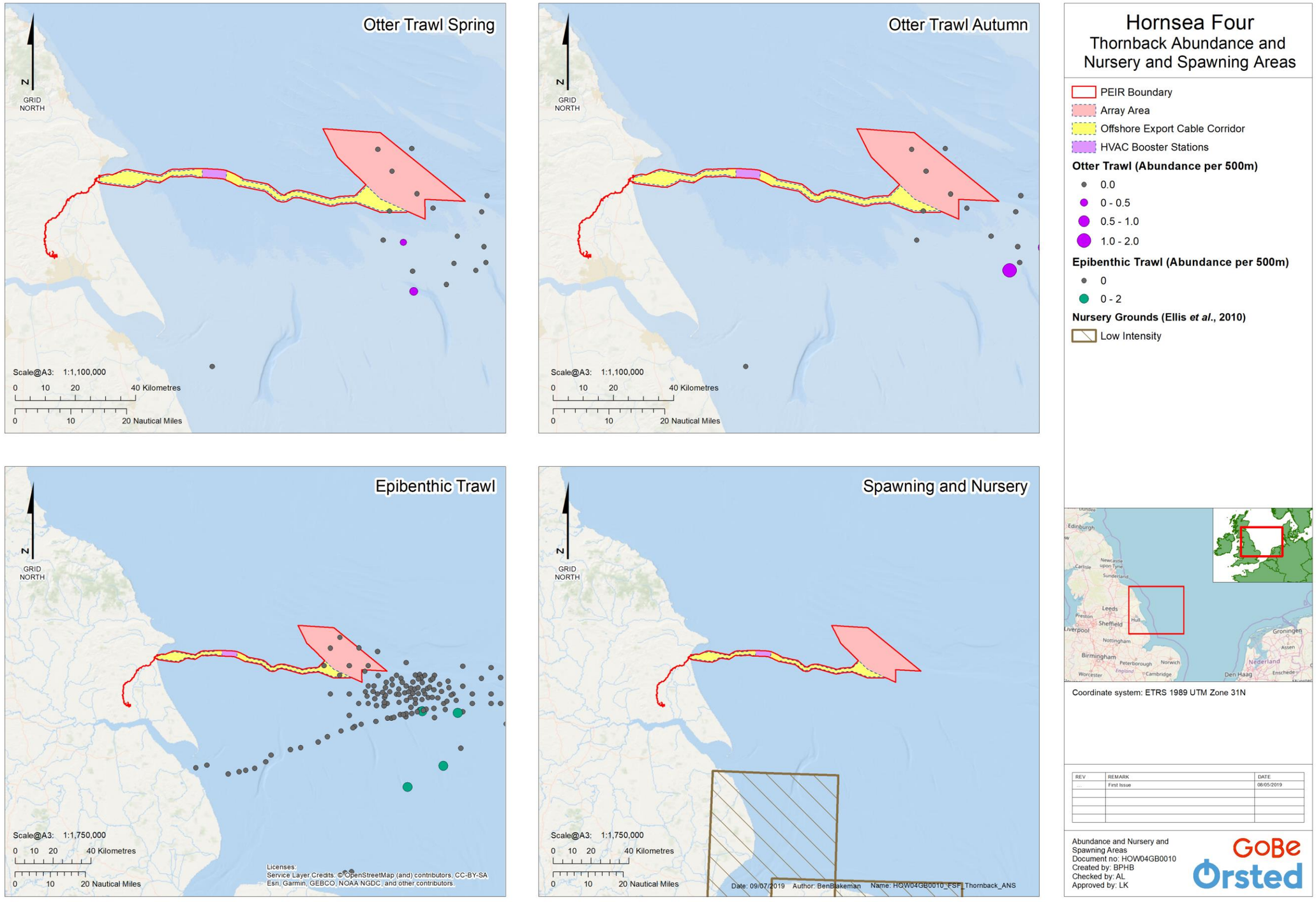


Figure 19: Thornback ray abundances within the Hornsea Four array area, with data from Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).

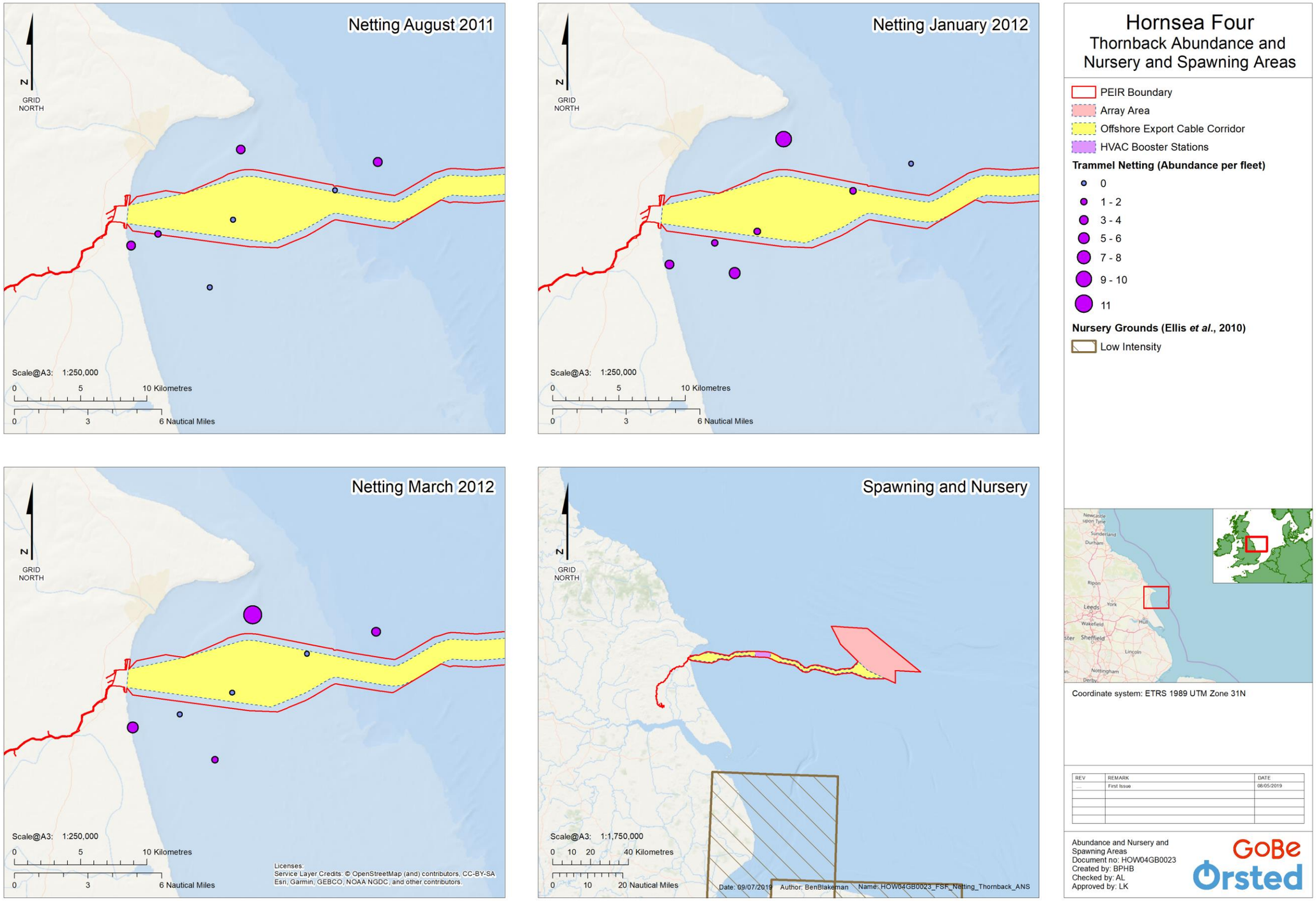


Figure 20: Thornback ray abundances within the Hornsea Four ECC, with data from Ellis *et al.* (2010) showing spawning and nursery habitats (not to scale).

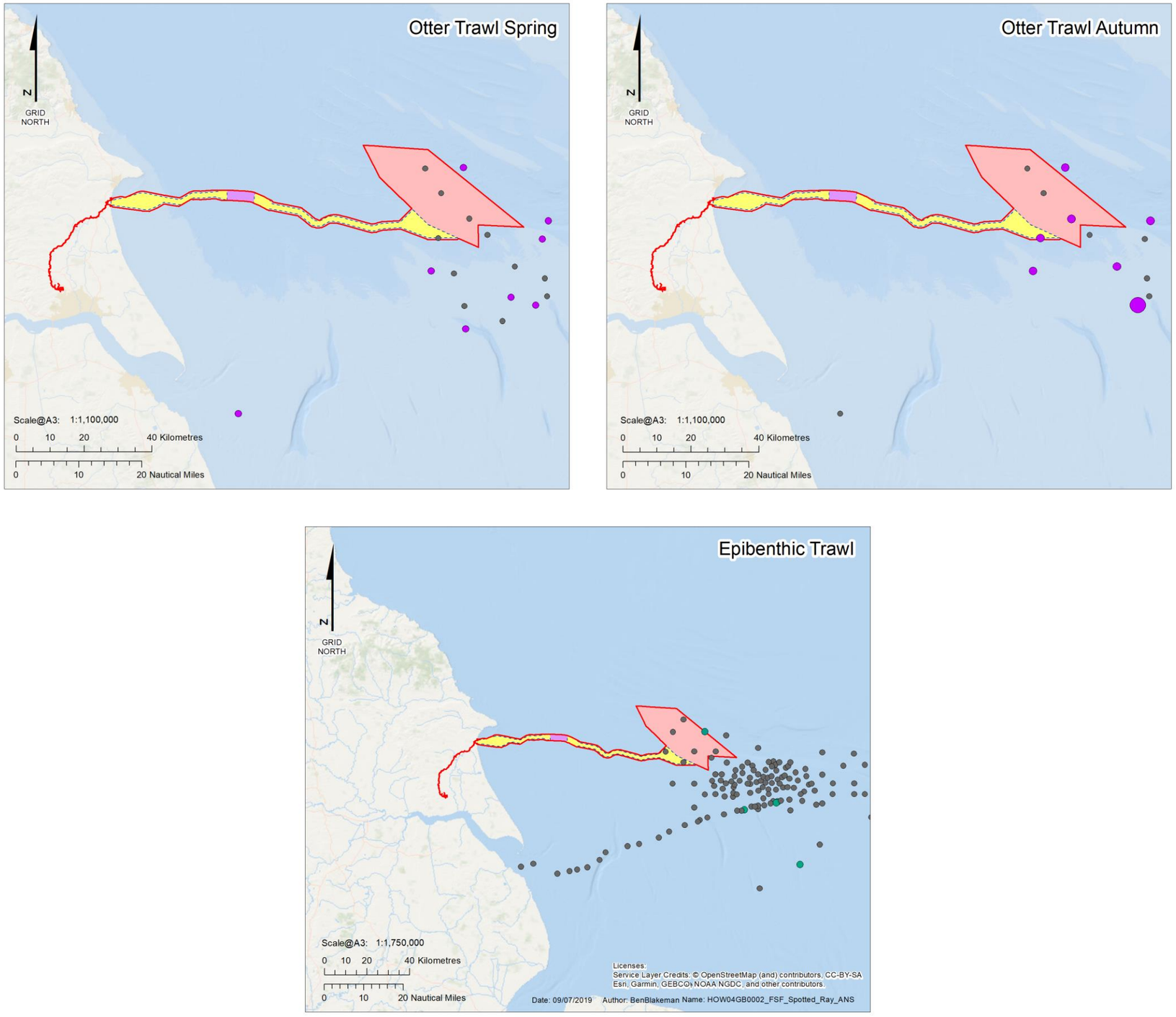
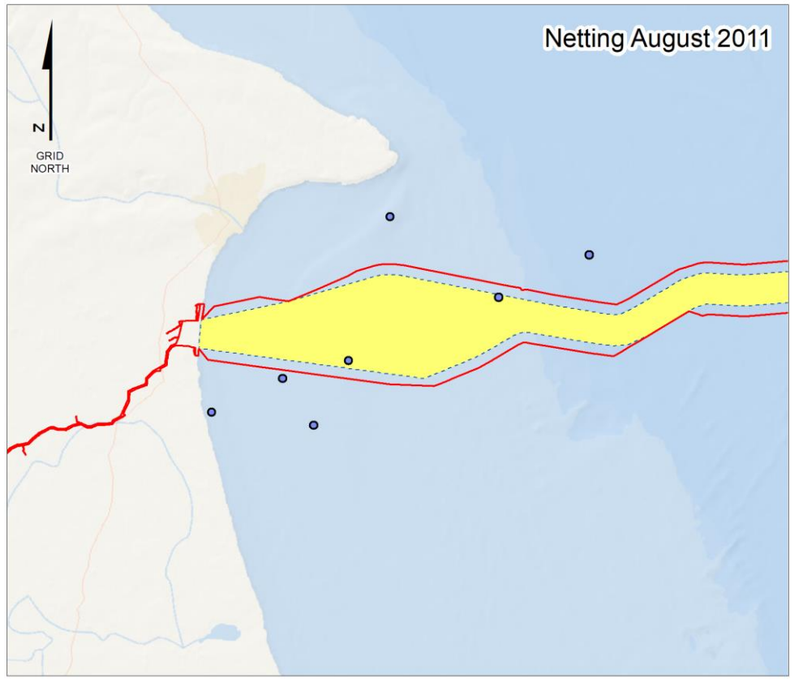
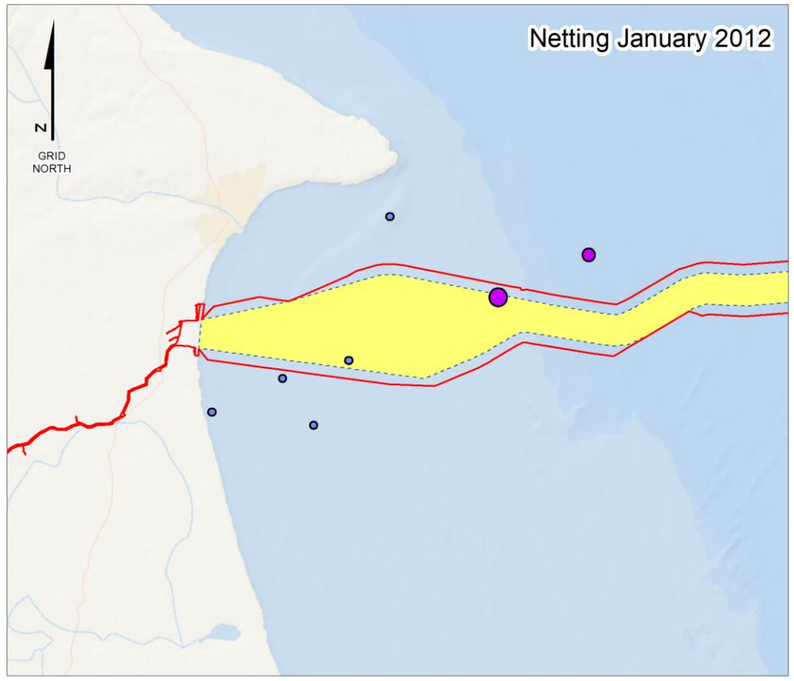
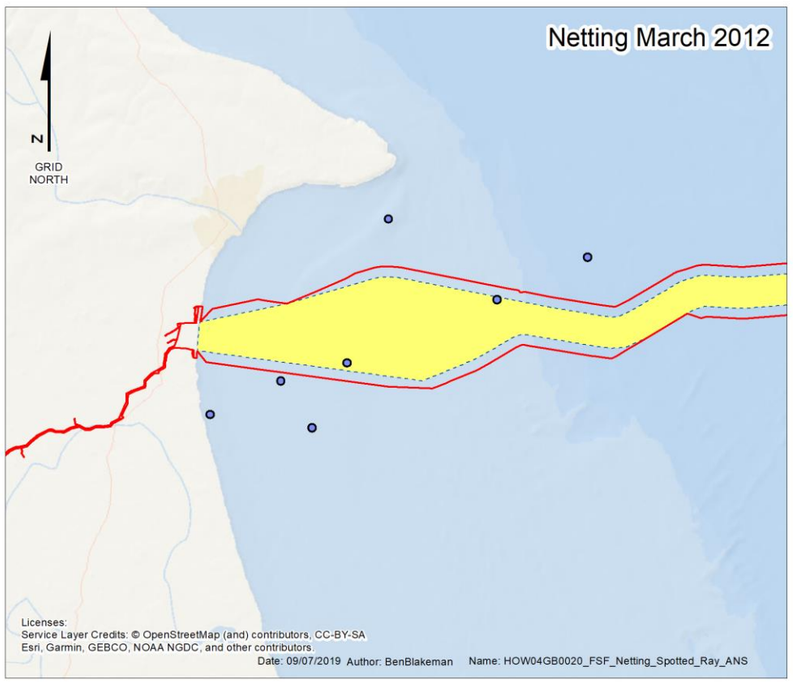


