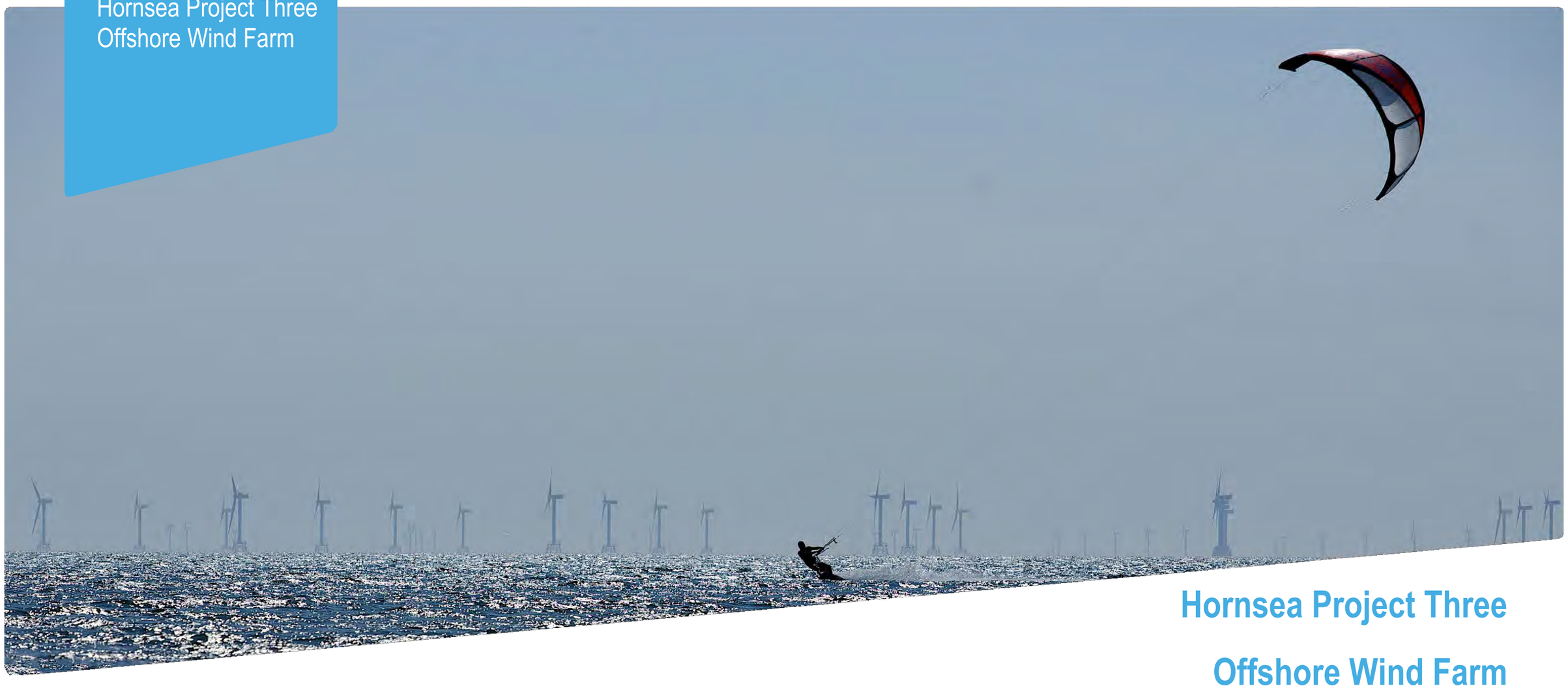
Hornsea Project Three
Offshore Wind Farm



Hornsea Project Three

Offshore Wind Farm

Preliminary Environmental Information Report:
Annex 3.1 – Fish and Shellfish Technical Report

Date: July 2017

Hornsea 3
Offshore Wind Farm

DONG energy

Environmental Impact Assessment

Preliminary Environmental Information Report

Volume 5

Annex 3.1 – Fish and Shellfish Technical Report

Liability

This report has been prepared by RPS, with all reasonable skill, care and diligence within the terms of their contracts with DONG Energy Power (UK) Ltd.

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This report is also downloadable from the Hornsea Project Three offshore wind farm website at:
www.dongenergy.co.uk/hornseaproject3

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Front cover picture: Kite surfer near one of DONG Energy's UK offshore wind farms © DONG Energy Hornsea Project Three (UK) Ltd., 2016.

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Glossary

Term	Definition
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.
Cloaca	A common cavity at the end of the digestive tract for the release of both excretory and genital products in vertebrates (except most mammals) and certain invertebrates.
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.
Epibenthic	Organisms living on the surface of the seabed.
Epifauna	Animals living on the surface of the seabed.
Intertidal	An area of a seashore that is covered at high tide and uncovered at low tide.
Mollusc	Invertebrate animal belonging to the phylum mollusca that includes the snails, clams, chitons, tooth shells, and octopi.
Multivariate statistical analysis	Statistical analysis that includes the simultaneous observation and analysis of more than one statistical variable.
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.
Oviduct	Tube through which an ovum or egg passes from an ovary.
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.
Pleopod	Forked swimming limb of a crustacean, five pairs of which are typically attached to the abdomen.
Polychaete	A class of segmented worms often known as bristleworms.
Spawning	The release or deposition of eggs and sperm, usually into water, by aquatic animals.
Spermatophore	Protein capsule containing a mass of spermatozoa, transferred during mating in arthropods (and other fauna, including insects and cephalopod molluscs).
Subtidal	Area extending from below low tide to the edge of the continental shelf.
Univariate statistical analysis	A statistical analysis carried out with only one variable.

Acronyms

Acronym	Description
3-D	Three Dimensional
2-D	Two Dimensional
ANOSIM	Analysis of Similarity
BIOENV	Biota-Environment Analysis
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CL	Carapace Length
CPA	Coast Protection Act
CW	Carapace Width
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
EBP	Early Benthic Phase
cable	Export Cable Route
EIA	Environmental Impact Assessment
EIFCA	Eastern Inshore Fisheries and Conservation Authority
EMF	Electro-Magnetic Fields
ESFJC	Eastern Sea Fisheries Joint Committee
EWG	Expert Working Group
FEPA	Food and Environment Protection Act
GSI	Gonadal Somatic Index
HRA	Habitats Regulations Assessment
IUCN	International Union for the Conservation of Nature
IBTS	International Bottom Trawl Surveys
ICES	International Council of the Exploration of the Sea
IHLS	International Herring Larvae Survey
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide

Acronym	Description
MAREA	Marine Aggregates Regional Environmental Assessment
MCZ	Marine Conservation Zone
MDS	Multidimensional Scaling
MHWS	Mean High Water Springs
MLS	Minimum Landing Size
MNA	Marine Natural Area
MMO	Marine Management Organisation
NERC	Natural Environment and Rural Communities
NIMF	Nationally Important Marine Features
NNFLAG	North Norfolk Fisheries Local Action Group
NPS	National Policy Statement
OESEA	Offshore Energy Strategic Environmental Assessment
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
PRIMER	Plymouth Routine in Multivariate Ecological Research
PSA	Particle Size Analysis
rMCZ	Recommended Marine Conservation Zone
SAC	Special Area of Conservation
SCI	Site of Community Importance
SEA	Strategic Environmental Assessment
SIMPER	Similarity Percentage Analysis
SIMPROF	Similarity Profile Analysis
UK BAP	United Kingdom Biodiversity Action Plan
VER	Valued Ecological Receptor

Units

Unit	Description
cm	centimetre
m	metre
mm	millimetre
MW	megawatt
NM	nautical mile
km	kilometre

1. Introduction

1.1 Project background

1.1.1.1 DONG Energy Power (UK) Ltd. (hereafter referred to as DONG Energy), on behalf of DONG Energy Hornsea Project Three (UK) Ltd. is promoting the development of the Hornsea Project Three Offshore Wind Farm (hereafter referred to as Hornsea Three). Hornsea Three is a proposed offshore wind farm project within the former Hornsea Zone, and includes the associated offshore export cable route (cable) corridor and onshore infrastructure. The proposal is for a wind farm with a total generating capacity of up to 2,400 MW which will be situated within the Hornsea Three array area in the east of the former Hornsea Zone. Hornsea Three is located in the central region of the North Sea, approximately 121 km to the northeast Tringham, Norfolk, 140 km to the east of the East Riding of Yorkshire coast and approximately 10.1 km west of the median line between UK and Netherlands waters (Figure 1.1).

1.1.1.2 RPS was commissioned to undertake a fish and shellfish ecology characterisation study of the Hornsea Three site and surrounding area. This included a detailed desktop study of the fish and shellfish ecology of a defined study area (see section 2.1) surrounding Hornsea Three, with historic trawl survey data from across the former Hornsea Zone, including the Hornsea Three array area, used to supplement the desktop.

1.2 Aims and objectives

1.2.1.1 The aim of this study was to provide an up to date characterisation of fish and shellfish ecological resources within a defined study area, which incorporates the Hornsea Three area and the zone of potential impact. This approach was agreed with the statutory consultees relevant to fish and shellfish ecology (i.e. Marine Management Organisation (MMO), Natural England, the Joint Nature Conservation Committee (JNCC) and the Centre for Environment, Fisheries and Aquaculture Science (Cefas)) through the Evidence Plan process (see section 2.2).

1.2.1.2 Based on this and using both existing data (including historic trawl data from across the former Hornsea Zone) and the site-specific survey data (where necessary), the objective was to give a general description of fish and shellfish assemblages within the southern North Sea fish and shellfish study area (Figure 1.1). These were then compared with the fish and shellfish populations found in the immediate vicinity of Hornsea Three (i.e. within the Hornsea Three fish and shellfish study area; see Figure 2.1) in order to provide the basis for evaluating the importance of species, or groups of species, as 'valued ecological receptors' for consideration in the impact assessment. The relationship between these two study areas is discussed in section 2.1. Information that fed into this characterisation included identification of:

- The fish and shellfish assemblages that characterise the southern North Sea fish and shellfish study area, describing ecological patterns such as seasonality, habitat associations, and size distributions within the population;
- The commercial and conservation interest of fish and shellfish within the southern North Sea;
- The potential ecological interest within the southern North Sea fish and shellfish study area (i.e. spawning grounds, nursery grounds, migratory routes and important prey species for other marine species); and
- The characteristics of spawning and nursery activity for individual species.

1.2.1.3 Guidance on the issues associated with offshore renewable energy developments in general have been obtained through reference to the Overarching National Policy Statement (NPS) for Energy (EN-1; DECC, 2011a) and the NPS for Renewable Energy Infrastructure (EN-3, DECC, 2011b) (for fish: section 2.6.74). Further advice in relation to Hornsea Three specifically has been sought through consultation with the statutory consultees through the Evidence Plan process and from the Scoping Opinion received with respect to Hornsea Three (PINS, 2016).

1.2.1.4 Guidance on the Environmental Impact Assessment (EIA) process will be sought from the following resources:

- Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater and Coastal, Second Edition (Chartered Institute of Ecology and Environmental Management (CIEEM) 2016); and
- Guidance note for EIA in Respect of Food and Environment Protection Act 1985 (FEPA) and Coast Protection Act 1949 (CPA) Requirements (Cefas *et al*., 2004).

1.2.1.5 In addition, the EIA will follow the legislative framework as defined by the Wildlife and Countryside Act 1981 (as amended) and the Marine and Coastal Access Act, 2009, with consideration of the Offshore Marine Conservation (Natural Habitats, & c.) Regulations 2007 and the Conservation of Habitats and Species Regulations 2010 (Habitats Regulations), although these relate to the Habitats Regulations Assessment (HRA) and not specifically to EIA.

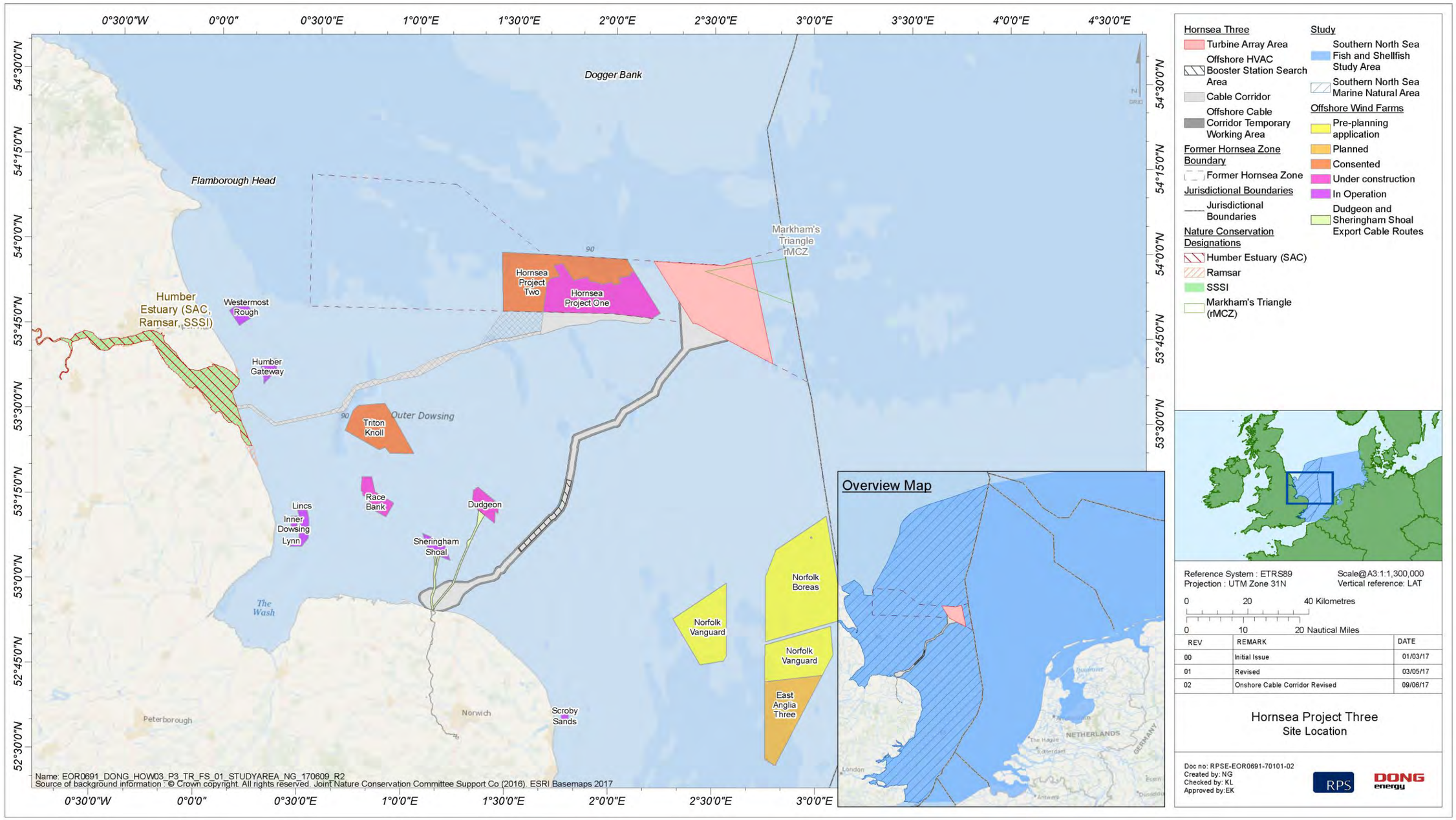


Figure 1.1: Location of Hornsea Three and the former Hornsea Zone, nature conservation designations with fish and shellfish features and other offshore wind farm sites in the southern North Sea fish and shellfish study area (i.e. the southern North Sea Marine Natural Area).

2. Methodology

2.1 Fish and shellfish study area

2.1.1.1 For the purposes of the fish and shellfish ecology characterisation, two study areas were defined:

- The Hornsea Three fish and shellfish study area – this was defined as the area encompassing the Hornsea Three array area, the offshore cable corridor and temporary working areas, and the area in the immediate vicinity of the landfall site. The Hornsea Three fish and shellfish study area also included much of the former Hornsea Zone, including a 4 km buffer to the north and south of the boundary (i.e. the zone of influence for most impacts on fish and shellfish). This study area was the area in which survey data were collected, including historic trawl surveys undertaken across the former Hornsea Zone (see paragraph 2.2.1.6 and Figure 2.1); and
- The southern North Sea fish and shellfish study area – this is the regional fish and shellfish study area and was defined as the southern North Sea region which coincides with the southern North Sea Marine Natural Area (MNA; Jones *et al*., 2004; Figure 1.1). This study area also included areas within territorial waters of Netherlands, Germany and Denmark, broadly following the 50 m depth contour which separates the southern North Sea fish and shellfish communities from those of the central and northern North Sea (Teal, 2011; see section 3.1). This study area provided a wider context for the survey data from within the Honrsea Three fish and shellfish study area and impacts expected to affect more extensive areas (e.g. underwater noise effects). This formed the area covered by the desktop review.

2.2 Evidence Plan

2.2.1.1 The purpose of the Hornsea Three Evidence Plan process (see Draft Envidence Plan (DONG Energy 2017)) is to agree the environmental information DONG Energy needs to supply to the Planning Inspectorate (PINS), as part of a Development Consent Order (DCO) application for Hornsea Three. The Evidence Plan seeks to ensure compliance with the EIA and HRA requirements.

2.2.1.2 As part of the Evidence Plan process, the Marine Processes, Benthic Ecology and Fish and Shellfish Ecology Expert Working Group (EWG) was established with representatives from the key regulatory bodies and their advisors and statutory nature conservation bodies, including the MMO, Cefas, Natural England and JNCC. Between June 2016 and publication of this Preliminary Environmental Information Report (PEIR), a number of EWG meetings were have been held to discuss key issues with regard to the fish and shellfish elements of Hornsea Three, including characterisation of the baseline environment and the impacts to be considered within the impact assessment.

2.2.1.3 The approach proposed by Hornsea Three for the purposes of characterising the fish and shellfish communities within the two study areas defined in paragraph 2.1.1.1, was an evidence based approach to the EIA, which involves utilising existing data and information from sufficiently similar or analogous studies to inform baseline understanding and/or impact assessments for Hornsea Three. In this way, the evidence based approach does not necessarily require new data to be collected, or new modelling studies to be undertaken, in order to characterise the potential impact with sufficient confidence for the purposes of EIA (see volume 1, chapter 5: Environmental Impact Assessment Methodology).

2.2.1.4 The scope of the issues for assessment for fish and shellfish ecology is very similar (although not identical) to that previously considered for Hornsea Project One and Hornsea Project Two given the similarity of the proposed project infrastructure. The range of issues assessed in assessed within volume 2, chapter 3: Fish and shellfish ecology, are briefly summarised below. The spatial extent of the impacts assessed will vary depending on the impact, although the extents are expected to be similar to those identified for Hornsea Project One and Hornsea Project Two. Impacts considered within volume 2, chapter 3: Fish and shellfish ecology include (but are not limited to):

- Construction related activities leading to short term and localised changes (i.e. primarily within the Hornsea Three array area, offshore cable corridor and temporary working areas) in seabed sediments used by fish and shellfish assemblages for feeding, spawning or nursery habitats, including temporary habitat loss, increases in suspended sediments and subsequent deposition;
- Construction related noise, including piling operations, affecting fish and shellfish receptors (including spawning and nursery habitats) over a wider spatial extent within the southern North Sea fish and shellfish study area;
- Operation phase impacts related to the presence of offshore infrastructure, leading to relatively localised effects on fish and shellfish ecology (i.e. primarily within the Hornsea Three array offshore and cable corridor and temporary working areas) and the habitats on which these species are reliant for feeding, spawning and as nursery habitat. These include presence of subsea infrastructure leading to long term habitat loss and localised changes in fish populations and behavioural effects associated with noise from operational wind turbines, introduction of new subsea structures which could provide novel habitats for fish and shellfish (e.g. reef effects) and electro-magnetic fields (EMF) associated with electrical cabling; and
- Decommissioning phase impacts, with similar impacts to the construction phase (e.g. localised and temporary changes in seabed sediments used by fish and shellfish species), removal of subsea structures therefore reversal of any reef effects and permanent loss of fish and shellfish habitats in areas where some subsea infrastructure (e.g. cable protection) is left in place following decommissioning.

2.2.1.5 As detailed above, the scale of these impacts are expected to be similar for Hornsea Three as for Hornsea Project One and Hornsea Project Two (i.e. largely within the project boundaries) and will affect the same receptors as Hornsea Project One and Project Two due to the consistency in the fish and shellfish assemblages in this part of the southern North Sea. Therefore the background information, data and statistical analyses used to inform these projects is highly relevant to the Hornsea Three baseline characterisation. It is important to note that there are key differences in Hornsea Three compared to Hornsea Project One and Hornsea Project Two, including the offshore cable corridor route. Where these differences are evident, further information has been sought, including site-specific surveys in these areas, to ensure a robust characterisation of the fish and shellfish ecology of these parts of the Hornsea Three fish and shellfish ecology study area, as agreed with the Marine Processes, Benthic Ecology and Fish and Shellfish Ecology EWG.

2.2.1.6 Hornsea Three is located within the former Hornsea Zone, for which extensive data and knowledge regarding fish and shellfish ecology is already available. This data/knowledge has been acquired through zonal studies and from the surveys and characterisations undertaken for Hornsea Project One and Hornsea Project Two (see Figure 2.1). It was therefore proposed that the Hornsea Three fish and shellfish characterisation be completed using a combination of desktop data and information sources, and survey data collected as part of the characterisations of the Hornsea Project One and Hornsea Project Two offshore wind farms and the former Hornsea Zone. Over the series of Marine Processes, Benthic Ecology and Fish and Shellfish Ecology EWG meetings conducted between June 2016 and publication of this PEIR, it was agreed that this approach (fully detailed in the sections below) was appropriate and sufficient for the purposes of characterising the fish and shellfish ecology of the Hornsea Three area.

2.2.1.7 As agreed with the Marine Processes, Benthic Ecology and Fish and Shellfish Ecology EWG, no additional site specific survey data has been collected for fish and shellfish ecology. However, data collected as part of the benthic ecology surveys of the Hornsea Three array area and the offshore cable corridor, will also be incorporated into the baseline characterisation assessment (see paragraph 2.4.1.9 and Figure 2.1). Due to the timing of this survey, these data are not included within the PEIR (i.e. this report), but will be incorporated into the fish and shellfish technical report to be submitted as part of the ES which will accompany the DCO application. Site specific data will include:

- Grab sample data to characterise the suitability of sediments as sandeel *Ammodytes* sp. and herring *Clupea harengus* spawning habitats across the Hornsea Three offshore cable corridor (see annex 2.1: Benthic Ecology Technical Report for full details); and
- Epibenthic beam trawl data within the Hornsea Three offshore cable corridor to provide further site specific data on fish communities, to supplement desk based information (see paragraph 2.4.1.9). The epibenthic beam trawl methodology will be identical to that used in historic surveys across the former Hornsea Zone (see paragraph 2.4.1.6 and Figure 2.1 for proposed locations).

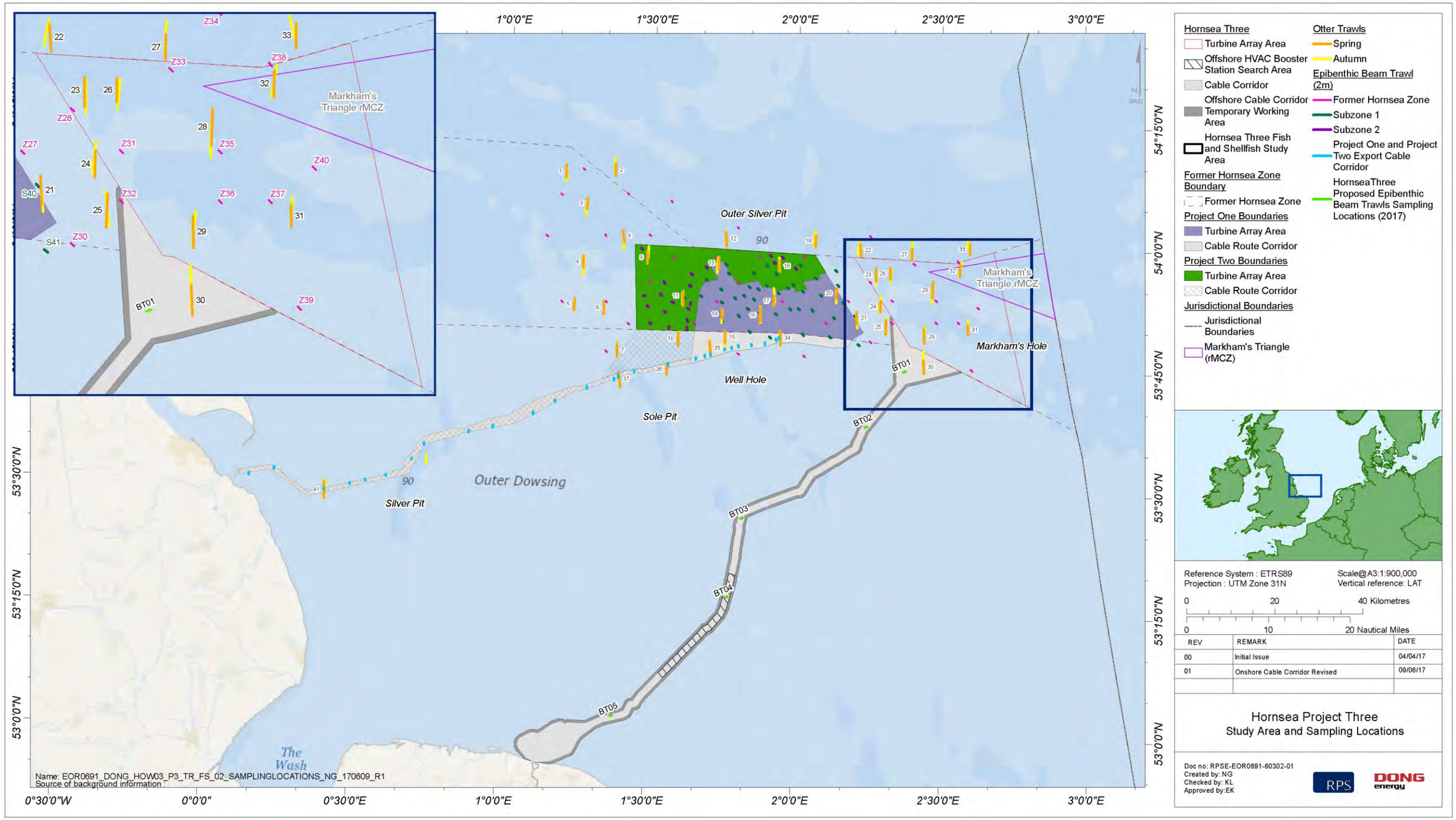


Figure 2.1: Historic otter trawl and epibenthic beam trawl sampling locations from across the former Hornsea Zone, used to inform the characterisation of fish and shellfish ecology within the Hornsea Three fish and shellfish study area. Figure also shows proposed site specific epibenthic beam trawl sampling locations.

2.3 Desktop review

2.3.1.1 A detailed literature search was carried out to establish the baseline of information available on fish and shellfish populations in the southern North Sea fish and shellfish study area (as defined in paragraph 2.1.1.1). Information was sought on fish and shellfish ecology in general and also on spawning and nursery activity.

2.3.1.2 Data from the offshore oil and gas industry and technical reports for Strategic Environmental Assessment (SEA) Areas 2 and 3 (Cefas, 2001; Rogers and Stocks, 2001) and the UK Offshore Energy SEA 3 (OESEA3; DECC, 2016a and 2016b) provide useful overviews of fish and shellfish ecology data and details of the literature available for the southern North Sea fish and shellfish study area.

2.3.1.3 Further information was obtained from broad scale studies of fisheries resources which provide information on fish ecology from trawl data collected (by a range of organisations including Cefas and Natural England) within the southern North Sea (e.g. Teal, 2011; Jones *et al.*, 2004; Callaway *et al.*, 2002; Rogers *et al.*, 1998). Data were also collated from online sources including those of the International Council of the Exploration of the Sea (e.g. ICES-FishMap; http://www.ices.dk/marine-data/maps/Pages/ICES-FishMap.aspx and International Bottom Trawl Surveys; IBTS, 2017). Gray (1995) and Pawson *et al.* (2002) also provide a useful overview of the types of coastal commercial fisheries around the UK coastline and the target species within these areas. Information on commercial fishing activity in the area (which includes review of the key commercial target species) has also been taken from annex 6.1: Commercial Fisheries Technical Report.

2.3.1.4 The main sources of information on fish spawning and nursery grounds within the UK are reports by Coull *et al.* (1998), Ellis *et al.* (2010) and Ellis *et al.* (2012) which include maps of the indicative extents of such areas for a number of species in UK waters.

2.3.1.5 Additional sources of information comprise baseline characterisation studies for other developments, including offshore wind farms, in the region. These included surveys at the Triton Knoll offshore wind farm undertaken between 2008 and 2010 (Triton Knoll Offshore Wind Farm Ltd., 2011a, 2011b and 2011c), Sheringham Shoal offshore wind farm undertaken between 2005 and 2009 (Brown and May, 2009; Scira Offshore Energy, 2006) and Dudgeon offshore wind farm undertaken in 2008 (Dudgeon Offshore Wind Limited, 2009; see Figure 1.1 for location of these projects in relation to Hornsea Three). In addition, information presented in the Marine Aggregates Regional Environmental Assessment (MAREA) of the Humber and the Outer Wash Region provided some regional information on fish assemblages (ERM, 2012).

2.3.1.6 Shellfish data, which were of particular relevance in the inshore areas of the Hornsea Three offshore cable corridor, were obtained through a number of sources, including landings data and charts of fishing activity compiled by the Eastern Inshore Fisheries and Conservation Authority (EIFCA). Other data sources used to inform the shellfish characterisation included stock assessments undertaken by Cefas and the EIFCA and other research into local shellfish populations, particularly those in inshore waters within which the Hornsea Three offshore cable corridor aligns (e.g. Jessop *et al.*, 2007; NNFLAG, 2015)).

2.4 Field surveys

2.4.1 Otter and beam trawls

2.4.1.1 As detailed in paragraph 2.2.1.6, seasonal otter trawl surveys were undertaken across the former Hornsea Zone (i.e. to inform zonal studies and from the surveys and characterisations undertaken for Hornsea Project One and Hornsea Project Two) during spring and autumn 2011. The spring survey was undertaken between 15 and 23 April 2011 and the autumn survey was undertaken between 29 September and 2 October 2011.

2.4.1.2 In total, the survey array consisted of 41 tow lines across the Hornsea Three fish and shellfish study area (Figure 2.1). This included trawl locations along the Hornsea Project One and Project Two offshore cable corridor extending into the Humber Estuary, which is separate and distinct from the Hornsea Three offshore cable corridor. Although these trawl locations are not within the Hornsea Three project area and therefore not directly applicable to the project, the data from these trawls are presented within the characterisation to provide further background information on the fish and shellfish communities in the southern North Sea.

2.4.1.3 Of the 41 otter trawl locations, three in spring and five in autumn were not trawled due to the presence of static fishing gear and receipt of advice from the fishing industry to avoid these areas. Each trawl was of 30 minutes duration. Once recovered to the deck, each catch was sorted and all species from each trawl were identified using appropriate keys. The entire catch was then enumerated and measured on a species-by-species basis. A full description of the survey method is provided in Appendix A.

2.4.1.4 The surveys were all conducted by EMU Ltd. aboard a commercial fishing vessel (F.V. Emulator) using a high-opening 5 m otter trawl with a 40 mm cod-end designed to catch semi-pelagic as well as demersal species (Figure 2.2). The gear used was comparable to those used in commercial fishing activities within the area.

Figure 2.2: Otter trawl sampling: F.V Emulator, otter trawl and typical catch.

2.4.1.5 During the spring otter trawl survey, high abundances of actively spawning herring were recorded at one trawl location, at the mouth of the Humber Estuary. Following identification of this spring spawning population, all mature herring captured during the autumn survey were analysed to determine their spawning condition. The gonads were examined and compared to the established ICES Gonadal Somatic Index (GSI) criteria and the fish grouped into one of eight developmental stages (see Figure 2.3; Bucholtz *et al*., 2008). These developmental stages can be grouped into five phases: Juvenile (Stage I), Maturation (Stages II-IV), Spawning (Stages V-VI), Spent-regeneration (Stage VII) and Abnormal (Stage VIII). Herring classified as spawning, spent-regeneration and in the late stages of maturation (Stages III-IV) are indicative of current, recent or imminent spawning activity (Bucholtz *et al.*, 2008). Although no GSI analysis was conducted during the spring surveys, the presence of obviously running herring was recorded, as specified by Cefas.

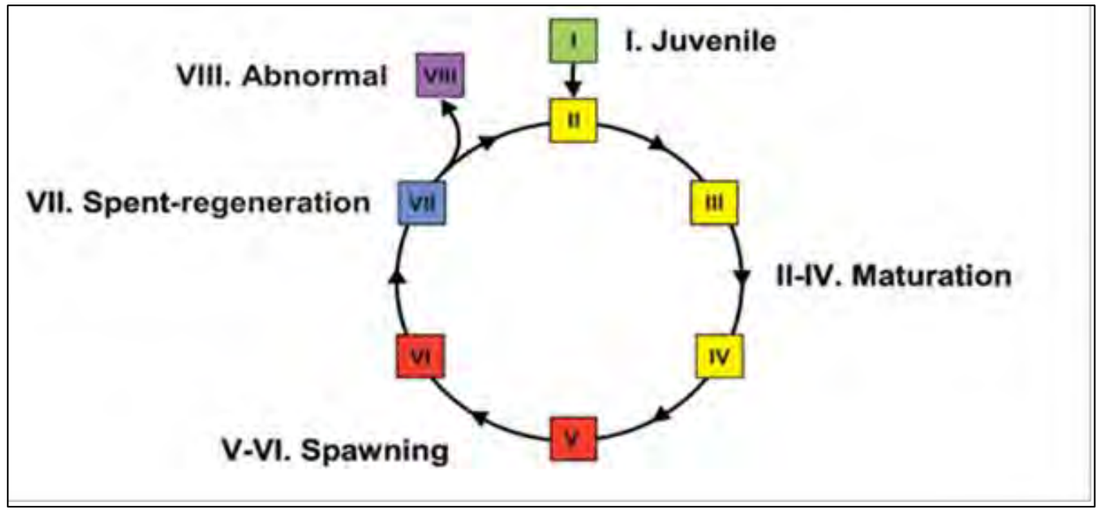


Figure 2.3: Developmental stages of herring used for GSI assessment (Bucholtz *et al.*, 2008).

2.4.1.6 Epibenthic beam trawl surveys were undertaken as part of the benthic ecology characterisation surveys (see annex 2.1: Benthic Ecology Technical Report). The surveys were conducted with a standard 2 m Cefas 'Jennings' beam trawl fitted with a 5 mm cod end and were standardised by duration, with each location trawled for 10 minutes.

2.4.1.7 The beam trawling characterisation surveys were undertaken in four mobilisations (as part of wider benthic survey), with the former Hornsea Zone survey undertaken in November and December 2010, a survey of the Hornsea Project Two array area undertaken in July 2012, a survey of the Hornsea Project One array area undertaken in July 2010 and the Hornsea Project One and Hornsea Project Two offshore cable corridor survey undertaken in June and October 2011. Beam trawl sampling locations are shown geographically in Figure 2.1 and comprised 40 locations for the former Hornsea Zone survey (including nine trawls within the Hornsea Three array area), 21 locations for the Hornsea Project Two survey, 41 locations for the Hornsea Project One survey and 28 locations for the Hornsea Project One and Hornsea Project Two offshore cable corridor survey. As detailed in paragraph 2.4.1.2, although the trawl locations along the Hornsea Project One and Hornsea Project Two offshore cable corridors are not within the Hornsea Three project area and therefore not directly applicable to the project, the data from these trawls are presented within the characterisation to provide further background information on the fish and shellfish communities in the southern North Sea.

2.4.1.8 Upon recovery of each trawl to the deck, the catch was sorted and all species from each trawl were identified using appropriate keys. The entire catch was then enumerated and measured on a species-by-species basis. A full description of the survey methodology is provided in annex 2.1: Benthic Ecology Technical Report. Beam trawl survey design was agreed with the MMO and their advisors (i.e. Cefas, Natural England and JNCC).

2.4.1.9 During the Evidence Plan process (section 2.2), it was agreed with the Marine Processes, Benthic Ecology and Fish and Shellfish Ecology EWG that further beam trawl samples would be collected in order to characterise the Hornsea Three offshore cable corridor. Hornsea Three proposed a further five locations to be sampled along the Hornsea Three offshore cable corridor (see Figure 2.1) during 2017 as part of the benthic ecology survey. As discussed in 2.2.1.7, due to the timing of this survey, these data are not included within the PEIR (i.e. this report), but will be incorporated into the fish and shellfish technical report to be submitted as part of the Environmental Statement which will accompany the DCO application.

2.5 Statistical analyses

2.5.1 General description of fish assemblages

2.5.1.1 The frequency of occurrence of fish species across the Hornsea Three fish and shellfish study area was calculated to give an indication of spatial and seasonal extent of each species recorded. This was calculated as the proportional representation of each fish species within all of the otter and epibenthic trawls combined (for each sampling location and over each survey event).

2.5.1.2 To determine which species dominated the fish community, the total abundance of each fish species was presented for both the otter trawl and epibenthic trawl separately, with the total abundance per season for each species also shown for the otter trawl data. The nature of trawl sampling is such that trawl lengths can vary due to environmental conditions such as tide, current, and wind speeds and directions. As a result, although trawls were broadly kstandardised in the field by duration (i.e. 30 minute otter trawls and 10 minute epibenthic trawls), it was necessary to standardise the data by trawl distance in order to ensure comparability between trawl sampling location. To ensure that trawl data from different sampling location (and trawl types) were comparable, the data were standardised to abundance per 500 m for both otter and epibenthic beam trawls.

2.5.1.3 For each sampling location, a number of univariate indices were calculated using all of the otter trawl and epibenthic trawl data (i.e. two seasonal otter trawl datasets and four epibenthic beam trawl datasets). The indices calculated were total species (S), total number of individuals (N), species richness (d), Pielou's evenness (J'), Simpson's dominance (lambda) and Shannon diversity (H'(loge)).

2.5.2 Spatial variation in fish assemblages

2.5.2.1 The similarity of fish communities across the sampling locations was investigated using multivariate analysis. The raw abundance data (i.e. from two otter trawl and four epibenthic trawl surveys) were imported into PRIMER v6 (Plymouth Routine in Multivariate Ecological Research; Clarke and Gorley, 2006). These were standardised by totals and a square root transformation applied to down weight the influence of numerically dominant species (e.g. whiting *Merlangius merlangus*, dab *Limanda limanda* and grey gurnard *Eutrigla gurnardus*, which were recorded at abundances of several hundred per 500 m in some trawls) over species recorded at lower abundances. A resemblance matrix using Bray-Curtis similarity was then produced as the basis of further analyses.

2.5.2.2 Cluster analysis with a similarity profile (SIMPROF) was performed to look for groupings of samples and to test for significant differences between and within groups identified by the cluster analysis. It could be argued that there is a degree of independence between samples since replicate trawls could not exactly pinpoint the same location from season to season. However, for the purposes of this analysis the samples are assumed to be replicates across seasons within the same sampling locations (where repeated sampling occurred at these locations).

2.5.2.3 Multidimensional scaling (MDS) was then performed to determine whether sampling locations were similar in terms of community composition with the SIMPROF groups superimposed on the resulting MDS plot. The influence of environmental factors (depth and sediment type) on the grouping was then investigated by producing a series of bubble plots. Environmental variables investigated included depth (metres below Lowest Astronomical Tide (LAT)), percentage gravel, sand, and mud (using Particle Size Analysis (PSA) data collected for the benthic ecology characterisation; annex 2.1: Benthic Ecology Technical Report). The environmental variables were first investigated for co-variance since there is only need to use one of any pair of variables which are strongly co-linear. The influence of selected environmental variables in shaping the fish community was subsequently determined using a biota-environment analysis (BIOENV) test. Finally, to interpret any differences between the fish assemblages within the groups identified during cluster analysis, a similarity percentage (SIMPER) analysis was performed to look at the percentage contributions of the main characterising species in each of the groups.

2.5.3 Seasonal variation in fish assemblages

2.5.3.1 Raw abundance data for each seasonal otter trawl survey were imported into PRIMER v6 and analysed as detailed above (see section 2.5.2) using cluster with SIMPROF, MDS, and SIMPER. In order to determine the seasonal variation in fish assemblages, Analysis of Similarity (ANOSIM) was used to test whether any differences in community composition across the sampling locations as defined by season were significant. The resulting test statistic (R) indicated the difference between the average of all rank similarities within seasons and the average of all rank similarities between seasons. R usually falls between 0 and 1 (although its range is –1 to +1); if R=1 all samples within seasons are more similar to each other than any samples from different seasons, if R is approximately zero then similarities between and within seasons will on average be the same (i.e. the latter result would indicate little or no influence of season, while R=1 would indicate a strong influence of season).

2.5.4 Size structure of population

2.5.4.1 Size-frequency graphs of selected fish species were produced using otter trawl and epibenthic data from all sampling locations combined. The species selected were primarily those of commercial importance, though species which were identified as characterising species in the assemblage (i.e. those recorded at high abundances throughout the Hornsea Three fish and shellfish study area) were also investigated for size structure.

2.5.4.2 These data give a baseline indication of the size distribution for a given species for future comparison. In addition, the analysis helps to identify the life stage (year class) of populations and therefore determine, amongst other things, whether the Hornsea Three fish and shellfish study area is being used as a nursery area (i.e. dominated by juveniles) or as a key feeding/spawning ground (dominated by adult fish).

2.6 Data limitations

2.6.1.1 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 Hornsea Three 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 Hornsea Three fish and shellfish study area at the time of sampling and the fish and shellfish assemblages may vary considerably both seasonally and annually. Furthermore, the efficiency of the survey methods employed at collecting particular 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 S*prattus 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 Hornsea Three fish and shellfish study area (e.g. sandeel or shrimp trawls and shellfish potting).

2.6.1.2 As such, the historic trawl survey data from across the former Hornsea Zone have been discussed in the context of literature reviewed for the wider southern North Sea fish and shellfish study area, including commercial fisheries consultation work undertaken as part of the commercial fisheries baseline characterisation (annex 6.1: Commercial Fisheries Technical Report), which provides a broader picture of the fish assemblages occurring across the area to ensure a robust characterisation for the purposes of the EIA.

2.6.1.3 Sampling was successful throughout most of the survey area with the exception of the following:

- Otter trawl sampling was not possible at three locations during the spring survey and five locations during the autumn survey due to the presence of static fishing gears in the area and receipt of advice from the fishing industry to avoid these areas. Due to the success of all other sampling across the Hornsea Project Three fish and shellfish study area and the use of desktop information to contextualise survey data, the absence of these data points will not affect the ability to provide a robust baseline characterisation.

2.6.1.4 As discussed in section 2.2, the approach to data collection, including the use of historic survey data from across the former Hornsea Zone (including Hornsea Project One and Hornsea Project Two), was agreed with the Marine Processes, Benthic Ecology and Fish and Shellfish Ecology EWG, including representatives from the MMO, Cefas and Natural England.

3. Results

3.1 Fish populations in the southern North Sea study area

3.1.1.1 The total British marine fish fauna is estimated to be 330 species, of which approximately 150 species are recorded from the North Sea (Maitland and Herdson, 2009). About 10% of the North Sea species are of significant commercial value and as such, the fish faunal abundance is affected by fishing pressure. The remaining species that occur in the North Sea are of little commercial value and so are not directly subject to fishing pressure. However many of these species are of significant ecological importance as prey items for other marine species (e.g. birds and marine mammals). Areas of high fish assemblage diversity (referred to as 'hotspots') have been observed in the North Sea, in areas with high influx of Atlantic waters from the north (Reiss *et al*., 2010), highlighting the relationship between fish distribution and underlying environmental and physical factors as well as the importance of immigration into the North Sea from surrounding regions (Tappin, 2011).

3.1.1.2 The southern North Sea is defined as the area to the south of the offshore frontal system, the Flamborough Front (discussed in full in annex 1.1: Marine Processes Technical Report), which creates a distinct thermocline between the waters to the north and south of Flamborough Head (Jones *et al*., 2004; Flamborough Head shown in Figure 1.1). Annex 1.1: Marine Processes Technical Report provides a detailed discussion and description of the Flamborough Front which occurs within the southern North Sea fish and shellfish study area. The southern North Sea is associated with distinct hydrographic conditions including shallow, well-mixed waters, exposing the bottom fauna to greater extremes of temperature compared to the deeper, stratified waters of the northern North Sea (i.e. north of the Dogger Bank; Figure 1.1). The shallow and well-mixed nature of the overlying waters creates conditions allowing for the majority of phytoplankton to reach the sea floor for consumption by benthic assemblages. These abundant benthic communities support diverse fish assemblages, consisting mainly of cool temperate species, making the North Sea one of the world's most important fishing grounds (Cefas, 2001).

3.1.1.3 The fish community in the North Sea can be broadly divided into two groups by the 50 m depth contour, a deeper northern group and a shallower southern group; with the Hornsea Three fish and shellfish study area included within the shallower southern North Sea (Teal, 2011; Callaway *et al*., 2002). Callaway *et al*. (2002) identified that the community of the shallower southern North Sea was generally characterised by species more typical of inshore waters. These included plaice, common sole, dab and whiting and small non-commercial species such as lesser weaver *Echiichthys vipera*, grey gurnard and solenette *Buglossidium luteum*. This was also reflected in the findings of Reiss *et al*. (2010), which noted that the key characterising fish species in the southern North Sea were dab, grey gurnard, whiting and plaice. In the deeper areas to the north (i.e. central and northern North Sea) the fish community was characterised by haddock, whiting, cod, mackerel *Scomber scombrus*, Atlantic horse mackerel *Trachurus trachurus*, herring, dab and plaice (Teal, 2011; Callaway *et al*., 2002). The central North Sea area has been found to contain a high diversity of fish species, likely due to an overlap in fish assemblages of both the northern and southern North Sea (Reiss *et al*., 2010).

3.1.1.4 Cefas beam trawl surveys (Parker-Humphreys, 2005) undertaken in the southern North Sea between 1993 and 2001, recorded 66 species of fish, including common sole, pouting *Trisopterus luscus*, pogge *Agonus cataphractus*, dab, whiting, poor cod *Trisopterus minutus*, plaice, lemon sole *Microstomus kitt*, common dragonet *Callionymus lyra*, and bull-rout *Myoxocephalus scorpius* as the top ten most abundant species.In the southern North Sea MNA (Jones *et al*., 2004) important commercial species recorded include cod, haddock, saithe *Pollachius virens*, whiting, pollack *Pollachius pollachius*, lemon sole, plaice, monkfish/anglerfish *Lophius* spp., lesser spotted dogfish *Scyliorhinus canicula*, dab, flounder *Platichthys flesus*, common sole, turbot *Scophthalmus maximus*, brill *Scophthalmus rhombus*, witch *Glyptocephalus cynoglossus*, skates/rays and sprat.

3.1.1.5 The abiotic factors important to the distribution of fish and shellfish include substrate type, temperature, salinity and depth (Teal, 2011; Callaway *et al*., 2002). The area of the southern North Sea coinciding with the former Hornsea Zone is characterised by water depths of between 30 to 40 m with slightly shallower areas of around 25 to 27 m to the south of Markham's Hole (Figure 2.1). Markham's Hole, located in the south east of the Hornsea Three array area, represents an area of comparatively deep water, reaching approximately 73 m. An area of deeper water known as Outer Silver Pit, corresponding to an area of shelf trough, exists just north of the former Hornsea Zone and reaches depths of 89 m. Further deep water troughs occur to the southwest of the Hornsea Three array area at Well Hole, Sole Pit and Silver Pit (Figure 2.1). As the Hornsea Three fish and shellfish study area lies within the shallower southern North Sea (i.e. water depths of <50 m), the fish communities present within it would be expected to be similar to those described for the shallow southern group described in paragraph 3.1.1.3. Due to the location of Hornsea Three close to the boundary of the two fish community groups (i.e. the 50 m depth contour; Teal, 2011; Callaway *et al*., 2002) and to the deeper waters to the north, the fish communities in this area may also have elements of the fish community associated with the deeper northern group.

3.1.1.6 The waters of the southern North Sea are slow moving with a southerly drift (ICES-Fishmap); they occasionally stratify and have considerable freshwater input from the River Humber. The sedimentary environment is variable consisting of mud, gravel and sand. According to the Folk classification, the area is dominated by slightly gravelly sand but has muddier sediments in the north and east of the Hornsea Three fish and shellfish study area (see annex 2.1: Benthic Ecology Technical Report).

