Norfolk Boreas Offshore Wind Farm

Appendix 11.1

Fish and Shellfish Ecology Technical Report

Environmental Statement

Volume 3

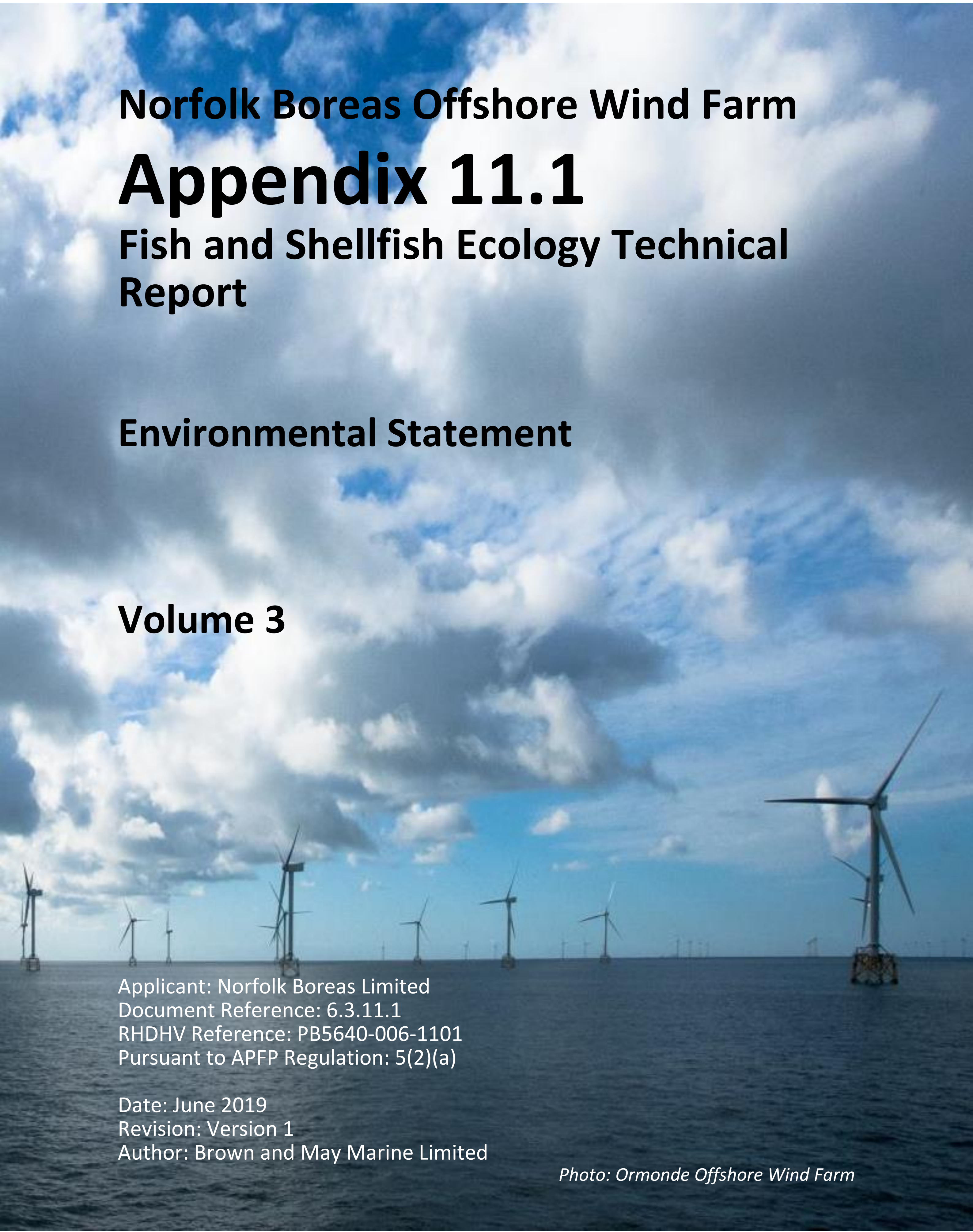

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Table of Contents

Figures

Tables

Glossary of Acronyms

BAP	Biodiversity Action Plan
BMM	Brown and May Marine Limited
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CGFS	Channel Ground Fish Surveys
CHARM	Channel Habitat Atlas for Marine Resource Management
CUFES	Continuous Underway Fish Egg Sampler
cm	centimetres
COWRIE	Collaborative Offshore Wind Research into the Environment
CPA	Coast Protection Act
CP-EGGS	North Sea Cod and Plaice Egg Surveys
CPUE	Catch Per Unit Effort
DATRAS	Database of Trawl Surveys
DEFRA	Department of Environment, Food and Rural Affairs
DTI	Department of Trade and Industry
EIA	Environmental Impact Assessment
EIFCA	Eastern Inshore Fisheries and Conservation Authority (formerly Eastern Sea Fisheries Joint Committee)
EPP	Evidence Plan Process
FEPA	Food and Environment Protection Act
IBTS	International Bottom Trawl Survey
ICES	International Council for the Exploration of the Sea
IHLS	International Herring Larvae Survey
ILVO	Belgian Institute for Agriculture, Fisheries and Food
IMARES	Netherlands Institute of Marine Resources and Ecosystem Studies
IUCN	International Union for the Conservation of Nature
JNCC	Joint Nature Conservation Committee
km	Kilometre
m	Metre
m^2	Metre squared
MCEU	Marine Consents and Environment Unit
MCZ	Marine Conservation Zone
MPA	Marine Protected Area
MMO	Marine Management Organisation
OSPAR	Oslo Paris Convention
PSA	Particle Size Analysis
SAC	Special Area of Conservation
SPA	Special Protection Area
UK	United Kingdom