Figure 21: Spotted ray abundances within the Hornsea Four array area (not to scale).







Hornsea Four
Spotted Ray Abundance

PEIR Boundary

Offshore Export Cable Corridor

Trammel Netting (Abundance per fleet)

0

1

3

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:250,000

0 5 10 Kilometres

0 3 6 Nautical Miles

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Figure 22: Spotted ray abundances within the Hornsea Four ECC (not to scale).

3.2 Spawning and nursery grounds

3.2.1.1 Many species of fish and shellfish are known to either spawn or have nursery areas in relatively close proximity to, or potentially overlapping with the Hornsea Four study area (Coull *et al*, 1998; Ellis *et al*, 2012). **Table 4** and **Table 5** detail fish species which have spawning and nursery grounds that are in close proximity to or overlap the Hornsea Four array area or ECC, the distances to the Hornsea Four High Voltage Alternating Current (HVAC) booster station search area are also within the table. Spawning times of these species are detailed in **Table 6**.

3.2.1.2 Herring and sandeel were highlighted as species of particular relevance in the scoping report (*Ørsted*, 2018) when considering the potential impacts of the Hornsea Four development, since they are demersal spawners (and with herring also being considered to be relatively noise sensitive).

3.2.1.3 Data from Coull *et al.* (1998) suggests that the Hornsea Four study area coincides with herring spawning grounds (**Table 4**). Ellis *et al.* (2012) also indicates that high intensity sandeel spawning sites occur within the Hornsea Four study area (**Table 4**). Potential interactions between herring and sandeel spawning sites and the proposed development are detailed further below.

Table 4: Summary of fish and shellfish spawning habitats within the Hornsea Four fish and shellfish study area from data presented in Coull *et al.* (1998), Ellis *et al.* (2010), Rogers *et al.* (1998), ERM (2012) and historic surveys across the former Hornsea Zone.

Species		Distance to Hornsea Four array area (km)	Distance to Hornsea Four ECC (km)	Distance to HVAC booster station search area (km)
Cod	*Gadus morhua*	0	0	0
Herring	*Clupea harengus*	3.41	0	0
Lemon Sole	*Microstomus kitt*	0	0	0
Mackerel	*Scomber scombrus*	0	5.09	57.97
Nephrops	*Nephrops norvegicus*	0	12.37	73.02
Plaice	*Pleuronectes platessa*	0	0	22.17
Sandeel	*Ammodytes spp*	0	0	0
Sprat	*Sprattus sprattus*	0	0	0
Whiting	*Merlangius merlangu*	95.79	113.75	134.44

Note: Distances presented should be interpreted with caution as boundaries drawn by Coull *et al.* (1998) and Ellis *et al.* (2010) should be considered guidelines rather than definitive boundaries.

Table 5: Summary of fish and shellfish nursery habitats within the Hornsea Four fish and shellfish study area from data presented in Coull *et al.* (1998), Ellis *et al.* (2010), Rogers *et al.* (1998), ERM (2012) and historic surveys across the former Hornsea Zone.

Species		Distance to Hornsea Four array area (km)	Distance to Hornsea Four ECC (km)	Distance to HVAC booster station search area (km)
Cod	*Gadus morhua*	37.25	0	0
Herring	*Clupea harengus*	68.96	32.08	43.90
Lemon Sole	*Microstomus kitt*	0	0	0
Mackerel	*Scomber scombrus*	123.12	127.92	161.96
Nephrops	*Nephrops norvegicus*	0	12.49	73.15
Plaice	*Pleuronectes platessa*	54.89	0	14.62
Sandeel	*Ammodytes spp*	0	0	0
Sprat	*Sprattus sprattus*	0	0	0
Whiting	*Merlangius merlangu*	0	0	0

Note: Distances presented should be interpreted with caution as boundaries drawn by Coull *et al.* (1998) and Ellis *et al.* (2010) should be considered guidelines rather than definitive boundaries.

Table 6: Summary of spawning timings in the southern North Sea for fish species known to have spawning habitats in the Hornsea Four fish and shellfish study area. Light blue indicates spawning period, dark blue indicates peak spawning period.

Species		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cod	*Gadus morhua*												
Herring	*Clupea harengus*												
Lemon sole	*Microstomus kitt*												
Mackerel	*Scomber scombrus*												
Plaice	*Pleuronectes platessa*												
Sandeel	*Ammodytes spp*												
Sprat	*Sprattus sprattus*												
Whiting	*Merlangius merlangu*												

3.2.2 Herring

3.2.2.1 The full ten-year IHLS dataset (larval class size <11 mm) (Figure 23); data aggregated across the ten year period, not averaged) shows a clear representation of the core larval density area for herring, showing two hotspots, both of which fall within the Coull *et al.* (1998) spawning ground areas, suggesting that the analysis used is an accurate estimation of the spawning locations (albeit that it does not directly sample the spawning grounds).

3.2.2.2 The IHLS dataset shows a strong correlation with the Coull *et al.* (1998) spawning ground around Flamborough Head. However, it is clear from the heatmap (Figure 23) that the larvae are found primarily within the northern section of this spawning ground, and the centre of the hotspot is to the north of Flamborough Head. The lower abundance area of the hotspot is traversed by the ECC, indicating a potential for disturbance to herring during spawning season (August to October) (Table 6).

3.2.2.3 The ten-year time-series for the full dataset (Figure 24 to Figure 26) clearly shows that there is a high degree of variation in the abundances recorded between years in the IHLS surveys (note that the scale shown for each figure is the same and thus visually demonstrates the relative abundance in each year). While the sampling dates for all the IHLS surveys are highly consistent between years (start dates +/- approximately 3 days) and sampling is undertaken across a week for each spawning component, these variations could have multiple causes including: delays in hatching until after the surveys have taken place; reduced spawning due to environmental or anthropogenic factors; or biological pressures such as competition with other plankton such as jellyfish (Lynam *et al.*, 2005).

3.2.2.4 Despite the high inter-annual variation, there is a high consistency with regards to the location of the larvae hotspot in each year, with only occasional variations observed. Only the 2010/11 data show a definite small shift in the hotspot location to just south of Flamborough head, and within the ECC, with a peak larval abundance of 2,050 m^2 (Figure 24).

3.2.2.5 The herring larval abundances within the ECC peak in the 2011/2012 spawning season (Figure 25), with abundances up to 9,325 m^2, within the highest density class. The data presented for the 2011/2012 spawning season indicates that any disturbance within the ECC has the potential for a significant impact on herring populations.

3.2.2.6 Herring larvae populations remain relatively low within the array boundary from the 2007/2008 spawning season to 2016/2017, with abundances peaking to 150 m^2 in spawning seasons 2010/2011 (Figure 24), 2012/2013 (Figure 25) and 2016/2017 (Figure 26).

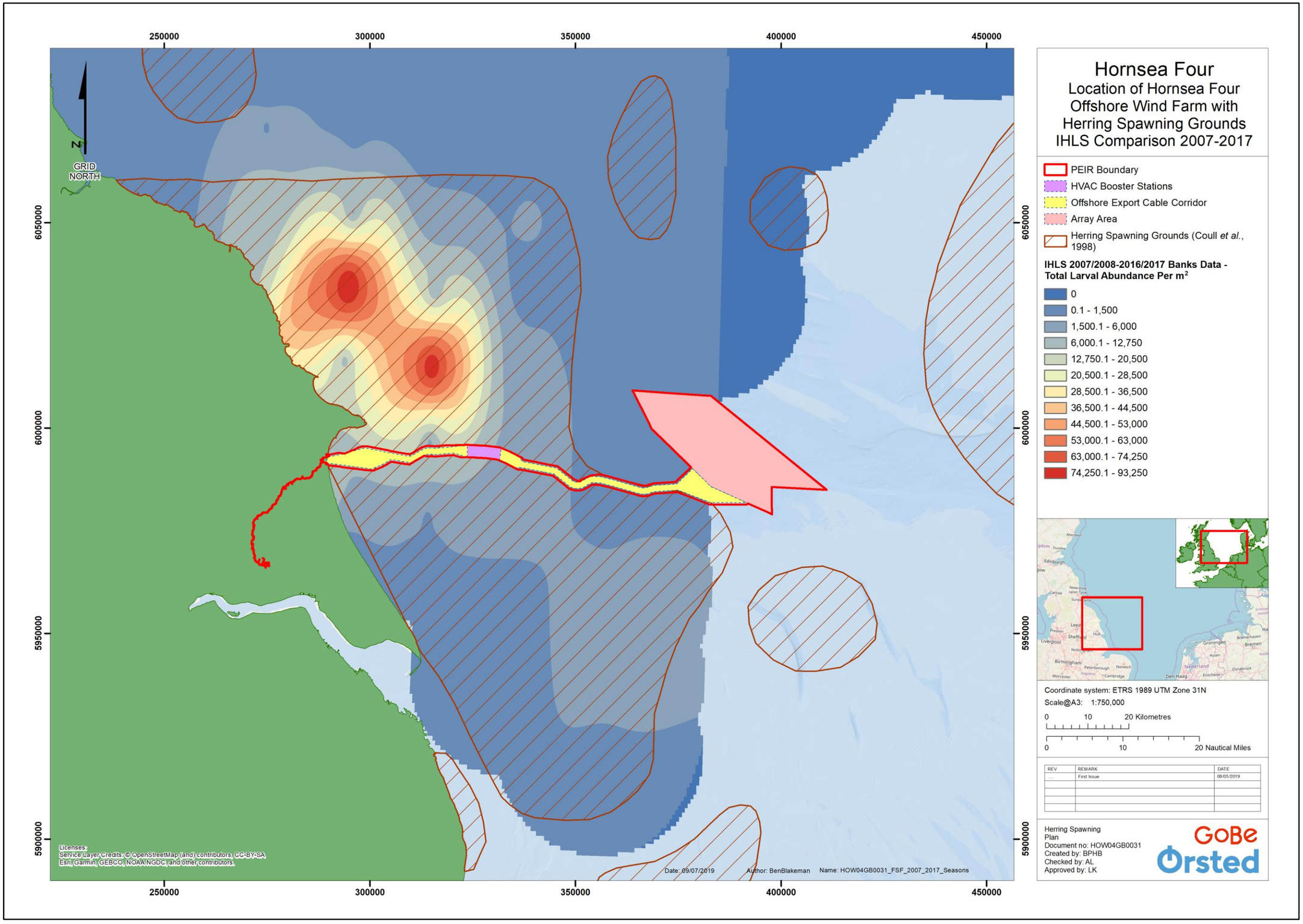

Figure 23: Location of Hornsea Four with herring spawning grounds IHLS comparison, full 10-year IHLS dataset, 2007 – 2017. Based on data from the IHLS (ICES, 2007–2017), and Coull *et al.* (1998) (not to scale).

