
# Hornsea Project Four: Environmental Statement (ES)

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# Volume A5, Annex 3.1: Fish and Shellfish Ecology Technical Report

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Version B

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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. |
| Commitment | A term used interchangeably with mitigation and enhancement measures. Commitments are Embedded Mitigation Measures. The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSEs), in EIA terms. Primary (Design) or Tertiary (Inherent) are both embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, Preliminary Environmental Information Report (PEIR) or ES). Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e. so that residual effects are acceptable. |
| Catch Per Unit Effort (CPUE) | CPUE is the total catch divided by the total amount of effort used to harvest the catch. |
| 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. |
| Hornsea Project Four Offshore Wind Farm | The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four. |
| 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. |
| Order Limits | The limits within which Hornsea Project Four (the 'authorised project) may be carried out. |
| Orsted Hornsea Project Four Ltd | The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO). |
| 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. |
| Philopatric | Species that tend to return to, or remain near, a particular site or area (typically associated with spawning behaviours). |
| Raster data | A matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing abundance information. |

| Term | Definition |
|---|---|
| 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 |
| CPUE | Catch Per Unit Effort |
| DCO | Development Consent Order |
| ECC | Export Cable Corridor |
| EIA | Environmental Impact Assessment |
| ES | Environmental Statement |
| GSI | Gonadal Somatic Index |
| 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 |
| NERC | Natural Environment and Rural Communities |
| NIMF | Nationally Important Marine Features |
| 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 |
| RIAA | Report to Inform Appropriate Assessment |
| rMCZ | Recommended Marine Conservation Zone |
| SAC | Special Area of Conservation |
| SCI | Site of Community Importance |
| SSSI | Site of Special Scientific Interest |
| 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 Orsted Hornsea Project Four Ltd (hereafter the 'Applicant') is proposing to develop the Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four'). Hornsea Four will be located approximately 69 km offshore the East Riding of Yorkshire in the southern North Sea and will be the fourth project to be developed in the former Hornsea Zone (please see **Volume A1, Chapter 1: Introduction** for further details on the Hornsea Zone). Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network. The location of Hornsea Four is illustrated in (**Figure 1**). The Order Limits combines the search areas for the offshore infrastructure.

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

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

1.1.1.4 GoBe Consultants Ltd. was commissioned by the Applicant to undertake a fish and shellfish study of the Hornsea Four Order Limits 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 benthic ecology characterisation surveys undertaken for Hornsea Four (**Section 2.2.2**).

1.1.1.5 This report has been produced following a review of the Scoping Opinion provided by the Planning Inspectorate (PINS) and subsequently the Section 42 responses provided by stakeholders in response to the publication of the PEIR.

### 1.1.2 Aims and Objectives

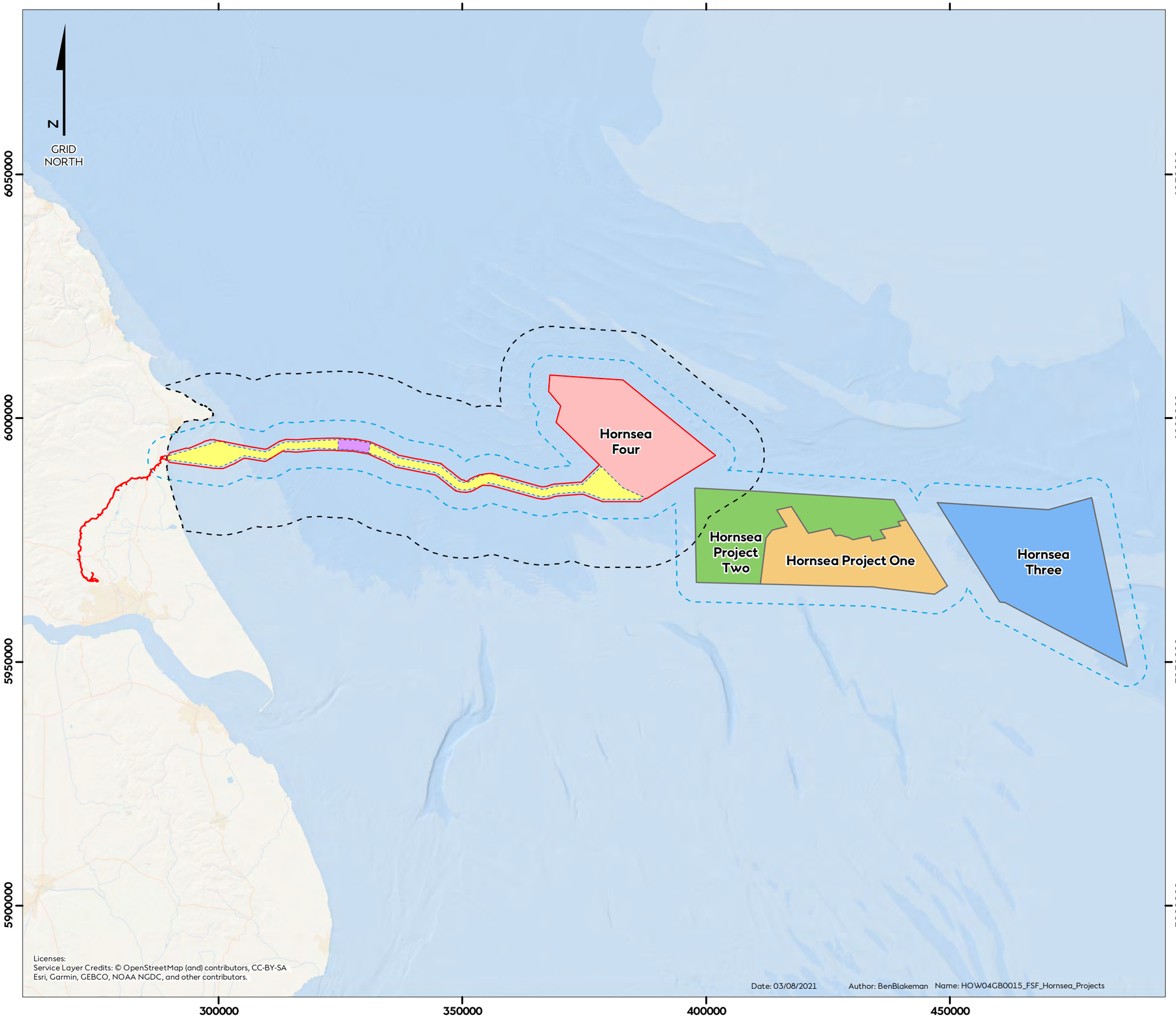
1.1.2.1 The aim of this study is to provide an up to date characterisation of the fish and shellfish ecological resources within a defined study area, which incorporates the offshore components of Hornsea Four and the zone of potential impact.

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), Hornsea Project Three Offshore Wind Farm (Hornsea Three), and Dogger Bank A and B Offshore Wind Farms (Dogger Bank A and B), together with new data collected specifically for Hornsea Four (**Section 2.2.2**), a general description of the fish and shellfish assemblages within the defined fish and shellfish study area is provided (**Figure 1**).

# Hornsea Four

Figure 1

Hornsea Four Fish and Shellfish Study Area




- Fish and Shellfish Study Area
- 4km Buffer from Hornsea projects, Hornsea Four array and Hornsea Four Offshore Export Cable Corridor
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations
- Hornsea Project One
- Hornsea Project Two
- Hornsea Three


Coordinate system: ETRS 1989 UTM Zone 31N

*Scale@A3:* 1:750,000

0 10 20 Kilometres

0 10 20 Nautical Miles

| REV | REMARK | DATE |
|---|---|---|
| ... | First Issue for PEIR | 08/05/2019 |
| A | Updated following PEIR consultations, for DCO | 03/08/2021 |
| | | |
| | | |
| | | |

The location of Hornsea Four and other Hornsea projects
Document no: HOW04GB0015
Created by: BPHB
Checked by: AdB
Approved by: LK

GoBe Ørsted

# 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. The area within this buffer was surveyed as part of previous Hornsea survey campaigns from 2010 to 2017; and
- A 10 km buffer surrounding the Hornsea Four array area, and a 14 km buffer around the offshore Export Cable Corridor (ECC), to represent the tidal ellipse distance, in order to incorporate the maximum distance sediments may travel in one tidal cycle.

2.1.1.2 A wider study area has been considered for noise impacts within the Environmental Statement (ES) assessment based on the results of the noise modelling. To provide the baseline data for the assessment, consideration is also given to the fish and shellfish populations within the wider area.

## 2.2 Desktop Review

### 2.2.1 Overview

2.2.1.1 A detailed desktop review has been 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 Figure 1). Information was sought on fish and shellfish ecology in general and on spawning and nursery behaviour and habitats for key species. Species of commercial importance were identified by reference to the Annex 6.1: Commercial Fisheries Technical Report, and the individual species accounts presented herein detail whether or not the species assessed are considered to be of commercial importance.

### 2.2.2 Data Sources

2.2.2.1 Data to support the baseline characterisation of the Hornsea Four study area has been derived 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 (SMart Wind 2013) | Used to provide information regarding the fish and shellfish ecology of the sites. The surveys also provided Particle Size Analysis (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 (SMart Wind 2015) | |
| Hornsea Three Technical Report (Orsted 2018a) | |
| Dogger Bank A and B ES baseline characterisation study (Forewind 2013) | |

| Data Source | Data utilisation |
|---|---|
| Hornsea Four Array Area Habitat Classification Report (Gardline 2019) (Appendix A of **Annex 2.1 Benthic and Intertidal Ecology Technical Report**) | Provided site-specific PSA data to provide an indication on the location of suitable habitat and spawning grounds for sandeel and herring along the Hornsea Four offshore ECC and array area. |
| Hornsea Four Export Cable Corridor Benthic Environmental Baseline Survey (GoBe 2020) (Appendix D of **Annex 2.1 Benthic and Intertidal Ecology Technical Report**) | |
| British Geological Society (BGS) Marine Sediment Particle Size dataset sourced from the BGS GeoIndex Offshore portal[1] | |
| Fisheries Sensitivity Maps in British Waters (Coull et al. 1998) | Used to provide information on likely spawning or nursery areas for commercial species. |
| Mapping spawning and nursery areas of species to be considered in Marine Protected Areas (Marine Conservation Zones) (Ellis et al. 2010). | Provided information on fish spawning and nursery grounds. |
| Spawning and nursery grounds of selected fish species in UK waters. Scientific Series Technical Report (Ellis et al. 2012) | |
| The International Herring Larval Survey (IHLS) data (ICES 2007–2021)[2] | Provided a quantitative estimate of herring larval abundance within potential and historic spawning grounds. |
| The International Bottom Trawl Surveys (IBTS) Report (ICES 2020) | Provided information on distribution of target species. |
| Full coverage Folk and European Nature Information System (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. |
| The Offshore Renewables Joint Industry Programme (ORJIP) Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options (Boyle and New 2018) | Provided guidance on the methodology used to determine herring spawning grounds. |

### 2.2.3 Survey methodology

2.2.3.1 Historic 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 fish and shellfish study area. Despite these survey locations not being within the Hornsea Four array area, the data from these trawls are presented within this characterisation to provide further background information on the fish and shellfish communities in this part of the Southern North Sea.

2.2.3.2 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 array areas of both projects. 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 numbers of actively spawning herring (*Clupea harengus*) 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.

[1] https://www.bgs.ac.uk/GeoIndex/offshore.htm#BGSOffMar
[2] http://www.ices.dk/marine-data/data-portals/pages/eggs-and-larvae.aspx).

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

- 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.

2.2.3.4 For a detailed description of the methodologies followed, refer to the Hornsea Three Fish and Shellfish Ecology Technical Report (Orsted 2018a).

2.2.3.5 Data from baseline characterisation surveys completed for Dogger Bank A and B were also used to inform this technical report within the offshore ECC, as the landfall location and nearshore parts of the Dogger Bank A and B ECC overlaps with the ECC for Hornsea Four. The Dogger Bank A and B surveys 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 Dogger Bank A and B 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 A and B Fish and Shellfish Ecology Technical Report (Forewind 2013).

2.2.3.6 This baseline report has used the data from historic surveys within the former Hornsea Zone, combined with information from wider survey work, including that in published literature, in order to identify the average abundance (based on catch per unit effort (CPUE)) of species within the locality of Hornsea Four. This information therefore clearly identifies whether species of concern are in the area and have the potential to be affected by the works (and are therefore required to be considered in the assessment).

### 2.2.4 Spawning and nursery habitats

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

2.2.4.2 In particular, herring and sandeel (*Ammodytes tobianus*) have been highlighted as key species of relevance in the Scoping Opinion (PINS 2018) when considering impacts to spawning habitats. This is primarily due to their demersal spawning behaviour, with each species having specific sediment requirements for spawning. A baseline characterisation of herring and sandeel spawning grounds within the study area has been undertaken using the annual IHLS data from the last ten years (ICES 2007–2021). In addition, habitat data has been reviewed for use as potential spawning habitat. An overview of the methodologies used are given below.

*Herring*

2.2.4.3 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 IHLS data from the last ten years to determine the key spawning habitats and to provide a more nuanced view of the spawning trends of herring over the previous decade, as actually recorded from the extensive herring larval survey program. The methodology used follows that of Boyle and New (2018).

2.2.4.4 IHLS data was first downloaded from the ICES Eggs and Larvae data pages[3] for the last ten available years (2007/08 to 2016/17 data) for all larval size classes <11 mm, to provide an updated analysis of herring larvae distribution. Since publication of the PEIR, new data is available for the IHLS from 2019 – 2021; this data has been combined with the 2007 – 2017 data to extend the timeseries. The time range of data utilised provides an up-to-date distribution of spawning activity (and by proxy the associated spawning habitat), 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).

2.2.4.5 The query outputs were separate annual spawning season datasets, and a dataset for the full period (2007/08 – 2020/21) 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 data points, so that the extrapolation of the heat maps covers the full IHLS survey area.

2.2.4.6 Rasters (a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing abundance information) produced were then categorised in ArcGIS, using the methodology summarised in **Figure 2**.

[3] ICES Eggs and Larvae data pages (http://www.ices.dk/marine-data/data-portals/Pages/Eggs-and-larvae.aspx

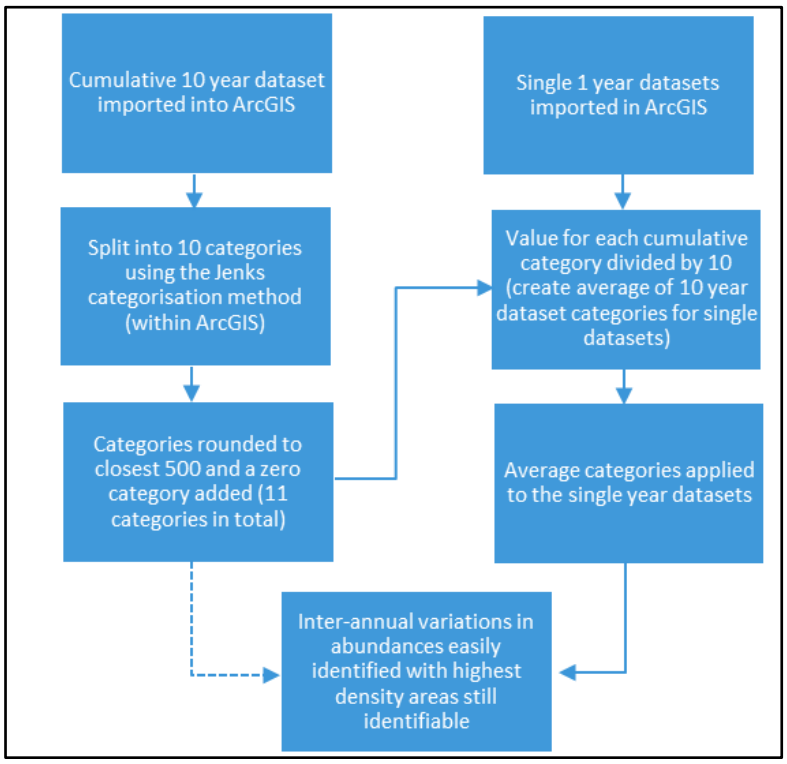



**Figure 2: Data categorisation methodology (reproduced from Boyle and New (2018)).**

2.2.4.7 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.

2.2.4.8 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, acting as proxy for the identification of the most important and active spawning grounds. The data have then been presented alongside the more broadscale Coull et al. (1998) fish sensitivity maps, that show historic and potential spawning sites and nursery areas. The results of this analysis are summarised in **Section 3** below.

2.2.4.9 In addition, PSA data from the benthic ecology and geophysical baseline characterisation surveys for the former Hornsea Zone, Hornsea Project One, Hornsea Project Two, Hornsea Three, and data from BGS have been presented alongside site-specific PSA data (presented in the Hornsea Four Array Area Habitat Classification Report (Gardline 2019) (Appendix A of **Annex 2.1 Benthic and Intertidal Ecology Technical Report**) and the Hornsea Four Export Cable Corridor Benthic Environmental Baseline Survey (GoBe, 2020) (Appendix D of **Annex 2.1 Benthic and Intertidal Ecology Technical Report**) and broadscale marine habitat data generated from EUNIS and Folk (1954) (Stephens and Diesing 2015).

2.2.4.10 These PSA data were processed in accordance with the methodologies described in Reach et al. (2013), and classified using the categories summarised 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, part sandy Gravel and part gravelly Sand | Unsuitable | Unsuitable |

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

*Sandeel*

2.2.4.12 PSA data from the baseline benthic ecology and geophysical characterisation surveys for the former Hornsea Zone, Hornsea Project One, Hornsea Project Two, Hornsea Three, and data from the BGS were presented alongside site-specific PSA data (Gardline 2019; GoBe 2020) and broadscale marine habitat data generated from EUNIS and Folk (1954) (Stephens and Diesing 2015).

2.2.4.13 The PSA data were processed in accordance to the methodologies described in Latto et al. (2013), and classified using the categories summarised in Table 3 to identify the 'preferred, marginal and unsuitable' sandeel 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 |

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

## 2.3 Data Limitations and sensitivities

### 2.3.1 Fish and Shellfish Ecology

2.3.1.1 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.

2.3.1.2 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).

### 2.3.2 Spawning and nursery grounds

2.3.2.1 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 and nursery habitats 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 historic 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.

2.3.2.2 The spatial extent of spawning habitats 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. Currently active spawning habitats may therefore be smaller in extent and display shorter spawning periods in some cases. In some cases, spawning grounds may no longer be active, for example the Dogger Bank herring spawning ground.

2.3.2.3 The EUNIS and Folk (1954) (Stephens and Diesing 2015) broadscale marine habitat data used as one of the data sets 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 of the datasets presented, to develop a clear overview of preferred sandeel and herring habitat.

2.3.2.4 It should also be noted that the use of PSA data and broadscale habitat mapping only provides a proxy for the presence of sandeel and herring spawning habitat 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 report in determining the location and relative importance of spawning habitats.

# 3 Results

## 3.1 Fish ecology

3.1.1.1 Historic trawl surveys (**paragraph 2.2.3.1** *et seq.*) have recorded the presence of a number of species of conservation importance within the Hornsea Four study area, including Atlantic salmon (*Salmo salar*), Atlantic cod (*Gadus morhua*), whiting (*Merlangius merlangus*),

plaice (*Pleuronectes platessa*), common sole (*Solea solea*), herring, mackerel (*Scomber scombrus*), lesser sandeel, spotted ray (*Raja montagui*). and thornback ray (*Raja clavate*) (Table 9). Sprat (*Sprattus sprattus*), dab (*Limanda limanda),* lemon sole (*Microstomus kitt*) and solenette (*Buglossidium luteum*) were also recorded.

3.1.1.2 A total of 84 species were recorded in the historic otter and epibenthic beam trawls undertaken within the study area; several species were recorded frequently with dab occurring in 93.2% of trawls.

3.1.1.3 Fish species recorded in historic epibenthic beam trawls within the study area were dominated in abundance by solenette. Additional flatfish species recorded included scaldfish (*Arnoglossus laterna*), dab, plaice and lemon sole. Common dragonet (*Callionymus lyra*), goby species (*Gobiidae* spp.), lesser weever (*Echiichthys vipera*), whiting and sandeels were also recorded in the area.

3.1.1.4 Historic otter trawls undertaken within the fish and shellfish study area (paragraph 2.2.3.1 *et seq*) were dominated by whiting and sprat, with herring recorded at high abundances during the spring. Dab and plaice were recorded, with moderate abundances, with brill (*Scophthalmus rhombus*), sole, lemon sole, cod, and sandeel recorded at much lower abundances in the area. Additional species recorded within the trawls include grey gurnard (*Eutrigla gurnardus*), lesser weever, and the European common squid (*Loligo vulgaris*). Limited seasonal variation is reflected in species catches, with slightly higher catches in spring, likely due to differences in the abundance of clupeid species.

3.1.1.5 Within baseline characterisation surveys conducted within the inshore section of the Dogger Bank A and B ECC (where it overlaps with the nearshore ECC and proposed landfall for the Hornsea Four ECC), the most dominant species caught in trammel net surveys were the lesser spotted dogfish (*Scyliorhinus canicula*), whiting and dab.

### 3.1.2 Species by species catch per unit effort (CPUE)

3.1.2.1 Figure 3 to Figure 22 show the distributions and CPUE of key species (those with the highest recorded abundances in historic surveys conducted across the study area (see paragraphs 2.2.3.1 *et seq.*)), and those of commercial importance (see Annex 6.1: Commercial Fisheries Technical Report). 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, a species of conservation importance (UK Biodiversity Action Plan (BAP)), and Natural Environment and Rural Communities (NERC) Act 2006), was one of the most abundant species recorded from historic otter and epibenthic beam trawl surveys conducted throughout the Hornsea Four fish and shellfish study area (see paragraphs 2.2.3.1 *et seq).* Figure 3 shows the abundance and distribution of whiting across the Hornsea Four fish and shellfish study area, with catches of up to 800 individuals per 500 m recorded within the Hornsea Four array area, and to the south east of the array area. Abundances recorded during historic epibenthic beam trawls were lower than that recorded from the otter trawl samples across the Hornsea Four fish and shellfish study area (up to 50 caught per 500 m). Whiting were also recorded in relatively high abundances in trammel net surveys (measured as catch per hour) conducted in the nearshore section of the Hornsea

Four ECC (as recorded in the Dogger Bank A and B surveys), with catches of up to 6.5 whiting per hour.

3.1.2.3 High intensity nursery grounds are located across the array area and EEC for Hornsea Four, with low intensity spawning grounds also present across the array area (**Figure 3** and **Figure 4**) (Ellis et al. 2010). In a broader context, whiting are widely distributed throughout the North Sea, with high densities found almost everywhere except surrounding the Dogger Bank (ICES 2005g). Data from the IBTS supports this conclusion, 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), including within the Hornsea Four ECC area.

*Dab*

3.1.2.4 As can be seen in **Figure 5**, dab were consistently recorded at high abundances within the Hornsea Four fish and shellfish study area, with highest abundances in offshore areas within the Hornsea Four array area (up to 250 caught per 500 m) and to the south east of the array, as observed in historic trawls throughout the Hornsea Four fish and shellfish study area (**paragraph 2.2.3.1** *et seq*).

3.1.2.5 Dab were also recorded in high numbers in inshore trammel net surveys carried out in the nearshore section of the Hornsea Four ECC (**Figure 6**) (up to 6.5 per hour) (as observed in the Dogger Bank A and B 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 fish and shellfish study area, with a high intensity spawning area located off Flamborough Head and along the southern edge of the Dogger Bank, offshore 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 have been identified as a species of commercial importance in **Annex 6.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

3.1.2.9 As shown in **Figure 7**, plaice were recorded throughout the array area and to the south east of the array in historic epibenthic and otter trawls (**paragraph 2.2.3.1** *et seq*) (up to 100 per 500 m in otter trawls). Trammel netting surveys undertaken in the nearshore section of the Hornsea Four ECC recorded lower catch rates of plaice (in the Dogger Bank A and B 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 also located to the west of the array area, across the nearshore section of the Hornsea Four ECC.

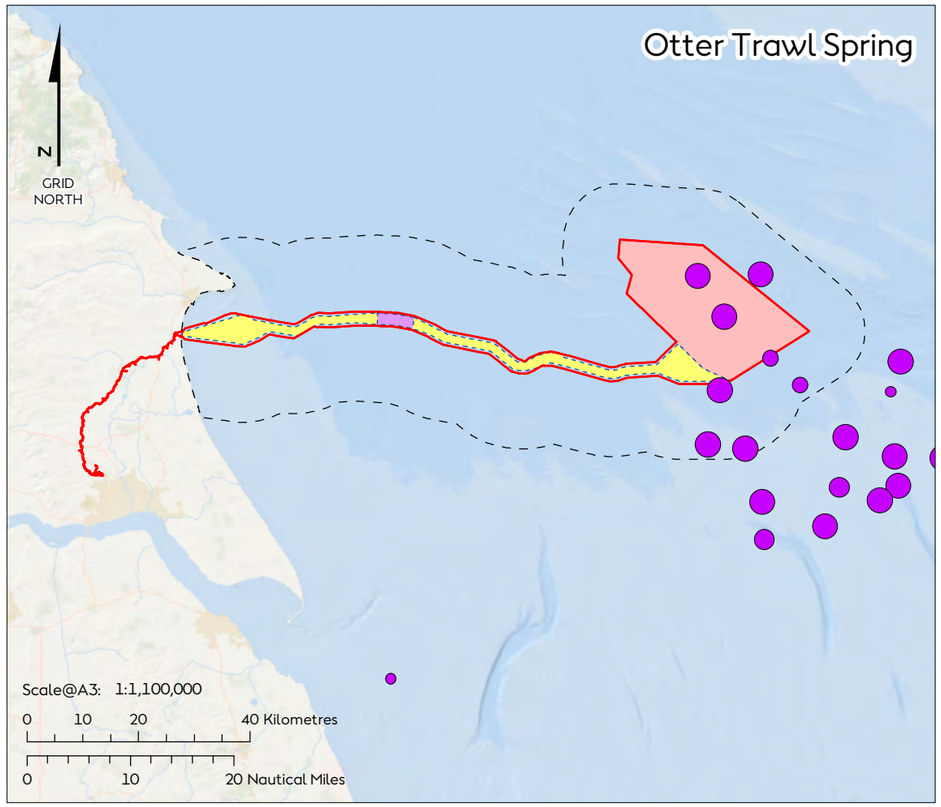
3.1.2.11 In a broader context, in the North Sea juvenile plaice are concentrated in the Southern and German Bights, and also occur along the east coast of Britain, and in the Skagerrak and Kattegat. Juveniles are typically of low densities in the Central North Sea, and almost absent for the north eastern 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)

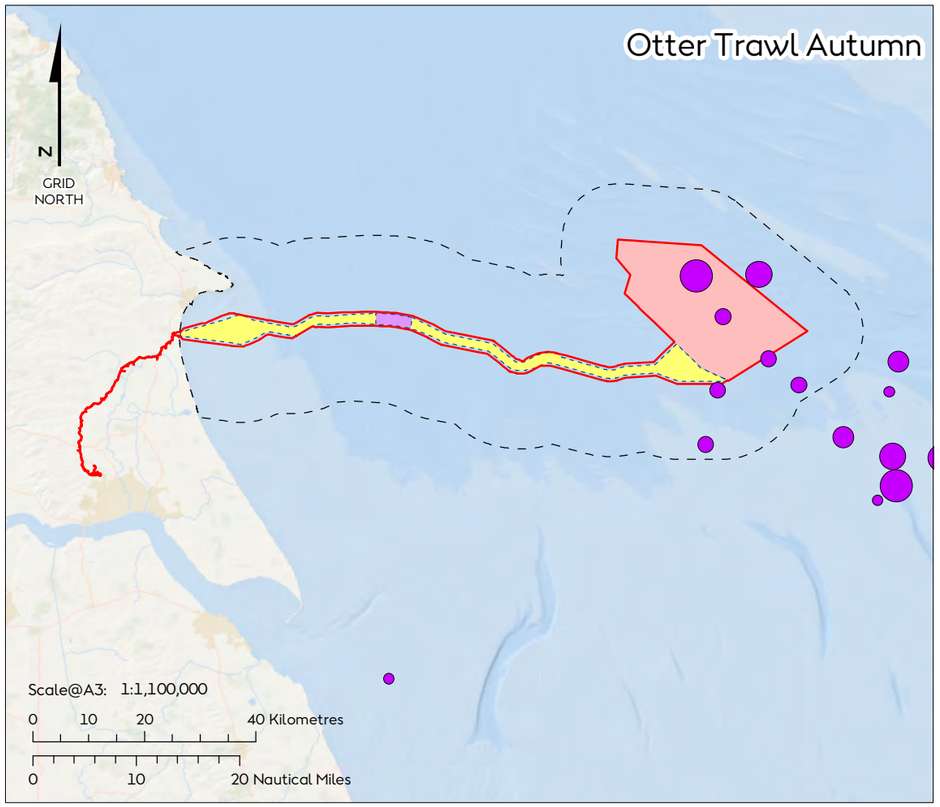
*Cod*

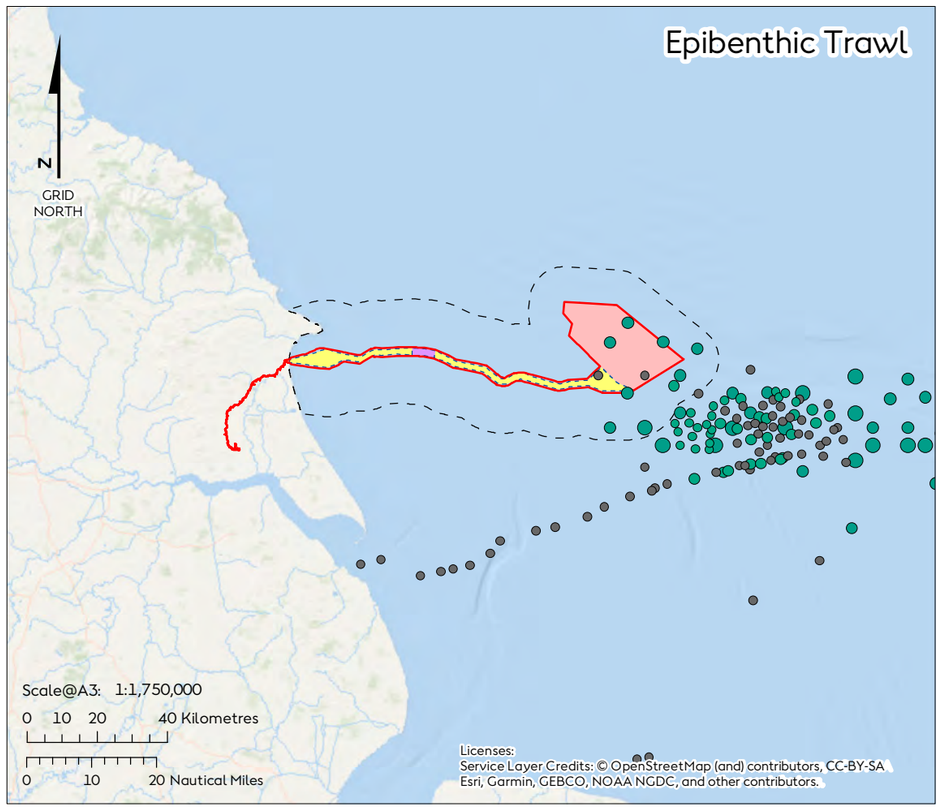
3.1.2.12 Cod were reviewed in this technical report due to their commercial importance as well as being a species of conservation importance (UK BAP and NERC Act 2006).

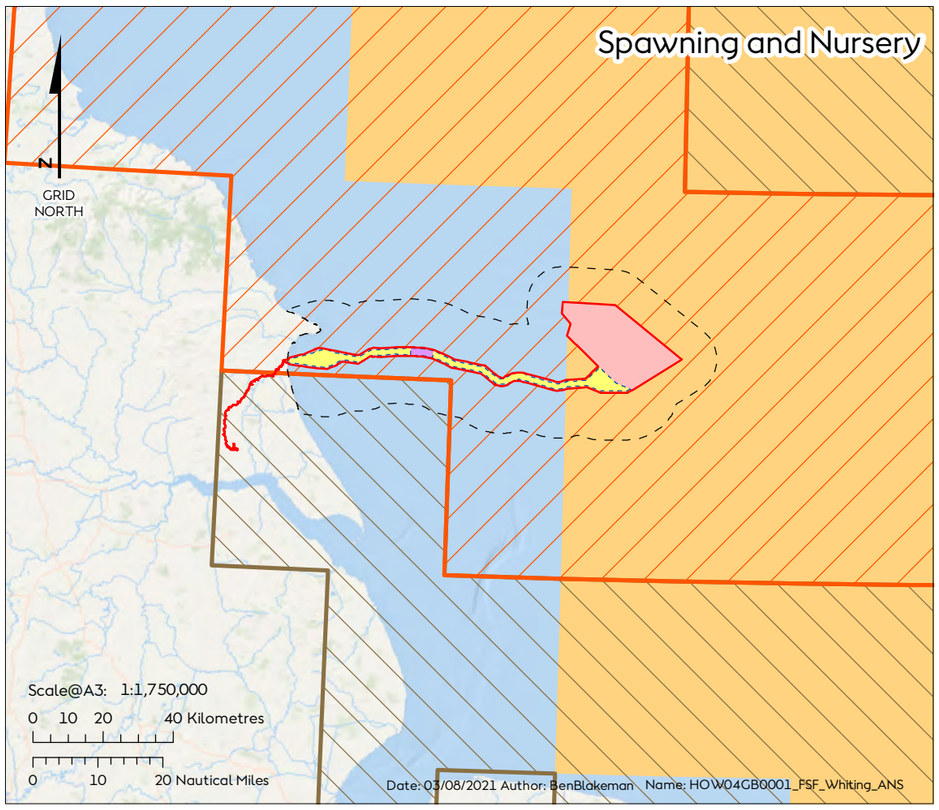
3.1.2.13 Historic trawl survey data for cod presence across the Hornsea Four fish and shellfish study area (**paragraph 2.2.3.1** *et seq*) indicates distribution patterns consistent with those observed in the IBTS data, with high abundances occurring in the Central and Northern North Sea, around Dogger Bank and in the Southern Bight (ICES 2005c). Cod were recorded in historic otter and epibenthic trawls (up to 30 per 500 m) to the south east of the Hornsea Four array area and was not found to be one of the main characterising species of the fish assemblage (**Figure 9**). Trammel net surveys (Dogger Bank A and B surveys) undertaken in the nearshore section of the Hornsea Four ECC recorded no catches of cod (**Figure 10**).

3.1.2.14 Cod spawning grounds are typically widespread and not restricted to specific areas, being recorded 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 Hornsea Four (Ellis et al., 2010), with low intensity nursery grounds located across the study area (Ellis et al. 2010) (**Figure 9**).