3.1.2 Fish populations at other offshore wind farm sites

3.1.2.1 Sheringham Shoal and Dudgeon offshore wind farms are located in close proximity to the Hornsea Three offshore cable corridor, with the arrays of these two wind farms being approximately 7 km and 11 km from the Hornsea Three offshore cable corridor at the nearest point, and the Hornsea Three offshore cable corridor crossing the export cables of both these offshore wind farms in the inshore area (Figure 1.1). The Triton Knoll offshore wind farm is located approximately 100 km to the southwest of the Hornsea Three array area (44 km to the west of the Hornsea Three offshore cable corridor; Figure 1.1).

3.1.2.2 The fish communities recorded within and around the Dudgeon offshore wind farm were generally reflective of the fish and shellfish communities of the southern North Sea described above. Communities recorded in otter trawls were characterised by relatively low species diversity and were dominated by species such as whiting, dab and grey gurnard, with lower abundances of plaice, lemon sole, herring and gadoids including cod and pouting. Small, demersal species were also recorded during beam trawl surveys including gobies *Pomatoschistus* spp., common dragonet, butterfish *Pholis gunnellus*, pogge and lesser weaver. Abundances were considerably lower in both otter and beam trawl samples during spring surveys compared to autumn (Dudgeon Offshore Wind Limited, 2009). Site specific surveys at Dudgeon offshore wind farm also recorded elasmobranch species including thornback ray *Raja clavata* and spotted ray *Raja montagui*, starry smooth hound *Mustelus asterias* and smooth hound *Mustelus mustelus* and lesser spotted dogfish.

3.1.2.3 Due to the location of the Dudgeon offshore wind farm in proximity to a herring spawning habitat (Coull *et al*., 1998), site specific herring trawl surveys were also undertaken during the herring spawning period (Dudgeon Offshore Wind Limited, 2009). These surveys recorded only small numbers of herring, with the majority of the catch characterised by sprat (see section 3.2.5.15 for further discussion of herring spawning).

3.1.2.4 Site specific surveys at and around Dudgeon offshore wind farm also recorded crustacean species including brown crab, lobster, velvet swimming crab *Necora puber* and pink shrimp *Pandalus montagui* which were recorded in high numbers in the autumn trawl survey (Dudgeon Offshore Wind Limited, 2009). All of these species are commercially exploited in this part of the southern North Sea. Shellfish populations in the Hornsea Three fish and shellfish study area are discussed in further detail in section 3.4.

3.1.2.5 Fish surveys undertaken at and around Sheringham Shoal, like the adjacent Dudgeon offshore wind farm, showed fish communities that were reflective of those of the southern North Sea. The fish assemblage was characterised by species including whiting, dab, plaice, along with other commercially important species at lower abundances such as cod and flatfish including lemon sole and common sole. Pelagic species recorded included sprat and herring, with lower abundances of mackerel and horse mackerel occurring seasonally (i.e. in autumn; Scira Offshore Energy, 2006). Herring were recorded at relatively high abundances in the spring trawl surveys, but were either absent, or present at very low abundances during subsequent surveys. Fish length data showed that the fish population was dominated by immature fish, suggesting that the area may represent nursery or feeding habitat for many of these species. Other small demersal species recorded during surveys included common dragonet, lesser weever (particularly abundant during the summer), greater sandeel *Hyperoplus lanceolatus* and short spined sea scorpion *Taurulus bubalis* (Scira Offshore Energy, 2006).

3.1.2.6 Elasmobranch species recorded during trawl surveys included lesser spotted dogfish, starry smooth hound, smooth hound, spotted ray and thornback ray, although these were generally present at low abundances. Shellfish were recorded during all surveys, with velvet swimming crab abundant across the survey area during all surveys. Lobster and edible crab were also recorded during trawl surveys, although this type of survey is not specifically designed to target these species. Pink shrimp were found to be present at low abundances in spring, with abundances increasing in summer and this species highly abundant in some trawls in autumn. This is in line with the finding at Dudgeon offshore wind farm (see paragraph 3.1.2.3). Shellfish populations in the Hornsea Three fish and shellfish study area are discussed in further detail in section 3.4.

3.1.2.7 Herring trawl surveys were also undertaken within and around the Sheringham Shoal offshore wind farm during the pre-construction phase (Brown and May, 2009) due to the herring spawning habitat mapped in the vicinity of this offshore wind farm (Coull *et al*., 1998). Data from these surveys are fully discussed in the context of other data on herring spawning in section 3.2.5.15. In briefthe pelagic trawls from these surveys were dominated by sprat and immature herring, with limited evidence of herring spawning in the area (Brown and May, 2009).

3.1.2.8 The Triton Knoll offshore wind farm fish ecology characterisation (Triton Knoll Offshore Wind Farm Ltd., 2011a) showed that the fish assemblage in the vicinity of this wind farm had relatively low species diversity. The dominant species (by abundance) included dab and a number of small demersal fish species such as bull-rout, pogge, common dragonet, sea snails *Liparis* spp. and gobies.

3.1.2.9 The fish communities were generally similar across the Triton Knoll survey area, which was characterised by coarse, gravelly sediments, with subtle seasonal and spatial differences between the fish communities at different sites in the survey area. Shallow, sandy areas (i.e. sandbanks to the south of Triton Knoll) were found to be significantly different from other areas in the survey area, with a nursery habitat for plaice identified in this area. Seven commercially important fish species were recorded at the Triton Knoll offshore wind farm site including, thornback ray, blonde ray *Raja brachyura*, cod (which were all present at low very abundances), whiting, plaice, common sole and lemon sole (Triton Knoll Offshore Wind Farm Ltd., 2011a). The most important shellfish species recorded during site-specific surveys in the vicinity of the Triton Knoll offshore wind farm were lobster and brown crab, with velvet swimming crab and common whelk *Buccinum undatum* also recorded at high abundances (discussed in further detail in section 3.4; Triton Knoll Offshore Wind Farm Ltd., 2011b).

3.2 Fish populations in the Hornsea Three fish and shellfish study area

3.2.1 General description of fish assemblages recorded during historic trawl surveys across the former Hornsea Zone

3.2.1.1 A total of 84 species were recorded during otter and epibenthic beam trawls. Several species were recorded frequently across the Hornsea Three fish and shellfish study area, with dab occurring in almost all otter and epibenthic trawls (94.5%). Plaice, whiting and grey gurnard were recorded at particularly high frequencies in otter trawls while solenette and scaldfish *Arnoglossus laterna* were recorded at high frequencies in epibenthic beam trawl samples (though at lower frequencies in otter trawls due to their small size). Common dragonet and lesser weever were also recorded in high frequencies in the epibenthic and otter trawls, respectively. Figure 3.1 presents the percentage occurrence for species across the Hornsea Three fish and shellfish study area for all sampling location and seasons combined (Note: only species recorded in >2% of trawls are presented). This figure is for illustrative purposes only, to give an indication of which species occur throughout the Hornsea Three fish and shellfish study area, as this combines presence/absence data from two different trawl survey methodologies which are not directly comparable (i.e. otter and epibenthic beam trawls). Due to the differences in these survey methods, for all other analyses, these datasets are analysed separately.

3.2.1.2 Pelagic species including herring, sprat and squid (e.g. European common squid *Alloteuthis subulata* and European squid *Loligo vulgaris*) were also frequently recorded during the otter and epibenthic beam trawl surveys although these species may have been under-recorded as these sampling techniques were not specifically designed to sample pelagic species.

3.2.1.3 Shellfish species, namely brown crab, *Nephrops*, European common squid and brown (*Crangon crangon*) and pink shrimp were also caught in the otter and epibenthic trawls (Figure 3.1); these data are presented in section 3.4.

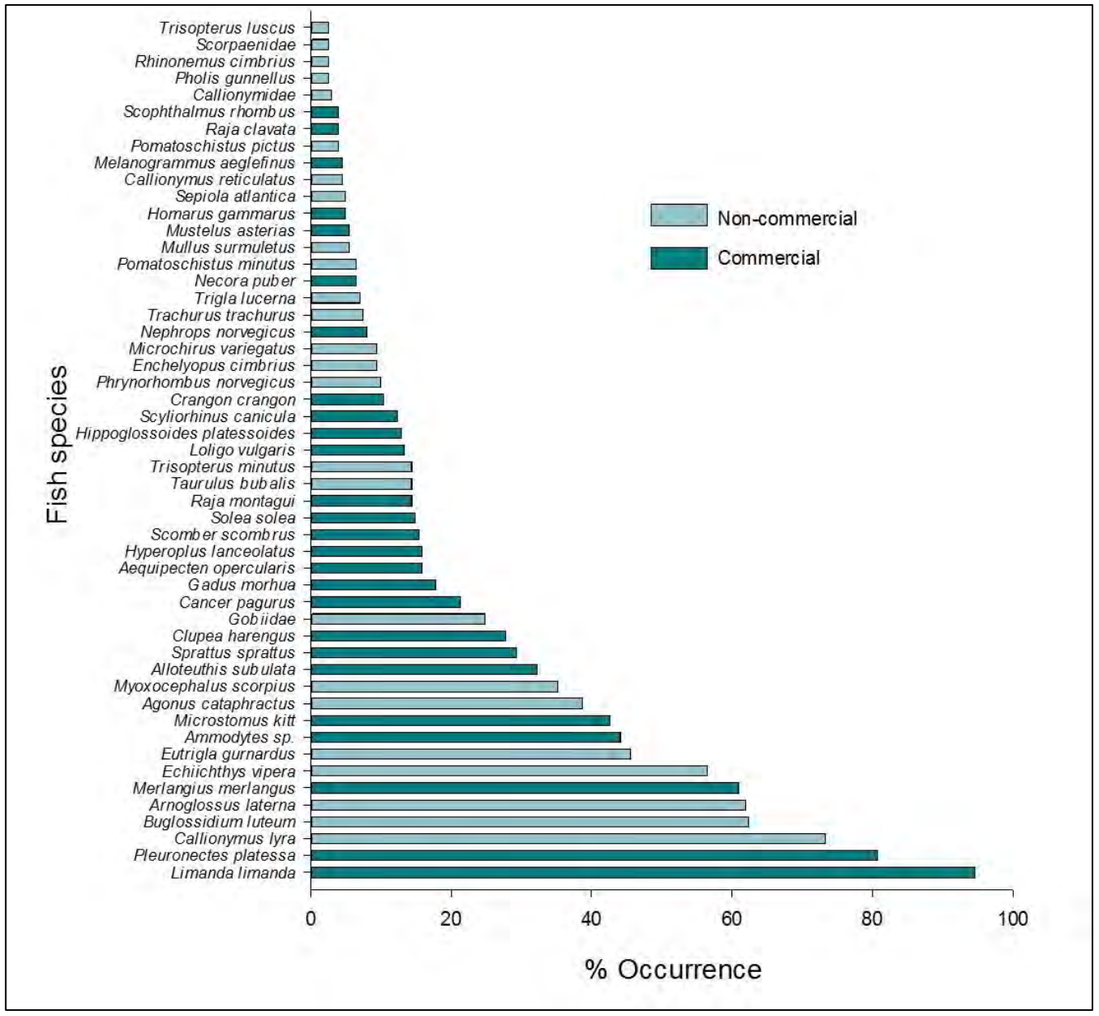


Figure 3.1: Frequency of occurrence of fish (and shellfish) species in otter and epibenthic beam trawls sampled within the Hornsea Three fish and shellfish study area. Note: Only species recorded in >2% of trawls are presented.

Abundance

3.2.1.4 Otter trawl samples were dominated by a small number of highly abundant species, with whiting, dab and sprat recorded at highest abundances (i.e. means of 141, 62 and 53 individuals per 500 m, respectively; Figure 3.2) and herring recorded at high abundances in spring. Of the flatfish species recorded in otter trawls only dab and plaice (mean of 16 individuals per 500 m) were recorded at moderate (i.e. plaice) to high abundances (i.e. dab) in samples, with other species including brill, sole and lemon sole recorded at much lower abundances (i.e. means of <1 individuals per 500 m). Other species recorded in otter trawls included two species of no commercial importance: grey gurnard (mean of 20 individuals per 500 m) and lesser weever (mean of 14 individuals per 500 m). Overall abundances across seasons were similar (means of 397 and 342 individuals per 500 m in spring and autumn, respectively; Figure 3.2), with the slightly higher abundance in spring likely due to the differences in clupeid abundances discussed above. Other species recorded in otter trawls included European common squid (mean of 25 individuals per 500 m). This species together with other shellfish caught in otter and epibenthic trawls are discussed in section 3.4.

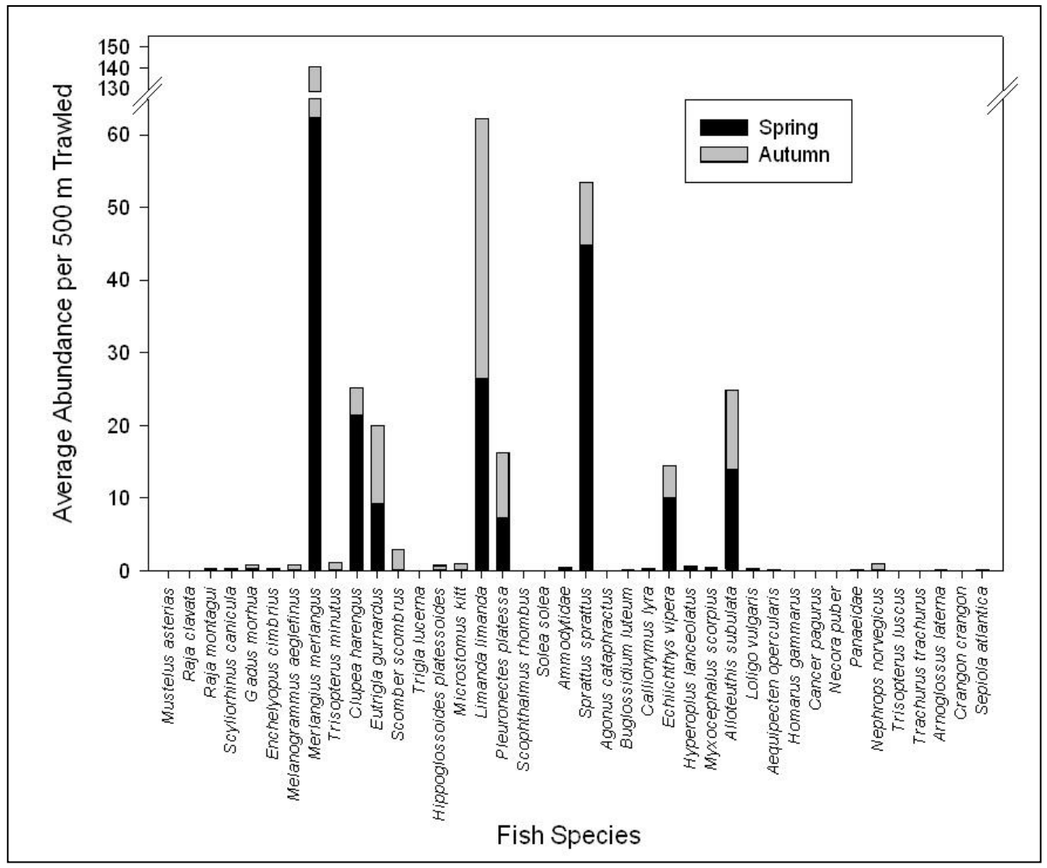


Figure 3.2: Average abundance (individuals per 500 m trawled) of fish (and shellfish) species recorded in seasonal otter trawls sampled within the Hornsea Three fish and shellfish study area.

3.2.1.5 The fish communities recorded during epibenthic beam trawls within the Hornsea Three fish and shellfish study area were dominated by small-bodied demersal fish species, with the flatfish solenette dominating the abundance of epibenthic trawls (mean abundance of over 60 individuals per 500 m; Figure 3.3). Other flatfish species recorded in epibenthic beam trawls included scaldfish, dab, plaice and lemon sole. Dragonets (including *C. lyra*, *C. reticulatus* and Callionymidae)., gobies (*Gobiidae* and *Pomatoschistus* spp.), lesser weever, pogge and sandeels were also recorded in beam trawl samples. Whiting were recorded, though at low abundances (mean of 3 individuals per 500 m) compared to those recorded during otter trawl samples.

3.2.1.6 Full species lists and abundance data recorded during otter trawl surveys are presented in Appendix B.

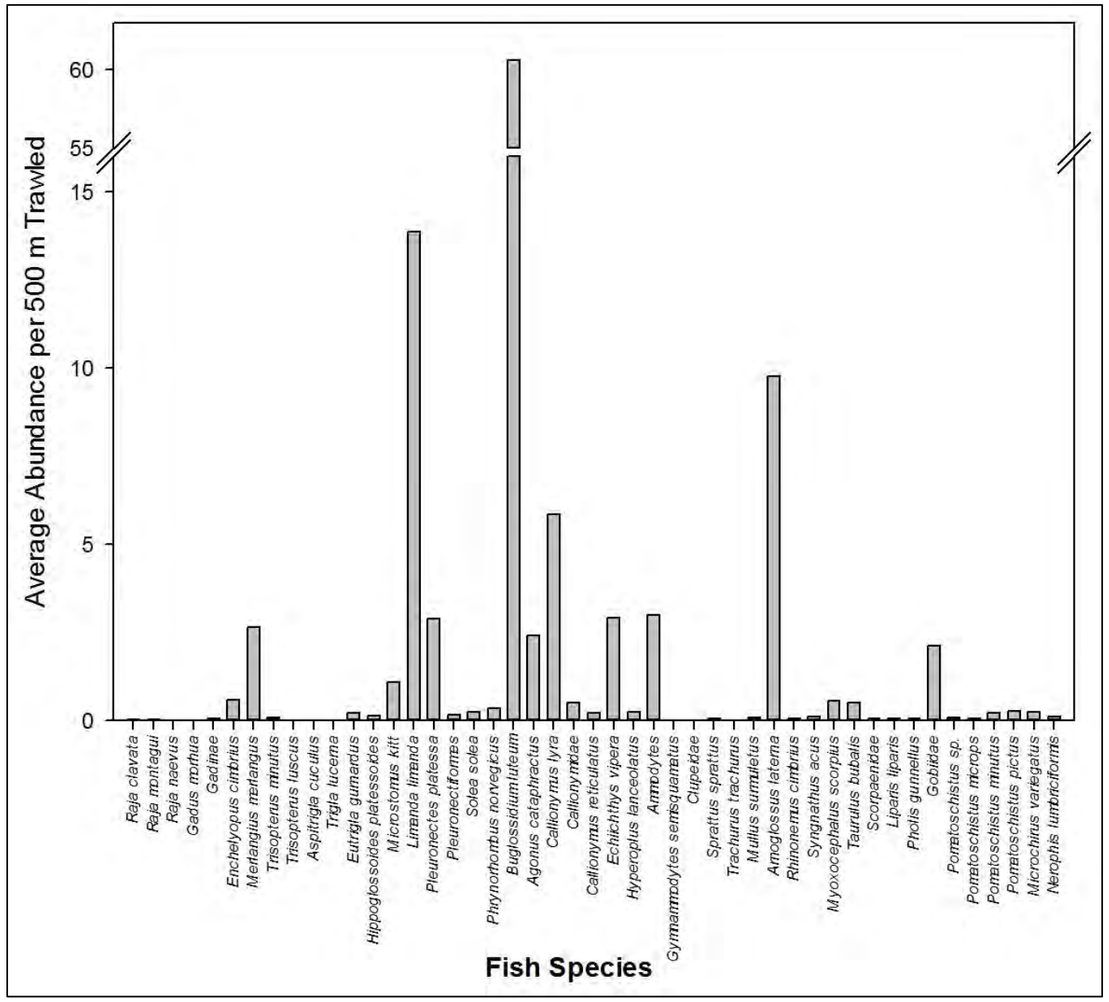


Figure 3.3: Average abundance (individuals per 500 m trawled) of fish species recorded in epibenthic beam trawls sampled within the Hornsea Three fish and shellfish study area.

3.2.2 Spatial variation in fish assemblages

Otter trawls

3.2.2.1 Spatial variation in the fish communities recorded in otter trawl sampling are illustrated by the cluster analysis undertaken for this dataset (Figure 3.4), which shows that the communities (spring and autumn data combined) were broadly grouped into three statistically distinct groups, with four of the trawl locations statistically distinct from one another and the main groups. Although three groups were identified as being statistically different from one another (using the SIMPROF statistical test), there was a high degree of similarity between these groups (i.e. >60%) and the species responsible for characterising these groups were similar. Whiting, dab, sprat, grey gurnard and European common squid were found to dominate most trawls, with herring and plaice also characterising the assemblage, though to a lesser extent. Differences between these groups were largely as a result of differences in the relative abundances of these key species as opposed to presence/absence of certain species. Spatially there are also some patterns, with many of the trawl locations within group f sited immediately to the south of the central part of the former Hornsea Zone. Figure 3.5 shows the spatial distribution of these SIMPROF groups relative to the Hornsea Three array area and the wider former Hornsea Zone, with seabed sediments represented by seabed interpretation from geophysical surveys for Hornsea Three, as well as Hornsea Project One and Hornsea Project Two (further discussed in annex 2.1: Benthic Ecology Technical Report). As can be seen in Figure 3.5, many of the trawl locations within group e were located in the northeast of the survey area, particularly in the deeper waters to the north of the Hornsea Three array and within Markham's Hole).

3.2.2.2 Four locations (trawl 32, 6, 41 and 39; see Figure 2.1) were distinct from each other and all other sampling locations in the Hornsea Three fish and shellfish study area (Figure 3.4; grey symbols). Whilst these four sampling locations showed some similarities with the other locations in the Hornsea Three fish and shellfish study area (i.e. prevalence of whiting, dab, sprat and grey gurnard), they also showed subtle differences, usually characterised by differences in abundance of a small number of key species. High abundances of cod (mean of 18 individuals per 500 m) and relatively high numbers of lemon sole compared to other areas (mean of four individuals per 500 m) characterised trawl 32, in the east of the Hornsea Three array area, within Markham's Triangle. Trawl 6 (in the west of the former Hornsea Zone; see Figure 2.1) was found to have high numbers of lesser weever (mean 329 individuals per 500 m in spring) and a low total number of species (14 species). Trawls 41 and 39 were located in the nearshore areas of the survey area (i.e. the Hornsea Project One and Hornsea ProjectTwo offshore cable corridor; see Figure 2.1) and therefore are not directly relevant to the Hornsea Three characterisation. Much of the distinctiveness of these two trawl locations was due to higher abundances of crustacea (e.g. lobster, velvet swimming crab, shrimps (*Panaeidae*) and brown shrimp. Relatively high abundances of herring (in spring at trawl 41) and poor cod (at trawl location 39) also explained the significant differences between these trawls and the rest of the survey area.

3.2.2.3 The full results of the SIMPER analysis are presented in Appendix C.

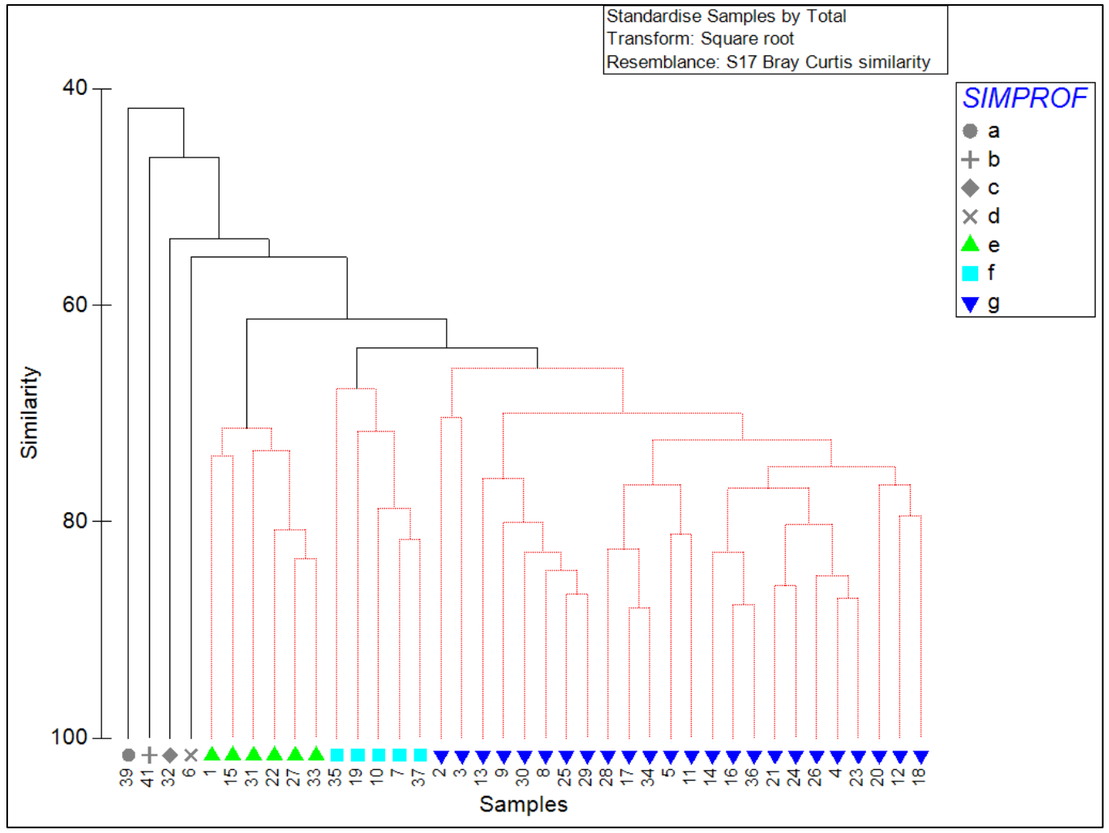


Figure 3.4: Dendogram using complete linking on Bray Curtis species similarities from standardised, square root transformed abundance data for otter trawl sampling locations. Significantly distinct groups/sampling locations (tested by SIMPROF) are separated by black lines.

3.2.2.4 Three environmental variables were tested for correlations with the fish assemblage dataset: % gravel, % mud and depth, with % sand excluded as it was found to be strongly negatively correlated with % gravel. The BIOENV analysis used to test the influence of these variables on the fish assemblage data found a weak correlation between the fish assemblage and the combination of % mud and depth (BIOENV, r = 0.409). Shallower waters were generally recorded in the nearshore areas (i.e. the Hornsea Project One and Hornsea Project Two offshore cable corridor), with deeper waters within Markham's Hole and to the north of the Hornsea Three array area and at trawl 39, within the Silver Pit feature (see Figure 3.5). Although the overall proportion of mud across most of the Hornsea Three fish and shellfish study area was small (see annex 2.1: Benthic Ecology Technical Report), relatively high proportions of mud were recorded in the deeper waters within Markham's Hole and to the north of the Hornsea Three array area (Figure 3.5).

3.2.2.5 Table 3.1 presents the mean univariate diversity measures for each of the SIMPROF groups identified in the cluster analysis previously discussed. These confirm many of the patterns described above, with most sampling locations (i.e. SIMPROF groups e, f and g) characterised by similar numbers of species (S=18.8 to 22.5) and high total abundances (N=667.5 to 1005 individuals per 500 m). These groups also had similar diversity indices, though the Simpson's dominance (lambda) value for group e was generally higher (Lambda=0.52) than all other groups, due to the very high numbers of whiting in these trawls.

3.2.2.6 As discussed above (section 3.2.2.2), trawl 6 (group d) was characterised by low numbers of species (S=14) and relatively high abundances (N=581; largely explained by high lesser weever abundance). Trawl 32 (group c) had the highest number of species (N=27) of all trawl samples, but had a relatively low abundance compared to other locations within the Hornsea Three fish and shellfish study area (N=326). The two nearshore trawl locations (trawls 41 and 39, or groups b and a, respectively) were both characterised by low abundances (N=104 and 129 per 500 m) but relatively high numbers of species (S =23 and 25, respectively). Diversity, evenness and dominance indices were generally found to be higher for the four statistically distinct trawl locations and this may be explained by the dominance of species such as dab and whiting in most of the other trawl samples, which would result in lower diversity scores.

3.2.2.7 Full results of the univariate diversity measures for each otter trawl location are presented in Appendix C.

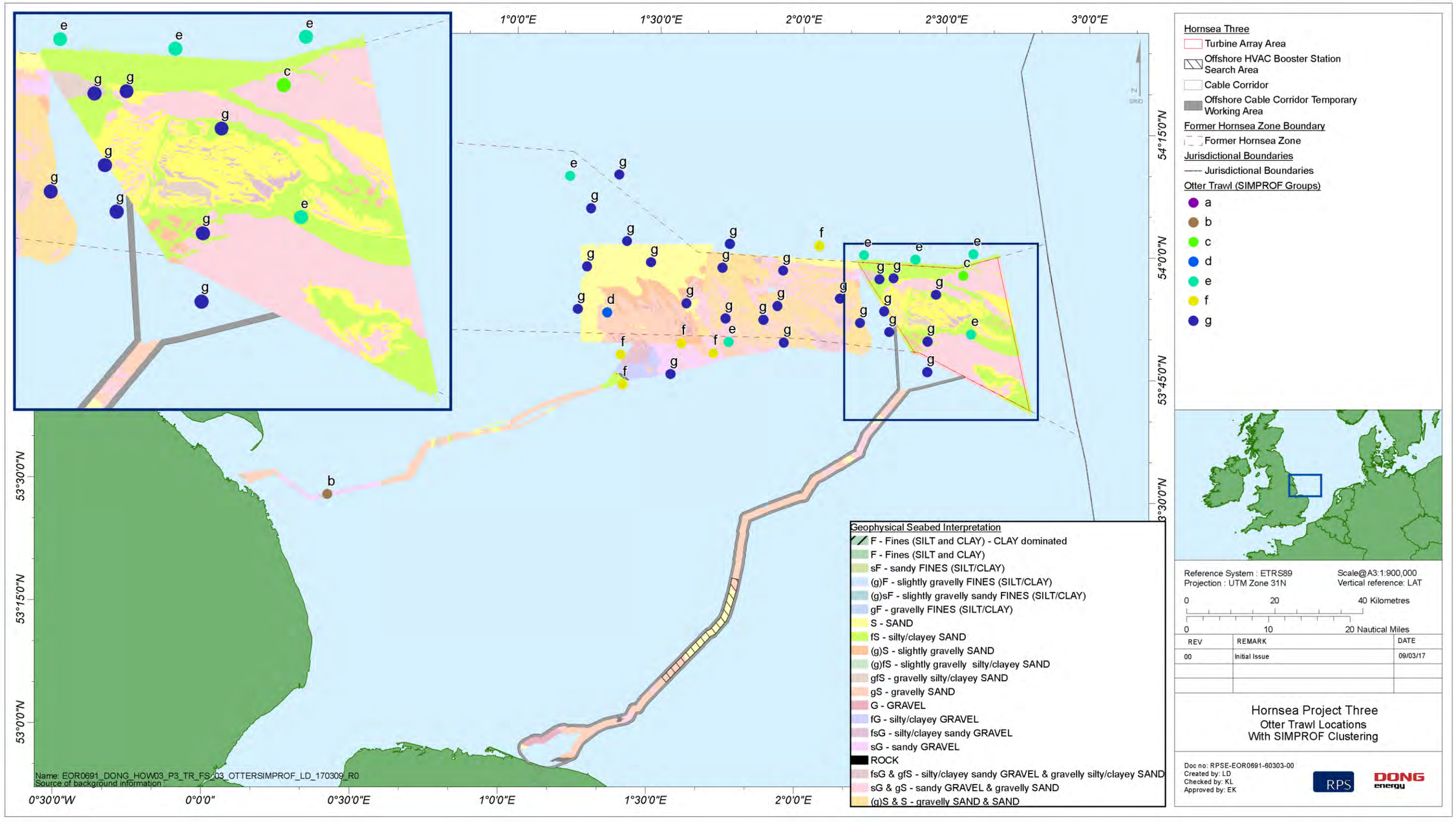


Figure 3.5: Otter trawl locations with SIMPROF groups and seabed interpretation from geophysical survey data from Hornsea Three and Hornsea Project One and Hornsea Project Two.

Table 3.1: Mean (± standard deviation) univariate diversity indices for SIMPROF groups identified in the otter trawl dataset. Where individual samples form a SIMPROF group, no standard deviation is reported as these are single values.

SIMPROF Group	S	N	D	J'	H'(loge)	Lambda
A	25	104	5.16	0.79	2.53	0.12
B	23	129	4.53	0.45	1.42	0.40
C	27	326	4.49	0.62	2.03	0.21
D	14	581	2.04	0.42	1.10	0.43
E	21.5 ± 3.3	1005 ± 572.1	3.03 ± 0.39	0.38 ± 0.05	1.16 ± 0.16	0.52 ± 0.07
F	18.8 ± 4.8	667.5 ± 472.8	2.81 ± 0.74	0.54 ± 0.11	1.54 ± 0.16	0.29 ± 0.07
G	19.7 ± 3	675.4 ± 202.8	2.89 ± 0.47	0.58 ± 0.06	1.72 ± 0.18	0.24 ± 0.06

S = Number of Species, N = Abundance per 500 m, d = Margalef's Diversity, J' = Pielou's Evenness, H'(loge) = Shannon-Weiner Diversity Index, Lambda = Simpson's Dominance Index. Epibenthic beam trawls.

3.2.2.8 Cluster analysis undertaken using the epibenthic beam trawl data showed 17 groups, with four sampling locations which were statistically different from all other locations (Figure 3.6). Figure 3.5 shows the spatial distribution of these SIMPROF groups relative to the Hornsea Three array area and the wider former Hornsea Zone, with seabed sediments represented by seabed interpretation from geophysical surveys for Hornsea Three as well as Hornsea Project One and Hornsea Project Two (further discussed in annex 2.1: Benthic Ecology Technical Report). As with the otter trawl data, many of the groups in the centre of the plot (i.e. groups f to l) were similar (>50% similarity) and were characterised by many of the same species, with the differences between the groups largely explained by differences in the relative abundances of these species. As previously discussed in paragraph 3.2.1.1, solenette dominated most of the epibenthic trawl samples (maximum abundance of 354 individuals per 500 m at the former Hornsea Zone survey trawl location 32 in the north east of the Hornsea Three array area; see Figure 2.1), with dab, scaldfish and common dragonet accounting for most of the rest of the similarities within these groups. Sandeels (*Ammodytes* spp.) were also identified as being characterising species within groups h, j and o (i.e. to the west of the Hornsea Three array area; see Figure 3.7), with abundances of between two and 30 individuals per 500 m recorded.

3.2.2.9 Those groups to the left and right of the plot (i.e. groups a to e and m to q; Figure 3.6) were distinguished from the other groups largely due to the lower abundances of solenette at these trawl locations (this species was absent from trawls in groups a to d located in the nearshore areas to the southwest of the former Hornsea Zone; Figure 3.7). These groups, which largely comprised trawls in the nearshore area (i.e. the Hornsea Project One and Hornsea Project Two offshore cable corridor and therefore not directly relevant to the Hornsea Three characterisation), were characterised by other small demersal species including common dragonet, bull-rout, short spined sea scorpion, pogge and lesser weever. Some sampling locations in the nearshore area were also characterised by low abundances of fish species or relatively high abundance of juveniles (e.g. high abundances of juvenile plaice were recorded in the most inshore trawl location within the Humber Estuary).

3.2.2.10 The full results of the SIMPER analysis are presented in Appendix C.

3.2.2.11 The influence of environmental variables was also investigated for the epibenthic beam trawl dataset, with the BIOENV test used to investigate the influence of % sand, % mud and depth.Gravel (%) was strongly negatively correlated with sand and was therefore excluded from the analysis; (r=-0.972). The test showed that individually, % sand and depth were weakly correlated with fish assemblage (BIOENV, r=0.380 and r=0.370 respectively) and when these two variables were combined, this correlation was somewhat stronger, though still representing a relatively weak correlation (BIOENV, r=0.497). The nearshore trawl locations were characterised by shallow waters and were statistically distinct (e.g. groups b, c and d) from most of the other trawl locations, located in deeper, offshore areas, particularly those trawls within and to the north of the Hornsea Three array area (i.e. groups i and l; see Figure 3.7).

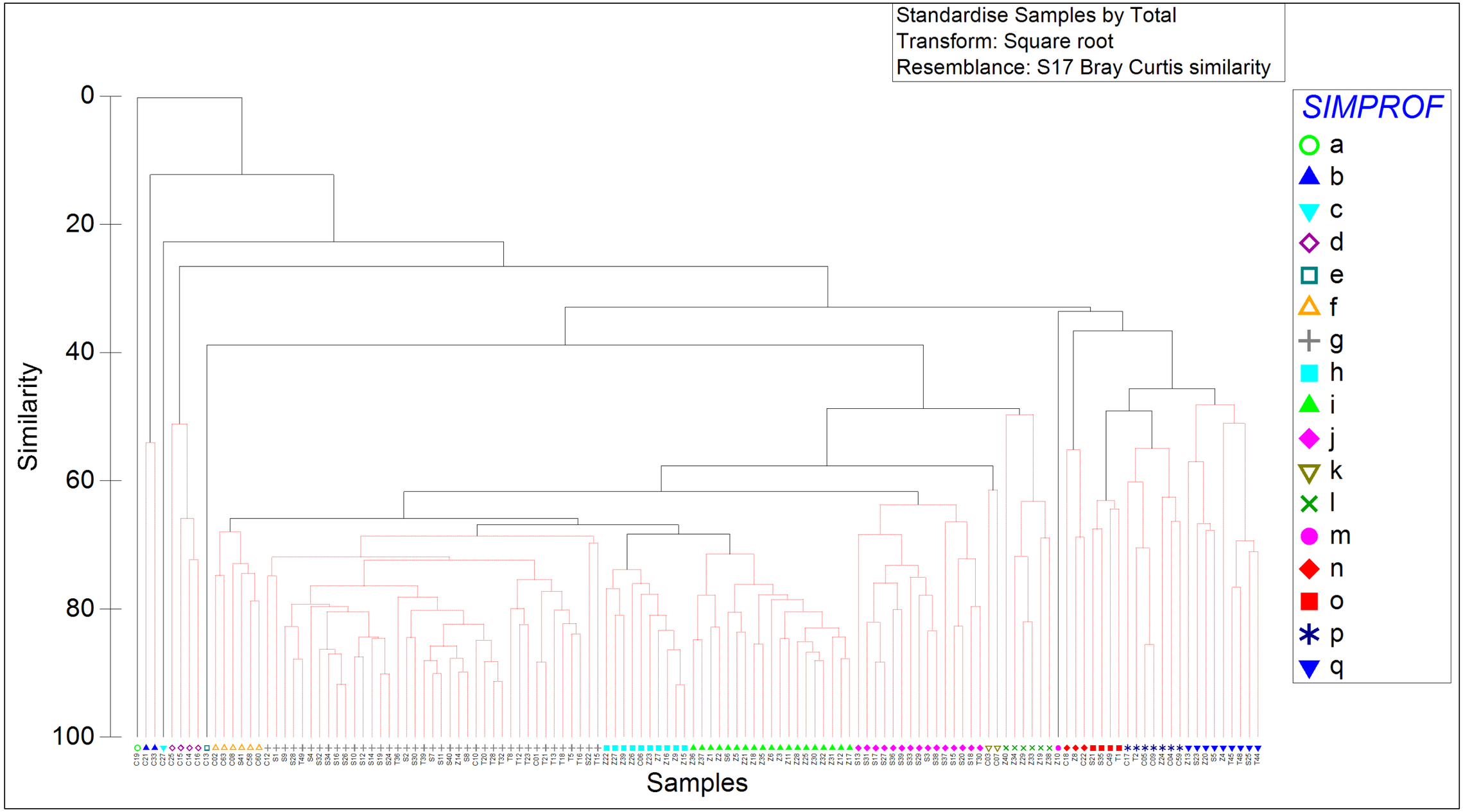


Figure 3.6: Dendogram using complete linking on Bray Curtis species similarities from standardised, square root transformed abundance data for epibenthic beam trawl sampling locations. Significantly distinct groups (tested by SIMPROF) are separated by black lines.

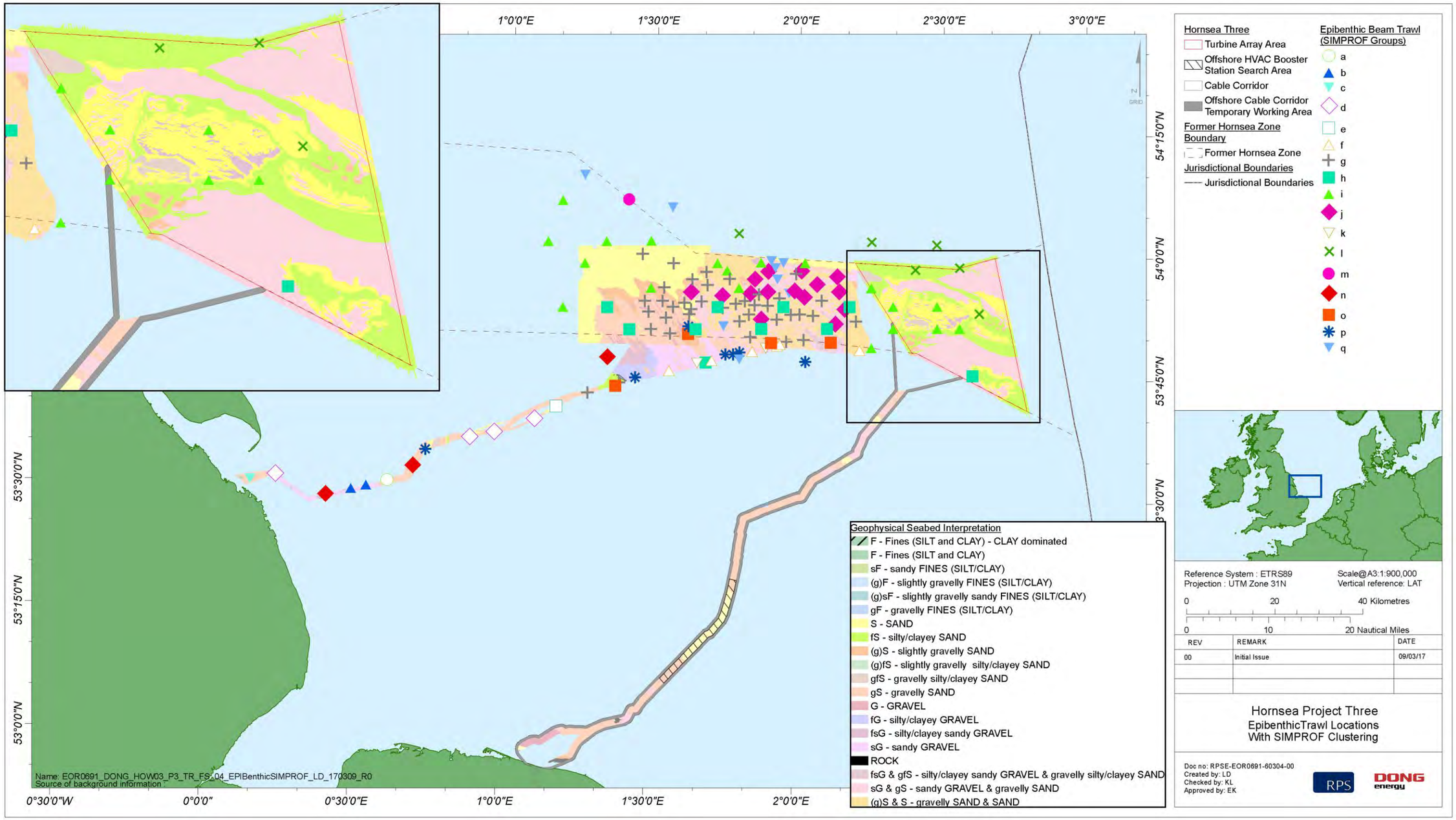


Figure 3.7: Epibenthic beam trawl locations with SIMPROF groups and seabed interpretation from geophysical survey data from Hornsea Three, and Hornsea Project One and Hornsea Project Two.

3.2.2.12 Table 3.2 presents the mean univariate diversity measures for the SIMPROF groups identified in the cluster analysis for the epibenthic trawl dataset. These show many of the same patterns discussed above. Groups g, h, i, j and l characterised most of the Hornsea Three fish and shellfish study area and were found to be similar in terms of fish assemblage in the epibenthic beam trawls (Figure 3.7). These were found to have a moderate number of species (N=8.7 to 10.2) and moderate to high abundances (N=56.1 to 253.9 individuals per 500 m). As detailed above, the trawls within these groups were found to be dominated by solenette and this was particularly evident in groups i and k which were found to have relatively low evenness scores (J'=0.5 and 0.4, respectively) and relatively high dominance scores (Lambda=0.5 and 0.64, respectively) due to extremely high abundances of this species. By contrast, groups j, l and o had relatively high evenness scores and low dominance scores as solenette was present in these trawls, though not at particularly high abundances.

3.2.2.13 As detailed above, the nearshore trawls (groups a and b), were found to have particularly low diversities, with low numbers of species (S=1 to 3) recorded and low abundances (N=1.7 to 20.1 individuals per 500 m).

3.2.3 Seasonal variation in fish assemblages

3.2.3.1 Mulitvariate analyses were also undertaken to investigate the influence of season on the fish and shellfish assemblage recorded in otter trawls, with analyses undertaken to compare trawl locations over the two survey events (i.e. spring and autumn). Statisical analyses using the ANOSIM statistical test revealed that there were significant differences between the autumn and spring otter trawl datasets (ANOSIM, R=0.269, p<0.001), though the low R value also indicated a high degree of overlap between the datasets.

3.2.3.2 SIMPER analysis was also undertaken to identify which species accounted for the differences observed in the MDS plot and ANOSIM test. As with the spatial variability in fish and shellfish assemblages, many of the seasonal differences in the communities were explained by differences in the abundances of the most common species in the Hornsea Three fish and shellfish study area (e.g. whiting, dab and European common squid). Greater differences in abundance were detected for the two clupeid species, sprat and herring, with sprat recorded at a mean abundance approximately five times higher in spring than in autumn and herring recorded at a mean abundance approximately seven times higher in spring than in autumn (Figure 3.2). This also contributed to the differences in the seasons, with sprat accounting for 14.49% and herring accounting for 8.16% of the dissimilarities between seasons.

3.2.3.3 A full list of species contributing to within season similarities and between season dissimilarities is presented in Appendix C.

Table 3.2: Mean (± standard deviation) univariate diversity indices for SIMPROF groups identified in the otter trawl dataset. Where individual samples form a SIMPROF group, no standard deviation is reported as these are single values.

SIMPROF Group	S	N	d	J'	H'(loge)	Lambda
a	1.0	1.7	0	0	0	1.0
b	3.0 ± 0	20.1 ± 3.7	0.67 ± 0.04	0.74 ± 0.32	0.81 ± 0.35	0.53 ± 0.25
c	7.0	55.3	1.49	0.87	1.7	0.2
d	6.8 ± 1.3	31.3 ± 15	1.73 ± 0.13	0.82 ± 0.05	1.56 ± 0.16	0.27 ± 0.05
e	5.0	22	1.29	0.85	1.36	0.3
f	13.3 ± 3.9	153.4 ± 34.8	2.48 ± 0.84	0.55 ± 0.06	1.41 ± 0.19	0.42 ± 0.06
g	8.7 ± 1.8	110.6 ± 29.5	1.64 ± 0.37	0.61 ± 0.11	1.31 ± 0.28	0.41 ± 0.12
h	10.2 ± 1.9	154.9 ± 53.2	1.84 ± 0.36	0.7 ± 0.06	1.61 ± 0.19	0.28 ± 0.07
i	8.8 ± 1.3	253.9 ± 117.9	1.46 ± 0.28	0.5 ± 0.12	1.1 ± 0.28	0.5 ± 0.13
j	9.8 ± 2.1	67.5 ± 25.1	2.12 ± 0.51	0.8 ± 0.07	1.81 ± 0.26	0.22 ± 0.07
k	7 ± 4.2	119.6 ± 33.6	1.29 ± 0.97	0.4 ± 0.26	0.82 ± 0.74	0.64 ± 0.33
l	8.8 ± 1.3	56.1 ± 19.8	1.99 ± 0.42	0.86 ± 0.06	1.86 ± 0.2	0.19 ± 0.04
m	13.0	45.8	3.14	0.9	2.31	0.12
n	7.3 ± 1.5	50.5 ± 48.7	1.76 ± 0.04	0.81 ± 0.12	1.59 ± 0.11	0.26 ± 0.04
o	10.8 ± 1.3	43.5 ± 8.5	2.59 ± 0.3	0.84 ± 0.02	1.98 ± 0.14	0.18 ± 0.03
p	9.9 ± 3.2	66.3 ± 22.6	2.15 ± 0.8	0.78 ± 0.1	1.75 ± 0.31	0.24 ± 0.08
q	8.3 ± 2.4	40.9 ± 19.1	2.02 ± 0.6	0.76 ± 0.15	1.6 ± 0.47	0.29 ± 0.17

S = Number of Species, N = Abundance per 500 m, d = Margalef's Diversity, J' = Pielou's Evenness, H'(loge) = Shannon-Weiner Diversity Index, Lambda = Simpson's Dominance Index.