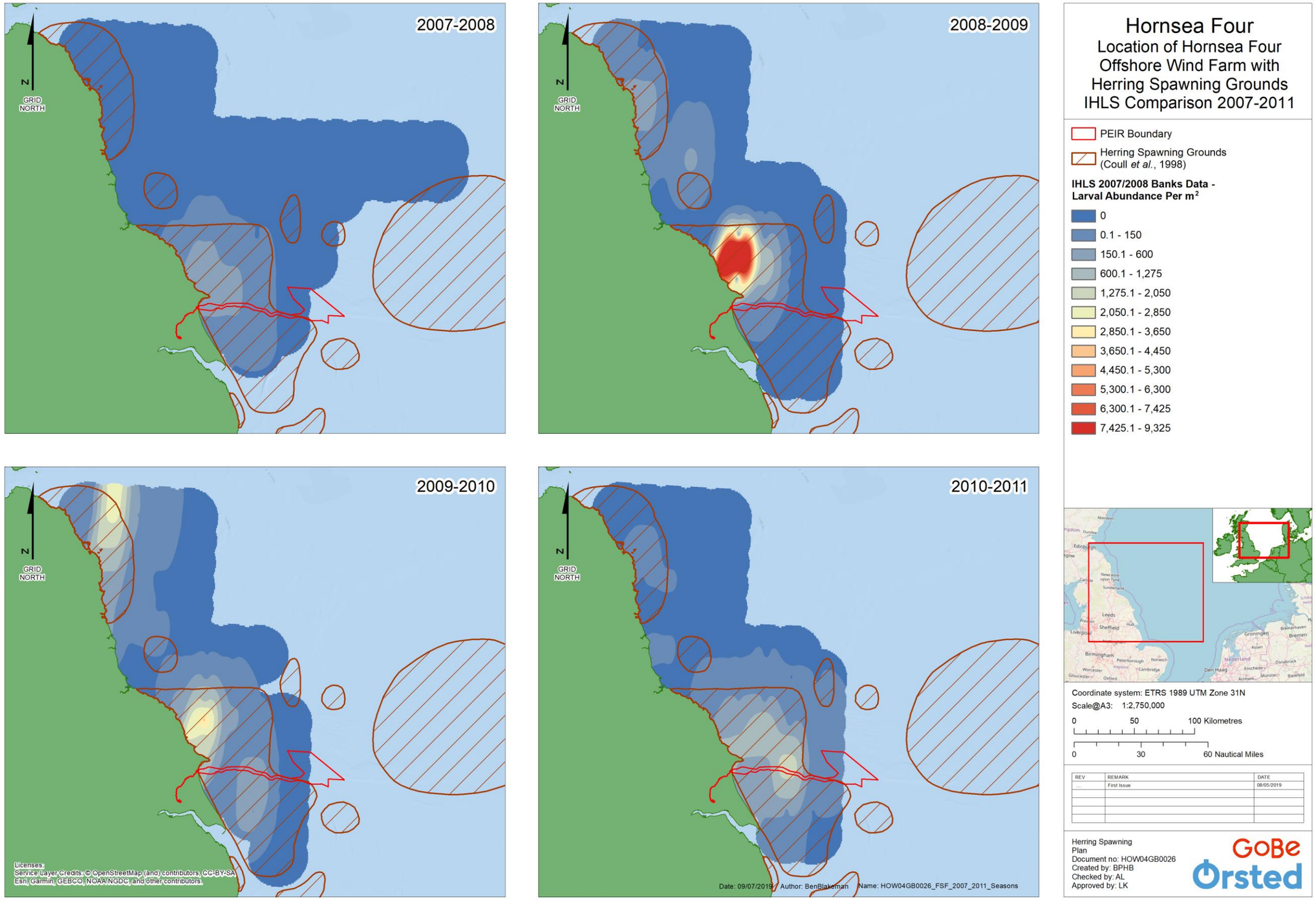

Figure 24: Location of Hornsea Four with herring spawning grounds IHLS comparison, 2007 – 2011. Based on data from the IHLS (ICES, 2007–2017), and Coull *et al.* (1998) (not to scale).

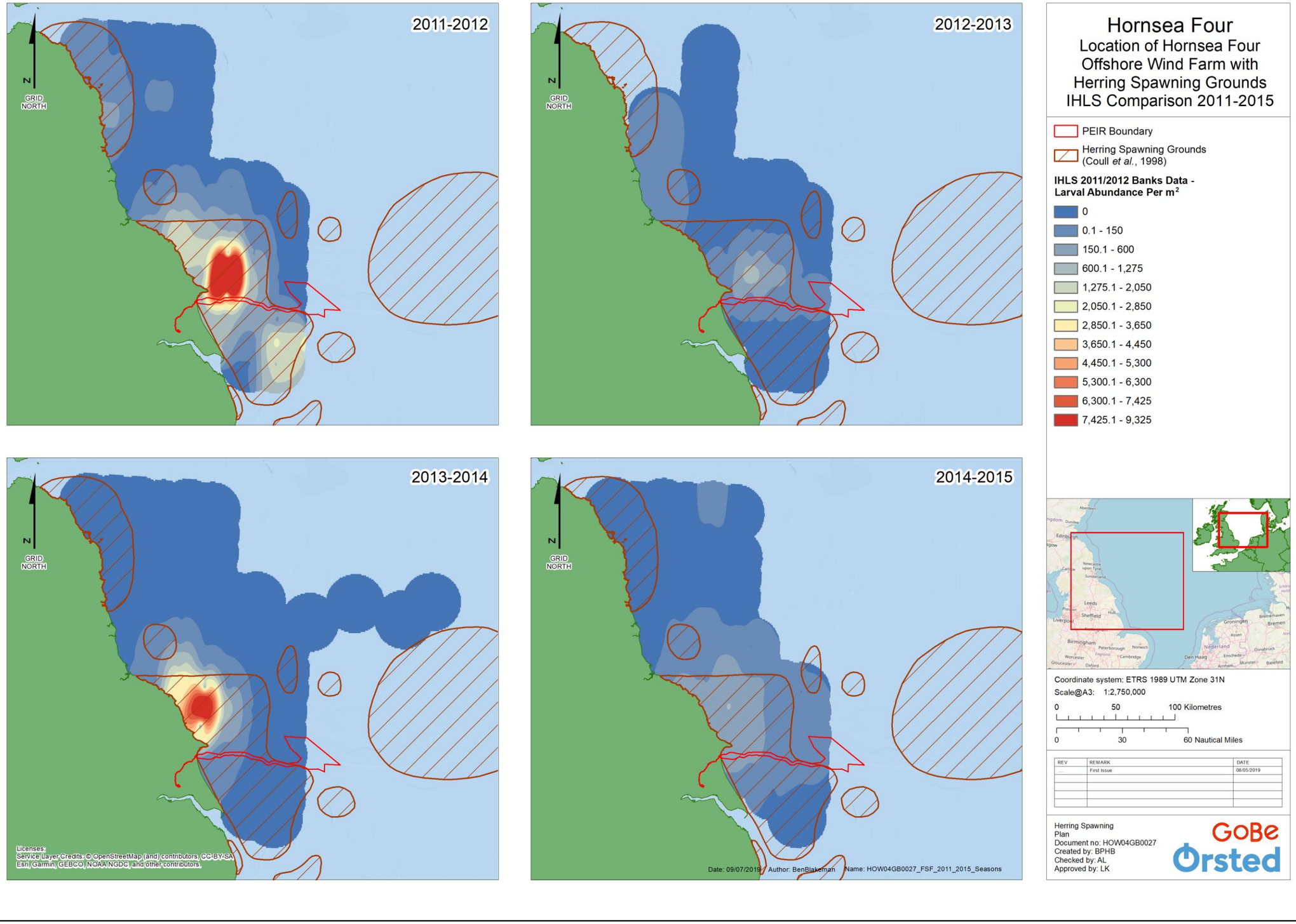

Figure 25: Location of Hornsea Four with herring spawning grounds IHLS comparison, 2011 – 2015. Based on data from the IHLS (ICES, 2007–2017), and Coull *et al.* (1998) (not to scale).

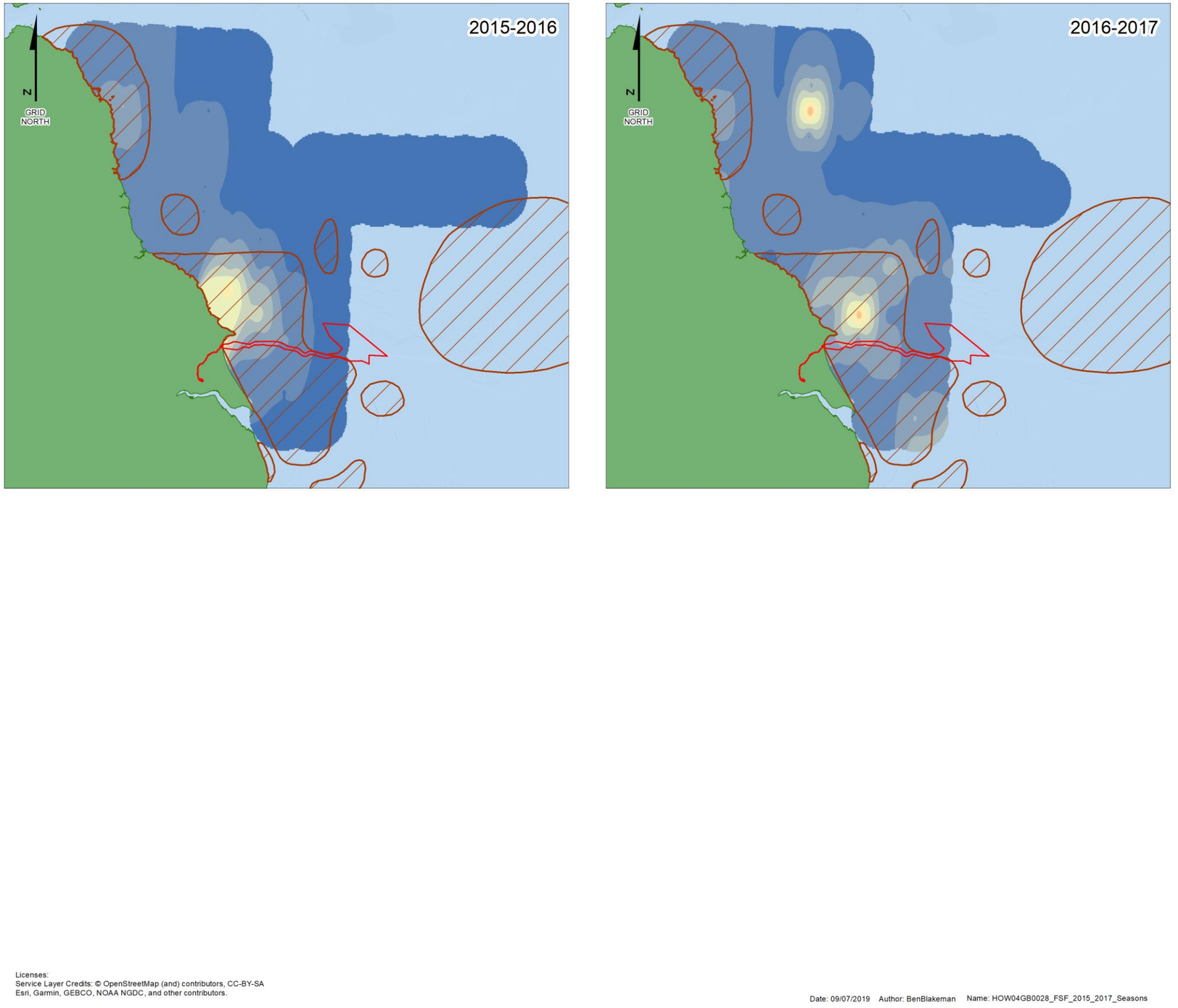

Figure 26: Location of Hornsea Four with herring spawning grounds IHLS comparison, 2015 – 2017. Based on data from the IHLS (ICES, 2007–2017), and Coull *et al.* (1998) (not to scale).

3.2.2.7 The results of the analyses described in **paragraph 2.3.4.10** are presented in **Table 7**, **Figure 27** and **Figure 28**, these habitat sediment preferences/classifications when mapped broadly correspond to the herring abundance patterns observed in **Figure 14**. The majority of the Hornsea Four fish and shellfish study area is categorised as unsuitable habitat for herring, with the habitat largely dominated by sand and muddy sand in the CEFAS broadscale habitat data (Stephens and Diesing 2015). Site specific grab sampling in the Hornsea Four study area supports this, showing unsuitable herring habitat sediments located across the array area, with sporadic areas of suitable (marginal) habitat located to the North and to the South-east of the array area. The offshore section of the proposed ECC is also characterised by sand and muddy sand by the CEFAS habitat data, with the inshore section dominated by coarse sediments **Figure 28**.

3.2.2.8 **Figure 28** presents PSA data collected from various sources, including BGS (2015), and Creyke Beck and the former Hornsea Zone baseline characterisation surveys; this data overlays the CEFAS EUNIS and Folk sediment classifications (Stephens and Diesing 2015) and is presented within the Hornsea Four study area. Within the study area the the majority of the area surrounding the array and the offshore section off the ECC are dominated by sand and muddy sand habitats (sediment unsuitable for herring spawning). Prime herring habitats (coarse sediments) are located across the nearshore section of the ECC, as shown by the EUNIS and Folk sediment classifications (Stephens and Diesing 2015). This reflects patterns observed in the PSA point data, with the majority of the area within and north of the array area, and in the offshore section of the ECC shown to be unsuitable for herring spawning, and areas south the array showing Prime and Sub-Prime habitats. Prime habitats for herring spawning were shown to be located within and surrounding the inshore section of the ECC.

3.2.2.9 When considering all the datasets on herring habitats and abundances discussed above, it indicates that herring spawning habitats, are present within the inshore section of the ECC, coinciding with the coarse sediments across the ECC.

Table 7: Site-specific data from the Hornsea Four Offshore Wind Farm Habitat Classification Report (Gardline, 2019) classified using methods in Reach *et al.* (2013).