Glossary of Terminology

Array cables	Cables which link wind turbine to wind turbine, and wind turbine to offshore electrical platforms.
Beam trawl	A trawl net whose lateral spread during trawling is maintained by a beam across

	its mouth.
Benthic	Relating to, or occurring at the sea bottom.
Clupeid	Any of various fishes of the family Clupeidae, which includes the herrings, sprats, sardines and shads.
Crustacean	An arthropod of the large, mainly aquatic group Crustacea, such as a crab, lobster, shrimp, or barnacle.
Demersal	Living on or near the seabed.
Diadromous	Migrating between fresh and salt water.
Elasmobranch	Any cartilaginous fish of the subclass Elasmobranchii which includes the sharks, rays and skates.
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to the EIA and information to support HRA.
Epibenthic	Relative to the flora and fauna living on the surface of the sea bottom.
Gadoid	A bony fish of an order (Gadiformes) that comprises the cods, hakes, and their relatives.
Gravid	Carrying eggs or young.
ICES rectangle	ICES rectangles are the smallest spatial unit used to collate commercial fisheries data and data from certain national and international fish surveys. The boundaries of each ICES rectangle align to 0.5° latitude by 1.0° longitude, giving whole rectangle dimensions of approximately 30 by 30 nautical miles, at UK latitudes.
Interconnector cables	Offshore cables which link offshore electrical platforms within the Norfolk Bores site.
Landfall	Where the offshore cables come ashore at Happisburgh South.
Mollusc	An invertebrate of a large phylum which includes snails, slugs, mussels, and octopuses. They have a soft unsegmented body and live in aquatic or damp habitats, and most kinds have an external calcareous shell.
Norfolk Boreas site	The Norfolk Boreas wind farm boundary. Located offshore, this will contain all the windfarm array.
Offshore cables	Refers to all offshore cables including: export, interconnector and array.
Offshore cable corridor	The corridor of seabed from the Norfolk Boreas site to the landfall site within which the offshore export cables will be located.
Offshore export cables	The cables which transmit power from the offshore electrical platform to the landfall.
Offshore project area	The area including the Norfolk Boreas site, project interconnector search area and offshore cable corridor.
Otter trawl	A trawl net fitted with two ‘otter’ boards which maintain the horizontal opening of the net.
Ovigerous	Carrying or bearing eggs.
Pelagic	Living in the water column.
Piscivorous	Feeding on fish.
Project interconnector cable	Offshore cables which would link either turbines or an offshore electrical platform in the Norfolk Boreas site with an offshore electrical platform in one of the Norfolk Vanguard OWF sites.
Project interconnector search area	The area within which the project interconnector cables would be installed.
The project	Norfolk Boreas Wind Farm including the onshore and offshore infrastructure.

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1 Introduction

1. The following document describes the fish and shellfish ecology existing environment in relation to Norfolk Boreas ("the project"). The areas of the project relevant to this baseline characterisation are the Norfolk Boreas site, the offshore cable corridor and the project interconnector search area. Collectively these project components are referred to as the 'offshore project area'.

2. The characterisation of the fish and shellfish ecology baseline has been derived using data and information from a number of sources including the scientific literature, fisheries statistical datasets, and fish and shellfish surveys undertaken for projects within the former East Anglia Zone.

3. In compiling this report due consideration has been given to the feedback received from stakeholders during consultation carried out in respect of Norfolk Boreas. In addition, where relevant, feedback received during consultation undertaken for the neighbouring Norfolk Vanguard project has also been incorporated in this document.

2 Guidance

4. To date, consultation regarding fish and shellfish ecology has been conducted through the Norfolk Boreas Scoping Report and Preliminary Environmental Information Report (PEIR) (Royal HaskoningDHV, 2017a, Royal HaskoningDHV, 2018).

5. In addition, consultation has been undertaken as part of the Evidence Plan Process (EPP) with the Fish and Shellfish Ecology Expert Topic Group (ETG) which includes: the Marine Management Organisation (MMO), the Eastern Inshore Fisheries and Conservation Authority (IFCA), Natural England and the Environment Agency. This included the submission to the ETG of a method statement in February 2018, detailing the assessment methodology proposed to assess the potential effects of Norfolk Boreas on fish and shellfish ecology and a meeting in February 2019 to discuss the feedback from the members of the ETG to the PEIR.

6. The feedback received on the Method Statement has been recorded in an agreement log which is provided as part of the Norfolk Boreas DCO application (document referebce 5.1). No further feedback was received from the ETG following the meeting in February 2019. The responses received from stakeholders to the Scoping Report, PEIR as well as feedback to date from the Fish and Shellfish Ecology ETG have been used to inform the structure and content of this report.

7. In addition, where relevant, feedback received during stakeholder consultation in respect of the Norfolk Vanguard Offshore Wind Farm Scoping Report (Royal HaskoningDHV, 2016) and Preliminary Environmental Information Report (PEIR)

(Royal HaskoningDHV, 2017b) has been used to inform this document. Other key guidance used to compile this report, includes:

- Centre for Environment, Fisheries and Aquaculture Science (Cefas), Department for Environment, Food and Rural Affairs (DEFRA), Department of Trade and Industry (DTI) and Marine Consents and Environment Unit (MCEU) (2004) Offshore Wind Farms - Guidance note for Environmental Impact Assessment In respect of FEPA and CPA requirements, Version 2;
- Cefas (2012) Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects. Contract report: ME5403, May 2012;
- Guidelines for ecological impact assessment in Britain and Ireland: Marine and Coastal. IEEM (2010); and
- Marine Licensing requirements (replacing Section 5 Part II of the Food and Environment Protection Act (FEPA) 1985 and Section 34 of the Coast Protection Act (CPA) 1949).