3.2.4 Species by species distribution and abundance

3.2.4.1 Figure 3.8 to Figure 3.21 show abundances of the key fish species recorded in the Hornsea Three fish and shellfish study area during the otter and epibenthic beam trawl surveys. Spawning and nursery habitats for these species are also shown where information is available (Coull *et al*., 1998; Ellis *et al*., 2010; Ellis *et al*., 2012). Whilst this information is briefly discussed here in context of the historic survey data from across the former Hornsea Zone, a more detailed review of spawning and nursery habitats of key fish species occurring in the Hornsea Three fish and shellfish study area is presented in section 3.2.5.15.

Whiting

3.2.4.2 Whiting (Figure 3.8) was the most abundant species recorded across the Hornsea Three fish and shellfish study area and was found to be one of the key characterising fish species recorded during otter trawl surveys (see paragraph 3.2.2.1). Figure 3.8 shows that whiting was abundant throughout the former Hornsea Zone and Hornsea Three array area, though abundances recorded during epibenthic beam trawls were lower than those in otter trawl samples.

3.2.4.3 Data from the IBTS show that whiting are widely distributed throughout the North Sea, with consistently high abundances recorded in most areas, with the exception of Dogger Bank where abundances are generally low (ICES, 2005a; ICES, 2017). During summer, juveniles are particularly abundant in the German Bight and off the Dutch coast. High abundances of adult whiting occur south of Shetland during winter, while during the summer, the entire southern North Sea and the area off the Scottish coast is densely populated by adult whiting (ICES, 2005a). This was reflected in recent IBTS data (reported as individuals recorded per hour trawl), which showed highest abundances along the east coast of England (including the former Hornsea Zone) and Scotland with thousands of individuals recorded per hour trawling in 2011 to 2013 (ICES, 2017). High abundances of whiting (i.e. over 1,000 individuals per hour) were also reported during IBTS data at locations further offshore in the southern North Sea, to the east and northeast of the former Hornsea Zone. These abundances were comparable with those recorded for the former Hornsea Zone, including the Hornsea Three fish and shellfish study area (i.e. tens to thousands of individuals recorded per 30 minute trawl; see Appendix B).

3.2.4.4 IBTS data also indicate lower abundances of whiting (i.e. tens of individuals per hour trawling) in inshore areas off the north Norfolk coast (i.e. the nearshore section of the Hornsea Three offshore cable corridor), although the raw data indicate that these abundances are variable annually, with over 900 individuals per hour trawling recorded in spring 2015. Data from the Dudgeon and Sheringham Shoal offshore wind farms also indicate that whiting is a key characterising species within the nearshore sections of the Hornsea Three offshore cable corridor (see section 3.1.2). A fully quantitative comparison between Hornsea Three data and IBTS data was not possible due to difficulties in standardising data (e.g. differences in sampling methods, timing of surveys etc).

3.2.4.5 The spawning and nursery habitats for this species (Figure 3.8)) mirror these patterns in abundance, with low intensity spawning and high intensity nursery habitats coinciding with the Hornsea Three array area and former Hornsea Zone, where the highest abundances were recorded, and low intensity nursery habitats coinciding with the majority of the Hornsea Three offshore cable corridor.

Cod

3.2.4.6 Cod was recorded at considerably lower abundances than whiting and was not found to be one of the main characterising species of the assemblage, though the presence of this species in certain trawl samples contributed to some of the differences observed (see paragraph 3.2.2.2). Figure 3.9 shows that this species was recorded at low abundances throughout the Hornsea Three fish and shellfish study area. The highest abundances of this species were consistently recorded in otter trawls at two locations; in the east of the Hornsea Three array area and to the north of the former Hornsea Zone in the deeper water of Outer Silver Pit. Historic trawl survey data from across the former Hornsea Zone showed consistent patterns with those observed in the IBTS, with highest abundances occurring in the central and northern North Sea, around Dogger Bank and in the Southern Bight (ICES, 2005b). Data from Dudgeon and Sheringham Shoal offshore wind farms (in proximity to the nearshore sections of the Hornsea Three offshore cable corridor) also reflected this trend with cod in these shallower waters recorded at low abundances, if at all (see section 3.1.2).

3.2.4.7 The Hornsea Three fish and shellfish study area coincides with low intensity spawning and low intensity nursery habitats for this species (Figure 3.9), and is therefore not particularly important for this species, which may partly explain the relatively low abundances recorded.

Dab

3.2.4.8 Dab was the most frequently recorded species in all trawl samples and was one of the main characterising species of the fish assemblages recorded in both otter and epibenthic beam trawl datasets. As can be seen in Figure 3.10, dab was consistently recorded at high abundances throughout the Hornsea Three fish and shellfish study area, with highest abundances in offshore areas, compared with lower abundances in the nearshore trawls. No information on spawning or nursery habitats is available for this species in this part of the southern North Sea.

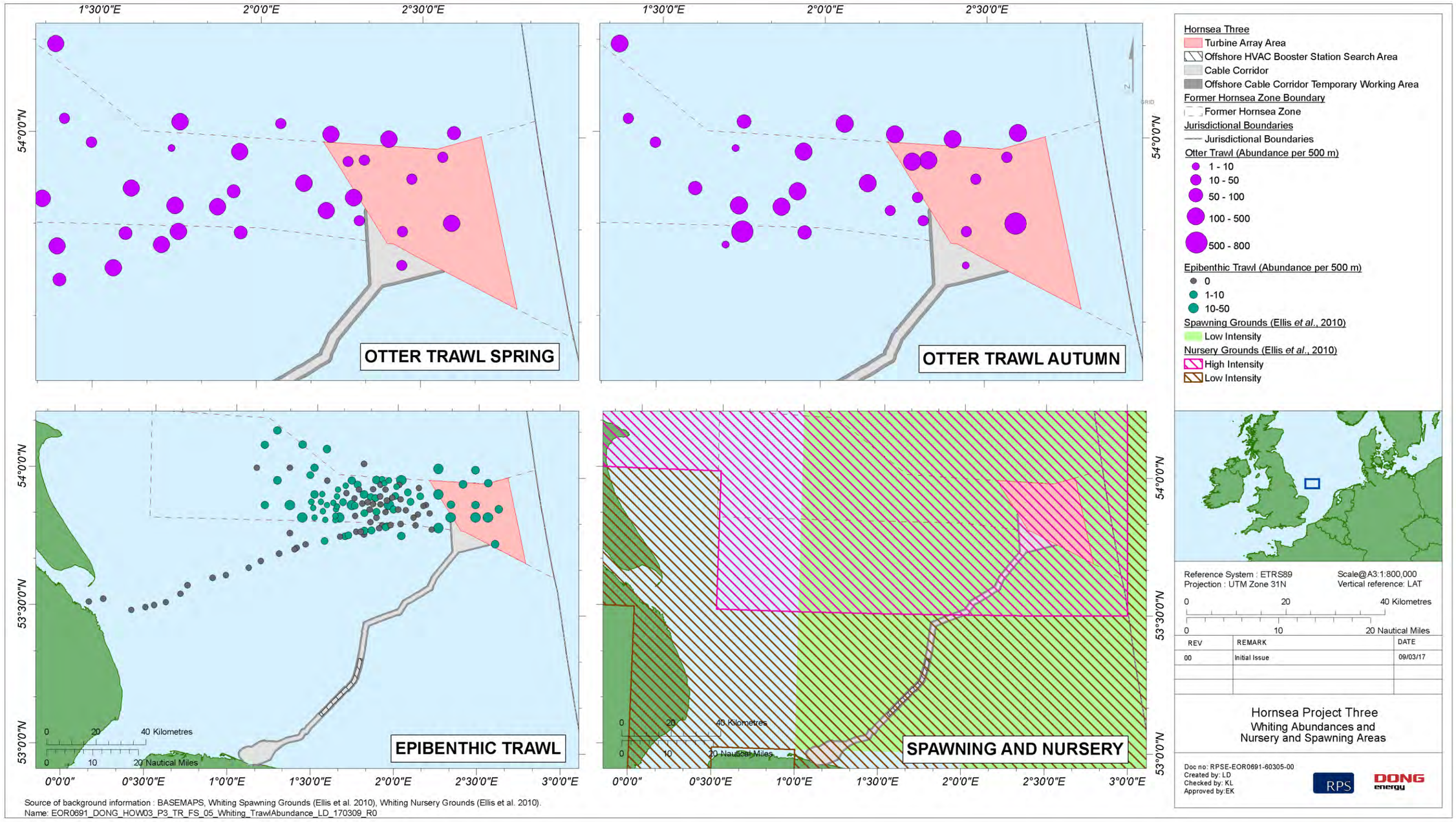


Figure 3.8: Whiting abundances and spawning and nursery habitats within the Hornsea Three fish and shellfish study area.

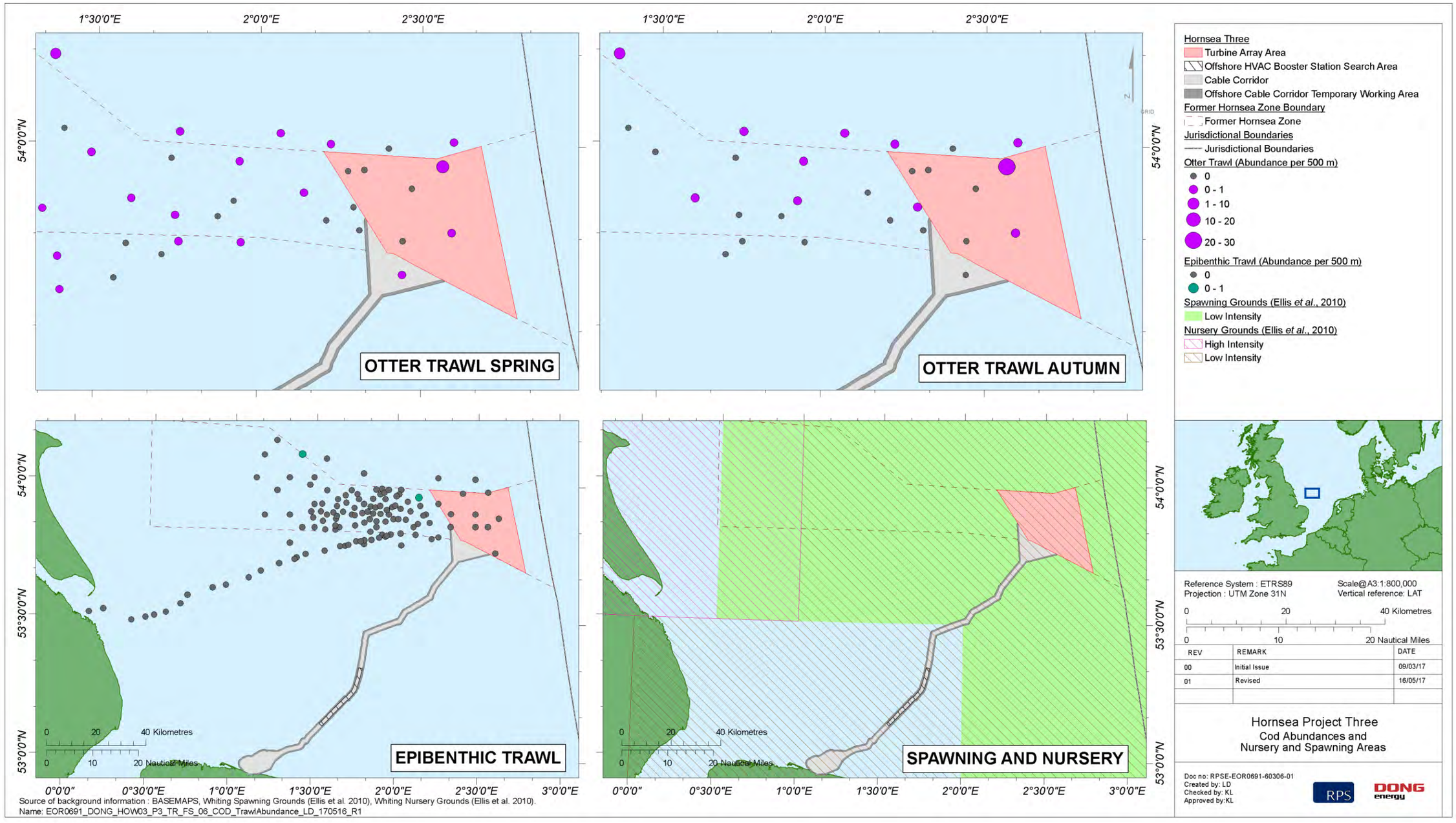
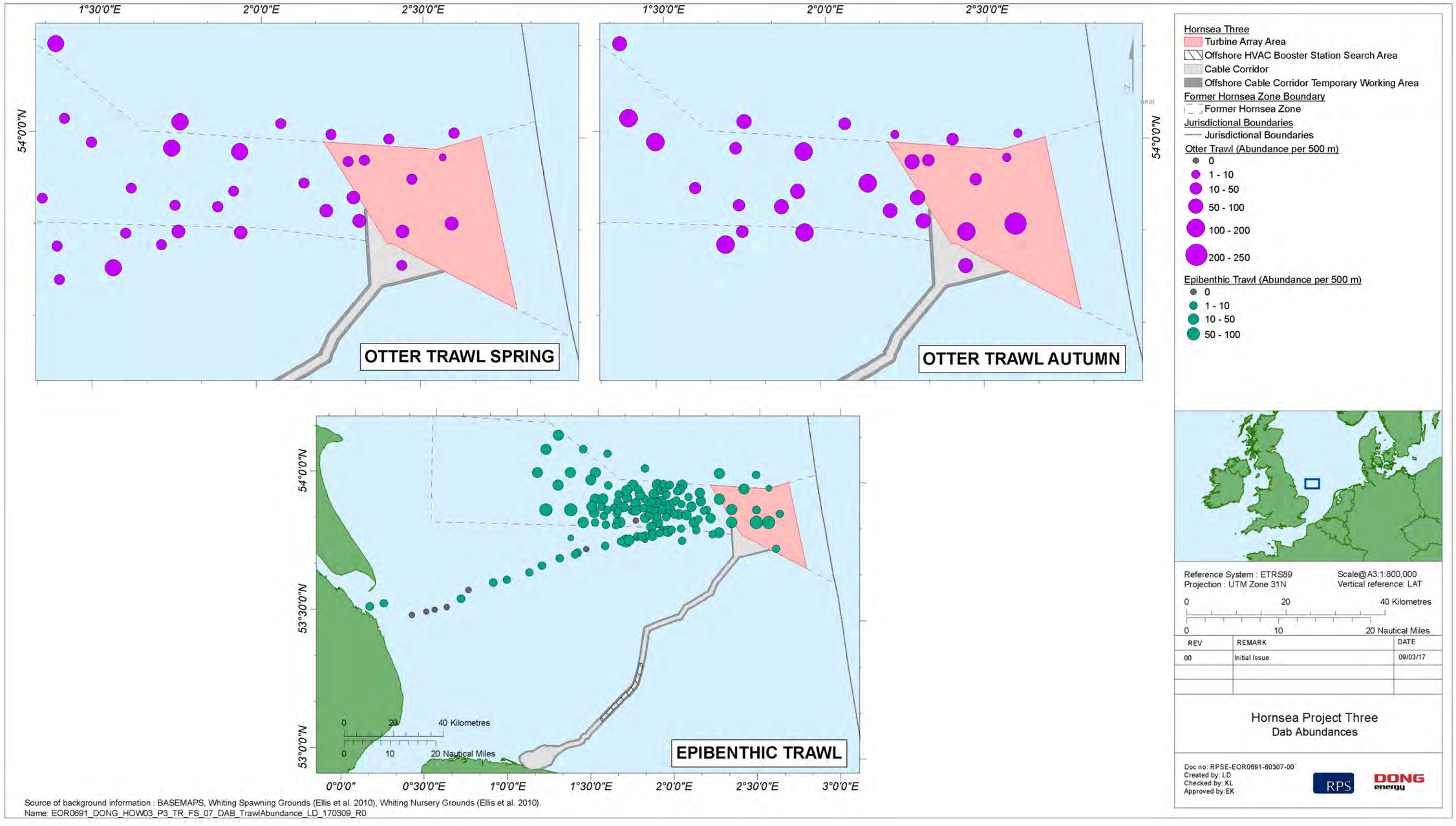


Figure 3.9: Cod abundances and spawning and nursery habitats within the Hornsea Three fish and shellfish study area.



Source of background information : BASEMAPS, Whiting Spawning Grounds (Ellis et al. 2010), Whiting Nursery Grounds (Ellis et al. 2010).
Name: EOR0691_DONG_HOW03_P3_TR_FS_07_DAB_TrawlAbundance_LD_170309_R0

Figure 3.10: Dab abundances within the Hornsea Three fish and shellfish study area.

Plaice

3.2.4.9 Plaice was also one of the most frequently recorded flatfish species, though this species was present at lower abundances throughout the Hornsea Three fish and shellfish study area than dab. This was also one of the characterising species recorded in otter trawls, though to a lesser extent than dab and whiting. Figure 3.11 shows that plaice were present at relatively low abundances throughout the Hornsea Three fish and shellfish study area, with no noticeable temporal patterns in this data. This reflects the patterns shown in the IBTS data, which showed that plaice were abundantly recorded throughout the southern North Sea (see also paragraph 3.1.1.3), with highest abundances recorded in the Southern and German Bights and along the east coast of Britain (ICES, 2005c). Data from the Dudgeon and Sheringham Shoal offshore wind farms indicated that although plaice were recorded in trawl samples, this species was not one of the most abundant species and was often only present at low abundances (see section 3.1.2).

3.2.4.10 The Hornsea Three fish and shellfish study area coincides with a high intensity spawning ground for this species with a low intensity nursery habitat in the nearshore half of the Hornsea Three offshore cable corridor (Figure 3.11). This largely mirrors the abundance patterns for this species as recorded in the historic trawl survey data from across the former Hornsea Zone and in the desktop data for the Hornsea Three offshore cable corridor.

Lemon sole

3.2.4.11 Lemon sole was recorded at low abundances throughout the Hornsea Three fish and shellfish study area (Figure 3.12), with relatively high abundances, compared to the overall low density population, recorded in otter trawls in the east of the Hornsea Three array area and to the north of the former Hornsea Zone, within the deeper waters of Outer Silver Pit. The Hornsea Three array area is outside the mapped spawning and nursery habitats for this species (Figure 3.12), which is located in more inshore waters, although much of the Hornsea Three offshore cable coincides with this area.

Common sole

3.2.4.12 Common sole was also recorded at very low abundances throughout the Hornsea Three fish and shellfish study area with highest abundances (i.e. <4 individuals per 500 m) recorded in the east of the Hornsea Three array area and in the northwest of the former Hornsea Zone (these are not shown on a plot due to the consistently low abundances). The low abundances of common sole during surveys supported the conclusion that this part of the southern North Sea does not represent particularly important spawning or nursery habitat for this species (further discussed in paragraph 3.2.6.3).

Solenette

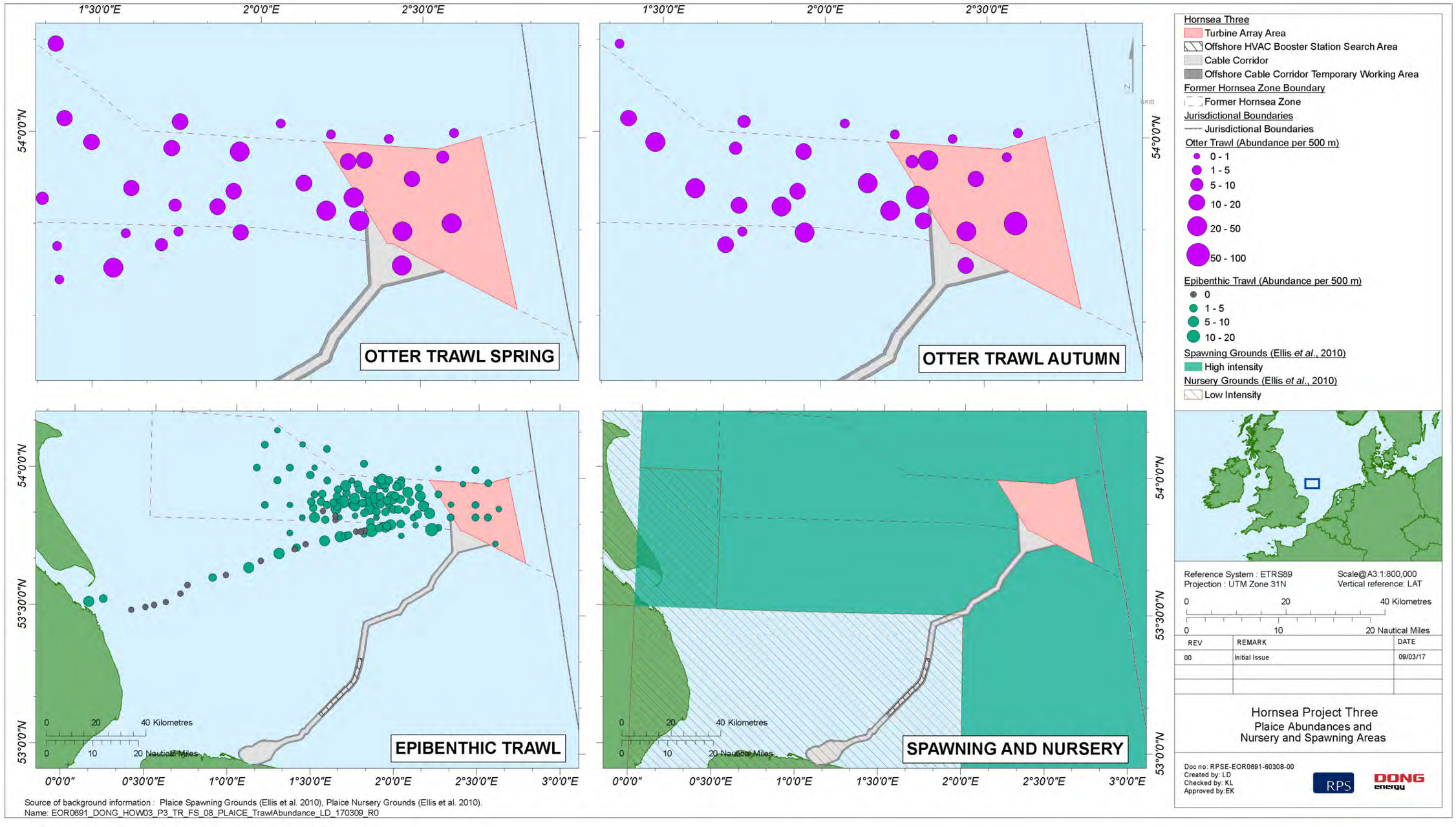
3.2.4.13 Solenette was the main characterising species recorded during epibenthic beam trawl sampling (paragraph 3.2.1.5) and Figure 3.13 shows that this species was recorded, often at high abundances, across the Hornsea Three fish and shellfish study area, particularly in the offshore areas of the former Hornsea Zone.This species was absent in inshore areas. This species was also recorded in otter trawls though at considerably lower abundances due to the small size of this species (otter trawl mesh size at cod end = 40 mm, with most solenette measuing less than 100 mm length; see paragraph 3.2.5.7). No information on spawning or nursery habitats is available for this species in this part of the southern North Sea.

Grey gurnard

3.2.4.14 Grey gurnard was one of the key characterising species in the fish assemblage recorded in otter trawls (see paragraph 3.2.2.1). Figure 3.14 shows that this species was ubiquitous across the Hornsea Three fish and shellfish study area, being recorded in all but one otter trawl sample (in autumn to the northeast of the Hornsea Three array area), with highest abundances generally recorded in the west and northwest of the Hornsea Three fish and shellfish study area. Abundances of grey gurnard were much lower in the epibenthic beam trawls. Grey gurnard distribution and abundances in the North Sea have been reported to vary considerably throughout the year, with winter populations occurring in the central North Sea at depths of 50-100 m. Distributions then change substantially in spring, with dense populations in the southern North Sea (i.e. south of 56°N) and the previously high abundances in the central North Sea disappearing until the following winter (ICES, 2005d). No information on spawning or nursery habitats is available for this species in this part of the southern North Sea.

Mackerel

3.2.4.15 Mackerel was recorded throughout the Hornsea Three fish and shellfish study area during the autumn otter trawl survey, with only very low abundances recorded during spring (Figure 3.15). As with sprat and herring, this is a pelagic species and as a result this species was not recorded in epibenthic beam trawls. 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, 2005g). Mackerel spawning habitat coincides with the Hornsea Three array area and the offshore section of the cable corridor (Figure 3.15), and low intensity mackerel nursery habitats occur across the Hornsea Three fish and shellfish study area, including the Hornsea Three offshore cable corridor. The seasonal variation in abundances is not thought to be directly related to spawning behaviour (the spawning period for this species is March to July; see section 3.2.5.15; Coull *et al.*, 1998).



Source of background information : Plaice Spawning Grounds (Ellis et al. 2010), Plaice Nursery Grounds (Ellis et al. 2010).
Name: EOR0691_DONG_HOW03_P3_TR_FS_08_PLAICE_TrawlAbundance_LD_170309_R0

Figure 3.11: Plaice abundances and spawning and nursery habitats within the Hornsea Three fish and shellfish study area.

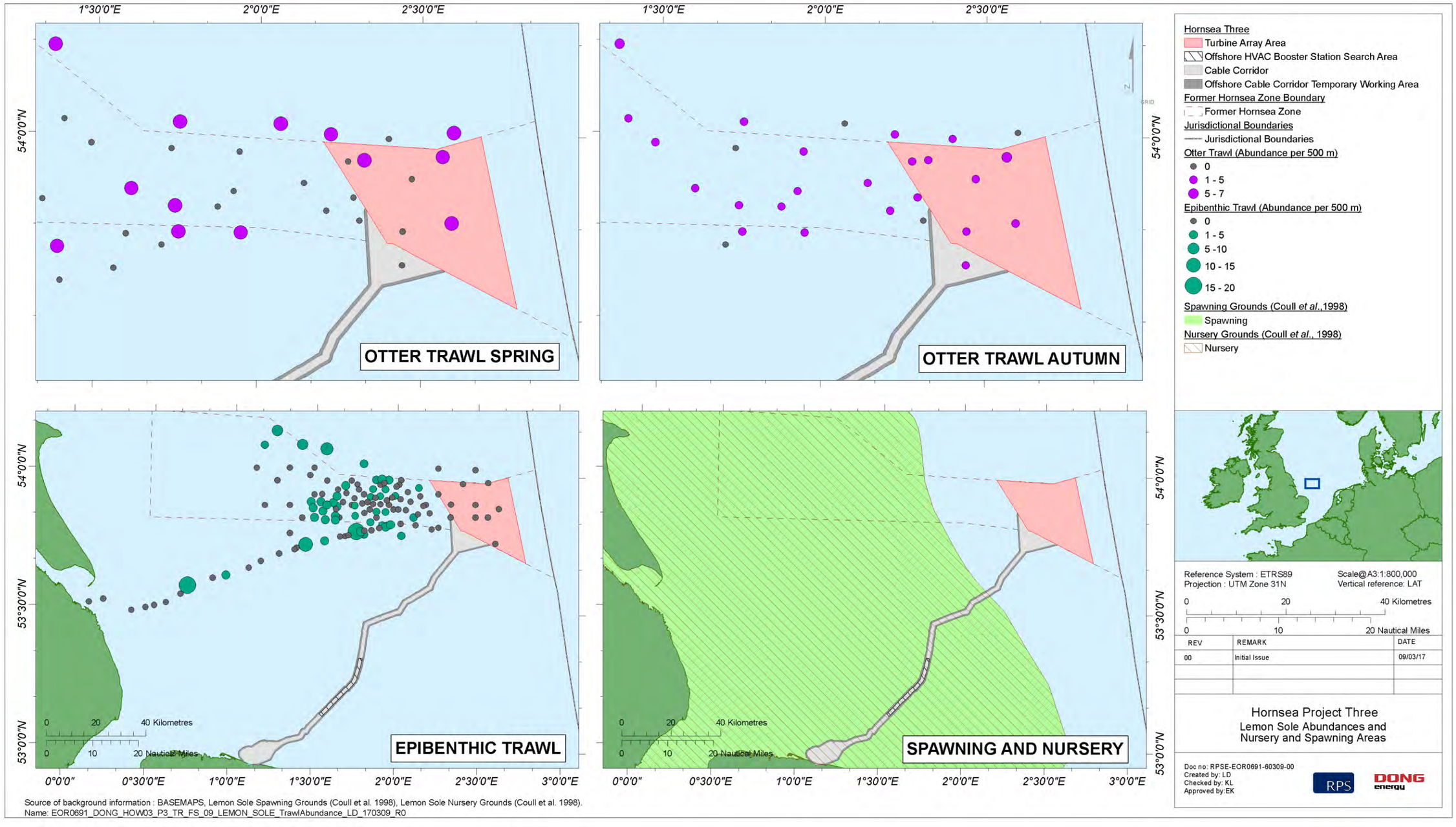


Figure 3.12: Lemon sole abundances and spawning and nursery habitats within the Hornsea Three fish and shellfish study area.

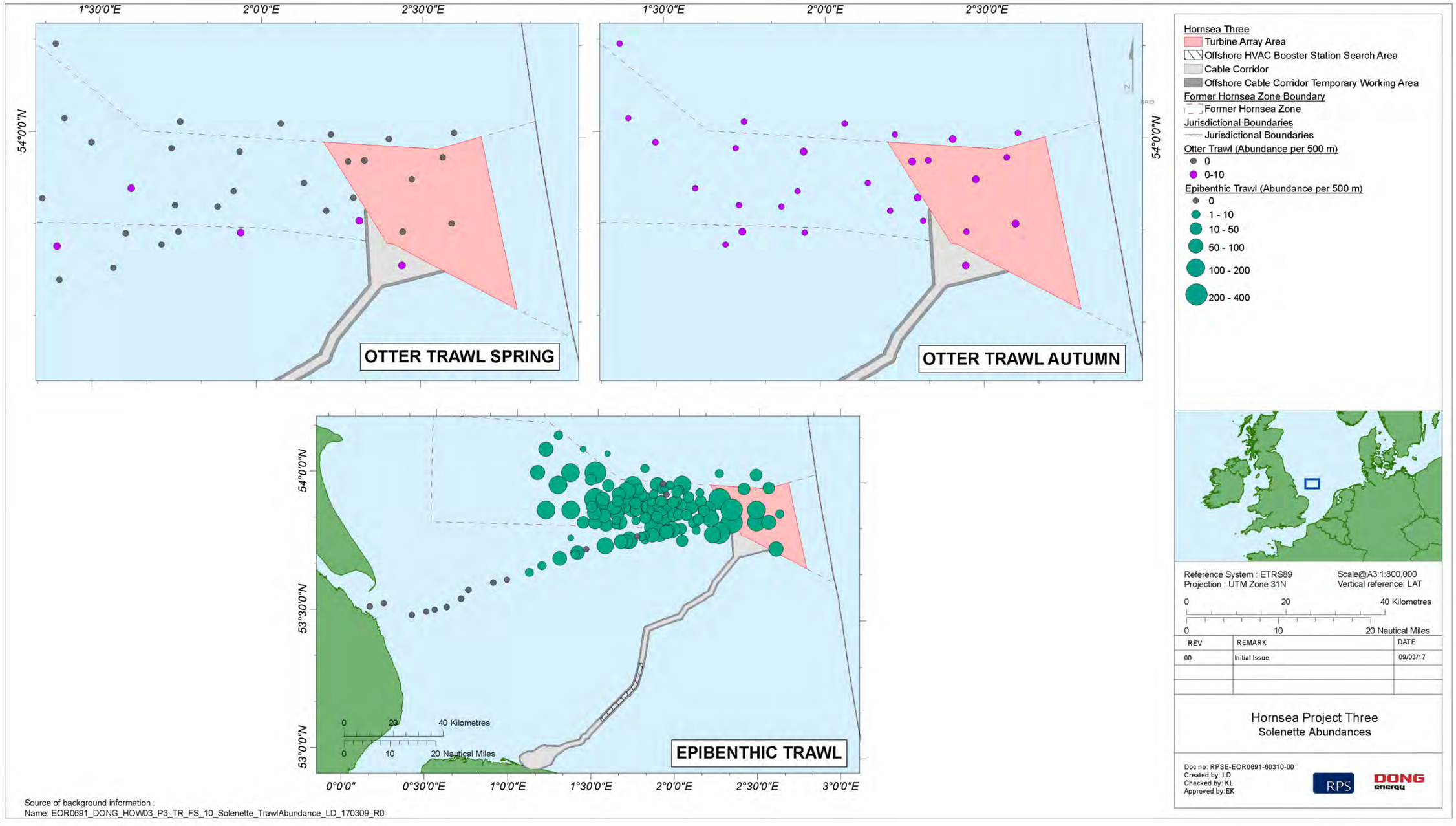


Figure 3.13: Solenette abundances within the Hornsea Three fish and shellfish study area.

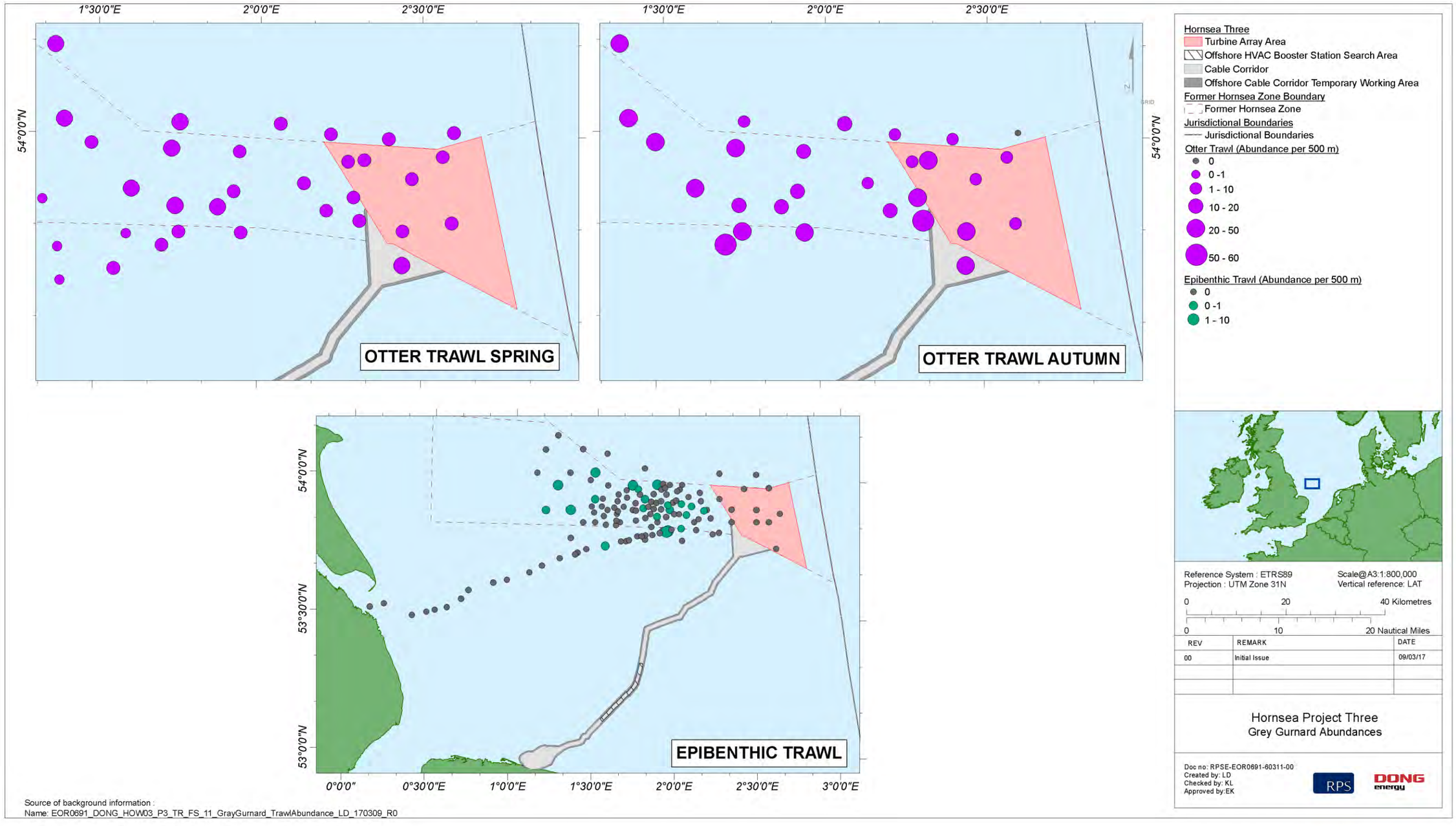


Figure 3.14: Grey gurnard abundances within the Hornsea Three fish and shellfish study area.

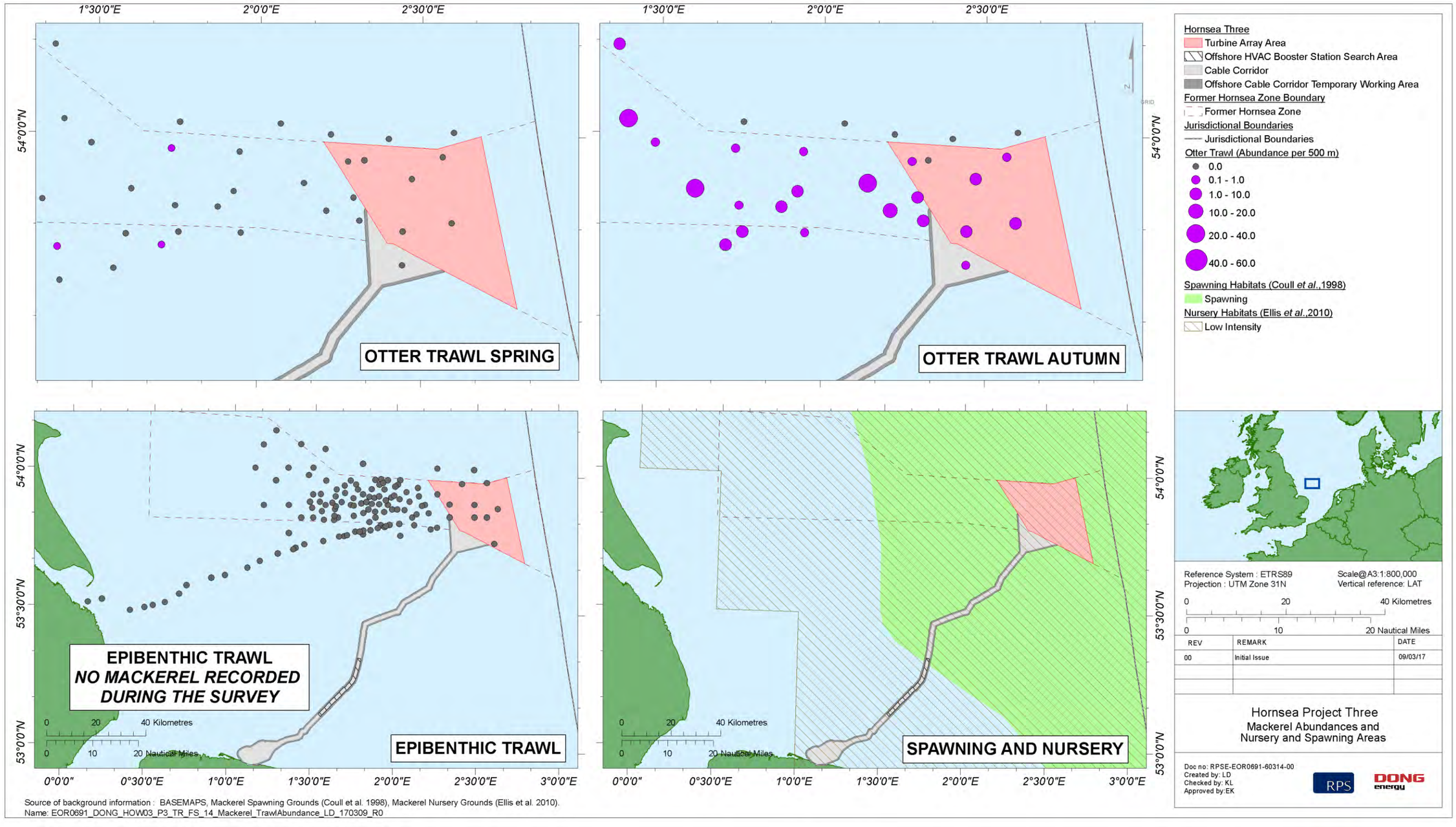


Figure 3.15: Mackerel abundances and spawning and nursery habitats within the Hornsea Three fish and shellfish study area.

Sprat

3.2.4.16 As discussed in paragraph 3.2.2.1, sprat (a clupeid species) was one of the main characterising species in otter trawls. Figure 3.16 shows that there was a strong seasonal difference in abundances of this species, with notably higher abundances in spring than autumn. Sprat was only recorded at low abundances in epibenthic beam trawls, though as a pelagic species sampled with a demersal/benthic trawl this result was to be expected. Data from the IBTS show that sprat largely occur within the 50 m depth contour throughout the southern North Sea (including the former Hornsea Zone), with secondary concentrations in the Firth of Forth and Moray Firth (ICES, 2005e). IBTS data also show that the highest concentrations generally occur to the east and northeast of the former Hornsea Zone, within Dutch and German territorial waters (ICES, 2005e; ICES, 2017).

3.2.4.17 Spawning and nursery habitats coincide with the Hornsea Three fish and shellfish study area, with nursery habitats extending inshore to the west, although these areas do not coincide with much of the Hornsea Three offshore cable corridor (Figure 3.16). The high abundances recorded during the spring (April) otter trawl survey may coincide with the start of the peak spawning period for this species (May to June; see section 3.2.5.15; Coull *et al*., 1998).

Herring

3.2.4.18 Herring, another clupeid (and pelagic) species, was recorded primarily during otter trawl surveys, though small numbers of this species were also recorded in epibenthic beam trawls (Figure 3.17). As with sprat, there was a strong seasonal pattern in the data for this species, with high abundances recorded within the Hornsea Three fish and shellfish study area during spring and lower abundances in autumn. During the spring survey, particularly high abundances were recorded immediately to the south of the central section of the former Hornsea Zone and in the inshore areas at the mouth of the Humber Estuary. The IBTS data show that herring occur throughout the North Sea, though 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, 2005f).

3.2.4.19 The Hornsea Three array area coincides with low intensity nursery habitat for herring, with some discrete spawning habitats also shown in Figure 3.17. These are discussed in more detail in paragraph 3.2.6.11 *et seq*.

Elasmobranchs

3.2.4.20 Thornback rayand spotted ray were recorded at low abundances during both otter and epibenthic beam trawl surveys, with only sporadic records of these species throughout the Hornsea Three fish and shellfish study area (Figure 3.18 and Figure 3.19, respectively). Spawning habitats for both of these species have not been mapped in the vicinity of the Hornsea Three fish and shellfish study area, though the Wash and north Norfolk coast may be used for mating/spawning (see paragraph 3.2.6.8) and a low intensity nursery habitat for thornback ray has been mapped in the inshore section of the Hornsea Three offshore cable corridor (i.e. from the Wash along the north Norfolk coast (Figure 3.18)). Four other elasmobranch species were recorded during trawl surveys, cuckoo ray *Raja naevus*, starry smooth hound, lesser spotted dogfish and spurdog *Squalus acanthias*, all of which were recorded at low abundances throughout the Hornsea Three fish and shellfish study area.

3.2.4.21 A number of ray species have also been recorded off the north Norfolk coast (i.e. in the nearshore sections of the Hornsea Three offshore cable corridor), with thornback and spotted ray recorded during surveys around Dudgeon offshore wind farm (Dudgeon Offshore Wind Limited, 2009) and at Sheringham Shoal offshore wind farm, although generally at low abundances (Scira Offshore Energy, 2006). Thornback ray, spotted ray and blonde ray were also recorded and tagged in proximity to the nearshore section of the Hornsea Three offshore cable corridor (i.e. offshore of Wells-next-the-Sea) in a recent tagging study by Cefas (McCully *et al*., 2013). The catches were dominated by thornback ray, with proportionally more large females recorded here than other nearshore areas surveyed (e.g. off of Southwold and Lowestoft). A number of the mature females recorded had egg cases (purses) extruding from the cloaca indicating spawning habitat for this species in the area (see paragraph 3.2.6.8 for further discussion).

3.2.4.22 The smooth hound and tope shark *Galeorhinus galeus* have also been recorded in the southern North Sea fish and shellfish study area (ERM, 2012), with spawning for both these species, lesser spotted dogfish, starry smooth hound, spurdog and spotted ray reported to occur within the southern North Sea fish and shellfish study area (see paragraph 3.2.6.8; ERM, 2012). Starry smooth hound were also recorded and tagged in proximity to the nearshore section of the Hornsea Three offshore cable corridor (i.e. offshore of Wells-next-the-Sea) in a recent tagging study by Cefas, although these individuals had not been recaptured at the time of reporting (McCully *et al*., 2013). Three further species of small shark, (i.e. starry smooth hound, smooth hound and lesser spotted dogfish), were also recorded at low abundances at the Dudgeon and Sheringham Shoal offshore wind farms (i.e. in the vicinity of the nearshore sections of the Hornsea Three offshore cable corridor; see section 3.1.2). Although elasmobranchs have historically been recorded within the southern North Sea fish and shellfish study area, abundances during trawl surveys are typically low (ERM, 2012), reflecting the patterns observed in the historic survey data from across the former Hornsea Zone.

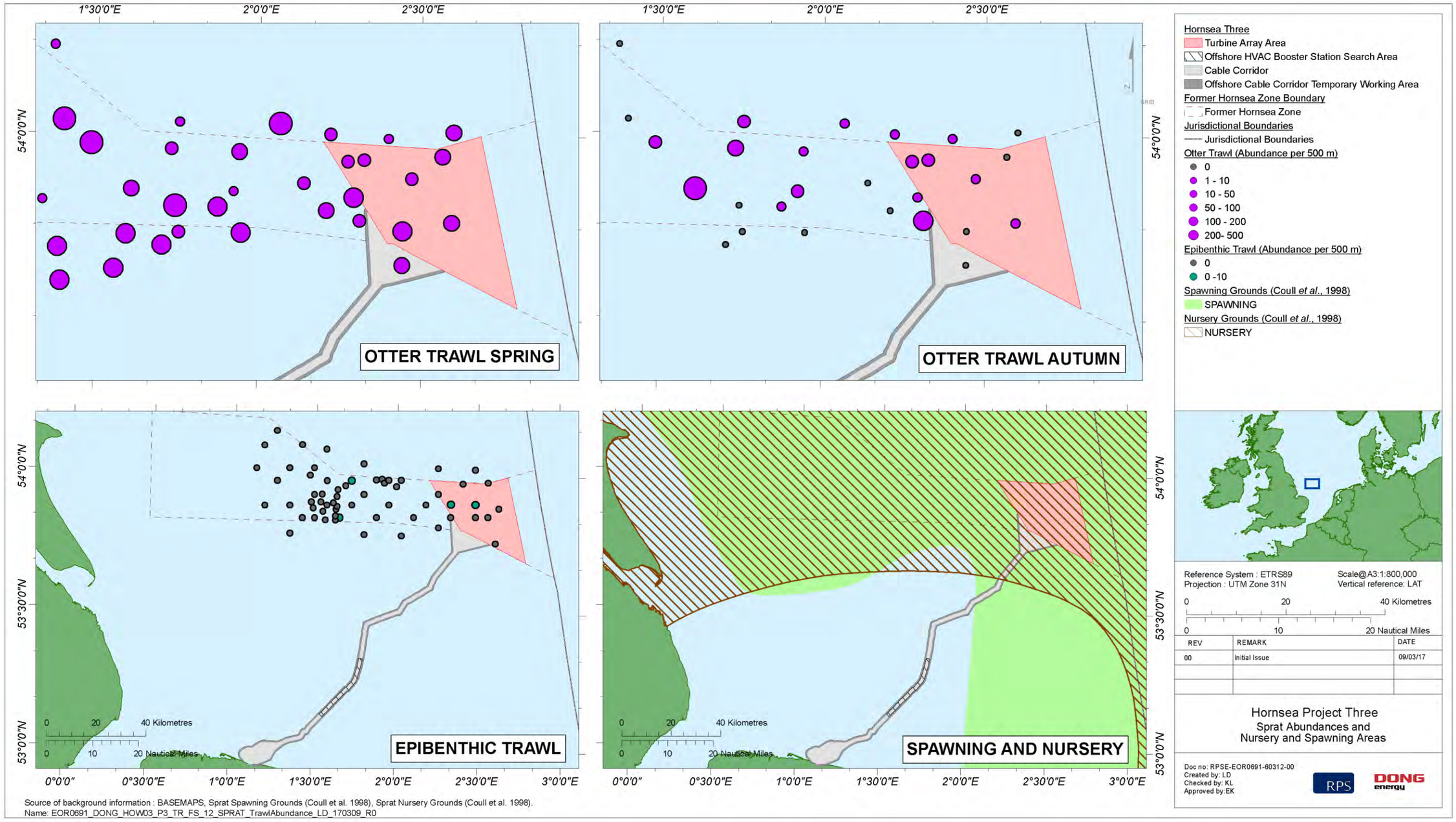


Figure 3.16: Sprat abundances and spawning and nursery habitats within the Hornsea Three fish and shellfish study area.