Station[8]	Folk (1954) Classification	Reach *et al.* 2013. Habitat sediment preference	Reach *et al.* 2013. Habitat sediment classification
1	Sand	Unsuitable	Unsuitable
2	Slightly gravelly sand	Suitable	Marginal
4	Sand	Unsuitable	Unsuitable
5	Sand	Unsuitable	Unsuitable
6	Sand	Unsuitable	Unsuitable
8	Sand	Unsuitable	Unsuitable
9	Muddy sand	Unsuitable	Unsuitable
10	Sand	Unsuitable	Unsuitable
11	Sand	Unsuitable	Unsuitable
14	Sand	Unsuitable	Unsuitable
15	Sand	Unsuitable	Unsuitable

[8] Stations are shown in Figure 5.1 of **Volume 5, Annex 2.1: Benthic and Intertidal Ecology Technical Report**

Station[8]	Folk (1954) Classification	Reach *et al.* 2013. Habitat sediment preference	Reach *et al.* 2013. Habitat sediment classification
16	Gravelly sand	Suitable	Suitable
17	Gravelly muddy sand	Unsuitable	Unsuitable
18	Sand	Unsuitable	Unsuitable
19	Gravelly muddy sand	Unsuitable	Unsuitable
20	Sand	Unsuitable	Unsuitable
21	Sand	Unsuitable	Unsuitable
22	*Sand*	Unsuitable	Unsuitable
23	*Sand*	Unsuitable	Unsuitable
24	Gravelly sand	Suitable	Marginal
25	Slightly gravelly sand	Suitable	Marginal

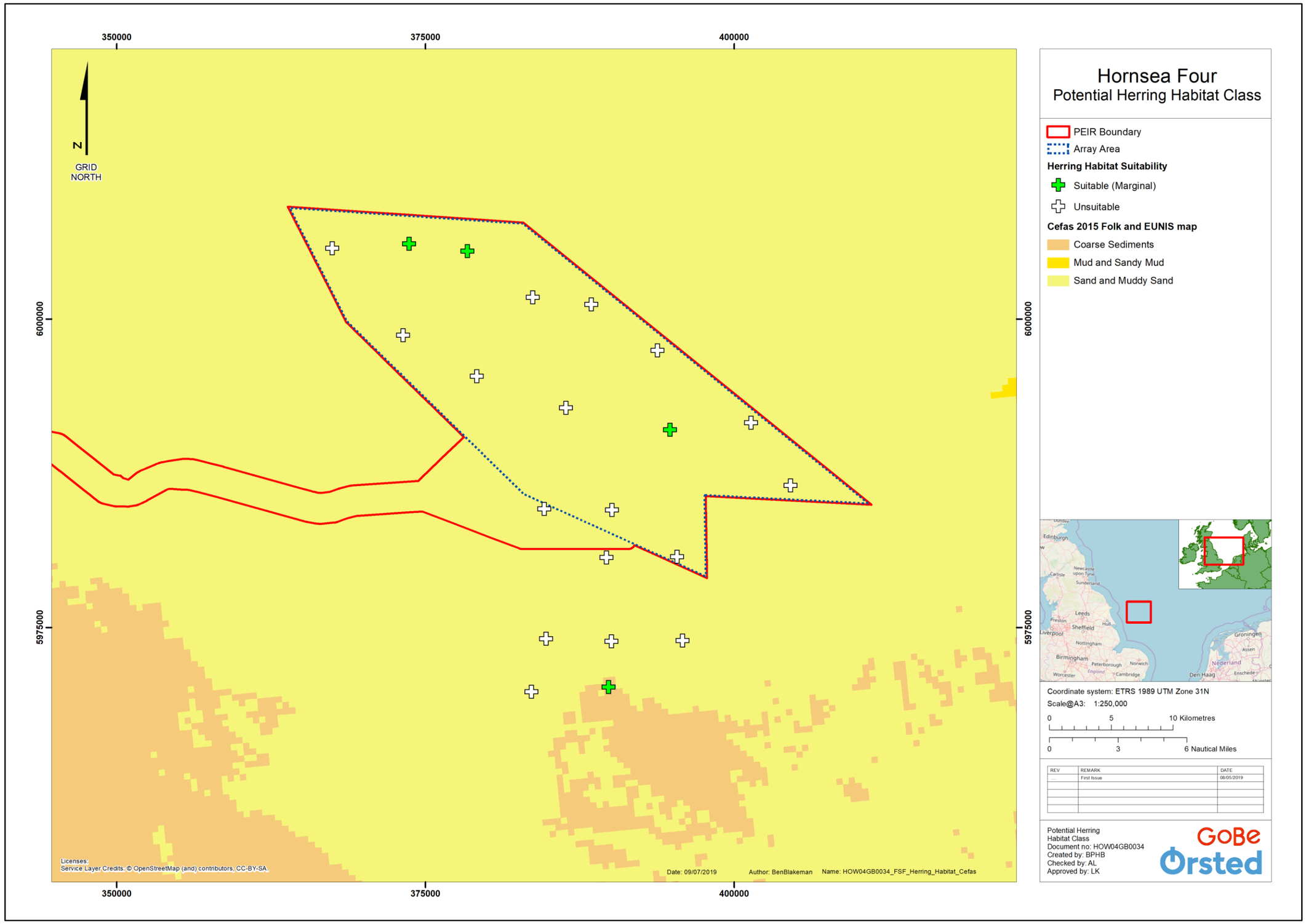

Figure 27: Potential herring habitat sediment classifications within the Hornsea Four study area following methods in Reach *et al.* (2013). Based on data from Cefas 2015 full coverage Folk and EUNIS map (Stephens and Diesing 2015) and site-specific data from the Hornsea Four Offshore Wind Farm Habitat Classification Report (Gardline, 2019) (not to scale).

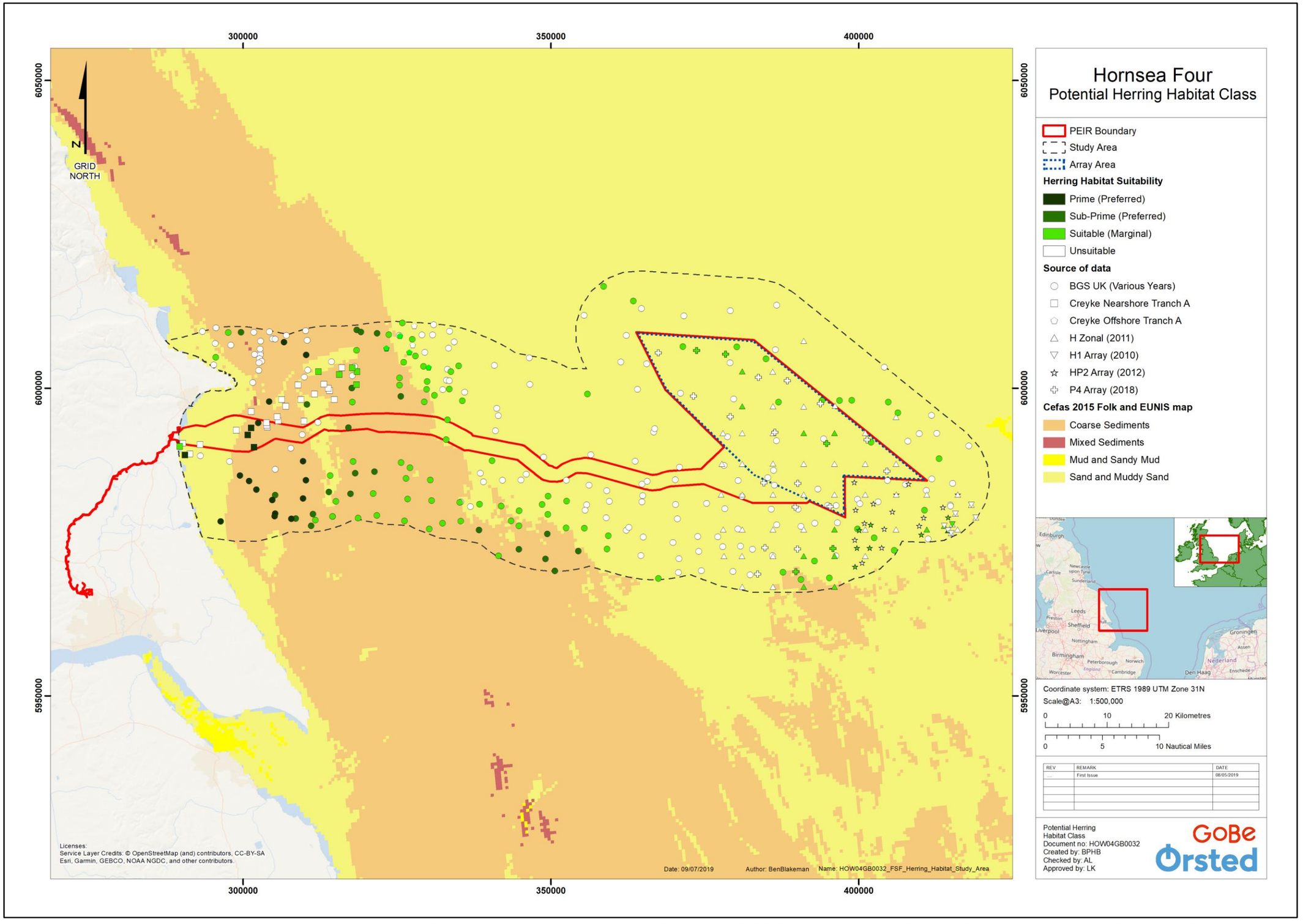

Figure 28: Potential herring habitat sediment classifications within the Hornsea Four study area following methods in Reach *et al.* (2013). Based on data from Cefas 2015 full coverage Folk and EUNIS map (Stephens and Diesing 2015) and PSA data from the Hornsea baseline characterisation surveys and the BGS GeoIndex Offshore Portal (not to scale).

3.2.3 Sandeel

3.2.3.1 The results of the analyses described in Section 2.3.4 are presented in Table 8, Figure 29 and Figure 30. Figure 29 presents the site-specific grab sampling data collected across Hornsea Four for the Habitat Classification Report; that data overlays broadscale marine habitat data derived from EUNIS and Folk sediment classifications (Stephens and Diesing 2015). The grab data are classified into sandeel habitat preferences. These habitat sediment preferences/classifications when mapped, broadly correspond to the sandeel abundance patterns observed in Figure 17 and Figure 18. The majority of the Hornsea Four fish and shellfish study area is categorised as sandeel preferred habitat (i.e. sand) by the CEFAS broadscale habitat data (Stephens and Diesing 2015), whereas site specific grab sampling in the Hornsea Four array area shows prime and sub-prime (preferred) sediments located at the north west and southern extents of the array area. With suitable (marginal) and unsuitable sediments (higher mud composition) in the central array area. The offshore section of the proposed ECC is characterised by sand by the CEFAS broadscale habitats data, with the inshore section dominated by coarser sediments (Figure 30).

3.2.3.2 Figure 30 presents PSA data collected from various sources, including BGS, and Creyke Beck and the former Hornsea Zone baseline characterisation survey; this data overlays the CEFAS EUNIS and Folk sediment classifications (Stephens and Diesing 2015) and is presented within the Hornsea Four study area. The majority of Prime and Sub-prime habitats are within and surrounding the array boundary and the offshore section of the ECC. Unsuitable and suitable (marginal) habitats are located in the inshore section of the ECC, corresponding with the coarser sediments.

3.2.3.3 It should also be noted that Figure 29 and Figure 30 provides only a proxy for the presence of sandeels in these locations (based on the potential suitability of habitats).

3.2.3.4 When considering all the datasets on sandeel habitats and abundances discussed above, it indicates that sandeel habitats, and therefore potential spawning habitats, are present within the Hornsea Four array area, coinciding with the sandy areas throughout the centre of the array area. The datasets also indicate that the majority of the offshore section of the Hornsea Four ECC are also suitable as sandeel habitat, with inshore areas of the ECC classified as unsuitable.

Table 8: Site-specific data from the Hornsea Four Offshore Wind Farm Habitat Classification Report (Gardline, 2019) classified using methods in Latto *et al.* (2013).

Station[9]	Folk (1954) Classification	Latto *et al.* (2013) Habitat sediment preference	Latto *et al.* (2013) Habitat sediment classification
ENV1	Sand	Prime	Preferred
ENV2	Slightly gravelly sand	Prime	Preferred
ENV4	Sand	Suitable	Marginal
ENV5	Sand	Prime	Preferred

[9] Stations are shown in Figure 5.1 of the Benthic and Intertidal Ecology Technical Report (A5.2.1)

Station[9]	Folk (1954) Classification	Latto *et al.* (2013) Habitat sediment preference	Latto *et al.* (2013) Habitat sediment classification
ENV6	Sand	Suitable	Marginal
ENV8	Sand	Suitable	Marginal
ENV9	Muddy sand	Unsuitable	Unsuitable
ENV10	Sand	Suitable	Marginal
ENV11	Sand	Suitable	Marginal
ENV14	Sand	Suitable	Marginal
ENV15	Sand	Suitable	Marginal
ENV16	Gravelly sand	Suitable	Marginal
ENV17	Gravelly muddy sand	Unsuitable	Unsuitable
ENV18	Sand	Prime	Preferred
ENV19	Gravelly muddy sand	Unsuitable	Unsuitable
ENV20	Sand	Sub-Prime	Preferred
ENV21	Sand	Suitable	Marginal
ENV22	*Sand*	Suitable	Marginal
ENV23	*Sand*	Sub-Prime	Preferred
ENV24	Gravelly sand	Sub-Prime	Preferred
ENV25	Slightly gravelly sand	Prime	Preferred