3 Data Sources

8. Key sources of data and information used to characterise the fish and shellfish ecology baseline for Norfolk Boreas are outlined in Table 3.1.

Table 3.1 Data Sources

Data	Year	Coverage
Results of adult and juvenile fish characterisation surveys for East Anglia THREE and the former East Anglia FOUR projects	2013	East Anglia THREE and the former East Anglia FOUR sites (ICES Rectangles 33F2, 34F2 and 34F3)
Results of benthic characterisation surveys (Fugro/EMU, 2013) for East Anglia THREE and the former East Anglia FOUR projects	2013	East Anglia THREE and the former East Anglia FOUR sites (ICES Rectangles 33F2, 34F2 and 34F3)
Results of benthic zonal surveys (MESL, 2010) in the former East Anglia Zone	2010	Former East Anglia Zone
UK landings weights data by species (MMO, 2017)	2007-2016	ICES Rectangles 34F1, 34F2, 34F3, 35F2, 35F3
Dutch landings weights data by species (Netherlands Institute of Marine Research (IMARES, 2018)	2010-2017	ICES Rectangles 34F1, 34F2, 34F3, 35F2, 35F3
Belgian landings weights data by species (Belgian Institute for Agriculture, Fisheries and Food (ILVO, 2016)	2010-2014	ICES Rectangles 34F1, 34F2, 34F3, 35F2, 35F3

Data	Year	Coverage
Danish satellite tracking (VMS) data for sandeel trawlers (Ministeriet for Fødevarer, Landbrug og Fiskeri, 2017)	2011-2015	North Sea
International Bottom Trawl Survey (IBTS) data	2008-2017	ICES Rectangles 34F1, 34F2, 34F3, 35F2, 35F3
ICES International Herring Larvae Survey (IHLS) data	2007-2017	Eastern and Northern North Sea
North Sea cod and plaice egg Survey (CP-EGGS) data	Plaice (2003, 2004, 2008, 2009); cod (2004, 2009)	ICES Rectangles 34F1, 34F2, 34F3, 35F2, 35F3
Channel Habitat Atlas for Marine Resource Management (CHARM) (Carpentier et al., 2009)	2003-2008	The eastern English Channel
Distribution of Spawning and Nursery Grounds as defined in Coull et al. (1998) (Fisheries Sensitivity Maps in British Waters) and in Ellis et al. (2010, 2012) (mapping spawning and nursery areas of species to be considered in Marine Protected Areas (Marine Conservation Zones).	Coull et al., 1991 - 1996 Ellis et al., Varies by species but generally between 1983 and 2008	UK territorial waters and the remainder of the North Sea.

9. In addition to the data sources described above, the following resources have been accessed to inform this report:

- Eastern Inshore Fisheries Conservation Authority (EIFCA) publications;
- Cefas publications;
- Joint Nature Conservation Committee (JNCC) publications;
- Institute for Marine Resources and Ecosystem Studies (IMARES) publications;
- International Council for the Exploration of the Sea (ICES) stock assessments and publications; and
- Other relevant peer-review publications.

3.1 Data Limitations and Sensitivities

3.1.1 Spawning and Nursery Grounds

10. Coull et al. (1998) and Ellis et al. (2010, 2012) provide a broad scale overview of the potential spatial extent of spawning/nursery grounds and the relative intensity and duration of spawning for a range of fish species. The spawning and nursery grounds described in Coull et al. (1998), are based on historic research and may in some instances not account for recent trends in the distribution of fish species and preferred spawning and nursery grounds. The information in Ellis et al. (2010, 2012) whilst based on more recent data, is also subject to limitations such as the wide

distribution of sampling sites used in the surveys which inform the report. This results in broad scale grids of spawning and nursery grounds.

3.1.2 Commercial Landings Data

11. Data on commercial fisheries landings from UK and other European countries active in the study area, particularly the Netherlands and Belgium, have been analysed to inform the fish and shellfish ecology baseline.

12. It is important to consider that commercial fisheries landings data do not necessarily provide an accurate picture of the fish and shellfish community or species composition, relative abundance or biomass. This is because the species and associated quantities available for landing are determined through a system of Total Allowable Catches (TACs) and quotas (Appendix 14 Commercial Fisheries Technical Report) and allocated quota varies between fleets and individual vessels. Therefore, landings do not necessarily reflect either abundance or biomass and in any case are not corrected for fishing effort.

13. Furthermore, only a limited number of species are targeted by commercial fisheries, and therefore reflected in landings statistics. Commercial landings data have therefore only been used to provide an indication of key commercial species present in areas relevant to the project, rather than to provide an accurate description of the fish and shellfish assemblage in areas relevant to the project.

3.1.3 ICES (International Council for the Exploration of the Sea) Survey Data

3.1.3.1 International Bottom Trawl Survey (IBTS)

14. IBTS data has been accessed via the ICES Data Portal (DATRAS, the Database of Trawl Surveys: http://datras.ices.dk). The DATRAS online database contains trawl information and biological data on all surveys conducted by the ICES IBTS sampling programme. Since 1997 surveys have employed a standardised method with a GOV trawl[1] used to sample a series of fixed stations, twice per year in the 1st and 3rd quarters of the year (ICES, 2015a). The species abundance data presented in Table 6.6 refers to the average number of fish caught per hour (in those ICES rectangles corresponding to the defined study area) by IBTS North Sea surveys conducted between 2008 and 2017.

15. Whilst IBTS provides valuable information on the distribution and relative abundance of demersal fish species, the limitations of bottom trawl surveys to adequately target some species (i.e. shellfish species, clupeids, sandeels and diadromous migratory fish) should be recognised.