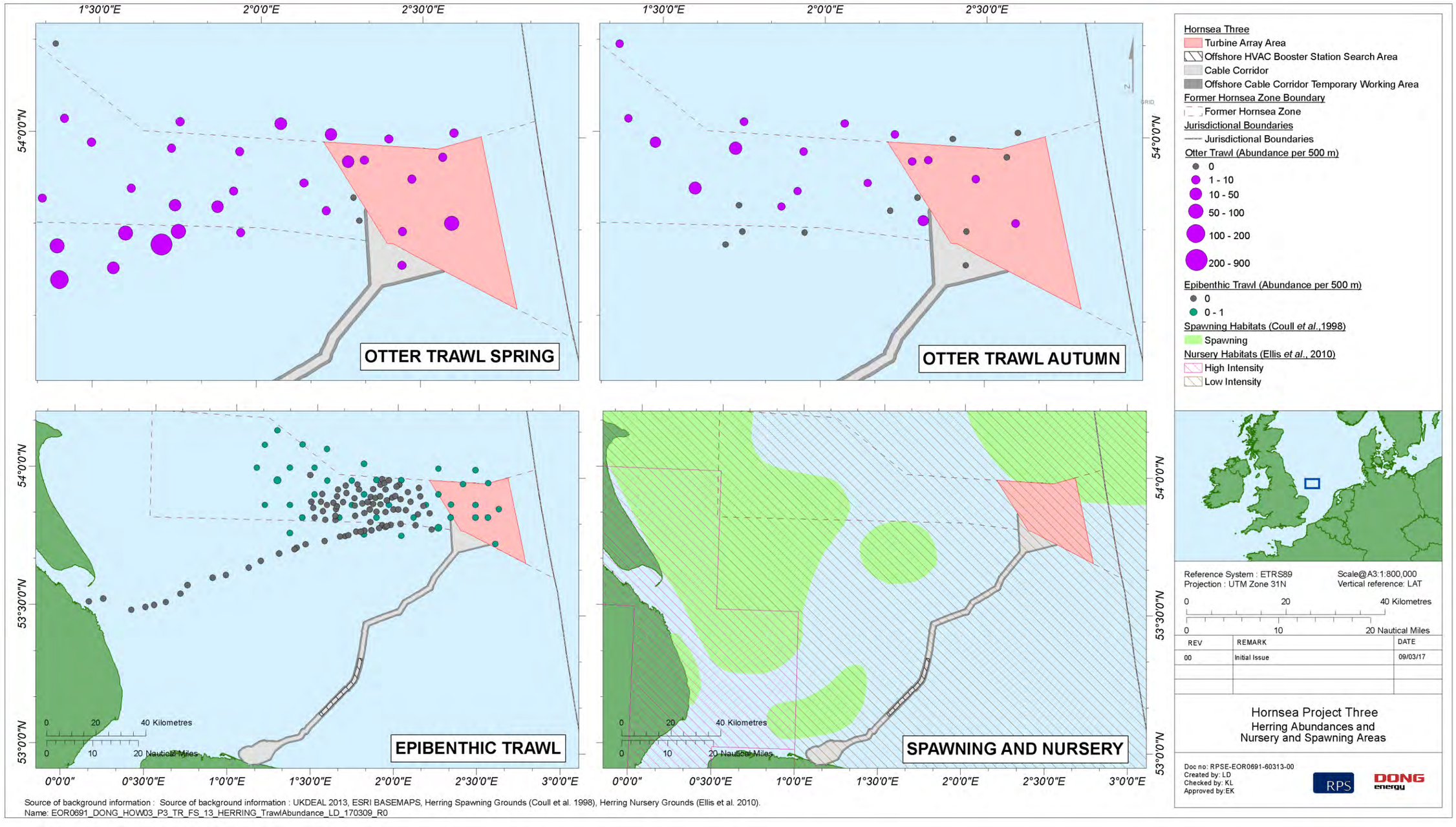


Figure 3.17: Herring abundances and spawning and nursery habitats within the Hornsea Three fish and shellfish study area.

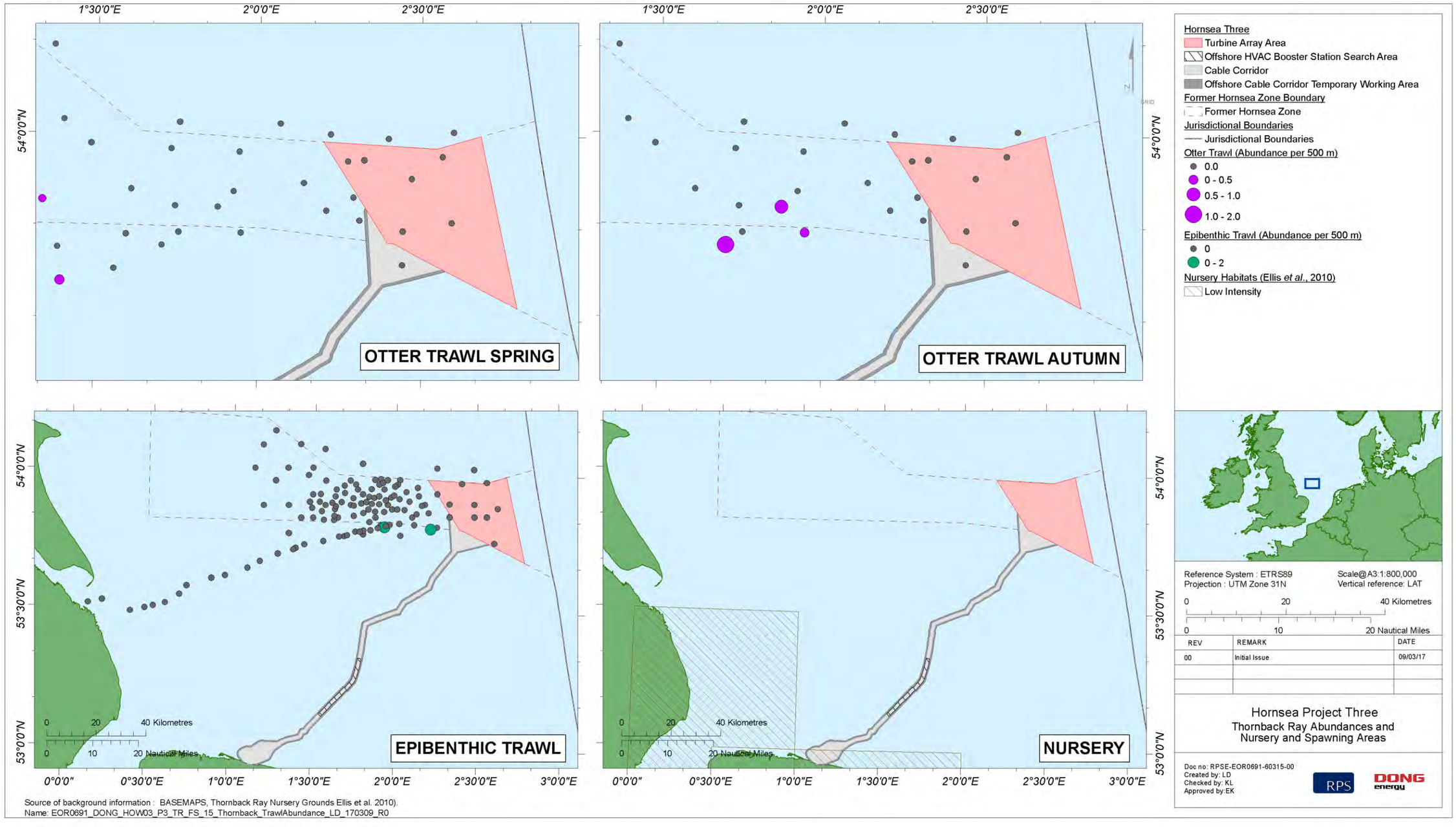


Figure 3.18: Thornback ray abundances and nursery habitats within the Hornsea Three fish and shellfish study area.

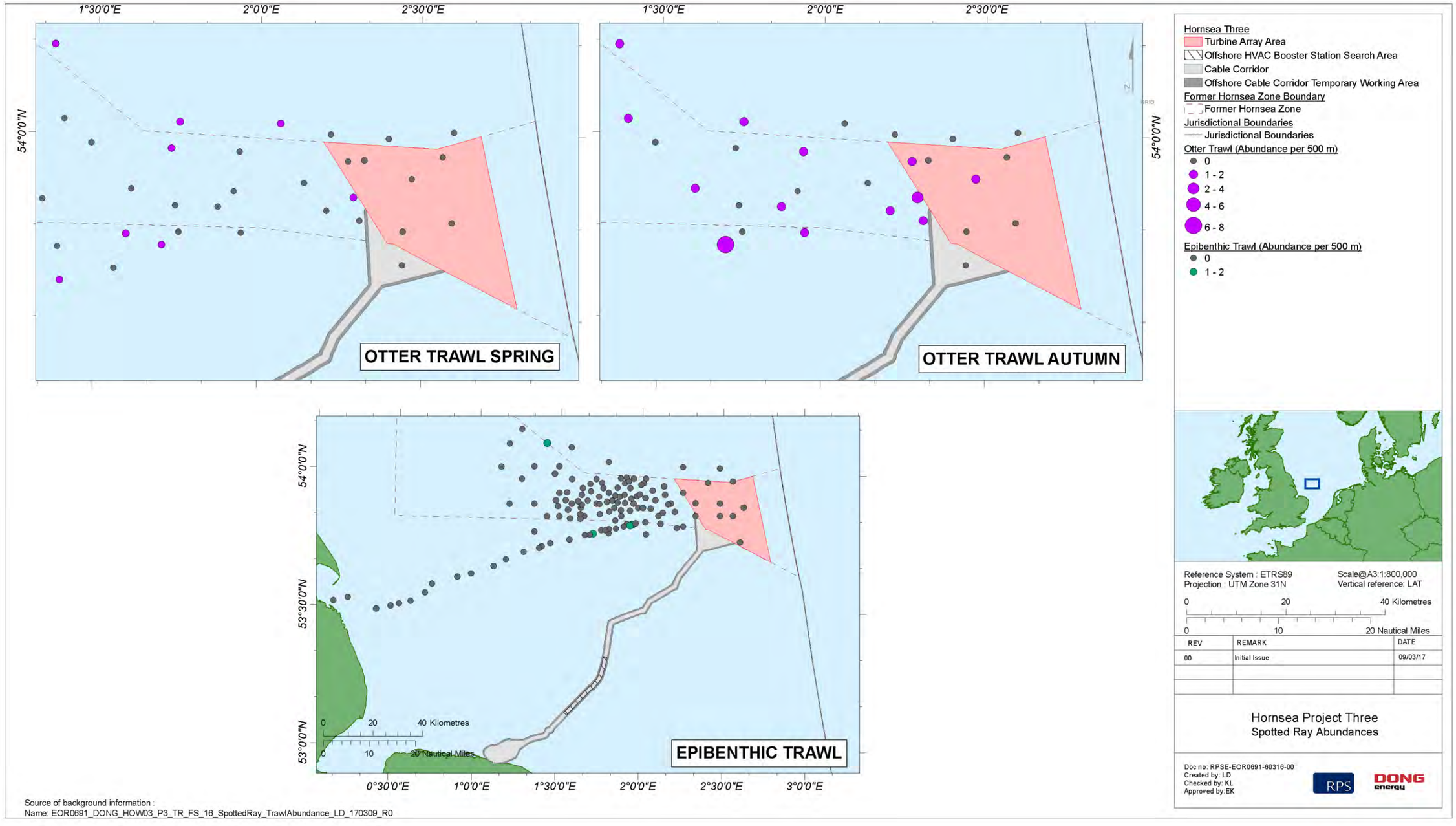


Figure 3.19: Spotted ray abundances within the Hornsea Three fish and shellfish study area.

3.2.4.23 In addition, a single basking shark *Cetorhinus maximus* was recorded during historic boat based marine mammal surveys undertaken across the former Honrsea Zone (annex 4.1: Marine Mammal Technical Report). Although basking shark are recorded in the North Sea, these records are typically sporadic indicating a low occurrence in the North Sea, with this species more commonly recorded off the west coasts of Britain and Ireland (Southall *et al*., 2005).

Sandeel

3.2.4.24 Lesser sandeel *Ammodytes tobianus* abundances were generally higher in epibenthic beam trawl sampling than in otter trawls. This is likely to be due to the narrow body shape and small size of these species (adults typically less than 20 cm in length; Rowley, 2008) and the relatively large mesh size (40 mm cod end) used during otter trawling (Figure 3.20). Sandeels (both lesser and greater) were generally recorded at highest abundances along the west and southwestern boundary of the Hornsea Three array area and also in the central part of the former Hornsea Zone (see Figure 3.20 and Figure 3.21). These coincide with the sandy areas of the Hornsea Three fish and shellfish study area (annex 2.1: Benthic Ecology Technical Report).

3.2.4.25 Sandeel habitats in the North Sea were mapped by Jensen *et al.* (2010) using data collected from fishing vessels targeting sandeels (i.e. global positioning system data from individual ships, vessel monitoring data and maps provided by fishers) and these are presented in Figure 3.22. Due to the nature of the data used to map these areas (i.e. fishing data), the habitats mapped do not represent all the sandeel habitats in the North Sea, with sandeel habitats also likely to occur in other areas not shown in this figure (e.g. shallow or inshore waters and other areas which cannot be trawled). The habitats mapped in Figure 3.22 largely reflect the patterns observed in the Hornsea Three data, with sandeel habitats coinciding with the central part of the former Hornsea Zone, to the west of the Hornsea Three array area. Sandeel habitats are also known to occur along the Hornsea Three offshore cable corridor, particularly within the sandy sediments of the North Norfolk Sandbanks. Other sandeel habitats also occur throughout the wider southern North Sea fish and shellfish study area, including the mapped sandeel habitats to the north and northwest of the former Hornsea Zone and Dogger Bank further north.

3.2.4.26 PSA data from across the former Hornsea Zone and site specific Hornsea Three PSA data (presented in detail in annex 2.1: Benthic Ecology Technical Report) and broadscale SeaZone HydroSpatial sediment data were processed according to the methodologies described in Latto *et al*. (2013) in order to identify the preferred, marginal and unsuitable sandeel habitats in the Hornsea Three and wider southern North Sea fish and shellfish study areas. PSA data from across the former Hornsea Zone and site specific Hornsea Three PSA data were categorised according to the proportions of sand and mud at each grab sample location to determine the sandeel habitat classifications (see Table 3.3). Similarly, SeaZone HydroSpatial sediment data were categorised according to the following categories, based on the Folk classification (Folk, 1954) of sediment conditions and using categories specified by Latto *et al*. (2013) (all other sediment types are considered to be unsuitable for sandeel):

- Sandeel preferred habitat: Sand, slightly gravelly sand and gravelly sand; and
- Sandeel marginal habitat: Sandy gravel.

Table 3.3: Sandeel habitat sediment classifications.

% contribution (mud = <63 µm)	Habitat sediment preference (Latto *et al*., 2013)	Habitat sediment classification ((Latto *et al*., 2013))
<1% mud, >85% sand	Prime	Preferred
<4% mud, >70% sand	Sub-prime	Preferred
<10% mud, >50% sand	Suitable	Marginal
>10% mud, <50% sand	Unsuitable	Unsuitable

3.2.4.27 The results of these analyses are presented in Figure 3.23 and these habitat sediment preferences/classifications when mapped broadly correspond to the patterns discussed above in paragraphs 3.2.4.24 and 3.2.4.25. While the majority of the Hornsea fish and shellfish study area is categorised as sandeel preferred habitat (i.e. prime or sub-prime sediments), the highest quality habitat (i.e. prime sediments) is largely concentrated within the central section of the former Hornsea Zone (to the west of the Hornsea Three array area). This is reflected in the sandeel abundances recorded during historic survey data from across the former Hornsea Zone (Figure 3.20 and Figure 3.21) and the sandeel habitats mapped by Jensen *et al*. (2010; Figure 3.22). The sediments within the Hornsea Three array area were variable with some areas of prime or sub-prime (i.e. particularly in the west of the array area), but with significant areas of unsuitable sediment, particularly in the deeper water areas in the north and southwest of the Hornsea Three array area, which were characterised by muddy sediment, and the coarse, gravelly areas in the northeast of the array area (i.e. within Markham's Triangle).

3.2.4.28 As discussed in paragraph 3.2.4.25, the offshore sections of the Hornsea Three cable corridor were characterised by sediments which were favourable to sandeels (i.e. particularly in the vicinity of the North Norfolk Sandbanks), but the inshore areas were considered to be marginal, according to the Seazone HydroSpatial sediment data, due to the prevalence of coarser, gravelly sediments. Whilst Figure 3.23 gives an indication of which sediments are most suitable as sandeel habitats, it does not necessarily mean that sandeels will be resident within these areas. This drawing should therefore not be considered in isolation, but interpreted in the context of the other datasets discussed here.

3.2.4.29 Sandeel abundances recorded within the former Hornsea Zone were lower than those recorded to the north, such as around Dogger Bank, although it should be noted that the Dogger Bank fish and shellfish characterisation surveys were specifically designed to target sandeels through use of a sandeel dredge. However, commercial fisheries data support this finding, a greater effort by Danish sandeel vessels focussing on Dogger Bank (see annex 6.1: Commercial Fisheries Technical Report).

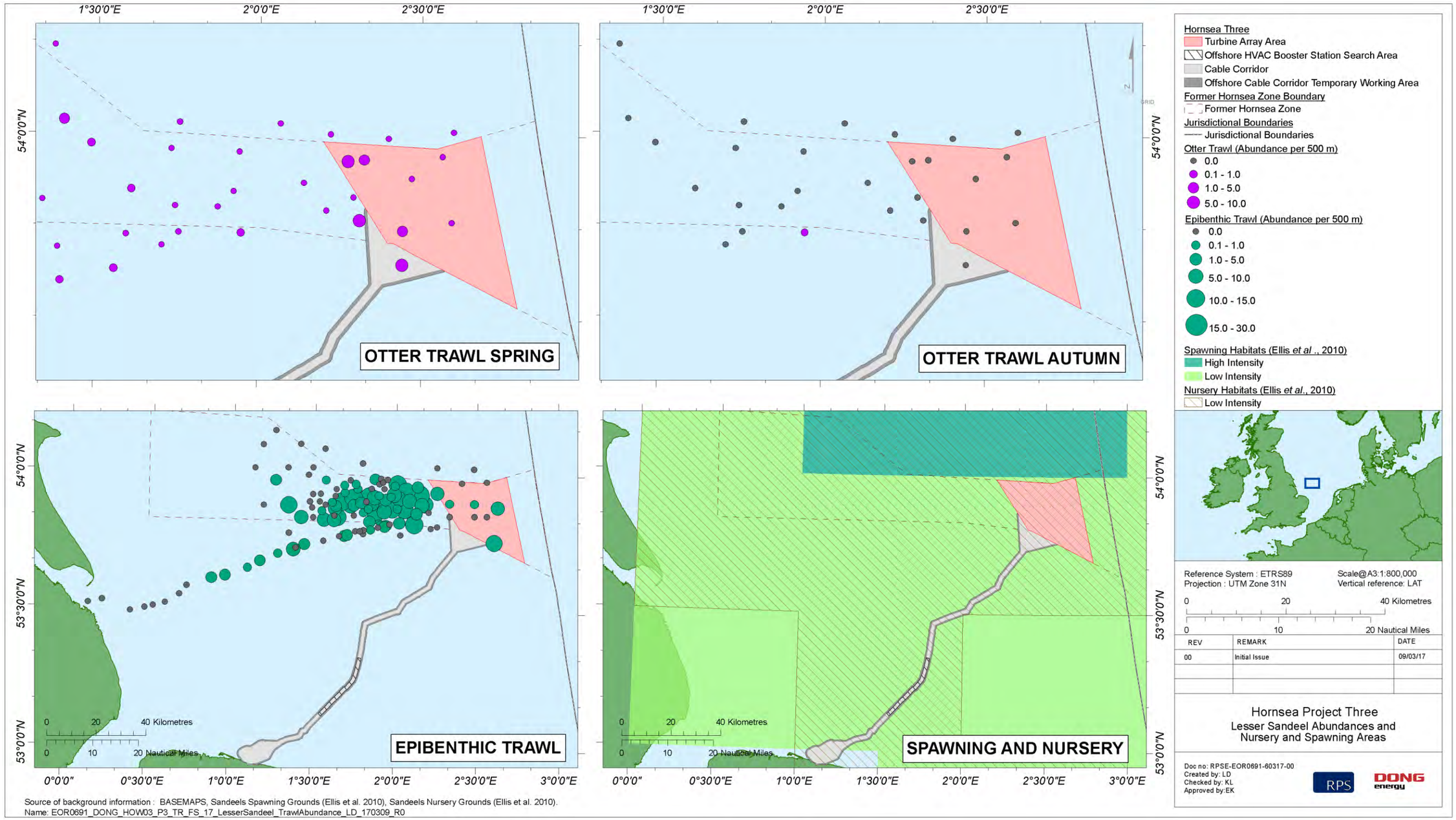


Figure 3.20: Lesser sandeel abundances and spawning and nursery habitats within the Hornsea fish and shellfish study area.

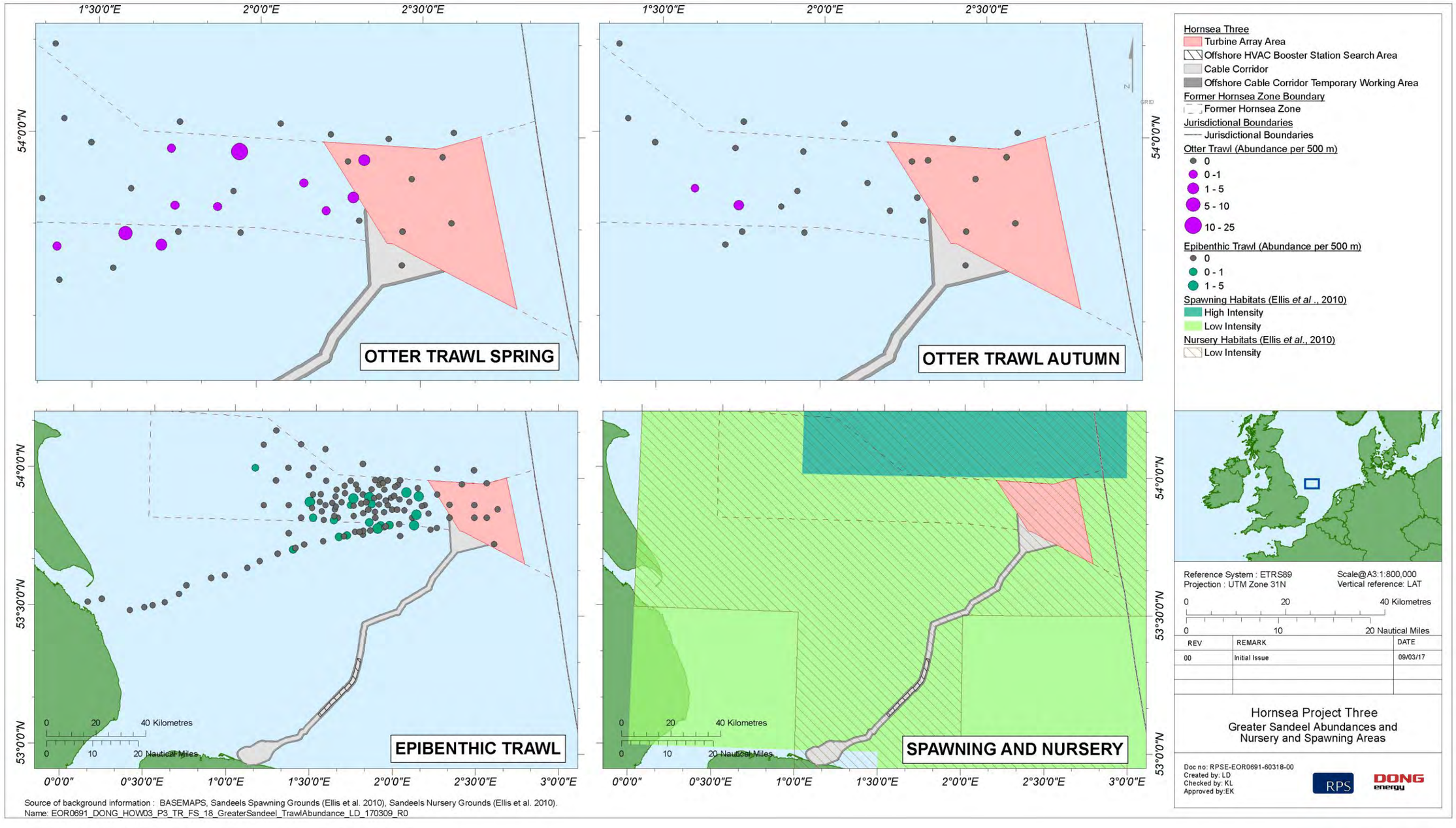


Figure 3.21: Greater sandeel abundances and spawning and nursery habitats within the Hornsea Three fish and shellfish study area.

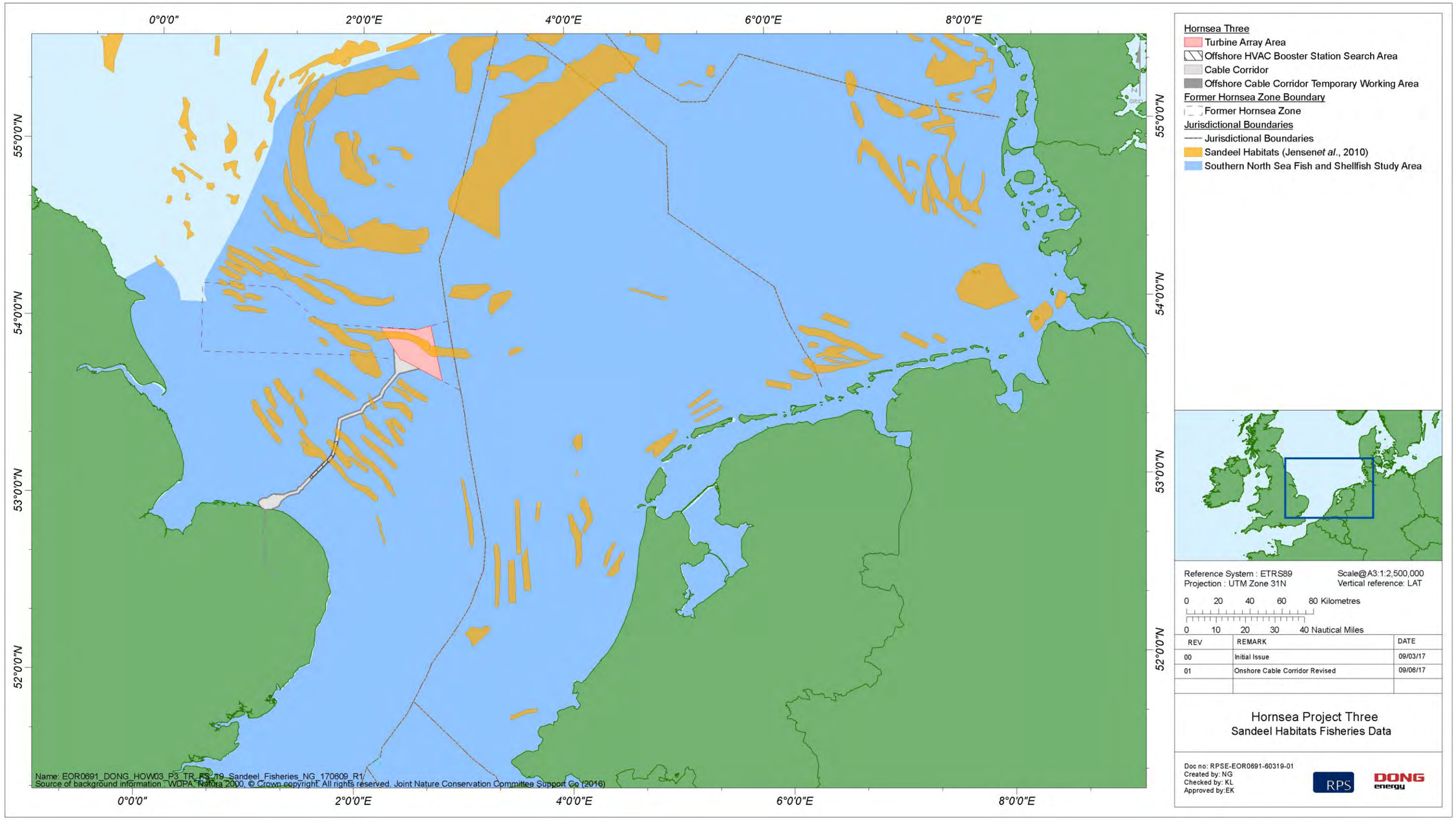


Figure 3.22: Sandeel habitats in the southern North Sea fish and shellfish study area (as mapped by Jensen *et al.*, 2010, using commercial fisheries data).

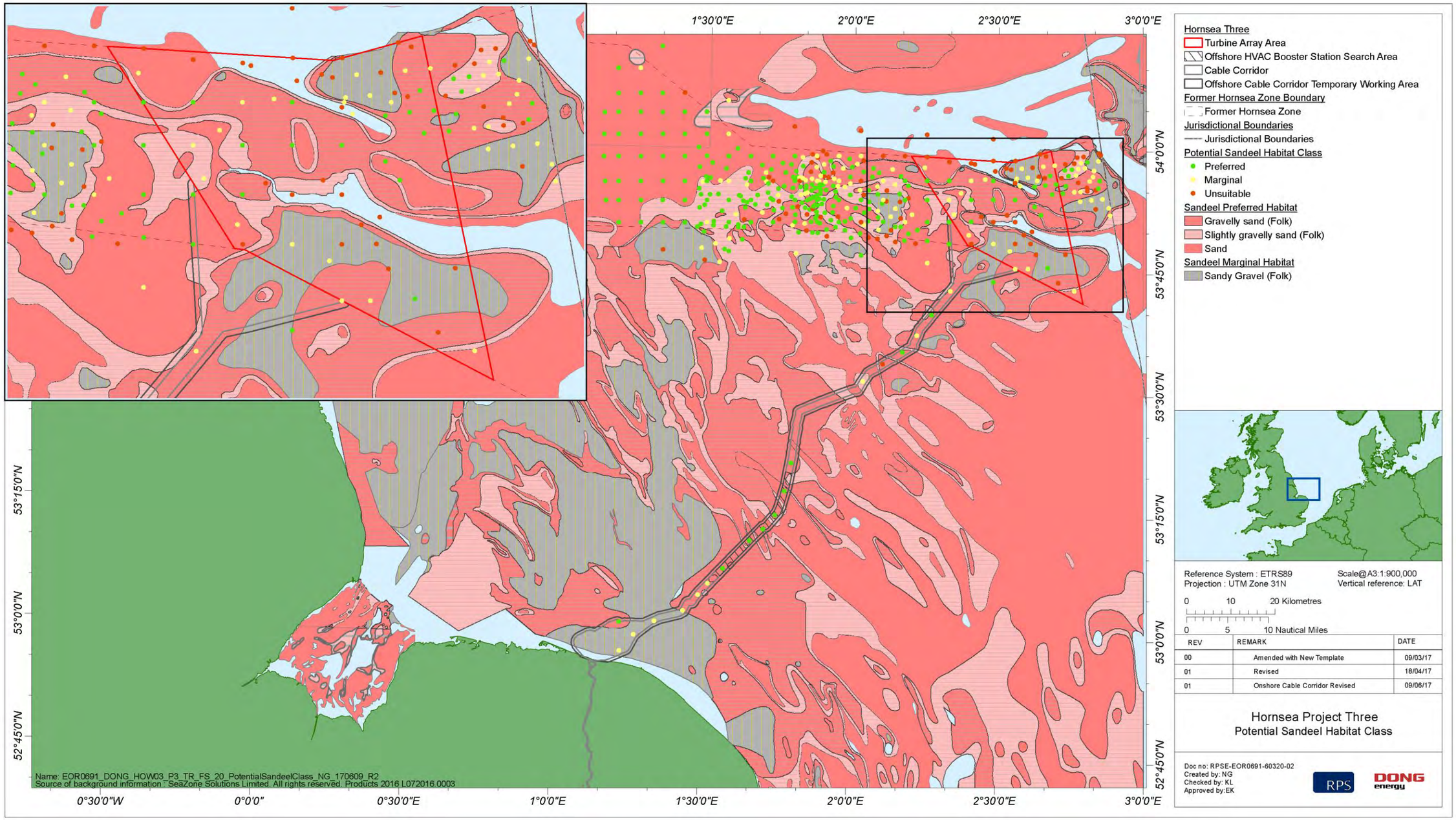


Figure 3.23: Potential sandeel habitat sediment classifications within the Hornsea Three and southern North Sea fish and shellfish study areas following methods in Latto *et al.* (2013). All other sediment types not plotted here (i.e. appear as pale blue) were considered to be unsuitable habitat for sandeels. Note: These data should not be considered in isolation but interpreted in the context of other datasets presented (see paragraphs 3.2.4.24 *et seq.*).

3.2.4.30 Low intensity spawning and nursery habitats coincide with the Hornsea Three fish and shellfish study area, including the Hornsea Three offshore cable corridor, with high intensity spawning habitats to the north of the Hornsea Three array area, which broadly reflects the patterns of sandeel abundance throughout the Hornsea Three fish and shellfish study area.

3.2.5 Size structure of population

3.2.5.1 The main characterising fish species identified from multivariate analysis, species of commercial importance in the area and species which have nursing or spawning habitats in the area were selected for further investigation of the length of individuals recorded during trawl surveys. Fish lengths were combined for all trawl survey events (i.e. otter trawl sampling during spring and autumn and epibenthic beam trawl sampling in the Hornsea Three fish and shellfish study area) and the data used to produce size frequency distribution graphs of fish lengths within the Hornsea Three fish and shellfish study area, giving an indication of the size structure of the populations recorded.

Whiting

3.2.5.2 Whiting was the most abundantly recorded species during otter trawl surveys and this species was recorded at high abundances throughout the Hornsea Three fish and shellfish study area. Figure 3.24 shows the length distribution for whiting with a minimum of 2 cm and a maximum of 41 cm and peaks between 14 and 16 cm and between 18 and 22 cm. Juvenile whiting range from 2 to 19 cm (Ellis *et al*., 2010) and the data therefore indicate that the population was dominated by adults (i.e. fish measuring at least 20 cm) albeit with a significant proportion of juveniles in the population. Given that the former Hornsea Zone coincides with a high intensity nursery habitat for this species (see section 3.2.5.15), the presence of juveniles in the trawl samples was to be expected.

Cod

3.2.5.3 Cod is a commercially important species in the southern North Sea, although not necessarily within Hornsea Three. This species was not one of the main characterising fish species identified during trawl surveys, due to the generally low abundances recorded in the Hornsea Three fish and shellfish study area. The size range of this species was wide with a minimum of 3 cm and a maximum of 72 cm recorded, with most of the fish recorded measuring between 25 and 50 cm; Figure 3.24). Juvenile cod are considered to be those with lengths of less than 22 cm (Ellis *et al*., 2010) and therefore the population recorded during trawl surveys is an adult population with few juveniles. This is consistent with the Hornsea Three fish and shellfish study area being a low intensity spawning and nursery area (see section 3.2.5.15 and Figure 3.9).

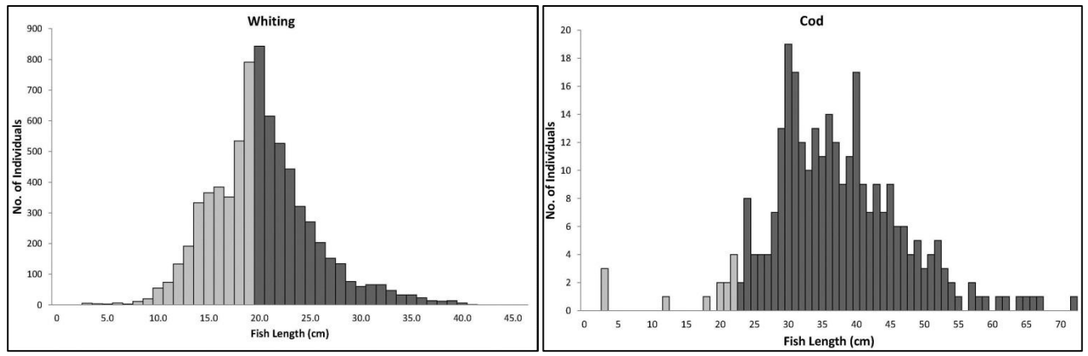


Figure 3.24: Fish length analysis for whiting (left) and cod (right) from otter and epibenthic beam trawl sampling within the Hornsea Three fish and shellfish study area (juvenile size classes in light grey).

Dab

3.2.5.4 Dab was one of the key characterising species of the fish assemblage, being the most frequently recorded species during otter and beam trawl sampling and one of the most abundant species recorded. Lengths for this species ranged between a minimum of 2 cm and a maximum of 40 cm, with most individuals ranging between 10 and 23 cm in length (Figure 3.25). Length at maturity ranges between 13 and 25 cm, with dab likely to reach a maximum size of 40 cm (www.fishbase.org). The dab population recorded during historic surveys across the former Hornsea Zone is therefore likely to be a mixture of juvenile and adult fish. As discussed in paragraph 3.2.4.8, there is currently no data on the spawning and nursery grounds of dab in the North Sea.

Plaice

3.2.5.5 Plaice was the second most frequently recorded species in both otter and beam trawls, though this species was recorded at lower abundances than dab. The length data for this species showed a wide range of size classes with a minimum length of 1 cm and a maximum length of 54.5 cm (Figure 3.25). Juvenile plaice are considered to measure less than 12 cm (Ellis *et al*., 2010) and therefore the plaice population recorded during historic surveys across the former Hornsea Zone was composed primarily of adults as demonstrated by Figure 3.25. This is consistent with the absence of known plaice nursery habitats coinciding with the Hornsea Three array area and former Hornsea Zone (see section 3.2.5.15 and Figure 3.11).

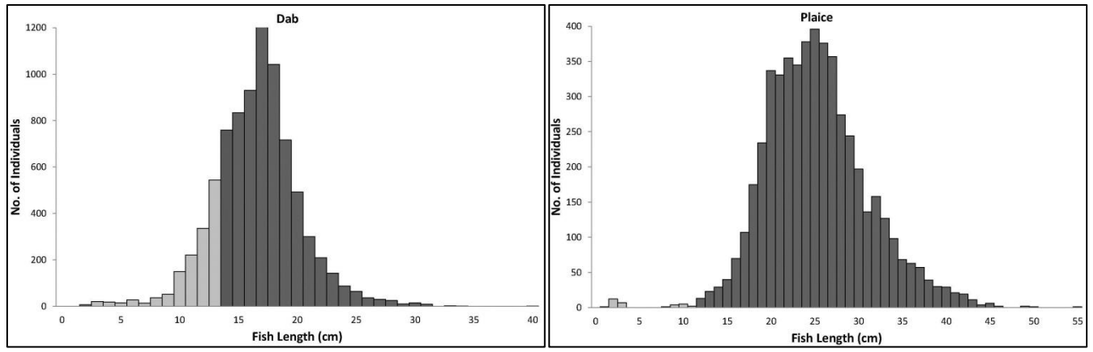


Figure 3.25: Fish length analysis for dab (left) and plaice (right) from otter and epibenthic beam trawl sampling within the Hornsea Three fish and shellfish study area (juvenile size classes in light grey).

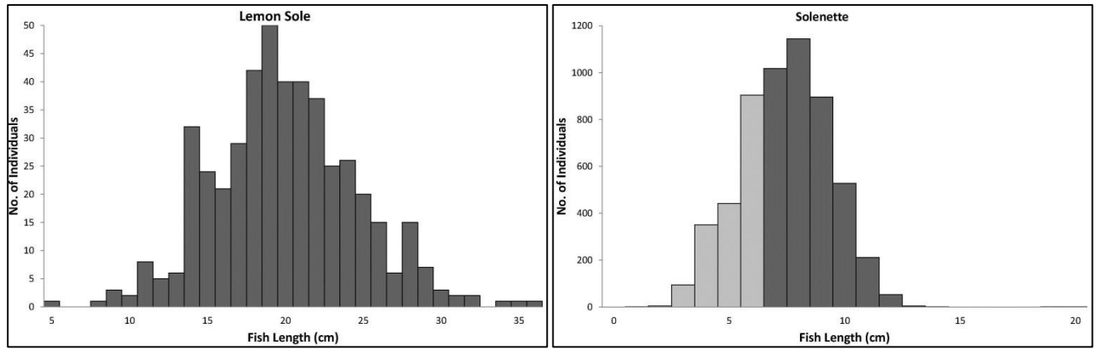


Figure 3.26: Fish length analysis for lemon sole (left) and solenette (right) from otter and epibenthic beam trawl sampling within the Hornsea Three fish and shellfish study area (juvenile size classes in light grey; unknown for lemon sole).

Lemon sole

3.2.5.6 Lemon sole was another frequently recorded flatfish species during trawl surveys and is a commercially important fish species in the region. This species was recorded at considerably lower abundances than plaice and ranged in size from between 5 and 35.5 cm, with most fish recorded measuring between 14 and 24 cm in length (Figure 3.26). There is limited data on the size of juveniles for this species, though lemon sole typically reach maturity at 20 to 30 cm in length (Barnes, 2008) and therefore the length ranges are indicative of a mixed population of juvenile and adult fish. Spawning and nursery grounds for lemon sole occur to the west of the Hornsea Three array area and in the inshore sections of the Hornsea Three offshore cable corridor (Figure 3.12), reflecting the patterns shown here, with overall low abundances and no clear dominance of adults or juveniles in the population.

Solenette

3.2.5.7 Solenette, a species with no commercial value to fisheries in the Hornsea Three fish and shellfish study area, was the most abundant fish species recorded in epibenthic beam trawls and one of the main characterising species of the assemblage. This small flatfish species was recorded throughout the Hornsea Three fish and shellfish study area (except within inshore areas) and ranged in length from 1 to 20 cm, with a peak between 6 and 9 cm in length (Figure 3.26). This species reaches first maturity at 7 to 8 cm (www.fishbase.org) and the data therefore indicate that the population was dominated by adults, though juveniles of this species are also present in the area.

Grey gurnard

3.2.5.8 Grey gurnard, a species with no commercial importance in the Hornsea Three fish and shellfish study area, was one of the most frequently recorded species in the Hornsea Three fish and shellfish study area. It was recorded in over 50% of trawls and was particularly abundant in otter trawls. Length distributions for this species ranged between 4 and 40 cm, with most individuals measuring between 15 and 25 cm (Figure 3.27). This species reaches maturity at approximately 19 cm (www.fishbase.org) and therefore the length distributions presented in Figure 3.27 indicate that the population was dominated by adults, with only a small proportion of juveniles.

Mackerel

3.2.5.9 As a non-target pelagic fish (otter trawl surveys were undertaken using a high opening otter trawl designed to capture demersal and semi pelagic fish; see section 2.4.1), mackerel were recorded at variable abundances throughout the Hornsea Three fish and shellfish study area. Mackerel are important commercially in the area, with French trawlers targeting this species (see annex 6.1: Commercial Fisheries Technical Report). Individuals ranged in size between 16 and 38 cm, with a distinct peak at 25 to 26 cm; Figure 3.27). Juvenile mackerel are considered to measure less than 24 cm (Ellis *et al*., 2010) and although the Hornsea Three fish and shellfish study area coincides with a low intensity nursery area (Figure 3.15) the mackerel population recorded during historic surveys across the former Hornsea Zone was found to be dominated by adults. However given the limitations of the survey methods for sampling pelagic species, this conclusion should be interpreted with caution and the historic survey data from across the former Hornsea Zone have therefore been considered alongside other desktop information.

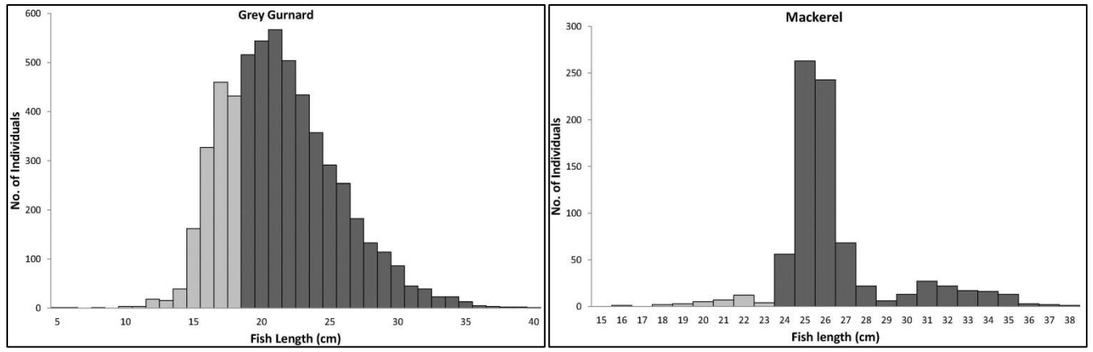


Figure 3.27: Fish length analysis for grey gurnard (left) and mackerel (right) from otter and epibenthic beam trawl sampling within the Hornsea Three fish and shellfish study area (juvenile size classes in light grey).

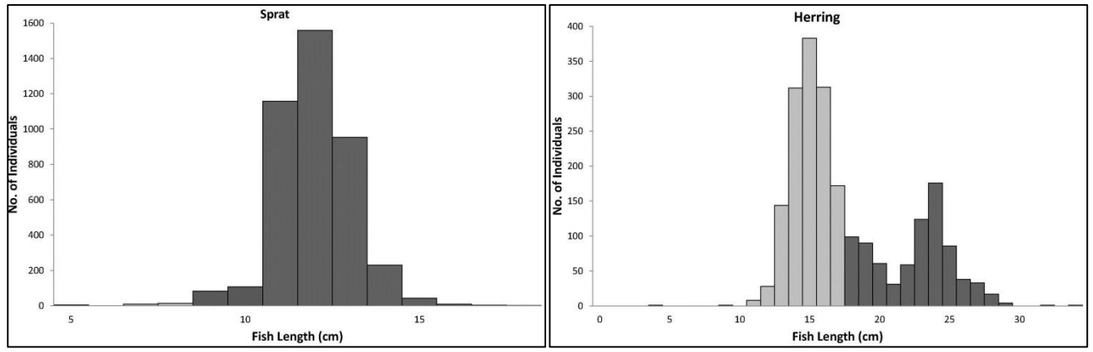


Figure 3.28: Fish length analysis for sprat (left) and herring (right) from otter and epibenthic beam trawl sampling within the Hornsea Three fish and shellfish study area (juvenile size classes in light grey).

Sprat

3.2.5.10 Sprat was also one of the key characterising species recorded during otter trawls, with particularly high abundances recorded during the spring survey. Length data for this species (Figure 3.28) showed records ranging from 5 to 18 cm with most sprat measuring between 11 and 13 cm. Length at maturity for this species ranges between 8 to 12 cm with this species reaching a maximum length of approximately 16 cm (www.fishbase.org; Wheeler, 1978). The population recorded during the surveys is therefore likely to be dominated by adults, with a smaller proportion of juveniles consistent with the Hornsea Three array area coinciding with both spawning and nursery habitat for this species (Figure 3.16).

Herring

3.2.5.11 The other clupeid species recorded during otter trawl surveys, herring, was recorded at highest abundances in spring in the inshore part of the survey area (i.e. at the mouth of the Humber Estuary; up to 867 individuals per 500 m were recorded at trawl 35 in spring). The length distribution for this species ranged between 4 and 34 cm with the largest peak between 13 and 17 cm and a smaller peak between 23 and 24 cm (Figure 3.28). Juvenile herring are considered to have lengths of less than 17.5 cm (Ellis *et al*., 2010) and therefore the herring population recorded during historic surveys across the former Hornsea Zone are considered to be dominated by juveniles, with a smaller proportion of adults, consistent with the area being a nursery ground for herring (Figure 3.17).