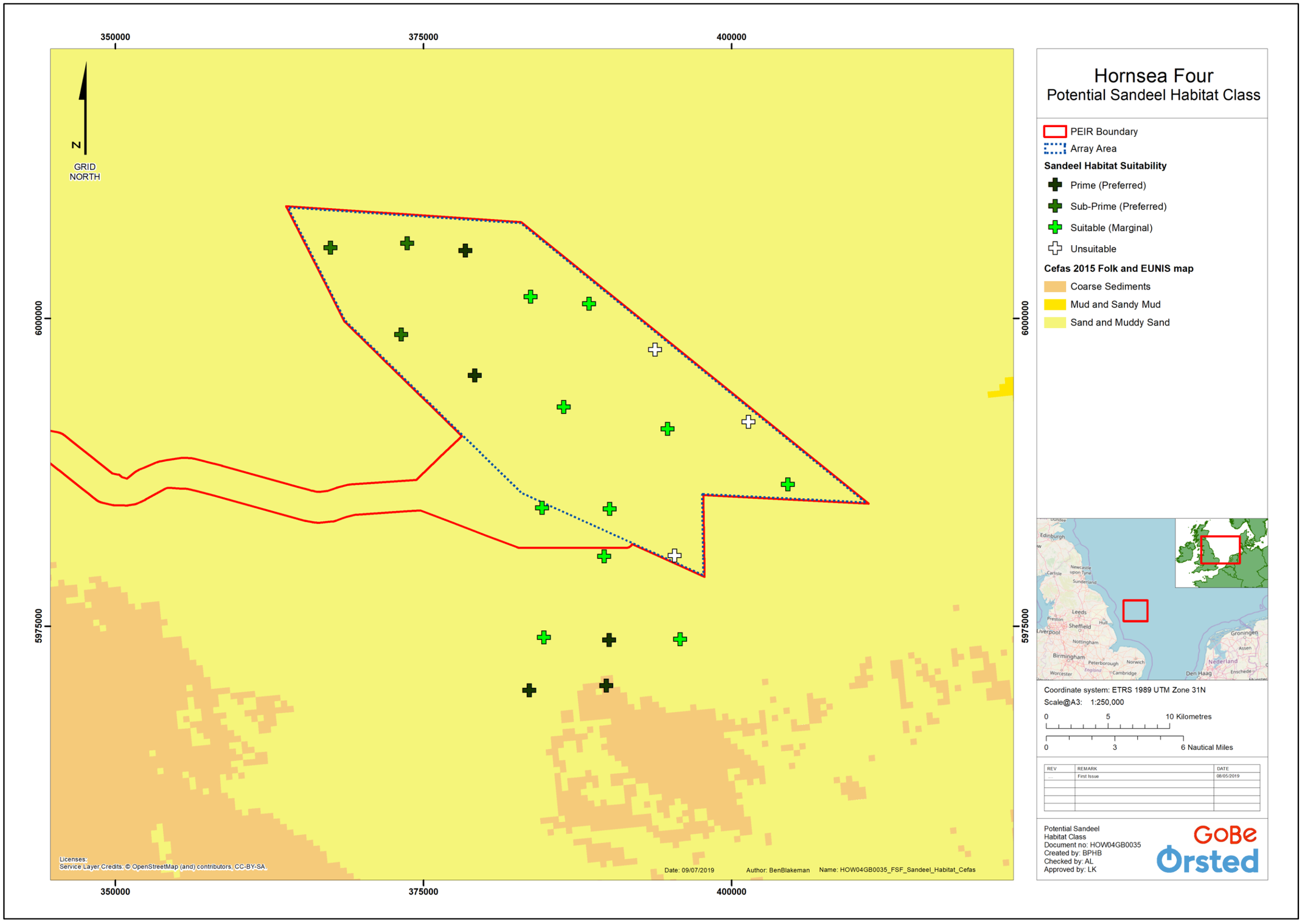

Figure 29: Potential sandeel habitat sediment classifications within the Hornsea Four study area following methods in Latto *et al.* (2013).Based on data from Cefas 2015 full coverage Folk and EUNIS map (Stephens and Diesing 2015) and site-specific data from the Hornsea Four Offshore Wind Farm Habitat Classification Report (Gardline, 2019) (not to scale).

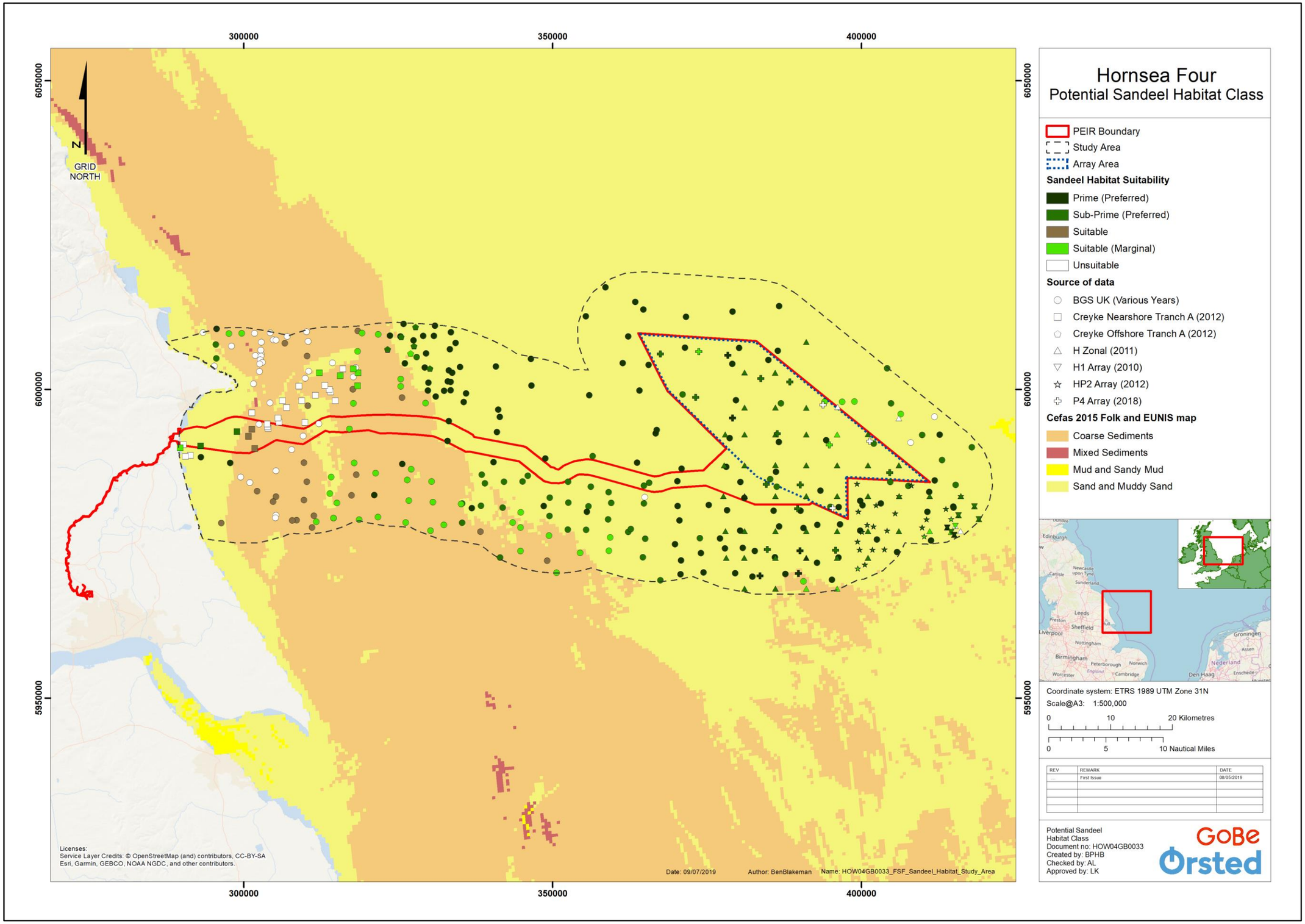

Figure 30: Potential sandeel habitat sediment classifications within the Hornsea Four study area following methods in Reach *et al.* (2013). Based on data from Cefas 2015 full coverage Folk and EUNIS map (Stephens and Diesing 2015) and PSA data from the Hornsea baseline characterisation surveys and the BGS GeoIndex Offshore Portal (not to scale).

3.3 Migratory fish species

3.3.1.1 The Humber Estuary is known to host several key migratory species which are known to spawn in the freshwater environments of tributaries flowing into the estuary, including the River Derwent Special Area of Conservation (SAC). These include sea lamprey *Petromyzon marinus* and river lamprey *Lampetra fluviatilis* (both qualifying species of the Humber Estuary SAC and SSSI), Atlantic salmon *Salmo salar*, sea trout *Salmo trutta*, European eel *Anguilla anguilla*, twaite shad *Alosa fallax* and allis shad *Alosa alosa* (Perez-Dominguez, 2008; Allen *et al*, 2003; Proctor *et al*, 2000; Proctor and Musk, 2001). The key migratory species receptors identified in the Hornsea Four Scoping Report (Ørsted, 2018) were Atlantic salmon, sea trout and European eel.

3.3.1.2 A study by Marine Scotland (2017) investigated the movements of Atlantic salmon smolt in the Cromarty and Moray Firths; the study observed relatively rapid downstream migration, with the fish taking an average of 8 days to travel approximately 62 km. An eastern movement of smolt was observed from the Cromarty Firth, with observations made up to 30 km from shore in the marine environment, and >60 km from the river mouth. This is supported by Thorstad *et al.* (2004) and Finstad *et al.* (2005) who noted that smolts undergo rapid migrations towards open marine areas, away from their river of origin, and in general do not follow nearby shores. However contradictory evidence from Malcolm *et al.* (2010), suggests that smolt utilise nearshore areas at the commencement of their marine migration.

3.3.1.3 A study investigating the migratory routes of adult Atlantic salmon in Scotland observed a general migratory pattern, whereby Salmon migrate through the North Sea, and then travel along the coast back to their home river (Malcom *et al*, 2010), suggesting the potential for integration between adult Atlantic salmon and the nearshore section of the ECC, although this is expended to be of short duration.

3.3.1.4 During trawl surveys a single Atlantic salmon was recorded in the mouth of the Humber estuary (as observed in Hornsea Three baseline characterisation surveys). However, due to the location of Hornsea Four (46 km from the Humber estuary) there is limited potential for this species to occur in significant numbers in the vicinity of the Hornsea Four array area. Taking this into consideration, the evidence suggests that there is the potential for salmon smolt to occur within the Hornsea Four site due to their offshore migration, although this is expended to be for a short duration.

3.3.1.5 The Humber estuary is known to host sea trout, with the species known to occur in the Wash and along the North Norfolk coast. In common with salmon, sea trout also spend a number of years in fresh water before migrating to sea, however in contrast to salmon, the species often return to fresh water to over-winter. Netting and tracking data for post-smolt sea trout suggest relative local movement to the coast, for the first couple of months in the sea (Finstad *et al*, 2005 as cited in Malcolm *et al*, 2010). There is little consistency in observed migratory patterns of adult sea trout, with studies on the west coast of Scotland suggesting locally constrained areas, and contrasting studies suggesting wide range migrations, supported by offshore fishing vessel catches of the species

suggesting offshore movement and migrations (Malcolm *et al*, 2010). No records of sea trout were made during baseline surveys in the former Hornsea Zone for the Dogger Bank Creyke Beck EIA.

3.3.1.6 The Humber estuary is also known to host European eel, with the species known to occur in the Wash and along the North Norfolk coast. The movements of juveniles migrating from the spawning grounds in the Sargasso Sea are thought to primarily dictated by the course of prevailing currents, and there is a general assumption that proximity to Atlantic currents is associated with high eel numbers (Malcolm *et al*, 2010), and due to the location and direction of the North Atlantic Drift current, the migratory movements of juvenile European eel are assumed to follow a southern movement along the coast. In contrast to this, the migration routes of adult eels do not appear to hug the UK coastline, however data on the understanding of European eel movements is scarse (Malcolm *et al*, 2010). No records of European eel species were made during baseline surveys in the former Hornsea Zone or for the Dogger Bank Creyke Beck EIA.

3.4 Species of conservation importance

3.4.1.1 A number of the fish species which were recorded during historic surveys across the former Hornsea Zone or identified as having the potential to be present within the Hornsea Four fish and shellfish study area, are listed under conservation legislation. These are summarised in **Table 9**.

Table 9: Species of conservation importance recorded during historic surveys across the former Hornsea Zone or likely to occur within the Hornsea Four fish and shellfish study area.

Species		Recorded in historic surveys across the former Hornsea Zone	Annex II Species	UK BAP species	Nationally Important Marine Features (NMF)	OSPAR threatened or declining	Marine Conservation Zone (MCZ) features	International Union for the Conservation of Nature (IUCN) red list	NERC Species of Principal Importance
Atlantic salmon	*Salmo salar*	✓	✓	✓		✓			✓
Sea trout	*Salmo trutta*			✓					✓
European eel	*Anguilla anguilla*			✓		✓	✓	✓	✓
Sea Lamprey	*Petromyzon marinus*		✓	✓					✓
River Lamprey	*Lampetra fluviatilis*		✓	✓		✓			✓
Quahog	*Arctica islandica*						✓		
Cod	*Gadus morhua*	✓		✓b	✓	✓		✓	✓
Whiting	*Merlangius merlangus*	✓		✓b	✓				✓
Plaice	*Pleuronectes platessa*	✓		✓b					✓
Common Sole	*Solea solea*	✓		✓b					✓
Herring	*Clupea harengus*	✓		✓b	✓				✓
Mackerel	*Scomber scombrus*	✓		✓b	✓				✓
Lesser sandeel	*Hyperoplus lanceolatus*	✓		✓	✓				✓
Tope shark	*Galeorhinus galeus*			✓					✓
Spurdog	*Squalus acanthias*	✓		✓		✓		✓	✓
Spotted ray	*Raja montagui*	✓			✓	✓			
Thornback ray	*Raja clavata*	✓			✓	✓			

Species		Recorded in historic surveys across the former Hornsea Zone	Annex II Species	UK BAP species	Nationally Important Marine Features (NMF)	OSPAR threatened or declining	Marine Conservation Zone (MCZ) features	International Union for the Conservation of Nature (IUCN) red list	NERC Species of Principal Importance
	a Only species with IUCN Red List status designations categorised as threatened (i.e. 'vulnerable', 'endangered' and 'critically endangered') are listed here. These do not include species listed as 'Least Concern' or 'Near Threatened'. b Commercial marine fish grouped action plan.								

3.5 Shellfish populations in the fish and shellfish study area

3.5.1.1 The following sections provides a summary of the ecology and distribution of the key shellfish species in the Hornsea Four fish and shellfish study area, including discussion of abundances of these as recorded during historic surveys undertaken across the former Hornsea Zone (e.g. trawl sampling) and other desktop data sources.

Brown Crab

3.5.1.2 Brown crab (*Cancer pagurus*) were identified as a species of commercial importance in **Volume 5, Annex 7.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

3.5.1.3 Brown crab was recorded during otter and epibenthic trawl surveys throughout the Hornsea Four fish and shellfish study area, though these survey techniques were not specifically designed to capture shellfish species (see **paragraph 2.4.1.2**). Highest abundances of brown crab were recorded to the western end of the study area, within the proposed Hornsea Four array area.

3.5.1.4 Berried brown crab were recorded at low abundances during the spring otter trawl survey in the centre of the fish and shellfish study area.