[1] GOV - "Grande Ouverture Verticale": Standard otter trawl gear used in the IBTS

3.1.3.2 International Herring Larval Survey (IHLS)

16. IHLS data has been accessed via the ICES Data Portal (http://eggsandlarvae.ices.dk). The IHLS surveys routinely collect information on the size, abundance and distribution of herring eggs and larvae (and other species) in the North Sea. The values for larval abundance presented in this report refer to the number of herring larvae in the smallest reported size category (<11mm total length) caught per square metre at each site sampled per fortnight in the 3rd quarter in each year (ICES, 2013) between 2007 and 2017.

3.1.3.3 North Sea cod and plaice egg Survey (CP-EGGS) data

17. CP-EGGS data has been accessed via the ICES Data Portal (http://eggsandlarvae.ices.dk). The CP-EGGS survey is undertaken to gather information on cod and plaice egg and larval distributions in the North Sea. Survey data is available for plaice for the years 2003, 2004, 2008 and 2009. Surveys data is available for cod for the years 2004 and 2009. Surveys were conducted during winter months.

3.1.3.4 The Channel Habitat Atlas for Marine Resource Management (CHARM)

18. CHARM is a collaborative Franco-British project (Interreg IIIA) initiated to support decision-making for the management of essential fish habitats. The Atlas relates fish geographic distribution and environmental factors in order to delineate the optimum habitat for a number of species. The Atlas is based on data obtained from IFREMER's Channel Ground Fish Surveys (CGFS), including species abundance and environmental data, and fish eggs data collected using Continuous Underway Fish Egg Sampler (CUFES) during the French part of the IBTS (2006-2010). Habitat suitability models (HIS) are used to produce GIS outputs of optimum habitats, spawning grounds, nursery areas and presence probability. Unless otherwise specified, estimates of egg abundance equates to the number of eggs per 20 m^3 following log-transformation (log10(x+1)).

3.1.4 East Anglia THREE, formerEast Anglia FOUR and former East Anglia Zone Surveys

19. Data derived from fish and epibenthic surveys carried out for the East Anglia THREE and the former East Anglia FOUR projects, have been used to inform this fish and shellfish technical report. Whilst the areas sampled in these surveys are not specific to the offshore project area, the findings of the surveys are of relevance to Norfolk Boreas, given its proximity to East Anglia THREE and the former East Anglia FOUR. In addition, data collected in areas relevant to Norfolk Boreas during epibenthic surveys carried out in the former East Anglia Zone have also been used to inform this report. This approach has been agreed with the MMO, Natural England and the EIFCA during consultation on the Fish and Shellfish Ecology Method Statement as part of the EPP for Norfolk Boreas.

20. It should also be noted that the surveys carried out only provide reliable information on the distribution and abundance of demersal fish species, in light of the specific gear types used (otter trawl, 4m beam trawl and 2m scientific beam trawl). The presence and abundance of some species/species groups may therefore be misrepresented in the survey results (i.e. shellfish species, clupeids, sandeels and diadromous migratory fish).

3.1.5 Knowledge Gaps

21. It is acknowledged that gaps exist in understanding the distribution, behaviour and ecology of some fish and shellfish species in offshore areas. This is particularly apparent for a number of migratory species (e.g. lampreys, salmonids) for which little is currently known about their migration routes and behaviour in offshore areas (section 6.2.5).

4 Study Area

22. Norfolk Boreas is located approximately 73km off the Norfolk coast, in ICES Division IVc (Southern North Sea).

23. The study area used to characterise the fish and shellfish ecology baseline is shown in Figure 4.1. This has been defined with reference to the relevant ICES rectangles where the offshore project area is located. These are as follows:

- ICES rectangle 34F1 – where the inshore section of the offshore cable corridor is located;
- ICES rectangles 34F2 – where the south west section of the Norfolk Boreas site, the project interconnector search area and the offshore section of the offshore cable corridor are located;
- ICES rectangle 34F3 – where the south east corner of the Norfolk Boreas site is located;
- ICES rectangle 35F2 – where the north west section of the Norfolk Boreas site is located; and
- ICES rectangle 35F3 – where the north east section of the Norfolk Boreas site is located.

24. Where necessary, broader geographic areas have been used to provide information in wider contexts in the Southern North Sea with particular relevance to life history aspects for fish and shellfish, such as the distribution of spawning grounds and migration routes.