Thornback and spotted ray

3.2.5.12 Three ray species were recorded during trawl surveys, spotted ray, thornback ray and cuckoo ray, all of which were recorded at low abundances throughout the Hornsea Three fish and shellfish study area. The length distributions for thornback and spotted ray are presented in Figure 3.29 (only four cuckoo ray were recorded during all surveys and therefore the lengths of these are not presented). These show that rays ranged between 25 and 90 cm in length and for spotted ray the majority of individuals were between 40 and 65 cm in length. Thornback ray were recorded in low numbers for all size classes. Juveniles of these species typically measure 18 cm or less in length and therefore all the individuals recorded were considered adults.

3.2.5.13 Studies of North Sea thornback ray have indicated that for males, first maturity occurs at approximately 47 cm, with 50% of individuals mature at 66.6 cm while for females the smallest mature female was 57 cm with 50% of females being mature at 73.7 cm length. For spotted ray the length at 50% maturity for males was 50.3 while that for females was 64 cm. A recent tagging study by Cefas recorded a number of spawning female thornback ray off Wells-next-the-Sea, the lengths of which ranged from 71 to 92 cm (McCully *et al*., 2013). This indicates that the population recorded in offshore areas around the Hornsea Three array area were adult, although many of these were not fully mature. Studies undertaken in the vicinity of the nearshore sections of the Hornsea Three offshore cable corridor conversely showed clear evidence of mature thornback ray, some of which were actively spawning (see paragraph 3.2.6.8 *et seq*.).

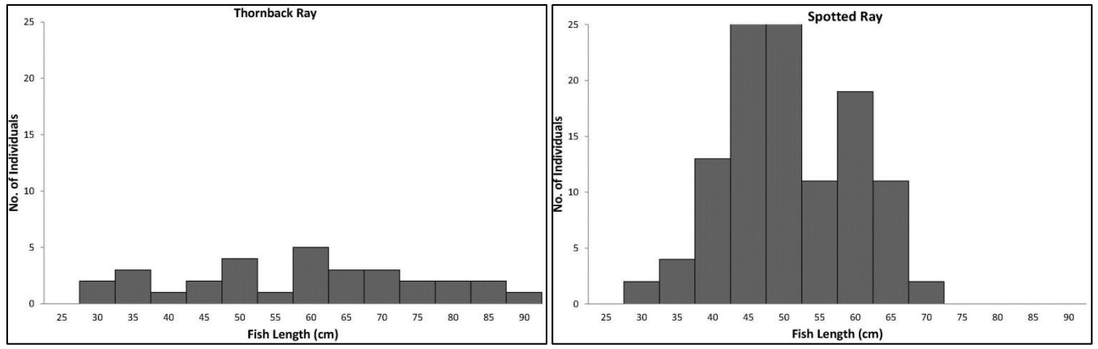


Figure 3.29: Fish length analysis for thornback ray (left) and spotted ray (right) from otter and epibenthic beam trawl sampling within the Hornsea Three fish and shellfish study area.

Sandeels

3.2.5.14 Two sandeel species were recorded in trawl surveys within the Hornsea Three fish and shellfish study area: lesser sandeel and greater sandeel. These species were generally recorded at low abundances during trawl surveys compared to many of the other characterising species. Length data for lesser sandeel shows individuals ranged between 5 and 27 cm, with a peak frequency between 11 and 15 cm (Figure 3.30). This species reaches maturity at lengths of between 11 and 15 cm (Ellis *et al*., 2010; www.fishbase.org) and therefore the majority of individuals recorded represent adults.

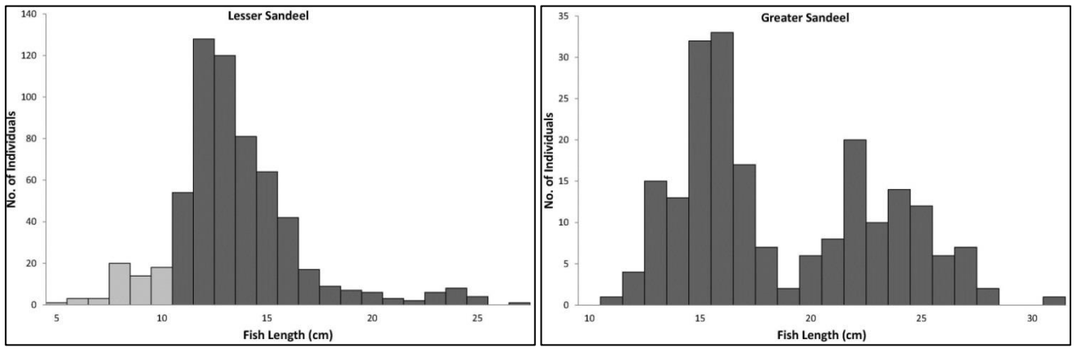


Figure 3.30: Fish length analysis for lesser sandeel (left) and greater sandeel (right) from otter and epibenthic beam trawl sampling within the Hornsea Three fish and shellfish study area (juvenile size classes in light grey).

3.2.5.15 Greater sandeel was recorded at lower abundances than lesser sandeel and had lengths of between 11 and 31 cm (Figure 3.30). As with lesser sandeel, this species reaches maturity at between 11 and 15 cm and therefore all greater sandeels recorded during historic surveys across the former Hornsea Zone were likely to be adults.

3.2.6 Fish spawning and nursery habitats

3.2.6.1 Known spawning and nursery habitats of fish species in UK waters have been mapped by Coull *et al*. (1998) and Ellis *et al*. (2010) and these are illustrated in Figure 3.8 to Figure 3.21 for the key species recorded in the Hornsea Three fish and shellfish study area and in Figure 3.31 and Figure 3.32 for the less important species in the Hornsea Three fish and shellfish study area (i.e. anglerfish *Lophius piscatorius*, common sole, spurdog, tope, blue whiting *Micromesistius poutassou*, European hake *Merluccius merluccius*, haddock and ling *Molva molva*). Further information on inshore nursery grounds was reported by Rogers *et al*. (1998) based on surveys, undertaken between 1981 and 1997, of the abundance and distribution of juvenile fish in shallow coastal waters. Although it was not possible to map these areas, these are discussed below and summarised in Table 3.4. Spawning timings for species known to have spawning grounds in the Hornsea Three fish and shellfish study are presented in Table 3.5.

3.2.6.2 The Hornsea Three fish and shellfish study area coincides with spawning and nursery habitats for cod, whiting, plaice, lemon sole, common sole, sprat, sandeel and mackerel. Nursery and spawning grounds for herring are discussed separately in paragraphs 3.2.6.11 to 3.2.6.19. Whiting was found to be present throughout the Hornsea Three fish and shellfish study area, with the population composed of both adults and juveniles, which supports the conclusion that spawning (low intensity) and nursery habitats (high and low intensity) are present in the vicinity of the Hornsea Three fish and shellfish study area. The Hornsea Three fish and shellfish study area also coincides primarily with low intensity cod spawning habitat and this is largely supported by the results of the historic surveys across the former Hornsea Zone which showed low abundances of this species throughout the survey area, with locally high abundances in the north (i.e. the Hornsea Three fish and shellfish study area does not represent a particularly important habitat for cod). Similarly, the presence of a low intensity nursery habitat for cod within the Hornsea Three fish and shellfish study area, including the Hornsea Three offshore cable corridor was supported by the small proportion of juvenile cod recorded during historic surveys across the former Hornsea Zone, with more important nursery habitats (i.e. high intensity nursery habitats) likely to occur in the inshore areas to the west of the former Hornsea Zone.

Table 3.4: Summary of spawning and nursery habitats within the Hornsea Three 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. 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.

Species		Spawning Habitats		Nursery Habitats	
		Description	Distance to Hornsea Three (km)	Description	Distance to Hornsea Three (km)
Whiting	*Merlangius merlangus*	Low intensity spawning habitat coinciding with Hornsea Three fish and shellfish study area, including inshore sections of the Hornsea Three offshore cable corridor. Spawns February to June.	0	High intensity nursery habitat across most of the Hornsea Three fish and shellfish study area. Low intensity nursery habitat in inshore sections of Hornsea Three offshore cable corridor.	0
Cod	*Gadus morhua*	Low intensity spawning habitat coinciding with Hornsea Three fish and shellfish study area. Spawns January to April.	0	Low intensity nursery habitat coinciding with Hornsea Three (array and offshore cable corridor); high intensity nursery habitat to the west of former Hornsea Zone.	0
Dab	*Limanda limanda*	No known spawning habitats in Hornsea Three fish and shellfish study area.	N/A	Juvenile dab recorded in sandy coastal habitats, including the Wash and inshore along the north Norfolk coast.	No mapping data available [b]
Plaice	*Pleuronectes platessa*	High intensity spawning habitat coinciding with Hornsea Three fish and shellfish study area. Spawns January to March.	0	Low intensity nursery habitat coinciding with inshore sections of the Hornsea Three offshore cable corridor.	0
Lemon sole	*Microstomus kitt*	Spawning grounds coinciding with Hornsea Three offshore cable corridor, though not Hornsea Three array area. Spawns April to September.	0	Nursery habitat coinciding with Hornsea Three offshore cable corridor.	0
Common sole	*Solea solea*	Low intensity spawning habitat coinciding with the inshore sections of the Hornsea Three offshore cable corridor and to the north of Hornsea Three array area. Spawns March to May.	0	Low intensity nursery habitat coinciding with inshore sections of the Hornsea Three offshore cable corridor.	0
Sprat	*Sprattus sprattus*	Spawning habitat coinciding with Hornsea Three, excluding much of the Hornsea Three offshore cable corridor. Spawns May to August.	0	Nursery habitats coinciding with Hornsea Three (array and offshore cable corridor), though not inshore sections of Hornsea Three offshore cable corridor.	0
Herring	*Clupea harengus*	Autumn spawning (September to October) habitat to the west of Hornsea Three array area, with spring (April) spawning population in the Wash.	Hornsea Three array area: 83[a] Hornsea Three offshore cable corridor: 52[a]	Low intensity nursery habitat coinciding with Hornsea Three (array and offshore cable corridor), with high intensity nursery habitat further west in the Wash.	0
Mackerel	*Scomber scombrus*	Spawning habitat coinciding with Hornsea Three array area and much of the Hornsea Three offshore cable corridor. Spawns May to August.	0	Low intensity nursery habitats coinciding with Hornsea Three (array and offshore cable corridor).	0
Thornback ray	*Raja clavata*	Spawning females recorded off Wells-next-the-Sea indicating the waters off north Norfolk coast and the Greater Wash (i.e. the nearshore sections of the Hornsea Three offshore cable corridor) represent spawning habitat for this species (McCully *et al.*, 2013). Reported to spawn in summer months, with records above made in June and July.	No mapping data available [b]	Low intensity nursery habitat in inshore section of Hornsea Three offshore cable corridor and to the west within and around the Wash.	0
Spotted ray	*Raja montagui*	Spawning in the southern North Sea fish and shellfish study area. Lay egg cases in April to July.	No mapping data available [b]	Nursery habitat within the southern North Sea fish and shellfish study area.	No mapping data available [b]
Sandeel	*Ammodytes spp.*	High intensity spawning grounds to the north of Hornsea Three array, with low intensity spawning grounds coinciding with Hornsea Three (array and offshore cable corridor). Spawns November to February.	0	Low intensity nursery habitats coinciding with Hornsea Three (array and offshore cable corridor).	0
Anglerfish	*Lophius spp.*	No known spawning habitats in Hornsea Three fish and shellfish study area.	N/A	Low intensity nursery habitat coinciding with the Hornsea Three array area and offshore section of Hornsea Three offshore cable corridor. Hornsea Three lies at the southern extent of anglerfish nursery habitats in the North Sea.	0

Species		Spawning Habitats		Nursery Habitats	
Spurdog	*Squalus acanthias*	Females give birth in coastal waters in the southern North Sea fish and shellfish study area between August and December.	No mapping data available [b]	Low intensity nursery habitat coinciding with the Hornsea Three array area and offshore section of Hornsea Three offshore cable corridor. Hornsea Three lies at the southern extent of spurdog nursery habitats in the North Sea.	0
Tope shark	*Galeorhinus galeus*	Spawning in the southern North Sea fish and shellfish study area during the summer months.	No mapping data available [b]	Low intensity nursery habitat coinciding with the Hornsea Three array area and offshore section of Hornsea Three offshore cable corridor. Hornsea Three lies at the eastern extent of tope nursery habitat in the southern North Sea.	0
Smooth hound	*Mustelus mustelus*	Mating and birth in the southern North Sea fish and shellfish study area in summer.	No mapping data available [b]	No known nursery habitats in Hornsea Three fish and shellfish study area.	N/A
Starry smooth hound	*Mustelus asterias*	Mating and birth in the southern North Sea fish and shellfish study area in summer.	No mapping data available [b]	No known nursery habitats in Hornsea Three fish and shellfish study area.	N/A
Lesser spotted dogfish	*Scyliorhinus canicula*	Spawning within the southern North Sea fish and shellfish study area in spring and early summer, though little is known about where eggs are deposited.	No mapping data available [b]	No known nursery habitats in Hornsea Three fish and shellfish study area.	N/A
Blue whiting	*Micromesistius poutassou*	No known spawning habitats in Hornsea Three fish and shellfish study area.	N/A	Low intensity nursery habitat immediately to the north of Hornsea Three array. Hornsea Three lies at the southern extent of blue whiting nursery habitats in the North Sea.	0
Ling	*Molva molva*	No known spawning habitats in Hornsea Three fish and shellfish study area.	N/A	Low intensity nursery habitat immediately to the north of Hornsea Three array. Hornsea Three lies at the southern extent of ling nursery habitats in the North Sea.	0
Hake	*Merluccius merluccius*	No known spawning habitats in Hornsea Three fish and shellfish study area.	N/A	Low intensity nursery habitat immediately to the north of Hornsea Three array. Hornsea Three lies at the southern extent of hake nursery habitats in the North Sea.	0
Haddock	*Melanogrammus aeglefinus*	No known spawning habitats in Hornsea Three fish and shellfish study area.	N/A	Nursery habitats located far to the northwest of Hornsea Three array.	168

a: Distance to herring spawning ground as mapped using IHLS data 2001-2015 (see Figure 3.33).

b: Distances measured using GIS data (e.g. Coull *et al.* (1998) and Ellis *et al.* (2010)). Where information is based on literature only and not supported by GIS mapping data, distances have not been presented.

Table 3.5: Summary of spawning timings in the southern North Sea for fish species known to have spawning habitats in the Hornsea Three fish and shellfish study area. Light purple indicates spawning period, dark purple indicates peak spawning period.

Species	January	February	March	April	May	June	July	August	September	October	November	December
Whiting												
Cod												
Plaice												
Lemon sole												
Common sole												
Sprat												
Herring												
Mackerel												
Sandeel												
Thornback ray												
Spotted ray												
Tope												
Spurdog												
Smooth hound												
Starry smooth hound												
Lesser spotted dogfish												

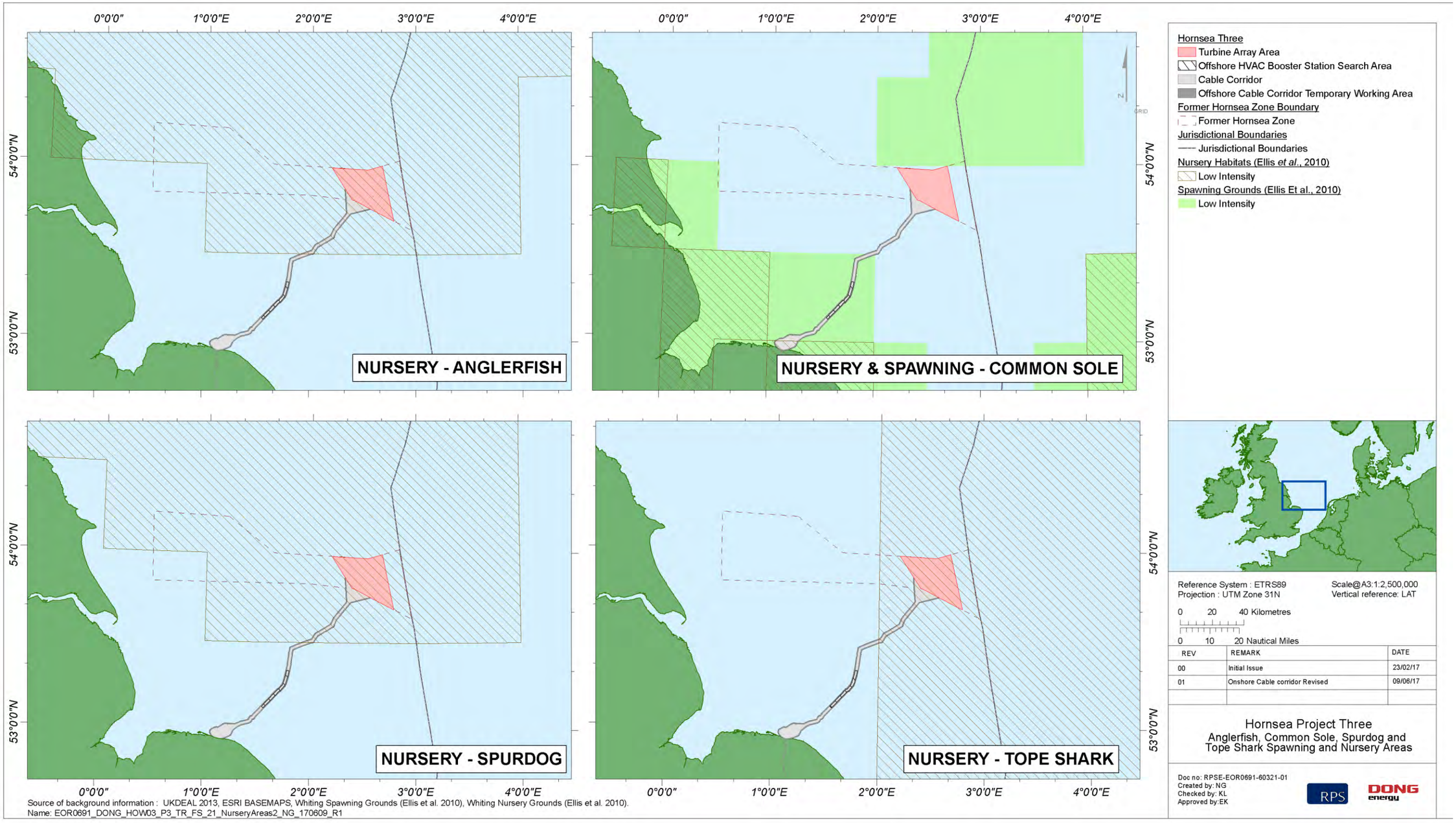


Figure 3.31: Nursery and spawning habitats for anglerfish, common sole, spurdog and tope in the vicinity of the Hornsea Three fish and shellfish study area.

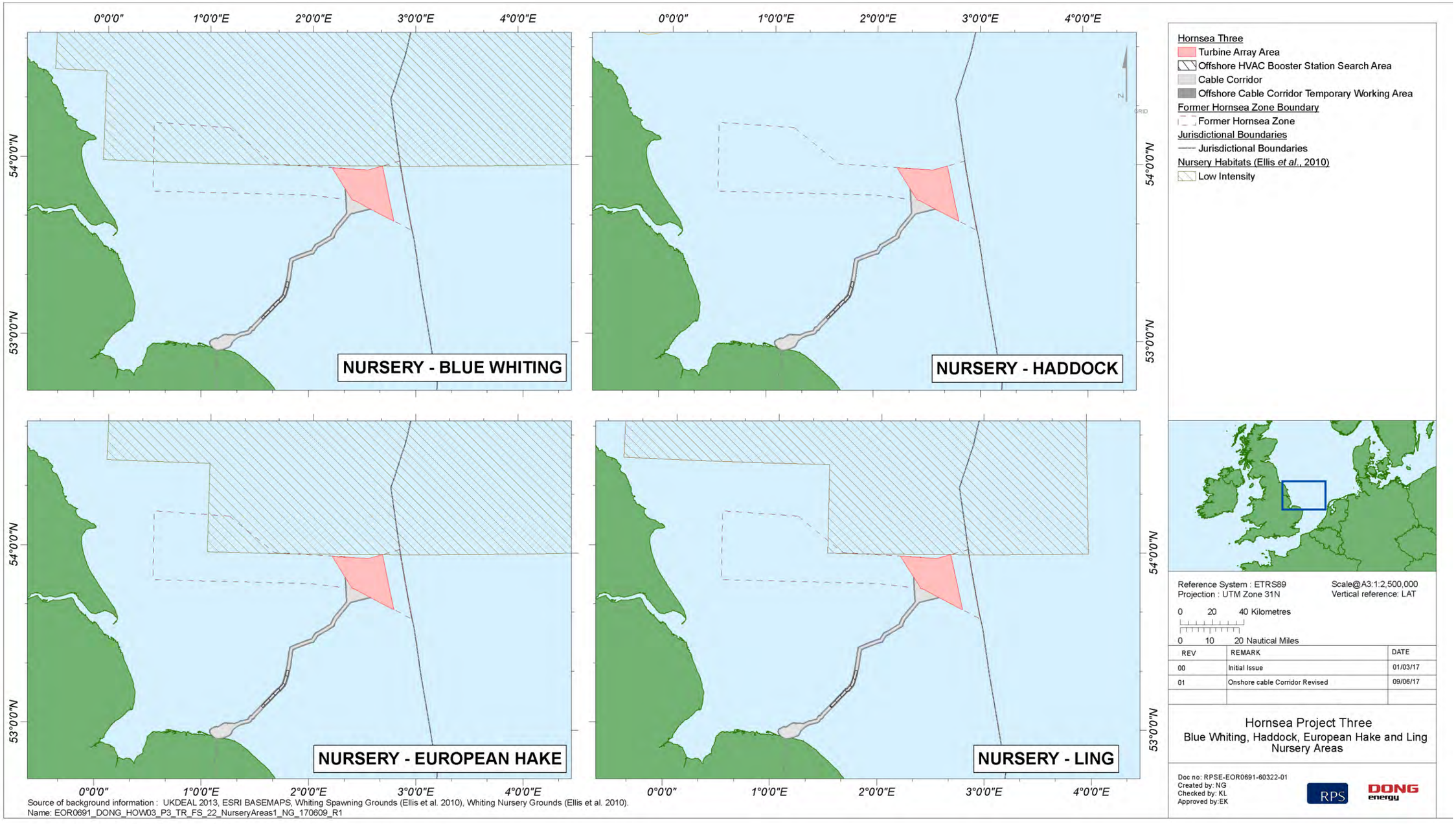


Figure 3.32: Nursery habitats for blue whiting, haddock, European hake and ling in the vicinity of the Hornsea Three fish and shellfish study area.

3.2.6.3 High intensity plaice spawning habitat is present across the Hornsea Three fish and shellfish study area and this was evident from the prevalence of this species recorded during the historic surveys across the former Hornsea Zone. Low intensity nursery habitats are also present in the inshore areas of the Hornsea Three offshore cable corridor, with data from other wind farms in proximity to the nearshore Hornsea Three offshore cable corridor also showing limited numbers of plaice in these parts of the southern North Sea (see section 3.1.2). Lemon sole spawning and nursery habitats coincide with the western section of the former Hornsea Zone, though historic surveys across the former Hornsea Zone did not provide clear evidence for this, with this species recorded at low abundances throughout the whole Hornsea Three fish and shellfish study area. Similarly, for common sole, low intensity spawning and nursery habitats are shown to the north of the Hornsea Three array area and along the offshore cable corridor. Common sole was only recorded at very low abundances during historic surveys across the former Hornsea Zone and at other offshore wind farms close to the nearshore section of the Hornsea Three offshore cable corridor (see section 3.1.2). This species is targeted by commercial fishing vessels in the region (see annex 6.1: Commercial Fisheries Technical Report; though the landings by weight are a fraction of those for plaice) and therefore are present in the area, but it is likely that areas further south (i.e. closer to the Thames Estuary and English Channel) are more important for this species.

3.2.6.4 There is currently limited information on spawning and nursery habitats for other flatfish species, including dab, though Rogers *et al*. (1998) reported juvenile dab use sandy coastal waters and have been abundantly recorded in inshore areas including the Wash and extending to the east towards the north Norfolk coast, close to the inshore section of the Hornsea Three offshore cable corridor. Rogers *et al*. (1998) reported that other flatfish species including brill and turbot have been recorded in inshore waters along the east coast of England, including the north Norfolk coast and the Wash, though these are thought to be at the northern limit of their distribution in the North Sea.

3.2.6.5 Sprat spawning and nursery habitats coincide with most of the Hornsea Three fish and shellfish study area, though these habitats are not thought to occur along much of the Hornsea Three offshore cable corridor. This was mirrored in the historic survey data from across the former Hornsea Zone which showed a dominance of adult sprat in the trawl data in offshore areas around the Hornsea Three array area. Although sprat were recorded during surveys at other offshore wind farms in the vicinity of the inshore sections of the Hornsea Three offshore cable corridor (see section 3.1.2), there was no evidence of these areas being used for spawning or as nursery habitat (i.e. as evidenced by high abundances of juveniles.

3.2.6.6 Sandeel low intensity spawning grounds coincide with the Hornsea Three fish and shellfish study area, with high intensity spawning grounds to the north of the Hornsea Three array area. The area is also characterised by low intensity nursery habitats, which also occur in the inshore section of the Hornsea Three offshore cable corridor on the north Norfolk coast. Sandeels (greater and lesser) recorded during trawl surveys were primarily adults, with only a minor contribution of juveniles recorded.

3.2.6.7 Mackerel spawning and nursery (low intensity) habitats coincide with the Hornsea Three fish and shellfish study area and historic surveys across the former Hornsea Zone showed that adult mackerel were recorded during the autumn trawl survey (with much lower abundances recorded in spring). Since this species spawns between May and August, this seasonal difference cannot clearly be explained by the timing of spawning for this species.

3.2.6.8 Nursery habitats for the elasmobranch species thornback ray and spurdog have also been mapped in the vicinity of the Hornsea Three fish and shellfish study area, though these are primarily located to the south and north, respectively. It has been suggested that these species may spawn in the same areas used for nursery habitats (e.g. the Wash; Ellis *et al*., 2010), though spawning habitats for these species have not been mapped. Adult thornback ray have been reported to occur in shallow inshore areas during summer months, potentially for mating and spawning (Walker *et al*., 1997). Further evidence for this was obtained through a recent tagging study undertaken by Cefas along the east coast of England (i.e. between Skegness to Felixstowe; McCully *et al*., 2013). This study recorded a number of large female thornback ray in June and July in the waters off Wells-next-the-Sea, with ten of these with egg cases (purses) extruding from the cloaca. The presence of actively spawning thornback ray in this area is a strong indication that the seabed around the Greater Wash and the north Norfolk coast (i.e. in the vicinity of the nearshore sections of the Hornsea Three offshore cable corridor) represent spawning habitat for this species (McCully *et al*., 2013).

3.2.6.9 Abundances of thornback ray in the southern North Sea have been reported to be highest in the Wash (ERM, 2012). During historic survey data from across the former Hornsea Zone, elasmobranch species were recorded at low abundances (primarily focussed in offshore areas around the former Hornsea Zone), suggesting that the Hornsea Three array area does not represent important elasmobranch spawning grounds. While the limitations of the survey methods employed should be acknowledged (see section 2.6), this conclusion is supported by desktop information which indicate that these species are generally recorded in lower abundances in offshore areas of the southern North Sea (see section 3.1 and paragraph 3.2.4.20 *et seq*.). The findings of a study by Ellis *et al*. (2004) also provide some context for this finding, and the spawning habitat in the vicinity of the nearshore sections of the Hornsea Three offshore cable corridor. This study reported that although ray species, including thornback ray and spotted ray, occur in this part of the North Sea and throughout UK waters, abundances in this part of the southern North Sea are considerably lower than those in other areas (e.g. the Thames Estuary and the English Channel). Based on the available information from historic surveys across the former Hornsea Zone and the desktop review, although elasmobranch spawning habitats are present in the nearshore areas of the Hornsea Three offshore cable corridor, these are not expected to be as important as spawning habitats in other parts of the southern North Sea (e.g. the greater Thames Estuary; Ellis *et al*., 2004).

3.2.6.10 Other species identified as having nursery habitats in the vicinity of the Hornsea Three fish and shellfish study area include blue whiting, ling, hake and anglerfish, with these habitats generally occurring to the north of Hornsea Three. Historic data from across the former Hornsea Zone showed that these species were absent from trawl surveys (with the exception of ling which was recorded at very low abundances) and therefore the Hornsea Three fish and shellfish study area is considered unlikely to represent an important nursery habitat for these species. This is largely supported by the results of the desktop study (see section 3.1), which did not identify these species as being particularly abundant in the southern North Sea, though anglerfish has been reported to be commercially exploited in the southern North Sea; see paragraph 3.1.1.4.

Herring spawning and nursery habitats

3.2.6.11 The Hornsea Three fish and shellfish study area coincides with low intensity nursery habitats for herring, with high intensity nursery located to the west of Hornsea Three array, around the Wash and Humber Estuary (see Figure 3.17). This was supported by historic survey data from across the former Hornsea Zone with trawl data showing the herring population to be dominated by juveniles (paragraph 3.2.5.11) and historic data from other offshore wind farms also showing a dominance of immature herring (see section 3.1.2).

3.2.6.12 The main spawning habitat for this herring population (i.e. the Banks herring stock) is located to the west of the former Hornsea Zone, off Flamborough Head, with this population spawning in autumn (September to October). Data collected during the International Herring Larvae Survey (IHLS) between 2001 and 2015 has been mapped and is presented in Figure 3.33. Based on the IHLS data, herring spawning grounds have been defined (by RPS) as areas with recorded abundances of >100 larvae (of <10 mm length) per m^2. When herring larvae hatch, they are usually between 6 and 7 mm in length, though they can range between 4 and 10 mm (Henderson *et al*., 1984; http://www.larvalbase.org) and therefore the presence of high abundances of larvae with lengths of <10 mm is considered to be indicative of recent spawning activity. This shows that this herring population consistently spawn off Flamborough Head, with some spatial variation between years. As can be seen in Figure 3.33, there is no overlap observed between the spawning habitats used by the Banks herring stock and the Hornsea Three boundaries (i.e. the Hornsea Three array area and offshore cable corridor). As detailed in Table 3.5, the Hornsea Three array area is approximately 83 km from the spawning habitats mapped using the IHLS datasets from the last 15 years.

3.2.6.13 Historic spawning grounds have also been mapped for the southern North Sea (Schmidt *et al.*, 2009) and these are also shown in Figure 3.33. These show that herring spawning has historically occurred in the vicinity of Dogger Bank, to the north of the former Hornsea Zone, with this spawning ground extending as far south as the Hornsea Three array area. Herring spawning activity (i.e. evidence of recently spawned herring larvae) has not, however, been recorded in this area in recent years and therefore recolonisation has not yet occurred (Schmidt *et al*., 2009). While the IHLS dataset is the most reliable indicator of herring spawning habitat within the southern North Sea, the habitats mapped by Coull *et al*. (1998) give an indication of the suitable habitats potentially available for herring spawning in the Hornsea Three fish and shellfish study area. These areas were mapped based on historic spawning grounds whilst also considering the substrate required for herring spawning (i.e. gravelly sediments) and therefore are a good indication of available herring spawning habitat, though, as with the Schmidt *et al*. (2009) data, herring spawning has not recently been recorded in these areas (i.e. within the last 40 years of IHLS sampling). It should be noted, however, that the IHLS sample these areas only intermittently, with sampling in the vicinity of these historic spawning habitats occurring most recently in 1999, when herring larvae were either absent or recorded at very low abundances (eggsandlarvae.ices.dk).

3.2.6.14 High abundances (i.e. over 600 individuals) of actively spawning herring were recorded at one of the trawl sampling locations (Trawl 41, at the mouth of the Humber Estuary) during the spring otter trawl survey. This suggested the presence of a spring spawning population at the mouth of the Humber Estuary. This is likely to be a northerly component of the spring spawning population which is known to occur in the Wash (Cefas 2009).

3.2.6.15 Following identification of this spring spawning population, all mature herring captured during the autumn survey were analysed to determine their spawning condition. The gonads were examined and compared to the established ICES GSI criteria (see paragraph 2.4.1.5) and the fish grouped into one of seven maturity stages (see Figure 2.3; Bucholtz *et al*., 2008). Only 27 mature fish were recorded at nine trawl sampling locations during the autumn survey, all of which were indicative of either imminent (i.e. mid to final maturing, Stages III-IV), current (spawning, Stages V-VI) or recent (spent, Stage VII) spawning activity. The distribution of these are presented in Figure 3.34, though the low abundances of herring in spawning condition during the autumn survey indicates that herring spawning is not likely to occur in the Hornsea Three fish and shellfish study area in autumn (i.e. the key spawning period for this population). This supports the conclusion that herring spawning primarily occurs off Flamborough Head for the Banks population.

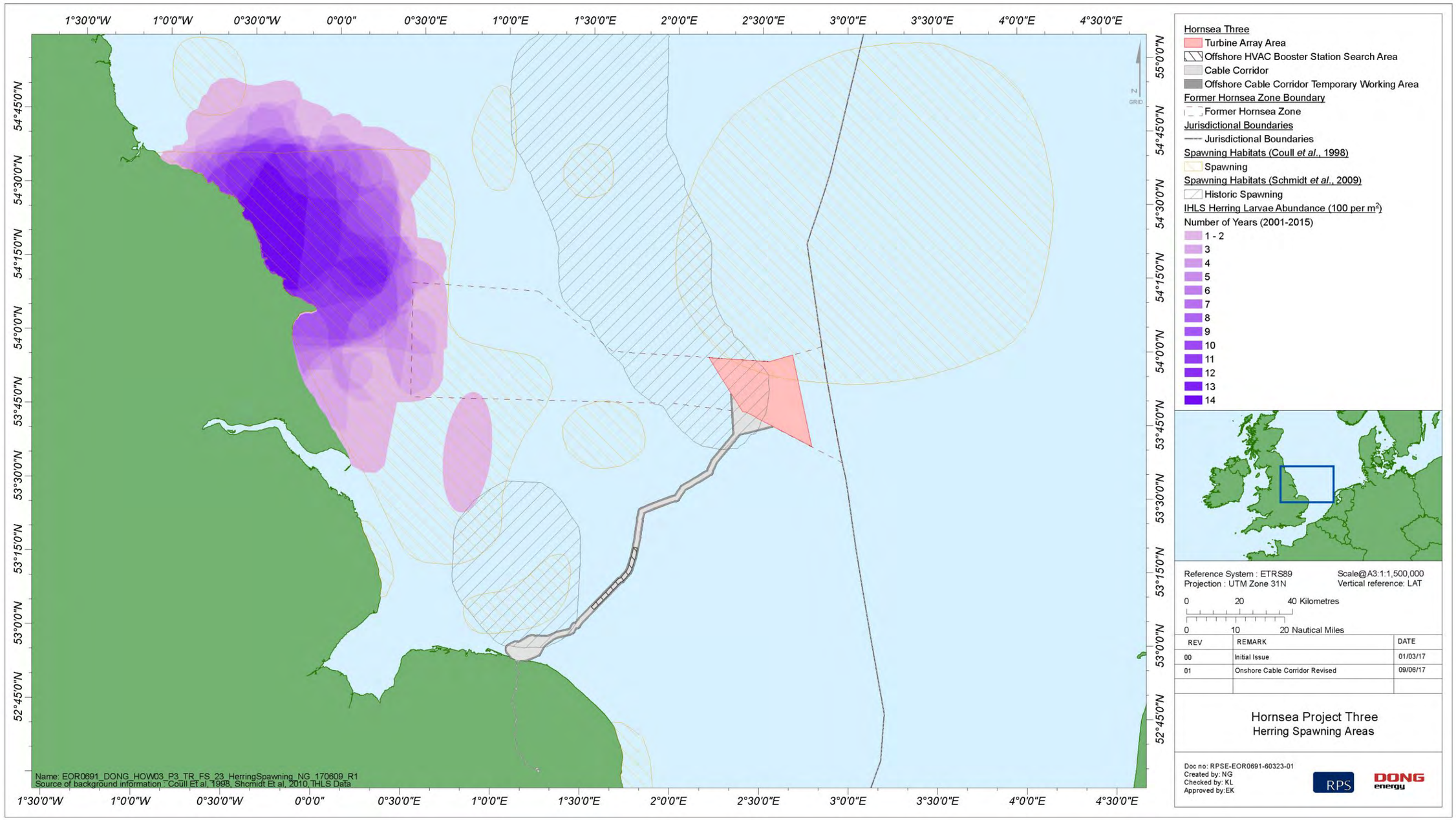


Figure 3.33: Herring spawning habitats in the southern North Sea based on data from the International Herring Larvae Survey (IHLS; 2001 to 2015), Coull *et al.* (1998) and Schmidt *et al.* (2009).

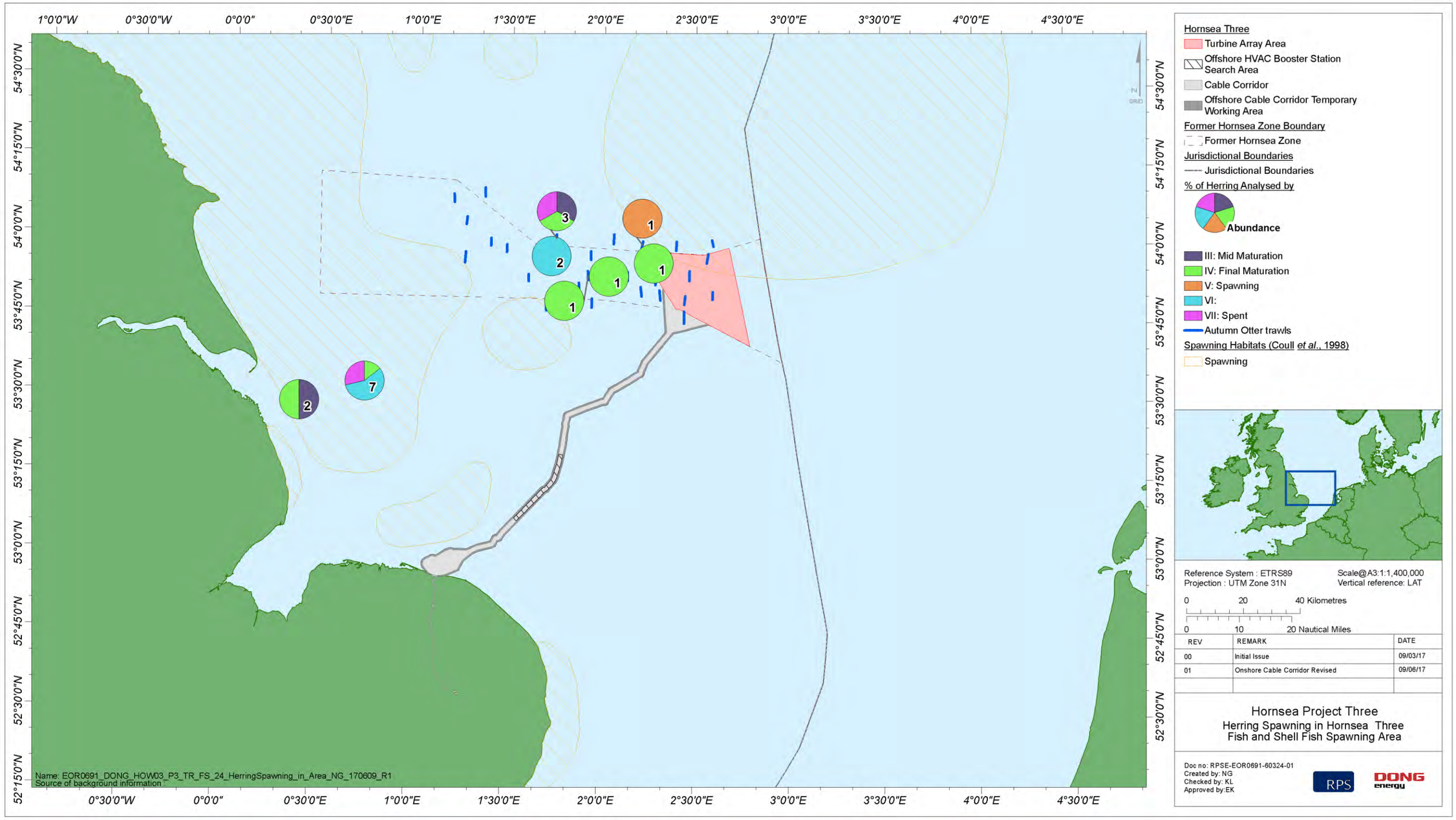


Figure 3.34: Evidence of herring spawning within the Hornsea Three fish and shellfish study area during the autumn otter trawl survey.

3.2.6.16 Site specific herring larvae surveys undertaken in 2009 and 2010 to inform the Triton Knoll fish ecology characterisation also provide information on herring spawning in the area. These surveys showed low abundances of recently spawned larvae in the vicinity of the Triton Knoll offshore wind farm site and the area to the north of it (i.e. the southern periphery of the Banks spawning grounds off Flamborough Head). Although these surveys represent snapshots of herring larval abundances during the peak spawning period for this population, the data from these surveys add further weight to the conclusion that the main spawning habitat for this population is located off Flamborough Head, with limited spawning activity occurring south of the Humber Estuary (Triton Knoll Offshore Wind Farm Ltd., 2011c).

3.2.6.17 Site specific herring spawning surveys were undertaken within and around the Sheringham Shoal offshore wind farm (i.e. in the vicinity of the nearshore section of the Hornsea Three offshore cable corridor) in autumn 2009, targeting at an area of herring spawning habitat identified by Coull *et al*. (1998) and Schmidt *et al*. (2009). These pelagic trawl surveys targeted adult herring, with herring caught classified according to their developmental stage (i.e. similar to the classifications in paragraph 2.4.1.5). Surveys were timed to coincide with the main spawning period for this species in the region (i.e. September to December). These surveys found that in the majority of cases, trawls were dominated by sprat, although one trawl recorded a large shoal of herring in the survey area. The majority (approximately two thirds) of the herring recorded were virgin or late virgin (i.e. stages I and II; see Figure 2.3). Within the single trawl where a large shoal of herring was recorded, approximately 97% of the over 45,000 individuals recorded were classified as Stage 4: ripening. During the subsequent surveys, no further evidence of recent herring spawning (i.e. high abundances of fish at Stage 6: Ripe or Stage 7: Spent) was recorded, with only six herring at Stage 6: Ripe recorded during all surveys between September and December 2009. It was concluded that the area off the north Norfolk coast is more likely to represent a feeding area for immature fish, which is reflected in this area being identified as a low intensity nursery habitat for this species, but may also represent a transitory route for fish moving towards winter spawning grounds further south (Brown and May, 2009).

3.2.6.18 Herring spawn *en masse*, depositing their eggs on benthic substrates with high gravel contents, low fine sediments (i.e. muds) and high hydrodynamic energy (Maravelias, 2001; Morrison *et al*., 1991; Whitehead, 1985). PSA data data from across the former Hornsea Zone and site specific Hornsea Three PSA data (presented in detail in annex 2.1: Benthic Ecology Technical Report) and broadscale SeaZone HydroSpatial sediment data were processed according to the methodologies described in Reach *et al*. (2013) in order to identify the preferred, marginal and unsuitable herring spawning potential habitats in the Hornsea Three and wider southern North Sea fish and shellfish study areas. PSA data from across the former Hornsea Zone and site specific Hornsea Three PSA data were categorised according to the proportions of mud and gravel at each grab sample location to determine the herring spawning potential habitat classifications (see Table 3.6). Similarly, SeaZone HydroSpatial sediment data were categorised according to the following categories, based on the Folk classification (Folk, 1954) of sediment conditions and using categories specified by Reach *et al*. (2013) (all other sediment types are considered to be unsuitable for herring spawning):

- Herring preferred potential spawning habitat: Gravel and sandy gravel; and
- Herring marginal potential spawning habitat: Gravelly sand.

Table 3.6: Herring potential spawning habitat sediment classifications.

% contribution (mud = <63 µm)	Habitat sediment preference (adapted from Reach *et al*., 2013)	Habitat sediment classification (adapted from Reach *et al*., 2013)
<5% mud, >50% gravel	Prime	Preferred
<5% mud, >25% gravel	Sub-prime	Preferred
<5% mud, >10% gravel	Suitable	Marginal
>5% mud, <10% gravel	Unsuitable	Unsuitable

3.2.6.19 The results of these analyses are presented in Figure 3.35 and show that sediments suitable for herring spawning occur across a wide area to the west and southwest of the Hornsea Three array area. PSA data showed that parts of the Hornsea Three array area and the wider former Hornsea Zone (i.e. to the west of the Hornsea Three array area) is unsuitable for herring spawning, with sediments largely comprising sand (see annex 2.1: Benthic Ecology Technical Report for further details). Within the Hornsea Three array area, preferred sediments are present in the northeast of the array (i.e. Markham's Triangle) and in the south of the array area, coincidental with the areas of gravelly sediments (Figure 3.35). Within the wider former Hornsea Zone the sediments with the highest herring spawning potential (i.e. prime) occurred in the centre of the former Hornsea Zone, though this was limited to a small number of grab samples, with the majority of PSA data in this area being classified as either marginal or unsuitable. Sediments along the Hornsea Three offshore cable corridor varied, with unsuitable sediments occurring in some areas (e.g. in the vicinity of sandwaves) and prime/sub-prime sediments occurring in others (particularly the inshore sections of the Hornsea Three offshore cable corridor). These patterns broadly reflect the patterns discussed above, with herring spawning recorded close to the Humber estuary during spring and occasionally during the autumn spawning period (likely to be peripheral to the main spawning ground at Flamborough Head). Sediments off Flamborough Head were characterised by sandy gravel and gravelly sand, with small patches of gravel, which according to Reach *et al*. (2013) are considered suitable for herring spawning. It should be noted that Figure 3.35 gives an indication of the location of sediments which are most suitable for herring spawning, though this does not necessarily mean that herring spawning will occur in these areas. This drawing should therefore not be considered in isolation, but interpreted in the context of the other datasets discussed here.

3.2.7 Migratory fish species

3.2.7.1 A number of migratory fish species have the potential to occur in the southern North Sea fish and shellfish study area, migrating to and from rivers and other freshwater bodies in the area which these species use either for spawning habitat or growth and development to the adult phase, with spawning occurring at sea (i.e. European eel *Anguilla anguilla*). These species hae the potential to occur in a number of rivers in the southern North Sea fish and shellfish study area, including those flowing into the Wash, although the most important of these on the east coast of England is the Humber Estuary.

3.2.7.2 The Humber Estuary is known to host a number of key migratory species which are known to spawn in the freshwater environments of tributaries flowing into the estuary, including the River Derwent SAC. These include sea lamrey *Petromyzon marinus* and river lamprey *Lampetra fluviatilis* (both qualifying species of the Humber Estuary Special Area of Conservation (SAC)), Atlantic salmon *Salmo salar*, sea trout *Salmo trutta*, European eel *Anguilla anguilla*, twaite shad *Alosa fallax* and allis shad *Alosa alosa* (Perez-Dominguez, 2008; Allen *et al*., 2003; Proctor *et al*., 2000; Proctor and Musk, 2001). Some of these species also have the potential to occur in the Wash and the rivers flowing into it, although there are fewer records of migratory fish species in these areas. This includes sea trout which are known to occur in the Wash and along the North Norfolk coast, feeding on sprat and sandeel (Aprahamian and Robson, 1998; DECC, 2016a). Local partnerships have been established, including the Welland Sea Trout Project, aiming to restore freshwater habitats for sea trout (and other migratory fish species) by making improvements in river habitats to benefit these migratory fish populations (http://www.wildtrout.org/news/welland-sea-trout-project-update).

3.2.7.3 During trawl surveys, a single twaite shad was recorded at trawl location 26, in the west of Hornsea Three (during the autumn survey) and a single Atlantic salmon was recorded at the mouth of the Humber Estuary (spring survey), although due to the location of Hornsea Three over 140 km offshore from the Humber Estuary, there is limited potential for these species to occur in significant numbers in the vicinity of the Hornsea Three array area. There is greater potential for these species to occur in the vicinity of the Hornsea Three offshore cable corridor, particularly in the inshore areas, although data concerning the distribution and migratory routes of these species in coastal and offshore waters are acknowledged to be sparse.