# Hornsea Four

Figure 3

Whiting Abundance and Nursery and Spawning Grounds within the Hornsea Four array area

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Otter Trawl CPUE (catch/500m)**

- 1 - 10
- 10 - 50
- 50 - 100
- 100 - 500
- 500 - 800

**Epibenthic Trawl CPUE (catch/500m)**

- 0
- 1 - 10
- 10 - 50

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

- Low Intensity

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

- High Intensity
- Low Intensity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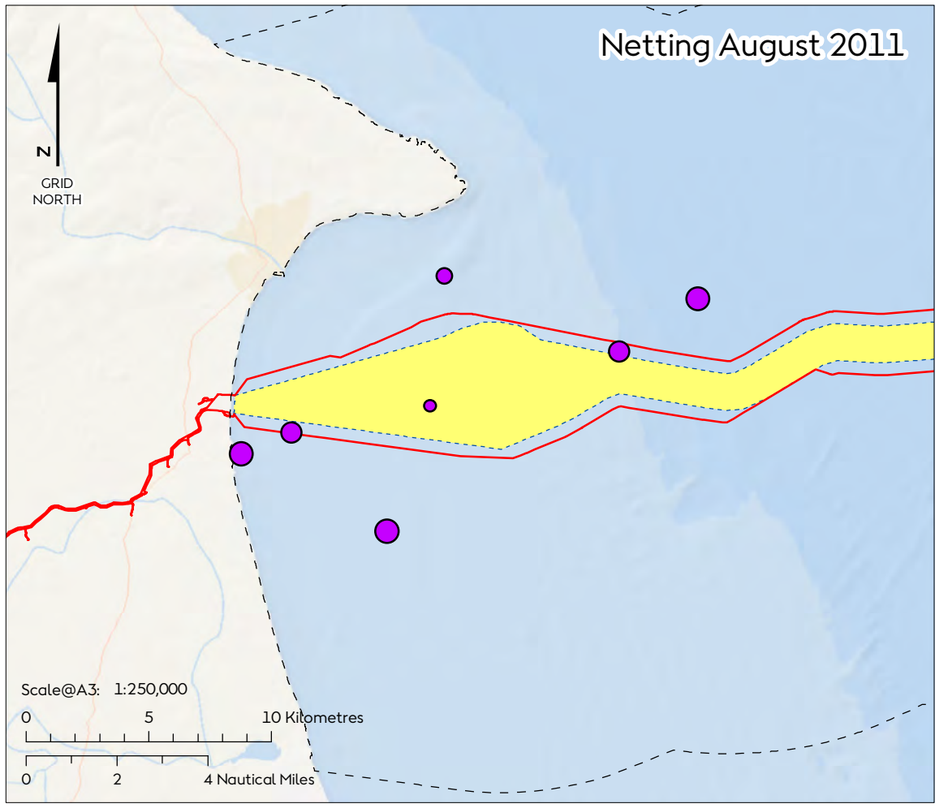
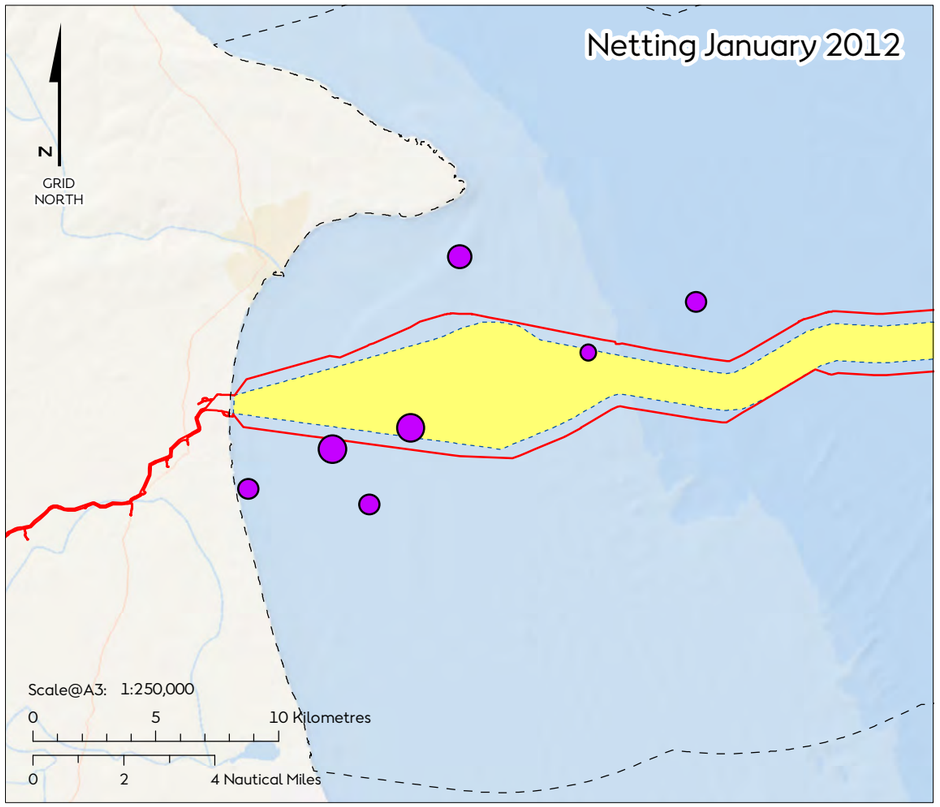
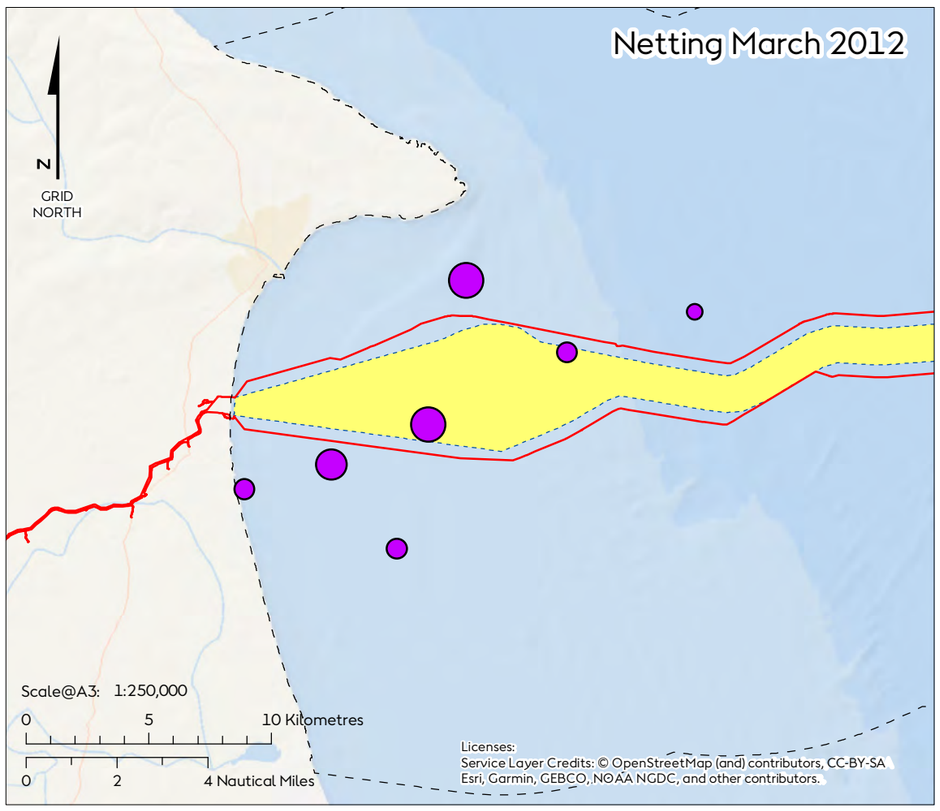
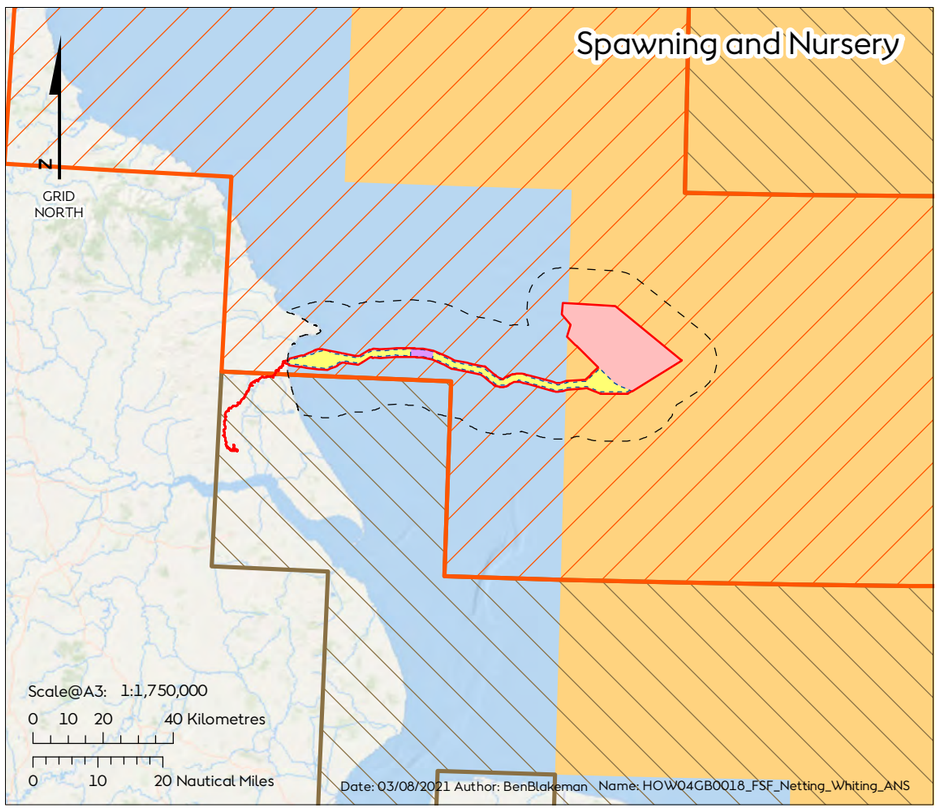



# Hornsea Four

Figure 4

Whiting Abundance and Nursery and Spawning Grounds within the Hornsea Four ECC

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Trammel Netting CPUE (abundance/hour)**

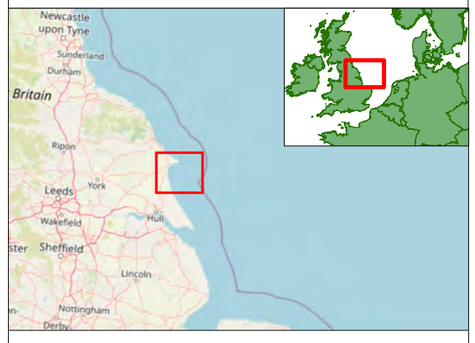
- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- 4 - 6.5

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

- Low Intensity

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

- High Intensity
- Low Intensity

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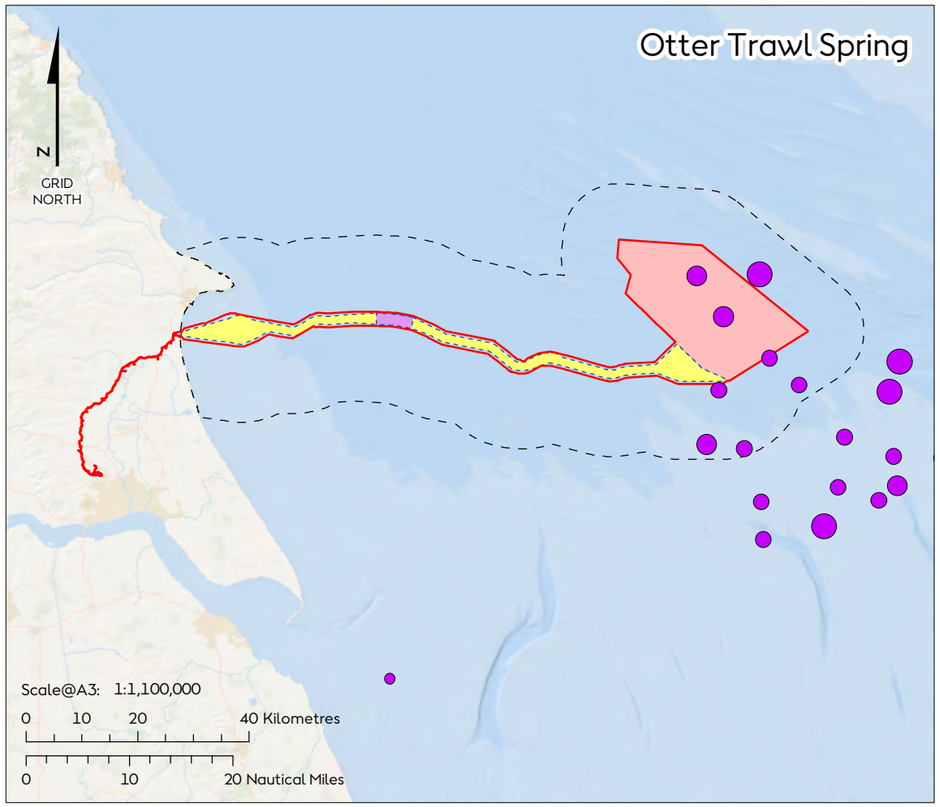


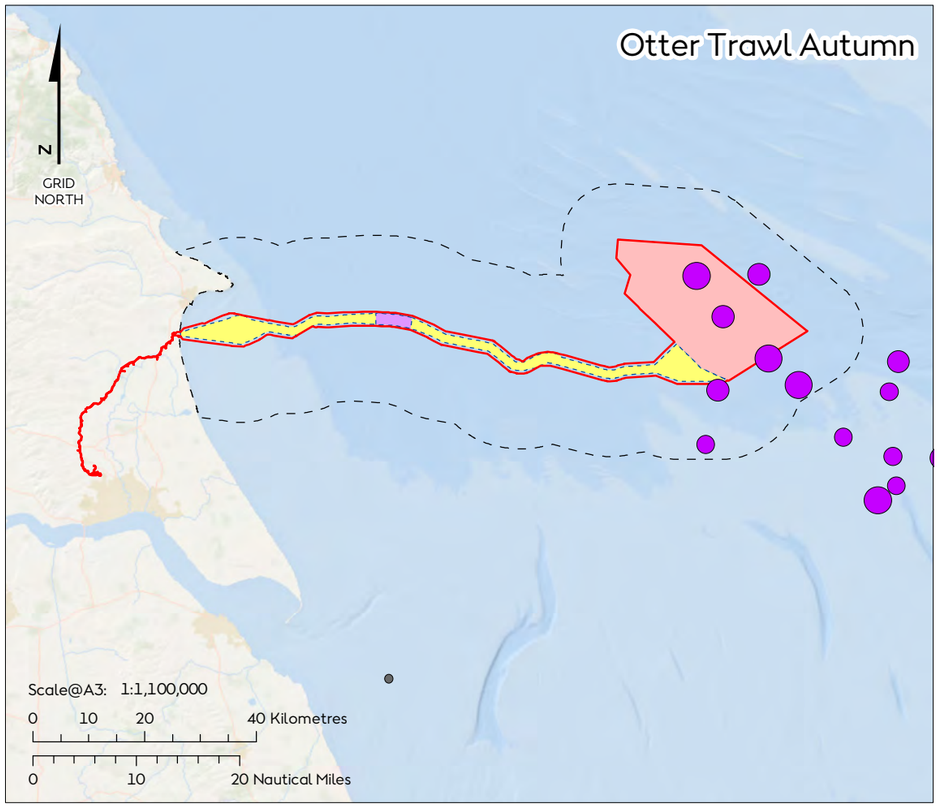


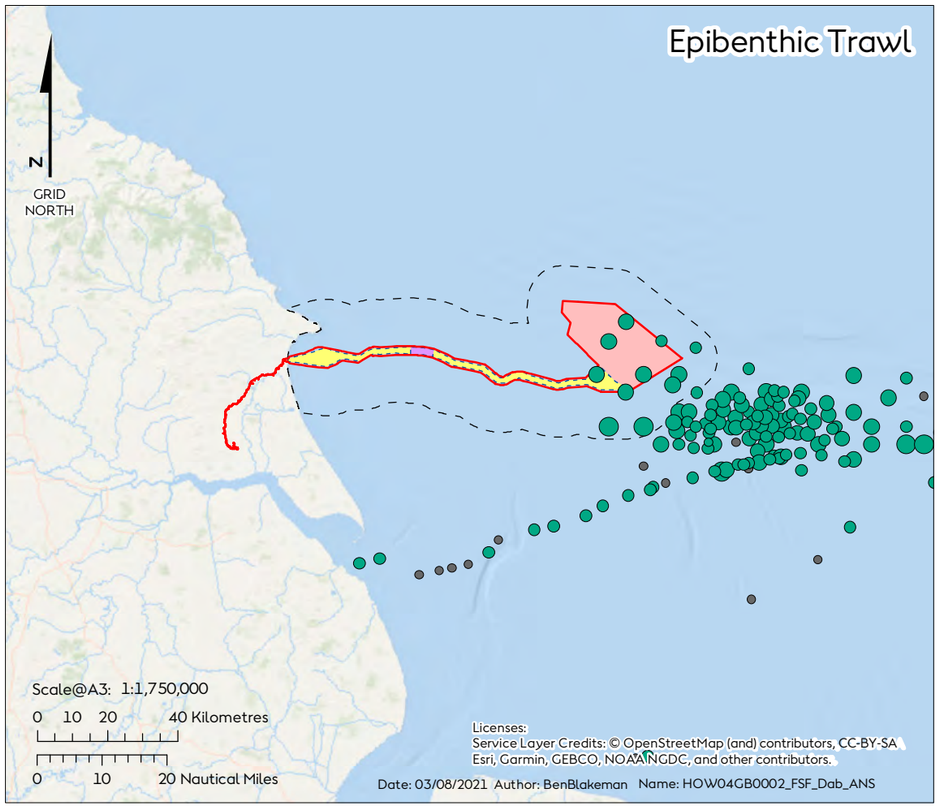


# Hornsea Four

Figure 5

Dab Abundances within the Hornsea Four Array Area

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Otter Trawl CPUE (catch/500m)**

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

**Epibenthic Trawl CPUE (catch/500m)**

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


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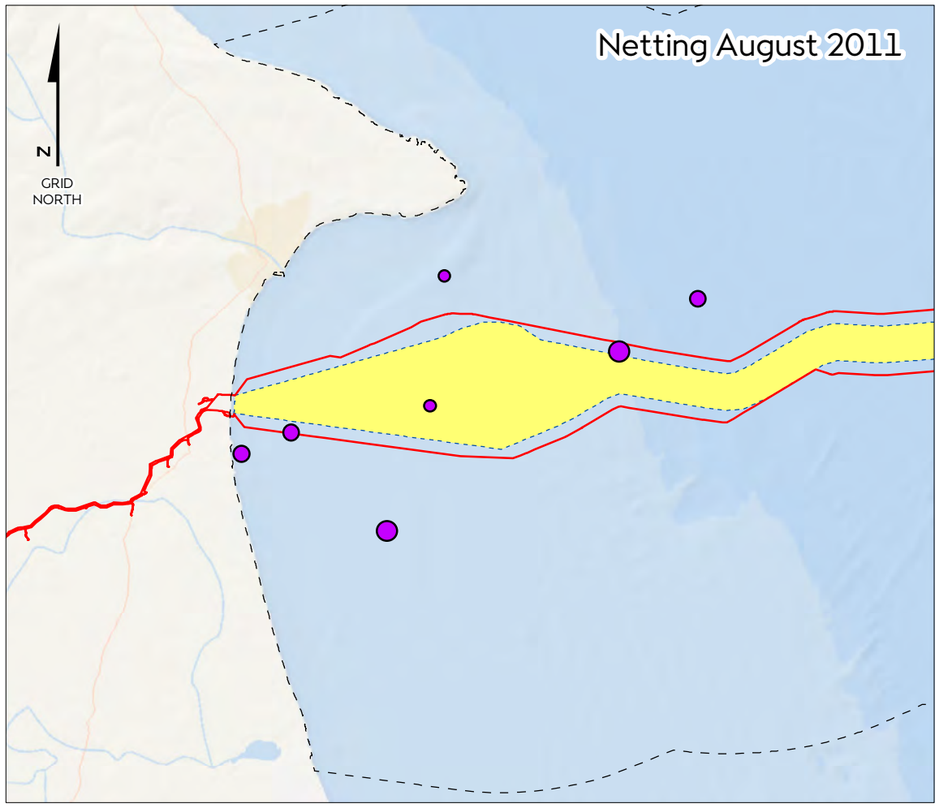
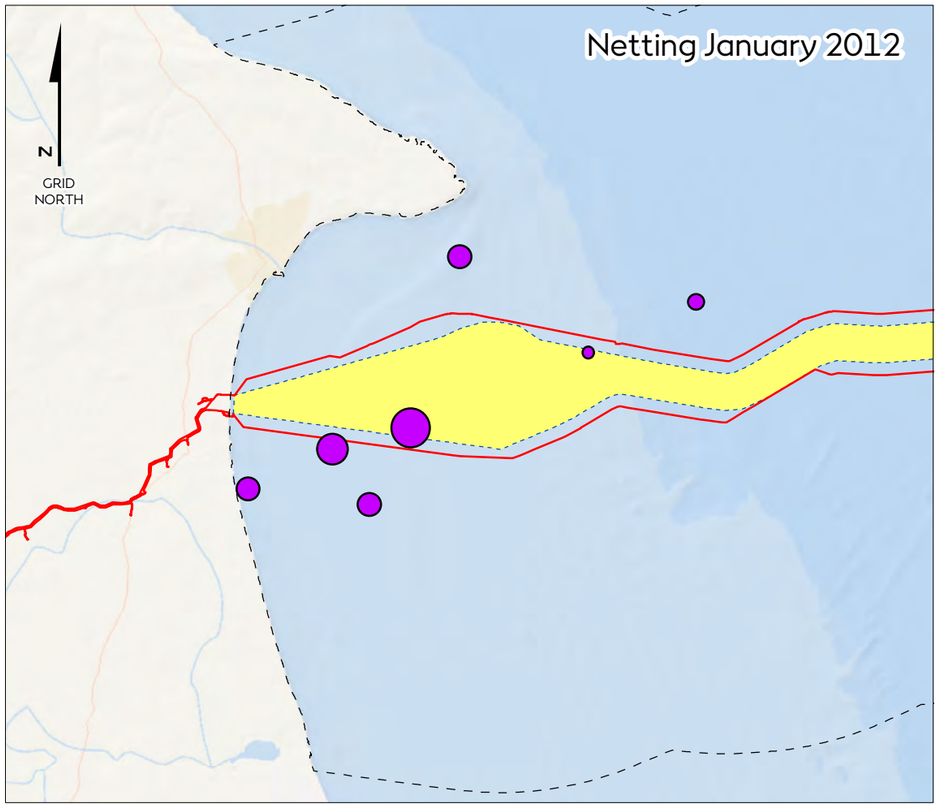
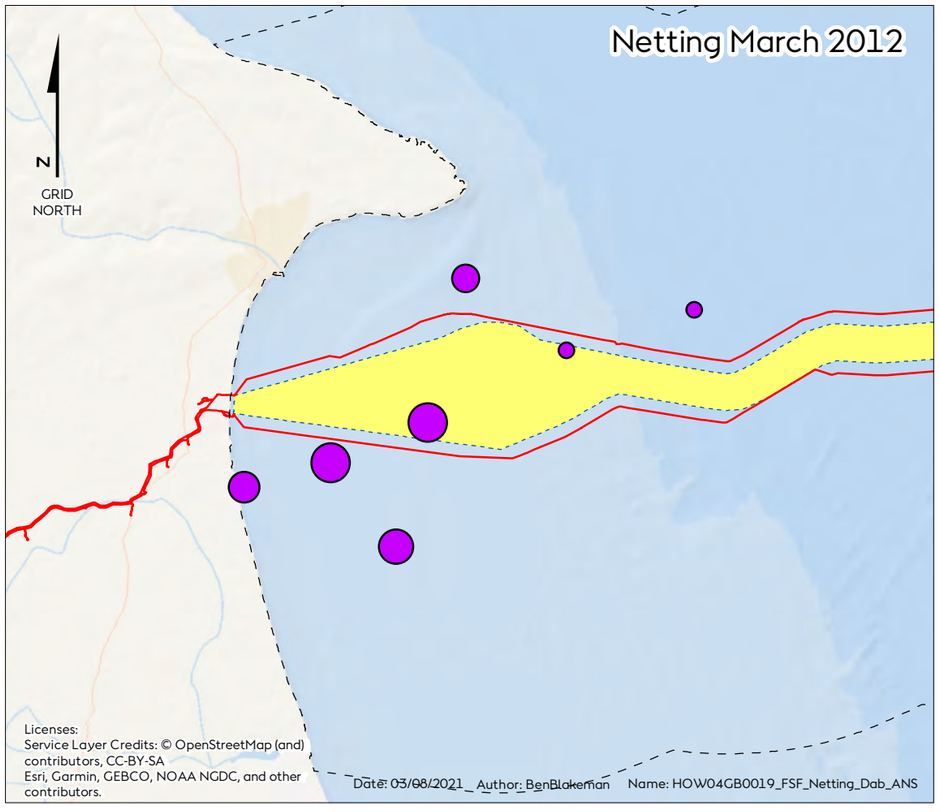



# Hornsea Four

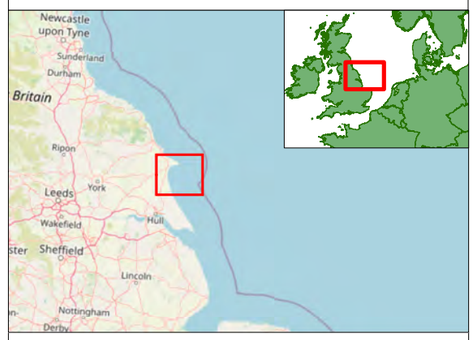
Figure 6

Dab abundances within the Hornsea Four ECC

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Trammel Netting CPUE (abundance/hour)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- 4 - 6.5

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0 5 10 Kilometres

0 2 4 Nautical Miles

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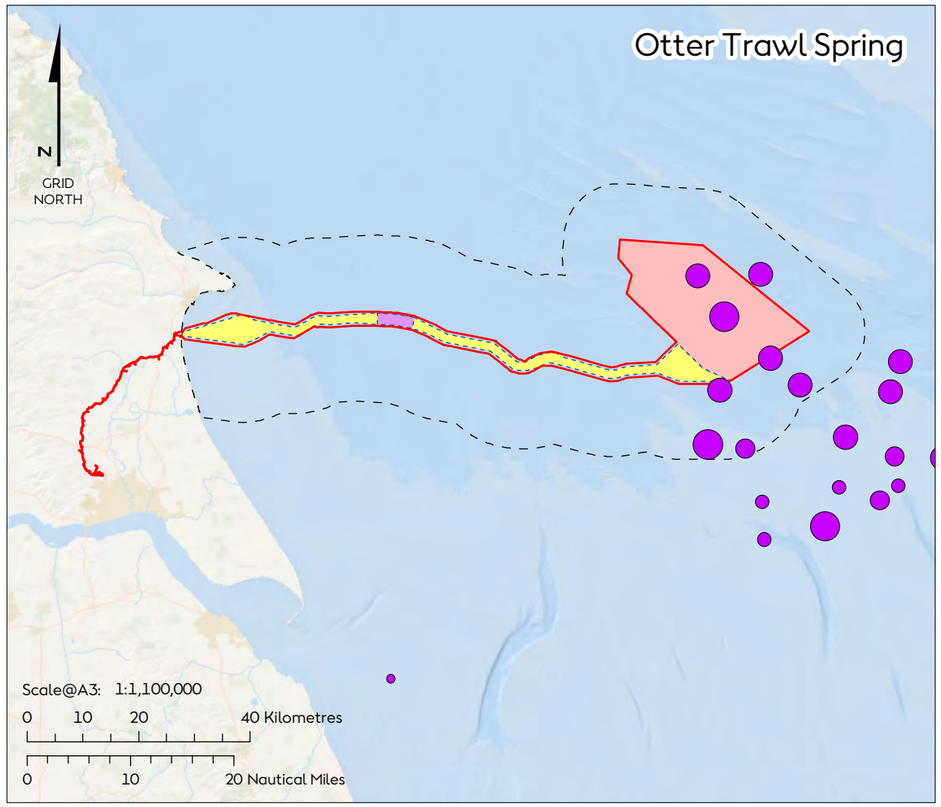


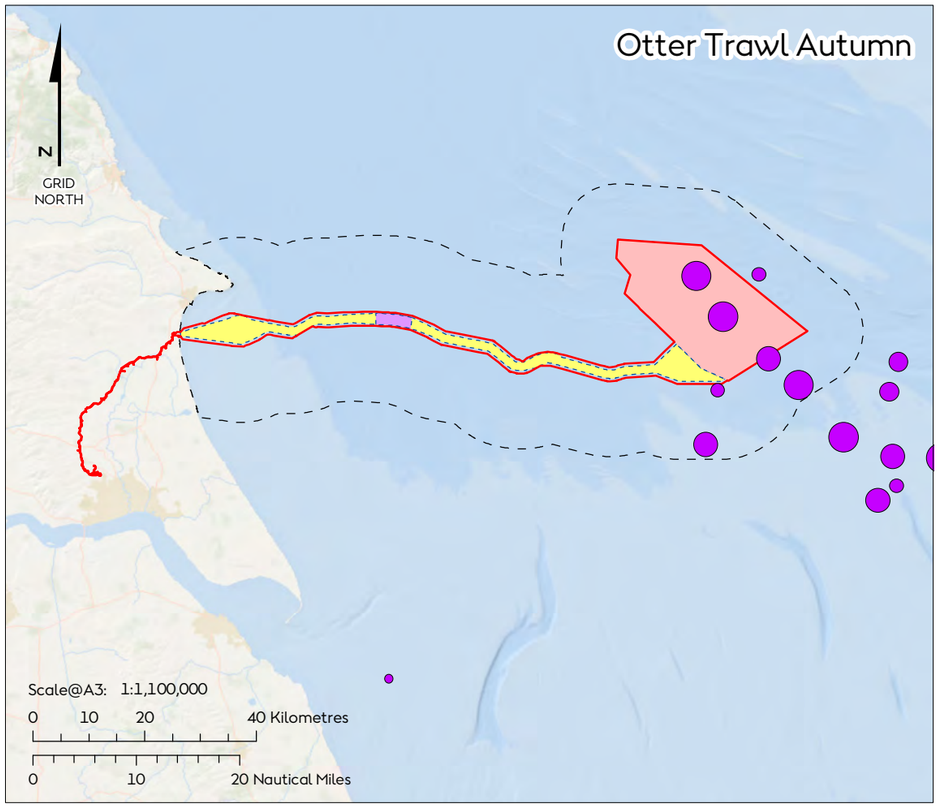


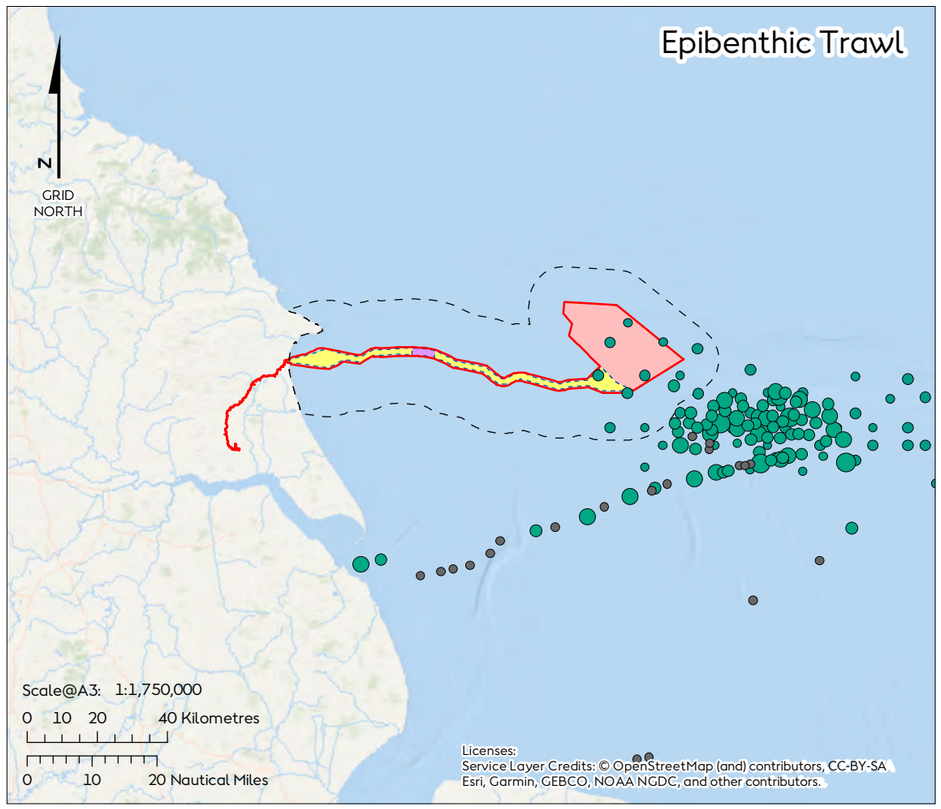


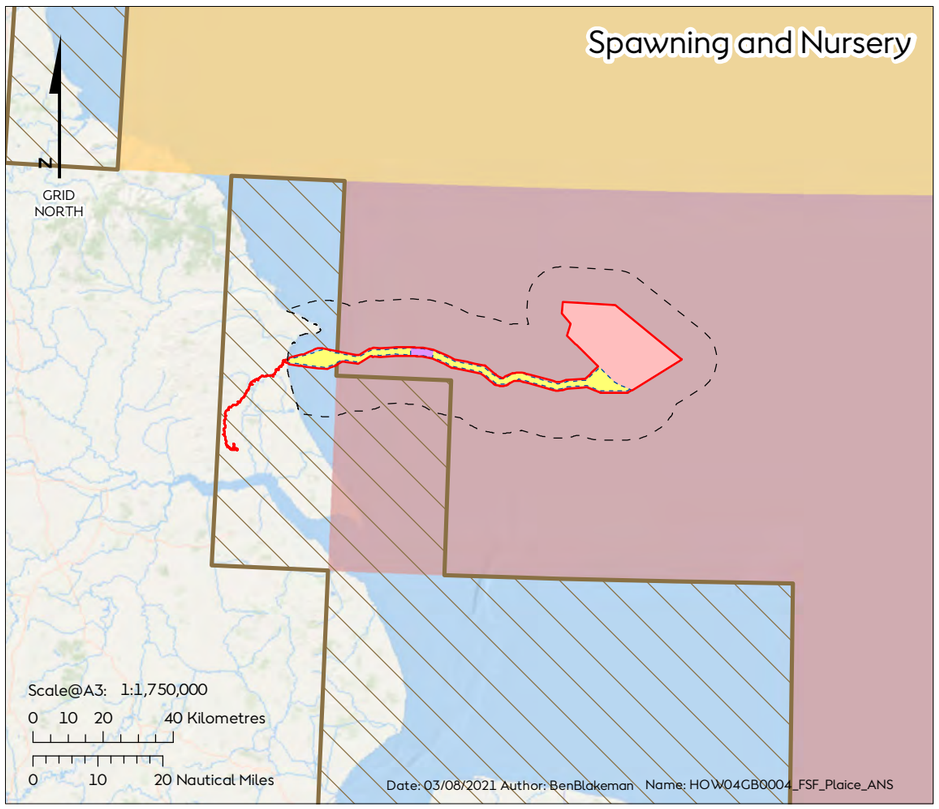


# Hornsea Four

Figure 7

Plaice Abundance and Nursery and Spawning Grounds within the Hornsea Four Array Area

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Otter Trawl CPUE (catch/500m)**

- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100

**Epibenthic Trawl CPUE (catch/500m)**

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

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

- High Intensity
- Low Intensity

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

- Low Intensity


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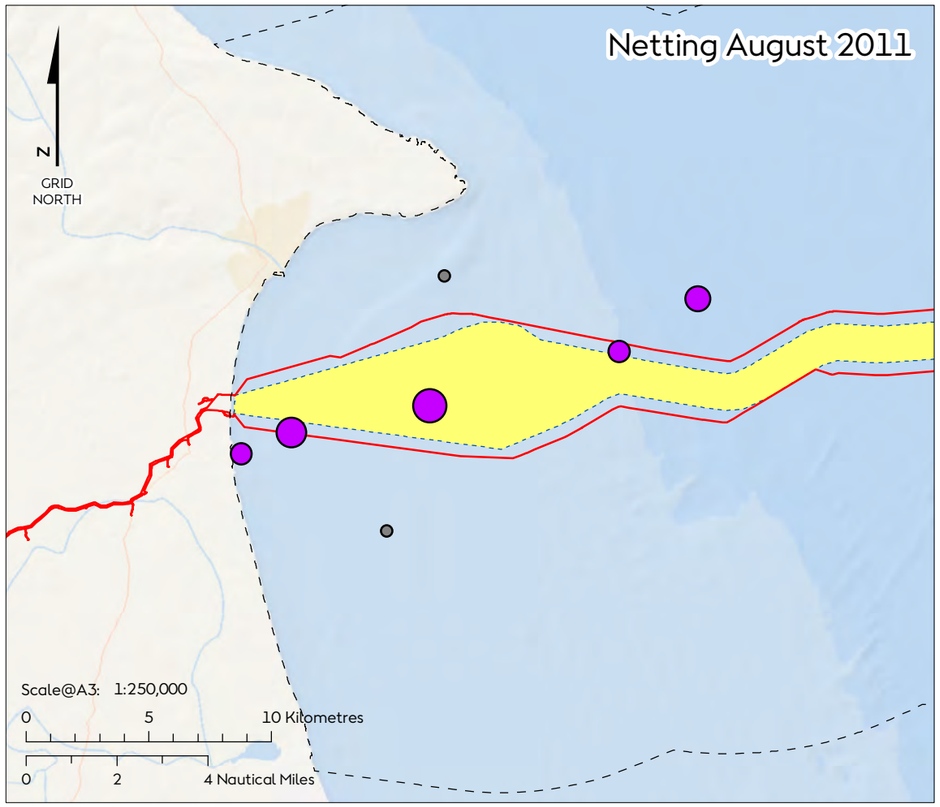
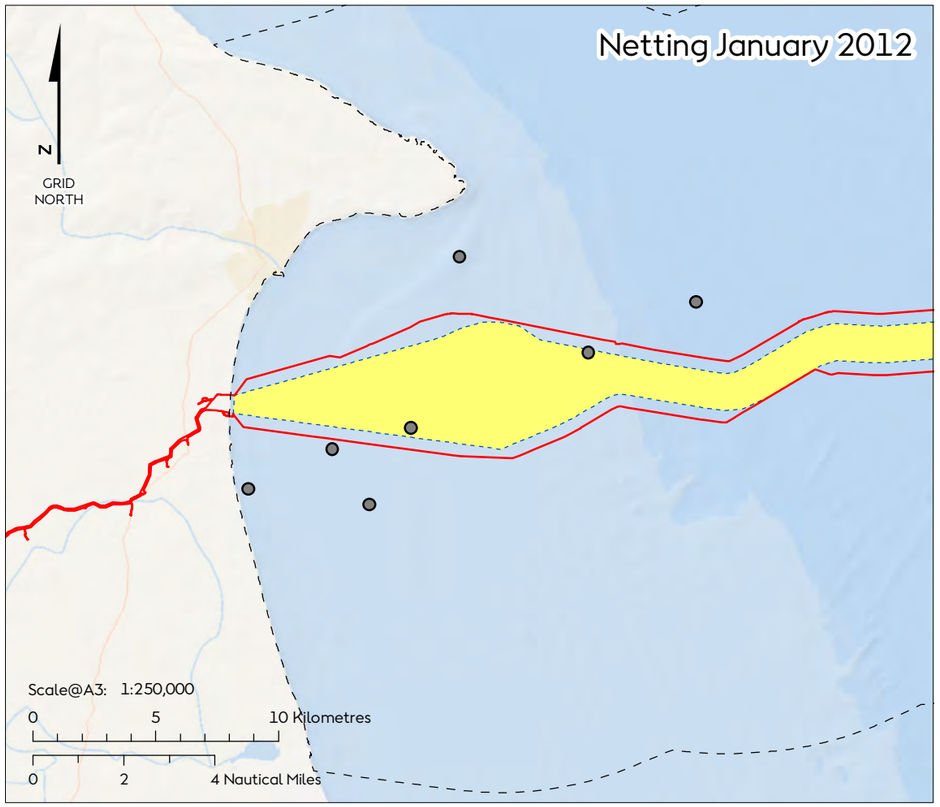
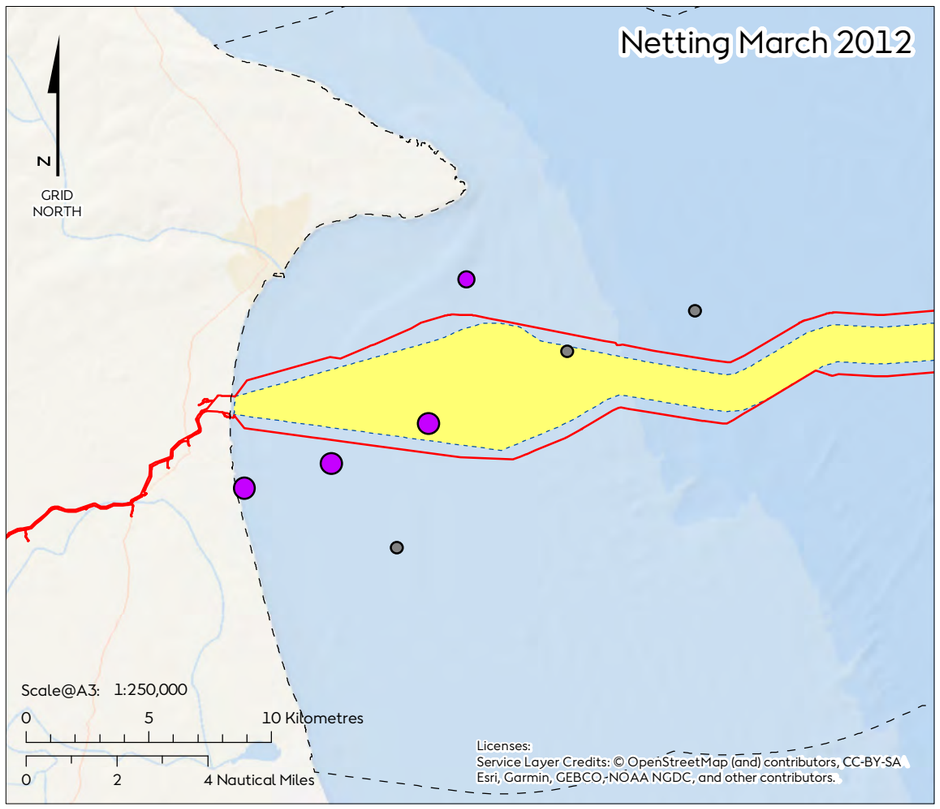
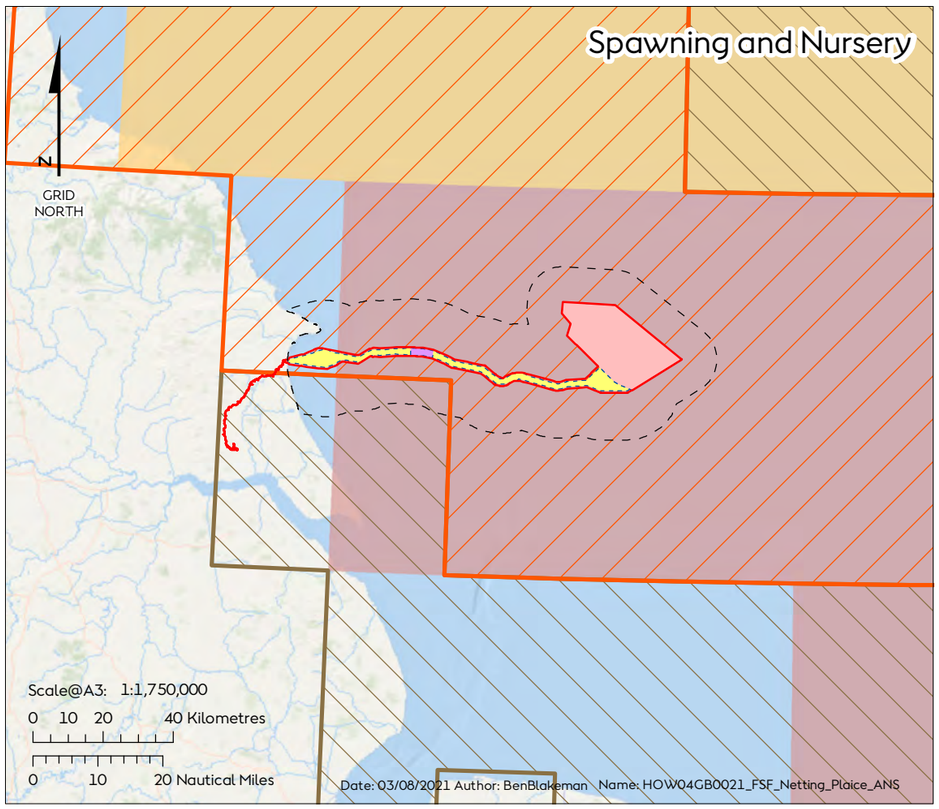



# Hornsea Four

Figure 8

Plaice Abundance and Nursery and Spawning Grounds within the Hornsea Four ECC

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Trammel Netting CPUE (abundance/hour)**

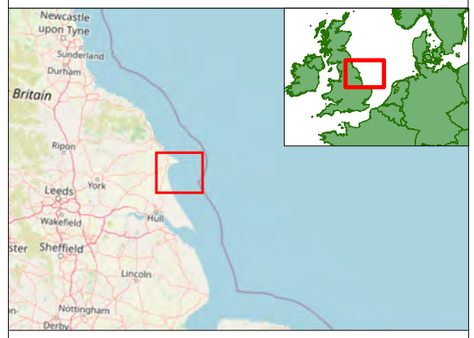
- 0
- 0 - 0.02
- 0.02 - 0.04
- 0.04 - 0.06
- 0.06 - 0.08
- 0.08 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4

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

- High Intensity
- Low Intensity

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

- High Intensity
- Low Intensity

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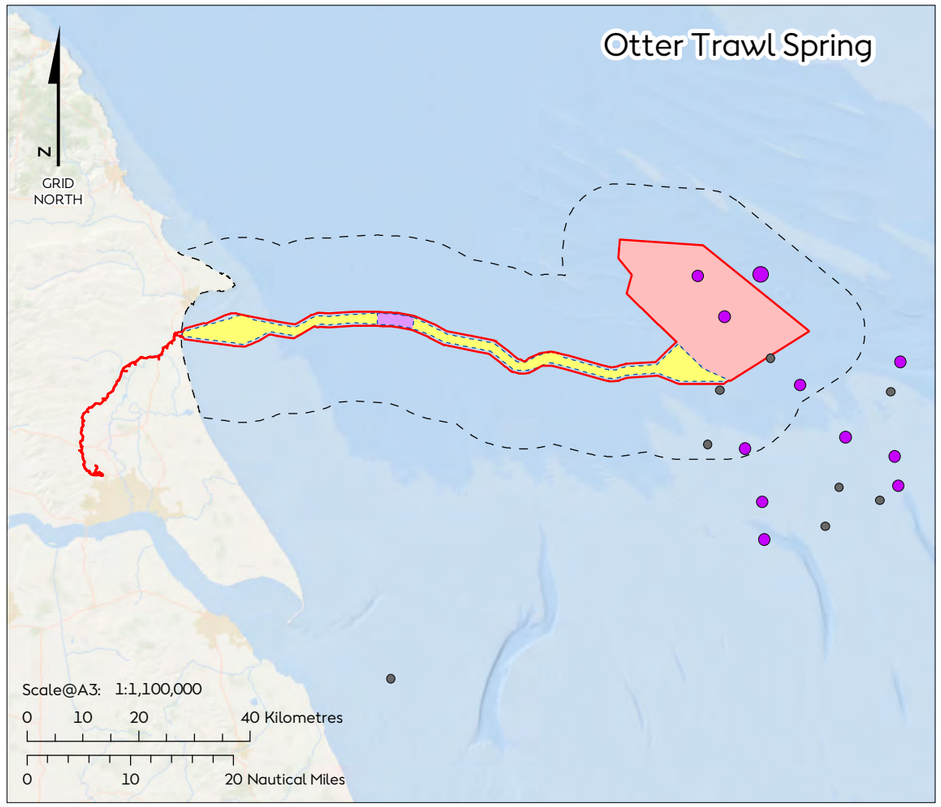


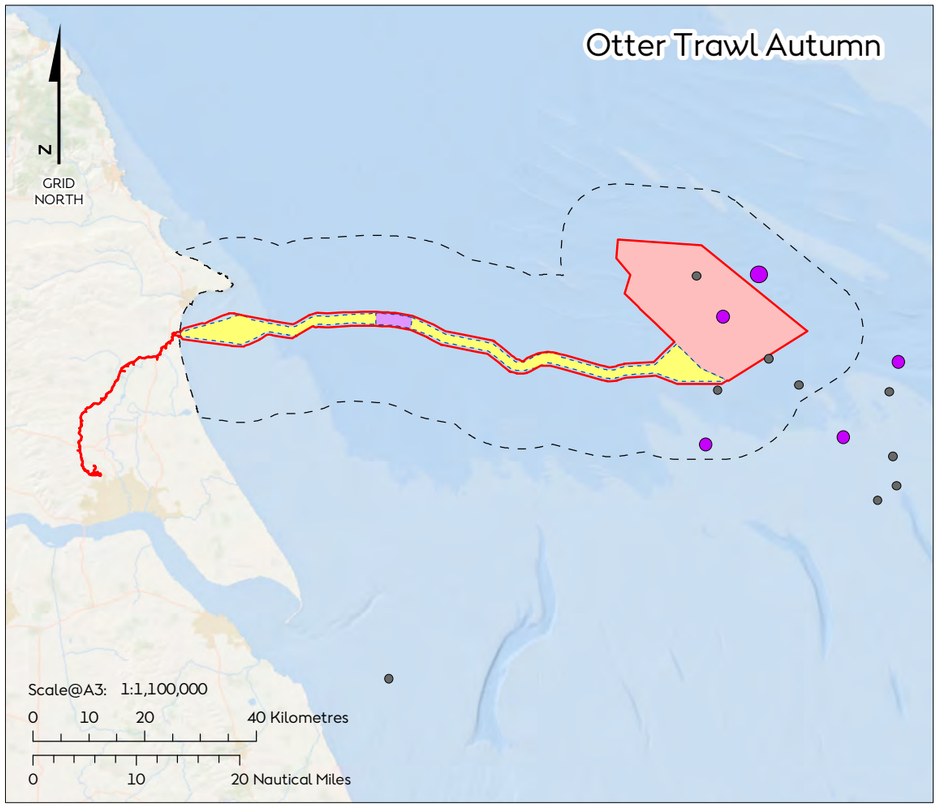


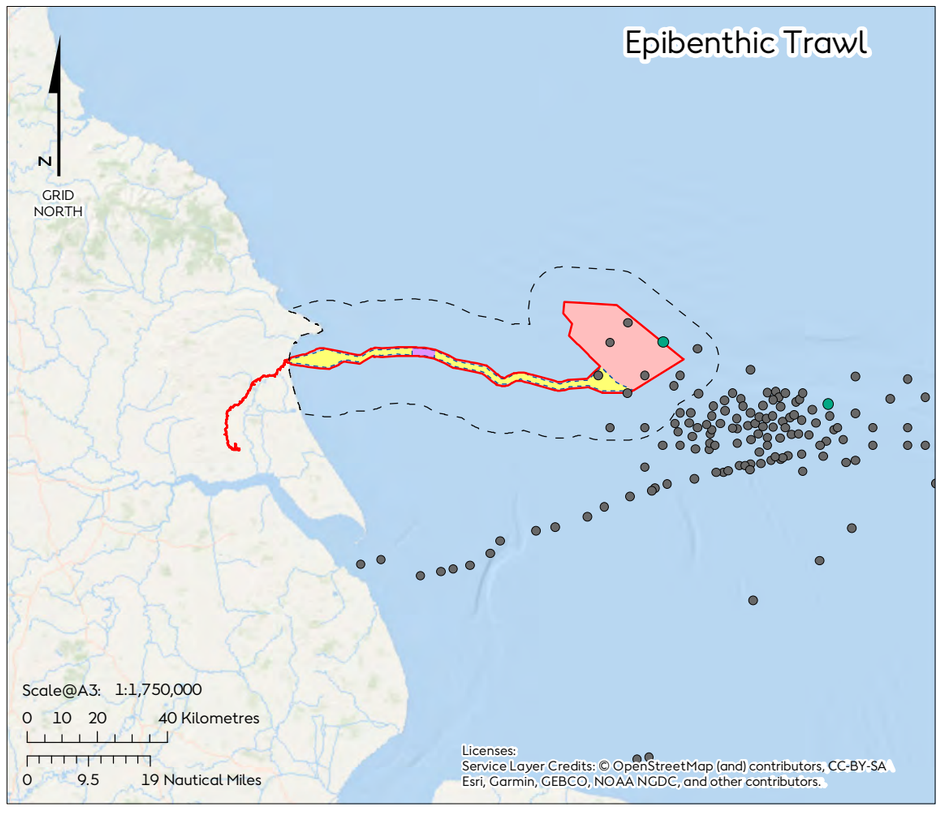


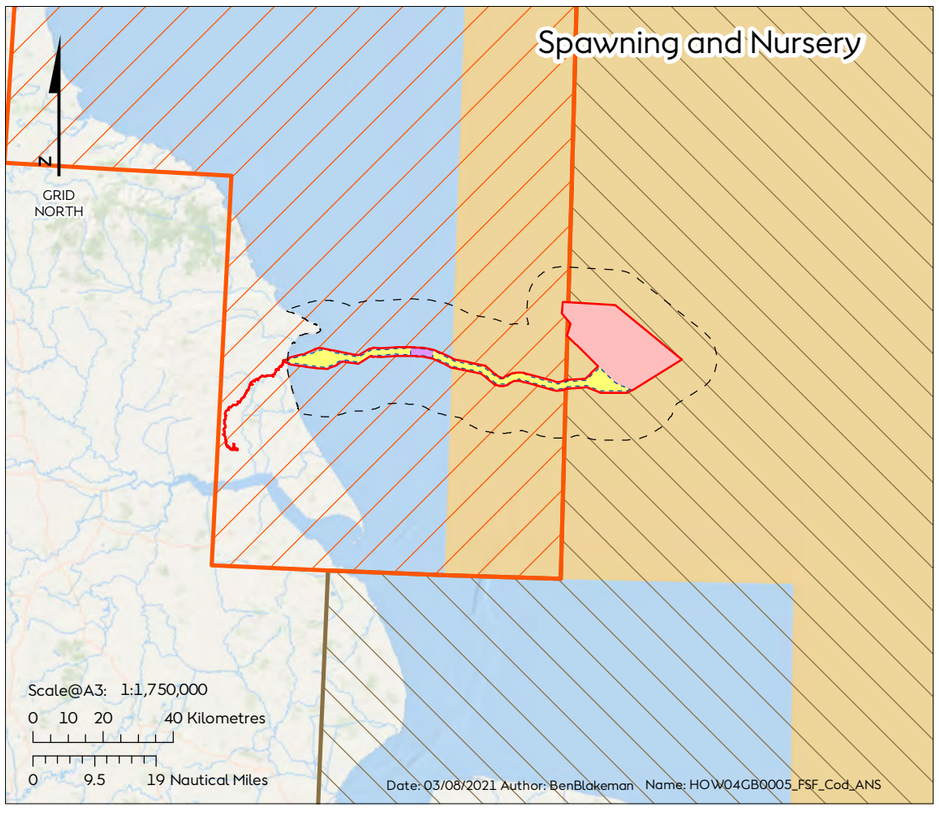


# Hornsea Four

Figure 9

Cod Abundance and Nursery and Spawning Grounds within the Hornsea Four Array Area

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Otter Trawl CPUE (catch/500m)**

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

**Epibenthic Trawl CPUE (catch/500m)**

- 0
- 0 - 1

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

- Low Intensity

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

- High Intensity
- Low Intensity


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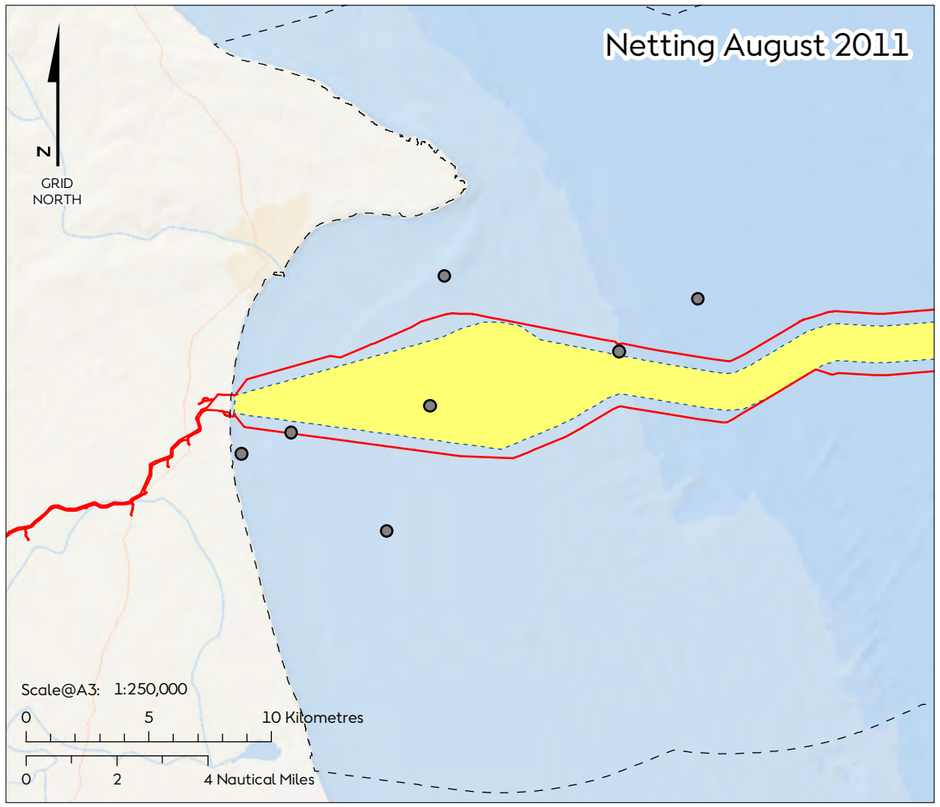


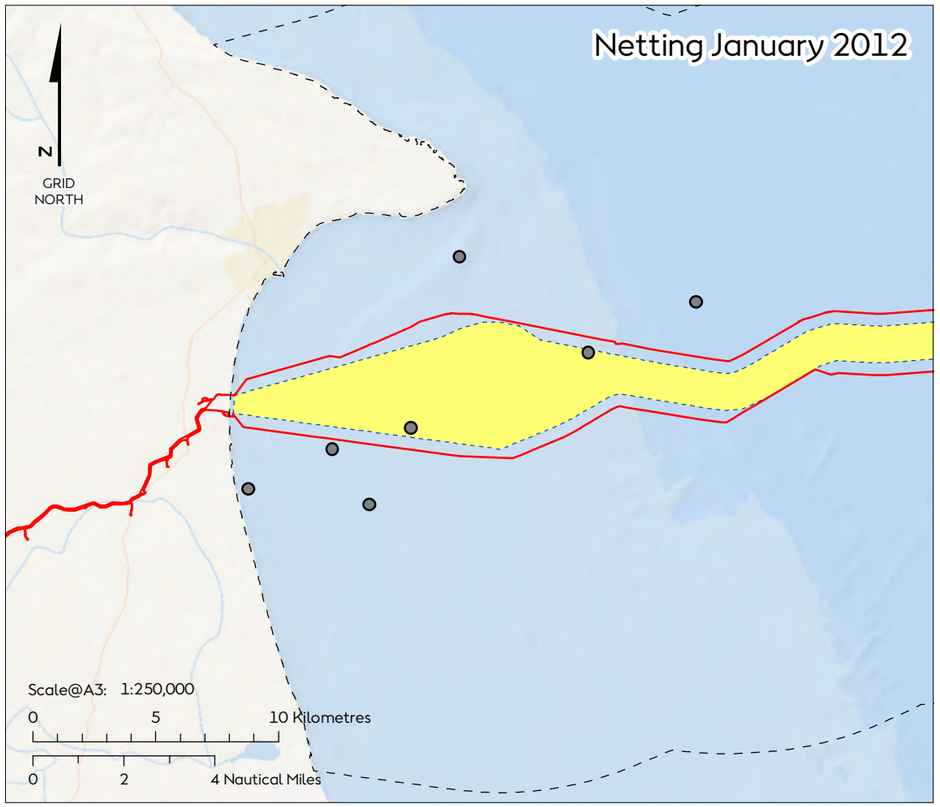


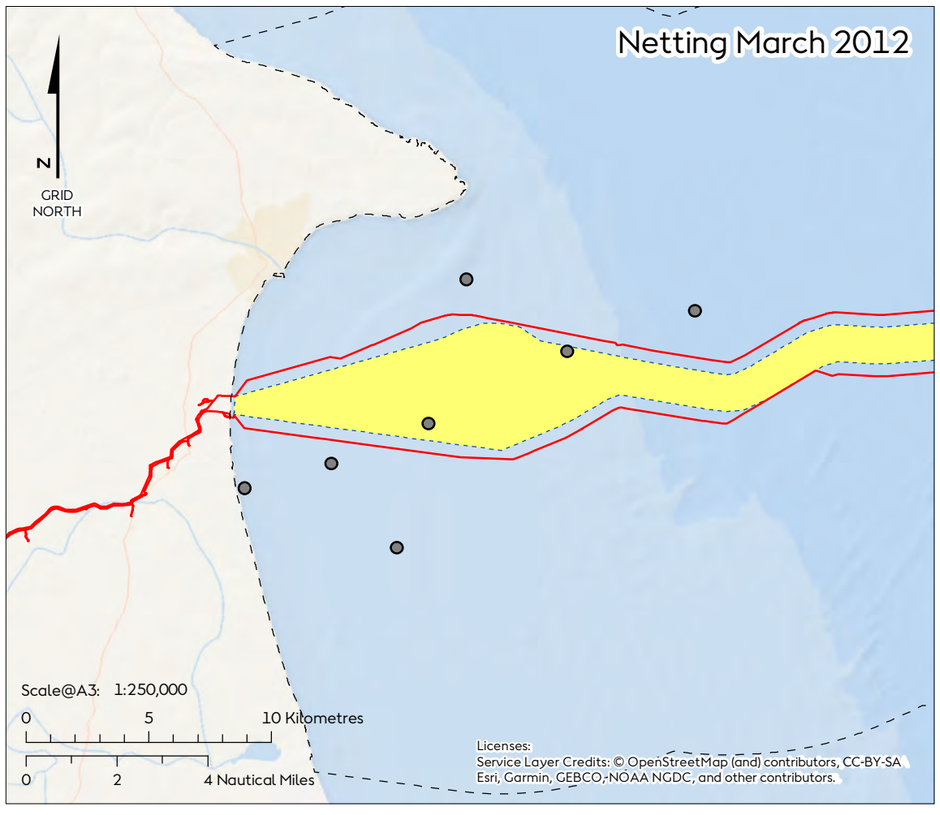


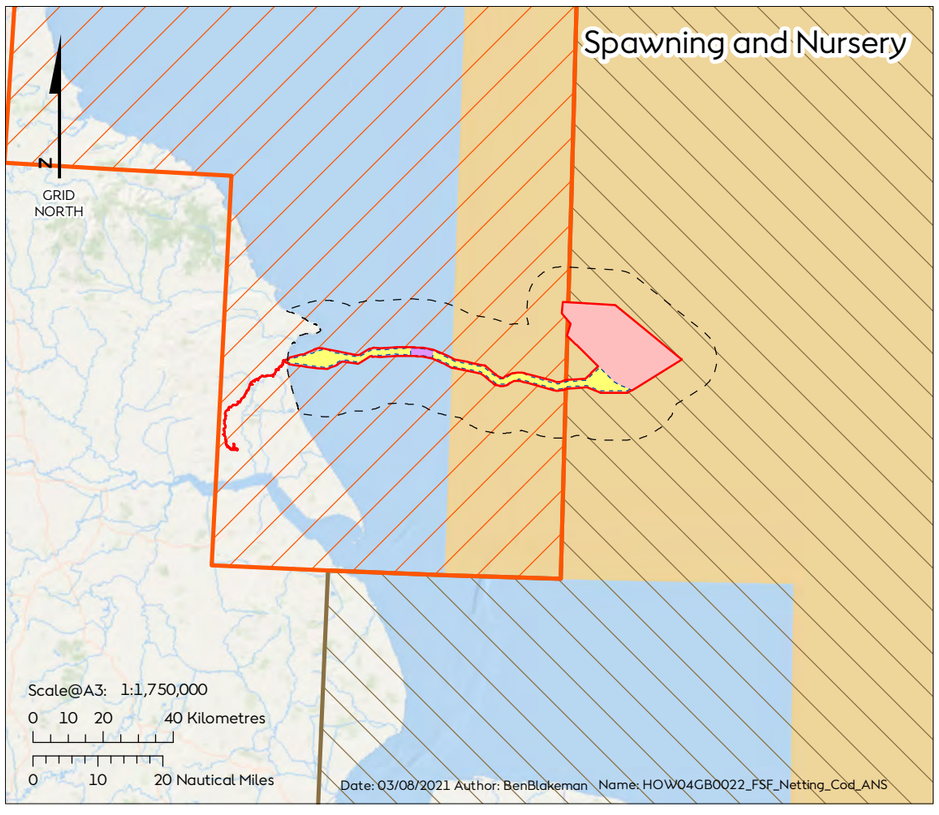


# Hornsea Four

Figure 10

Cod Abundance and Nursery and Spawning Grounds within the Hornsea Four ECC

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Trammel Netting CPUE (abundance/hour)**

- 0
- 0 - 0.02
- 0.02 - 0.04
- 0.04 - 0.06
- 0.06 - 0.08
- 0.08 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4

**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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*Lemon sole*

3.1.2.15 Lemon sole was recorded at low abundances throughout the Hornsea Four fish and shellfish study area (**Figure 11**) during historic otter and epibenthic trawls (**paragraph 2.2.3.1** *et seq*), with higher abundances 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*

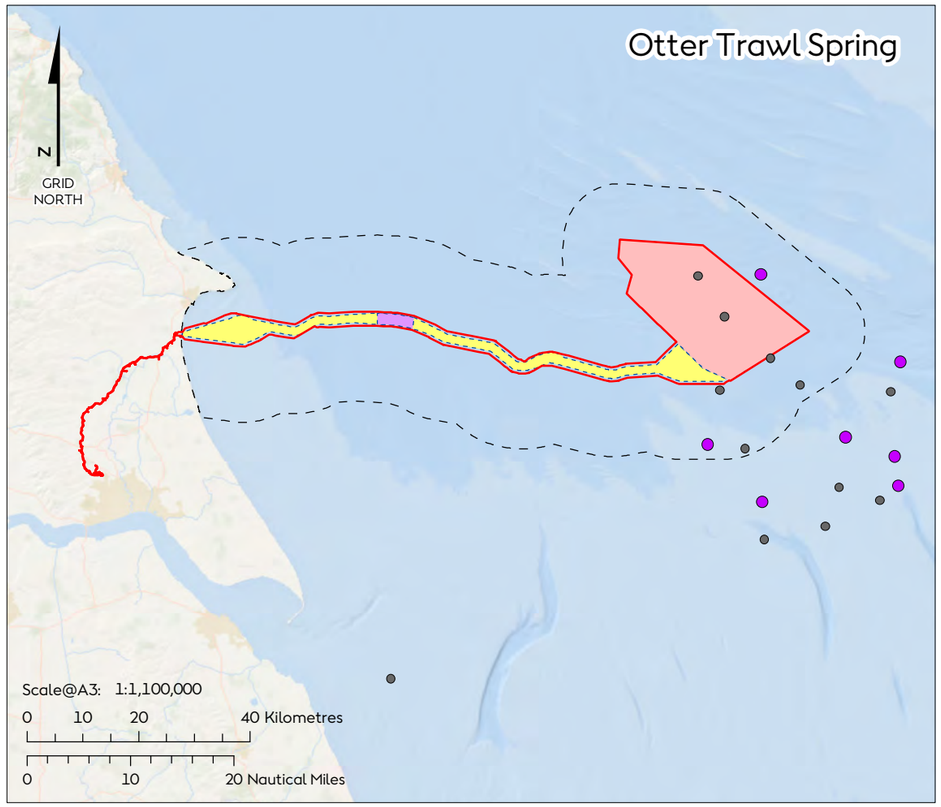
3.1.2.16 Common sole, a species of conservation importance (UK BAP and NERC Act 2006), was recorded at high abundances in the northwest of the former Hornsea Zone and were repeatedly recorded at low abundances across the Hornsea Four fish and shellfish study area during historic otter and epibenthic trawls (**paragraph 2.2.3.1** *et seq*), with the highest abundances (i.e. <4 individuals per 500 m) recorded in the study area. These are not plotted due to the low abundances recorded.

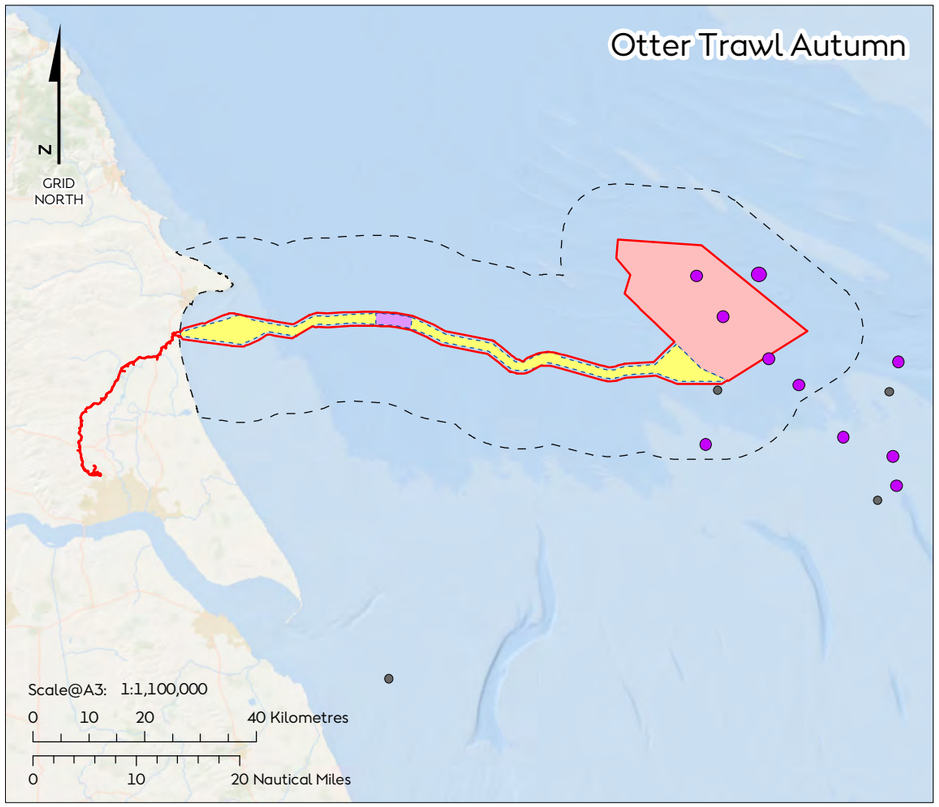
3.1.2.17 Spawning grounds for common sole typically occur all along the southern coasts, with IBTS data indicating high intensity spawning grounds located within the Wash. Moderate intensity spawning grounds are located in the Humber estuary and along the coast to the south of Flamborough Head (ICES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

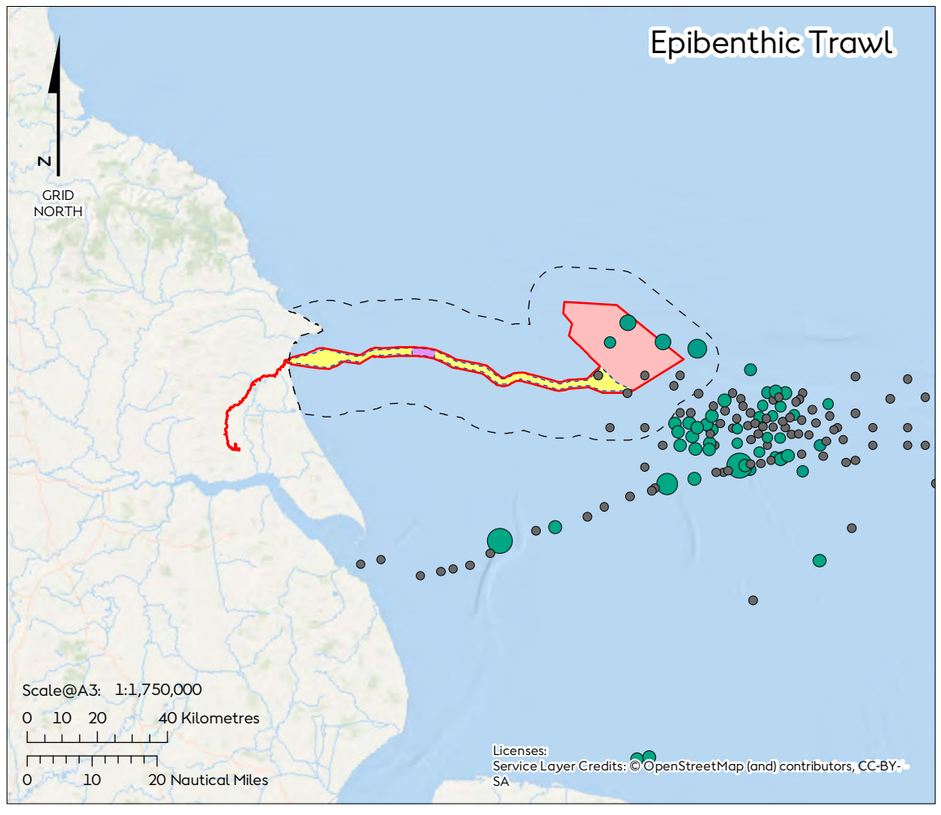
*Solenette*

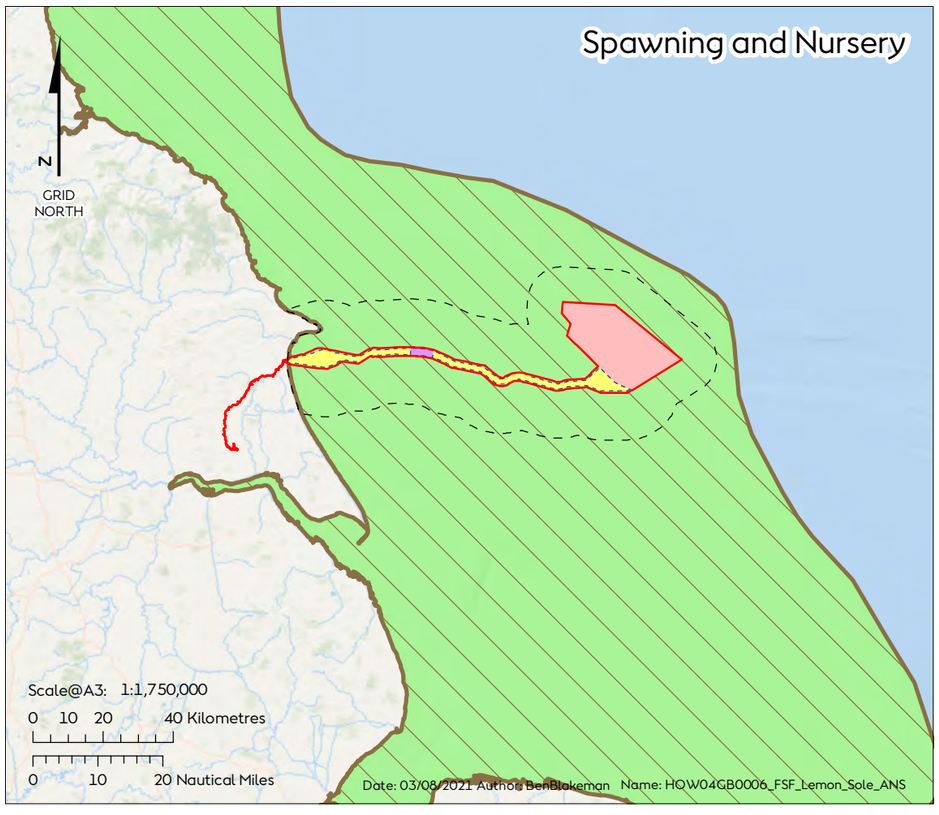
3.1.2.18 Solenette was recorded at high abundances in the offshore section of the former Hornsea Zone, and was the main characterising species recorded during historic epibenthic beam trawl sampling in the study area (**paragraph 2.2.3.1** *et seq*). Solenette were recorded with highest abundances within the mid and eastern sections of the Hornsea Four fish and shellfish study area, although the species was not recorded within the Hornsea Four array area. This species was recorded in historic 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 was observed within the historic otter trawl records (undertaken within the study area - **paragraph 2.2.3.1** *et seq*), with increased abundance recorded in autumn.