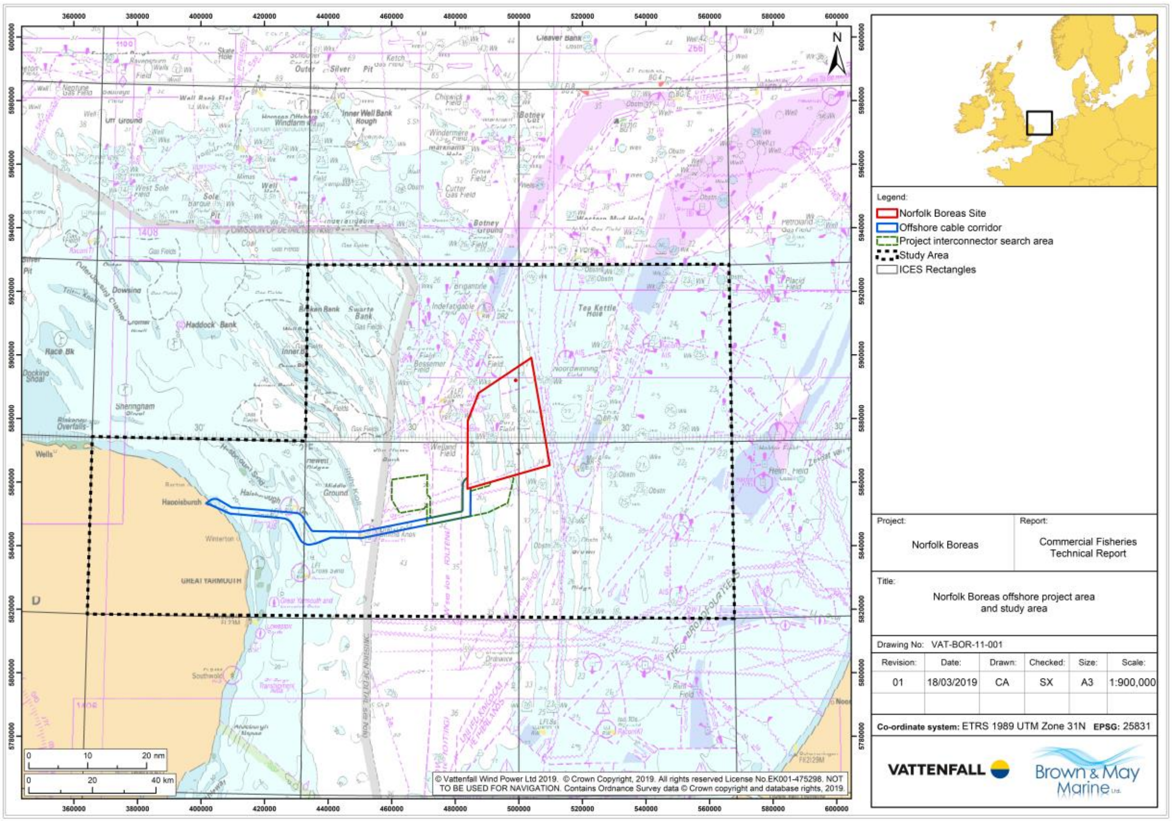


Figure 4.1 Norfolk Boreas offshore project area and study area

5 Marine Protected Areas (MPAs)

25. Designated Marine Protected Areas (MPAs) in the study area are shown in Figure 5.1. As shown, the offshore cable corridor overlaps with the Haisborough, Hammond and Winterton Special Area of Conservation (SAC). Qualifying features of this site include Sandbanks which are slightly covered by sea water at all times and *Sabellaria spinulosa* reefs.

26. In addition, the offshore cable corridor overlaps with the Greater Wash Special Protection Area (SPA) and the offshore project area overlaps with the Southern North Sea SAC which are designated for bird and marine mammal features respectively.

27. No fish or shellfish species are amongst the qualifying features for designation of any of these sites. However, in the case of the Haisborough, Hammond and Winterton SAC, the importance of the site in terms of provision of habitat to fish and shellfish species is recognised. In the case of the Greater Wash SPA and Southern North Sea SAC, the importance of some fish species as prey for marine mammals and birds, including Annex II species should also be acknowledged.

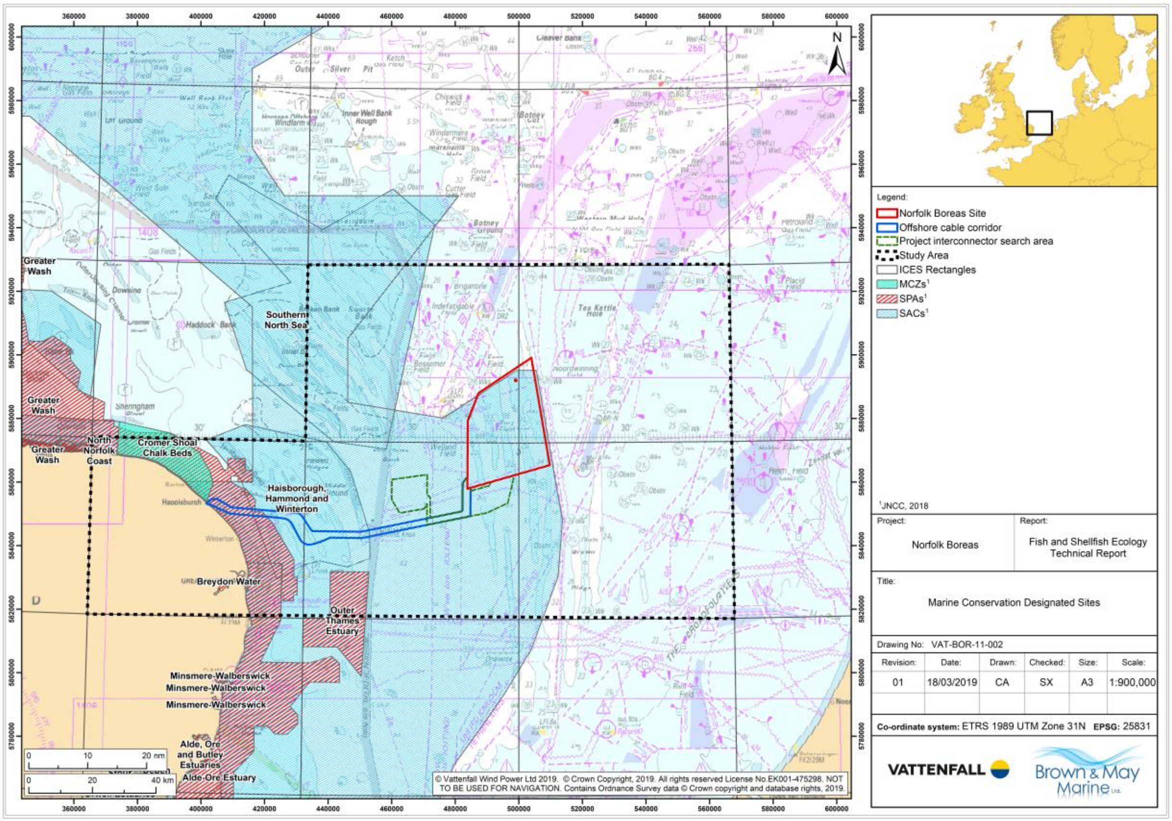


Figure 5.1 Designated marine conservation sites in the vicinity of Norfolk Boreas

6 Existing Environment

6.1 Overview

6.1.1 Fish and Shellfish Surveys in East Anglia Three, the former East Anglia FOUR and the Former East Anglia Zone

28. The results of fish characterisation and epibenthic surveys carried out in East Anglia THREE and the former East Anglia FOUR (February and May 2013), have been used to inform the baseline characterisation for Norfolk Boreas. In addition, the results of epibenthic surveys carried out in the former East Anglia Zone in 2010, have also been taken account of in this report. These are highly relevant to the project due the overlap and/or close proximity between the offshore project area and the areas where these surveys were undertaken (Figure 6.1 and Figure 6.2).