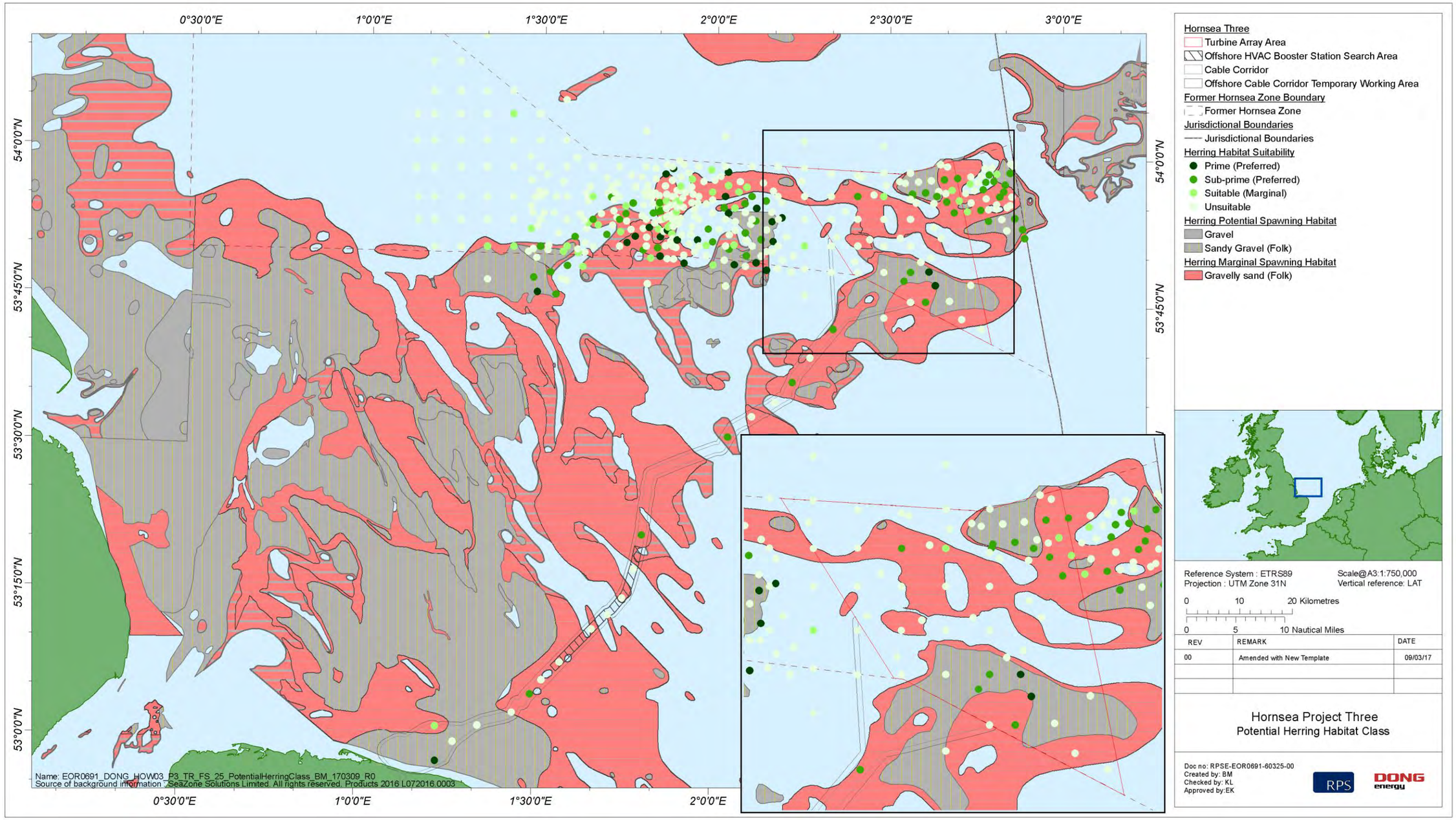


Figure 3.35: Herring spawning habitat sediment classifications within the Hornsea Three and southern North Sea fish and shellfish study areas following the methodologies in Reach *et al.* (2013). All other sediment types not plotted here (i.e. appear as pale blue) were considered to be unsuitable for herring spawning. Note: These data should not be considered in isolation but interpreted in the context of other datasets presented (see paragraphs 3.2.6.11 *et seq.*).

3.3 Species of conservation importance

3.3.1.1 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 Three fish and shellfish study area, are listed under conservation legislation. These are summarised in Table 3.7. Of the species likely to occur in the Hornsea Three fish and shellfish study area, five are listed as Annex II species under the EU Habitats Directive, including sea lamprey and river lamprey which are listed as qualifying features of the Humber Estuary SAC, but not primary reasons for site selection. There is currently limited understanding of how these species use the Humber Estuary (e.g. during migration), with no site specific lamprey monitoring of this species undertaken within the SAC. The Humber Management Scheme Action Plan and Delivery Plan (Humber Nature Partnership, 2014) has therefore identified specific actions relating to monitoring of sea and river lamprey in the Humber Estuary, including investigating the effect of water quality (i.e. dissolved oxygen) on migration. The purpose of this monitoring will be to update the management requirements for these species in the Humber Estuary SAC.

3.3.1.2 In addition, the River Derwent SAC, a tributary of the Humber Estuary, also lists river and sea lamprey as qualifying features, with river lamprey listed a primary feature for selection of the site. A number of other Natura 2000 sites within the southern North Sea fish and shellfish study area, though outside UK waters, list these Annex II fish species as features. These are presented relative to Hornsea Three in Figure 3.36 and include:

- Vlakte van de Raan Site of Community Importance (SCI; Belgium; twaite shad and sea lamprey);
- Bokrum-Riffgrund SCI (twaite shad);
- Hamburgisches Wattenmeer SCI (twaite shad, sea lamprey and river lamprey);
- Unterelbe SCI (twaite shad, Atlantic salmon, sea lamprey and river lamprey);
- NTP S-H Wattenmeer un angrenzende Küstengebiete SCI (sea lamprey and river lamprey);
- Sylt Outer Reef SCI (twaite shad and river lamprey);
- Vlakte van de Raan SAC (Netherlands; twaite shad, river lamprey, sea lamprey);
- Waddenzee SAC (twaite shad, river lamprey, sea lamprey);
- Noordzeekustzone SAC (twaite shad, river lamprey, sea lamprey); and
- Noordzeekustzone II SCI (allis shad, twaite shad, river lamprey, sea lamprey).

3.3.1.3 All the Annex II fish species above are also listed as United Kingdom (UK) Biodiversity Action Plan (BAP) species, along with eight other species which have species action plans (i.e. lesser sandeel, tope, porbeagle shark *Lamna nasus*, blue whiting, spurdog, basking shark, European eel, sea trout and European smelt *Osmerus eperlanus*). A number of commercially important species in the southern North Sea are also listed under the UK BAP but have a grouped action plan for Commercial Marine Fish (i.e. cod, herring, hake, mackerel, plaice, anglerfish, saithe and common sole). All these species, with the exception of saithe and hake are commercially exploited species within the Hornsea Three fish and shellfish study area. The UK BAP species lists and supporting information were used to help identify species of principal importance listed under the Natural Environment and Rural Communities (NERC) Act 2006 (see Table 3.7) and therefore there is a high level of overlap between these lists.

3.3.1.4 Many of the same species are listed by OSPAR as threatened and/or declining species and/or Nationally Important Marine Features (NIMF), along with whiting, ling, common goby *Pomatoschistus microps*, sand goby *Pomatoschistus minutus*, basking shark, thornback ray and spotted ray. European eel is listed as critically endangered on the International Union for the Conservation of Nature (IUCN) red list, while cod and spurdog are listed as vulnerable on the IUCN red list. Basking shark is listed as vulnerable on the IUCN red list, though occurrences of this species in the North Sea are expected to be low (see paragraph 3.2.4.23).

3.3.1.5 The Net Gain Marine Conservation Zone (MCZ) project made recommendations to the UK government in 2011 on the designation of MCZs within the southern North Sea (coinciding with the UK portion of the southern North Sea fish and shellfish study area) and the southern part of the northern North Sea (Net Gain, 2011). European eel and European smelt are both listed as features under the MCZ project, with European eel reported as being recorded in the Markham's Triangle rMCZ (see Figure 3.36), although it was not proposed as a feature for designation due to uncertainties regarding the importance of this species to this site (Net Gain, 2011).

Table 3.7: Species of conservation importance recorded during historic surveys across the former Hornsea Zone or likely to occur within the Hornsea Three fish and shellfish study area.

Species	Recorded in historic surveys across the former Hornsea Zone	Annex II species	UK BAP species	NIMF	OSPAR threatened or declining	MCZ features	IUCN Red List[a]	NERC Species of Principal Importance
River lamprey		✓	✓					✓
Sea lamprey		✓	✓		✓			✓
Allis shad		✓	✓		✓			✓
Twaite shad	✓	✓	✓	✓				✓
Atlantic salmon	✓	✓	✓		✓			✓
Sea trout			✓					✓
European eel			✓		✓	✓	✓	✓
European smelt			✓			✓		✓
Cod	✓		✓[b]	✓	✓		✓	✓
Whiting	✓		✓[b]	✓				✓
Ling	✓		✓[b]	✓				✓
Saithe			✓					
Hake			✓[b]					
Blue whiting			✓					✓
Plaice	✓		✓[b]					✓
Common sole	✓		✓[b]					✓
Anglerfish			✓[b]	✓				
Herring	✓		✓[b]	✓				✓
Mackerel	✓		✓[b]	✓				✓
Lesser sandeel	✓		✓	✓				✓
Common goby	✓			✓				
Sand goby	✓			✓				
Tope shark			✓					✓
Porbeagle shark			✓		✓			✓
Spurdog	✓		✓		✓		✓	✓
Spotted ray	✓			✓	✓			
Thornback ray	✓			✓	✓			
Basking shark	✓		✓	✓	✓		✓	✓

a: Only species with IUCN Red List status designations categorised as threatened (i.e. 'vulnerable', 'endangered' and 'critically endangered') are listed here. These do not include species listed as 'Least Concern' or 'Near Threatened'.

b: Commercial marine fish grouped action plan.

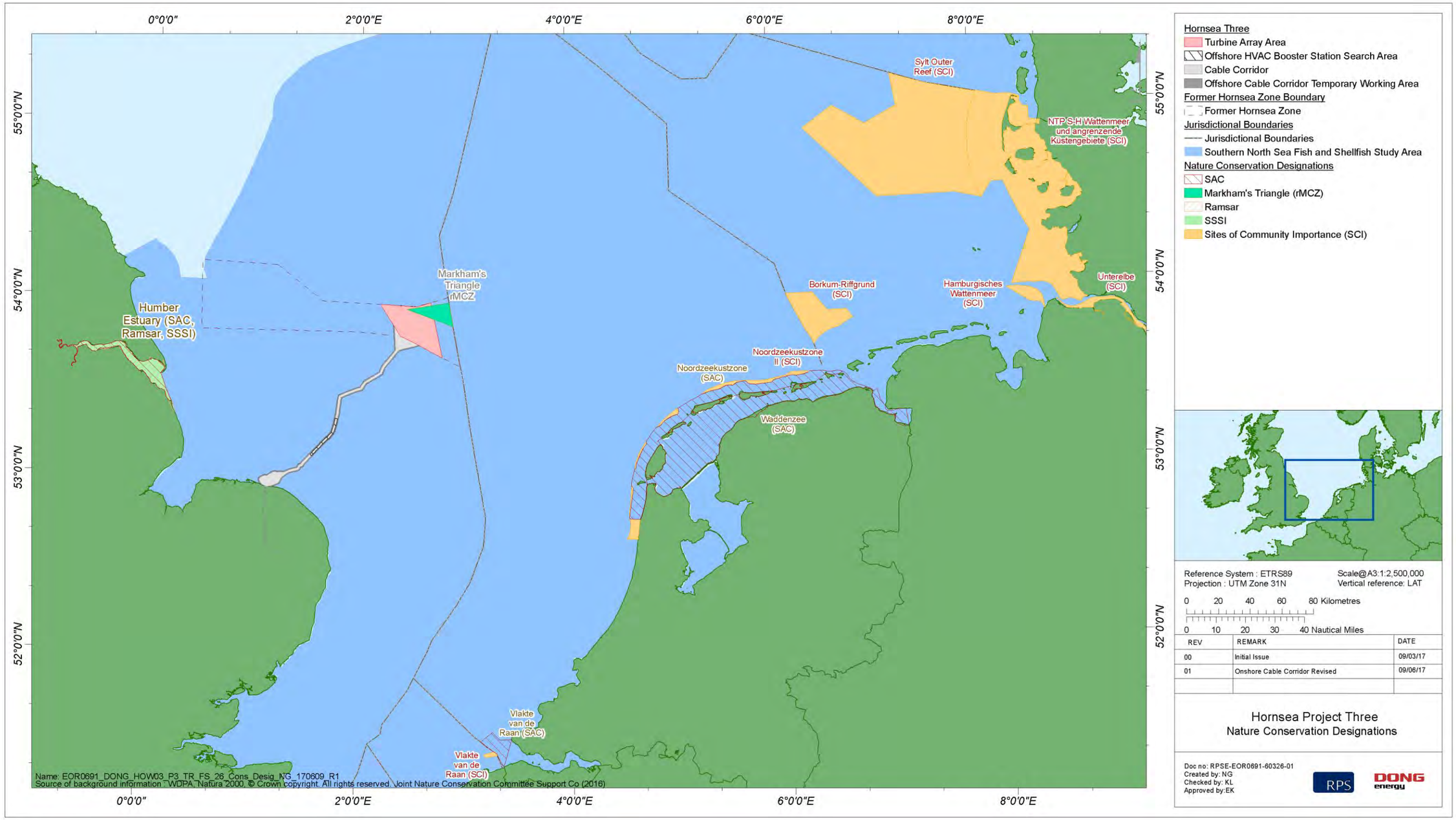


Figure 3.36: Nature conservation designations within the southern North Sea fish and shellfish study area with Annex II fish species listed as qualifying features.

3.4 Shellfish populations in the fish and shellfish study area

3.4.1 Commercial shellfish ecology

3.4.1.1 Full details of the commercial fisheries in the vicinity of the Hornsea Three fish and shellfish study area, including landings data and valuation of the commercial fisheries in the area, are described in annex 6.1: Commercial Fisheries Technical Report. Commercial shellfisheries in the Hornsea Three fish and shellfish study area are primarily focussed along the Hornsea Three offshore cable corridor, although *Nephrops* are targeted in offshore areas around the Hornsea Three array area.

3.4.1.2 Along the north Norfolk coast there are two important shellfisheries targeting crustaceans: one typified by small beach-launched vessels and another characterised by larger harbour based vessels (Cefas, 2014). The most abundant shellfish species is brown crab, with the highest landings (by weight) recorded and as a result, brown crab is the most important species to this fishery (EIFCA, 2105). While lobster is also landed in this area, these represent a fraction of the landings (by weight) of brown crab (EIFCA, 2015). Common whelk is also landed in significant quantities in the nearshore sections of the Hornsea Three offshore cable corridor (annex 6.1: Commercial Fisheries Technical Report), with brown and pink shrimp and velvet swimming crab less important to fisheries in this area.

3.4.1.3 Larger brown crab from offshore areas are usually landed in late winter, while during summer months there is a preference for smaller (i.e. close to minimum landing size; MLS) crab for the tourist market (Cefas, 2014). Although fishing activity continues during winter months, landings are diminished as brown crab and European lobster overwinter, becoming less mobile and feeding less, thus making them less likely to be caught. Days at sea are also lower during winter due to weather conditions and so fishing effort is reduced during winter months. The same fishing gear is used for both of these species (i.e. parlour pots and creels) and so vessels will fish for both concurrently.

3.4.1.4 Other shellfish species that occur in the southern North Sea and are likely to occur in the vicinity of the Hornsea Three fish and shellfish study area include *Nephrops* and squid, which occur in offshore areas around the Hornsea Three array area, and further inshore along the Hornsea Three offshore cable corridor, common whelk, brown shrimp and pink shrimp. *Nephrops* are targeted by demersal otter trawlers operating within the Hornsea Three array area (i.e. within the deep sandy mud sediments of Markham's Hole and along the northern boundary) and to the north of the Hornsea Three array area within the deep waters of the Outer Silver Pit (see annex 6.1: Commercial Fisheries Technical Report). Brown and pink shrimp typically occur in shallow, inshore areas, with the main fishery for these species located further south close to the Wash (ESFJC, 2010) and limited trawling in the vicinity of the Hornsea Three offshore cable corridor due to the prevalence of static gear in this area (annex 6.1: Commercial Fisheries Technical Report). Squid, although found throughout the Hornsea Three fish and shellfish study area (see section 3.2.1) are not a commercially targeted species in the southern North Sea (annex 6.1: Commercial Fisheries Technical Report).

3.4.1.5 The following sections provide some detail on the ecology and distribution of the key shellfish species in the Hornsea Three fish and shellfish study area and wider southern North Sea fish and shellfish study area, including discussion of abundances of these as recorded during historic surveys undertaken across the former Hornsea Zone (e.g. trawl sampling) and other desktop data sources.

Brown crab

3.4.1.6 Brown crab is widely distributed in the northeast Atlantic, from Norway to North Africa. Traditionally the major brown crab fisheries in England have been located in the English Channel, from Dungeness westwards to Cornwall, and in the North Sea off the coasts of South Yorkshire, north Norfolk and East Anglia (Nautilus Consultants, 2009). The North Sea fishery has expanded over the last 15 years to include the eastern North Sea off Germany, Holland and Denmark and areas around the eastern Scottish coast, particularly Grampian and the Moray Firth and further north around Orkney and the Shetland Isles.

3.4.1.7 Brown crab reach maturity at around 2 to 3 years old, following 9 to 10 moults proceeding through larval and juvenile stages. Bennett (1974) suggested a minimum carapace width (CW) of 91 mm at maturity. Evidence from North Sea populations suggests an average size of males/females at maturity of 110 mm and 127 to 130 mm CW respectively (Ungfors, 2007; Nautilus Consultants, 2009).

3.4.1.8 Breeding occurs during the winter months. Following mating, females dig a pit in sand or other soft sediment and remain there for 6 to 9 months, during which they will not feed (Neal and Wilson, 2008). Tagging studies (Jessop *et al*., 2007; MAFF, 1966) and larval studies (Eaton *et al*., 2003) have indicated that mature females make significant northward migrations along the Yorkshire coast to spawn (males are relatively sedentary, seldom displaying significant migrations). Hatching occurs around 6 to 9 months after spawning, during late spring to early summer. This is thought to coincide with increased levels of primary productivity in plankton, providing maximum food availability for the developing larvae (Nautilus Consultants, 2009). Larvae spend about two months in the plankton before settling as benthic juveniles in the intertidal zone where they will remain for about three years, reaching 60 to 70 mm in CW (Nautilus Consultants, 2009).

3.4.1.9 Brown crab was recorded during trawl surveys in the Hornsea Three fish and shellfish study area, though these were not specifically designed to capture shellfish species (see section 2.6), with records throughout the Hornsea Three fish and shellfish study area during otter and epibenthic beam trawl surveys (see paragraph 3.2.1.3; Figure 3.37). Although brown crab was recorded within the former Hornsea Zone (particularly in the middle of the zone), highest abundances were recorded along the inshore sections of the survey area (i.e. to the west and southwest of the former Hornsea Zone). Individuals recorded in these inshore areas tended to be smaller than those recorded in offshore areas. Berried brown crab were also recorded at low abundances during the spring otter trawl survey within the Hornsea Three fish and shellfish study area (i.e. trawls 17 and 18 in the centre of the former Hornsea Zone and trawl 32 in the north of the Hornsea Three array area; see Figure 2.1).

3.4.1.10 Brown crab was also recorded during site specific surveys at Dudgeon and Sheringham Shoal offshore wind farms (i.e. close to the inshore areas of the Hornsea Three offshore cable corridor) and while these were generally recorded at low abundances, the sampling methods employed (i.e. trawl surveys) did not specifically target this species and therefore it is expected that these would be underrepresented (Dudgeon Offshore Wind Limited, 2009; Scira Offshore Energy, 2006). Data collected as part of the Triton Knoll shellfish characterisation may provide some context for shellfish stocks in more offshore sections of the Hornsea Three offshore cable corridor and showed brown crab to be present throughout the Triton Knoll offshore wind farm site and in areas to the north and northeast, with highest abundances associated with the gravelly substrates offshore. In inshore areas (i.e. close to the mouth of the Humber Estuary) smaller individuals were generally more abundant, with females making up a larger proportion of the individuals measured than males. This finding (in line with those indicated by historic trawl survey data from across the former Hornsea Zone; paragraph 3.4.1.9) was indicative of an inshore population dominated by resident immature females which had not yet joined the migratory populations offshore (Triton Knoll Offshore Wind Farm Ltd., 2011b).

3.4.1.11 This pattern is also reflected in at-sea observations reported by NNFLAG (2015) which describes a difference between crabs caught in the inshore grounds (off Cromer, Sheringham and Runton) and those caught in offshore areas including the Race Bank and the Well area of the Wash. Offshore catches were reported to have a high proportion of male crabs, and a greater range of sizes caught. In contrast, inshore catches had a high proportion of females and a higher frequency of crabs (65%) below the minimum landing size of 115 mm CW. The few berried crabs caught were all from the inshore grounds. This suggests some differentiation between grounds locally, with the inshore grounds possibly acting as a nursery area, although the sample sizes and survey coverage mean that further work is needed to confirm this (NNFLAG, 2015).

European lobster

3.4.1.12 The European lobster has a wide distribution in northeast Atlantic waters, from Northern Norway south to the Atlantic coast of Morocco (Prodöhl *et al*., 2007). It is a long lived species which supports a valuable fishery in the UK, particularly in Scotland, the North Sea and southwest England. Usual seabed habitat for adult lobsters is hard ground, such as cobble or rocky substrata which offers cracks and crevices, and provides a defence from predators and other lobsters. Lobsterfeed on molluscs, polychaete worms and other crustaceans.

3.4.1.13 Age and size at sexual maturity in European lobster vary between sexes and locations. As an example one study suggests that lobsters from the Firth of Forth fishery are smaller at onset of sexual maturity (male/female carapace lengths (CL) of 80 mm/79 mm, respectively) than those from the Hebridean fishery (male/female CL of 98 mm/110 mm, respectively; Lizarraga-Cubedo *et al*., 2003). A general UK average would seem to be around 85 mm CL (Burton, 2003). Due to differential growth rates between individuals as a result of environmental variations (e.g. water temperature; Prodöhl *et al*., 2007), age at maturity is also likely to vary but is generally thought to be in the range five to eight years old (Burton, 2003; Lizarraga-Cubedo *et al*., 2003).

3.4.1.14 Reproduction generally occurs during the summer months and can only occur once the female has moulted. Spawning will occur once the female's shell has hardened. Eggs are released from the oviducts, fertilised by passing them across the stored spermatophore and then cemented to the pleopods under the abdomen. At this point the female is described as being 'berried'. Development of the eggs to hatching stage usually takes 9 to 12 months dependent upon water temperature, with release occurring in the following spring (March to May). Hatching continues until September through to as late as October in more northerly areas.

3.4.1.15 Released larvae are free-swimming and will undergo three moults before metamorphosing into a postlarval stage (stage IV). At this stage the postlarvae will start to settle onto the seabed and having found suitable habitat will undergo another moult and become a stage V, Early Benthic Phase (EBP) lobster. Suitable habitat for EBP larvae is thought to be those which provide pre-existing shelter in the form of interstitial spaces (i.e. cobbles and shells; Linnane *et al*., 2000; Mercer *et al*., 2001).

3.4.1.16 There is currently a lack of information about natural movements of wild European lobster due to the difficulty of tracking them successfully. Mark-recapture studies (in inshore waters) using tags of various kinds have shown that natural movements in the wild are normally limited to a few kilometres (Smith *et al*., 1999; 2001). A report by the Eastern Sea Fisheries Joint Committee (ESFJC) (Jessop *et al*., 2007) showed that there was a significant offshore migration of some lobster in the southern North Sea. Approximately 40% of lobster indiviudals tagged and released in inshore waters were recaptured in offshore waters and individuals which showed the most extensive migrations tended to migrate northwards. This report suggested that mature lobster from the Wash and Norfolk coast may migrate northwards, against the prevailing current, to spawn off the Yorkshire coast, so that larvae drift back to inshore grounds and encounter a suitable environment in which to settle. However, there are limited data, particularly lobster larvae data, to lend more support to this theory. European lobster are nocturnal and activity levels seem to relate to water temperature, showing seasonal differences, with low activity in winter and increased movements in the summer months (Smith *et al*., 1999).

3.4.1.17 Although lobster were recorded during historic trawl survey data from across the former Hornsea Zone, these were sporadic and at very low abundances and have therefore not been mapped. Lobster were also recorded at low abundances during site specific surveys at Dudgeon and Sheringham Shoal offshore wind farms (i.e. close to the inshore areas of the Hornsea Three offshore cable corridor) although the sampling methods employed (i.e. trawl surveys) did not specifically target this species and therefore it is expected that this species would be underrepresented. Data collected as part of the Triton Knoll shellfish characterisation may provide some context for shellfish stocks in more offshore locations and showed that lobster abundances were generally highest in areas of rocky and coarse, gravelly sediment and that the majority of the lobster reoorded in the Triton Knoll survey area were noted as being mature (Triton Knoll Offshore Wind Farm Ltd., 2011b). A relatively high number of berried females were recorded in the Triton Knoll survey area during the June survey which were found to be absent during the August survey, suggesting that the lobster recorded were spawning in the vicinity of the Triton Knoll offshore wind farm site. As discussed in paragraph 3.4.1.2, lobster is landed (within ICES rectangle 34F1) in the inshore sections of the Hornsea Three offshore cable corridor, although at a fraction of the weights landed for brown crab. This pattern is replicated across most of the EIFCA area, although due to the high value of lobster, brown crab and lobster contribute equally to the annual mean value of the catch in the EIFCA area (EIFCA, 2015).

Nephrops

3.4.1.18 *Nephrops* live in burrows dug into muddy and sandy sediments, at depths between 20-800 m (Sabatini and Hill, 2008). They feed mainly on detritus, small crustaceans and worms and are most active at night (Scottish Government, 2017). Mating occurs in summer followed by spawning in autumn, when females become "berried", carrying their eggs under their tails for approximately nine months. Females are relative inactive during this period, remaining hidden in burrows so as to make them less vulnerable to fishing during this period. *Nephrops* is more abundant in northern UK waters, although significant populations exist in the Irish and Celtic Seas and on the Fladen Ground off the east coast of Scotland (DECC, 2016a).

3.4.1.19 *Nephrops* was recorded during trawl surveys (see paragraph 3.2.1.3; Figure 3.37) at consistently high abundances within the Hornsea Three array area and in the deep water areas to the north of it (in both otter and beam trawls) and at lower abundances to the northwest of the former Hornsea Zone. These areas of the Hornsea Three fish and shellfish study area are characterised by sandy mud sediments, the preferred habitat for this species. Of those *Nephrops* recorded in the Hornsea Three fish and shellfish study area, 13 were found to be berried during the autumn trawl survey. These berried individuals were recorded in deep water areas to the north of the Hornsea Three array area (trawls 27 and 33) and in Markham's Hole (trawl 31) within the Hornsea Three array area (*Nephrops* spawning habitats are further discussed in section 3.4.2 below).

Common whelk

3.4.1.20 The common whelk is an opportunistic carnivorous marine gastropod widely distributed in the northeast Atlantic and the North Sea and commonly found all around the UK coast. It provides locally important fisheries, particularly on the south and east coasts of Britain. It is slow growing and slow to reach maturity, which makes this species vulnerable to disturbance (e.g. fishing pressure or aggregate extraction; Marine Ecological Surveys Limited 2008).

3.4.1.21 Breeding in European populations of the common whelk occurs during late autumn. Female whelk will usually delay spawning until the water temperature has dropped to 9°C or less, normally in November (Hancock, 1967). Egg clusters are laid onto hard substratum and consist of a number of egg capsules, each containing up to 3,000 eggs (Hancock, 1967).

3.4.1.22 Although whelk can be found in the intertidal zone, they will more normally inhabit subtidal areas. Whelk can be recorded on all types of seabed substratum (Ager, 2008) including gravel, sand, mud and rock, but are typically found in areas of soft seabed, usually comprising a mixture of sand and mud, in which whelk may spend some of their time buried in the sediment (Hancock, 1967). As mentioned above, spawning requires the presence of hard substratum to which egg clusters are attached as they are laid.

3.4.1.23 Whelk were not recorded in surveys undertaken for the Dudgeon or Sheringham Shoal offshore wind farms, although data from the Triton Knoll shellfish characterisation (Triton Knoll Offshore Wind Farm Ltd., 2011b) showed that highest abundances of this species were generally found around the Silver Pit feature. This species is targeted by commercial fisheries operating from the north Norfolk coast and in recent years has become an increasingly important component of the commercial fisheries in the area, both in terms of value and weight of landings (annex 6.1: Commercial Fisheries Technical Report).

Other shellfish species

3.4.1.24 As detailed in section 3.4.1, other commercially important crustacean species known to occur off the north Norfolk coast and the greater Wash (i.e. in the vicinity of the Hornsea Three offshore cable corridor, including velvet swimming crab and shrimps (i.e. brown shrimp and pink shrimp)).

3.4.1.25 Data collected as part of the Triton Knoll shellfish characterisation may provide some context for shellfish stocks in more offshore locations and showed that velvet swimming crab was generally found to be associated with coarse sediments within the Triton Knoll site and around the Silver Pit feature (Triton Knoll Offshore Wind Farm Ltd., 2011b). This species was also found to be abundant in trawl samples during the Dudgeon and Sheringham Shoal offshore wind farm surveys (i.e. close to the nearshore sections of the Hornsea Three offshore cable corridor; Dudgeon Offshore Wind Limited, 2009; Scira Offshore Energy, 2006). This species has only recently been considered a commercially important species in the region and is only stated as being recorded as a "major species" in the ESFJC Annual Reports in 2005 (Jessop *et al*., 2007).

3.4.1.26 As detailed in paragraph 3.4.1.4, brown and pink shrimp are targeted by commercial fishing vessels in the region and both species were recorded during epibenthic beam trawl surveys (see paragraph 3.2.1.3; Figure 3.38). Brown shrimp was recorded throughout the Hornsea Three fish and shellfish study area with highest abundances within the Hornsea Three array area and to the south of the former Hornsea Zone. Pink shrimp was recorded in low abundances in offshore areas, including the former Hornsea Zone, but were present at extremely high abundances (>1000 individuals per 500 m) in inshore areas, particularly in the vicinity of the Silver Pit feature offshore from the Humber Estuary, which is characterised by coarse, gravelly sediments.

3.4.1.27 These species were also abundantly recorded during characterisation studies for both the Dudgeon and Sheringham Shoal offshore wind farms (i.e. in the vicinity of the nearshore section of the Hornsea Three offshore cable corridor; Dudgeon Offshore Wind Limited, 2009; Scira Offshore Energy, 2006). Pink shrimp in particular were recorded in extremely high abundances in late summer and autumn trawl samples, with lower abundances in spring. The shrimp fishery in the region is largely concentrated in areas to the west of the Hornsea Three offshore cable corridor in the Wash and along the Lincolnshire coast, although fishing activity targeting shrimp species also extends to the inshore areas along the north Norfolk coast (ESFJC, 2010).

3.4.1.28 European common squid was recorded throughout the Hornsea Three fish and shellfish study area, within the Hornsea Three array area and across the wider former Hornsea Zone (Figure 3.38), and was identified as one of the characterising species in the otter trawl dataset (see paragraph 3.2.1.4). Abundances were generally similar between spring and autumn.

3.4.1.29 The southern North Sea is not an ideal habitat for most cephalopods due to its shallow water depths with European common squid, the dominant cephalopod species in this region. This species is widespread throughout the North Sea, and is most abundant in central and northern parts in winter (DECC, 2016b). It favours warmer waters and so typically migrates into shallower water in summer (including the southern North Sea) and into deeper, relatively warmer waters in winter. During spawning males and females are known to move inshore during summer for the spawning season, which is restricted to June and July in the North Sea (Hastie *et al*., 2009).

3.4.2 Shellfish spawning and nursery habitats

3.4.2.1 There is limited information available on shellfish spawning and nursery habitats in the southern North Sea, though information on these habitats for some species has been provided by a number of sources and these have been mapped to show their location in relation to the Hornsea Three fish and shellfish study area.

3.4.2.2 The most commonly recorded shellfish species in the Hornsea Three fish and shellfish study area was brown crab and information on crab spawning habitats has been previously collected through crab larvae surveys undertaken in 1976, 1993 and 1999 (Eaton *et al*., 2003). These surveys showed that the epicentres of brown crab spawning activity were located between the south Yorkshire coast and Hornsea Three array and an area to the west of the offshore section of the Hornsea Three cable corridor (Eaton *et al*., 2003; see Figure 3.37). This supports the findings of tagging studies (Jessop *et al*., 2007; MAFF, 1966) which indicated that mature females make significant northward migrations along the Yorkshire coast to spawn. A recent Defra (2008) study on the genetic differences of North Sea brown crab populations concluded that there were no significant genetic differences between sites within the North Sea, suggesting that the North Norfolk crab stock is relatively well mixed with stocks in other fishing grounds up and down the east coast. As discussed in paragraph 3.4.1.9, the historic surveys across the former Hornsea Zone showed that berried crab were present in low abundances in spring trawls in the centre of the former Hornsea Zone and to the north of the Hornsea Three array area. Due to the presence of this species (including berried individuals) within the Hornsea Zone and records of this species from desktop information along the Hornsea Three offshore cable corridor (as discussed in section 3.4.1 above), it is likely that overwintering crab occur generally within the Hornsea fish and shellfish study area.

3.4.2.3 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.

3.4.2.4 There is limited information on lobster spawning or nursery habitats in the southern North Sea and abundances of lobster during Hornsea Three surveys and supporting desktop information were generally reported to be low. It has been suggested that nearshore waters close to the Humber Estuary may represent overwintering grounds and/or nursery habitat for this species, although it is difficult to make firm conclusions due to the low abundances in these areas (SMart Wind, 2015).

3.4.2.5 Coull *et al*. (1998) mapped *Nephrops* spawning and nursery habitats which coincide with the Hornsea Three fish and shellfish study area (including the Hornsea Three array area) and extend further to the east, northeast and southeast. Spawning is likely to occur throughout the year, with a peak between April and June. *Nephrops* were recorded within and to the north of the Hornsea Three array area and berried *Nephrops* were recorded during the autumn trawl survey in deep waters within the Hornsea Three array area and immediately to the north of it. This supports the conclusion that spawning and nursery grounds for this species are present in the area (Figure 3.37).

3.4.2.6 There is limited information on squid spawning or nursery habitats in the southern North Sea. Although no spawning grounds have been positively identified in the North Sea, squid in spawning condition are caught every year in the North Sea, particularly during January to March (DTI, 2002; DECC, 2016b).

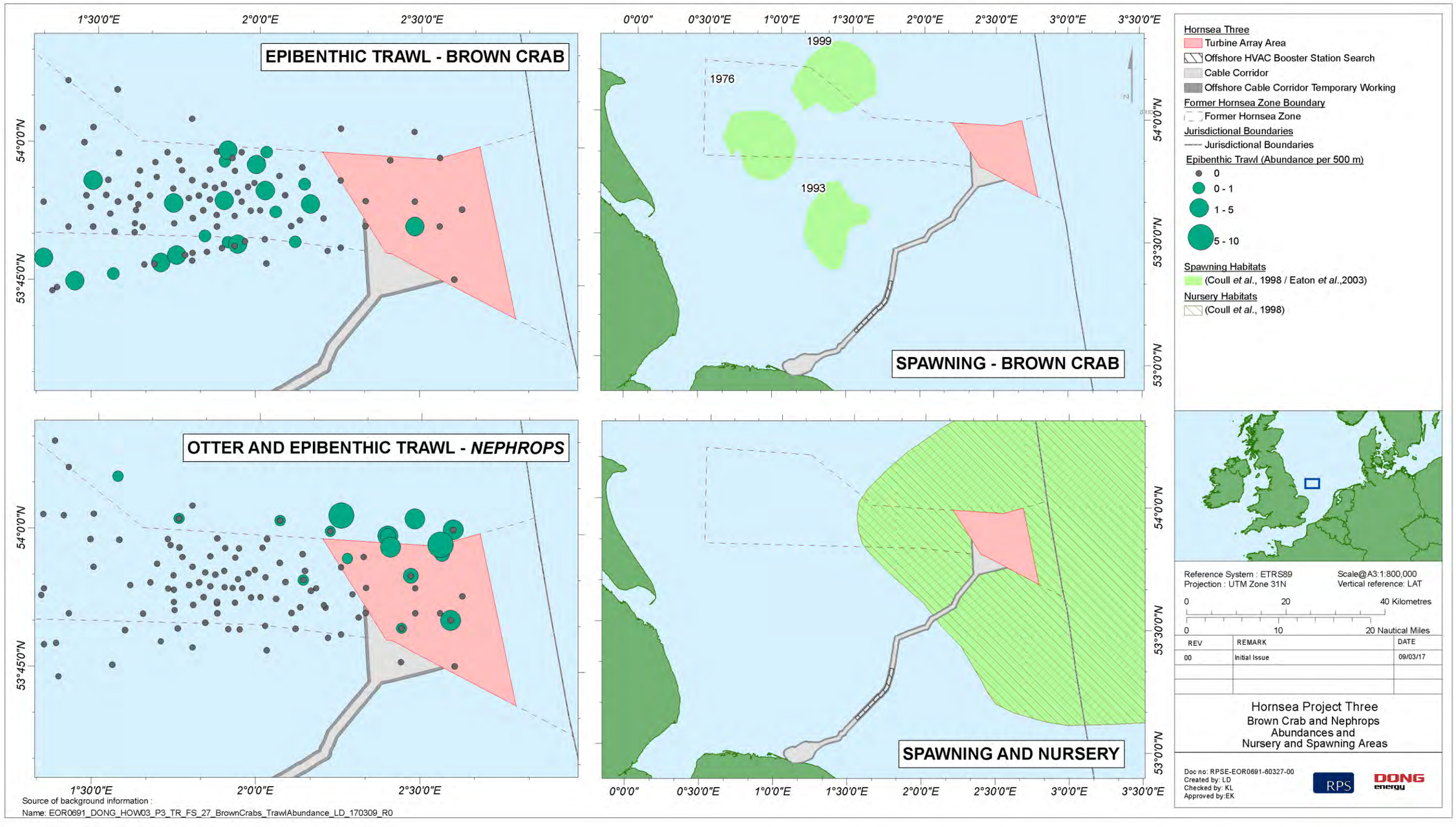


Figure 3.37: Brown crab and *Nephrops* abundances and nursery and spawning habitats within the Hornsea Three fish and shellfish study area.

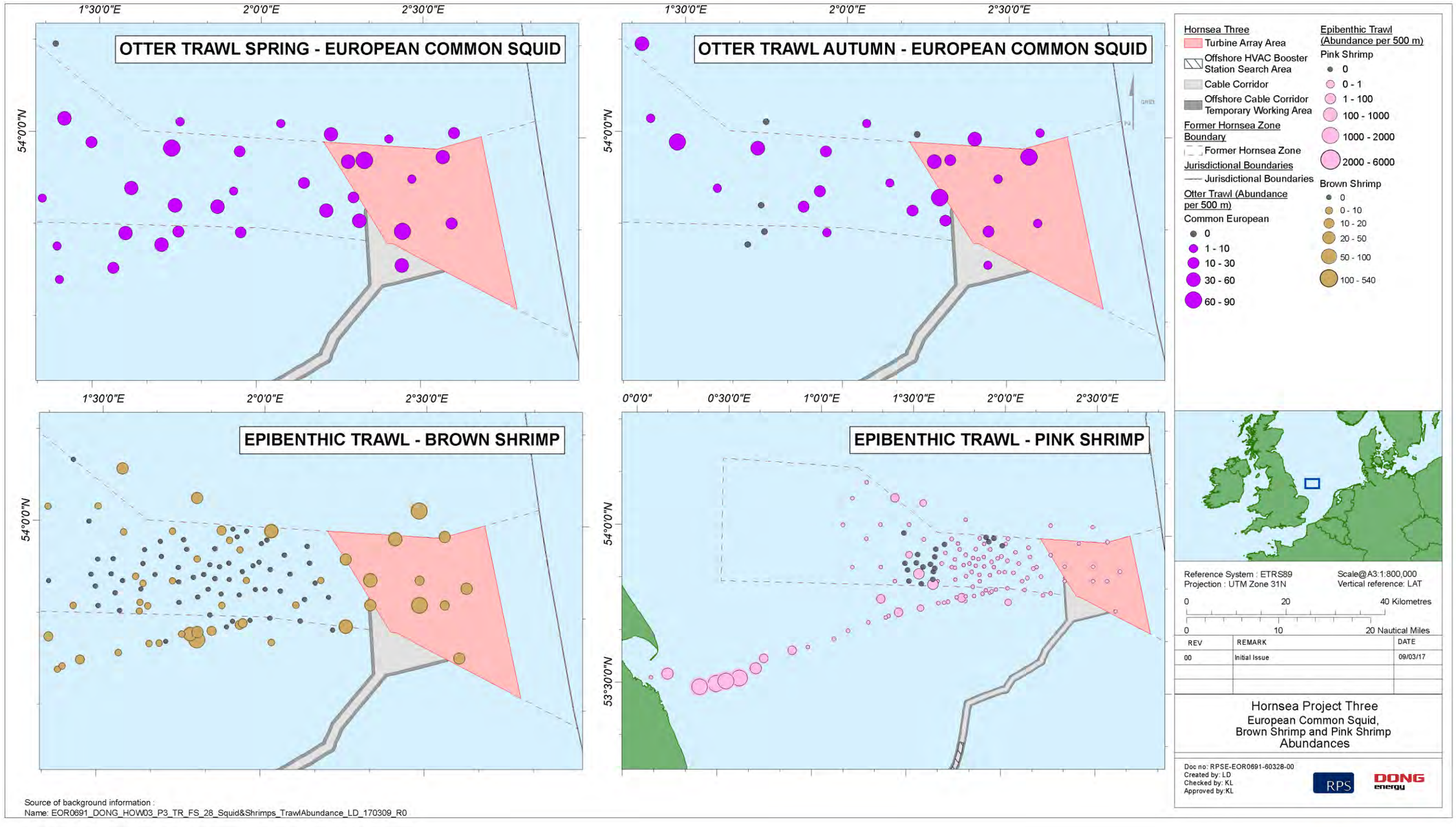


Figure 3.38: European common squid, brown shrimp and pink shrimp abundances within the Hornsea Three fish and shellfish study area.

4. Discussion

4.1 Overview

4.1.1.1 This study has described the key attributes of the fish and shellfish community in the Hornsea Three fish and shellfish study area and the wider southern North Sea and identified valuable features including distribution and abundance of key fish and shellfish species, spawning and nursery activity, commercial and conservation importance, migratory species and species of ecological importance (e.g. important prey species for other marine species, including other fish species, birds and marine mammals). This section provides a summary of each of the fish and shellfish receptors that have the potential to be impacted by Hornsea Three 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 southern North Sea fish and shellfish study area has been provided.

4.2 Definition of Valued Ecological Receptors

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 rMCZs). However, only a very small proportion of marine habitats and species are afforded protection under the existing legislative or policy framework and therefore evaluation must also assess value according to the functional role of the habitat or species. For example, some features may not have a specific conservation value in themselves, but may be functionally linked to a feature of high conservation value (e.g. fish as prey species for protected bird or marine mammal species). The following table shows the criteria applied to determining the ecological value of valued ecological receptors (VERs) within the geographic frame of reference applicable to the Hornsea Three fish and shellfish study area (Table 4.1), and have been derived using guidelines published by the CIEEM (2016).

Table 4.1: Criteria used to inform the valuation of ecological receptors in the Hornsea Three fish and shellfish study area.

Value of VER	Criteria to define value
International	Internationally designated sites. Species protected under international law (i.e. Annex II species listed as features of SACs).
National	Nationally designated sites. Species protected under national law. Annex II species which are not listed as features of SACs in the Hornsea Three fish and shellfish study area. UK BAP priority species (including 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 broad scale habitats), species of principal importance and NIMF that have nationally important populations within the Hornsea Three fish and shellfish study area, particularly in the context of species/habitat that may be rare or threatened in the UK [a]. Species that have spawning or nursery areas within the Hornsea Three fish and shellfish study area that are important nationally (e.g. may be primary spawning/nursery area for that species).
Regional	UK BAP priority species (including 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 broad scale habitats), species of principal importance or NIMF that have regionally important populations within the Hornsea Three fish and shellfish study area (i.e. are locally widespread and/or abundant). Species that are of commercial value to the fisheries which operate within the southern North Sea fish and shellfish study area. Species that form an important prey item for other species of conservation or commercial value and that are key components of the fish assemblages within the Hornsea Three fish and shellfish study area. Species that have spawning or nursery areas within the Hornsea Three fish and shellfish study area that are important regionally (i.e. species may spawn in other parts of the UK but that this is key spawning/nursery area within the southern North Sea fish and shellfish study area as the region of interest).
Local	Species that are of commercial importance but do not form a key component of the fish assemblages within the Hornsea Three fish and shellfish study area (e.g. they may be exploited in deeper waters outside the Hornsea Three fish and shellfish study area). The spawning/nursery area for the species are outside the Hornsea Three fish and shellfish study area. The species is common throughout the UK but forms a component of the fish assemblages in the Hornsea Three fish and shellfish study area.

a: Measured against criteria such as OSPAR threatened/declining species and IUCN Red List of threatened species.

4.3 Fish ecology

4.3.1.1 The fish ecology of the Hornsea Three fish and shellfish study area was 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 Three fish and shellfish study area included lemon sole, common sole, cod, elasmobranchs (e.g. thornback and spotted ray), sandeels (important prey species for other fish species, marine mammals and birds) and small demersal species such as lesser weever, scaldfish and common dragonet. Pelagic fish species were also recorded abundantly throughout the Hornsea Three fish and shellfish study area with sprat identified as one of the key characterising species of the fish assemblage and herring also recorded throughout the Hornsea Three fish and shellfish study area. Both of these pelagic species were found to vary seasonally with both species much more abundant during spring than autumn, and are likely to represent important prey for marine mammal and bird species in the region. Mackerel, another pelagic species, was recorded at higher abundances in autumn than spring. These differences in abundances accounted for the seasonal variation in the trawl dataset. Depth was found to have an influence on the spatial patterns in the trawl datasets, with the fish communities in the shallow, inshore areas close to the Humber Estuary found to be significantly different from those of the deeper offshore parts of the Hornsea Three fish and shellfish study area (i.e. the Hornsea Three array area).

4.3.1.2 Fish communities in the nearshore section of the Hornsea Three offshore cable corridor reflect those patterns discussed above, with the fish assemblage typical of the southern North Sea fish assemblage, albeit at lower abundances than in offshore areas. In addition, inshore areas provide nursery habitats for a number of species including plaice, lemon sole and herring. The influence of shellfish communities on the overall assemblage was also found to be greater in this area, with commercial fisheries dominated by these species (see section 4.3.1.3).

4.3.1.3 Table 4.2 provides a summary of the fish species (i.e. VERs) recorded within the Hornsea Three fish and shellfish study area, with specific reference to the commercial, conservation and ecological importance of each species within the Hornsea Three fish and shellfish study area in order to assign valuations to each of the receptors following the criteria in Table 4.1.

4.4 Shellfish ecology

4.4.1.1 The shellfish ecology of the Hornsea Three fish and shellfish study area was found to be primarily characterised by four commercial species: brown crab, European lobster, *Nephrops* and common whelk. Of these species, brown crab was found to be by far the most abundant species in the Hornsea Three fish and shellfish study area, especially along the nearshore section of the Hornsea Three offshore cable corridor where it is targeted by commercial fisheries along the north Norfolk coast. Lobster is also present along the Hornsea Three offshore cable corridor though at much lower abundances. Both these species are particularly important to commercial fisheries in the southern North Sea. Whelk is also targeted by commercial fisheries along the Hornsea Three offshore cable corridor, with increasing importance to commercial fisheries in recent times.

4.4.1.2 *Nephrops*, in contrast, were recorded consistently in deep water, sandy mud habitats within the Hornsea Three array area and in the deep waters to the north and northwest of it, where they are targeted by commercial fishing fleets from the UK, Belgium and Netherlands.

4.4.1.3 Other shellfish species known to occur in the Hornsea Three fish and shellfish study area including velvet swimming crab, pink shrimp (both abundant in inshore areas), brown shrimp and European common squid (both abundant throughout the former Hornsea Zone).

4.4.1.4 Potential nursery habitats for brown crab occur in the nearshore sections of the Hornsea Three offshore cable corridor with historic records of relatively high abundances of juveniles recorded in these areas. Spawning and nursery habitats for *Nephrops* are also known to occur in the Hornsea Three fish and shellfish study area, with egg bearing *Nephrops* recorded in the Hornsea Three array area.

4.4.1.5 As for fish VERs, Table 4.2 provides a summary of the shellfish species (i.e. VERs) recorded within the Hornsea Three fish and shellfish study area, with specific reference to the commercial and ecological importance of each species within the Hornsea Three fish and shellfish study area in order to assign valuations to each of the receptors following the criteria in Table 4.1.

Table 4.2: Summary of Fish and Shellfish Valued Ecological Receptors (VERs) and their value/importance within the Hornsea Three fish and shellfish study area.