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 across the south-eastern North Sea (Sundby et al. 2017), with no spawning areas identified within the study area.




# Hornsea Four

Figure 11

Lemon Sole Abundance and Nursery and Spawning Grounds within the Hornsea Four Array Area

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Otter Trawl CPUE (catch/500m)**

- 0
- 1 - 5
- 5 - 7

**Epibenthic Trawl CPUE (catch/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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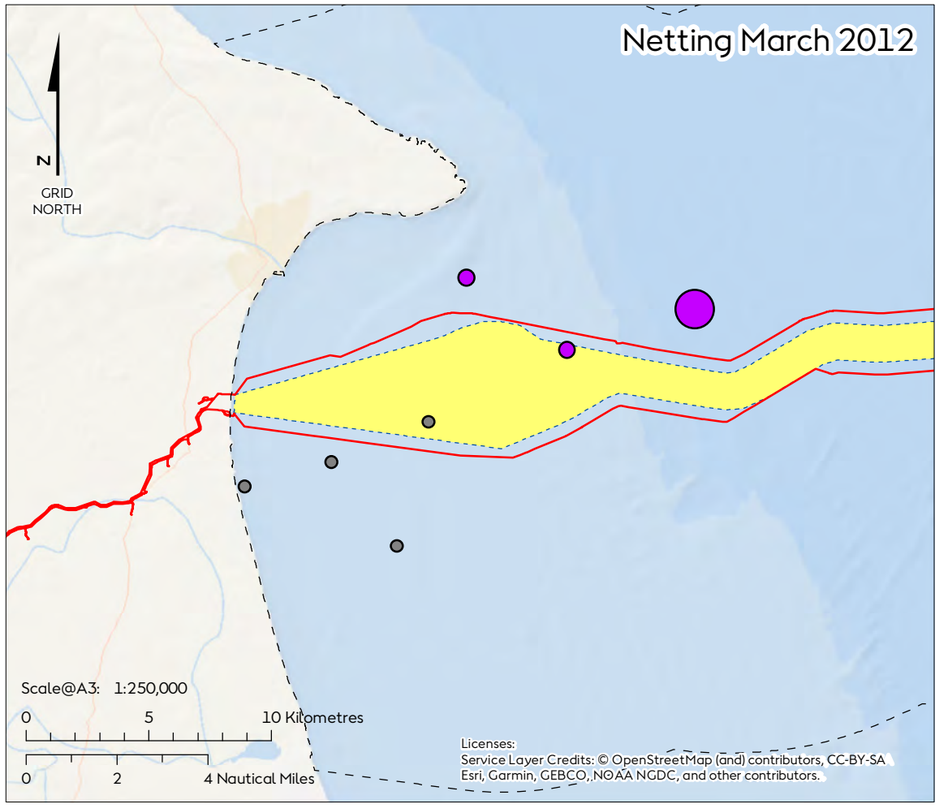


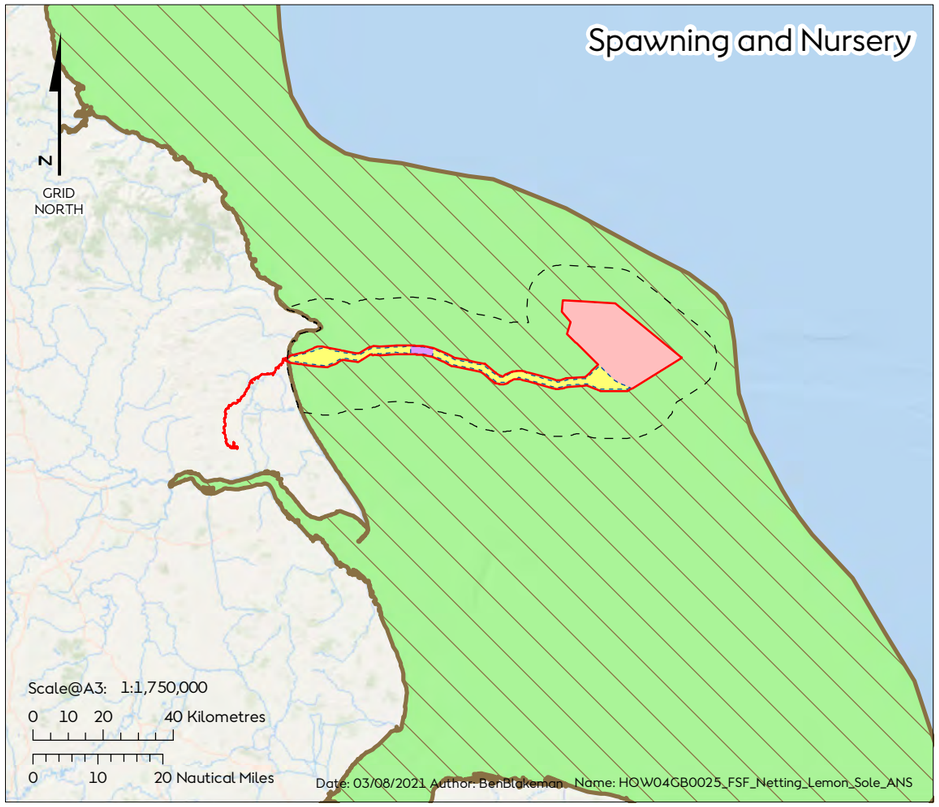


# Hornsea Four

Figure 12

Lemon sole Abundance and Nursery and Spawning Grounds within the Hornsea Four ECC

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Trammel Netting CPUE (abundance/hour)**

- 0
- 0 - 0.02
- 0.02 - 0.04
- 0.04 - 0.06
- 0.06 - 0.08
- 0.08 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4

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

- Spawning

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

- Nursery


Coordinate system: ETRS 1989 UTM Zone 31N

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*Grey Gurnard*

3.1.2.20 Grey gurnard was one of the key characterising species in the fish assemblage recorded in historic otter trawls within the Hornsea Four fish and shellfish study area, with highest abundances generally recorded in the west and northwest of the study area (**paragraph 2.2.3.1** *et seq*). Abundances of grey gurnard were much lower in the historic epibenthic beam trawls. Grey gurnard were not recorded within the 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 are widely distributed within the North Sea and are an important potential 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 the historic otter trawls conducted within the Hornsea Four fish and shellfish study area (**paragraph 2.2.3.1** *et seq*). **Figure 13** shows that there was a strong seasonal difference in the abundances of this species, with notably higher catches in spring than autumn. Sprat was recorded at low abundances in historic 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 catches of sprat in October, although low abundances of the species were observed in trammel net surveys in the same area (as recorded in the Dogger Bank A and B surveys).

3.1.2.23 Within the North Sea, spawning occurs in both coastal and offshore waters, with IBTS data indicating important sprat spawning areas located in the inner German Bight, off Jutland, along the English coast, and in areas west and north of Scotland (ICE, 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 are identified as a species of commercial importance in **Annex 6.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

3.1.2.25 High abundances of herring, a species of conservation importance (UK BAP and NERC Act 2006), were recorded in historic surveys across the Hornsea Four fish and shellfish study area (**paragraph 2.2.3.1** *et seq*), 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. 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 historic otter trawl surveys in the study area, though small numbers of this species were also recorded in historic epibenthic beam trawls (**paragraph 2.2.3.1** *et seq*). 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 (up to 900 per 500 m) and lower abundances in autumn (up to 100 per 500m) (**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).

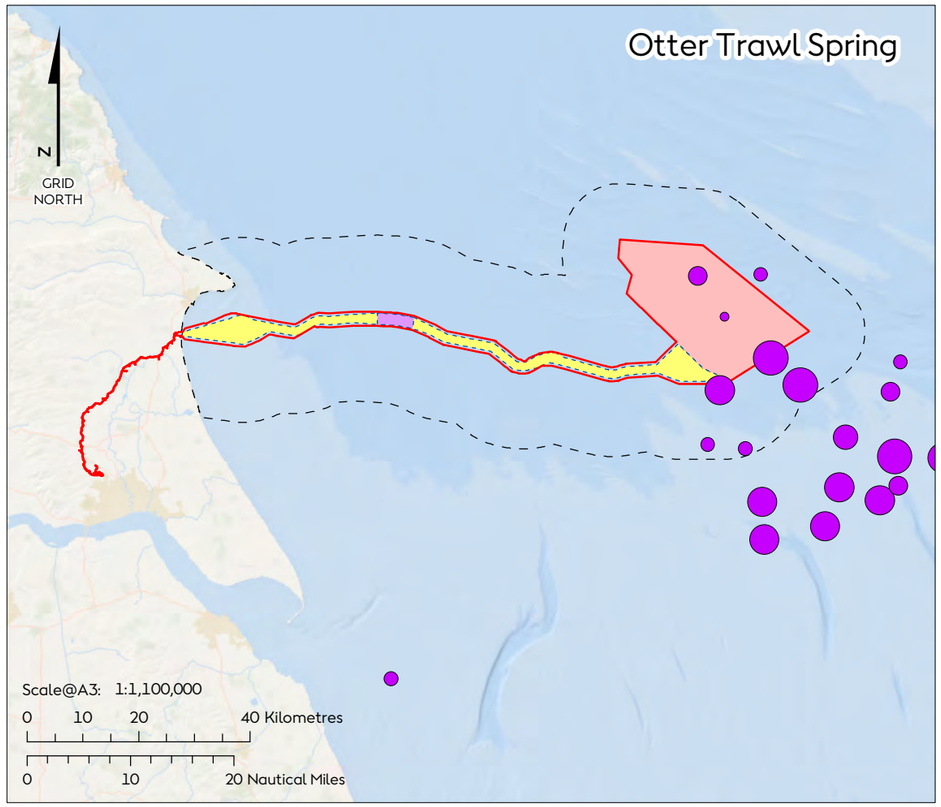
*Mackerel*

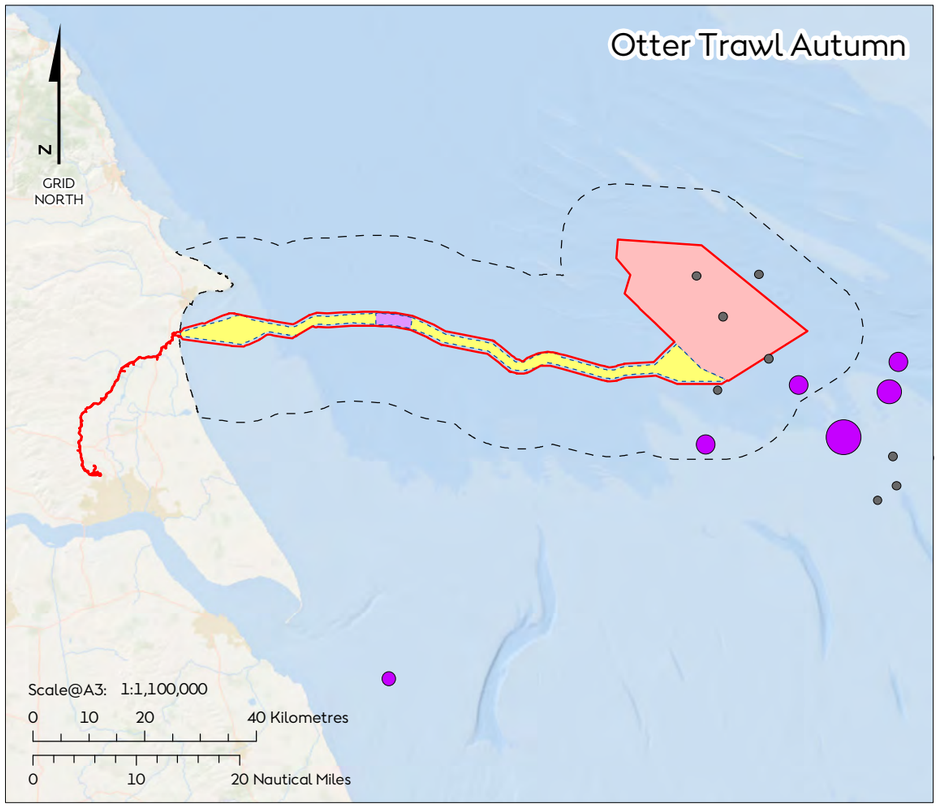
3.1.2.28 Mackerel are identified as a species of commercial importance in **Annex 6.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

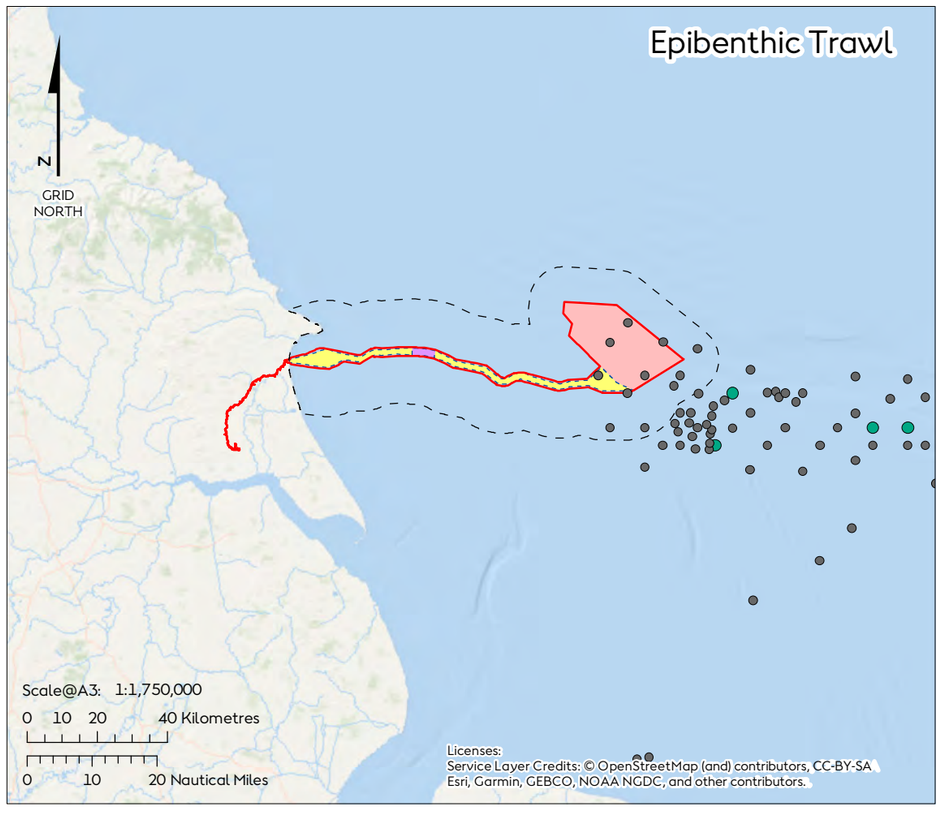
3.1.2.29 Mackerel typically have a widespread distribution throughout the North Sea; they are of importance as a potential prey resource for larger pelagic predators including sharks and marine mammals. They are also consumed by seabirds (ICES 2005e).

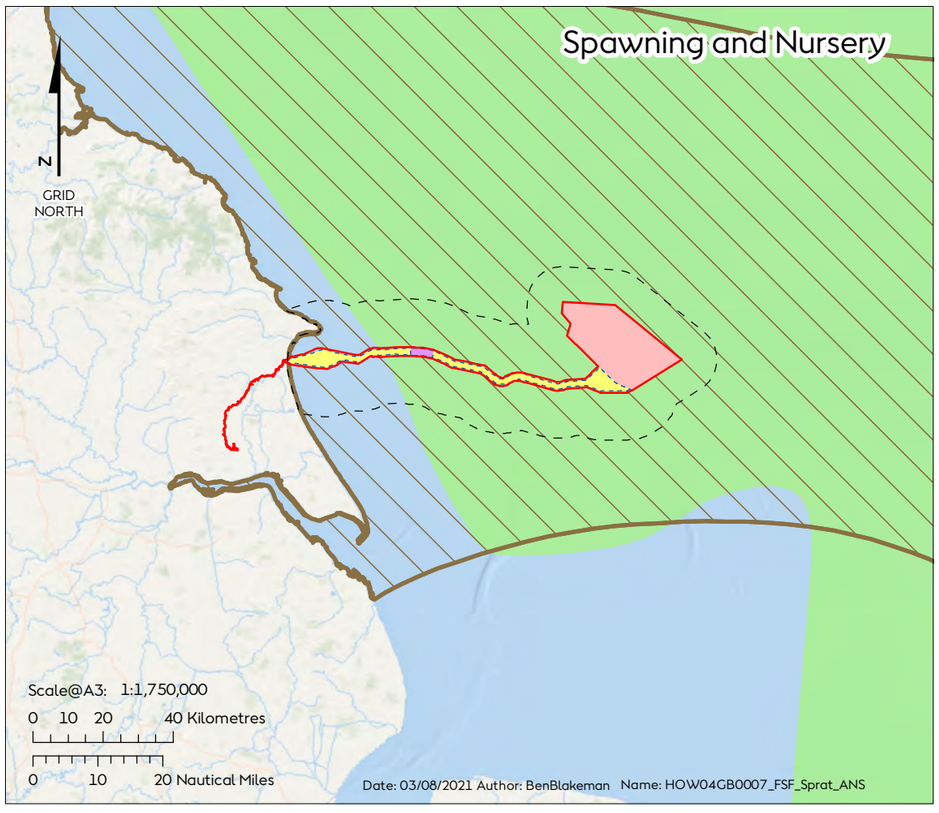
3.1.2.30 Historic data collected within the Hornsea Four fish and shellfish study area (**paragraph 2.2.3.1** *et seq*) shows the presence of mackerel, a species of conservation importance (UK BAP and NERC Act 2006), within the area. Mackerel were recorded throughout the fish and shellfish study area during the autumn otter trawl surveys, with low abundances recorded during spring (**Figure 15**). Mackerel is a pelagic species and as a result this species was not recorded in epibenthic beam trawls. Mackerel were also caught in moderate abundances in the August trammel net surveys (up to 0.4 per hour) within the inshore section of the Hornsea Four ECC (as recorded in Dogger Bank A and B 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 fish and shellfish 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 ECC (**Figure 15**). The seasonal variation in abundances observed are consistent with migratory behaviours to and from the spawning grounds (the spawning period for this species is March to July (Coull et al. 1998)).




# Hornsea Four

Figure 13

Sprat Abundance and Nursery and Spawning Grounds within the Hornsea Four Array Area and ECC

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Otter Trawl CPUE (catch/500m)**

- 0
- 1 - 10
- 10 - 50
- 50 - 100
- 100 - 200
- 200- 500

**Epibenthic Trawl CPUE (catch/500m)**

- 0
- 0 - 10

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

- Spawning

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

- Low Intensity


Coordinate system: ETRS 1989 UTM Zone 31N

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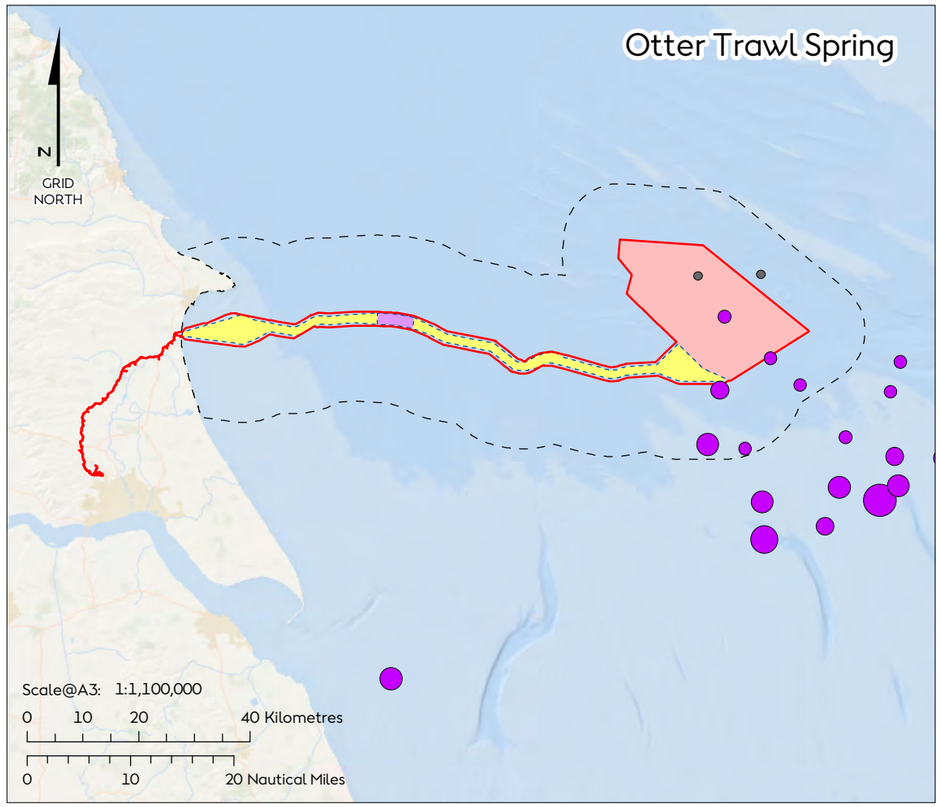


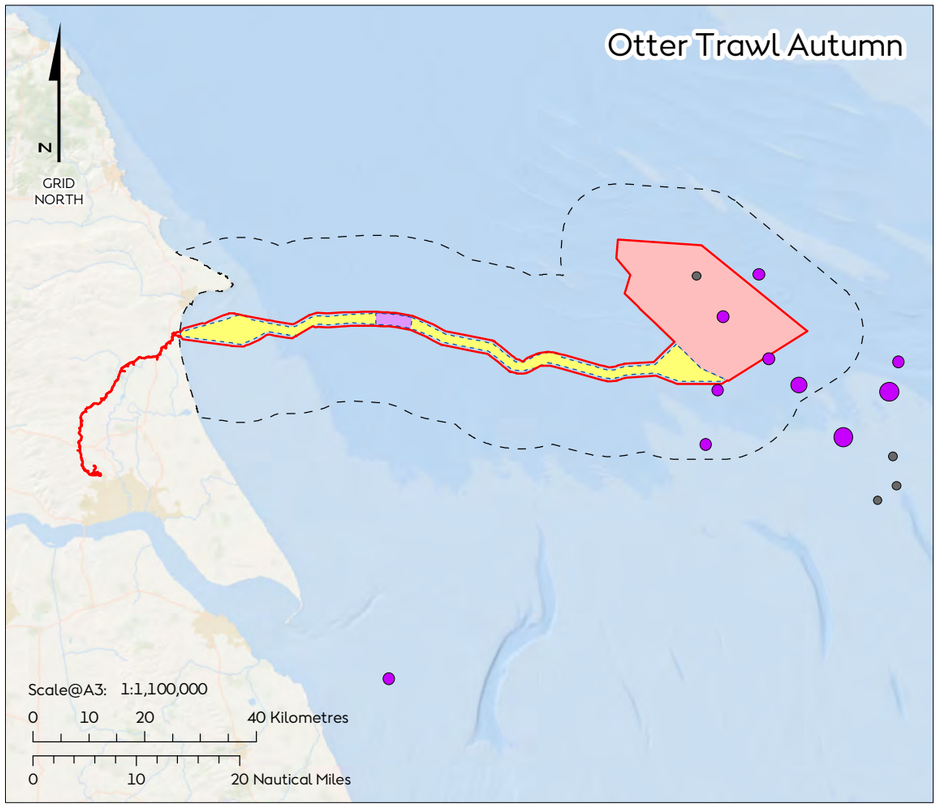


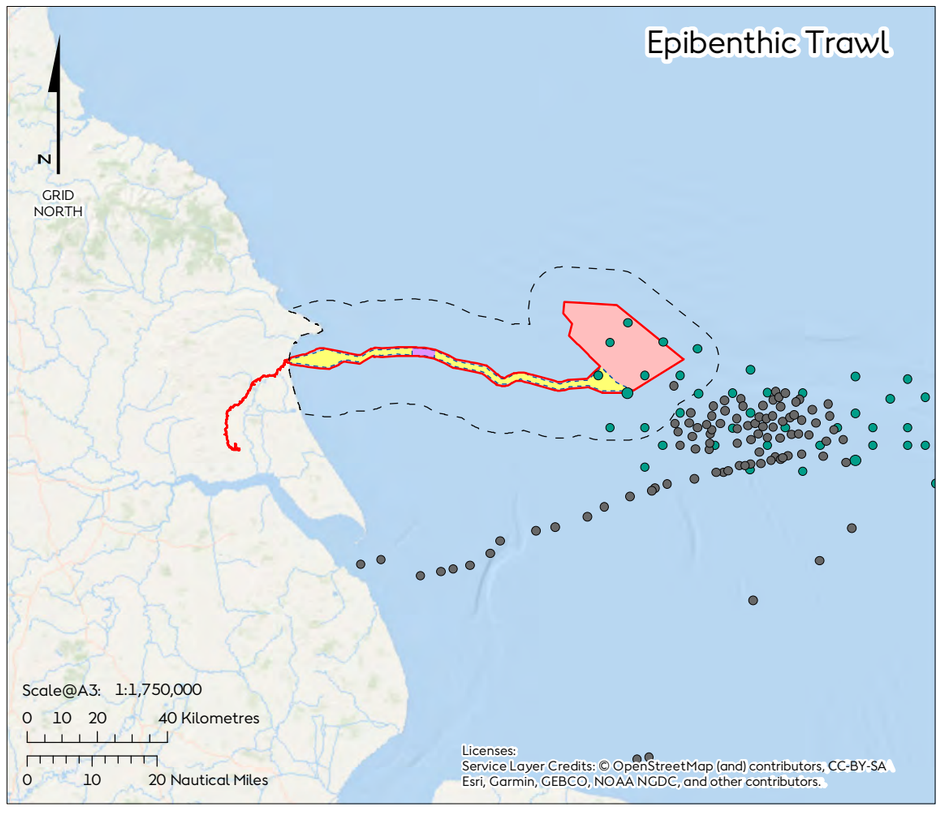


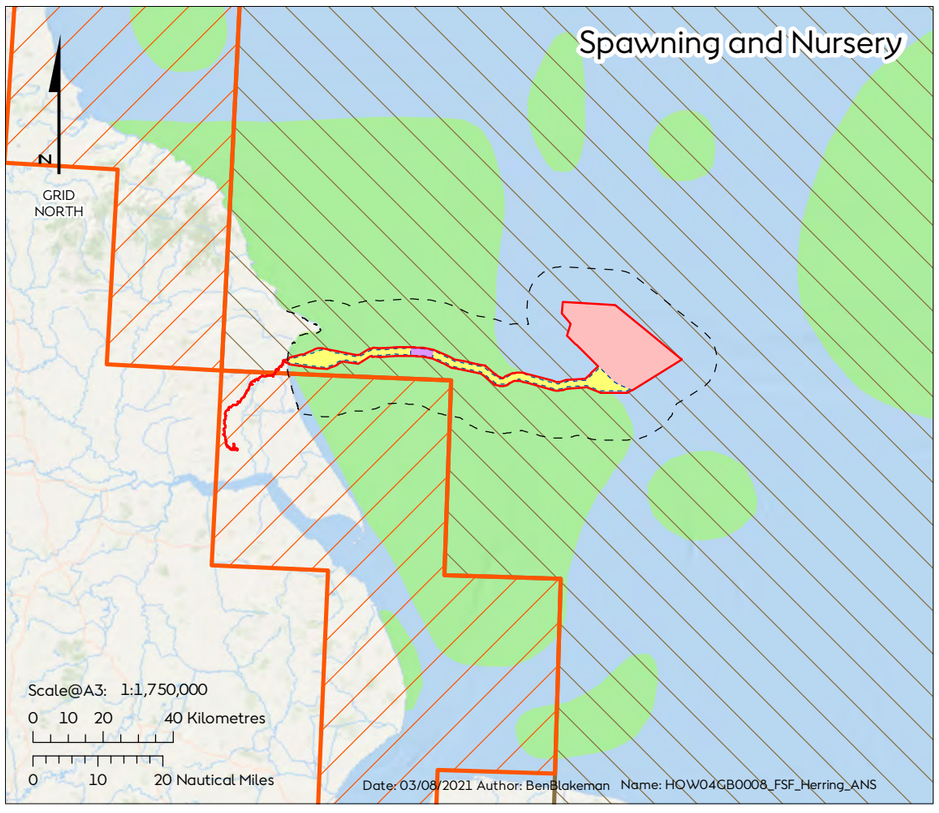


# Hornsea Four

Figure 14

Herring Abundance and Nursery and Spawning Grounds within the Hornsea Four Array Area and ECC

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Otter Trawl CPUE (catch/500m)**

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

**Epibenthic Trawl CPUE (catch/500m)**

- 0
- 0 - 1

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

- Spawning

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

- High Intensity
- Low Intensity


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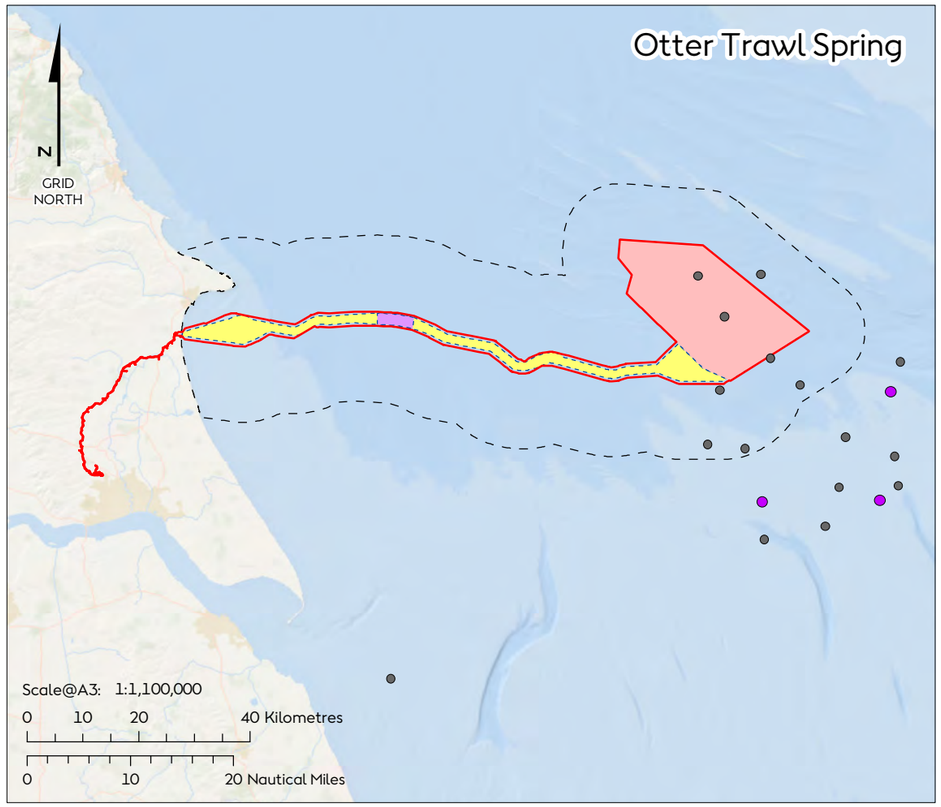


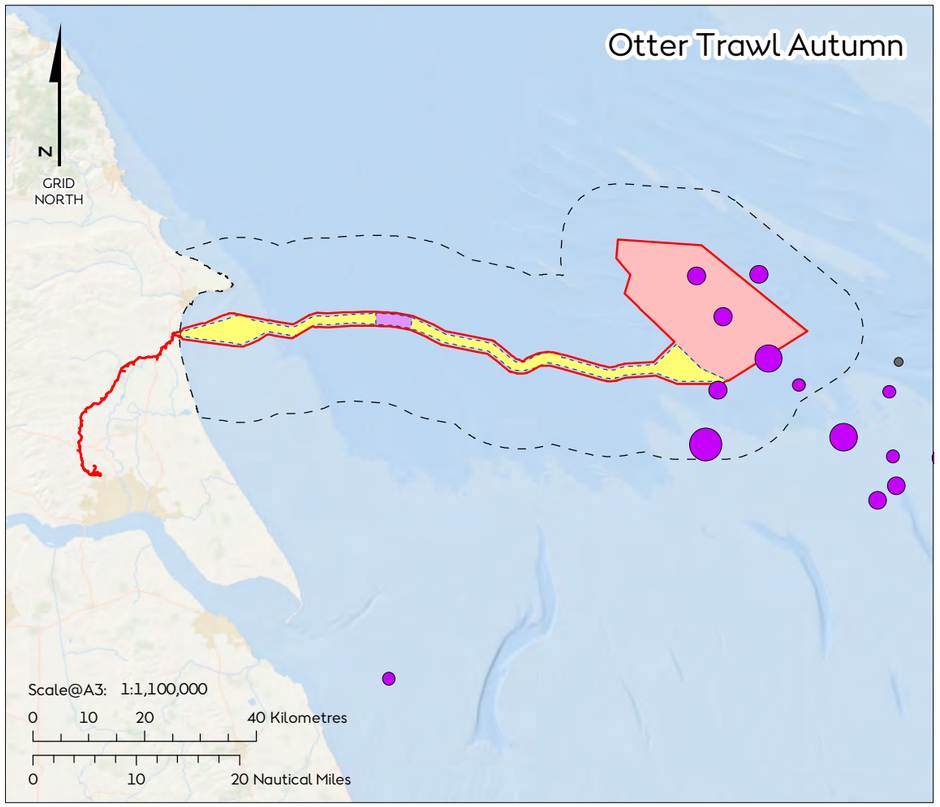


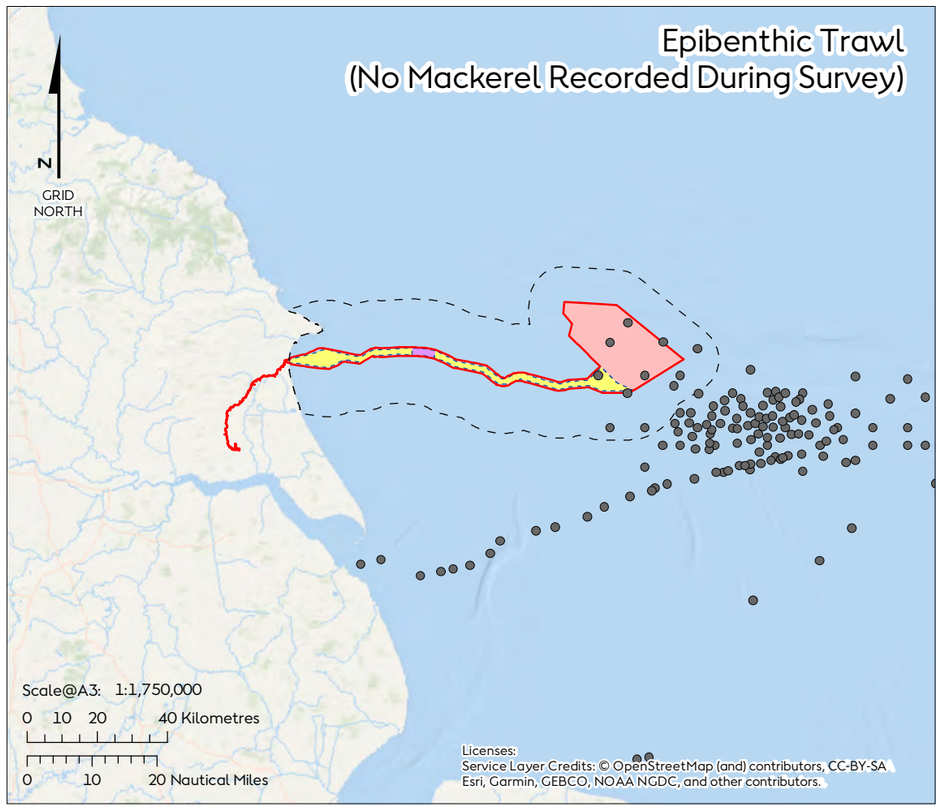


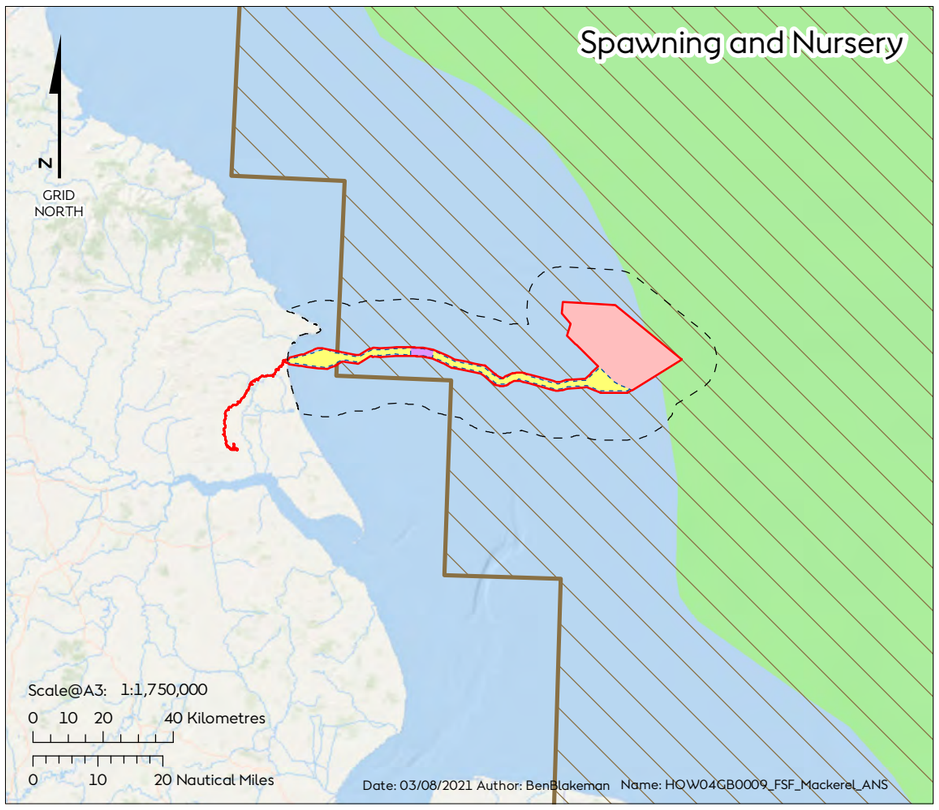


# Hornsea Four

Figure 15

Mackerel Abundance and Nursery and Spawning Grounds within the Hornsea Four Array Area