29. A description of the surveys undertaken is given in Table 6.1, including survey dates, methodology and sampling effort. The location of the sampling stations is illustrated in Figure 6.1 and Figure 6.2.

30. The results of these surveys are provided in the following sections.

31. As caveated in section 2.4.4., the absence/low numbers of shellfish and pelagic fish species in the results from these surveys should be interpreted with caution due to limitations associated with the sampling gear.

Table 6.1 Summary of surveys undertaken in East Anglia THREE,the former East Anglia FOUR and the former East Anglia Zone

Survey and Gear Type	Survey area	Sampling Effort	Time of Surveys
Otter trawl survey (commercial otter trawl with a 100mm mesh cod-end)	East Anglia THREE and former East Anglia FOUR sites	• 9 x 20 minute tows (5 within East Anglia FOUR and 4 in adjacent areas at control locations) • 9 x 20 minute tows (6 within East Anglia THREE and 3 in adjacent areas at control locations)	February and May 2013
Beam trawl survey (4m commercial beam trawl with 80mm mesh cod-end)		• 8 x 20 minute tows (5 within East Anglia FOUR and 3 in adjacent areas at control locations). • 8 x 20 minutes tows (4 within East Anglia THREE and 4 in adjacent areas at control locations)	
Epibenthic survey (2m scientific beam trawl)	East Anglia THREE and former East Anglia FOUR sites and East Anglia THREE offshore cable corridor	• 3 x 10 minute tows within the East Anglia FOUR site • 3 x approx. 10 minute tows within the East Anglia THREE site • 6 x 10 minute tows along East Anglia THREE offshore cable corridor	May 2013
	Former East Anglia Zone	• 78 x 10 minute tows across the former East Anglia Zone (45 tows within the study area defined for Norfolk Boreas)	August- September 2010

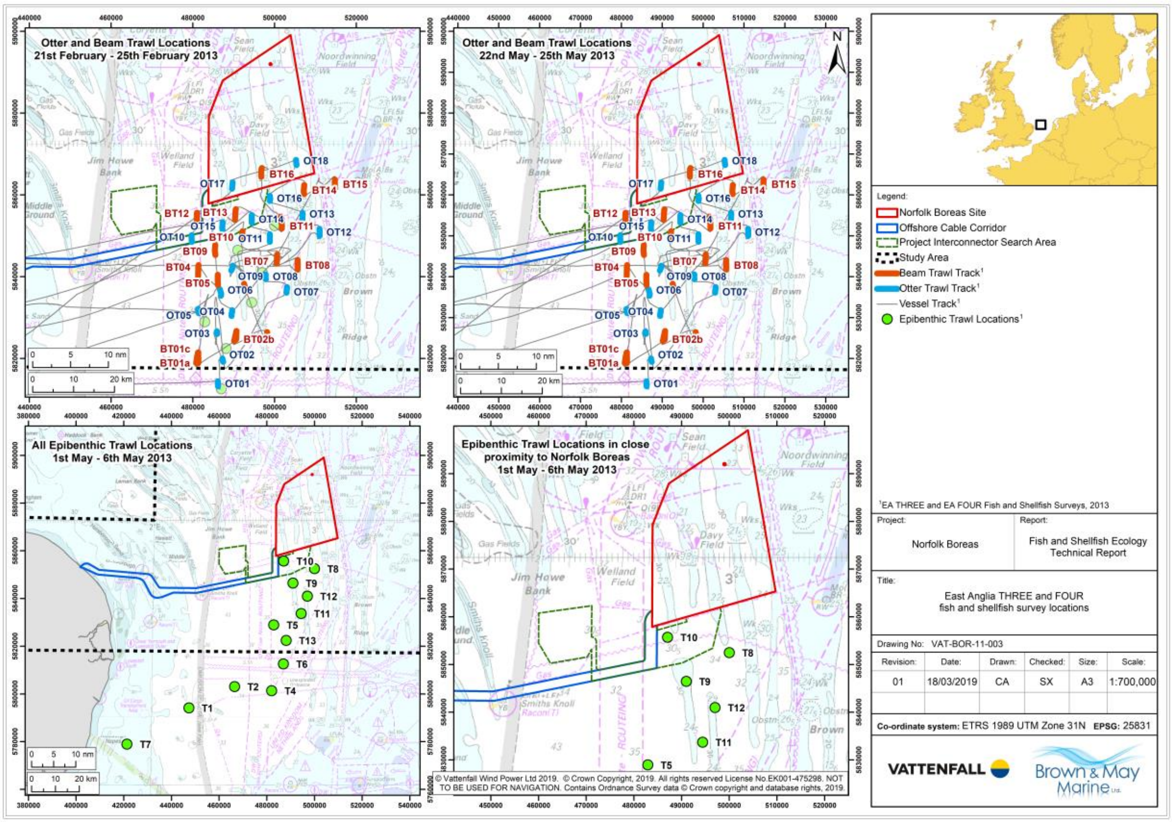


Figure 6.1 Sampling locations of otter trawl, beam trawl and epibenthic surveys conducted in East Anglia THREE and the former East Anglia FOUR