VER	Valuation	Justification
Demersal Fish Species		
Whiting	Regional	Most abundantly recorded species and widely distributed across the Hornsea Three 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).
Cod	Regional	Recorded at low abundances throughout the Hornsea Three fish and shellfish study area. Low intensity spawning and nursery habitats, with high intensity nursery to the west of the former Hornsea Zone. Commercially important species. UK BAP species, listed by OSPAR as threatened and/or declining and listed as vulnerable on the IUCN Red List.
Dab	Regional	Abundantly recorded throughout Hornsea Three fish and shellfish study area and one of the key characterising species. Fished commercially, though usually as by-catch.
Plaice	Regional	Recorded at moderate abundances throughout the Hornsea Three fish and shellfish study area and one of the key characterising species. High intensity spawning habitats with low intensity nursery habitats in inshore areas. Commercially important species. UK BAP species.
Lemon sole	Local	Recorded at low abundances. Spawning and nursery habitats coinciding with the Hornsea Three fish and shellfish study area. Targeted by commercial fishing vessels.
Common sole	Local	Recorded at very low abundances within the Hornsea Three fish and shellfish study area. Low intensity spawning and nursery grounds, though likely to be at the northern extent of the main spawning and nursery areas. Commercially important species. UK BAP species.
Other demersal species	Local	Includes grey gurnard and solenette (key characterising species of the fish assemblage) and small demersal species. No information on spawning or nursery habitats. Little or no commercial importance. Not listed under nature conservation legislation. Likely prey items for fish, bird and marine mammal species.
Elasmobranchs	Local	Species include thornback, spotted, blonde and cuckoo ray, spurdog, starry smooth hound, basking shark and lesser spotted dogfish. All recorded at low abundances. Spawning and nursery habitats for thornback ray in inshore sections of Hornsea Three offshore cable corridor and low intensity nursery for spurdog and tope. Low commercial value in the southern North Sea. Many elasmobranch species listed as UK BAP species or listed by OSPAR as threatened and/or declining.
Pelagic Fish Species		
Herring	Regional	Recorded at moderate abundances. Nursery habitats likely to occur throughout the Hornsea Three fish and shellfish study area. Autumn spawning ground located to the west of the former Hornsea Zone, off Flamborough Head. UK BAP species and nationally important marine feature. Prey species for birds and marine mammals. Important commercial fish species.
Sprat	Regional	Abundantly recorded throughout the Hornsea Three 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.
Mackerel	Local	Seasonally abundant, with relatively high abundances in autumn within the Hornsea Three fish and shellfish study area. Spawning and nursery habitats (low intensity) present. UK BAP species and nationally important marine feature. Commercially important species.
Benthopelagic Fish Species		
Sandeels	Regional	Recorded throughout the Hornsea Three fish and shellfish study area. Low intensity spawning and nursery habitats occur across the Hornsea Three fish and shellfish study area, high intensity spawning grounds immediately to the north of the Hornsea Three array area. Important prey species for fish, birds and marine mammals. Commercially important species. UK BAP species and a nationally important marine feature.
Migratory Fish Species		
River lamprey, sea lamprey, Atlantic salmon, twaite shad, allis shad, sea trout, European eel and European smelt	Regional to International	Likely to undertake migratory movements through the Humber Estuary and other SACs/SCIs in the southern North Sea fish and shellfish study area. Atlantic salmon and twaite shad recorded during historic surveys across the former Hornsea Zone, albeit at very low abundances. River and sea lamprey, Atlantic salmon and allis and twaite shad are 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. Sea trout, European eel and European smelt are all listed as UK BAP priority species and European eel is listed as critically endangered on the IUCN Red List and therefore of regional importance.
Shellfish Species		
Brown (Edible) crab	Regional	Most important commercial shellfish species in the Hornsea Three fish and shellfish study area, particularly along the Hornsea Three offshore cable corridor. Targeted by north Norfolk commercial fisheries. Likely to overwinter within the Hornsea Three fish and shellfish study area and potential nursery habitat in inshore areas.
European lobster	Regional	Considerably less abundant than brown crab but high commercial value and therefore important species to local fisheries.
Nephrops	Regional	Recorded primarily in deep water within the Hornsea Three array area and to the north of it, coinciding with known spawning and nursery habitats. Commercially important in the Hornsea Three fish and shellfish study area.
Common whelk	Local	Present within the nearshore section of the Hornsea Three offshore cable corridor and of increasing commercial importance to north Norfolk fisheries.
Other shellfish species	Local	Species include velvet swimming crab, brown and pink shrimp in the nearshore section of the Hornsea Three offshore cable corridor and are targeted by commercial fishing fleets in the southern North Sea fish and shellfish study area. European common squid recorded throughout the Hornsea Three fish and shellfish study area though of limited value to commercial fisheries.

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Appendix A Otter Trawl Method Statement

A.1 Hornsea Three fish and shellfish study area

A.1.1.1 Figure A.1 shows the locations of the otter trawl samples deployed to collect data on fish and shellfish resources across the Hornsea Three fish and shellfish study area during both the spring and autumn surveys. In total, the survey array consisted of 41 tow lines although three of these in spring and five in autumn were not trawled due to the presence of static fishing gears and receipt of advice from the fishing industry to avoid these areas. The rationale for a broad scale sampling strategy was to characterise spatial and temporal trends in highly mobile and wide ranging receptors to inform project level assessments and the Zone Appraisal and Planning (ZAP) processes. A number of trawl samples were also collected outside of the boundaries of the former Hornsea Zone to provide a wider context within which the Hornsea data could be set.

A.2 Sample survey design

A.2.1.1 The survey was designed in consultation with Cefas, on behalf of the MMO and also the NFFO (representing local commercial fishing organisations) to ensure all relevant statutory and non-statutory concerns were addressed. As detailed in section 2.2, the approach proposed by Hornsesa Three for the purposes of characterising the fish and shellfish communities within the study area was an evidence based approach to the EIA, which involves utilising existing data and information from sufficiently similar or analogous studies to inform baseline understanding and/or impact assessments for a new proposed development. The data/knowledge acquired through the former Hornsea Zone studies and from the surveys and characterisations undertaken for Hornsea Project One and Hornsea Project Two were therefore used to inform the EIA for Hornsea Three. This approach was agreed during a series of meetings conducted between June 2016 and February 2017 with the MMO, Cefas and Natural England (see section 2.2).

A.2.1.2 Trawl sample locations were located on the basis of bathymetry and broad seabed habitat type as defined by the Mapping European Seabed Habitats (MESH) project. The findings of scientific beam trawl sampling surveys undertaken as part of earlier benthic ecology surveys across the former Hornsea Zone were also taken into account to inform the sample array of spatial population trends.

A.2.1.3 Surveys were carried out between the 15 and 23 April 2011 (spring) and the 29 September and 2 October 2011 (autumn) to account for seasonal changes in the abundance of fish and shellfish. Demersal trawls were collected using a commercial fishing vessel (MFV Emulator) on charter from the NFFO (Figure A.2). Care was taken to ensure that sampling methods and gears used were identical for both survey occasions to allow spatial and temporal comparison of the abundance, species richness and size and age structure of fishes present.

A.3 Gear set-up

A.3.1.1 A Whitby Jet otter trawl was used throughout. The construction of the net was:

- Net: 96 foot (ft) fishing line, 76 ft headline. Cod-end mesh: 40 mm diamond constructed from 4 mm double braided twine. Lifting bag mesh 180 mm;
- Ground Gear: 16” rockhoppers with 8” spacers in central 21 ft. 14” rockhoppers with 8-15” spacers in 21 ft on either side. 15 ft wing chains of 5/8” links;
- Sweeps (Bridles): Top: 24 fathom wire. Bottom: 24 fathom chain. Doors: Patent B. 6’6”, 72 stone (458 kg); and
- Fishing gear characteristics: Estimated headline height: 15 ft. Door-to-door spread estimated at approximately 90 ft with 80 fathoms of warp out and 98 ft with 100 fathoms out, towing at 3-4 knots.

A.3.1.2 The standard gear used was a high opening otter trawl with a 40 mm cod-end mesh, used to retain small fish. The gear was towed at approximately 4 knots (over the ground) for 30 minutes, averaging 2 nautical miles (NM) per tow. Fishing was only carried out in daylight, shooting after sunrise and hauling no later than sunset, as the vertical distribution of some species is known to vary diurnally.

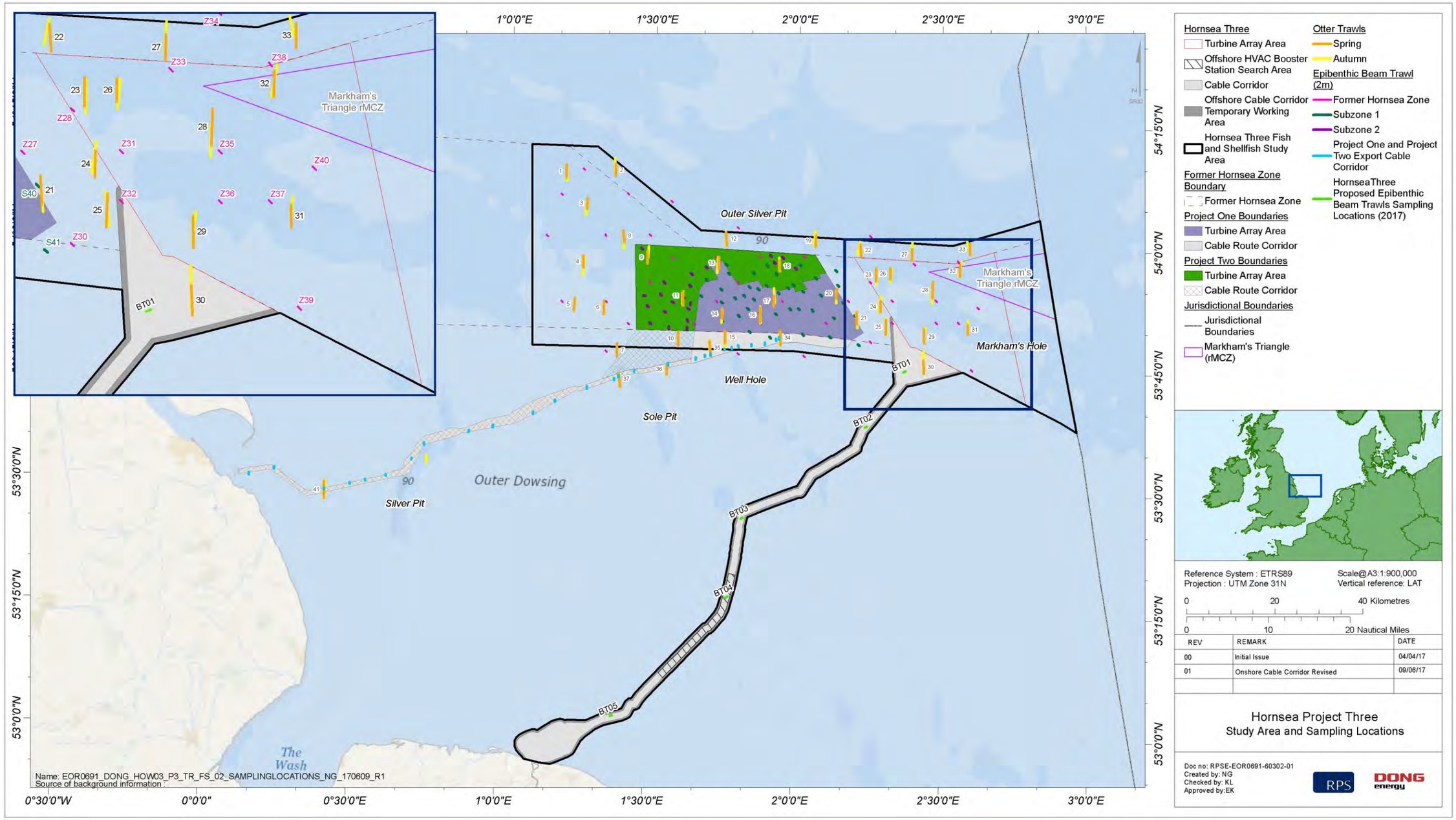

Figure A.1: Locations of completed trawl surveys, spring and autumn 2011 (note trawls 38 and 40 were not completed during either the spring or autumn survey).

Figure A.2: F.V. Emulator.

A.4 On-board sample treatment and recording

A.4.1 Observer recording

A.4.1.1 Once on board, trawl samples were displayed on a sorting tray and photographed (see Appendix B). The catch was then sorted to species level, where possible, with any unidentified species returned to EMU's marine biological laboratory for identification. Species were identified based on Maitland and Herdson (2010) and Whitehead *et al.* (1986).

A.4.1.2 Elasmobranchs, lobster and brown crab were sorted by sex. Total lengths (TL) were measured to the nearest millimetre for shellfish and rounded down to the nearest half centimetre for all fish species (Table A.2). Species names were standardised to the nomenclature of Appletans *et al*. (2011).

Table A.1: Categories for each catch and record types.

Category	Portion of Catch	Record
1	Elasmobranchs (and other large or conspicuous species, if applicable).	Species Abundance Length frequency distribution Sex
2	Commercially important species (e.g. plaice, sole, cod, whiting, haddock, herring); Species of nature conservation importance (UK BAP species) and migratory species (e.g. eel, lamprey, shad); and Sandeels.	Species Abundance Length frequency distribution Presence of obviously running/gravid herring and other species where possible
3	Commercially important shellfish species (e.g. brown crab, lobster, scallop).	Species Abundance Length frequency distribution Berried/gravid Soft (e.g. recently moulted)
4	Other species: Low-commercial value fish (e.g. horse mackerel, gurnard) and trash fish (e.g. dragonets, seasnails, pogge).	Species Abundance Length frequency distribution
5	Other observations.	Residual substrate material Weed / sessile epifauna Litter

A.4.1.3 Categories 1-4 above were identified to species level then enumerated and measured (as specified in Table A.2 below).

Table A.2: Measurements taken of taxa caught in the trawls.

Taxa	Measurement
Fish	Total length
Rajids	Disk width and TL
Lobster, spider crab, Norway lobster	Carapace length
Brown (edible) crab	Carapace width
Squid, cuttlefish	Mantle length
Bivalves (scallop)	Shell width
Gastropod (whelk)	Shell length

A.4.1.4 Adult herring (individuals larger than 20 cm total length) caught during the autumn survey were transferred to the laboratory for Gonado-Somatic Index analysis (GSI). This calculates the mass of the gonads as a proportion of the total body mass. It is a tool to assess sexual maturity in correlation to gonad development. The maturity scale used was from Bucholtz *et al*. (2008), a modification of ICES GSI, 1963.

A.4.2 Environmental data

A.4.2.1 Depth soundings as recorded by the survey vessel echosounder were recorded at the beginning and end of each trawl. The depths were converted from fathoms to metres and then further converted using the TotalTide software package. Daily average sea surface temperatures were gathered from the oceanographic wave buoys deployed in the Hornsea region. Information on substrate type was acquired as part of the on-site observations of the contents of each trawl and from the previous benthic ecology characterisation survey (annex 2.1: Benthic Subtidal and Intertidal Ecology Technical Report).

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Appendix B Otter Trawl Logs and Data

B.1 Logs

B.1.1 Otter trawling positions and related information – Spring

Hornsea Round Three Offshore Wind Farm Zone Fish Ecology Surveys J/1/03/1784

Entered by: LJB & ELH

Date entered: 6/5/11

QC by: JLW

Date of QC:

Sampling Location	Date	Point on line	WGS84 UTM (Z31N)		WGS84 (DD)		Time (GMT)	Depth (BCD m)	Trawl speed (knots)	Distance (m)	Direction of travel	Comments
			Easting	Northing	Latitude	Longitude						
T1	15/04/11	Start	382138	6003731	54.168100°N	1.194567°E	15:16	75.7	3.2	3049	With Current	Photos of entire sample split.
		End	382070	6000682	54.140700°N	1.194717°E	12:46	55.3				
T2	15/04/11	Start	393368	6001162	54.147483°N	1.367417°E	14:34	71.9	2.7	2672	Into Current	
		End	393295	6003834	54.171467°N	1.365350°E	15:04	75.4				
T3	15/04/11	Start	386928	5996125	54.100850°N	1.270750°E	16:33	51.6	3.1	2468	With Current	
		End	386788	5993661	54.078683°N	1.269533°E	17:03	46.2				
T4	16/04/11	Start	385978	5983119	53.983800°N	1.261117°E	05:35	37.6	3.4	2794	With Current	Photo of subsample- not a sub, just part of main trawl.
		End	385965	5980325	53.958700°N	1.261967°E	06:05	38.4				
T5	22/04/11	Start	383718	5970623	53.871033°N	1.231417°E	16:15	32.4	3.7	2797	With Current	
		End	383961	5973409	53.896117°N	1.234067°E	16:45	32.6				
T6	22/04/11	Start	390540	5969760	53.864767°N	1.335433°E	13:14	29.9	3.7	3086	With Current	
		End	390608	5972845	53.892500°N	1.335367°E	13:44	32.4				

Sampling Location	Date	Point on line	WGS84 UTM (Z31N)		WGS84 (DD)		Time (GMT)	Depth (BCD m)	Trawl speed (knots)	Distance (m)	Direction of travel	Comments
			Easting	Northing	Latitude	Longitude						
T7	22/04/11	Start	393584	5960231	53.779783°N	1.385000°E	11:04	26.2	3.3	2969	Into Current	
		End	393565	5963199	53.806450°N	1.383683°E	11:34	28.5				
T8	16/04/11	Start	394930	5988709	54.035917°N	1.395650°E	10:29	45.5	2.5	2571	Into Current	
		End	395224	5986155	54.013033°N	1.401017°E	10:59	39.5				
T9	16/04/11	Start	400391	5981251	53.970000°N	1.481433°E	12:26	37.4	3.2	2829	Across Current	
		End	400531	5984077	53.995417°N	1.482650°E	12:57	37.8				
T10	21/04/11	Start	407378	5962729	53.804867°N	1.593517°E	15:58	26.7	3.9	3103	With Current	
		End	407421	5965831	53.832750°N	1.593233°E	16:28	27.4				
T11	16/04/11	Start	408561	5975023	53.915550°N	1.607850°E	15:50	34.6	3.3	3369	With Current	
		End	408488	5971655	53.885267°N	1.607717°E	16:20	31.9				
T12	17/04/11	Start	418260	5988333	54.036767°N	1.751867°E	05:42	72.3	3.0	3083	Into Current	
		End	418458	5985256	54.009150°N	1.755717°E	06:12	66.5				
T13	17/04/11	Start	416661	5982799	53.986783°N	1.728983°E	08:27	34.3	3.2	2732	Into Current	
		End	416648	5980067	53.962233°N	1.729533°E	08:57	29.7				
T14	17/04/11	Start	417362	5970977	53.880667°N	1.742867°E	10:52	30.3	2.4	2147	Into Current	
		End	417324	5968830	53.861367°N	1.742867°E	11:22	30.9				
T15	21/04/11	Start	418050	5965935	53.835467°N	1.754683°E	11:15	29.9	3.2	2689	Into Current	
		End	418020	5963246	53.811300°N	1.754933°E	11:45	31.4				
T16	17/04/11	Start	425942	5967919	53.854483°N	1.874100°E	13:15	29.2	3.6	3412	With Current	
		End	426002	5971331	53.885150°N	1.874183°E	13:45	30.0				
T17	17/04/11	Start	429110	5971526	53.887333°N	1.921417°E	15:57	27.7	2.9	2424	Across Current	
		End	429255	5973945	53.909100°N	1.923067°E	16:27	28.8				
T18	18/04/11	Start	430485	5979470	53.958917°N	1.940533°E	05:48	38.1	2.9	2489	Into Current	
		End	430409	5981959	53.981267°N	1.938800°E	06:18	37.9				
T19	18/04/11	Start	438751	5987685	54.033783°N	2.064833°E	09:09	69.3	3.4	2592	Across Current	
		End	438635	5985096	54.010500°N	2.063583°E	09:39	79.7				
T20	18/04/11	Start	443471	5975493	53.924750°N	2.139150°E	13:33	30.6	2.5	2210	Into Current	
		End	443273	5973292	53.904950°N	2.136550°E	14:03	29.8				

Sampling Location	Date	Point on line	WGS84 UTM (Z31N)		WGS84 (DD)		Time (GMT)	Depth (BCD m)	Trawl speed (knots)	Distance (m)	Direction of travel	Comments
			Easting	Northing	Latitude	Longitude						
T21	21/04/11	Start	447856	5970291	53.878467°N	2.206817°E	05:54	31.3	3.5	2886	With Current	
		End	447983	5967408	53.852567°N	2.209233°E	06:24	32.5				
T22	18/04/11	Start	448945	5982871	53.991633°N	2.221267°E	11:22	58.1	3.1	2702	Into Current	Small Dab roe becoming visible
		End	448772	5985568	54.015850°N	2.218183°E	11:53	72.9				
T23	19/04/11	Start	452324	5980226	53.968183°N	2.273217°E	07:47	49.5	3.5	2986	Across Current	
		End	452303	5977241	53.941350°N	2.273367°E	08:17	37.6				
T24	18/04/11	Start	453338	5970124	53.877483°N	2.290217°E	15:33	34.9	3.2	2728	Across Current	
		End	453417	5972851	53.902000°N	2.291000°E	16:03	36.0				
T25	20/04/11	Start	454496	5965126	53.832667°N	2.308567°E	15:22	32.0	4.1	3375	With Current	
		End	454628	5968498	53.862983°N	2.310083°E	15:52	35.8				
T26	19/04/11	Start	455595	5980164	53.967917°N	2.323083°E	10:50	51.9	3.1	2431	Slack Water	
		End	455574	5977733	53.946067°N	2.323117°E	11:20	37.1				
T27	19/04/11	Start	460446	5981971	53.984550°N	2.396800°E	05:38	63.0	2.5	2576	Into Current	
		End	460522	5984546	54.007700°N	2.397617°E	06:08	67.7				
T28	20/04/11	Start	465232	5977069	53.940833°N	2.470333°E	05:39	36.2	3.5	3731	With Current	
		End	465080	5973341	53.907317°N	2.468450°E	06:09	35.6				
T29	20/04/11	Start	463300	5963029	53.814517°N	2.442583°E	12:05	32.2	3.7	3226	With Current	
		End	463221	5966254	53.843500°N	2.441000°E	13:24	39.7				
T30	20/04/11	Start	463078	5959244	53.780483°N	2.439667°E	10:51	28.5	3.8	2987	With Current	
		End	463187	5956260	53.753667°N	2.441683°E	11:21	27.9				
T31	20/04/11	Start	473181	5965128	53.833983°N	2.592483°E	07:53	43.2	3.0	2243	Into Current	
		End	473123	5967370	53.854133°N	2.591400°E	08:23	30.6				
T32	19/04/11	Start	471454	5980889	53.975550°N	2.564767°E	15:28	48.8	2.9	2619	Across Current	
		End	471392	5978271	53.952017°N	2.564067°E	15:58	39.6				
T33	19/04/11	Start	473651	5983188	53.996333°N	2.598067°E	13:26	62.1	3.2	2520	With Current	
		End	473679	5985708	54.018983°N	2.598267°E	13:56	55.5				
T34	21/04/11	Start	430576	5966058	53.838400°N	1.944950°E	08:28	27.2	4.0	3295	With Current	
		End	430618	5962764	53.808800°N	1.946333°E	08:58	28.3				

Sampling Location	Date	Point on line	WGS84 UTM (Z31N)		WGS84 (DD)		Time (GMT)	Depth (BCD m)	Trawl speed (knots)	Distance (m)	Direction of travel	Comments
			Easting	Northing	Latitude	Longitude						
T35	21/04/11	Start	414847	5960255	53.783917°N	1.707583°E	13:40	29.5	4.2	3476	With Current	
		End	414484	5963712	53.814917°N	1.701117°E	14:10	33.8				
T36	22/04/11	Start	404790	5956033	53.744233°N	1.556300°E	05:45	26.7	2.7	2505	Slack Water	
		End	404922	5958534	53.766733°N	1.557533°E	06:15	26.8				
T37	22/04/11	Start	393842	5956546	53.746733°N	1.390183°E	08:27	47.4	4.0	3253	With Current	
		End	394232	5953317	53.717800°N	1.397200°E	08:57	26.9				
T41	23/04/11	Start	327074	5932021	53.508650°N	0.392250°E	06:09	13.7	4.2	3956	With Current	Herring Running
		End	326958	5928066	53.473100°N	0.392683°E	06:39	12.3				

B.1.2 Otter trawling positions and related information – Autumn

Hornsea Round Three Offshore Wind Farm Zone Fish Ecology Surveys J/1/03/1784 (6 Sheets)

Entered by: RXP02

Date entered: 05/10/2011

QC by: PMF

Date of QC: 14/10/11

Sampling Location	Date	Point on line	WGS84 UTM (Z31N)		WGS84 (DD)		Time (GMT)	Depth (BCD m)	Trawl speed (knots)	Distance (m)	Direction of travel	Comments
			Easting	Northing	Latitude	Longitude						
T1	26/09/2011	Start	6000105.49	382274.266	54.135567	1.198067	06:13	51.9	3.4	2951	S	
		End	6003054.39	382169.812	54.162033	1.195317	06:43	56.1				
T2	26/09/2011	Start	6001945.84	393183.62	54.154483	1.364317	09:44	69.6	3.7	3231	S	
		End	6005176.74	393136.55	54.183500	1.362450	10:14	65.5				
T3	26/09/2011	Start	5992268.40	386447.36	54.066100	1.264850	13:06	47.6	3.2	2723	S	
		End	5994977.76	386719.95	54.090500	1.268000	13:44	50.0				
T4	26/09/2011	Start	5982637.96	386148.94	53.979517	1.263900	15:27	38.0	3.9	3979	N	
		End	5978672.12	385824.09	53.943817	1.260433	16:01	39.9				
T5	01/10/2011	Start	5984632.02	395053.30	53.999317	1.398933	13:26	31.3	3.6	2693	S	
		End	5987323.89	395128.38	54.023517	1.399150	13:58	31.9				
T6	NO SAMPLE	Start								0		
		End										
T7	NO SAMPLE	Start								0		
		End										
T8	26/09/2011	Start	5984632.02	395053.30	53.999317	1.398933	17:21	39.0	3.3	2693	N	
		End	5987323.89	395128.38	54.023517	1.399150	17:52	40.9				
T9	27/09/2011	Start	5985129.18	400787.45	54.004917	1.486217	06:04	37.4	3.1	2706	N	
		End	5982430.85	400582.16	53.980633	1.483967	06:35	34.9				

Sampling Location	Date	Point on line	WGS84 UTM (Z31N)		WGS84 (DD)		Time (GMT)	Depth (BCD m)	Trawl speed (knots)	Distance (m)	Direction of travel	Comments
			Easting	Northing	Latitude	Longitude						
T10	NO SAMPLE	Start								0		
		End										
T11	27/09/2011	Start	5974544.20	408322.86	53.911200	1.604333	08:15	34.2	3.0	2521	N	
		End	5972023.21	408334.60	53.888550	1.605267	08:45	31.2				
T12	27/09/2011	Start	5985541.20	418280.23	54.011683	1.752933	14:51	75.7	3.3	3071	S	
		End	5988611.63	418237.16	54.039267	1.751450	15:30	71.1				
T13	27/09/2011	Start	5979108.69	416307.22	53.953567	1.724600	11:43	30.2	4.4	3635	S	
		End	5982739.01	416486.27	53.986217	1.726333	12:13	32.8				
T14	01/10/2011	Start	5970611.70	417467.32	53.877400	1.744567	11:04	30.3	3	2787	N	
		End	5967833.48	417247.07	53.852400	1.741967	11:34	30.2				
T15	01/10/2011	Start	5965722.23	418120.24	53.833567	1.755800	08:36	29.9	3.5	3625	N	
		End	5962100.66	417974.40	53.801000	1.754550	09:06	30.9				
T16	27/09/2011	Start	5971495.82	426007.61	53.886633	1.874233	17:00	28.6	3.4	3768	N	
		End	5967729.09	426119.98	53.852800	1.876850	17:32	28.1				
T17	28/09/2011	Start	5975675.13	429179.56	53.924633	1.921517	06:12	32.1	3.7	3207	S	
		End	5972473.23	429353.22	53.895883	1.924900	06:42	27.6				
T18	28/09/2011	Start	5979562.29	430419.95	53.959733	1.939517	08:47	37.6	3.3	3041	S	
		End	5982602.81	430370.38	53.987050	1.938067	09:17	39.2				
T19	28/09/2011	Start	5985156.03	438278.21	54.011000	2.058133	11:34	78.9	4.1	3445	N	
		End	5988588.67	438573.84	54.041883	2.061950	12:09	69.0				
T20	28/09/2011	Start	5975140.90	443264.92	53.921567	2.136083	15:33	29.8	4.1	2884	S	
		End	5972257.90	443352.47	53.895667	2.137950	16:04	28.0				
T21	28/09/2011	Start	5969970.71	447852.79	53.875583	2.206817	17:03	31.7	3.6	3305	S	
		End	5966676.10	448114.24	53.846000	2.211350	17:35	31.7				
T22	28/09/2011	Start	5983432.23	448211.05	53.996600	2.209983	13:42	72.9	3.5	2743	S	
		End	5986124.76	448732.52	54.020850	2.217483	14:15	70.9				
T23	29/09/2011	Start	5980004.57	452423.17	53.966200	2.274767	06:14	43.7	3.2	3389	N	
		End	5976616.15	452451.96	53.935750	2.275733	06:46	37.8				

Sampling Location	Date	Point on line	WGS84 UTM (Z31N)		WGS84 (DD)		Time (GMT)	Depth (BCD m)	Trawl speed (knots)	Distance (m)	Direction of travel	Comments
			Easting	Northing	Latitude	Longitude						
T24	30/09/2011	Start	5970601.86	453028.21	53.881750	2.285433	16:09	34.7	3.6	3199	N	
		End	5973770.44	453465.26	53.910267	2.291600	16:38	37.3				
T25	30/09/2011	Start	5965240.24	454762.19	53.833717	2.312600	13:57	32.1	3.6	3530	S	
		End	5968755.68	454437.83	53.865283	2.307150	14:29	34.6				
T26	29/09/2011	Start	5980042.47	455913.84	53.966850	2.327967	08:12	50.4	3.7	3038	S	
		End	5977020.83	455601.80	53.939667	2.323650	08:44	35.4				
T27	29/09/2011	Start	5982789.49	460378.76	53.991900	2.395667	11:40	63.3	3.6	3154	S	
		End	5985936.58	460584.71	54.020200	2.398400	12:13	66.7				
T28	30/09/2011	Start	5975465.62	465101.35	53.926417	2.468533	08:51	35.2	3.7	3327	N	
		End	5972139.44	465021.65	53.896517	2.467700	09:23	35.2				
T29	30/09/2011	Start	5966749.06	463527.22	53.847967	2.445600	10:14	36.1	3.8	3154	N	
		End	5963616.16	463163.69	53.819783	2.440450	10:45	33.5				
T30	30/09/2011	Start	5961241.74	463033.00	53.798433	2.438750	12:24	28.9	2.8	4266	N	
		End	5956976.31	463083.90	53.760100	2.440033	12:55	28.1				
T31	30/09/2011	Start	5965409.76	473167.63	53.836517	2.592250	06:13	59.0	3.5	2769	S	
		End	5968177.86	473242.73	53.861400	2.593150	06:47	57.5				
T32	29/09/2011	Start	5978294.66	471167.92	53.952217	2.560650	16:29	38.4	4.1	3257	N	
		End	5981504.93	471719.04	53.981100	2.568750	17:02	52.2				
T33	29/09/2011	Start	5986437.42	472995.97	54.025500	2.587783	14:34	63.6	3.6	2380	N	
		End	5984127.27	473566.96	54.004767	2.596700	15:08	62.8				
T34	01/10/2011	Start	5965939.15	430605.61	53.837333	1.945433	06:03	27.6	3.1	3236	S	
		End	5962704.21	430515.83	53.808250	1.944800	06:33	28.5				
T35	01/10/2011	Start	5963999.34	414487.94	53.817500	1.701100	12:38	33.5		2252	N	
		End	5961748.44	414546.68	53.797283	1.702617	15:02	30.8				
T36	NO SAMPLE	Start								0		
		End										
T37	NO SAMPLE	Start								0		
		End										

Sampling Location	Date	Point on line	WGS84 UTM (Z31N)		WGS84 (DD)		Time (GMT)	Depth (BCD m)	Trawl speed (knots)	Distance (m)	Direction of travel	Comments
			Easting	Northing	Latitude	Longitude						
T38	NO SAMPLE	Start								0		
		End										
T39	02/10/2011	Start	5936127.82	350313.37	53.552667	0.740417	06:14	61.3	2.9	1761	N	
		End	5937888.98	350308.52	53.568483	0.739500	06:46	65.7				
T40	NO SAMPLE	Start								0		
		End										
T41	02/10/2011	Start	5932122.51	327285.79	53.509633	0.395383	08:58	13.9	4.2	3405	N	
		End	5928724.11	327079.59	53.479050	0.394150	09:28	12.8				

B.2 Otter trawl data

B.2.1 Otter trawl full species list - Spring

Hornsea Round Three Offshore Wind Farm Zone Fish Ecology Surveys J/1/03/1784 (6 Sheets)

Entered by: JSH CAB

Date entered: 06-12/10/2011 10-11/20/2011

QC by: ELH PMF

Date of QC: 13-14/10/11 14/10/11

P = Present

Taxon		MCS Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
Latin name	Common name															
Elasmobranchs																
Mustelus asterias	Starry smouth-hound	ZF0037	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Raja clavata	Thornback ray	ZF0089	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Raja montagui	Spotted ray	ZF0094	0	4	0	0	1	0	0	0	0	1	0	3	1	0
Scyliorhinus canicula	Lesser spotted dogfish	ZF0028	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Gadoids																
Gadus morhua	Cod	ZG0116	1	6	2	0	0	1	2	0	1	0	1	1	0	1
Ciliata mustela	Five bearded rockling	ZG0111	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchelyopus cimbrius	Four bearded rockling	ZG0140	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melanogrammus aeglefinus	Haddock	ZG0121	2	16	0	0	0	0	0	0	0	0	0	0	0	0
Merlangius merlangus	Whiting	ZG0123	1664	972	713	1724	1053	1144	729	72	151	566	822	934	13	967
Molva molva	Ling	ZG0129	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trisopterus minutus	Poor cod	ZG0144	6	5	0	2	0	0	3	0	0	0	0	9	0	0
Commercially important non gadoid species																
Round fish																
Clupea harengus	Herring	ZG0034	0	0	2	269	387	10	503	35	12	490	42	10	4	54
Dicentrarchus labrax	Bass	ZG0312	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Taxon		MCS Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
Latin name	Common name															
Eutrigla gurnardus	Grey gurnard	ZG0265	196	132	245	202	200	56	24	128	98	33	205	207	236	115
Salmo salar	Atlantic salmon	ZG0050	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scomber scombrus	Mackerel	ZG0511	0	0	0	0	0	0	5	0	0	0	0	0	1	0
Trigla lucerna	Tub gurnard	ZG0269	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Flatfish																
Hippoglossoides platessoides	Long rough dab	ZG0568	0	3	0	0	0	0	0	0	0	0	0	2	1	0
Microstomus kitt	Lemon sole	ZG0574	0	13	0	0	5	0	1	0	0	0	4	6	0	1
Limanda limanda	Dab	ZG0572	523	718	346	217	336	239	251	143	249	214	319	959	552	162
Platichthys flesus	Flounder	ZG0576	0	0	1	0	0	0	0	0	0	0	0	2	0	0
Pleuronectes platessa	Plaice	ZG0578	73	78	125	65	126	32	6	63	108	27	121	75	102	38
Scophthalmus rhombus	Brill	ZG0556	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solea solea	Common sole	ZG0591	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Taxon		MCS Code	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28
Latin name	Common name															
Elasmobranchs																
Mustelus asterias	Starry smouth hound	ZF0037	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Raja clavata	Thornback ray	ZF0089	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Raja montagui	Spotted ray	ZF0094	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Scyliorhinus canicula	Lesser spotted dogfish	ZF0028	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gadoids																
Gadus morhua	Cod	ZG0116	4	0	0	1	2	1	0	2	0	0	0	0	0	0
Ciliata mustela	Five bearded rockling	ZG0111	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchelyopus cimbrius	Four bearded rockling	ZG0140	0	0	0	0	1	0	0	0	0	0	0	0	2	0
Melanogrammus aeglefinus	Haddock	ZG0121	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Merlangius merlangus	Whiting	ZG0123	975	994	328	1085	199	550	968	582	293	1400	273	115	628	77
Molva molva	Ling	ZG0129	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Taxon		MCS Code	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28
Latin name	Common name															
Trisopterus minutus	Poor cod	ZG0144	3	0	0	0	0	0	0	0	0	0	0	0	2	0
Commercially important non gadoid species																
Round fish																
Clupea harengus	Herring	ZG0034	332	234	12	15	53	10	7	61	74	0	0	3	3	47
Dicentrarchus labrax	Bass	ZG0312	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eutrigla gurnardus	Grey gurnard	ZG0265	78	143	75	53	62	72	61	83	85	98	86	68	52	91
Salmo salar	Atlantic salmon	ZG0050	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scomber scombrus	Mackerel	ZG0511	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trigla lucerna	Tub gurnard	ZG0269	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Flatfish																
Hippoglossoides platessoides	Long rough dab	ZG0568	0	0	0	0	3	0	0	15	3	0	0	1	26	0
Microstomus kitt	Lemon sole	ZG0574	21	0	0	0	2	0	0	3	0	0	0	1	0	0
Limanda limanda	Dab	ZG0572	287	239	230	570	203	131	409	94	169	352	448	235	85	248
Platichthys flesus	Flounder	ZG0576	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pleuronectes platessa	Plaice	ZG0578	9	85	73	107	23	49	261	5	62	128	165	70	7	95
Scophthalmus rhombus	Brill	ZG0556	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solea solea	Common sole	ZG0591	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Taxon		MCS Code	T29	T30	T31	T32	T33	T34	T35	T36	T37	T41	Total
Latin name	Common name												
Elasmobranchs													
Mustelus asterias	Starry smooth hound	ZF0037	0	0	0	0	0	0	1	0	1	0	5
Raja clavata	Thornback ray	ZF0089	0	0	0	0	0	0	0	0	4	0	5
Raja montagui	Spotted ray	ZF0094	0	0	0	0	0	0	1	0	4	1	18
Scyliorhinus canicula	Lesser spotted dogfish	ZF0028	0	0	0	1	0	0	0	0	0	1	3
Gadoids													
Gadus morhua	Cod	ZG0116	0	2	2	74	2	4	0	0	1	0	111

Taxon		MCS Code	T29	T30	T31	T32	T33	T34	T35	T36	T37	T41	Total
Latin name	Common name												
Ciliata mustela	Five bearded rockling	ZG0111	0	0	0	0	0	0	0	0	0	0	1
Enchelyopus cimbrius	Four bearded rockling	ZG0140	0	0	0	0	0	0	0	0	0	0	3
Melanogrammus aeglefinus	Haddock	ZG0121	0	0	0	1	0	1	0	0	0	0	22
Merlangius merlangus	Whiting	ZG0123	318	94	1840	85	437	431	926	1507	448	79	26156
Molva molva	Ling	ZG0129	0	0	0	2	0	0	0	0	0	0	2
Trisopterus minutus	Poor cod	ZG0144	0	0	2	12	1	3	0	0	1	1	50
Commercially important non gadoid species													
Round fish													
Clupea harengus	Herring	ZG0034	8	15	388	19	38	46	6027	88	656	612	10566
Dicentrarchus labrax	Bass	ZG0312	0	0	0	0	0	0	0	0	0	0	1
Eutrigla gurnardus	Grey gurnard	ZG0265	98	148	82	77	74	89	77	72	45	13	3959
Salmo salar	Atlantic salmon	ZG0050	0	0	0	0	0	0	0	0	0	1	1
Scomber scombrus	Mackerel	ZG0511	0	0	0	0	0	0	3	0	0	0	9
Trigla lucerna	Tub gurnard	ZG0269	2	0	0	0	0	0	0	0	0	0	4
Flatfish													
Hippoglossoides platessoides	Long rough dab	ZG0568	0	0	1	1	3	0	0	0	0	0	59
Microstomus kitt	Lemon sole	ZG0574	0	0	5	9	1	1	0	0	0	0	73
Limanda limanda	Dab	ZG0572	470	222	363	35	77	343	122	508	271	2	11341
Platichthys flesus	Flounder	ZG0576	0	0	0	0	0	0	0	0	0	0	4
Pleuronectes platessa	Plaice	ZG0578	139	278	203	35	15	94	43	128	32	0	3145
Scophthalmus rhombus	Brill	ZG0556	0	0	0	0	1	0	0	0	0	0	1
Solea solea	Common sole	ZG0591	0	0	1	0	0	0	0	2	0	0	4

Taxon		MCS Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
Latin name	Common name															
Other Fish																
Ammodytidae	Sandeel	ZG0441	16	0	4	3	2	2	0	17	9	0	5	0	0	2
Sprattus sprattus	Sprat	ZG0038	114	3	0	628	1	40	615	1051	2794	992	382	34	97	1353
Agonus cataphractus	Pogge	ZG0291	0	0	0	0	2	2	1	0	0	0	0	0	0	0
Buglossidium luteum	Solenette	ZG0585	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Callionymus lyra	Common dragonet	ZG0452	0	1	1	1	5	2	2	0	1	0	1	0	0	0
Cyclopterus lumpus	Lumpsucker	ZG0294	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Echiichthys vipera	Lesser weever	ZG0405	1	0	0	37	426	2030	4	2	2	157	472	7	5	9
Hyperoplus lanceolatus	Greater sandeel	ZG0449	0	0	0	0	0	0	2	0	0	41	0	0	4	1
Myxocephalus scorpius	Short spined sea scorpion	ZG0281	1	3	3	7	4	3	3	0	1	2	10	0	2	14
Phrynorhombus norvegicus	Norwegian topknot	ZG0551	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commercially important shellfish																
Alloteuthis subulata	European common squid	W2341	26	0	0	448	17	25	32	175	105	320	208	10	453	167
Loligo vulgaris	European squid	W2338	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aequipecten opercularis	Queen scallop	W1773	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Homarus gammarus	European lobster	S1400	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cancer pagurus	Brown crab	S1566	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Necora puber	Velvet swimming crab	S1589	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Buccinum undatum	Common whelk	W0708	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Panaeidae	Shrimp	S1282	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nephrops norvegicus	Norway lobster	S1402	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Taxon		MCS Code	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28
Latin name	Common name															
Other Fish																
Ammodytidae	Sandeel	ZG0441	0	0	0	0	0	0	0	1	51	0	49	12	0	0
Sprattus sprattus	Sprat	ZG0038	165	1363	32	359	1473	142	315	87	235	626	291	96	22	289
Agonus cataphractus	Pogge	ZG0291	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buglossidium luteum	Solenette	ZG0585	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Callionymus lyra	Common dragonet	ZG0452	5	2	2	4	0	0	0	0	0	0	1	0	0	0
Cyclopterus lumpus	Lumpsucker	ZG0294	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Echiichthys vipera	Lesser weever	ZG0405	8	33	438	1	0	119	9	0	12	6	4	0	0	293
Hyperoplus lanceolatus	Greater Sandeel	ZG0449	0	3	0	121	0	1	1	0	0	14	0	7	0	0
Myxocephalus scorpius	Short spined sea scorpion	ZG0281	38	6	3	5	0	5	2	0	1	3	4	3	1	1
Phrynorhombus norvegicus	Norwegian topknot	ZG0551	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Commercially important shellfish																
Alloteuthis subulata	European common squid	W2341	141	329	20	52	40	48	276	254	311	133	400	294	22	41
Loligo vulgaris	European squid	W2338	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aequipecten opercularis	Queen scallop	W1773	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Homarus gammarus	European lobster	S1400	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Cancer pagurus	Brown crab	S1566	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Necora puber	Velvet swimming crab	S1589	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buccinum undatum	Common whelk	W0708	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Panaeidae	Shrimp	S1282	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nephrops norvegicus	Norway lobster	S1402	0	0	0	0	0	0	0	0	3	0	0	0	13	0

Taxon		MCS Code	T29	T30	T31	T32	T33	T34	T35	T36	T37	T41	Total
Latin name	Common name												
Other Fish													
Ammodytidae	Sandeel	ZG0441	13	41	0	0	0	8	0	9	9	0	253
Sprattus sprattus	Sprat	ZG0038	1230	496	406	273	259	678	837	701	822	25	19326
Agonus cataphractus	Pogge	ZG0291	0	0	0	0	1	1	1	0	1		9
Buglossidium luteum	Solenette	ZG0585	0	1	0	0	0	2	0	0	0	0	7
Callionymus lyra	Common dragonet	ZG0452	0	1	4	0	0	1	1	4	4	1	44
Cyclopterus lumpus	Lumpsucker	ZG0294	0	0	0	0	0	0	0	0	0	1	3
Echiichthys vipera	Lesser weever	ZG0405	0	17	2	0	1	260	70	87	45	3	4560
Hyperoplus lanceolatus	Greater sandeel	ZG0449	0	0	0	0	0	0	26	0	0	0	221
Myxocephalus scorpius	Short spined sea scorpion	ZG0281	1	3	7	1	0	9	1	11	1	6	165
Phrynorhombus norvegicus	Norwegian topknot	ZG0551	0	0	0	0	0	0	0	0	0	0	1
Commercially important shellfish													
Alloteuthis subulata	European common squid	W2341	544	288	57	224	115	109	261	128	8	4	6085
Loligo vulgaris	European squid	W2338	0	0	0	0	0	0	0	0	2	0	2
Aequipecten opercularis	Queen scallop	W1773	0	0	0	2	0	0	1	0	0	0	6
Homarus gammarus	European lobster	S1400	0	0	0	0	0	0	0	0	0	5	7
Cancer pagurus	Brown crab	S1566	0	0	0	1	0	0	0	0	1	1	5
Necora puber	Velvet swimming crab	S1589	0	0	0	0	0	0	0	0	1	0	2
Buccinum undatum	Common whelk	W0708	0	0	0	2	0	0	0	0	0	0	2
Panaeidae	Shrimp	S1282	0	0	0	0	0	0	0	0	0	23	23
Nephrops norvegicus	Norway lobster	S1402	0	0	0	0	0	0	0	0	0	0	16

Taxon		MCS Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
Latin name	Common name															
Other Epifauna																
Actiniidae	Anemone	D0673						P	P							
Alcyonidium diaphanum	Sea chervil / Dogger bank itch	Y0076					P	P								P
Alcyonium digitatum	Dead-man's fingers	D0597	P	P	P	P	P	P	P	P		P	P	P		P
Ampelisca reef	Amphipod reef	S0422														
Aphrodita aculeata	Sea mouse	P0019			P						P			P		
Ascidiacea	Sea squirt	ZD0002					P	P	P							P
Asterias rubens	Common starfish	ZB0100	P	P	P	P	P	P	P	P	P	P	P		P	P
Astropecten irregulais	Sand star	ZB0026					P					P	P		P	P
Botryllus schlosseri	Star ascidian	ZD0126							P							
Corystes cassivelaunus	Masked crab	S1552					P		P						P	
Crossaster papposus	Sun star	ZB0075														
Echinocardium cordatum	Sea potato	ZB0223									P		P	P	P	
Filograna/Salmacina	Serpulid worms	P1349/P1360														
Flustra foliacea	Hornwrack	Y0187	P		P		P	P	P			P	P		P	P
Fucus	Brown macroalgae	ZR0376												P		
Henricia	Bloody Henry starfish	ZB0082														
Hydractinia echinata	Rough hydroid	D0273														
Liocarcinus	Swimming crab	S1577						P	P		P	P		P		
Luidia sp.	Starfish	ZB0021														
Nudibranchia	Sea slug	W1243														
Ophiothrix fragilis	Common brittlestar	ZB0124		P		P							P		P	
Ophiura albida	Brittlestar	ZB0168														
Ophiura sp.	Brittlestar	ZB0166														
Pagurus bernhardus	Common hermit crab	S1457										P				
Polychaeta	Worm	P0002														
Porifera	Sponge	C0001						P				P				P
Psammechinus miliaris	Green sea urchin	ZB0193														

Taxon		MCS Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
Latin name	Common name															
Sabellaria spinulosa	Ross Worm	P1115														
Triviidae	Cowrie	W0455														
Urticina sp.	Dahlia anemone	D0682								P						
Total number of species			15	18	15	15	22	22	30	12	16	18	21	19	19	20