3.5.1.5 Data collected as part of the Triton Knoll shellfish characterisation, showed in inshore areas, close to the mouth of the Humber estuary, smaller individuals were more abundant, with females making up a larger proportion of the population, indicative of an inshore population dominated by resident immature females which had not yet joined the migratory populations offshore (Triton Knoll Offshore Wind Farm Ltd., 2011b).

3.5.1.6 Information on crab spawning habitats have been previously collected through crab larvae surveys in 1976, 1993 and 1999 (Eaton *et al*, 2003); two areas of spawning habitat were identified in the fish and shellfish study area, and within the proposed Hornsea Four array area. Nursery habitats for brown crab have not previously been mapped in the southern North Sea, though desktop information and historic survey data from across the former Hornsea Zone indicated the presence of inshore nursery habitats along the Lincolnshire and north Norfolk coasts for this species.

Nephrops

3.5.1.7 *Nephrops* were identified as a species of commercial importance in **Volume 5, Annex 7.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

3.5.1.8 *Nephrops* was recorded during trawl surveys at consistently high abundances in the eastern side of the Hornsea Four fish and shellfish study area and in the deep-water areas to the north of it (in both otter and beam trawls) and at lower abundances to the northwest of the study area, proximal to the proposed Hornsea Four array area. Of the *Nephrops* recorded in the study area, 13 were found to be berried during the autumn trawl

survey, located in deep water areas to the north of the eastern side of the study area, and in Markham's Hole (as recorded in the Hornsea Three baseline characterisation baseline).

3.5.1.9 Spawning and nursery habitats were recorded within the eastern side of the study area but are shown to be absent in the proposed Hornsea Four array and offshore ECC area (Coull *et al*, 1998; Eaton *et al*, 2003).

European lobster

3.5.1.10 The European lobster (*Homarus Gammarus*) is reviewed in this technical report due to its commercial importance as identified in **Volume 5, Annex 7.1: Commercial Fisheries Technical Report**. Lobster was recorded during historic trawl survey data from across the former Hornsea Zone, and within the study area. However, this was sporadic and with low abundances, and therefore has not been mapped.

3.5.1.11 Shellfish potting surveys undertaken as part of the as part of the Dogger Bank Creyke Beck EIA baseline within the nearshore section of the Hornsea Four ECC found lobsters in relatively high abundance.

3.5.1.12 There is limited information on lobster spawning or nursery habitats in the southern North Sea and abundances of lobster have generally been reported as low. It has been suggested that nearshore waters close to the Humber Estuary may represent overwintering grounds and/or nursery habitat for this species, this is supported by Bennet *et al*. (2006), who suggest that lobster nursery grounds are typically located on rocky coastal areas, although it is difficult to make firm conclusions due to the low abundances in these areas (SMart Wind, 2015).

3.5.1.13 A recent Cefas stock assessment (Cefas, 2019) reports that that exploitation of the lobster stock in the Yorkshire/Humber region is very high but has decreased in recent years.

Velvet swimming crab

3.5.1.14 Data collected as part of the Dogger Bank Creyke Beck EIA baseline characterisation potting surveys found that velvet crab (*Necora puber)* were abundant in the shellfish potting surveys which were carried out in the inner section of the export cable corridor, proximal to where the Hornsea Four ECC is proposed. The velvet swimming crab is common across all British and Irish coasts, and throughout the North Sea (Wilson *et al*, 2008).

Common whelk

3.5.1.15 Common whelk (Buccinum undatum) were identified as a species of commercial importance in **Volume 5, Annex 7.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

3.5.1.16 No common whelks were recorded in the shellfish potting surveys (in Creyke Bank surveys), carried out within the nearshore area of the Hornsea Four ECC, or in surveys undertaken in the study area. However, the species is reportedly common off all British coasts, and is

distributed from Iceland and Norway to the Bay of Biscay and throughout the North Atlantic (Ager, 2008).

Brown and pink shrimp

3.5.1.17 Brown shrimp (*Crangon crangon*) has a high productivity and is an important prey species for many birds, fish and crustaceans, in addition to this, the species is also commercially exploited for human consumption (Neal, 2008), with the species being targeted by commercial fishing vessels within the region. Brown shrimp are common across all British and Irish coasts, and is widely distributed across the North Sea, with distinct populations located from Spurn Head northwards, and from Spurn Head to Dungeness, kept distinct by fronts of water masses preventing larval mixing (Henderson *et al.*, 1990, as cited in Neal, 2008).

3.5.1.18 Pink shrimp (*Pandulus montagui*) are common within the North Sea, typically inhabiting depths between 20 and 100 m. The species migrate to deeper waters for spawning during October and November (Ruiz, 2008). The species is also of commercial importance, with commercial shipping vessels targeting pink shrimp within the region.

3.5.1.19 Both brown and pink shrimp were recorded in the epibenthic beam trawl surveys (in the Hornsea Three baseline characterisation surveys), conducted within the study area. Brown shrimp was recorded throughout the study area with highest abundances recorded to the eastern end of the study area. Relatively low abundances of brown shrimp were recorded within the proposed array area for Hornsea Four. Pink shrimp were recorded in low abundances throughout the study area for Hornsea Four.

European common squid

3.5.1.20 The European common squid (*Alloteuthis subulate)* is the most common cephalopod species within the region, being widespread throughout the North Sea. During spawning season males and females are known to move inshore in June and July (Hastie *et al*, 2009). The European common squid was recorded throughout the Hornsea Four study area, in epibenthic beam trawls and was one of the characterising species within the otter trawl surveys conducted for the Hornsea Three baseline characterisation. Relatively high abundances were observed in the proposed array area for Hornsea Four. No seasonal differences were observed between the spring and autumn surveys).

Scallop

3.5.1.21 King Scallop (*Pecten maximus*) were identified as a species of commercial importance in **Volume 5, Annex 7.1: Commercial Fisheries Technical Report** on account of their landings weight and value. King scallop fisheries around the UK coast represent the most valuable commercial species in the region. In 2018, an area located along the Yorkshire coast was defined as an area of importance to UK fisheries, and monitoring was undertaken to estimate King scallop stocks in the area.

3.5.1.22 A dredge survey undertaken in 2018 along the coast of Yorkshire, North of Spurn point, showed the biomass of scallop (>100 mm) (Lawler, Masefield and Wynne, 2019) within the location of the nearshore section of the Hornsea Four ECC. The greatest biomass (Tonnes)

was observed south of Flamborough Head, south of the proposed location for the nearshore section of the Hornsea Four ECC, with biomass within the 75th centile measuring at 5739 tonnes. Lower abundances of the species were observed within the proposed ECC boundary. It should be noted that these estimates were based on the fished portion of stock only, with this data providing an indication on distribution and abundances of the species within the Hornsea Four study area.

3.5.1.23 A recent stock assessment by Cefas (2019) identifies the presence of two main king scallop beds in the regions, one of which overlaps with the ECC.

3.6 Designated Sites

3.6.1.1 All designated sites within the study area where impacts to fish or shellfish receptors could impact the conservation objectives or features of the site by the Hornsea Four development are shown in **Figure 31** below.

3.6.1.1 A number of the key species identified as having the potential to be present within the Hornsea Four fish and shellfish study area, are listed under conservation legislation with three of these species listed as Annex II species under the EU Habitats Directive; the Atlantic Salmon, Sea Lamprey and River Lamprey. Both sea lamprey and river lamprey are listed as qualifying features of the Humber Estuary SAC. These two species are also listed as features under the Humber Estuary Ramsar and Humber Estuary SSSI designations. These species are known to migrate through the Humber Estuary to freshwater spawning habitats, including in the River Derwent SAC, a tributary of the Humber Estuary which lists river and sea lamprey as qualifying features, with river lamprey listed a primary feature for selection of this site. A full assessment of the impacts on these species is undertaken through the HRA which will examine the potential impacts on the Humber Estuary SAC, which overlaps with the SSSI and the Ramsar site.

3.6.1.2 The Southern North Sea SAC is designated for the Annex II species Harbour Porpoise *Phocoena phocoena*. The SAC has a Conservation Objective to maintain Favourable Conservation for the harbour porpoise, which includes the maintenance of the availability of prey (typically consists of non-spiny fish such as herring, whiting and cod, squid and sprat).

3.6.1.3 Two MCZs lie within the Hornsea Four study area; the Holderness Inshore MCZ (4.4 km from Hornsea Four) and the Holderness Offshore MCZ (0.75 km from Hornsea Four). The only MCZ of relevance to fish and shellfish receptors is the Holderness Offshore MCZ which is designated for the Ocean Quahog *Arctica islandica*, a species found in sandy seabeds throughout the North Sea.

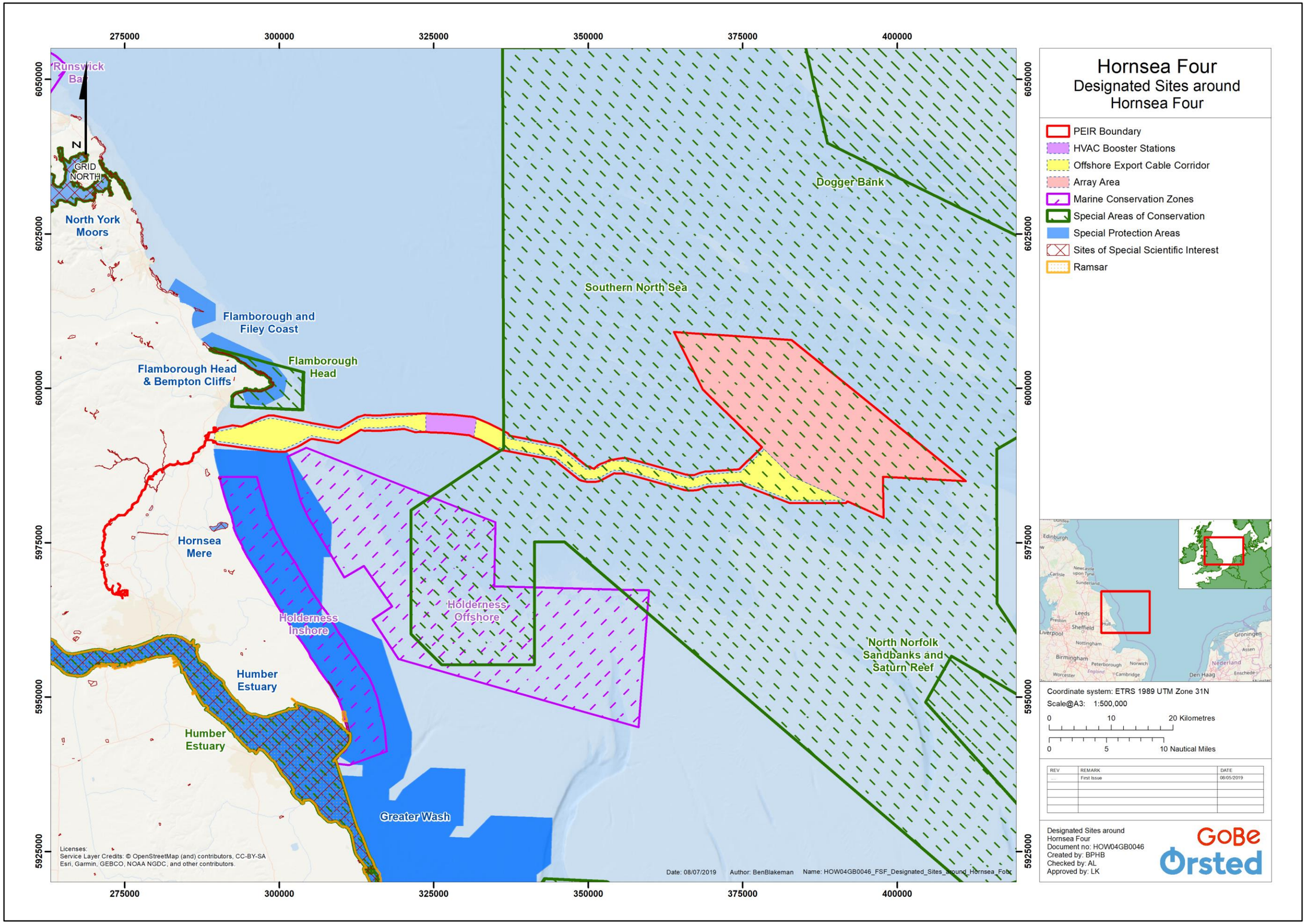

Figure 31: Designated sites surrounding Hornsea Four (not to scale).

4 Discussion

4.1.1.1 This study has described the key attributes of the fish and shellfish community in the Hornsea Four fish and shellfish study area and identified valuable features including distribution and abundance of key fish and shellfish species, spawning and nursery activity, commercial and conservation importance, migratory species and species of ecological importance. This section provides a summary of each of the fish and shellfish receptors that have the potential to be impacted by Hornsea Four and therefore require consideration in the EIA. With consideration of each receptor's distribution and abundance, spawning and nursery activity, as well as their commercial, conservation and ecological importance, an assessment of the value of each of these receptors within the defined fish and shellfish study area has been provided.

4.2 Definition of valued ecological receptors (VERs)

4.2.1.1 The value of ecological features is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (CIEEM, 2016). The most straightforward context for assessing ecological value is to identify those species and habitats that have a specific biodiversity importance recognised through international or national legislation or through local, regional or national conservation plans (e.g. Annex II species under the Habitats Directive, UK BAP species or species of principal importance listed under the NERC Act 2006, and species listed as features of existing or recommended MCZs). Evaluation has also assessed the receptor value in accordance to the functional role of the habitat or species. The criteria used to inform this assessment are listed in **Table 10** below.

Table 10: Criteria used to inform the valuation of ecological receptors in the Hornsea Four fish and shellfish study area (derived from guidance published by CIEEM (2016)).

VER Value	VER Criteria used to define value
International	Internationally designated sites, or species designated under international law (i.e. Annex II species listed as features of SACs).
National	Nationally designated sites, or species designated under international law. Annex II species that are not listed as features of SACs. UK BAP priority species (these include grouped action plans) that continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework, MCZ/rMCZ features (species classified as features of conservation importance, and broadscale habitats), species of principal importance and NIMF that have regionally important populations within the Hornsea Four study area, p[particularly the context of species/habitat that may be rare or threatened in the UK.
Regional	UK BAP priority species (these include grouped action plans) that continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework, MCZ/rMCZ features (species classified as features of conservation importance, and broadscale habitats), species of principal importance and NIMF that have regionally important populations within the Hornsea Four study area (are locally widespread and/or abundant). Species of commercial importance, to fisheries in the area. Species of ecological importance (i.e. are an important prey item for other species of conservation or commercial value and that are key components of the

VER Value	VER Criteria used to define value
	fish assemblages in the Hornsea Four study area. Species that have spawning or nursery areas within the study area that are important regionally.
Local	Species of commercial importance but do not form a key component of the fish assemblages within the Hornsea Four study area. The spawning/nursery area for the species is located outside of the study area. The species is common throughout the UK but forms a component of the fish assemblages in the study area.