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Otter Trawl CPUE (catch/500m)**

- 0
- 0.1 - 1.0
- 1.0 - 10.0
- 10.0 - 20.0
- 20.0 - 40.0
- 40.0 - 60.0

**Epibenthic Trawl CPUE (catch/500m)**

- 0

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

- Spawning

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

- Low Intensity


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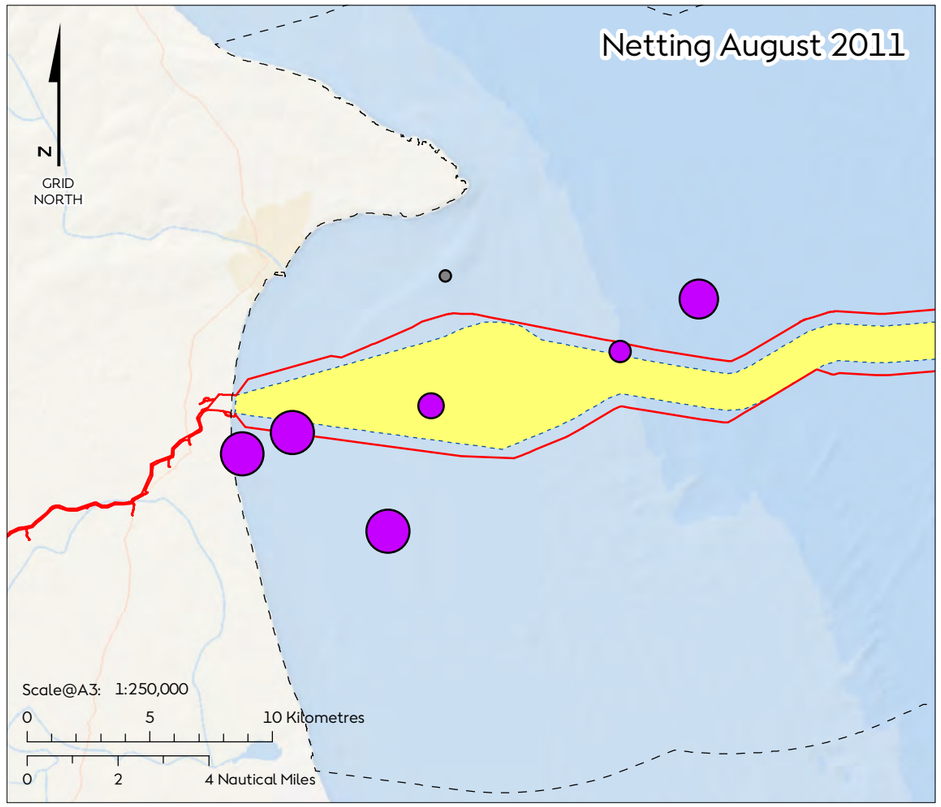
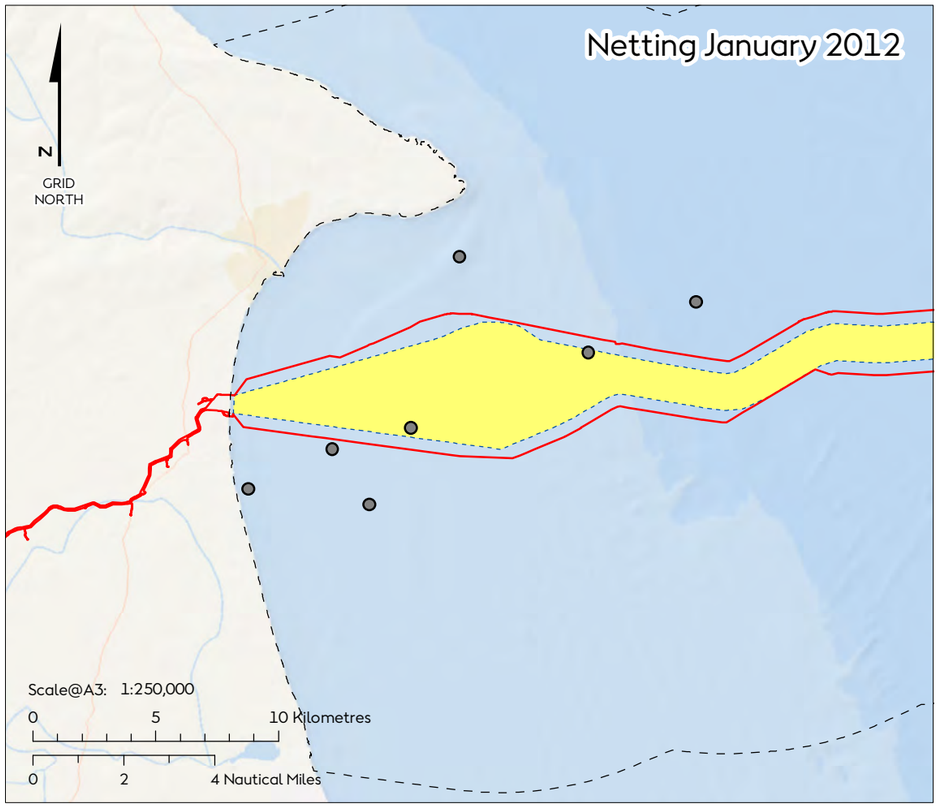
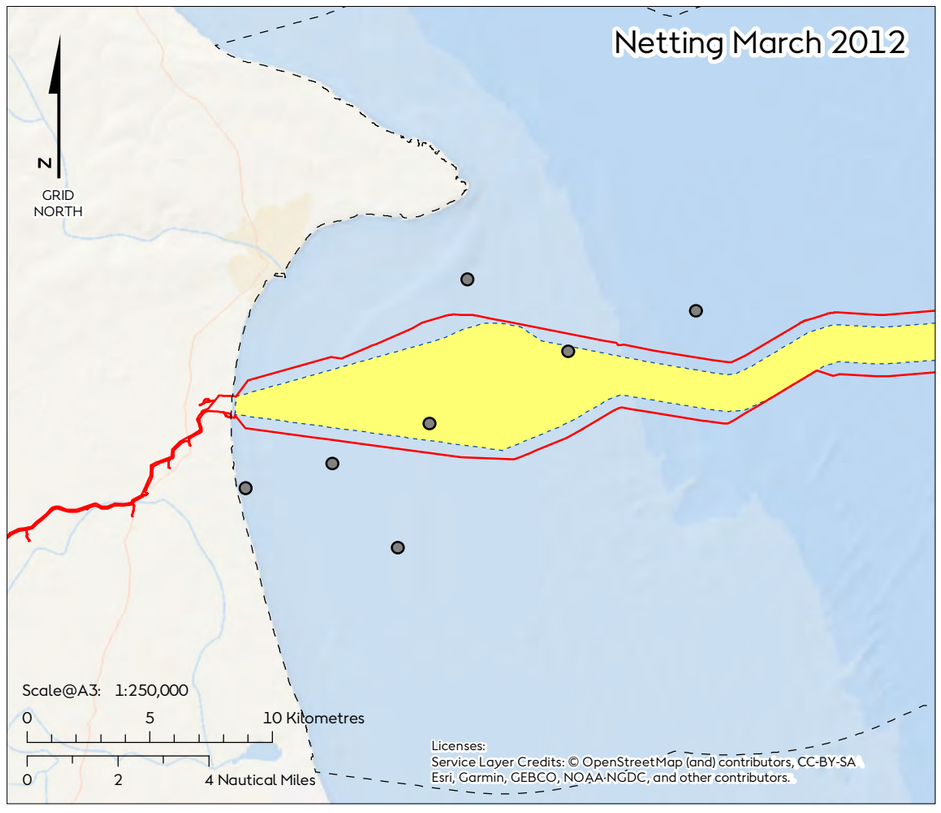
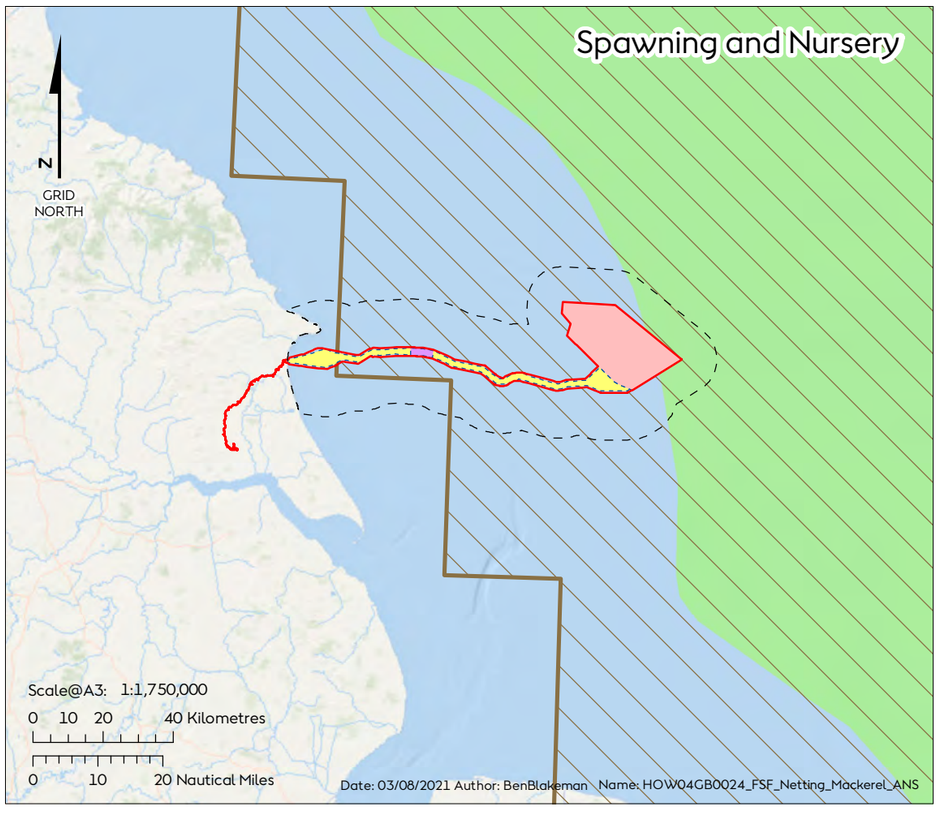



# Hornsea Four

Figure 16

Mackerel Abundance and Nursery and Spawning Grounds within the Hornsea Four ECC

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Trammel Netting CPUE (abundance/hour)**

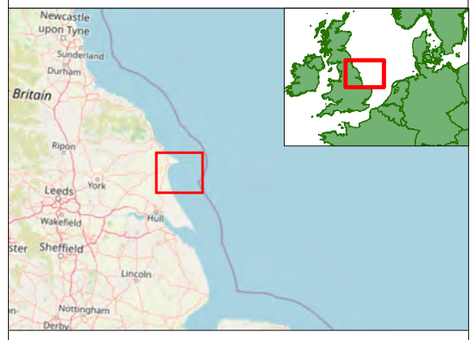
- 0
- 0 - 0.02
- 0.02 - 0.04
- 0.04 - 0.06
- 0.06 - 0.08
- 0.08 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4

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

- Spawning

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

- Nursery

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*Sandeel*

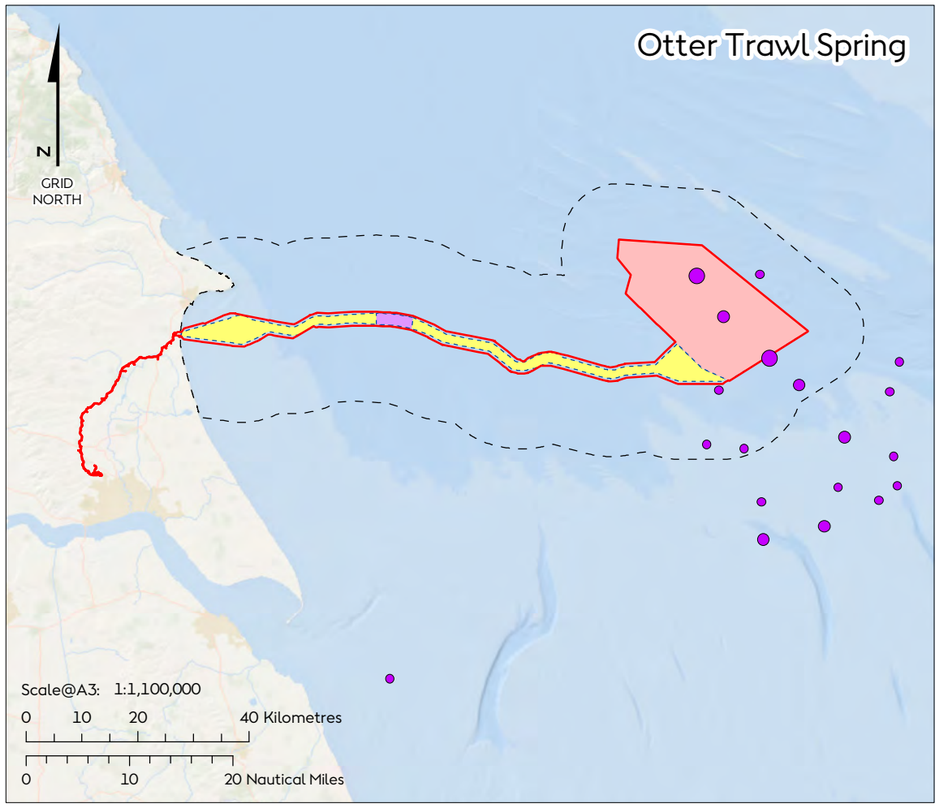
3.1.2.32 Sandeel are of commercial importance as identified in **Annex 6.1: Commercial Fisheries Technical Report**, particularly to the Danish commercial fishing fleet in the Dogger Bank area. In addition to this, sandeels are of importance in the food web being a key prey species for piscivorous fish, seabirds and marine mammals.

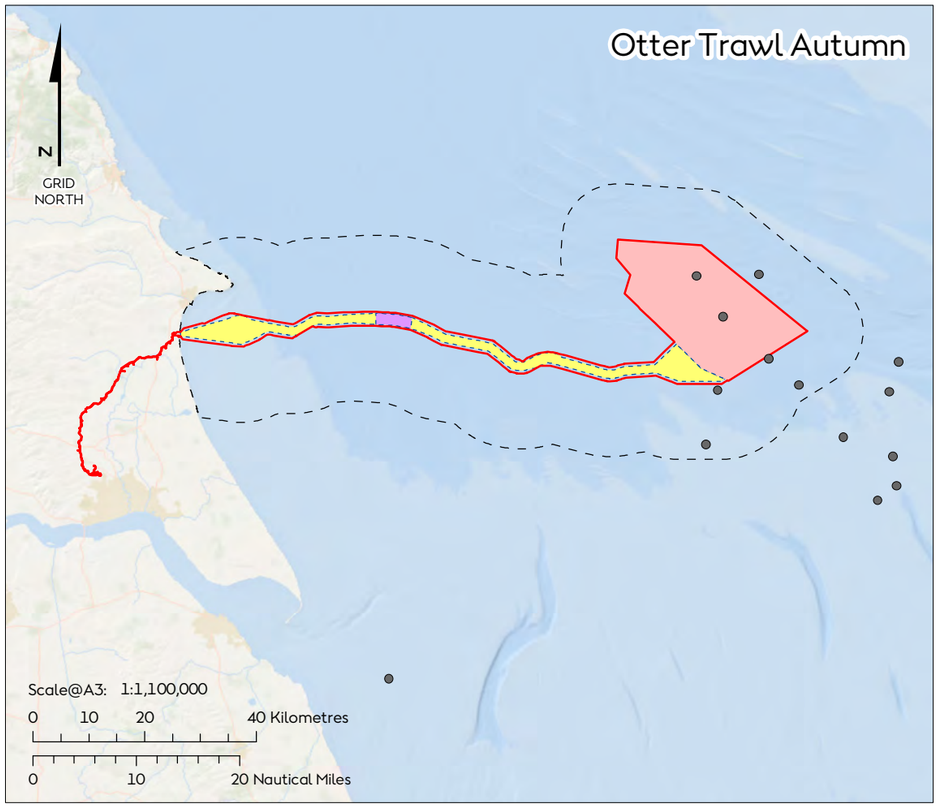
3.1.2.33 The presence of lesser sandeel, a species of conservation importance (UK BAP and NERC Act, 2006), has been recorded in historic surveys conducted within the Hornsea Four fish and shellfish study area (**paragraph 2.2.3.1** *et seq*). Lesser sandeel abundances were generally highest in epibenthic beam trawls (up to 30 per 500 m) compared to abundances recorded in otter trawls (up to 10 per 500 m). 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, together with the difference in how these gear types target benthic and demersal species). Sandeel 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**).

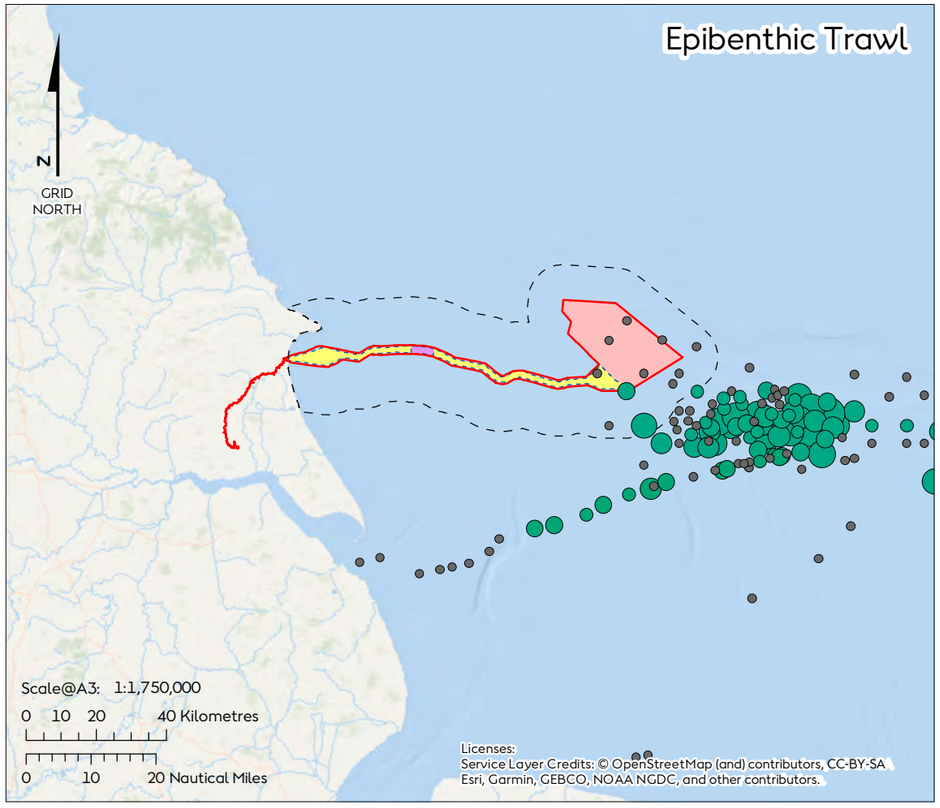
3.1.2.34 Surveys undertaken within the nearshore section of the Hornsea Four ECC, showed relatively high abundances of sandeel, with a peak in catches observed in August; this is likely due to the seasonal cycle of the species, with the August data collected at the end of the feeding season, likely best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

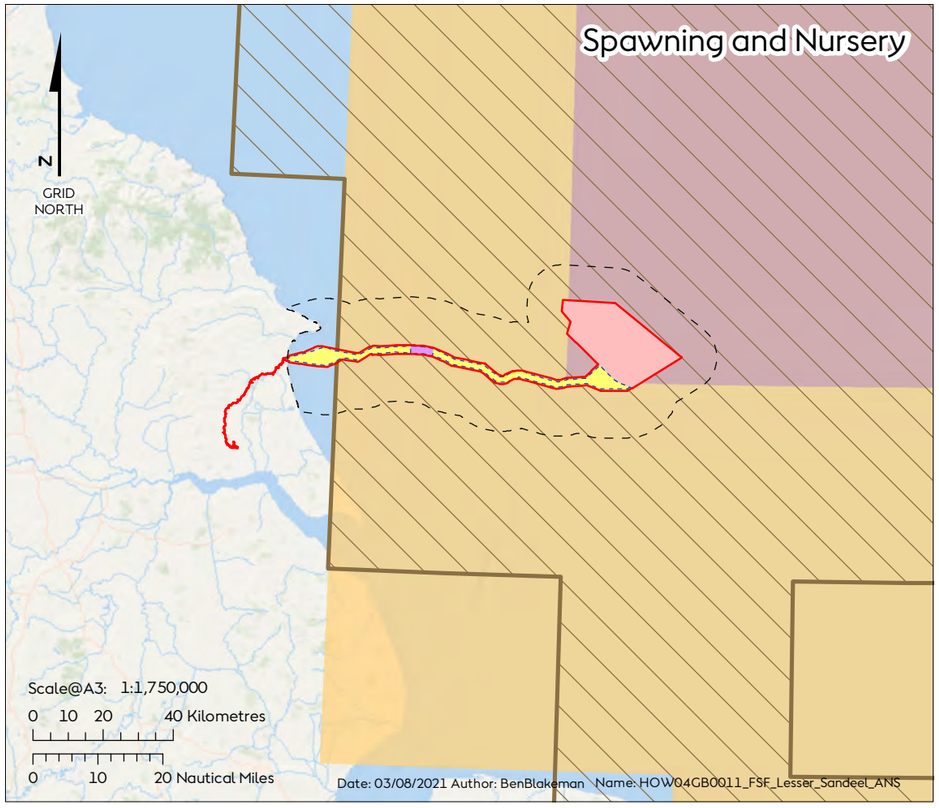
3.1.2.35 Sandeel spawning habitats are known to occur throughout the Southern North Sea, with habitats occurring to the north and north west of the former Hornsea Zone, and further north of Dogger Bank. Lower intensity lesser and greater sandeel spawning and nursery habitats are located within the Hornsea Four array area. Higher 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 historic trawl surveys (**paragraph 2.2.3.1** *et seq*).

3.1.2.36 Suitable sandeel habitats have been mapped using data from EUNIS and Folk (1954) (Stephens and Diesing 2015), site specific PSA data (Gardline 2019; GoBe 2020), and from the former Hornsea Zone from BGS (2015); the outputs of this analysis of potential sandeel spawning habitats are presented in **Section 3.2.3**.




# Hornsea Four

Figure 17

Lesser Sandeel Abundance and Nursery and Spawning Grounds within the Hornsea Four Array Area and ECC

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Otter Trawl CPUE (catch/500m)**

- 0.0
- 0.1 - 1.0
- 1.0 - 5.0
- 5.0 - 10.0

**Epibenthic Trawl CPUE (catch/500m)**

- 0
- 0.1 - 1
- 1.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 30.0

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

- High Intensity
- Low Intensity

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

- Low Intensity


Coordinate system: ETRS 1989 UTM Zone 31N

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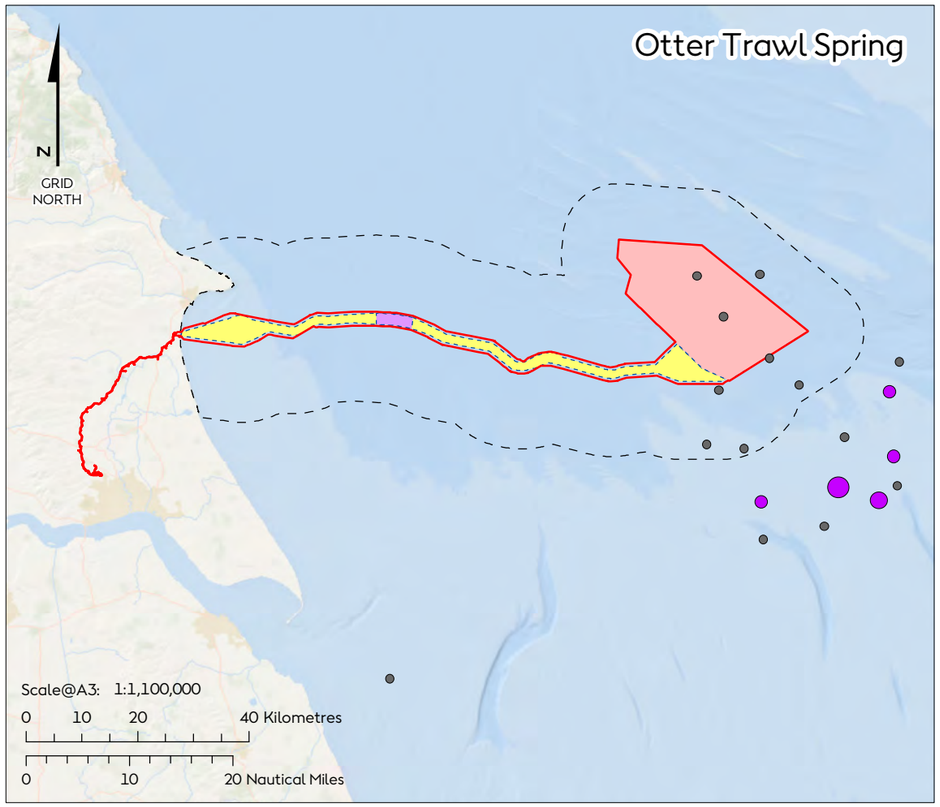


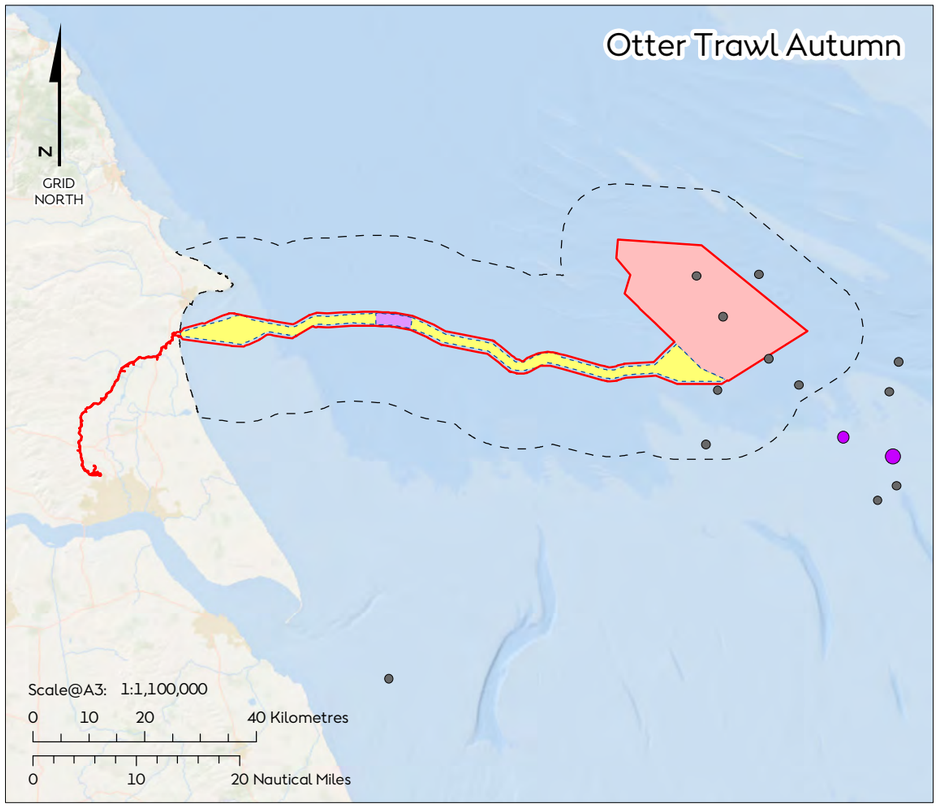


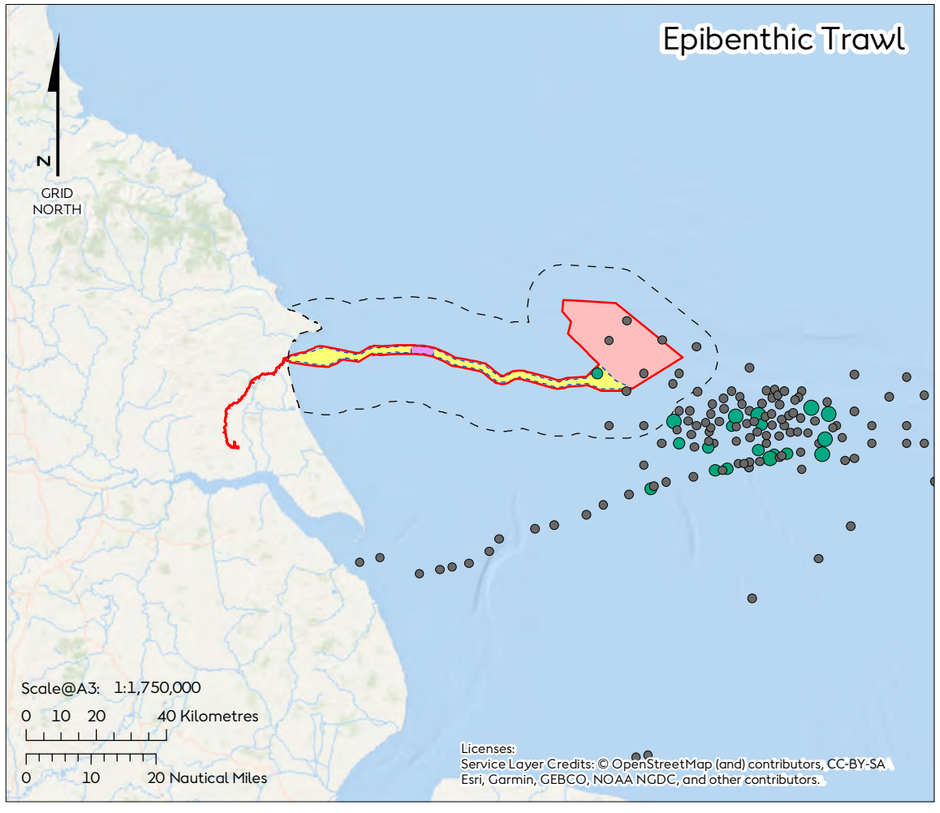


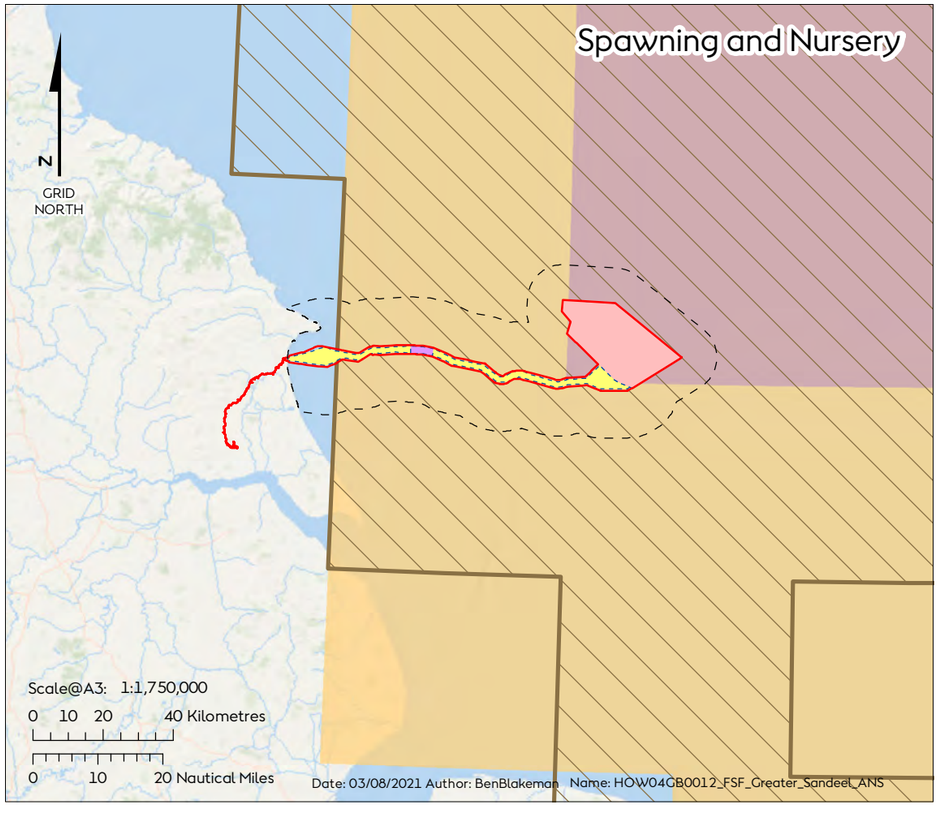


# Hornsea Four

Figure 18

Greater Sandeel Abundance and Nursery and Spawning Grounds within the Hornsea Four Array Area and ECC

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Otter Trawl CPUE (catch/500m)**

- 0
- 0 -1
- 1 - 5
- 5 - 10
- 10 - 25

**Epibenthic Trawl CPUE (catch/500m)**

- 0
- 0 - 1
- 1 - 5

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

- High Intensity
- Low Intensity

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

- Low Intensity


Coordinate system: ETRS 1989 UTM Zone 31N

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*Elasmobranchs*

3.1.2.37 Thornback ray and spotted ray, both species of conservation importance (Oslo Paris Convention (OSPAR)), have been recorded in historic surveys conducted within the Hornsea Four study area (**paragraph 2.2.3.1** *et seq*). The species were recorded sporadically during both otter and epibenthic beam trawl surveys (**Figure 19**, **Figure 20**, **Figure 21** and **Figure 22**). No spawning or nursery habitats have been mapped in the vicinity of the Hornsea Four fish and shellfish study area.

3.1.2.38 In a broader context, thornback ray are typically most abundantly recorded 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 habitats (ICES 2005i).

3.1.2.39 Spotted ray distributions are focused within the south-western North Sea, particularly near the outer parts of estuaries, and with a low abundance over the northern and eastern parts of the southern North Sea basin (Sguotti et al. 2016). This is supported by catch rate data which indicated highest concentrations around southern England, but also Scotland (Daan, Heessen and ter Hofstede 2005).

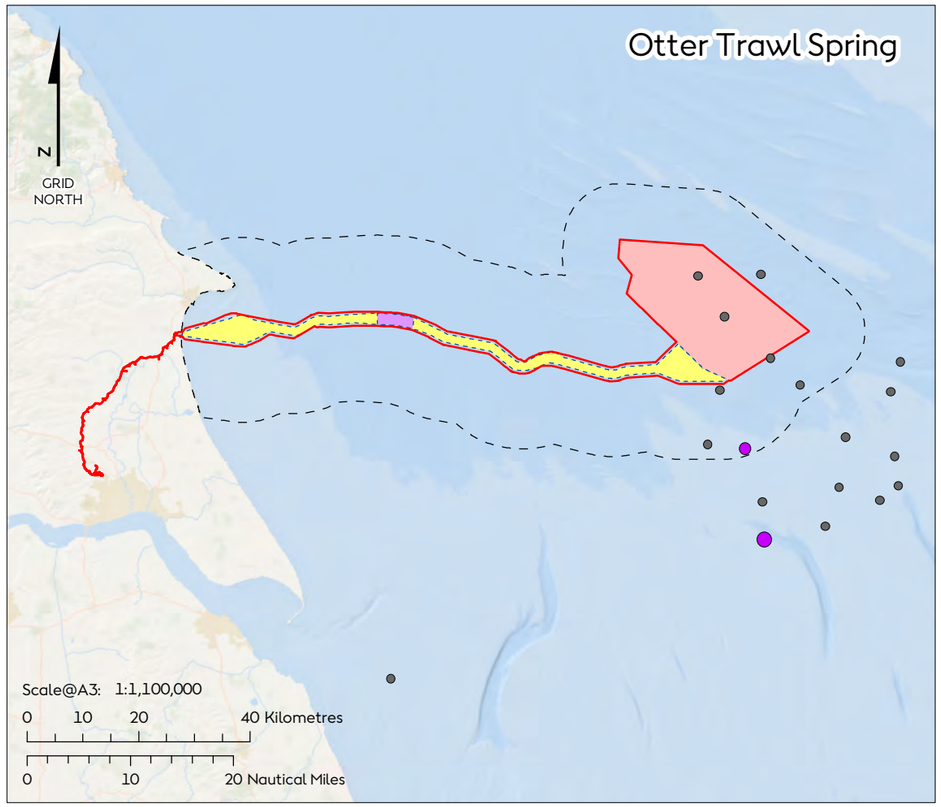
3.1.2.40 Blonde ray (*Raja brachyura*) distributions typically range from the north coast of Scotland to the southeast, south, and southwest coast of England (Gibson-Hall 2018). Blonde ray were not recorded within the Hornsea Four fish and shellfish study area, or the inshore section of the Hornsea Four 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 Dogger Bank A and B surveys).