Taxon		MCS Code	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28
Latin name	Common name															
Other Epifauna																
Actiniidae	Anemone	D0673		P				P								
Alcyonidium diaphanum	Sea chervil / Dogger bank itch	Y0076		P	P	P		P	P			P	P			
Alcyonium digitatum	Dead-man's fingers	D0597	P	P	P	P		P		P		P	P		P	P
Ampelisca reef	Amphipod reef	S0422		P												
Aphrodita aculeata	Sea mouse	P0019					P			P	P			P	P	P
Ascidiacea	Sea squirt	ZD0002	P	P					P			P				
Asterias rubens	Common starfish	ZB0100	P	P	P	P	P	P	P	P	P	P	P	P	P	
Astropecten irregulais	Sand star	ZB0026	P	P	P	P	P		P		P	P	P	P	P	P
Botryllus schlosseri	Star ascidian	ZD0126														
Corystes cassivelaunus	Masked crab	S1552					P									
Crossaster papposus	Sun star	ZB0075														
Echinocardium cordatum	Sea potato	ZB0223											P			
Filograna/Salmacina	Serpulid worms	P1349/P1360														
Flustra foliacea	Hornwrack	Y0187	P	P		P		P	P				P		P	
Fucus	Brown macroalgae	ZR0376									P					
Henricia	Bloody Henry starfish	ZB0082														
Hydractinia echinata	Rough hydroid	D0273														
Liocarcinus	Swimming crab	S1577	P		P		P		P	P		P	P			P
Luidia sp.	Starfish	ZB0021											P			

Taxon		MCS Code	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28
Latin name	Common name															
Nudibranchia	Sea slug	W1243	P													
Ophiothrix fragilis	Common brittlestar	ZB0124														
Ophiura albida	Brittlestar	ZB0168														
Ophiura sp.	Brittlestar	ZB0166												P		
Pagurus bernhardus	Common hermit crab	S1457					P		P				P			
Polychaeta	Worm	P0002				P										
Porifera	Sponge	C0001	P	P				P				P				
Psammechinus miliaris	Green sea urchin	ZB0193														
Sabellaria spinulosa	Ross worm	P1115														
Triviidae	Cowrie	W0455		P												
Urticina sp.	Dahlia anemone	D0682														
Total number of species			25	23	17	20	19	17	17	15	17	17	20	16	17	13

Taxon		MCS Code	T29	T30	T31	T32	T33	T34	T35	T36	T37	T41	Total
Latin name	Common name												
Other Epifauna													
Actiniidae	Anemone	D0673						P			P		6
Alcyonidium diaphanum	Sea chervil / Dogger bank itch	Y0076		P				P					12
Alcyonium digitatum	Dead-man's fingers	D0597			P	P	P	P	P	P	P	P	30
Ampelisca reef	Amphipod reef	S0422											1
Aphrodita aculeata	Sea mouse	P0019	P										10
Ascidiacea	Sea squirt	ZD0002			P						P		10
Asterias rubens	Common starfish	ZB0100	P	P	P	P		P	P	P	P	P	35
Astropecten irregulais	Sand star	ZB0026						P	P				19
Botryllus schlosseri	Star ascidian	ZD0126											1
Corystes cassivelaunus	Masked crab	S1552	P		P								6
Crossaster papposus	Sun star	ZB0075										P	1

Taxon		MCS Code	T29	T30	T31	T32	T33	T34	T35	T36	T37	T41	Total
Latin name	Common name												
Echinocardium cordatum	Sea potato	ZB0223	P										6
Filograna/Salmacina	Serpulid worms	P1349/P1360										P	1
Flustra foliacea	Hornwrack	Y0187	P	P					P		P	P	21
Fucus	Brown macroalgae	ZR0376											2
Henricia	Bloody Henry starfish	ZB0082										P	1
Hydractinia echinata	Rough hydroid	D0273						P					1
Liocarcinus	Swimming crab	S1577			P			P		P	P	P	18
Luidia sp.	Starfish	ZB0021	P										2
Nudibranchia	Sea slug	W1243				P			P				3
Ophiothrix fragilis	Common brittlestar	ZB0124				P		P					6
Ophiura albida	Brittlestar	ZB0168			P								1
Ophiura sp.	Brittlestar	ZB0166											1
Pagurus bernhardus	Common hermit crab	S1457						P					5
Polychaeta	Worm	P0002											1
Porifera	Sponge	C0001		P				P	P		P	P	12
Psammechinus miliaris	Green sea urchin	ZB0193				P							1
Sabellaria spinulosa	Ross worm	P1115								P	P		2
Triviidae	Cowrie	W0455											1
Urticina sp.	Dahlia anemone	D0682											1
Total number of species			16	17	21	23	15	27	22	16	28	25	

B.2.2 Otter trawl full species list - Autumn

Hornsea Round Three Offshore Wind Farm Zone Fish Ecology Surveys J/1/03/1784

Entered by: JSH CAB

Date entered: 06-12/10/2011 10-11/20/2011

QC by: ELH PMF

Dateof QC: 13-14/10/11 14/10/11

P = Present. 0.5l and 1.5l refer to subsample volumes (if taken)

Taxon		MCS Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
Latin name	Common name															
Elasmobranchs																
Mustelus asterias	Starry smooth hound	ZF0037														3
Leucoraja naevus	Cuckoo ray															
Raja clavata	Thornback ray	ZF0089														
Raja montagui	Spotted ray	ZF0094		1		2	1			1			1	2		
Squalus acanthias	Spurdog														1	
Scyliorhinus canicula	Lesser spotted dogfish	ZF0028		2		1	1			1			3			13
Gadoids																
Gadus morhua	Cod	ZG0116		52	1		1						1	2		
Ciliata mustela	Five bearded rockling	ZG0111														
Enchelyopus cimbrius	Four bearded rockling	ZG0140														
Melanogrammus aeglefinus	Haddock	ZG0121		327												
Merlangius merlangus	Whiting	ZG0123	4397	1808	99	220	133			153	91		312	566	49	2190
Molva molva	Ling	ZG0129														
Trisopterus luscus	Bib															
Trisopterus minutus	Poor cod	ZG0144	8	224		1								4		

Taxon		MCS Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
Latin name	Common name															
Commercially important non gadoid species																
Round fish																
Clupea harengus	Herring	ZG0034		27	2	3	10			1	153		456	8	600	
Alosa fallax	Twaite shad															
Engraulis encrasicolus	Anchovy										1					
Dicentrarchus labrax	Bass	ZG0312														
Eutrigla gurnardus	Grey gurnard	ZG0265	153	214	300	128	217			249	159		111	42	219	105
Aspitrigla cuculus	Red gurnard															1
Lophiuspiscatorius	Monkfish															
Salmo salar	Atlantic salmon	ZG0050														
Scomber scombrus	Mackerel	ZG0511	9	11	30	10	300			146	2		104		1	1
Trachurus trachurus	Scad			1			2									1
Mullus surmuletus	Striped red mullet		1	1												
Trigla lucerna	Tub gurnard	ZG0269			2					2						

Taxon		MCS Code	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28
Latin name	Common name															
Elasmobranchs																
Mustelus asterias	Starry smooth hound	ZF0037	13	1				2				1				
Leucoraja naevus	Cuckoo ray											1				
Raja clavata	Thornback ray	ZF0089		4												
Raja montagui	Spotted ray	ZF0094		3		1			3		1	20	4			6
Squalus acanthias	Spurdog															
Scyliorhinus canicula	Lesser spotted dogfish	ZF0028	30	8	3	2		25	2	1		2	1		1	
Gadoids																
Gadus morhua	Cod	ZG0116			1	3	3			4		2				
Ciliata mustela	Five bearded rockling	ZG0111				1										

Taxon		MCS Code	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28
Latin name	Common name															
Enchelyopus cimbrius	Four bearded rockling	ZG0140					2			2				1	41	
Melanogrammus aeglefinus	Haddock	ZG0121			1											
Merlangius merlangus	Whiting	ZG0123	4731	1803	773	787	1490	844	134	1018	679	150	131	986	2305	139
Molva molva	Ling	ZG0129														
Trisopterus luscus	Bib										1					
Trisopterus minutus	Poor cod	ZG0144	69			3	21			2				1		
Commercially important non gadoid species																
Round fish																
Clupea harengus	Herring	ZG0034		1	6	2	6	1		1	10		208	22		2
Alosa fallax	Twaite shad													1		
Engraulis encrasicolus	Anchovy															
Dicentrarchus labrax	Bass	ZG0312														
Eutrigla gurnardus	Grey gurnard	ZG0265	148	78	114	107	76	50	70	24	60	263	380	171	27	55
Aspitrigla cuculus	Red gurnard													1		
Lophiuspiscatorius	Monkfish															
Salmo salar	Atlantic salmon	ZG0050														
Scomber scombrus	Mackerel	ZG0511	42	49	8	3		220	96		2	24	26			10
Trachurus trachurus	Scad		3					1	2			6	7	1		
Mullus surmuletus	Striped red mullet															
Trigla lucerna	Tub gurnard	ZG0269	1		1				1			4	3			3

Taxon		MCS Code	T29	T30	T31	T32	T33	T34	T35	T36	T37	T38	T39	T40	T41
Latin name	Common name														
Elasmobranchs															
Mustelus asterias	Starry smooth hound	ZF0037						1							
Leucoraja naevus	Cuckoo ray								2						
Raja clavata	Thornback ray	ZF0089						1	8				10		

Taxon		MCS Code	T29	T30	T31	T32	T33	T34	T35	T36	T37	T38	T39	T40	T41
Latin name	Common name														
Raja montagui	Spotted ray	ZF0094						6	37						
Squalus acanthias	Spurdog														
Scyliorhinus canicula	Lesser spotted dogfish	ZF0028	2	3	3			9	35				2		
Gadoids															
Gadus morhua	Cod	ZG0116			2	142	2						4		
Ciliata mustela	Five bearded rockling	ZG0111													
Enchelyopus cimbrius	Four bearded rockling	ZG0140			53		37								
Melanogrammus aeglefinus	Haddock	ZG0121				3									
Merlangius merlangus	Whiting	ZG0123	235	64	4304	100	1311	461	34				100		46
Molva molva	Ling	ZG0129				1									
Trisopterus luscus	Bib					3							6		
Trisopterus minutus	Poor cod	ZG0144			1	17		1					37		
Commercially important non gadoid species															
Round fish															
Clupea harengus	Herring	ZG0034			1								7		2
Alosa fallax	Twaite shad														
Engraulis encrasicolus	Anchovy														
Dicentrarchus labrax	Bass	ZG0312													
Eutrigla gurnardus	Grey gurnard	ZG0265	265	187	15	50		139	267				25		3
Aspitrigla cuculus	Red gurnard					2									
Lophiuspiscatorius	Monkfish												1		
Salmo salar	Atlantic salmon	ZG0050													
Scomber scombrus	Mackerel	ZG0511	10	2	25	3		6	24				2		1
Trachurus trachurus	Scad		2			4							1		2
Mullus surmuletus	Striped red mullet								1						
Trigla lucerna	Tub gurnard	ZG0269				1			2						

Taxon		MCS Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
Latin name	Common name															
Flatfish																
Hippoglossoides platessoides	Long rough dab	ZG0568		1										12		
Microstomus kitt	Lemon sole	ZG0574	7	35	13		2			13	5		3	2		13
Limanda limanda	Dab	ZG0572	946	631	411	550	100			623	928		107	512	314	100
Platichthys flesus	Flounder	ZG0576														
Pleuronectes platessa	Plaice	ZG0578	155	23	168	30	73			73	117		201	47	48	96
Scophthalmus rhombus	Brill	ZG0556		1	1	1										1
Glyptocephalus cynoglossus	Witch															
Scophthalmus maximus	Turbot												1			
Arnoglossus laterna	Scaldfish			1	1					1						
Solea solea	Common sole	ZG0591					1							1		
Other Fish																
Ammodytidae	Sandeel	ZG0441														
Sprattus sprattus	Sprat	ZG0038					96				137		1041	165	424	
Agonus cataphractus	Pogge	ZG0291														
Buglossidium luteum	Solenette	ZG0585														
Callionymus lyra	Common dragonet	ZG0452	1	4	3		2			5					1	1
Cyclopterus lumpus	Lumpsucker	ZG0294														
Echiichthys vipera	Lesser weever	ZG0405			2	1	116			1			102			187
Hyperoplus lanceolatus	Greater sandeel												5			13
Myxocephalus scorpius	Short spined sea scorpion	ZG0281								1						
Phrynorhombus norvegicus	Norwegian topknot	ZG0551														
Commercially important shellfish																
Alloteuthis subulata	European common squid	W2341	347	363	412	374	32			38	331		32		295	
Loligo vulgaris	Common squid		8	22	3	1								1	1	1
Aequipecten opercularis	Queen scallop	W1773												1		1
Homarus gammarus	European lobster	S1400	2				1									
Cancer pagurus	Brown crab	S1566		1												2

Taxon		MCS Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
Latin name	Common name															
Crangon crangon	Brown shrimp															
Inachus sp.	Spider crab															
Necora puber	Velvet swimming crab	S1589														
Buccinum undatum	Common whelk	W0708														
Octopus vulgaris	Common octopus															
Eledone cirrhosa	Curled octopus													1		
Panaeidae	Shrimp	S1282														
Sepiola atlantica	Little cuttlefish															
Nephrops norvegicus	Norway lobster	S1402												1		

Taxon		MCS Code	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28
Latin name	Common name															
Flatfish																
Hippoglossoides platessoides	long rough dab	ZG0568		1			29	2		19					57	
Microstomus kitt	Lemon sole	ZG0574	9	6	2	10		6	1	6	4	4		4	8	2
Limanda limanda	Dab	ZG0572	246	708	603	644	150	594	649	38	372	468	525	230	89	149
Platichthys flesus	Flounder	ZG0576														
Pleuronectes platessa	Plaice	ZG0578	7	168	80	112	14	164	211	18	55	330	131	130	17	111
Scophthalmus rhombus	Brill	ZG0556		1							1					
Glyptocephalus cynoglossus	Witch															
Scophthalmus maximus	Turbot														1	1
Arnoglossus laterna	Scaldfish			1		3		2	2	1	5		2	1	2	1
Solea solea	Common sole	ZG0591					1					1				
Other Fish																
Ammodytidae	Sandeel	ZG0441														
Sprattus sprattus	Sprat	ZG0038		8	239	21	16			18	68	38	1004	200	7	57
Agonus cataphractus	Pogge	ZG0291	3													

Taxon		MCS Code	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28
Latin name	Common name															
Buglossidium luteum	Solenette	ZG0585	1			1					2	1			2	1
Callionymus lyra	Common dragonet	ZG0452	2	1	2	16	5	1			3	3		12	2	2
Cyclopterus lumpus	Lumpsucker	ZG0294														
Echiichthys vipera	Lesser weever	ZG0405	8	7	436	3		65			15			8		77
Hyperoplus lanceolatus	Greater sandeel															
Myxocephalus scorpius	Short spined sea scorpion	ZG0281		4		1								1		
Phrynorhombus norvegicus	Norwegian topknot	ZG0551														
Commercially important shellfish																
Alloteuthis subulata	European common squid	W2341		100	81	106	12	25	134		205	384	178	137	211	49
Loligo vulgaris	Common squid		1	1	2			3	3	1	3	2	1	3		1
Aequipecten opercularis	Queen scallop	W1773	12													
Homarus gammarus	European lobster	S1400		2												
Cancer pagurus	Brown crab	S1566												2		1
Crangon crangon	Brown shrimp									16						
Inachus sp.	Spider crab															
Necora puber	Velvet swimming crab	S1589														
Buccinum undatum	Common whelk	W0708														
Octopus vulgaris	Common octopus														2	
Eledone cirrhosa	Curled octopus															
Panaeidae	Shrimp	S1282														
Sepiola atlantica	Little cuttlefish						4			2			1	1	13	
Nephrops norvegicus	Norway lobster	S1402					1	1		1					79	7

Taxon		MCS Code	T29	T30	T31	T32	T33	T34	T35	T36	T37	T38	T39	T40	T41
Latin name	Common name														
Flatfish															
Hippoglossoides platessoides	Long rough dab	ZG0568			36	5	62								
Microstomus kitt	Lemon sole	ZG0574	2	3	13	41		7					42		
Limanda limanda	Dab	ZG0572	998	636	1130	30	45	705	733				27		
Platichthys flesus	Flounder	ZG0576													
Pleuronectes platessa	Plaice	ZG0578	200	121	392	31	14	223	89				4		1
Scophthalmus rhombus	Brill	ZG0556			1										
Glyptocephalus cynoglossus	Witch						1								
Scophthalmus maximus	Turbot														
Arnoglossus laterna	Scaldfish			4	13		4		2						
Solea solea	Common sole	ZG0591			5								3		
Other Fish															
Ammodytidae	Sandsel	ZG0441						1							
Sprattus sprattus	Sprat	ZG0038			1										2
Agonus cataphractus	Pogge	ZG0291							1						
Buglossidium luteum	Solenette	ZG0585		1	31										
Callionymus lyra	Common dragonet	ZG0452		6		6			2				8		
Cyclopterus lumpus	Lumpsucker	ZG0294													
Echiichthys vipera	Lesser weever	ZG0405		2				900	3						
Hyperoplus lanceolatus	Greater sandeel														
Myxocephalus scorpius	Short spined sea scorpion	ZG0281			1	2		1	1				4		
Phrynorhombus norvegicus	Norwegian topknot	ZG0551													
Commercially important shellfish															
Alloteuthis subulata	European common squid	W2341	147	7	1	550	29	15					2		115
Loligo vulgaris	Common squid		3	1	6	14	1		4				3		15
Aequipecten opercularis	Queen scallop	W1773			1	32							1		
Homarus gammarus	European lobster	S1400											6		5
Cancer pagurus	Brown crab	S1566	1		1										1

Taxon		MCS Code	T29	T30	T31	T32	T33	T34	T35	T36	T37	T38	T39	T40	T41
Latin name	Common name														
Crangon crangon	Brown shrimp						5						6		
Inachus sp.	Spider crab							P							
Necora puber	Velvet swimming crab	S1589											17		3
Buccinum undatum	Common whelk	W0708													
Octopus vulgaris	Common octopus														
Eledone cirrhosa	Curled octopus														
Panaeidae	Shrimp	S1282											31		7
Sepiola atlantica	Little cuttlefish			1	1	3	15						19		
Nephrops norvegicus	Norway lobster	S1402	2		122	19	82								5

Taxon		MCS Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
Latin name	Common name															
Other Epifauna																
Actiniidae	Anemone	D0673														
Alcyonidium diaphanum	Sea chervil / Dogger bank itch	Y0076														
Alcyonium digitatum	Dead-man's fingers	D0597	P	P	P	P	P			P					P	P
Aphrodita aculeata	Sea mouse	P0019													1	
Ascidiacea	Sea squirt	ZD0002														
Asterias rubens	Common starfish	ZB0100				1	P			2						P
Astropecten irregulais	Sand star	ZB0026														
Botryllus schlosseri	Star ascidian	ZD0126														
Corystes cassivelaunus	Masked crab	S1552														
Crossaster papposus	Sun star	ZB0075														
Echinocardium cordatum	Sea potato	ZB0223				1										
Echinus esculentus	Common sea urchin															
Filograna/Salmacina	Serpulid worms	P1349/P1360														
Flustra foliacea	Hornwrack	Y0187												P	P	

Taxon		MCS Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
Latin name	Common name															
Fucus	Brown macroalgae	ZR0376														
Henricia	Bloody Henry starfish	ZB0082														
Hydractinia echinata	Rough hydroid	D0273														
Liocarcinus spp.	Swimming crab	S1577			1					4	6			2	1	
Luidia sp.	Starfish	ZB0021														
Metridium senile	Plumose anemone															
Nudibranchia	Sea slug	W1243														
Ophiothrix fragilis	Common brittlestar	ZB0124														
Ophiura albida	Brittlestar	ZB0168														
Ophiura sp.	Brittlestar	ZB0166														
Ophiura ophiura	Brittlestar															
Pagurus bernhardus	Common hermit crab	S1457				1										
Polychaeta	Worm	P0002														
Porifera	Sponge	C0001														
Psammechinus miliaris	Green sea urchin	ZB0193														
Sabellaria spinulosa	Ross worm	P1115														
Triviidae	Cowrie	W0455														
Urticina sp.	Dahlia anemone	D0682														
Total number of species			13	22	18	20	19	0	0	20	12	0	15	19	17	19

Taxon		MCS Code	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28
Latin name	Common name															
Other Epifauna																
Actiniidae	Anemone	D0673														
Alcyonidium diaphanum	Sea chervil / Dogger bank itch	Y0076														
Alcyonium digitatum	Dead-man's fingers	D0597														
Aphrodita aculeata	Sea mouse	P0019														
Ascidiacea	Sea squirt	ZD0002														
Asterias rubens	Common starfish	ZB0100	P	3	2	1						P				
Astropecten irregulais	Sand star	ZB0026										P				
Botryllus schlosseri	Star ascidian	ZD0126														
Corystes cassivelaunus	Masked crab	S1552														
Crossaster papposus	Sun star	ZB0075														
Echinocardium cordatum	Sea potato	ZB0223														
Echinus esculentus	Common sea urchin															
Filograna/Salmacina	Serpulid worms	P1349/P1360														
Flustra foliacea	Hornwrack	Y0187			P											
Fucus	Brown macroalgae	ZR0376														
Henricia	Bloody Henry starfish	ZB0082														
Hydractinia echinata	Rough hydroid	D0273														
Liocarcinus spp.	Swimming crab	S1577		2	1		P					P				
Luidia sp.	Starfish	ZB0021														
Metridium senile	Plumose anemone															
Nudibranchia	Sea slug	W1243														
Ophiothrix fragilis	Common brittlestar	ZB0124														
Ophiura albida	Brittlestar	ZB0168														
Ophiura sp.	Brittlestar	ZB0166														
Ophiura ophiura	Brittlestar											4				
Pagurus bernhardus	Common hermit crab	S1457														
Polychaeta	Worm	P0002														

Taxon		MCS Code	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28
Latin name	Common name															
Porifera	Sponge	C0001														
Psammechinus miliaris	Green sea urchin	ZB0193														
Sabellaria spinulosa	Ross worm	P1115														
Triviidae	Cowrie	W0455														
Urticina sp.	Dahlia anemone	D0682														
Total number of species			18	25	21	21	16	17	13	17	17	24	15	20	17	19

Taxon		MCS Code	T29	T30	T31	T32	T33	T34	T35	T36	T37	T38	T39	T40	T41
Latin name	Common name														
Other Epifauna															
Actiniidae	Anemone	D0673													
Alcyonidium diaphanum	Sea chervil / Dogger bank itch	Y0076		P				P							
Alcyonium digitatum	Dead-man's fingers	D0597		P					P						
Aphrodita aculeata	Sea mouse	P0019													
Ascidiacea	Sea squirt	ZD0002													
Asterias rubens	Common starfish	ZB0100						P	P						
Astropecten irregulais	Sand star	ZB0026						P							
Botryllus schlosseri	Star ascidian	ZD0126													
Corystes cassivelaunus	Masked crab	S1552													
Crossaster papposus	Sun star	ZB0075													
Echinocardium cordatum	Sea potato	ZB0223													
Echinus esculentus	Common sea urchin												P		
Filograna/Salmacina	Serpulid worms	P1349/P1360													P
Flustra foliacea	Hornwrack	Y0187		P				P							P
Fucus	Brown macroalgae	ZR0376													
Henricia	Bloody Henry starfish	ZB0082													2
Hydractinia echinata	Rough hydroid	D0273													

Taxon		MCS Code	T29	T30	T31	T32	T33	T34	T35	T36	T37	T38	T39	T40	T41
Latin name	Common name														
Liocarcinus spp.	Swimming crab	S1577						P					P		12
Luidia sp.	Starfish	ZB0021													
Metridium senile	Plumose anemone							P							
Nudibranchia	Sea slug	W1243													
Ophiothrix fragilis	Common brittlestar	ZB0124													
Ophiura albida	Brittlestar	ZB0168													
Ophiura sp.	Brittlestar	ZB0166													
Ophiura ophiura	Brittlestar														
Pagurus bernhardus	Common hermit crab	S1457													
Polychaeta	Worm	P0002													
Porifera	Sponge	C0001													
Psammechinus miliaris	Green sea urchin	ZB0193													
Sabellaria spinulosa	Ross worm	P1115													
Triviidae	Cowrie	W0455													
Urticina sp.	Dahlia anemone	D0682													
Total number of species			12	17	24	22	13	21	19	0	0		27		20

Appendix C Data Analysis

C.1 SIMPER analysis results otter trawl data

SIMPER: Similarity Percentages - species contributions

One-Way Analysis

Data worksheet

Name: Data3

Data type: Abundance

Sample selection: All

Variable selection: All

Parameters

Resemblance: S17 Bray Curtis similarity

Cut off for low contributions: 90.00%

Table C.1: Group e / Average similarity: 74.00.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Merlangius merlangus	8.41	32.61	15.20	44.07	44.07
Limanda limanda	2.91	9.51	4.59	12.86	56.92
Alloteuthis subulata	2.06	6.09	2.26	8.23	65.15
Eutrigla gurnardus	1.67	5.69	3.88	7.69	72.84
Sprattus sprattus	1.81	5.17	3.27	6.98	79.83
Pleuronectes platessa	1.24	3.24	2.47	4.38	84.20
Clupea harengus	1.21	2.55	0.93	3.44	87.65
Hippoglossoides platessoides	0.81	1.49	0.71	2.01	89.65
Microstomus kitt	0.44	1.32	2.49	1.78	91.43

Table C.2: Group g / Average similarity: 72.19.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Limanda limanda	4.58	14.54	4.55	20.14	20.14
Merlangius merlangus	5.07	14.51	2.40	20.10	40.25
Sprattus sprattus	3.70	9.76	1.85	13.52	53.76
Eutrigla gurnardus	2.64	7.98	5.02	11.06	64.82
Alloteuthis subulata	2.73	7.44	2.36	10.31	75.13
Pleuronectes platessa	2.42	7.25	4.65	10.04	85.16
Clupea harengus	1.38	2.88	1.44	3.99	89.15
Echiichthys vipera	1.45	2.07	0.76	2.86	92.01

Table C.3: Group f / Average similarity: 72.47.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sprattus sprattus	5.25	17.30	3.22	23.87	23.87
Merlangius merlangus	4.87	15.40	4.45	21.25	45.12
Clupea harengus	4.67	12.17	1.87	16.79	61.91
Limanda limanda	3.10	11.16	14.07	15.40	77.31
Eutrigla gurnardus	1.46	4.60	4.23	6.35	83.66
Alloteuthis subulata	1.59	3.76	2.61	5.19	88.85
Pleuronectes platessa	0.96	3.09	3.19	4.27	93.12

Group c

Less than 2 samples in group.

Group a

Less than 2 samples in group.

Group b

Less than 2 samples in group.

Group d

Less than 2 samples in group.

C.2 SIMPER analysis results otter trawl data: Seasonal

SIMPER: Similarity Percentages - species contributions

One-Way Analysis

Data worksheet

Name: Data6

Data type: Abundance

Sample selection: All

Variable selection: All

Parameters

Resemblance: S17 Bray Curtis similarity

Cut off for low contributions: 90.00%

Table C.4: Group Autumn / Average similarity: 55.24.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Merlangius merlangus	5.42	15.59	1.76	28.23	28.23
Limanda limanda	4.39	12.48	1.87	22.60	50.83
Eutrigla gurnardus	2.53	7.08	2.10	12.81	63.64
Pleuronectes platessa	2.18	6.12	2.07	11.09	74.73
Alloteuthis subulata	2.36	4.77	1.03	8.64	83.37
Scomber scombrus	0.98	1.59	0.90	2.87	86.24
Sprattus sprattus	1.32	1.45	0.46	2.63	88.87
Microstomus kitt	0.55	1.07	1.15	1.93	90.81

Table C.5: Group Spring / Average similarity: 65.25.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Merlangius merlangus	5.20	16.33	2.33	25.03	25.03
Limanda limanda	3.62	11.58	2.95	17.75	42.78
Sprattus sprattus	4.05	10.84	1.58	16.61	59.39
Eutrigla gurnardus	2.23	7.16	3.22	10.97	70.36
Alloteuthis subulata	2.47	6.09	1.47	9.33	79.69
Pleuronectes platessa	1.84	5.32	1.99	8.16	87.85
Clupea harengus	1.99	3.66	0.97	5.61	93.46

Table C.6: Groups Autumn and Spring / Average dissimilarity = 45.29.

Species	Group Autumn	Group Spring	Av.Diss	Diss/SD	Contrib%	Cum.%
	Av.Abund	Av.Abund				
Sprattus sprattus	1.32	4.05	6.56	1.47	14.49	14.49
Merlangius merlangus	5.42	5.20	5.26	1.39	11.62	26.11
Limanda limanda	4.39	3.62	4.08	1.41	9.01	35.12
Alloteuthis subulata	2.36	2.47	3.91	1.31	8.62	43.74
Clupea harengus	0.77	1.99	3.69	0.91	8.16	51.90
Echiichthys vipera	0.83	1.33	3.02	0.84	6.67	58.57
Eutrigla gurnardus	2.53	2.23	2.25	1.31	4.96	63.53
Pleuronectes platessa	2.18	1.84	2.18	1.35	4.81	68.35
Scomber scombrus	0.98	0.02	1.85	0.87	4.09	72.43
Microstomus kitt	0.55	0.18	0.94	0.99	2.08	74.52
Trisopterus minutus	0.34	0.15	0.76	0.67	1.67	76.19
Hippoglossoides platessoides	0.26	0.16	0.72	0.67	1.59	77.78
Gadus morhua	0.28	0.23	0.72	0.57	1.58	79.36
Loligo vulgaris	0.37	0.01	0.71	0.79	1.56	80.92
Ammodytidae	0.01	0.35	0.69	0.71	1.52	82.44
Myxocephalus Scorpius	0.09	0.38	0.69	1.36	1.51	83.95
Nephrops norvegicus	0.31	0.04	0.67	0.55	1.48	85.43
Scyliorhinus canicula	0.31	0.02	0.61	0.87	1.35	86.79
Callionymus lyra	0.31	0.15	0.55	1.11	1.22	88.00
Raja montagui	0.22	0.07	0.47	0.70	1.03	89.03
Hyperoplus lanceolatus	0.03	0.20	0.42	0.49	0.94	89.97
Arnoglossus laterna	0.18	0.00	0.35	0.88	0.78	90.74

C.3 SIMPER analysis results epibenthic beam trawl fish data

SIMPER: Similarity Percentages - species contributions

One-Way Analysis

Data worksheet

Name: Data18

Data type: Abundance

Sample selection: All

Variable selection: All

Parameters

Resemblance: S17 Bray Curtis similarity

Cut off for low contributions: 90.00%

N/C: Not Calculated - For groups with two samples, there is no standard deviation and therefore Sim/SD cannot be calculated.

Group a

Less than two samples in group.

Table C.7: Group b / Average similarity: 54.03.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Pomatoschistus pictus	7.45	36.02	N/C	66.67	66.67
Callionymus lyra	4.78	18.01	N/C	33.33	100.00

Group c

Less than two samples in group.

Table C.8: Group d / Average similarity: 59.60.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Callionymidae	6.38	24.52	5.35	41.13	41.13
Limanda limanda	3.40	12.02	4.26	20.16	61.29
Pleuronectes platessa	2.56	6.71	0.91	11.26	72.55
Echiichthys vipera	2.81	5.57	0.91	9.34	81.89
Taurulus bubalis	1.72	4.26	0.91	7.15	89.04
Ammodytes tobianus	1.38	3.26	0.90	5.46	94.50

Group e

Less than 2 samples in group.

Table C.9: Group f / Average similarity: 70.98.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Buglossidium luteum	7.93	29.04	10.74	40.91	40.91
Callionymus lyra	2.73	9.40	5.40	13.25	54.16
Arnoglossus laterna	2.51	8.30	6.73	11.70	65.86
Limanda limanda	2.65	7.96	2.89	11.21	77.07
Pleuronectes platessa	1.99	5.12	1.66	7.21	84.27
Merlangius merlangus	1.03	2.42	1.28	3.40	87.68
Gobiidae	1.20	2.35	0.75	3.31	90.98

Table C.10: Group g / Average similarity: 75.12.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Buglossidium luteum	7.68	31.21	6.17	41.55	41.55
Limanda limanda	3.33	12.29	4.30	16.36	57.91
Arnoglossus laterna	2.98	10.36	2.53	13.79	71.69
Echiichthys vipera	2.34	7.60	2.44	10.12	81.81
Pleuronectes platessa	1.81	6.36	3.12	8.46	90.28

Table C.11: Group h / Average similarity: 77.10.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Buglossidium luteum	6.60	23.96	11.77	31.08	31.08
Limanda limanda	4.42	14.02	3.66	18.18	49.26
Arnoglossus laterna	3.35	11.71	5.60	15.19	64.44
Ammodytes sp.	2.35	7.67	3.45	9.95	74.39
Callionymus lyra	1.73	4.83	1.74	6.27	80.66
Gobiidae	1.52	4.18	5.20	5.42	86.08
Echiichthys vipera	1.39	3.64	1.18	4.72	90.81

Table C.12: Group i / Average similarity: 76.49.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Buglossidium luteum	8.13	36.01	6.44	47.08	47.08
Limanda limanda	3.42	13.12	4.42	17.15	64.23
Arnoglossus laterna	3.16	12.68	5.31	16.58	80.81
Merlangius merlangus	1.76	6.12	1.79	8.00	88.81
Gobiidae	0.95	2.45	1.02	3.21	92.02

Table C.13: Group j / Average similarity: 68.94.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Buglossidium luteum	5.09	15.55	3.38	22.56	22.56
Limanda limanda	4.09	12.03	3.15	17.45	40.01
Callionymus lyra	3.84	11.81	2.96	17.13	57.14
Arnoglossus laterna	3.16	10.20	5.11	14.80	71.94
Pleuronectes platessa	2.48	7.36	4.24	10.68	82.61
Ammodytes sp.	2.68	5.62	1.00	8.15	90.76

Table C.14: Group k / Average similarity: 61.47.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Buglossidium luteum	8.74	40.00	N/C	65.08	65.08
Limanda limanda	2.34	9.66	N/C	15.72	80.80
Pleuronectes platessa	2.13	7.48	N/C	12.18	92.97

Table C.15: Group l / Average similarity: 61.51.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Buglossidium luteum	4.42	12.35	2.42	20.08	20.08
Arnoglossus laterna	3.38	10.70	5.42	17.39	37.47
Enchelyopus cimbrius	3.20	8.89	1.35	14.45	51.92
Merlangius merlangus	2.95	7.42	1.31	12.06	63.98
Limanda limanda	2.85	6.20	1.05	10.08	74.06
Gobiidae	2.99	6.00	1.08	9.75	83.82
Hippoglossoides platessoides	1.91	4.52	1.30	7.35	91.17

Group m

Less than two samples in group.

Table C.16: Group n / Average similarity: 59.71.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Callionymus lyra	4.82	16.51	3.66	27.64	27.64
Myoxocephalus scorpius	3.88	13.23	24.16	22.16	49.81
Taurulus bubalis	3.10	10.98	4.46	18.39	68.19
Gobiidae	4.45	9.33	0.58	15.62	83.81
Pholis gunnellus	2.29	6.17	1.57	10.33	94.14

Table C.17: Group 0 / Average similarity: 64.03.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Callionymus lyra	4.74	12.94	4.44	20.20	20.20
Buglossidium luteum	4.01	11.41	4.62	17.82	38.02
Agonus cataphractus	3.27	8.65	13.22	13.51	51.53
Ammodytes sp.	3.06	7.52	3.81	11.74	63.27
Limanda limanda	2.36	7.05	8.73	11.01	74.29
Hyperoplus lanceolatus	1.88	4.99	8.73	7.79	82.08
Arnoglossus laterna	2.20	4.84	0.91	7.56	89.63
Myoxocephalus scorpius	1.20	2.32	0.91	3.62	93.25

Table C.18: Group p / Average similarity: 59.90.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Agonus cataphractus	5.91	19.70	6.97	32.90	32.90
Callionymus lyra	4.00	13.46	3.86	22.46	55.36
Microstomus kitt	2.94	6.02	1.11	10.05	65.41
Taurulus bubalis	2.05	6.00	2.85	10.02	75.43
Phrynorhombus norvegicus	1.69	3.24	0.86	5.41	80.84
Myoxocephalus scorpius	1.71	2.93	0.79	4.89	85.73
Limanda limanda	1.38	2.70	0.85	4.50	90.23

Table C.19: Group q / Average similarity: 54.58.

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Callionymus lyra	5.81	19.08	2.49	34.96	34.96
Agonus cataphractus	2.64	8.07	2.24	14.78	49.74
Limanda limanda	3.04	6.41	1.07	11.74	61.49
Microstomus kitt	2.69	5.99	0.95	10.97	72.45
Microchirus variegatus	1.65	4.04	1.13	7.40	79.85
Buglossidium luteum	1.78	3.35	0.79	6.14	85.99
Pleuronectes platessa	2.01	2.92	0.54	5.35	91.34

C.4 Otter trawl diversity indices with SIMPROF groups

Trawl Location	SIMPROF Group	S	N	d	J'	H'(loge)	Lambda
1	e	18	1452.506	2.334829	0.35183	1.016919	0.524129
2	g	25	946.3337	3.502323	0.489413	1.575361	0.310558
3	g	19	558.2252	2.845957	0.565213	1.664236	0.216682
4	g	17	810.8967	2.388723	0.598584	1.695915	0.241545
5	g	21	624.7619	3.106859	0.63963	1.947368	0.182489
6	d	14	581.173	2.042404	0.416183	1.098331	0.426941
7	f	22	368.6426	3.553403	0.49411	1.527315	0.256148
8	g	17	570.7398	2.520902	0.628681	1.781187	0.222191
9	g	15	979.5784	2.032779	0.526646	1.426184	0.342796
10	f	11	458.1051	1.632094	0.732825	1.757239	0.212909
11	g	20	876.7348	2.80393	0.662594	1.984955	0.173209
12	g	19	588.9299	2.822065	0.45129	1.328794	0.344605
13	g	16	537.8549	2.385652	0.642596	1.781653	0.189656
14	g	23	1161.229	3.117368	0.444485	1.393682	0.363493
15	e	25	1119.522	3.418483	0.340103	1.094749	0.566355
16	g	22	895.3417	3.089505	0.533821	1.650064	0.26489
17	g	19	617.3167	2.80139	0.581229	1.711393	0.221916
18	g	22	777.3294	3.155112	0.502795	1.55416	0.295787
19	f	18	663.5576	2.616344	0.463712	1.3403	0.34393
20	g	21	602.9845	3.124077	0.562909	1.713789	0.267574
21	g	18	597.9166	2.658971	0.595422	1.720992	0.218571
22	e	19	433.2868	2.96472	0.425535	1.252963	0.478163
23	g	22	436.9212	3.454088	0.594396	1.837304	0.207267
24	g	22	772.3816	3.158142	0.567292	1.753524	0.214921
25	g	20	623.8902	2.952156	0.630685	1.889362	0.184972
26	g	23	500.9827	3.538928	0.566799	1.777194	0.218155
27	e	20	621.5344	2.953892	0.320736	0.960838	0.622708

Trawl Location	SIMPROF Group	S	N	d	J'	H'(loge)	Lambda
28	g	20	259.695	3.417569	0.676657	2.027084	0.154017
29	g	17	733.5121	2.425035	0.600903	1.702485	0.213586
30	g	19	390.5813	3.01627	0.633124	1.864196	0.185234
31	e	26	1861.8	3.320362	0.401202	1.307156	0.438937
32	c	27	325.6122	4.493833	0.61534	2.028062	0.208344
33	e	21	541.1881	3.177747	0.440977	1.342565	0.464643
34	g	23	698.3553	3.359431	0.593534	1.861022	0.186687
35	f	23	1484.766	3.012455	0.467056	1.464453	0.374769
36	g	12	647.7046	1.699252	0.627928	1.560342	0.291927
37	f	20	362.281	3.224482	0.533841	1.599244	0.249385
39	a	25	104.4861	5.162341	0.785219	2.527524	0.12184
41	b	23	128.9765	4.527094	0.452835	1.419861	0.399673

C.5 Epibenthic beam trawl diversity indices with SIMPROF groups

Trawl Number	SIMPROF Group	S	N	d	J'	H'(loge)	Lambda
C01	g	9	164.8	1.567	0.449	0.987	0.575
C02	f	18	124.5	3.524	0.561	1.622	0.373
C03	k	4	143.3	0.604	0.214	0.297	0.878
C04	p	15	60.2	3.417	0.799	2.163	0.192
C05	p	7	88.4	1.339	0.922	1.794	0.190
C06	h	12	198.0	2.080	0.663	1.649	0.280
C07	k	10	95.8	1.973	0.583	1.342	0.409
C08	f	13	159.7	2.365	0.474	1.216	0.514
C09	p	8	78.2	1.606	0.885	1.841	0.181
C10	g	7	86.7	1.345	0.538	1.047	0.537
C12	g	10	99.6	1.956	0.662	1.524	0.367
C13	e	5	22.0	1.293	0.847	1.364	0.302
C14	d	7	43.8	1.588	0.766	1.491	0.313
C15	d	8	41.7	1.876	0.795	1.653	0.245
C16	d	7	28.2	1.797	0.886	1.725	0.209
C17	p	6	34.7	1.410	0.729	1.307	0.334
C18	n	7	28.6	1.789	0.878	1.709	0.218
C19	a	1	1.7	0.000		0.000	1.000
C21	b	3	22.7	0.640	0.515	0.566	0.708
C22	n	6	16.5	1.782	0.882	1.581	0.259
C25	d	5	11.4	1.645	0.844	1.358	0.319
C27	c	7	55.3	1.495	0.871	1.695	0.201
C33	b	3	17.5	0.699	0.966	1.061	0.358
C49	o	11	50.7	2.547	0.840	2.013	0.171
C58	f	15	202.9	2.635	0.510	1.381	0.433
C59	p	10	46.2	2.348	0.694	1.598	0.320
C60	f	11	126.7	2.065	0.640	1.535	0.347

Trawl Number	SIMPROF Group	S	N	d	J'	H'(loge)	Lambda
C63	f	16	121.3	3.126	0.555	1.540	0.397
S01	g	8	168.4	1.365	0.701	1.458	0.339
S02	g	7	103.1	1.294	0.590	1.147	0.450
S03	j	9	113.1	1.692	0.873	1.919	0.179
S04	g	10	79.9	2.054	0.796	1.832	0.227
S05	q	6	20.1	1.667	0.800	1.433	0.306
S06	i	8	70.6	1.644	0.635	1.321	0.399
S07	g	8	108.3	1.494	0.487	1.014	0.526
S08	g	7	125.6	1.241	0.471	0.916	0.583
S09	g	9	105.4	1.718	0.738	1.622	0.238
S10	g	7	104.2	1.291	0.637	1.240	0.413
S11	g	7	126.6	1.239	0.616	1.198	0.420
S12	g	10	98.9	1.959	0.674	1.553	0.317
S13	j	14	64.2	3.123	0.861	2.272	0.130
S14	g	9	106.7	1.713	0.717	1.576	0.299
S15	j	7	48.4	1.547	0.728	1.416	0.306
S16	g	8	81.5	1.591	0.768	1.597	0.289
S17	j	10	83.6	2.033	0.766	1.763	0.226
S18	j	8	60.0	1.710	0.758	1.577	0.258
S19	g	7	104.9	1.290	0.775	1.508	0.295
S20	j	8	38.7	1.915	0.743	1.546	0.286
S21	o	9	33.7	2.274	0.810	1.779	0.229
S22	g	8	137.8	1.421	0.458	0.952	0.571
S23	q	4	21.4	0.979	0.593	0.823	0.566
S24	g	8	86.1	1.571	0.724	1.505	0.302
S25	q	8	61.9	1.696	0.797	1.657	0.233
S26	g	8	94.9	1.538	0.702	1.459	0.338
S27	j	11	63.4	2.410	0.790	1.894	0.199

Trawl Number	SIMPROF Group	S	N	d	J'	H'(loge)	Lambda
S28	g	8	99.6	1.521	0.690	1.435	0.308
S29	j	8	57.7	1.726	0.886	1.842	0.175
S30	g	7	81.2	1.365	0.637	1.239	0.405
S31	j	10	67.7	2.135	0.757	1.742	0.261
S32	g	8	105.2	1.503	0.822	1.710	0.222
S33	j	13	69.9	2.826	0.739	1.895	0.224
S34	g	10	101.6	1.948	0.619	1.425	0.357
S35	o	11	50.5	2.550	0.851	2.042	0.163
S36	j	9	40.3	2.164	0.815	1.791	0.204
S37	j	12	42.7	2.930	0.880	2.187	0.137
S38	j	11	128.5	2.059	0.818	1.961	0.170
S39	j	10	70.9	2.112	0.859	1.978	0.164
S40	g	6	170.0	0.974	0.521	0.934	0.547
S41	f	7	185.0	1.149	0.587	1.141	0.475
T01	o	12	39.0	3.003	0.844	2.096	0.156
T02	p	10	97.0	1.967	0.647	1.489	0.328
T05	g	12	130.0	2.260	0.608	1.510	0.376
T08	g	12	108.0	2.349	0.587	1.457	0.407
T12	g	13	124.0	2.489	0.658	1.687	0.305
T13	g	11	107.0	2.140	0.599	1.437	0.396
T15	g	10	140.0	1.821	0.673	1.550	0.320
T16	g	11	127.0	2.064	0.497	1.191	0.516
T18	g	9	98.0	1.745	0.499	1.097	0.528
T20	g	8	123.0	1.455	0.396	0.823	0.656
T21	g	10	151.0	1.794	0.484	1.115	0.520
T23	g	11	97.0	2.186	0.689	1.653	0.299
T28	g	7	99.0	1.306	0.542	1.055	0.485
T30	j	7	63.0	1.448	0.667	1.298	0.382

Trawl Number	SIMPROF Group	S	N	d	J'	H'(loge)	Lambda
T32	g	7	80.0	1.369	0.512	0.997	0.560
T36	g	7	76.0	1.385	0.637	1.239	0.370
T39	g	10	190.0	1.715	0.465	1.071	0.511
T44	q	10	32.0	2.597	0.832	1.916	0.193
T45	q	8	34.0	1.985	0.919	1.910	0.163
T48	q	10	25.0	2.796	0.904	2.082	0.146
T49	g	9	61.0	1.946	0.723	1.588	0.304
Z01	i	8	104.0	1.507	0.594	1.235	0.404
Z02	i	10	154.5	1.786	0.677	1.558	0.296
Z03	i	10	265.4	1.613	0.436	1.004	0.486
Z04	q	11	74.4	2.320	0.711	1.705	0.286
Z05	i	11	199.4	1.888	0.529	1.270	0.428
Z06	i	8	226.0	1.291	0.450	0.936	0.530
Z07	h	11	262.7	1.795	0.650	1.558	0.277
Z08	n	9	106.3	1.715	0.678	1.489	0.299
Z09	h	9	123.0	1.662	0.751	1.650	0.247
Z10	m	13	45.8	3.137	0.900	2.307	0.119
Z11	i	9	296.1	1.406	0.407	0.895	0.609
Z12	i	7	362.3	1.018	0.314	0.611	0.725
Z13	q	11	48.7	2.573	0.840	2.015	0.174
Z14	g	5	61.0	0.973	0.552	0.888	0.545
Z15	h	11	183.0	1.920	0.721	1.728	0.244
Z16	h	12	174.7	2.131	0.700	1.740	0.257
Z17	i	8	238.9	1.278	0.419	0.871	0.610
Z18	i	8	104.3	1.506	0.553	1.150	0.469
Z19	l	11	34.8	2.818	0.933	2.238	0.121
Z20	q	7	50.8	1.528	0.460	0.895	0.582
Z21	i	10	126.0	1.861	0.598	1.377	0.383

Trawl Number	SIMPROF Group	S	N	d	J'	H'(loge)	Lambda
Z22	h	7	125.8	1.241	0.783	1.523	0.271
Z23	h	13	142.9	2.418	0.738	1.894	0.221
Z24	p	13	59.2	2.940	0.811	2.080	0.167
Z25	i	7	274.0	1.069	0.493	0.959	0.533
Z26	h	10	78.4	2.064	0.705	1.623	0.261
Z27	h	8	160.5	1.378	0.568	1.182	0.474
Z28	i	10	462.4	1.467	0.387	0.891	0.599
Z29	l	7	42.9	1.596	0.905	1.762	0.191
Z30	i	10	450.4	1.473	0.416	0.958	0.567
Z31	i	9	293.9	1.408	0.334	0.735	0.688
Z32	i	7	442.9	0.985	0.393	0.765	0.650
Z33	l	9	79.2	1.830	0.779	1.711	0.241
Z34	l	9	77.1	1.841	0.783	1.720	0.224
Z35	i	11	202.2	1.884	0.532	1.275	0.445
Z36	i	9	323.3	1.384	0.641	1.409	0.342
Z37	i	8	227.9	1.289	0.765	1.591	0.252
Z38	l	9	63.7	1.925	0.857	1.883	0.198
Z39	h	9	100.4	1.736	0.702	1.542	0.313
Z40	l	8	39.1	1.910	0.887	1.845	0.179