4.3 Fish ecology

4.3.1.1 The fish ecology of the Hornsea Four fish and shellfish study area is characterised primarily by demersal fish species, with whiting, dab, plaice, gurnard and solenette identified as some of the key characterising species of the fish assemblage. Other demersal species recorded in the Hornsea Four fish and shellfish study area included lemon sole, common sole, cod, elasmobranchs (e.g. thornback and spotted ray), small demersal species such as lesser weever, scaldfish and common dragonet, and the benthopelagic species sandeel (important prey species for other fish species, marine mammals and birds).

4.3.1.2 Within the technical review, the demersal species whiting, dab, plaice, cod, lemon sole, common sole, solenette and grey gurnard were reviewed due to their increased abundances in the surveys undertaken within the study area, or their commercial importance in the region.

4.3.1.3 Whiting and sandeel were recorded throughout the former Hornsea Zone, with cod and lemon sole also in abundance within and to the North of the former Hornsea Zone. Whiting, sandeel, dab, plaice, solenette and grey gurnard were all recorded throughout the study area with low abundances of cod, lemon sole and common sole observed. Plaice, solenette and grey gurnard were all recorded as absent from the Hornsea four array area. Whiting and dab were recorded in high abundances in the inshore section of the Hornsea Four ECC, with plaice and cod experiencing low and moderate abundances respectively.

4.3.1.4 Seasonal changes in abundance or distribution within the array area were not observed in whiting, plaice, dab, cod or grey gurnard. Within the ECC however, whiting had increased abundance in April, and dab had increased abundances in October and April. Lemon sole and greater and lesser sandeel were found to vary seasonally, with all species having greater abundances during the spring than the autumn within the study area.

4.3.1.5 The pelagic species, sprat and herring were both recorded within the former Hornsea Zone; sprat were observed in high abundances within, and to the east and north west of the area. Herring were recorded in abundance to the south of the former Hornsea Zone.

4.3.1.6 Sprat were identified as one of the key characterising species of the fish assemblage within the study area, with herring and mackerel also recorded throughout the area. Sprat were also recorded in abundance in surveys within the nearshore section of the Hornsea Four ECC, with mackerel experiencing moderately high abundances in the same area.

4.3.1.7 Sprat and herring were found to vary seasonally with both species more abundant during spring than autumn and are likely to represent important prey for marine mammal and bird species in the region. Mackerel was recorded at higher abundances in autumn than spring. These differences in abundances accounted for the seasonal variation in the study area surveys.

4.3.1.8 The elasmobranchs thornback ray and spotted ray were observed at low abundances sporadically throughout the study area, no significant seasonal differences were observed. Starry smoothhound and lesser spotted dogfish were also recorded in the area, both of which were also observed within the nearshore section of the ECC.

4.3.1.9 No observations of the migratory species sea trout and European eel were made in the proposed array area or ECC area, however the species are known to occur in the area. A single Atlantic salmon was observed in the mouth of the Humber estuary indicating the potential for populations within the ECC, however data on this species is acknowledged to be sparse in this area.

4.3.1.10 **Table 11** provides a summary of the fish species (i.e. VERs) recorded within the Hornsea Four fish and shellfish study area, with specific reference to the commercial, conservation and ecological importance of each species within the study area in order to assign valuations to each of the receptors.

4.4 Shellfish ecology

4.4.1.1 The shellfish ecology of the Hornsea Four fish and shellfish study area was found to be primarily characterised by four commercial species: brown crab; European lobster; *Nephrops*; and common whelk.

4.4.1.2 Within this technical report, the shellfish species brown crab, *Nephrops,* European lobster, velvet swimming crab, common whelk, brown and pink shrimp and European common squid were reviewed due to their increased abundances in survey trawls, or their commercial importance within in the study area.

4.4.1.3 Of these species, brown crab was found to be by far the most abundant species in the study area. Lobster is also present within the study area within the inshore section of the Hornsea Four ECC. Both these species are particularly important to commercial fisheries in the southern North Sea. Common whelk also has increasing importance to commercial fisheries in recent times, although was not observed in surveys within the study area.

4.4.1.4 *Nephrops*, were recorded consistently in deep water, sandy mud habitats within the proposed array area and in the deep waters to the north and northwest of it where they are targeted by commercial fisheries. They were also recorded in surveys in the inshore section of the proposed EEC.

4.4.1.5 Other shellfish species known to occur in the Hornsea Four fish and shellfish study area include velvet swimming crab (abundant in the inshore section of the ECC), pink and brown

shrimp (low abundances in the array area) and European common squid (abundant throughout the study area).

4.4.1.6 Brown crab spawning sites are known to overlap the Hornsea Four array area and spawning and nursery habitats for *Nephrops* are known to occur in the study area, with egg bearing *Nephrops* recorded to the east of the Hornsea Four array area.

4.4.1.7 As for fish VERs, **Table 11** provides a summary of the shellfish species (i.e. VERs) recorded within the Hornsea Four fish and shellfish study area, with specific reference to the commercial and ecological importance of each species within the Hornsea Four fish and shellfish study area in order to assign valuations to each of the receptors.

4.5 Spawning and nursery grounds

4.5.1 Herring

4.5.1.1 Herring are of particular relevance when considering impacts to spawning areas as they are demersal spawners. The species typically prefer to spawn in coarser sediments comprising of sandy gravels to gravel.

4.5.1.2 Data from Coull *et al.* (1998) suggests that the Hornsea Four ECC lies near herring spawning grounds. Data from the IHLS supports this, showing that the main area for herring spawning within the study area is located to the north of Flamborough Head and the ECC (**Figure 24** to **Figure 26**). The array area has minimal spatial interaction with the spawning grounds. This herring stock has its peak spawning season from the end of August through to October (**Table 6**), with larval abundance peaks of up to 9,325 m^2 (**Figure 23** to **Figure 26**).

4.5.1.3 Whilst there is high inter-annual variation in the herring larval abundances, the hotspot locations remain relatively consistent, with the primary hotspot located to the north of the Hornsea Four ECC.

4.5.1.4 However, whilst herring are highly philopatric, returning to the same location each year to spawn, it should be noted that some spawning locations highlighted by Coull *et al.* (1998) can become disused. For example, Coull *et al.* (1998) shows that herring spawning has historically occurred in the vicinity of Dogger Bank, however the ICES IHLS data indicates that spawning has not been recorded in the area in recent years, and that therefore recolonisation has not occurred. Although the ICES IHLS provides the most reliable indicator of herring spawning habitat, the habitats mapped by Coull *et al.* (1998) give an indication of suitable habitats potentially available to herring spawning, that may be re-colonised in the future.

4.5.2 Sandeel

4.5.2.1 Sandeel are also of relevance when considering impacts to spawning areas as they are demersal spawners. The species typically prefer to spawn in coarser sediments comprising of sandy sediments (sand, slightly gravelly sand and gravelly sand).

4.5.2.2 Data from Ellis *et al.* (2010) showing indicative extents of sandeel spawning habitats suggests that the proposed Hornsea Four development overlaps a high intensity spawning area, and a low intensity nursery site.

4.5.2.3 Broadscale habitat mapping of the seafloor (EUNIS seabed habitats, 2017), presented alongside site specific PSA data from the Hornsea Four Offshore Wind Farm Habitat Classification Report (Gardline, 2019) and the former Hornsea Zone.

4.6 Valued Ecological Receptors

4.6.1.1 An ecological receptor valuation has been applied to each species assessed as part of the technical report. A screening exercise for impact receptor pathways will be undertaken as part of the Fish and Shellfish Ecology assessment, which will also identify which species have been taken forward for assessment.

Table 11: Summary of Fish and Shellfish Valued Ecological Receptors (VERs) and their value/importance within the Hornsea Four fish and shellfish study area.

VER	Valuation	Justification
Whiting	Regional	Species present in historic former Hornsea Zone surveys. Most abundantly recorded species and widely distributed across the Hornsea Four fish and shellfish study area. Low intensity spawning and high to low intensity nursery habitats. Commercially important fish species in the region and a key prey species for other marine species (particularly harbour porpoise).
Dab	Regional	Species present in historic former Hornsea Zone surveys. Abundantly recorded throughout Hornsea Four fish and shellfish study area and one of the key characterising species. Fished commercially, though usually as by-catch.
Plaice	Regional	Low abundances of plaice recorded within the nearshore area of the ECC, with no plaice records in the array area. High intensity spawning ground located within the study area, with a low intensity nursery ground located within the ECC boundary. UK BAP species (commercial marine fish grouped action plan) and NERC species of principal importance.
Cod	Regional	Species present in historic former Hornsea Zone surveys. Recorded at low abundances throughout the Hornsea Four fish and shellfish study area. Low intensity spawning and nursery habitats, with low intensity nursery grounds across the study area. Commercially important species. UK BAP species, listed by OSPAR as threatened and/or declining and listed as vulnerable on the IUCN Red List.

VER	Valuation	Justification
Lemon sole	Local	Species present to north of historic former Hornsea Zone. Recorded at low abundances. Spawning and nursery habitats coinciding with the Hornsea Four fish and shellfish study area. Targeted by commercial fishing vessels.
Common Sole	Local	Species present north west of historic former Hornsea Zone. Recorded at very low abundances within the Hornsea Four fish and shellfish study area. No important spawning or nursery sites in the area. Commercially important species. UK BAP species.
Solenette	Not considered to be a VER.	Species present offshore of historic former Hornsea Zone, and present within study area. Species absent in proposed array area. Considered of little commercial importance.
Grey Gurnard	Not considered to be a VER.	Species found throughout study area, although found to be absent in otter trawls in the array area. No spawning or nursery grounds are recorded in the area. Species has limited commercial importance, usually caught as a by-catch in demersal fisheries. No protection or management in place.
Sprat	Regional	Species present in historic former Hornsea Zone surveys. Abundantly recorded throughout the Hornsea Four fish and shellfish study area and a key characterising species in the fish assemblage. Spawning and nursery habitats present. Important prey species for bird and marine mammal species. Commercially important species.
Herring	Regional	Species present south of historic former Hornsea Zone. Recorded at moderate abundances across study area. Nursery habitats likely to occur throughout the Hornsea Four fish and shellfish study area. UK BAP species and nationally important marine feature. Prey species for birds and marine mammals. Important commercial fish species.
Mackerel	Local	Seasonally abundant, with relatively high abundances in autumn within the Hornsea Four fish and shellfish study area. Spawning and nursery habitats (low intensity) present. UK BAP species and nationally important marine feature. Commercially important species.
Sandeel	Regional	Species present in historic former Hornsea Zone surveys. Recorded throughout the Hornsea Four fish and shellfish study area. Low intensity spawning, and nursery habitats occur across the Hornsea Four fish and shellfish study area, high intensity spawning grounds immediately to the north of the Hornsea Four array area. Important prey species for fish, birds and marine mammals. Commercially important species. UK BAP species and a nationally important marine feature.
Thornback ray, spotted ray, blonde ray, starry smoothhound, lesser spotted dogfish and tope.	Regional	All elasmobranchs were recorded at low abundances across the study area. Low intensity tope nursery grounds located to the east of the proposed array area. Both thornback ray and spotted ray are both NIMF and OSPAR threatened or declining species. Tope is a UK BAP species and NERC species of principal importance. Spotted ray and thornback ray present in historic former Hornsea Zone surveys

VER	Valuation	Justification
Sea trout	Regional	Likely to undertake migratory movements through the Humber Estuary and other SACs/SCIs in the southern North Sea fish and shellfish study area. Listed as UK BAP priority species and European eel is listed as critically endangered.
European eel	Regional	Likely to undertake migratory movements through the Humber Estuary and other SACs/Sites of Community Importance (SCIs) in the southern North Sea fish and shellfish study area. Listed as UK BAP priority species and European eel is listed as critically endangered.
Atlantic salmon	International	Species present in historic former Hornsea Zone surveys. Likely to undertake migratory movements through the Humber Estuary and other SACs/SCIs in the southern North Sea. Atlantic salmon recorded during historic surveys across the former Hornsea Zone, albeit at very low abundances. Atlantic salmon are an Annex II species and are listed as qualifying features of a number of SACs/SCIs within the southern North Sea fish and shellfish study area. As such these are considered to be of international importance
Oceanic Quahog	International	The species is on the OSPAR list of threatened and/or declining species and habitats in the North Sea. It is also a Feature of Conservation Importance for which the Holderness Offshore MCZ is designated. As such these are considered to be of international importance
Sea Lamprey	International	Sea Lamprey are an Annex II species and are listed as qualifying features of the Humber Estuary SAC within the southern North Sea. The Sea Lamprey is also listed as feature under the Humber Estuary Ramsar and Humber Estuary SSSI designations. The species is known to migrate through the Humber Estuary to freshwater spawning habitats, including in the River Derwent SAC, a tributary of the Humber Estuary which lists sea lamprey as a qualifying feature, As such these are considered to be of international importance.
River Lamprey	International	River Lamprey are an Annex II species and are listed as qualifying features of the Humber Estuary SAC within the southern North Sea. The river lamprey is also listed as a feature under the Humber Estuary Ramsar and Humber Estuary SSSI designations. The species is known to migrate through the Humber Estuary to freshwater spawning habitats, including in the River Derwent SAC, a tributary of the Humber Estuary which lists river as qualifying features; river lamprey are also listed a primary feature for selection of this site. As such these are considered to be of international importance.
Brown (Edible) crab	Regional	Most important commercial shellfish species in the Hornsea Four fish and shellfish study area, particularly. Likely to overwinter within the Hornsea Four fish and shellfish study area and potential nursery habitat in inshore areas.
Nephrops	Regional	Recorded primarily in deep water within the array area and to the north of it, coinciding with known spawning and nursery habitats. Commercially important in the Hornsea Four fish and shellfish study area.
European lobster	Regional	Considerably less abundant than brown crab but high commercial value and therefore important species to local fisheries.