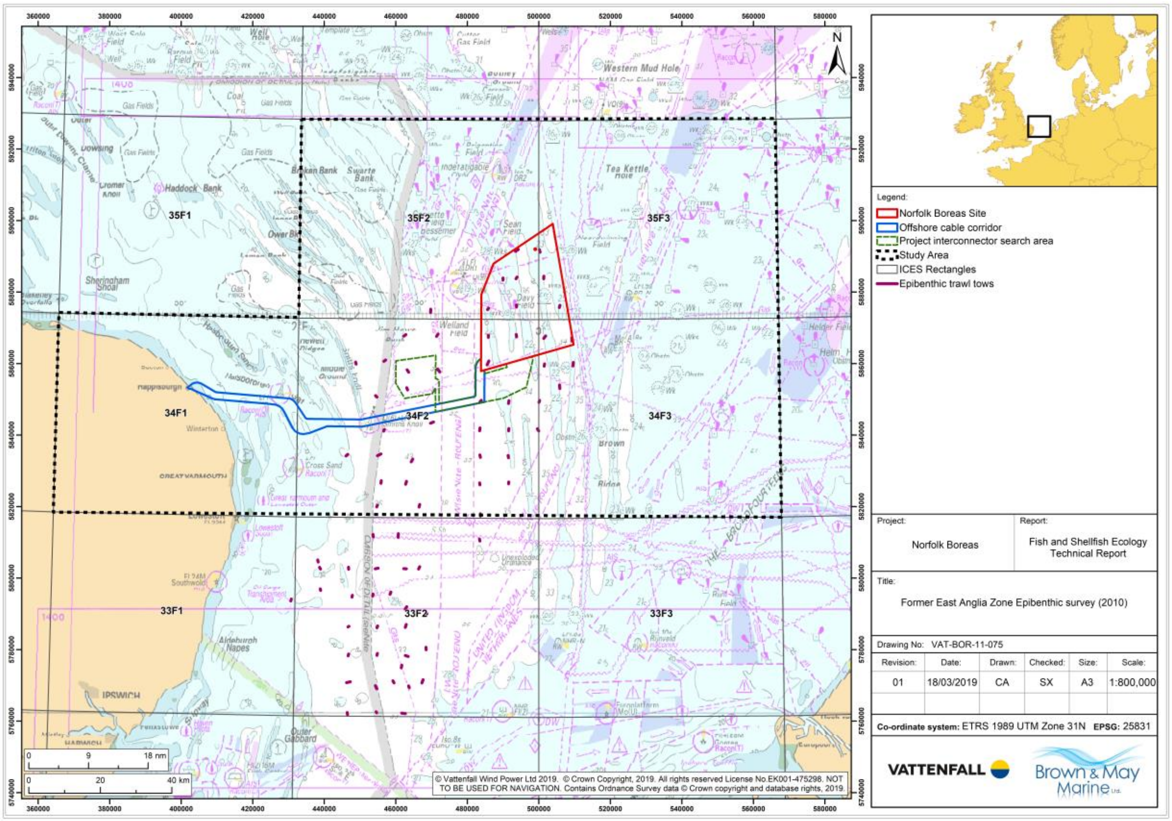


Figure 6.2 Sampling locations of the epibenthic survey undertaken in the former East Anglia Zone

6.1.1.1 Demersal Otter Trawl Sampling

32. During demersal otter trawl surveys undertaken for East Anglia THREE, a total of 18 species were caught; eight at control stations and eighteen within the East Anglia THREE site. Dab *Limanda limanda* was the most abundant species in otter trawl samples, followed by plaice *Pleuronectes platessa* and whiting *Merlangius merlangus*. Lesser spotted dogfish *Scyliorhinus canicula* was the only elasmobranch species found in these surveys.

33. In East Anglia FOUR, a total of 22 species were recorded in the otter trawl surveys; 17 at control stations and 17 within East Anglia FOUR. Overall, dab was again the most abundant species sampled, followed by plaice and whiting. Elasmobranch species recorded in these surveys included lesser spotted dogfish, thornback ray *Raja clavata* and spotted ray *Raja montagui*.

34. A summary of the results of the demersal otter trawl sampling is given in Table 6.2.

Table 6.2 Summary Results of the Demersal Otter Trawl Sampling (EA THREE & EA FOUR, February and May 2013)

Common name	Scientific name	CPUE (number of individuals per hour)							
		Control				Windfarm			
		EA THREE		EA FOUR		EA THREE		EA FOUR	
		Feb 2013	May 2013	Feb 2013	May 2013	Feb 2013	May 2013	Feb 2013	May 2013
Dab	*Limanda limanda*	72.8	9.0	100.8	29.9	60.5	12.8	78.6	40.6
Plaice	*Pleuronectes platessa*	33.9	7.5	62.7	23.2	31.3	16.6	48.2	33.4
Whiting	*Merlangius merlangus*	3.0	32.8	3.0	9.7	34.8	11.0	3.6	17.3
Grey gurnard	*Eutrigla gurnardus*	4.0	-	3.7	5.2	3.0	2.1	10.1	4.8
Lesser spotted dogfish	*Scyliorhinus canicula*	-	13.5	0.7	10.5	-	3.8	0.6	3.6
Sprat	*Sprattus sprattus*	-	-	3.0	-	1.5	0.4	14.9	-
Herring	*Clupea harengus*	-	-	1.5	-	6.9	-	8.9	-
Flounder	*Platichthys flesus*	3.0	-	4.5	-	2.0	-	4.8	-
Bullrout	*Myoxocephalus scorpius*	-	-	-	0.7	-	1.8	-	10.1
Lesser weever fish	*Echiichthys vipera*	2.0	1.2	-	0.7	-	0.9	0.6	3.6
Cod	*Gadus morhua*	1.0	-	-	0.7	2.0	-	-	0.6
Lemon sole	*Microstomus kitt*	-	-	-	0.7	-	0.4	-	1.2
Cuttlefish	*Sepia officinalis*	-	-	-	-	0.5	-	1.2	-
Tub Gurnard	*Trigla lucerna*	-	-	-	0.7	-	-	-	0.6
Three-bearded	*Gaidropsarus*	-	-	-	-	-	-	-	1.2