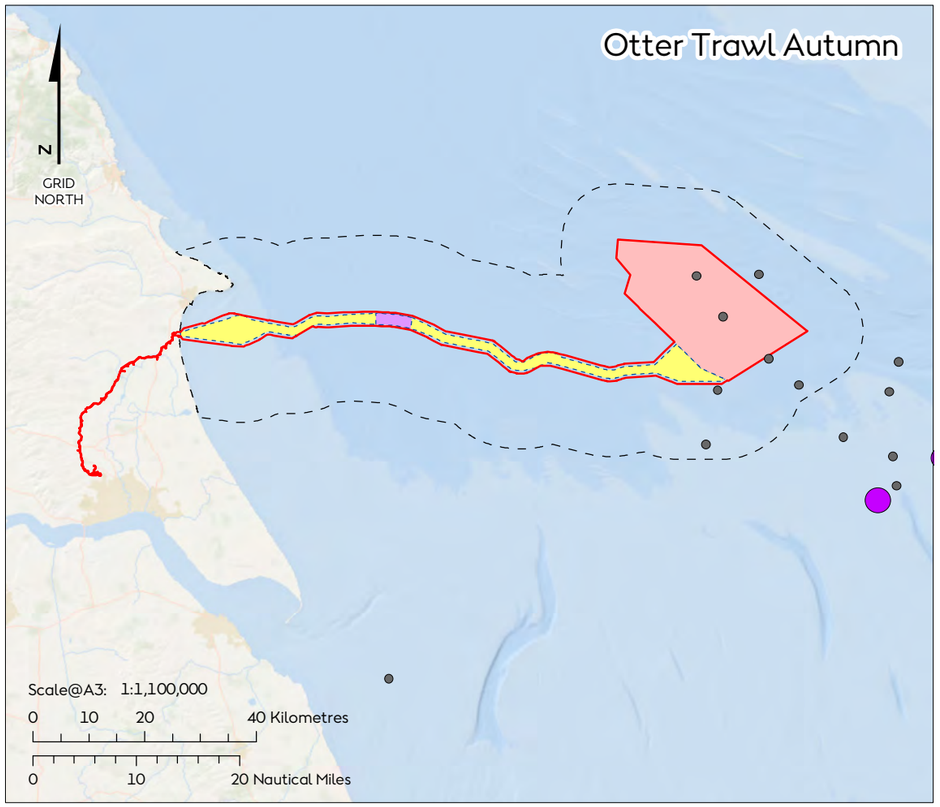
3.1.2.41 Additional elasmobranchs recorded at low abundances throughout the study area include cuckoo ray (*Raja naevus)*, starry smoothhound (*Mustelus asterias*) and spurdog (*Squalus acanthias).* Evidence suggests cuckoo ray are most abundant off the coast of Scotland, with surveys showing high abundances of the species off the west and east coasts of Scotland (ICES 2017b; Walker and Heesen 1996) suggesting that the main distribution of this species is located in the Northern North Sea.

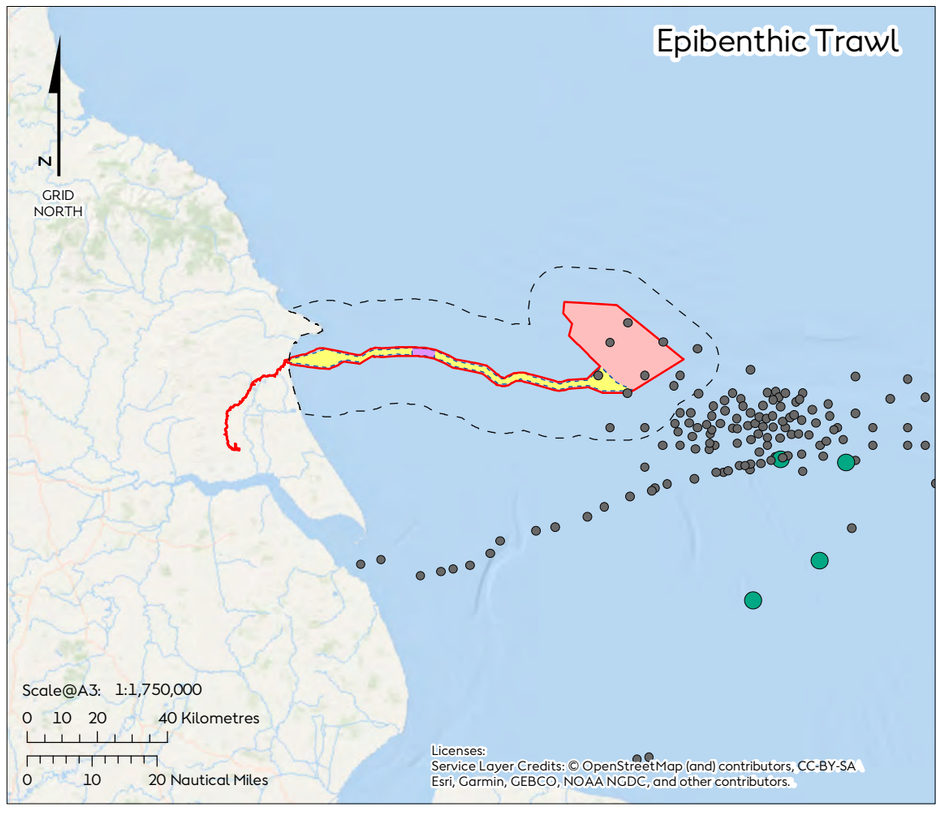
3.1.2.42 Modelled spatial distributions of lesser-spotted dogfish and spurdog showed lesser spotted dogfish populations concentrated within the southernmost parts of the North Sea, primarily in the Thames and Humber regions (Sguotti et al. 2016). Spurdog were widely distributed within the North Sea, with concentrations varying between the Northern and Southern North Sea (Sguotti et al. 2016).

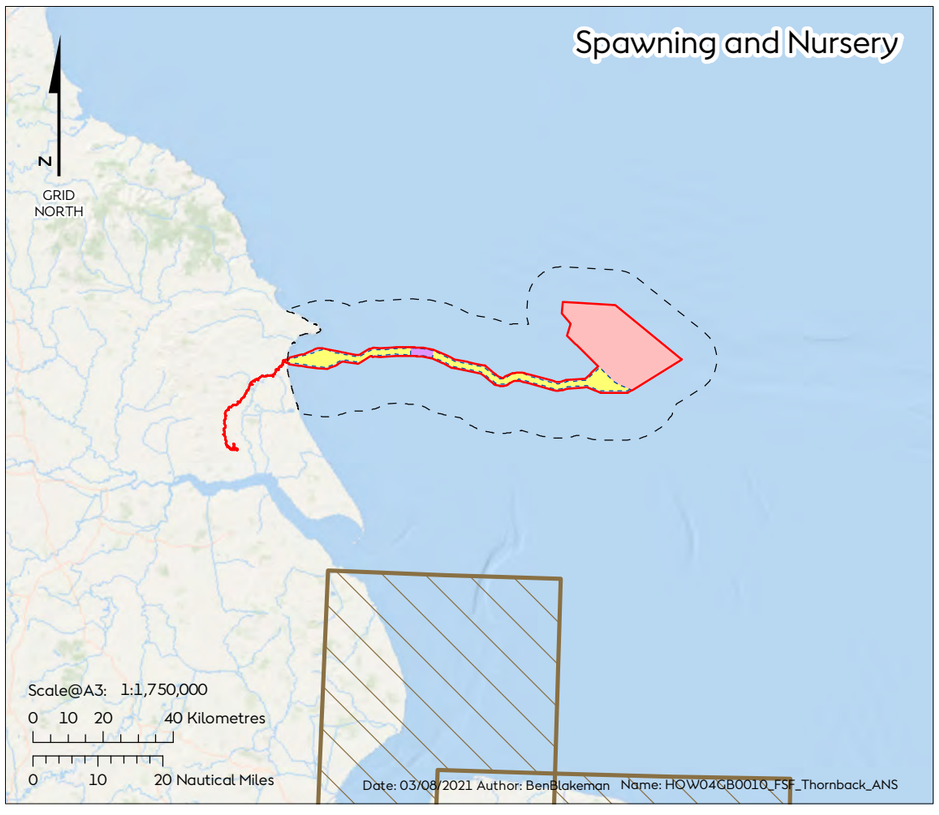
3.1.2.43 Starry smoothhound were observed in relatively low abundances in trammel net surveys conducted in the nearshore section of the Hornsea Four ECC (as observed in Dogger Bank A and B surveys). Modelled spatial distributions of smoothhound in the North Sea show concentrations primarily in the Southern North Sea, within the Thames region, and off the continental coast (Sguotti et al. 2016).

3.1.2.44 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).




# Hornsea Four

Figure 19

Thornback Ray Abundance and Nursery Grounds within the Hornsea Four Array Area

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Otter Trawl CPUE (catch/500m)**

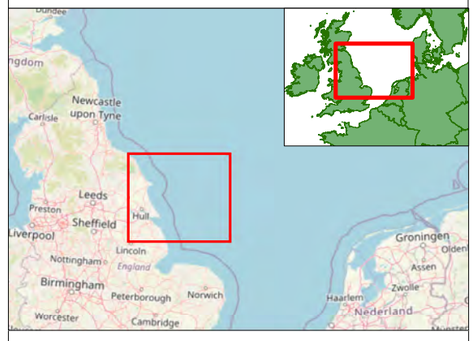
- 0.0
- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0

**Epibenthic Trawl CPUE (catch/500m)**

- 0
- 0 - 2

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

- Low Intensity

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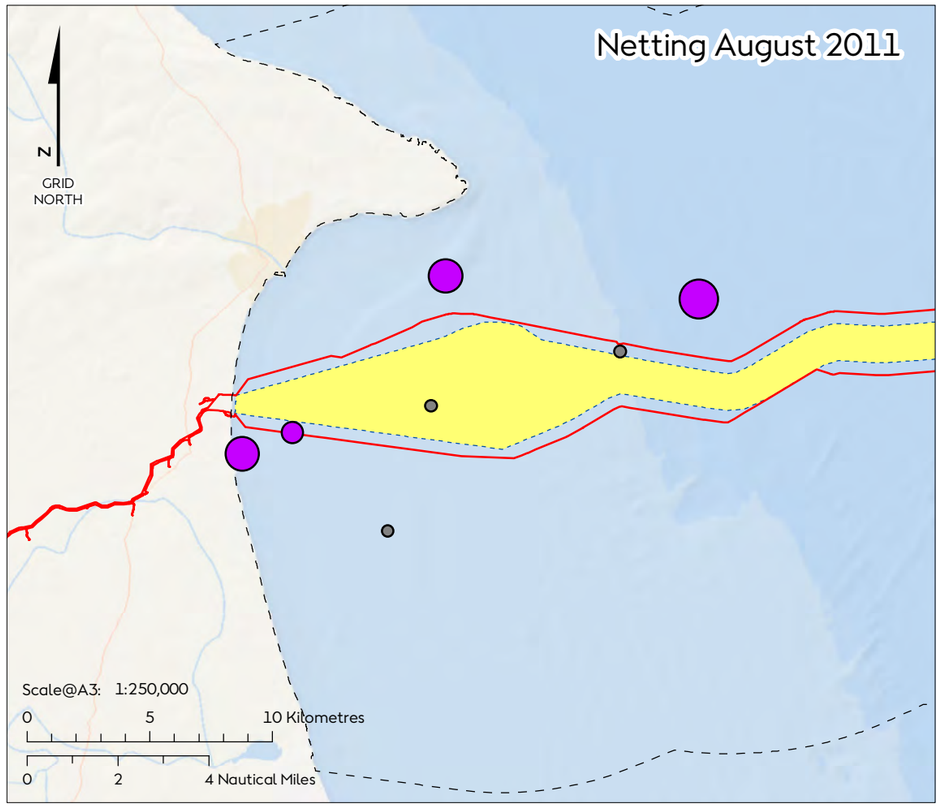
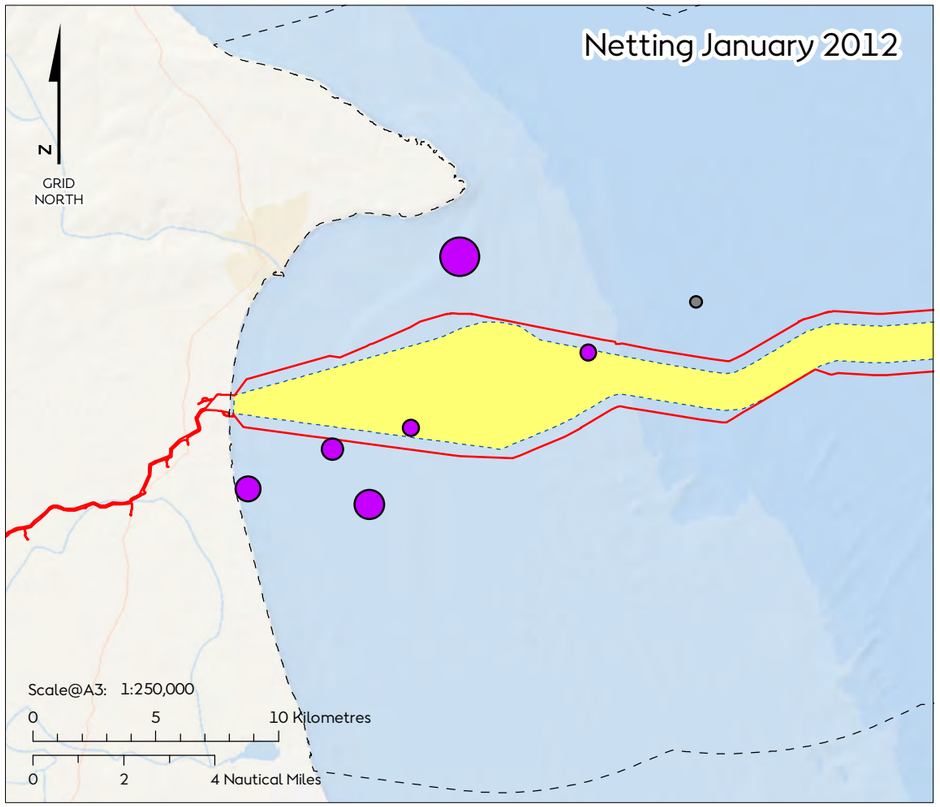
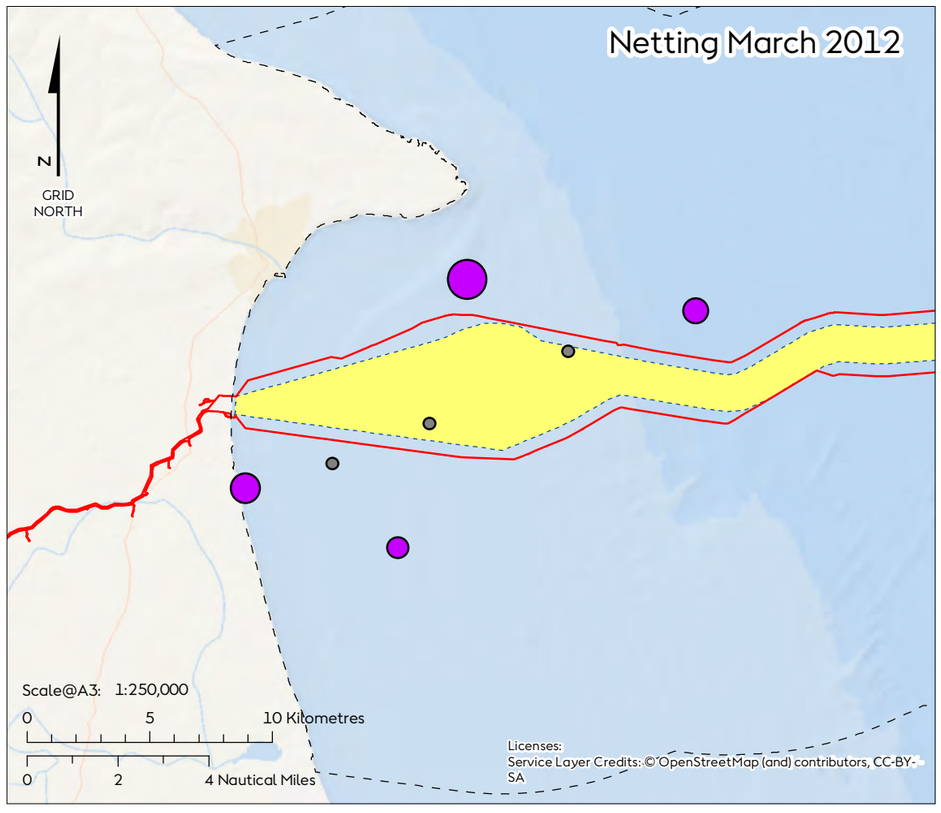
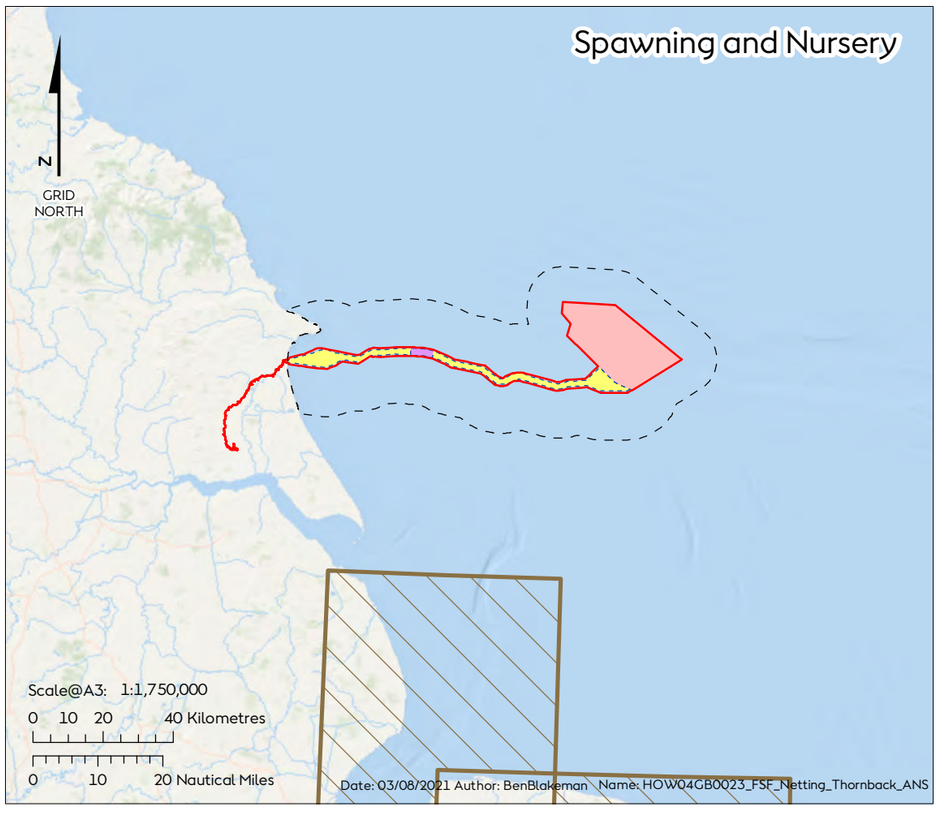



# Hornsea Four

Figure 20

Thornback Ray Abundance and Nursery Grounds within the Hornsea Four ECC

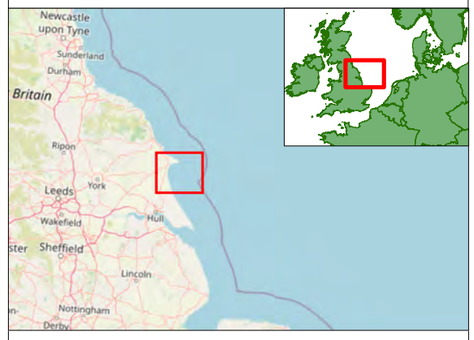
- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Trammel Netting CPUE (abundance/hour)**

- 0
- 0 - 0.02
- 0.02 - 0.04
- 0.04 - 0.06
- 0.06 - 0.08
- 0.08 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4

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

- Low Intensity

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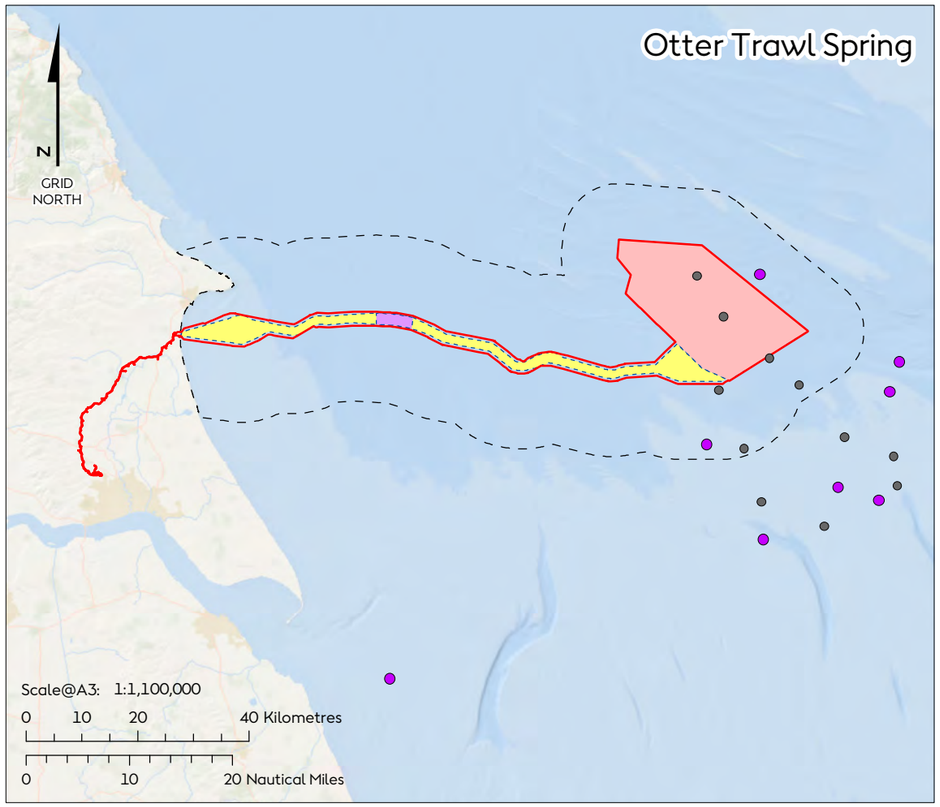


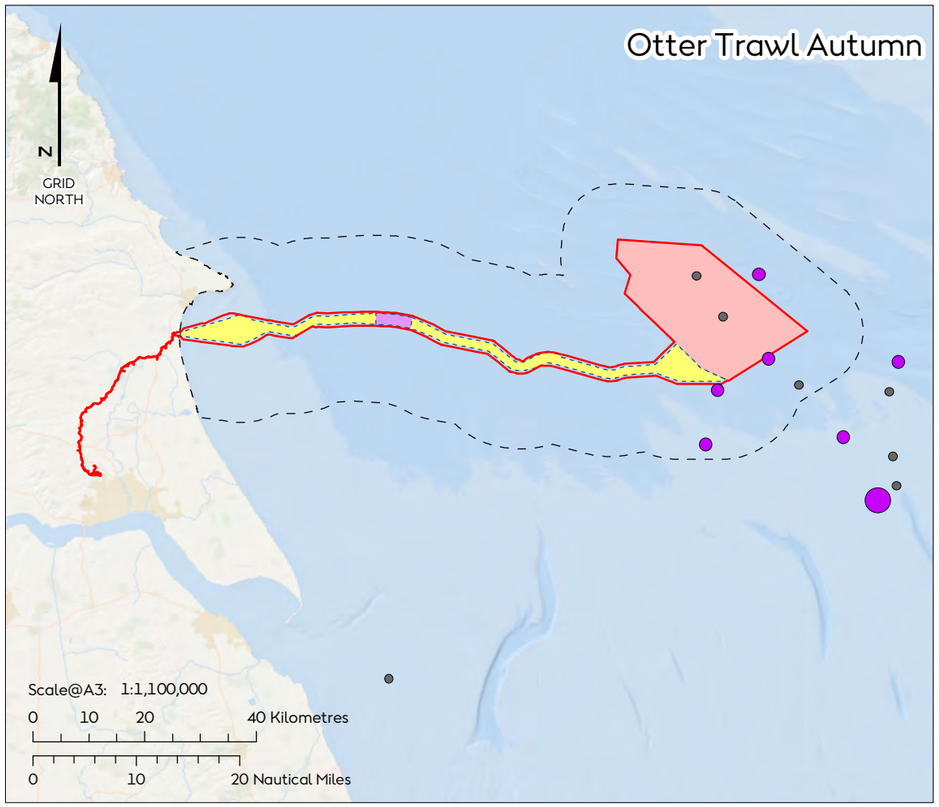


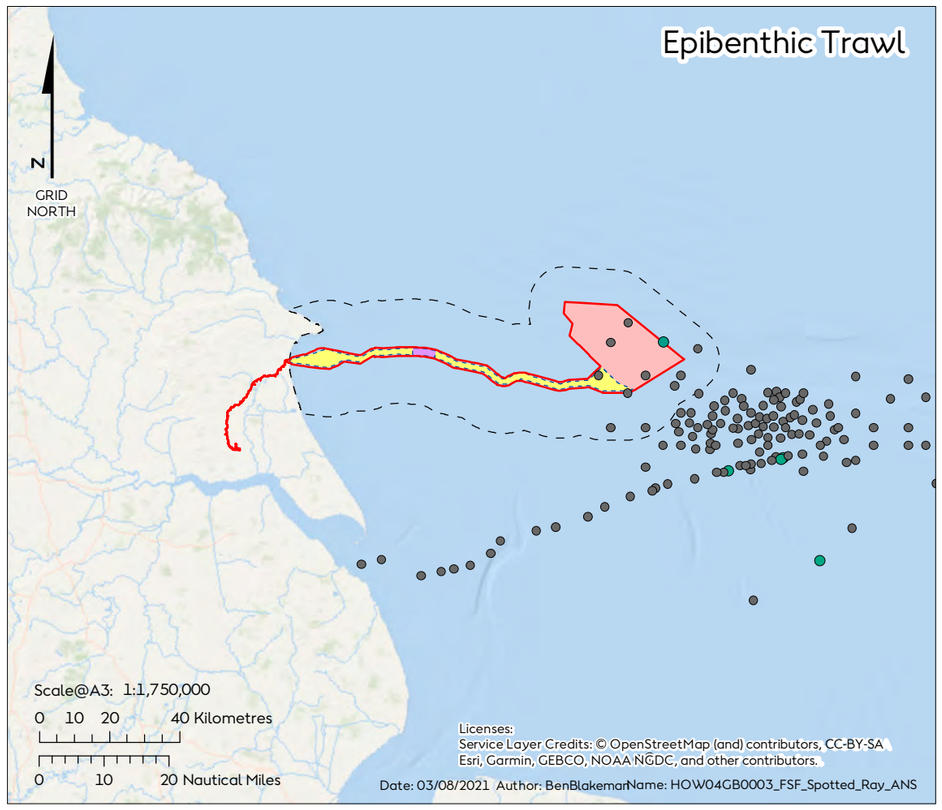


# Hornsea Four

Figure 21

Spotted Ray Abundances within the Hornsea Four Array Area

- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations

**Otter Trawl CPUE (catch/500m)**

- 0
- 1 - 2
- 2 - 4
- 4 - 6
- 6 - 8

**Epibenthic Trawl CPUE (catch/500m)**

- 0
- 1 - 2


Coordinate system: ETRS 1989 UTM Zone 31N

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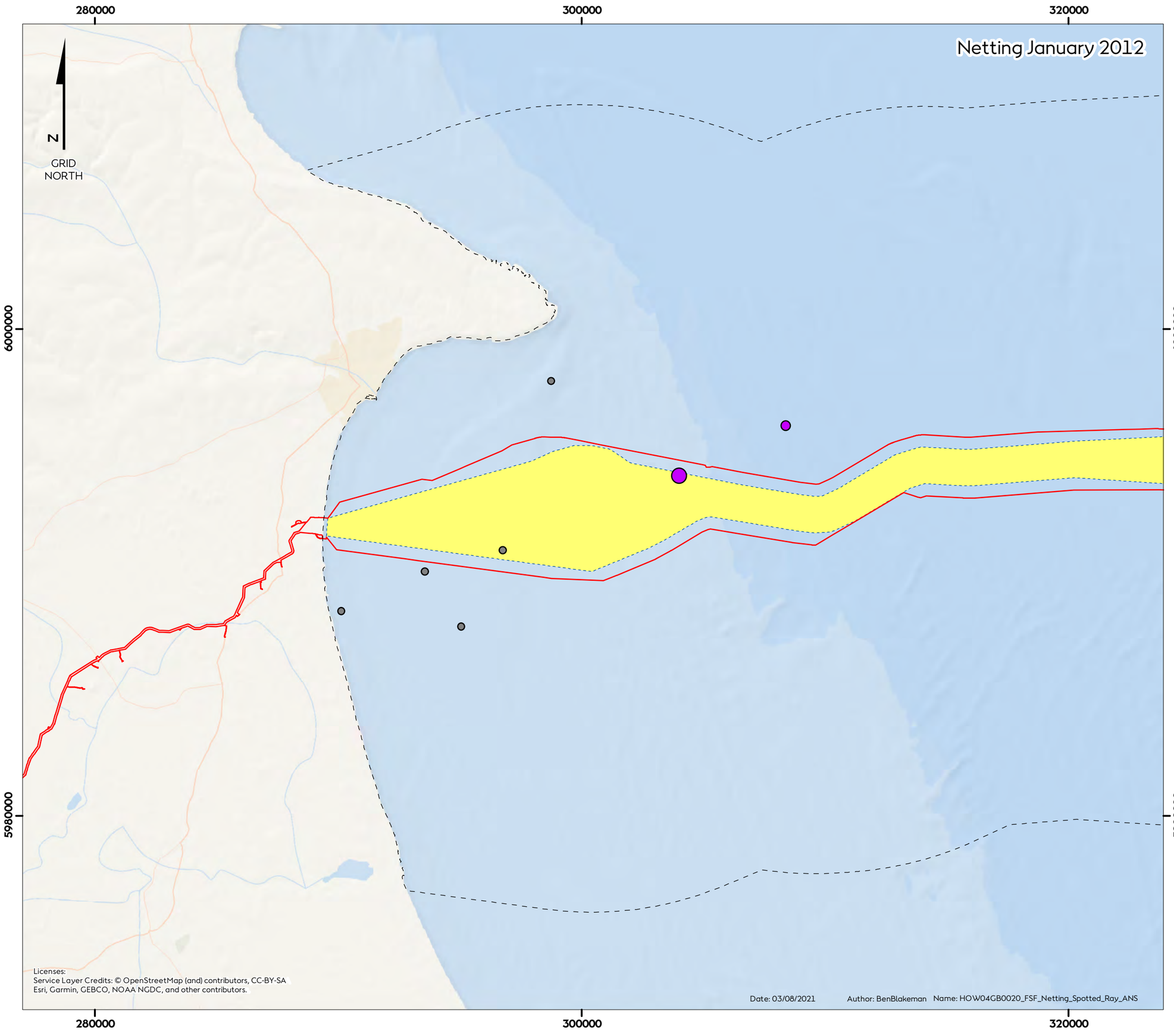


# Hornsea Four

Figure 22

Spotted Ray Abundances within the Hornsea Four ECC

- Fish and Shellfish Study Area
- Order Limits
- Offshore Export Cable Corridor

**Trammel Netting CPUE (abundance/hour)**

- 0
- 0 - 0.02
- 0.02 - 0.04
- 0.04 - 0.06
- 0.06 - 0.08
- 0.08 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4


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*Scale@A3:* 1:150,000

0 4 8 Kilometres

0 2 4 Nautical Miles

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## 3.2 Spawning and nursery habitats

3.2.1.1 A number of 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 fish and shellfish study area (Coull et al. 1998; Ellis et al. 2012). **Table 4** and **Table 5** detail fish species which have spawning and nursery habitats 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 tables. Spawning seasons 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 Opinion, (PINS 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 fish and shellfish study area coincides with the Banks (Central North Sea) 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), Eaton et al. (2003) 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* | 3.4 | 0 | 0 |
| *Lemon Sole* | *Microstomus kitt* | 0 | 0 | 0 |
| *Mackerel* | *Scomber scombrus* | 0 | 9.0 | 58.9 |
| *Nephrops* | *Nephrops norvegicus* | 5.4 | 16.9 | 73.8 |
| *Plaice* | *Pleuronectes platessa* | 0 | 0 | 0 |
| *Sandeel* | *Ammodytes tobianus* | 0 | 0 | 0 |
| *Sprat* | *Sprattus sprattus* | 0 | 0 | 0 |
| *Whiting* | *Merlangius merlangu* | 0 | 0 | 38.1 |
| *Brown crab* | *Cancer pagurus* | 1.6 | 0 | 0 |

Note: Distances presented should be interpreted with caution as boundaries drawn by Coull et al. (1998), Ellis et al. (2010) and Eaton et al. (2003) 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* | 0 | 0 | 0 |
| *Herring* | *Clupea harengus* | 0 | 0 | 0 |
| *Lemon Sole* | *Microstomus kitt* | 0 | 0 | 0 |
| *Mackerel* | *Scomber scombrus* | 0 | 0 | 0 |
| *Nephrops* | *Nephrops norvegicus* | 5.5 | 17.0 | 74.0 |
| *Plaice* | *Pleuronectes platessa* | 35.4 | 0 | 6.2 |
| *Sandeel* | *Ammodytes tobianus* | 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 tobianus* | | | | | | | | | | | | |
| *Sprat* | *Sprattus sprattus* | | | | | | | | | | | | |
| *Whiting* | *Merlangius merlangu* | | | | | | | | | | | | |

### 3.2.2 Herring

3.2.2.1 The 2007 – 2021 IHLS dataset[4] (larval class size <11 mm) (Figure 23) data aggregated across the selected period, not averaged) shows a clear representation of what should be considered to be the current, 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.

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 derived from the IHLS data (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 Hornsea Four ECC.

3.2.2.3 The time-series for the 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, variations in yearly spawning stock, 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 Hornsea Four ECC, with a peak larval abundance of 2,050 $m^2$ (Figure 24).

3.2.2.5 The herring larval abundances within the Hornsea Four ECC peak in the 2011/2012, 2019-2020 and 2020 - 2021 spawning seasons (Figure 25 and Figure 26), with abundances up to 9,325 $m^2$, within the highest density class.

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

[4] Note that data is unavailable for 2017/18 – 2018/19 due to resourcing of the surveys and data errors (ICES 2019).