VER	Valuation	Justification
Velvet swimming crab	Local	Velvet swimming crab are targeted by commercial fishing fleets in the southern North Sea fish and shellfish study area. Known to occur within the study area.
Common Whelk	Local	Species absent in array area and in ECC area.
Brown and pink shrimp	Local	Both species recorded at low abundances in the array area. Are targeted by commercial fishing fleets in the southern North Sea, and within the Hornsea Four fish and shellfish study area. Important prey species.
European common squid	Local	European common squid recorded throughout the Hornsea Four fish and shellfish study area though of limited value to commercial fisheries. Important prey species.
King scallop	Regional	Scallop are targeted by commercial fishing fleets in the southern North Sea, and within the Hornsea Four fish and shellfish study area. Known to occur within the study area. King scallop are high in commercial value and therefore important species to local fisheries.

References

Ager O.E.D. (2008). Buccinum undatum Common whelk. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews. Plymouth: Marine Biological Association of the United Kingdom. Available online: https://www.marlin.ac.uk/species/detail/1560

Allen J., Boyes S., Burdon D., Cutts N., Hawthorne E., Hemingway K., Jarvis S., Jennings K., Mander L., Murby P., Proctor N., Thomson S. and Waters R. (2003) The Humber Estuary: A comprehensive review of its nature conservation interest. English Nature Research Reports, Number 547.

Bennet D. B., Nichols J. and Huntington T. (2006). Certification Report for NESFC Lobster Fishery. Moody Marine Ltd.

Boyle G. and New P. (2018) ORJIP Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options. Final report –June 2018. The Carbon Trust, 247 pp.

BGS. (2015). Marine Sediment Particle Size Data from around the UK (1966 Onwards), electronic dataset. Available online: https://www.bgs.ac.uk/GeoIndex/offshore.htm#BGSOffMar.

Brown & May Marine (2013). Dogger Bank Creyke Beck Environmental Statement Chapter 13 Appendix A - Fish and Shellfish Technical Report.

Cefas, Defra, DTI. and MCEU (2004) Offshore Wind Farms: Guidance note for environmental impact assessment in respect of FEPA and CPA requirements, Version 2, Marine Consents Environment Unit.

Cefas (2019). Assessment of Scallop stock status for selected waters around the English Coast 2017/2018. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/799828/Scallop_assessment_2018.pdf

CIEEM (2016) Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater and Coastal. Chartered Institute of Ecology and Environmental Management. Second Edition.

Coull K.A., Johnstone R. and Rogers S.I. (1998) Fisheries Sensitivity Maps in British Waters. Published and distributed by UKOOA Ltd.,

Daan N., Heessen, H and ter Hofstede, R. (2005) North Sea Elasmobranchs: distribution, abundance and biodiversity. CM 2005 (N: 06). ICES, Copenhagen.

Eaton D.R., Brown J., Addison J.T., Milligan S.P. and Fernand L.J. (2003) Edible crab (*Cancer pagurus*) larvae surveys off the east coast of England: Implications for stock structure. Fisheries research (65), 191-199.

Ellis J.R., Milligan S., Readdy L., South A., Taylor N. and Brown M. (2010) Mapping spawning and nursery areas of species to be considered in Marine Protected Areas (Marine Conservation Zones). Report to DEFRA. Project Code MB5301.

Ellis J.R., Milligan S.P., Readdy L., Taylor N. and Brown M.J. (2012) Spawning and nursery grounds of selected fish species in UK waters. Scientific Series Technical Report. Cefas Lowestoft, (147), p56.

ERM (2012) Marine Aggregate Regional Environmental Assessment of the Humber and Outer Wash Region, Humber Aggregate Dredging Association (HADA).

Finstad, B. Økland, F. Thorstad, E. B. Bjørn, P. A. M. and McKinley, R. S. (2005) Migration of hatchery-reared Atlantic salmon and wild anadromous brown trout post-smolts in a Norwegian fjord system. Journal of Fish Biology, 66(1), 86-96.

Gardline (2019) Hornsea 4 Offshore Wind Farm Habitat Classification Report. A Survey Report for Ørsted Wind Power A/S.

Hastie L.C., Nyegaard M., Collins M.A., Moreno A., Pereira J.M.F., Piatkowski U. and Pierce G.J. (2009) Reproductive biology of the loliginid squid, Alloteuthis subulata, in the northeast Atlantic and adjacent waters. Aquatic Living Resources, (22), 35-44.

Henderson P.A., Seaby R. & Marsh, S.J. (1990) The population zoogeography of the common shrimp (Crangon crangon) in British waters. Journal of the Marine Biological Association of the United Kingdom, (70), 89-97.

Humber Nature Partnership (2016) Humber Management Scheme Action Plan. Available online: http://www.humbernature.co.uk/admin/resources/2016-action-plan-final.pdf.

ICES (2005a) Herring *Clupea harengus*. ICES – FishMap. Available online: http://www.ices.dk/explore-us/projects/EU-RFP/EU%20Repository/ICES%20FIshMap/ICES%20FishMap%20species%20factsheet-herring.pdf.

ICES (2005b) Mackerel *Scomber scombrus* Figure 3. ICES – FishMap. Available online: http://www.ices.dk/explore-us/projects/EU-RFP/EU%20Repository/ICES%20FIshMap/ICES%20FishMap%20species%20factsheet-mackerel.pdf.

ICES (2005c) Cod *Gadus morhua*. ICES – FishMap. Available online: http://www.ices.dk/explore-us/projects/EU-RFP/EU%20Repository/ICES%20FIshMap/ICES%20FishMap%20species%20factsheet-cod.pdf.

ICES (2005d) Grey gurnard Eutrigla gurnardus. ICES – FishMap. Available online: http://www.ices.dk/explore-us/projects/EU-RFP/EU%20Repository/ICES%20FIshMap/ICES%20FishMap%20species%20factsheet-greygurnard.pdf.

ICES (2005e). Sprat *Sprattus sprattus*. ICES- FishMap. Available online: http://www.ices.dk/explore-us/projects/EU-RFP/EU%20Repository/ICES%20FIshMap/ICES%20FishMap%20species%20factsheet-sprat.pdf.

ICES (2005f). Common Sole *Solea solea* Figure 3. ICES- FishMap. Available online: http://www.ices.dk/explore-us/projects/EU-RFP/EU%20Repository/ICES%20FIshMap/ICES%20FishMap%20species%20factsheet-sole.pdf.

ICES (2005g) Whiting *Merlangius merlangus*. ICES-FishMap. Available online: http://www.ices.dk/explore-us/projects/EU-RFP/EU%20Repository/ICES%20FIshMap/ICES%20FishMap%20species%20factsheet-whiting.pdf

ICES (2005h) Plaice *Pleuronectes platessa*. ICES-FishMap. Available online: http://www.ices.dk/explore-us/projects/EU-RFP/EU%20Repository/ICES%20FIshMap/ICES%20FishMap%20species%20factsheet-plaice.pdf

ICES (2005i) Thornback Ray *Raja clavate*. ICES-FishMap. Available online: http://www.ices.dk/explore-us/projects/EU-RFP/EU%20Repository/ICES%20FIshMap/ICES%20FishMap%20species%20factsheet-thornback.pdf

ICES (2013) ICES Data Centre, Eggs and Larvae Data Fact Sheet, 2013. Available online: http://www.ices.dk/marine-data/dataset-collections/Documents/EggsAndLarvaeDataset.pdf.

ICES (2017a) International Beam Trawl Survey. International Council for the Exploration of the Sea. Available online: http://datras.ices.dk/home/descriptions.aspx.

ICES (2017b). Report of the Working Group on Elasmobranchs. 1018 pp.

ICES (2007–2017) International Herring Larvae Survey, electronic dataset. [Accessed on 12 March 2019]. Available online: http://www.ices.dk/marine-data/data-portals/Pages/Eggs-and-larvae.aspx.

JNCC (2018) UKSeaMap. Available online: http://jncc.defra.gov.uk/ukseamap.

(

Latto P. L., Reach I.S., Alexander D., Armstrong S., Backstrom J., Beagley E., Murphy K., Piper R. and Seiderer L.J. (2013) Screening spatial interactions between marine aggregate application areas and sandeel habitat. A Method Statement produced for BMAPA.

Lawler A., Masefield R. and Wynne, S. (2019). Assessment of Scallop stock status for selected waters around the English Coast 20017/2018. CEFAS.

Lelievre S., Jerome M., Maes G.E., Vaz S., Calaivany S., Verrez-Bagnis V. (2012) Integrating molecular identification of pelagic eggs with geostatistical mapping to improve the delineation of North Sea fish spawning grounds. Marine Ecology Progress Series, (445), 161-172.

Lynam C.P., Heath M.R., Hay S.J. and Brierley A.S. (2005). Evidence for impacts by jellyfish on North Sea herring recruitment. Marine Ecology Progress Series, (298), 157-167.

Marine Ecological Surveys Limited (2008) Marine macrofauna genus trait handbook. Marine Ecological Surveys Limited. 184p.

Marine Scotland (2017). Atlantic Salmon *Salmo Salar* smolt movements in the Cromarty and Moray Firths, Scotland. [online] Available at: http://marine.gov.scot/sites/default/files/00534044.pdf.

Neal K and Wilson E. (2008). *Cancer pagurus*. Edible crab. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme. Plymouth: Marine Biological Association of the United Kingdom. Available online: https://www.marlin.ac.uk/species/detail/1179.

Neal K.J. (2008). *Crangon crangon* Brown shrimp. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews. Plymouth: Marine Biological Association of the United Kingdom. [cited 05-05-2019]. Available online: https://www.marlin.ac.uk/species/detail/2031

Ørsted (2018) Hornsea Four Environmental Impact Assessment: Scoping Report.

Perez-Dominguez R. (2008) Fish pilot studies in the Humber Estuary, UK. Institute of Estuarine & Coastal Studies (IECS), University of Hull, UK. Report produced as part of the European Interreg IIIB HARBASINS project.

Predictive European Nature Information System (EUNIS) seabed habitats. (2017) European Marine Observation and Data Network (EMODnet). Available online: http://www.emodnet.eu/.

Proctor N., Elliott M. and Allen J. (2000) Fish Impingement Assessment: South Humber Bank Power Station 1999-2000. Report to Humber Power Ltd., Report No. Z096-F1-2000.

Proctor N. and Musk W. (2001) Fish Impingement Assessment: South Humber Bank Power Station 2000-2001. Report to Humber Power Ltd., Report No. Z109-F-2001.

Reach I.S., Latto P., Alexander D., Armstrong S., Backstrom J., Beagley E., Murphy K., Piper R. And Seiderer L.J. (2013). Screening Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Areas. A Method Statement produced for the British Marine Aggregates Producers Association.

Rogers, S.I., Millner, R.S. and Mead, T.A. (1998) The distribution and abundance of young fish on the east and south coast of England (1981 to 1997). Cefas, Science Series Technical Report No. 108, 133p.

Rowley S.J. (2008) *Ammodytes tobianus* Lesser sand eel. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews. Plymouth: Marine Biological Association of the United Kingdom. Available online: https://www.marlin.ac.uk/species/detail/2067.

RPS (2018). Hornsea Three Offshore Windfarm Environmental Statement. Fish and Shellfish Ecology Technical Report. PINS Document Reference: A6.5.3.1. APFP Regulation 5(2)(a).

Ruiz A. (2008) *Pandalus montagui*. Pink shrimp. In Tyler-Walters H. and Hiscock K. (eds). Marine Life Information Network: Biology and Sensitivity Key Information Reviews. Plymouth: Marine Biological Association of the United Kingdom. Available online: https://www.marlin.ac.uk/species/detail/2181.

Scira Offshore Energy (2006) Sheringham Shoal offshore wind farm. Environmental Statement.

Squoitti, C., Lynam, C.P., Garcia-Careras, B., Ellis, J.R and Engelhard, G.H (2016) Distribution of skates and sharks in the North Sea:112 years of change. Global Change Biology. Doi: 10.1111/gcb.13316.

SMart Wind (2015) Hornsea Project Two Environmental Statement. Annex 5.3.1: Fish and shellfish technical report. PINS Document Reference: 7.5.3.1. APFP Regulations 5(2)(a).

Stephens, D. and Diesing, M. (2015) Towards Quantitative Spatial Models of Seabed Sediment Composition. PLoS One 10(11): 30142502. Doi: 10.1371/journal.pone.0142502.

Sundby, S., Kristiansen, T., Nash, R. and Johannessen, T. (2017). Dynamic Mapping of North Sea Spawning – Report of the KINO Project. Fisken og havet;2-2017. [online] Havforskningsinstituttet. Available at: http://hdl.handle.net/11250/2440959.

The Planning Inspectorate (PINS) (2018). Scoping Opinion. Proposed Hornsea Four Wind Farm. Available online: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010098/EN010098-000064-H4WF%20-%20Scoping%20Opinion.pdf.

Thorstad, E.B., Okland, F., Finstad, B., Silvertsgard, R., Bjorn, P.A. and McKinley, R.S. (2004) Migration speeds and orientation of Atlantic salmon and sea trout post-smolts in a Norwegian fjord system Environmental Biology of Fishes, (71), 305-311.

Triton Knoll Offshore Wind Farm Ltd. (2011) Triton Knoll Offshore Wind Farm. Shellfish ecology characterisation bi-monthly potting surveys. Prepared by RPS on behalf of Triton Knoll Offshore Wind Farm Ltd. May 2011, 20p.

van der Land, M.A. (1990). Distribution and mortality of pelagic eggs of by-catch species in the 1989 egg surveys in the southern North Sea. ICES CM 1990/H:19.

Walker, P. A. and Heesen, H.J.L. (1996) Long-term changes in ray populations in the North Sea. ICES J. Mar. Sci., 53: 1085–1093p.

Wilson, E. (2008). *Necora puber* Velvet swimming crab. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews. Plymouth: Marine Biological Association of the United Kingdom. [cited 05-05-2019]. Available online: https://www.marlin.ac.uk/species/detail/1181