# Hornsea Four

Figure 23

Hornsea Four with Herring Spawning Grounds IHLS Comparison, full IHLS dataset

250000 300000 350000 400000 450000

6050000 5950000 5900000

N

GRID NORTH

- Fish and Shellfish Study Area
- Order Limits
- Herring Spawning Grounds (Coull *et al.*, 1998)

**IHLS 2007/2008-2020/2021 Banks Data - Total Larval Abundance Per m²**

- 0
- 0 - 1,500
- 1,500.1 - 6,000
- 6,000.1 - 12,750
- 12,750.1 - 20,500
- 20,500.1 - 28,500
- 28,500.1 - 36,500
- 36,500.1 - 45,500
- 45,500.1 - 55,000
- 55,000.1 - 66,000
- 66,000.1 - 77,250
- 77,250.1 - 100,000
- 100,000.1 - 120,000


Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:750,000

0 10 20 Kilometres

0 10 20 Nautical Miles

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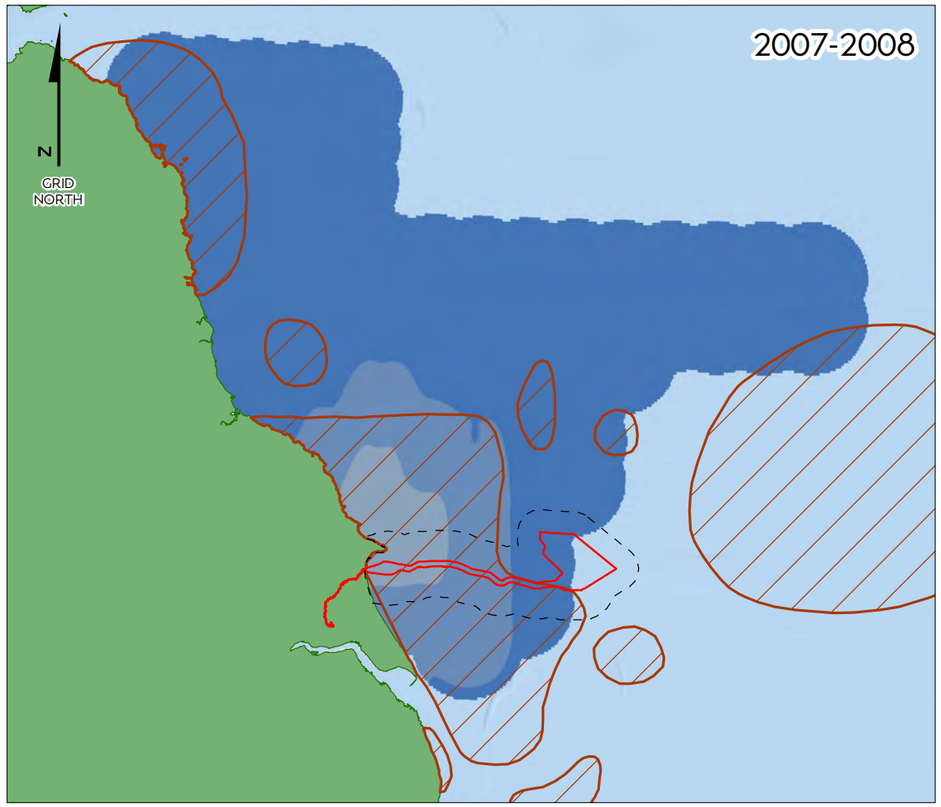
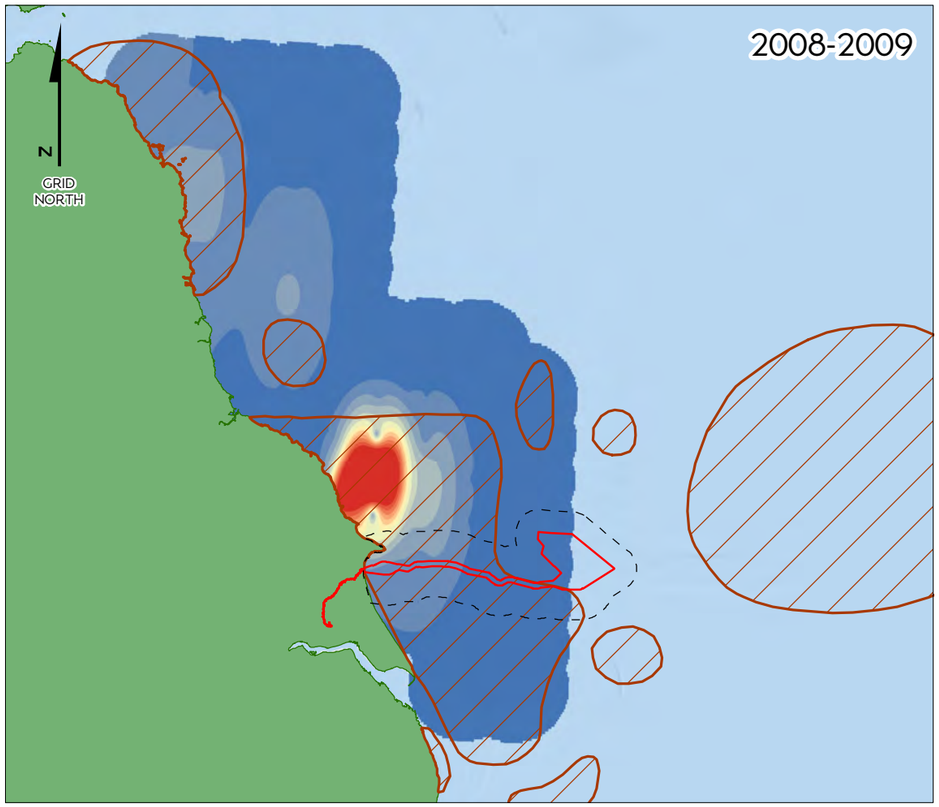
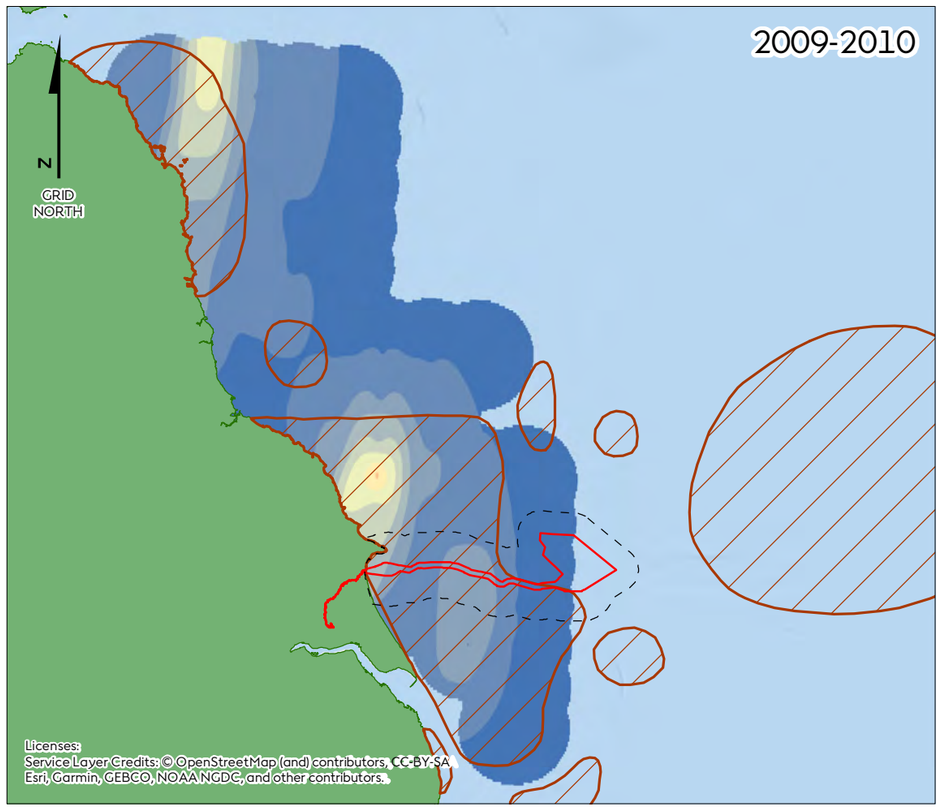
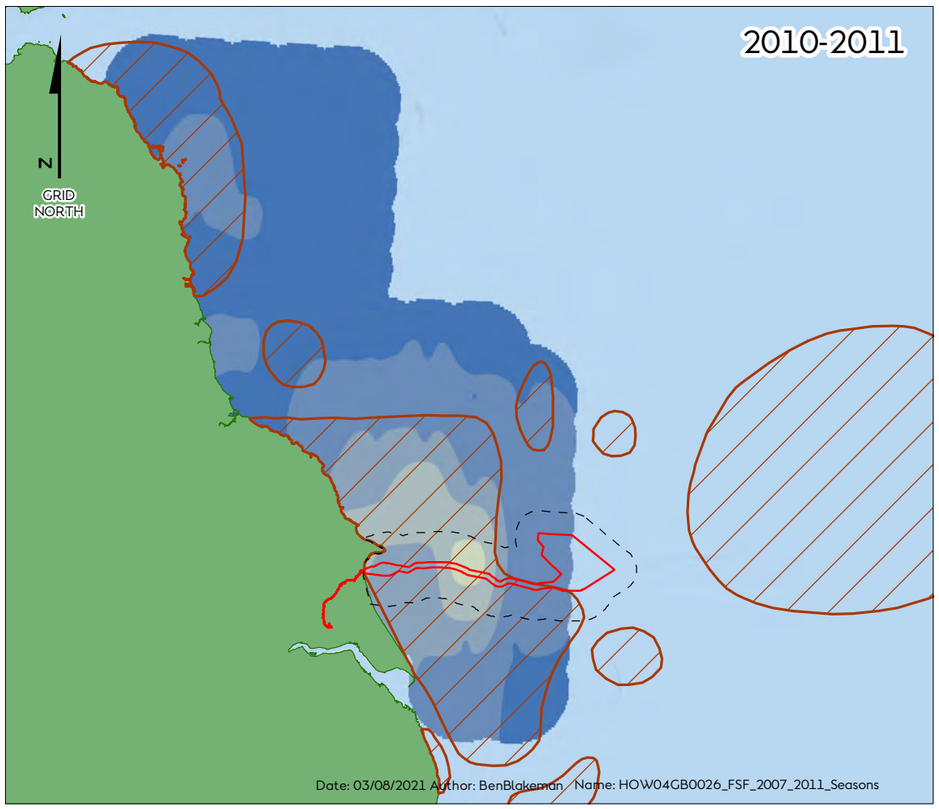
Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0031_FSF_2007_2021_Seasons




# Hornsea Four

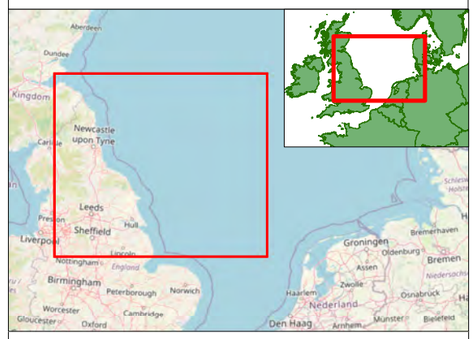
Figure 24

Hornsea Four with Herring Spawning Grounds IHLS Comparison, 2007 – 2011

- Fish and Shellfish Study Area
- Order Limits
- Herring Spawning Grounds (Coull *et al.*, 1998)

**IHLS Banks Data - Larval Abundance Per m²**

- 0
- 0.1 - 150
- 150.1 - 600
- 600.1 - 1,275
- 1,275.1 - 2,050
- 2,050.1 - 2,850
- 2,850.1 - 3,650
- 3,650.1 - 4,450
- 4,450.1 - 5,300
- 5,300.1 - 6,300
- 6,300.1 - 7,425
- 7,425.1 - 9,325




Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:2,750,000

0 50 100 Kilometres

0 25 50 Nautical Miles

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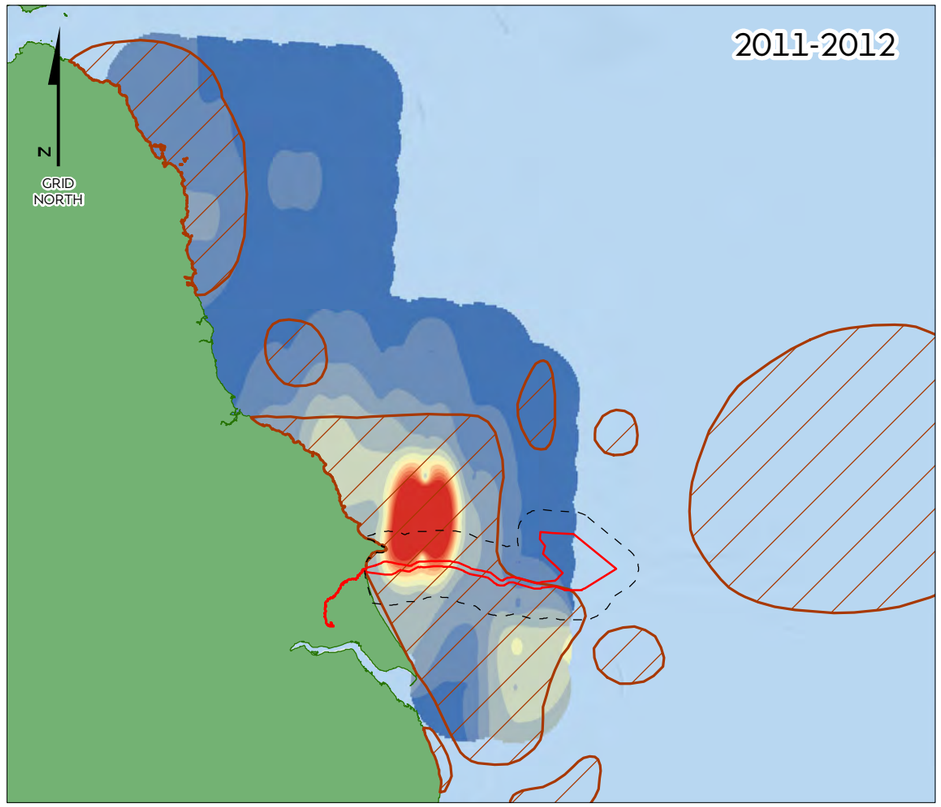
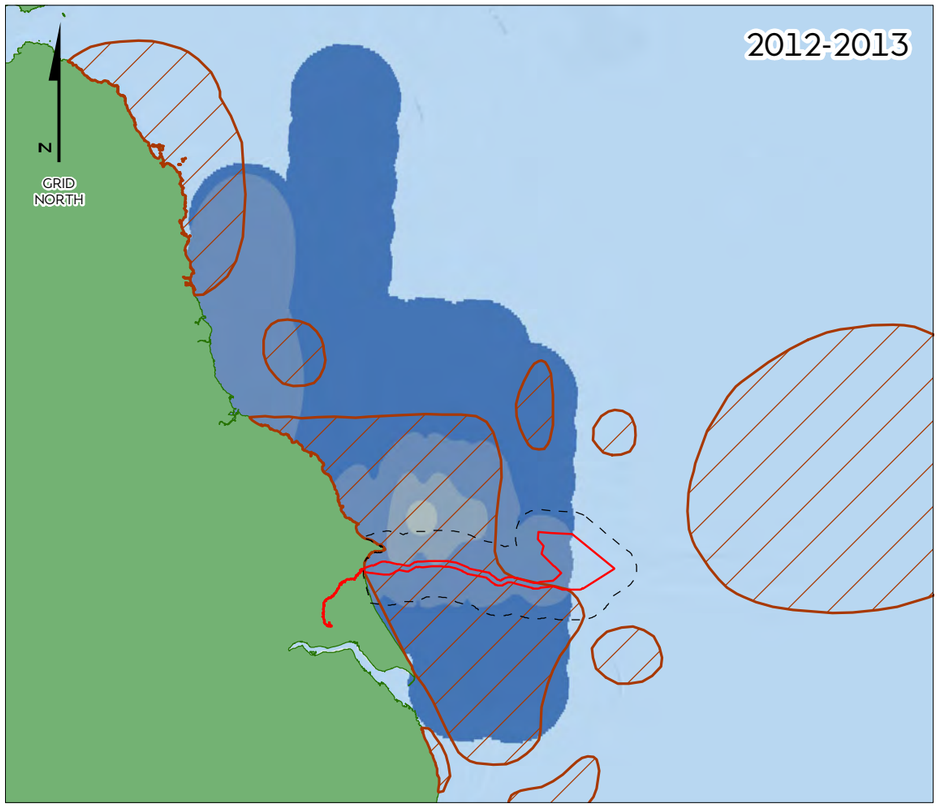
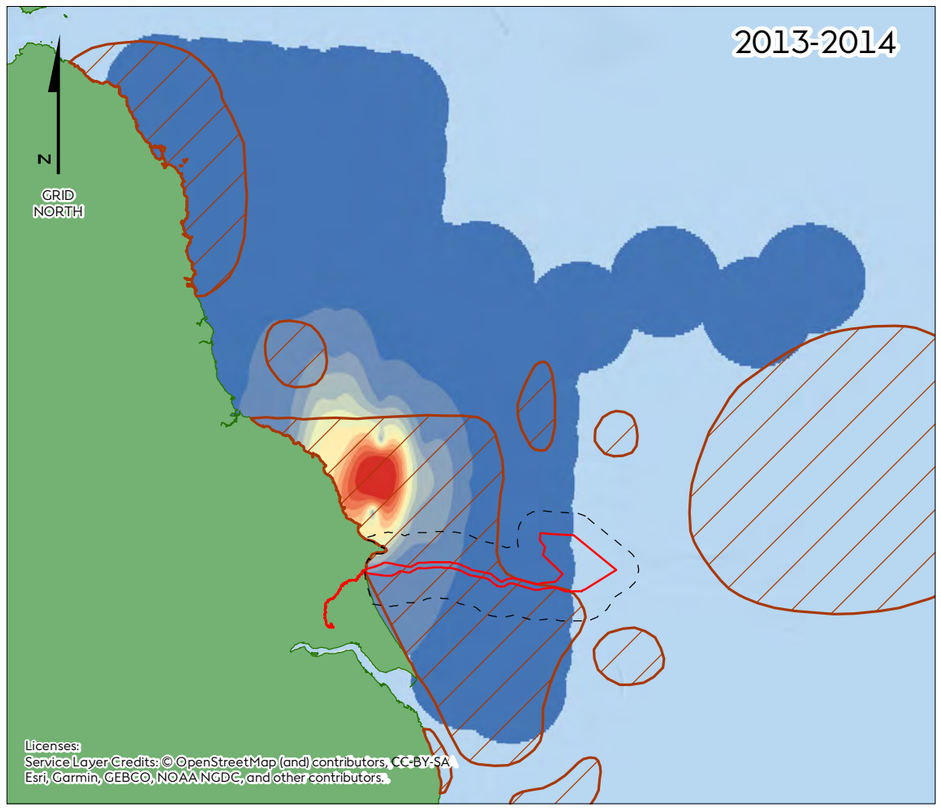
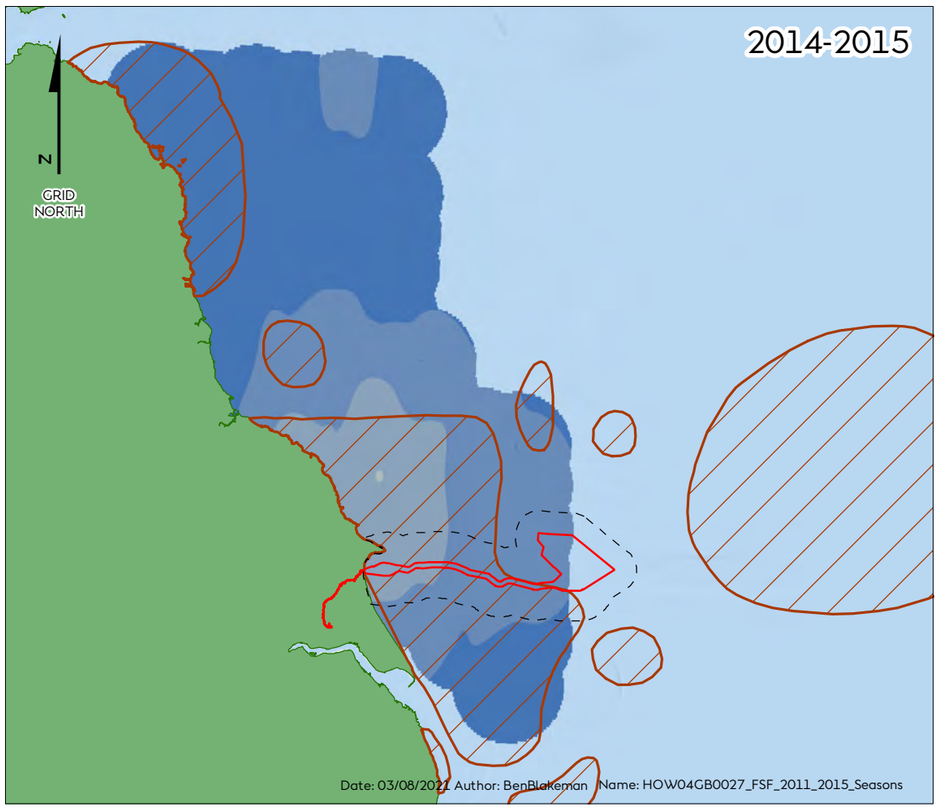



# Hornsea Four

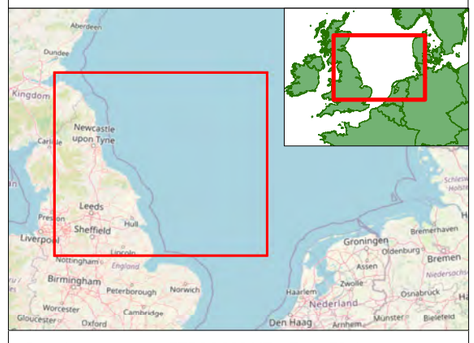
Figure 25

Hornsea Four with Herring Spawning Grounds IHLS Comparison, 2011 – 2015

- Fish and Shellfish Study Area
- Order Limits
- Herring Spawning Grounds (Coull *et al.*, 1998)

**IHLS Banks Data - Larval Abundance Per m²**

- 0
- 0.1 - 150
- 150.1 - 600
- 600.1 - 1,275
- 1,275.1 - 2,050
- 2,050.1 - 2,850
- 2,850.1 - 3,650
- 3,650.1 - 4,450
- 4,450.1 - 5,300
- 5,300.1 - 6,300
- 6,300.1 - 7,425
- 7,425.1 - 9,325




Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:2,750,000

0 50 100 Kilometres

0 25 50 Nautical Miles

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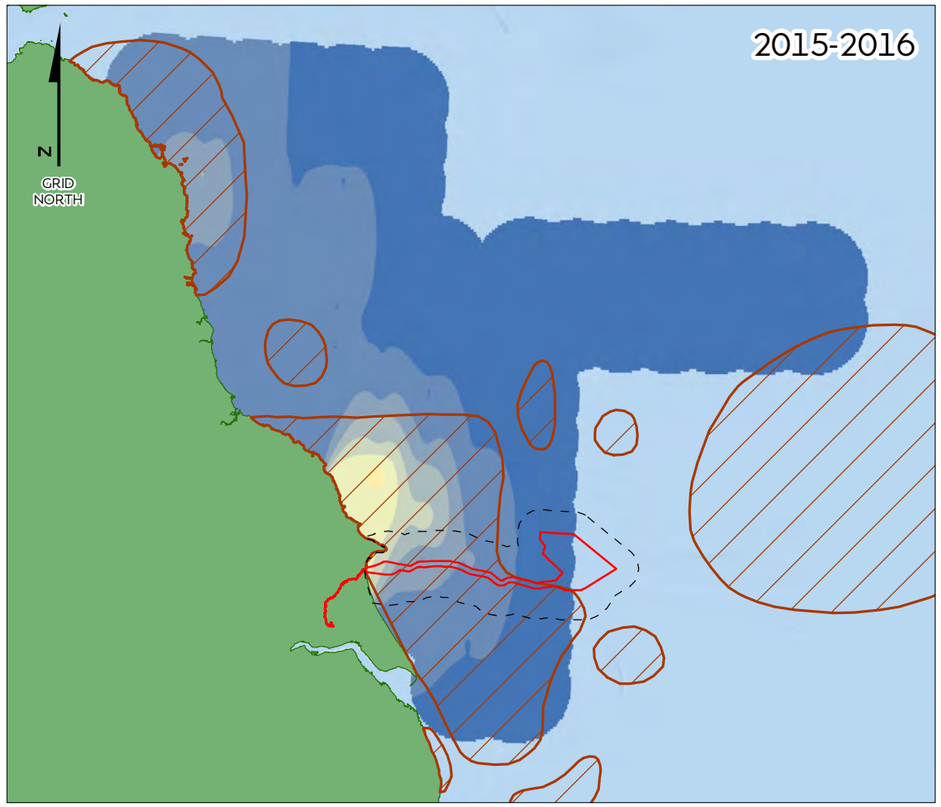
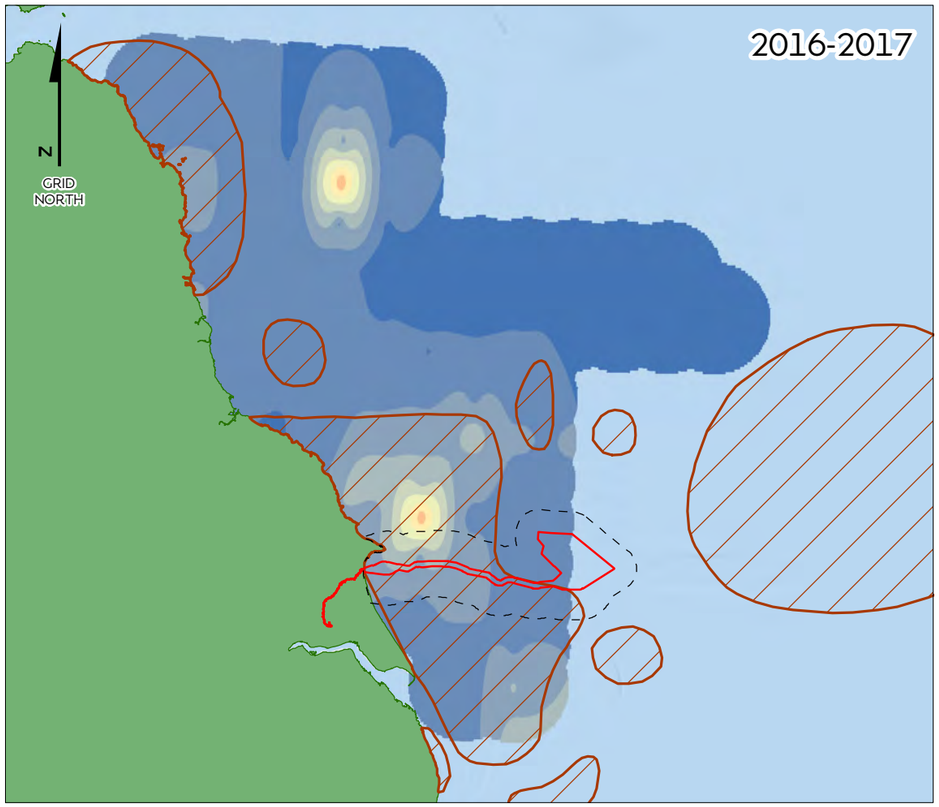
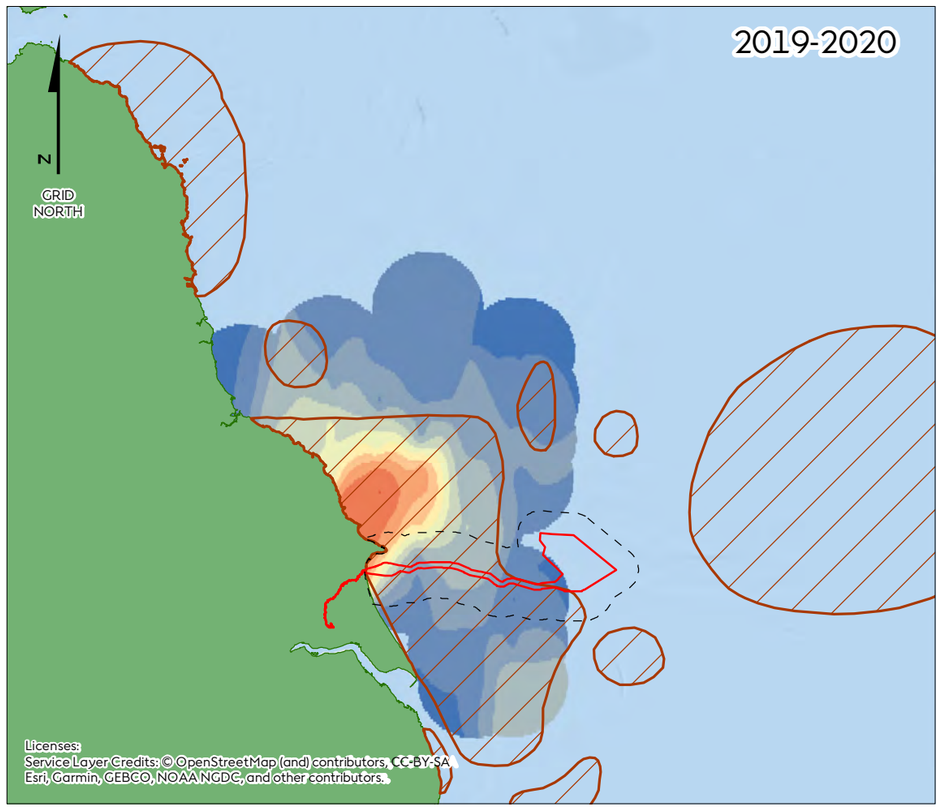
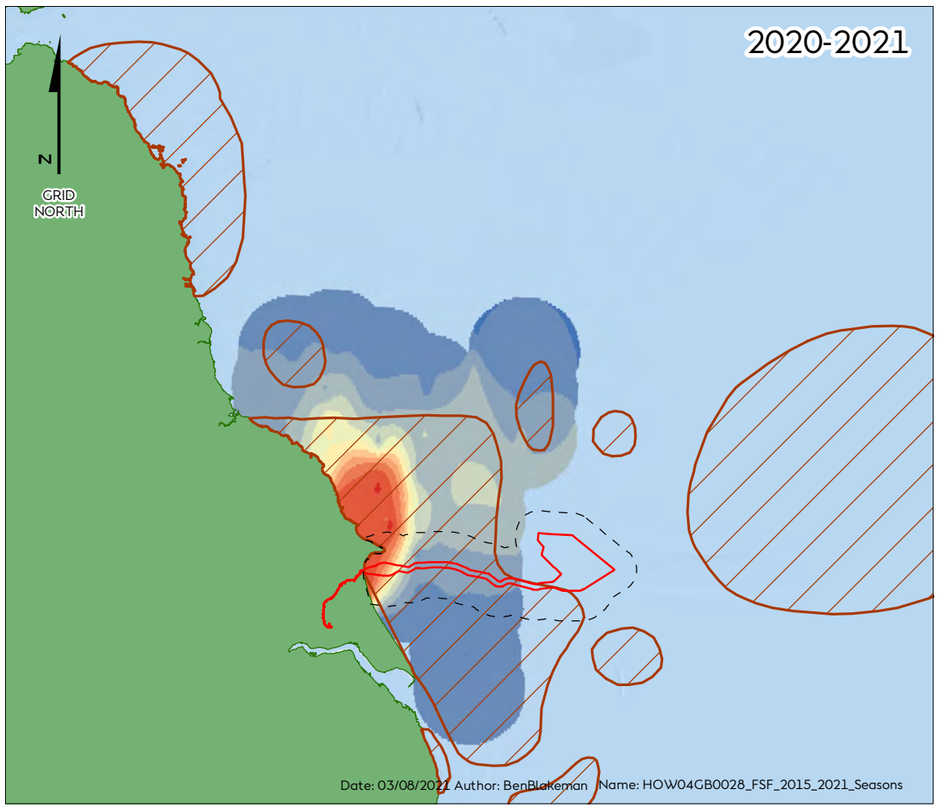



# Hornsea Four

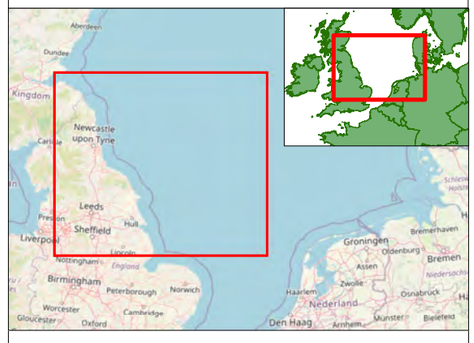
Figure 26

Hornsea Four with Herring Spawning Grounds IHLS Comparison, 2015 – 2021

- Fish and Shellfish Study Area
- Order Limits
- Herring Spawning Grounds (Coull *et al.*, 1998)

**IHLS Banks Data - Larval Abundance Per m²**

- 0
- 0.1 - 150
- 150.1 - 600
- 600.1 - 1,275
- 1,275.1 - 2,050
- 2,050.1 - 2,850
- 2,850.1 - 3,650
- 3,650.1 - 4,450
- 4,450.1 - 5,300
- 5,300.1 - 6,300
- 6,300.1 - 7,425
- 7,425.1 - 9,325




Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:2,750,000

0 50 100 Kilometres

0 25 50 Nautical Miles

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3.2.2.7 The results of the analyses described in **paragraph 2.2.4.9** are presented in **Table 7** and **Figure 27**, 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 spawning, 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 located across the array area, with sporadic areas of suitable (marginal) habitat located to the north of the array and in the south east corner of the array. The offshore section of the ECC is also characterised by sand and muddy sand by the Cefas habitat data, with the inshore section dominated by coarse sediments (**Figure 27**).

3.2.2.8 **Figure 27** presents PSA data collected from various sources, including BGS (2015), Dogger Bank A and B 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 fish and shellfish study area. Within the study area, the majority of the area surrounding the array and the offshore section of the ECC are dominated by sand and muddy sand habitats (sediment unsuitable for herring spawning). Prime herring spawning 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 of 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 (Gardline 2019; GoBe 2020) classified using methods in Reach et al. (2013).**

| Station[5] | Folk (1954) Classification | Reach et al. (2013). Habitat sediment preference | Reach et al. (2013). Habitat sediment classification |
|---|---|---|---|
| *Array (Gardline, 2019)* | | | |
| *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 |

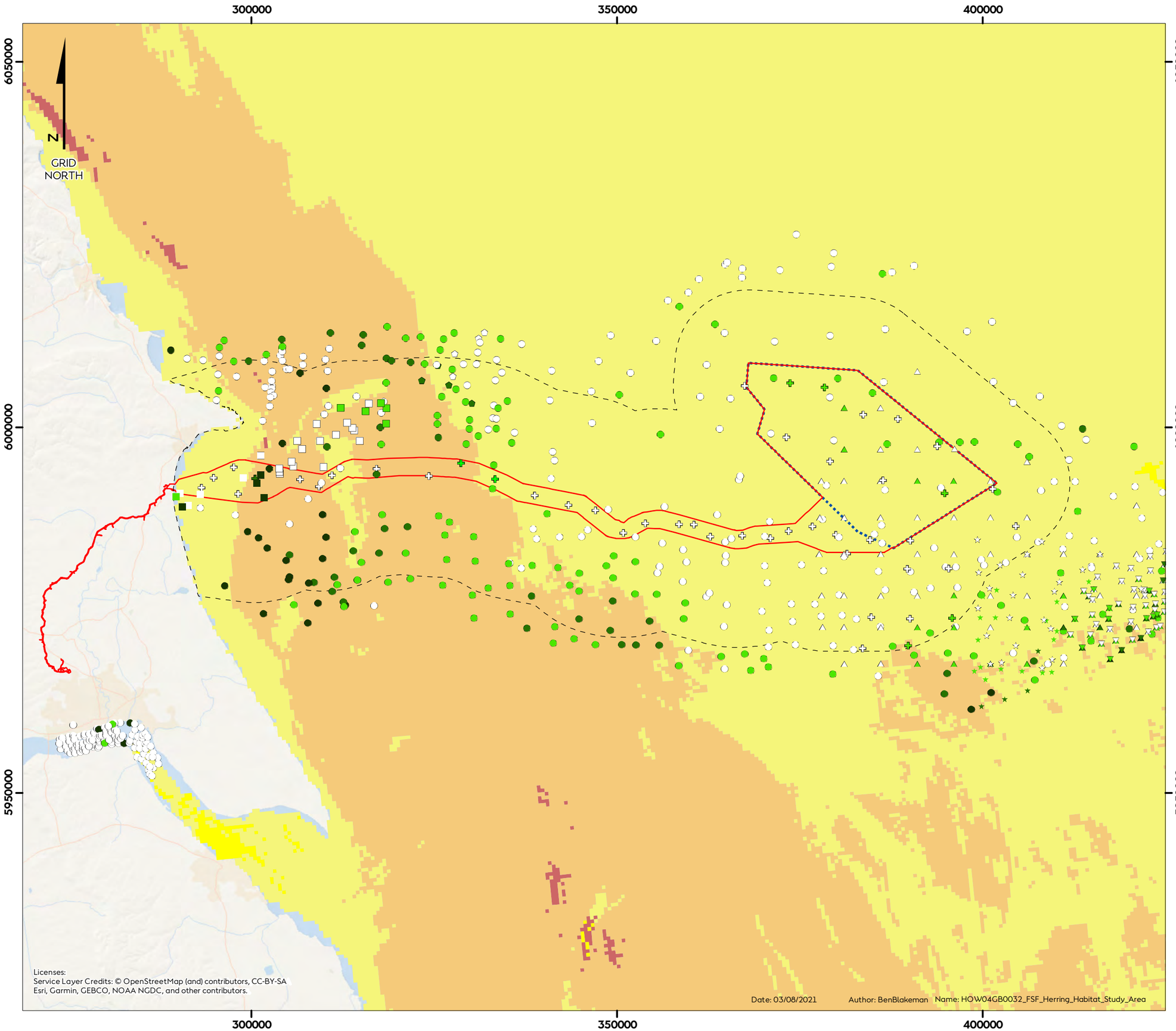
[5] Stations are shown in Figure 5.1 of **Annex 2.1: Benthic and Intertidal Ecology Technical Report**

| Station[5] | Folk (1954) Classification | Reach et al. (2013). Habitat sediment preference | Reach et al. (2013). Habitat sediment classification |
|---|---|---|---|
| *Array (Gardline, 2019)* | | | |
| *15* | Sand | Unsuitable | Unsuitable |
| *16* | Gravelly sand | Suitable | Marginal |
| *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 |
| *ECC (GoBe, 2020)* | | | |
| *1* | Sand | Unsuitable | Unsuitable |
| *2* | Sand | Unsuitable | Unsuitable |
| *3* | Sand | Unsuitable | Unsuitable |
| *4* | Muddy sand | Unsuitable | Unsuitable |
| *5* | Muddy sand | Unsuitable | Unsuitable |
| *6* | Muddy sand | Unsuitable | Unsuitable |
| *7* | Muddy sand | Unsuitable | Unsuitable |
| *8* | Sand | Unsuitable | Unsuitable |
| *9* | Sand | Unsuitable | Unsuitable |
| *10* | Sand | Unsuitable | Unsuitable |
| *11* | Muddy sand | Unsuitable | Unsuitable |
| *12* | Sand | Unsuitable | Unsuitable |
| *13* | Sand | Unsuitable | Unsuitable |
| *14* | Sand | Unsuitable | Unsuitable |
| *15* | Slightly gravelly sand | Suitable | Marginal |
| *16* | Slightly gravelly sand | Suitable | Marginal |
| *17* | Gravelly muddy sand | Unsuitable | Unsuitable |
| *18* | Muddy gravel | Unsuitable | Unsuitable |
| *19* | Muddy sandy gravel | Unsuitable | Unsuitable |
| *20* | Muddy gravel | Unsuitable | Unsuitable |
| *21* | Gravelly muddy sand | Unsuitable | Unsuitable |
| *22* | No sample | | |
| *23* | Sandy gravel | Prime | Preferred |
| *24* | Sand | Unsuitable | Unsuitable |
| *25* | Sand | Unsuitable | Unsuitable |
| *26* | Sand | Unsuitable | Unsuitable |
| *27* | Sand | Unsuitable | Unsuitable |
| *28* | No sample | | |

# Hornsea Four

Figure 27

Potential Herring Habitat Sediment Classifications within the Hornsea Four Study Area




- Fish and Shellfish Study Area
- Order Limits
- Array Area

**Cefas 2015 Folk and EUNIS map**

- Coarse Sediments
- Mixed Sediments
- Mud and Sandy Mud
- Sand and Muddy Sand

**Herring Habitat Suitability (Reach *et al.*, 2013)**

- Prime/Preferred
- Sub-Prime, Preferred
- Suitable, Marginal
- Unsuitable

**Source of Data**

- BGS UK (Various Years)
- Creyke Nearshore Tranch A (2012)
- Creyke Offshore Tranch A (2012)
- Hornsea Zonal (2011)
- Hornsea One Array (2010)
- Hornsea Two Array (2012)
- Hornsea Four Array and ECC (2018, 2019)

Data in Array (Gardline 2019), Data in ECC (GoBe (2020)


Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

| REV | REMARK | DATE |
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Potential Herring Habitat Class
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### 3.2.3 Sandeel

3.2.3.1 The results of the analyses described in Section 2.2.4 and are presented in Table 8. Figure 28 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 Hornsea Four ECC is characterised by sand by the Cefas broadscale habitats data, with the inshore section dominated by coarser (unsuitable) sediments (Figure 28).

3.2.3.2 Figure 28 presents PSA data collected from various sources, including BGS, and Dogger Bank A and B 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 PSA data largely reflects the Cefas broadscale habitats data, and the site specific grab sampling data, with the majority of prime and sub-prime habitats located 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 28 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 (Gardline 2019; GoBe 2020) classified using methods in Latto et al. (2013).**

| Station[6] | Folk (1954) Classification | Latto et al. (2013) Habitat sediment preference | Latto et al. (2013) Habitat sediment classification |
|---|---|---|---|
| *Array (Gardline, 2019)* | | | |
| *ENV1* | Sand | Prime | Preferred |
| *ENV2* | Slightly gravelly sand | Prime | Preferred |
| *ENV4* | Sand | Suitable | Marginal |
| *ENV5* | Sand | Prime | Preferred |
| *ENV6* | Sand | Suitable | Marginal |
| *ENV8* | Sand | Suitable | Marginal |
| *ENV9* | Muddy sand | Unsuitable | Unsuitable |

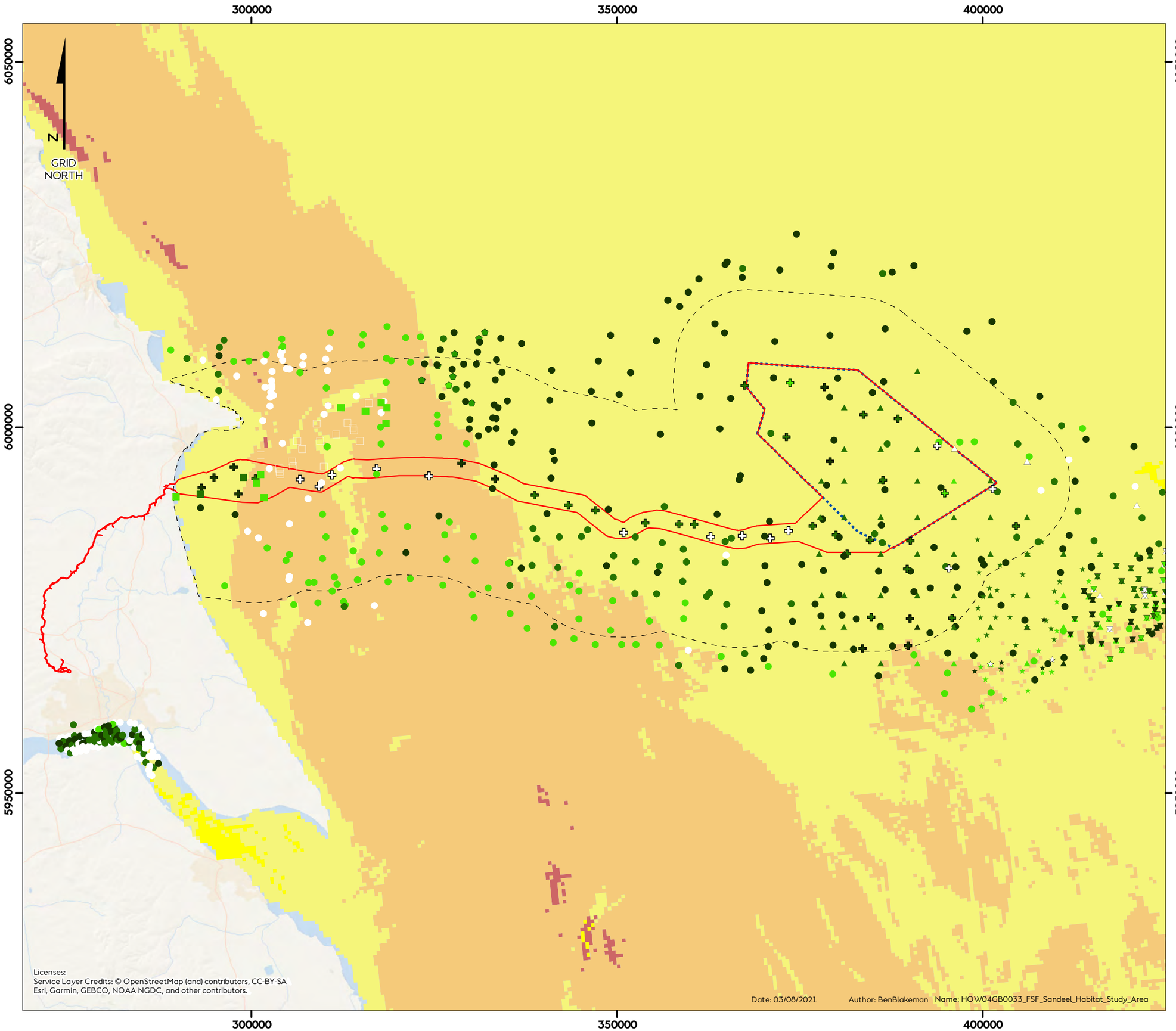
[6] Stations are shown in Figure 5.1 of the Benthic and Intertidal Ecology Technical Report (A5.2.1)

| Station[6] | Folk (1954) Classification | Latto et al. (2013) Habitat sediment preference | Latto et al. (2013) Habitat sediment classification |
|---|---|---|---|
| *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 |
| *ECC (GoBe, 2020)* | | | |
| *1* | Sand | Sub-Prime | Preferred |
| *2* | Sand | Sub-Prime | Preferred |
| *3* | Sand | Sub-Prime | Preferred |
| *4* | Muddy sand | Unsuitable | Unsuitable |
| *5* | Muddy sand | Unsuitable | Unsuitable |
| *6* | Muddy sand | Unsuitable | Unsuitable |
| *7* | Muddy sand | Unsuitable | Unsuitable |
| *8* | Sand | Sub-Prime | Preferred |
| *9* | Sand | Sub-Prime | Preferred |
| *10* | Sand | Sub-Prime | Preferred |
| *11* | Muddy sand | Unsuitable | Unsuitable |
| *12* | Sand | Sub-Prime | Preferred |
| *13* | Sand | Sub-Prime | Preferred |
| *14* | Sand | Sub-Prime | Preferred |
| *15* | Slightly gravelly sand | Prime | Preferred |
| *16* | Slightly gravelly sand | Prime | Preferred |
| *17* | Gravelly muddy sand | Unsuitable | Unsuitable |
| *18* | Muddy gravel | Unsuitable | Unsuitable |
| *19* | Muddy sandy gravel | Unsuitable | Unsuitable |
| *20* | Muddy gravel | Unsuitable | Unsuitable |
| *21* | Gravelly muddy sand | Unsuitable | Unsuitable |
| *22* | No sample | | |
| *23* | Sandy gravel | Sub-Prime | Preferred |
| *24* | Sand | Prime | Preferred |
| *25* | Sand | Prime | Preferred |
| *26* | Sand | Prime | Preferred |
| *27* | Sand | Prime | Preferred |
| *28* | No sample | | |

# Hornsea Four

Figure 28

Potential Sandeel Habitat Sediment Classifications within the Hornsea Four Study Area




Fish and Shellfish Study Area
Order Limits
Array Area

**Cefas 2015 Folk and EUNIS map**

- Coarse Sediments
- Mixed Sediments
- Mud and Sandy Mud
- Sand and Muddy Sand

**Sandeel Habitat Suitability (Latto *et al.*, 2013)**

- Prime/Preferred
- Sub-Prime, Preferred
- Suitable, Marginal
- Unsuitable

**Source of Data**

- BGS UK (Various Years)
- Creyke Nearshore Tranch A (2012)
- Creyke Offshore Tranch A (2012)
- Hornsea Zonal (2011)
- Hornsea One Array (2010)
- Hornsea Two Array (2012)
- Hornsea Four Array and ECC (2018, 2019)

Data in Array (Gardline 2019), Data in ECC (GoBe (2020)


Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

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Potential Sandeel Habitat Class
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## 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 Site of Special Scientific Interest (SSSI)), Atlantic salmon, 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 relevant migratory species receptors identified in the Hornsea Four Scoping Report (Orsted 2018b) 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 eight 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 the spring otter trawl survey (2011) undertaken within the Hornsea Four fish and shellfish study area - **paragraph 2.2.3.1** *et seq*). 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 Order Limits 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 also 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 that the species typically remain close to the coast for the first couple of months before moving further offshore (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 A and B 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 scarce (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 A and B 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 (NIMF) | 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 (NIMF) | 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'.<br>b Commercial marine fish grouped action plan. | | | | | | | | |

## 3.5 Shellfish Ecology

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 CPUEs of these as recorded during historic surveys undertaken across the former Hornsea Zone (e.g. trawl sampling), spawning and nursery habitats of key shellfish species in the area, and other relevant desktop data sources.

*Brown Crab*

3.5.1.2 Brown crab (*Cancer pagurus*) are identified as a species of commercial importance in **Annex 6.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

3.5.1.3 In historic otter and epibenthic beam trawl surveys for the former Hornsea Zone and Dogger Bank A and B, brown crab were recorded in low abundances across the Hornsea Four fish and shellfish study area, though it should be noted that the survey techniques were not specifically designed to capture shellfish species (**paragraph 2.3.1.2**). The highest abundances of brown crab were recorded to the western end of the study area, within the Hornsea Four array area. Berried brown crab were recorded at low abundances during the spring otter trawl survey in the centre of the Hornsea Four fish and shellfish study area.

3.5.1.4 Dogger Bank A and B inshore potting surveys (2011; 2012) recorded brown crab in the inshore section of the Hornsea Four ECC (**Figure 29**). This was reflected by data collected as part of the Triton Knoll shellfish characterisation, which showed that 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. 2011).

3.5.1.5 Post larvae are known to settle inshore and juvenile crabs are more common in shallow waters, with adult female crabs understood to undertake extensive migrations, which may be associated with the reproductive cycle. Berried female brown crabs exhibit a largely sedentary lifestyle during the overwintering period whilst brooding eggs. During this time, they typically bury themselves in soft mud and sand substrates.

3.5.1.6 Information on crab spawning habitats were 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, with one spawning ground directly overlapping the ECC, and another to the north west of the array area (Eaton et al. 2003) (**Figure 29**). 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 (Nephrops norvegicus) are* identified as a species of commercial importance in **Annex 6.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

3.5.1.8 *Nephrops are* common throughout the North Sea and inhabit shallow burrows within predominantly muddy substrata. The Hornsea Four fish and shellfish study area lies across a *Nephrops* ground and fishery (bottom trawl fisheries), the Botney Cut – Silver Pit Functional Unit. Exploratory *Nephrops* stock surveys of the Botney Cut – Silver Pit Functional Unit) indicate a relatively high density of the species compared to neighbouring units (Cefas, 2012).

3.5.1.9 *Nephrops* were recorded during Hornsea Project Two otter trawl surveys (**paragraph 2.2.3.1** *et seq*) offshore of the Hornsea Four fish and shellfish study area (up to 22 individuals caught per 500 m). No *Nephrops* we recorded within the study area itself (**Figure 30**). Of the *Nephrops* recorded offshore, 13 were found to be berried during the autumn trawl survey, located in deep waters to the north of the eastern side of the study area, and in Markham's Hole.

3.5.1.10 Spawning and nursery habitats were recorded within the eastern side of the study area, overlapping the south east corner of the proposed Hornsea Four array area (Coull et al. 1998) (**Figure 30**). This species constructs and inhabits complex burrows in environs characterised by stable mud, with berried females tending to be considered largely sedentary whilst brooding eggs, generally remaining within their burrows to overwinter.

*European lobster*

3.5.1.11 The European lobster (*Homarus gammarus*) is reviewed in this technical report due to its commercial importance as identified in **Annex 6.1: Commercial Fisheries Technical Report**.

3.5.1.12 Lobster were recorded during historic trawl and potting surveys (former Hornsea Zone, Dogger Bank A and B and Cefas surveys) within the Hornsea Four fish and shellfish study area (**paragraph 2.2.3.1** *et seq*). However, records were sporadic and of low abundances, and therefore the distribution of this species in the trawl survey data has not been shown.

3.5.1.13 Shellfish potting surveys undertaken as part of the as part of the Dogger Bank A and B EIA baseline characterisation (Forewind, 2013) within the nearshore section of the Hornsea Four ECC recorded lobsters with relatively high abundance. This is supported by micro-tagged lobster returns in the North Sea (1990-1994), which found lobster presence nearshore along the Holderness Coast (Cefas, 1990-1994) (**Figure 31**).

3.5.1.14 European lobster breed once per year in the summer and newly berried females begin to appear from September to December. Neither juveniles nor adult lobsters are thought to undertake any significant migrations and juveniles in the first three to four years of life may be particularly sedentary.

3.5.1.15 There is limited information on lobster spawning and nursery habitats in the Southern North Sea and abundances of lobster in the region 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 habitats 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 recorded (SMart Wind 2015).

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

*Velvet swimming crab*

3.5.1.17 Data collected as part of the Dogger Bank A and B EIA baseline characterisation potting surveys (Forewind 2013) found that velvet crab (*Necora puber)* were abundant in the shellfish potting surveys which were carried out in the inner section of the ECC, proximal to the Hornsea Four ECC. The velvet swimming crab is common across all British and Irish coasts, and throughout the North Sea (Wilson et al. 2008). There is no evidence that velvet crab undertake extensive migrations, with their movements thought to be restricted to a few hundred metres, the species are therefore presumed not be philopatric.

*Common whelk*

3.5.1.18 Common whelk (*Buccinum undatum*) are identified as a species of commercial importance in **Annex 6.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

3.5.1.19 No common whelks were recorded in the shellfish potting surveys (in the Dogger Bank A and B surveys) (Forewind 2013), carried out within the nearshore area of the Hornsea Four ECC. 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). Common whelk are not considered to be philopatric.

*Brown and pink shrimp*

3.5.1.20 Brown shrimp (*Crangon crangon*) have a high productivity and are 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 wider region. Brown shrimp are common across all British and Irish coasts, and are 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). Seasonal migrations of the brown shrimp typically occur in autumn-winter, and spring, with the transport of larvae to shallow inshore waters occurring in spring, where a mass grow-up of juveniles takes place in the summer (Boddeke 1976).

3.5.1.21 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, and then return to shallow waters again after spawning has ceased (Ruiz, 2008). The species is also of commercial importance, with commercial shipping vessels targeting pink shrimp within the region.

3.5.1.22 Both brown and pink shrimp were recorded in historic epibenthic beam trawl surveys (Hornsea Three baseline characterisation surveys), conducted within the Hornsea Four fish and shellfish study area (**paragraph 2.2.3.1** *et seq*). Brown shrimp were 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 Hornsea Four array area. Pink shrimp were recorded in low abundances throughout the study area for Hornsea

Four. Whilst seasonal spawning migrations do occur for this species, no specific spawning or nursery grounds are identified.

*European common squid*

3.5.1.23 The European common squid are 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, whilst juveniles (aged approximately three months) leave the region of the Northern North Sea in November, and return the following spring (Yau 1994, cited by Hastie et al. 2009). Whilst seasonal spawning migrations do occur for this species, no specific spawning or nursery grounds are identified.

3.5.1.24 European common squid were recorded throughout the Hornsea Four fish and shellfish study area, in epibenthic beam trawls (former Hornsea Zone surveys) and was one of the characterising species within historic otter trawl surveys undertaken within the Hornsea Four study area. Relatively high abundances were observed in the Hornsea Four array area. No seasonal differences were observed between the spring and autumn surveys).

*Scallop*

3.5.1.25 King Scallop (*Pecten maximus*) are identified as a species of commercial importance in **Annex 6.1: Commercial Fisheries Technical Report** on account of their landings weight and value.

3.5.1.26 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. Scallop undertake limited swimming, with swimming behaviours likely to be at a high energy cost, and generally associated with escape scenarios. Consequently, this species is not expected to travel large distances, and therefore no spawning or nursery grounds have been identified.

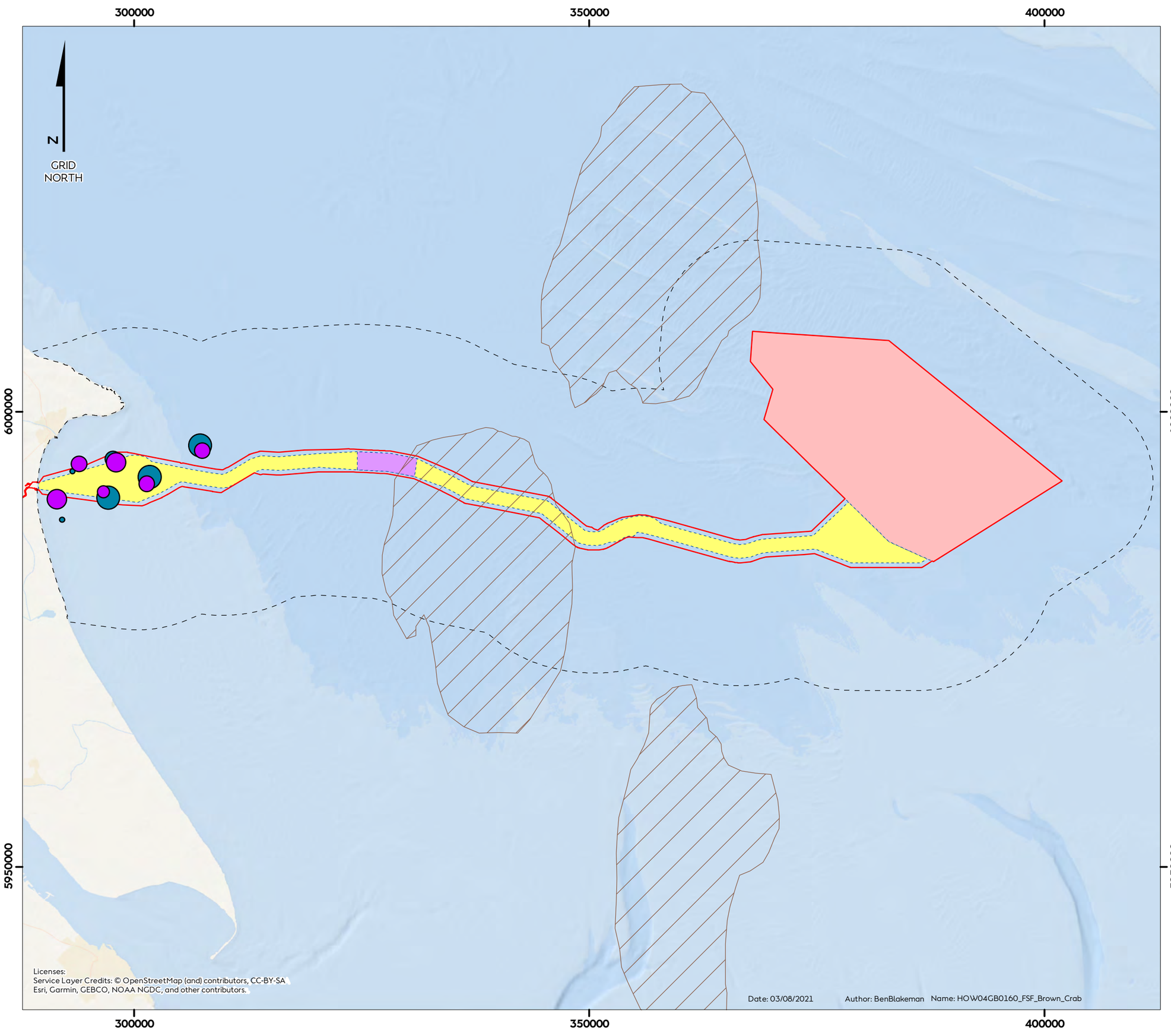
3.5.1.27 A dredge survey undertaken in 2018 along the coast of Yorkshire, North of Spurn point, showed the biomass of scallop (>100 mm) (Lawler, Masefield and Wynne 2019) within the location of the nearshore section of the Hornsea Four ECC. The greatest biomass (tonnes) was observed south of Flamborough Head, south of the proposed location for the nearshore section of the Hornsea Four ECC, with biomass within the 75$^{th}$ centile measuring at 5739 tonnes. Lower abundances of the species were observed within the offshore ECC. 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 fish and shellfish study area.

3.5.1.28 A recent stock assessment by Cefas (2019) identified the presence of two main king scallop beds in the regions, one of which overlaps with the inshore section of the ECC and part of the HVAC Booster Station Search Area (**Figure 32**).

# Hornsea Four

Figure 29

Brown Crab Spawning Grounds and CPUE from Inshore Historical Surveys




- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations
- Brown Crab Spawning Area (Eaton *et al.*, 2004)

**Creyke Beck inshore potting survey (2011)**
**Brown Crab CPUE (catch/pot/day)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4

**Creyke Beck inshore potting survey (2012)**
**Brown Crab CPUE (catch/pot/day)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4


Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 10 20 Kilometres

0 5 10 Nautical Miles

| REV | REMARK | DATE |
|---|---|---|
| ... | First Issue for DCO | 03/08/2021 |
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Brown Crab Distribution and Spawning Areas
Document no: HOW04GB0160
Created by: BPHB
Checked by: AL
Approved by: LK

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# Hornsea Four

Figure 30

Nephrops Spawning Grounds and CPUE within the Hornsea Four Array Area and ECC

300000 350000 400000 450000

6050000

6000000

5950000

N

GRID NORTH

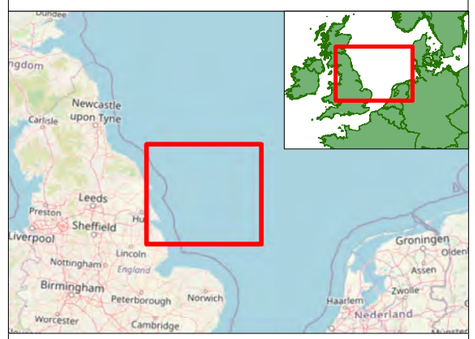
- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations
- Nephrops Spawning Grounds (Coull *et al.*, 1998)

**Nephrops Spring Trawl CPUE (catch/500m)**

- 0
- 1
- 3

**Nephrops Autumn Trawl CPUE (catch/500m)**

- 0
- 1
- 2
- 3
- 13
- 17
- 22




Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:600,000

0 10 20 Kilometres

0 5 10 Nautical Miles

| REV | REMARK | DATE |
|---|---|---|
| ... | First Issue for DCO | 03/08/2021 |
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Nephrops CPUE Distribution
Document no: HOW04GB0163
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Checked by: AL
Approved by: LK

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Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0163_FSF_Nephrops_Distribution

# Hornsea Four

Figure 31

Lobster presence and CPUE within the Hornsea Four Array Area and ECC

300000
350000
400000
6000000
5950000

N
GRID NORTH

Fish and Shellfish Study Area
Order Limits
Array Area
Offshore Export Cable Corridor
HVAC Booster Stations

**Tagged Returns Survey (CEFAS, 1990-1994)**
- European lobster

**Creyke Beck inshore potting survey (2011)**
**Lobster CPUE (catch/pot/day)**
- 0 - 0.025
- 0.025 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75

**Creyke Beck inshore potting survey (2012)**
**Lobster CPUE (catch/pot/day)**
- 0 - 0.025
- 0.025 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75


Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:400,000

0 10 20 Kilometres

0 5 10 Nautical Miles

| REV | REMARK | DATE |
|---|---|---|
| ... | First Issue for DCO | 03/08/2021 |
| | | |
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| | | |
| | | |

Lobster
Distribution
Document no: HOW04GB0161
Created by: BPHB
Checked by: AL
Approved by: LK

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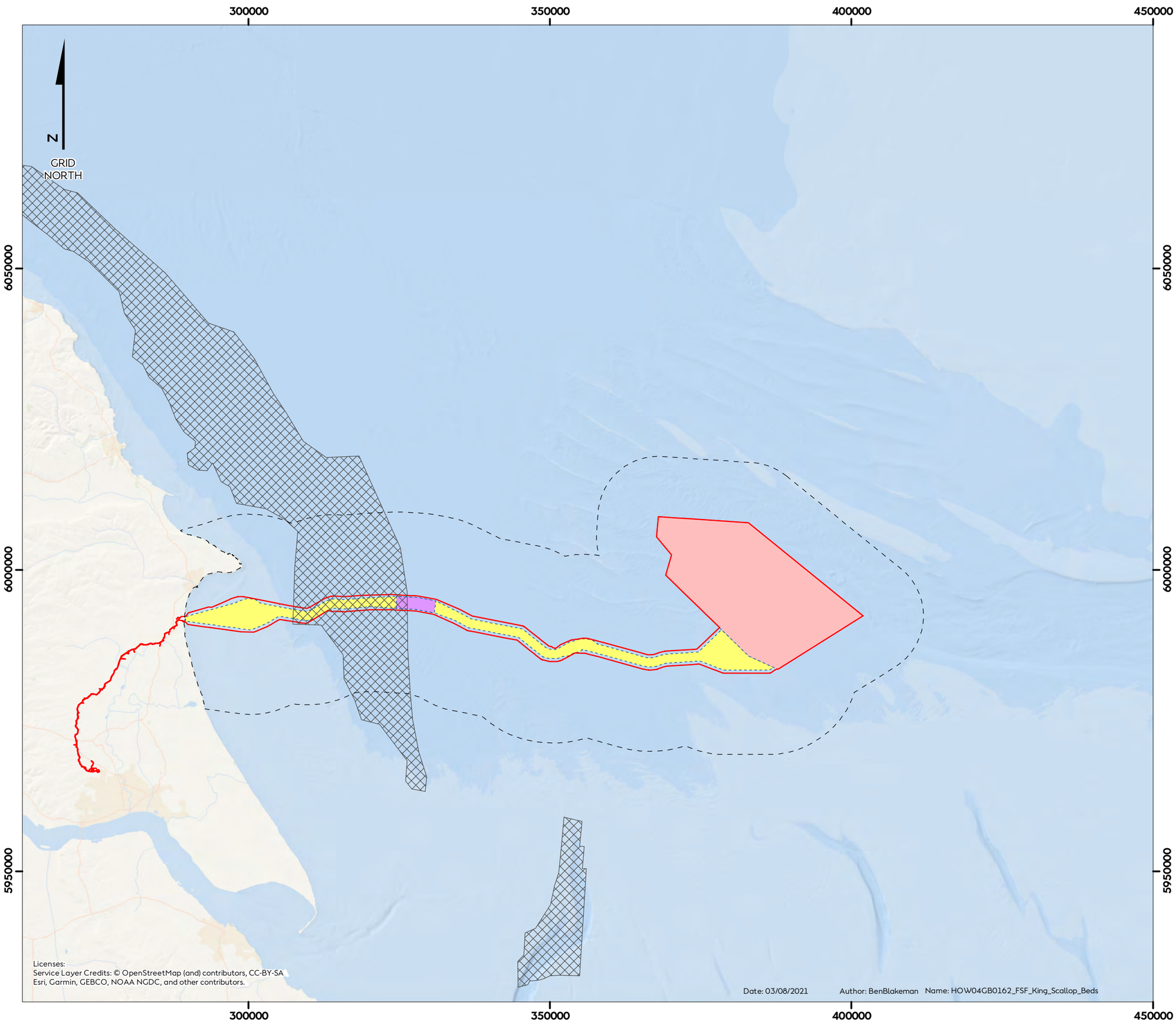
Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0161_FSF_Lobster_Distribution

# Hornsea Four

Figure 32

King Scallop Beds within the Hornsea Four Array and ECC




- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations
- King Scallop beds (Lawler, Masefield and Wynne, 2019)


Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:600,000

0 10 20 Kilometres

0 5 10 Nautical Miles

| REV | REMARK | DATE |
|---|---|---|
| ... | First Issue for DCO | 03/08/2021 |
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| | | |

King Scallop Beds
Document no: HOW04GB0162
Created by: BPHB
Checked by: AL
Approved by: LK

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## 3.6 Designated Sites

3.6.1.1 All designated sites within the Hornsea Four fish and shellfish study area where impacts to fish or shellfish receptors could impact the conservation objectives or features of the site are shown in **Figure 33** 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 Report to Inform Appropriate Assessment (RIAA) (**B2.2: Report to Inform Appropriate Assessment**) which examines 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). An assessment of the impacts on this site is undertaken in **B2.2: Report to Inform Appropriate Assessment.**

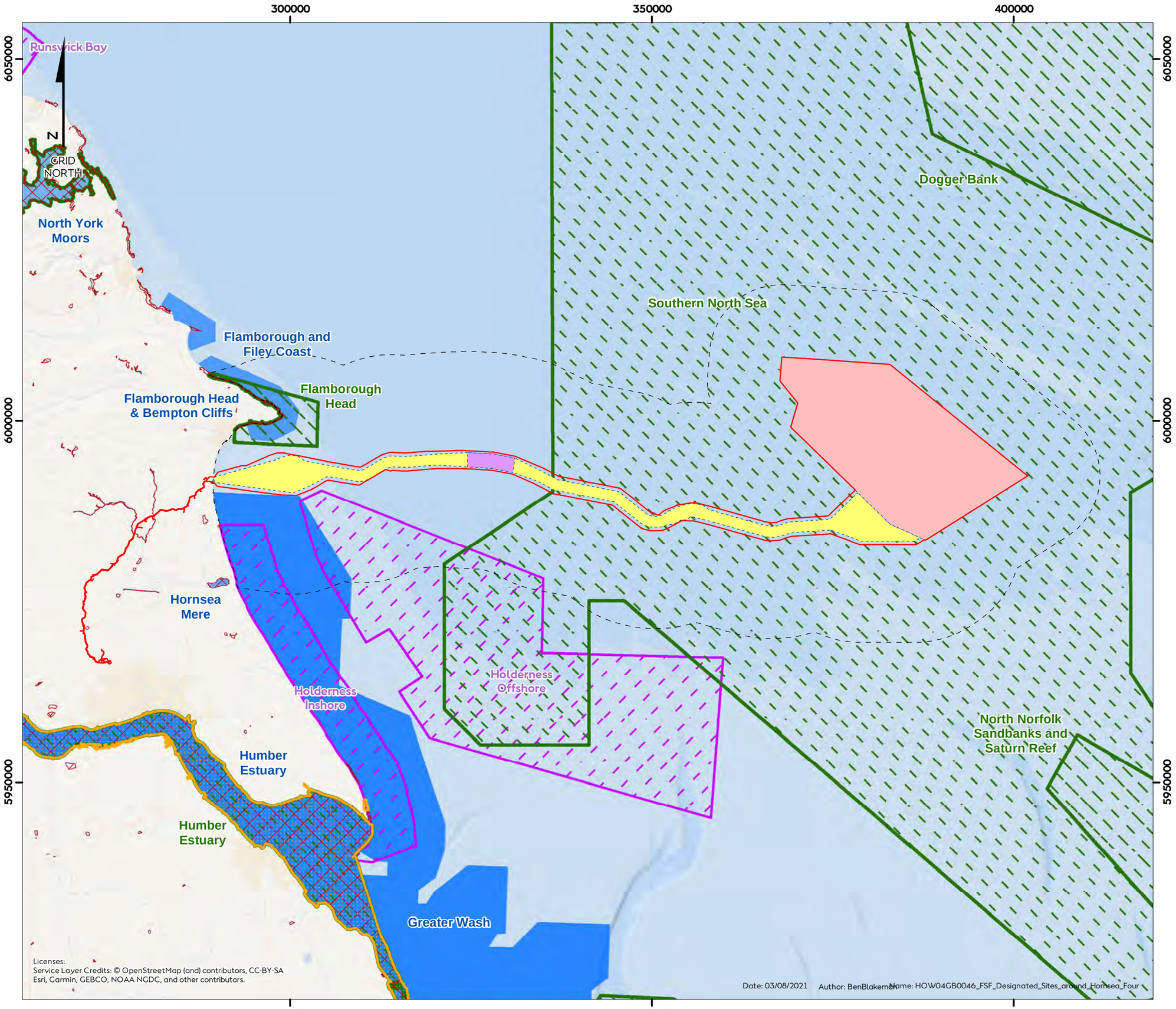
3.6.1.3 Two MCZs lie within the Hornsea Four fish and shellfish study area; the Holderness Inshore MCZ (4.4 km from Hornsea Four) and the Holderness Offshore MCZ (0.75 km from Hornsea Four). The only MCZ of relevance to fish and shellfish receptors is the Holderness Offshore MCZ which is designated for the Ocean Quahog (*Arctica islandica)*, a species found in sandy seabeds throughout the North Sea. An assessment on the impacts from Hornsea Four on these two MCZs is presented in **Annex 2.3: Marine Conservation Zone Assessment**).

3.6.1.4 The Greater Wash SPA and the Flamborough and Filey Coast SPA both lie within the Hornsea Four fish and shellfish study area (the Greater Wash SPA site lies adjacent to the nearshore section of the ECC, and the Flamborough and Filey Coast SPA lies 1.1 km from the nearshore section of the ECC). Both sites are designated for breeding and non-breeding birds, of which sandeels, gadoids, or clupeids such as herring and sardine fish, and various shellfish are key prey species for. An assessment of the impacts on these sites is undertaken in **B2.2: Report to Inform Appropriate Assessment**.

# Hornsea Four

Figure 33

Designated Sites Surrounding Hornsea Four




- Fish and Shellfish Study Area
- Order Limits
- Array Area
- Offshore Export Cable Corridor
- HVAC Booster Stations
- Marine Conservation Zones
- Special Areas of Conservation
- Special Protection Areas
- Sites of Special Scientific Interest
- Ramsar


Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

| REV | REMARK | DATE |
|---|---|---|
| --- | First Issue for PEIR | 08/05/2019 |
| A | Updated following PEIR consultations, for DCO | 03/08/2021 |
| | | |
| | | |
| | | |

Designated Sites around Hornsea Four
Document no: HOW04GB0046
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Checked by: AL
Approved by: LK

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# 4 Discussion

4.1.1.1 This report has described the key attributes of the fish and shellfish community in the Hornsea Four fish and shellfish study area and identified the distribution and relative CPUE 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/ recommended Marine Conservation Zone (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, 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 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 |

| VER value | VER criteria used to define value |
|---|---|
| | 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 CPUEs in the surveys undertaken within the Hornsea Four fish and shellfish 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 recorded in high abundances 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 for cod, lemon sole and common sole observed. Solenette and grey gurnard were recorded as absent from the Hornsea four array area. Whiting and dab were recorded with 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, lemon sole, plaice, dab, cod or grey gurnard. Within the ECC, whiting showed increased abundances in April, and dab had increased abundances in October and April. 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 caught in high abundances within, and to the south east of the study 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.

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

4.4.1.2 All species except the common whelk and *Nephrops* were recorded within the study area, with velvet swimming crab, European common squid and pink and brown shrimp having the highest abundances. It is, however, important to note that the survey methods used across the study area are not expected to provide a representative catch of shellfish species for the area.

4.4.1.3 Brown crab, *Nephrops*, European lobster, pink and brown shrimp, common whelk and scallop were identified as species of commercial importance in the Southern North Sea.

4.4.1.4 The highest abundances of brown crab were recorded in the nearshore section of the ECC, with spawning areas close to the north-western extent of the array, and overlapping the mid-section of the ECC (Eaton et al., 2004).

4.4.1.5 *Nephrops* were recorded offshore of the study area, with spawning and nursery habitats located in the same area and overlapping the Hornsea Four array area.

4.4.1.6 European lobster were recorded within the nearshore section of the proposed ECC. There is limited information available on lobster spawning and nursery grounds in the region.

4.4.1.7 Velvet swimming crab, European common squid and brown and pink shrimp were all recorded with high catches across the study area.

4.4.1.8 The greatest biomass of scallop (tonnes) along the coast of Yorkshire, North of Spurn point were observed to the south of the ECC, with lower abundances within the ECC. Two king scallop beds were observed in the region, with one bed overlapping the inshore section of the ECC and part of the HVAC Booster Station Search Area.

4.4.1.9 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 spawning season from August through to October, with the peak spawning period for the Banks stock being September to October (**Table 6**), in line with the trend for a later start to spawning for the more southerly herring stocks in the North Sea (ICES 2013b), 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 re-colonisation has not occurred. Although the ICES IHLS data 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 also 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 (Gardline 2019; GoBe 2020) 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 has been undertaken

within Volume A2, Chapter 3: Fish and Shellfish Ecology, which also identifies 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. 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 plaice recorded across 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. |
| 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 present 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 caught 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 in 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. |

| VER | Valuation | Justification |
|---|---|---|
| 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 |
| Sea trout | 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. |
| European eel | 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. |
| Atlantic salmon | International | Species present in historic former Hornsea Zone surveys.<br>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 |

| VER | Valuation | Justification |
|---|---|---|
| | | 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 offshore of the array area, with known spawning and nursery habitats located across the array and further offshore. 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. |
| 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. |

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