Common name	Scientific name	CPUE (number of individuals per hour)							
		Control				Windfarm			
		EA THREE		EA FOUR		EA THREE		EA FOUR	
		Feb 2013	May 2013	Feb 2013	May 2013	Feb 2013	May 2013	Feb 2013	May 2013
Rockling	*vulgaris*								
Common dragonet	*Callionymus lyra*	-	-	-	-	-	0.5	-	0.6
Bib	*Trisopterus luscus*	-	-	-	-	1.0	-	-	-
Edible Crab	*Cancer pagurus*	-	-	0.7	-	-	-	-	-
Starry Smoothhound	*Mustelus asterias*	-	-	0.7	-	-	-	-	-
Spotted Ray	*Raja montagui*	-	-	-	0.7	-	-	-	-
Thornback Ray	*Raja clavata*	-	-	-	0.7	-	-	-	-
Velvet Crab	*Necora puber*	-	-	-	0.7	-	-	-	-
Dover Sole	*Solea solea*	-	-	-	-	-	-	0.6	-
Squid	Alloteuthis sp.	-	-	-	-	-	0.5	-	-
Horse mackerel	*Trachurus trachurus*	-	-	-	-	-	0.5	-	-

6.1.1.2 Beam Trawl Surveys

35. For East Anglia THREE, a total of 23 species of fish and shellfish were caught in the 4m beam trawl surveys; 17 species at control stations and 19 within the East Anglia THREE site (Table 6.3). Plaice was the most abundant species, followed by dab. Catch rates of all other species were comparatively low.

36. For East Anglia FOUR, a total of 23 species of fish were caught in the beam trawl survey, 17 of which were found at the control stations and 17 within East Anglia FOUR (Table 6.3). Overall, plaice was the most abundant species caught, followed by dab; all other species were caught in relatively low numbers. The total catch rate was highest within East Anglia FOUR.

Table 6.3 Summary Results of 4m Beam Trawl sampling (EA THREE & EA FOUR, February and May 2013)

Common name	Scientific name	CPUE (number of individuals per hour)							
		Control				Windfarm			
		EA THREE		EA FOUR		EA THREE		EA FOUR	
		Feb 2013	May 2013	Feb 2013	May 2013	Feb 2013	May 2013	Feb 2013	May 2013
Plaice	*Pleuronectes platessa*	37.6	29.2	96.2	40.2	86.2	36.0	110.4	117.0
Dab	*Limanda limanda*	29.0	15.0	54.6	6.6	68.1	16.5	104.4	62.0

Common name	Scientific name	CPUE (number of individuals per hour)							
		Control				Windfarm			
		EA THREE		EA FOUR		EA THREE		EA FOUR	
		Feb 2013	May 2013	Feb 2013	May 2013	Feb 2013	May 2013	Feb 2013	May 2013
Whelk	*Buccinum undatum*	0.7	27.0	4.0	3.0	-	-	0.6	9.0
Solenette	*Buglossidium luteum*	0.7	3.0	3.0	3.0	5.2	6.8	4.2	9.0
Common dragonet	*Callionymus lyra*	-	2.2	-	1.2	0.7	1.5	-	25.0
Lesser weever fish	*Echiichthys vipera*	-	0.7	-	3.6	-	1.5	0.6	10.0
Scaldfish	*Arnoglossus laterna*	1.5	1.5	3.0	-	3.0	-	6.0	1.0
Bullrout	*Myoxocephalus scorpius*	-	-	2.0	-	5.2	1.5	-	7.0
Cuttlefish	*Sepia officinalis*	1.5	-	2.0	-	5.2	-	5.4	-
Lesser spotted dogfish	*Scyliorhinus canicula*	-	5.2	4.0	-	1.5	0.7	1.2	1.0
Grey gurnard	*Eutrigla gurnardus*	0.7	1.5	3.0	-	1.5	-	2.4	1.0
Dover Sole	*Solea solea*	-	0.7	6.0	0.6	-	0.8	-	2.0
Velvet crab	*Necora puber*	0.7	3.0	-	-	5.1	-	-	-
Whiting	*Merlangius merlangus*	-	0.7	-	1.2	0.7	-	0.6	4.0
Flounder	*Platichthys flesus*	-	-	4.0	-	-	-	3.0	-
Pogge	*Agonus cataphractus*	-	0.7	-	-	-	0.7	-	4.0
Thickback Sole	*Microchirus variegatus*	-	-	-	0.6	-	-	-	4.0
Brill	*Scophthalmus rhombus*	-	-	1.0	-	0.7	-	-	-
Lemon Sole	*Microstomus kitt*	-	-	-	-	-	-	0.6	1.0
Starry Smoothhound	*Mustelus asterias*	-	-	1.0	-	-	-	-	-
Squid	*Alloteuthis sp.*	-	-	-	-	-	-	-	1.0
Turbot	*Scophthalmus maximus*	-	-	-	-	-	0.8	-	-
John Dory	*Zeus faber*	-	-	-	-	-	0.7	-	-
Sea scorpion	*Taurulus bubalis*	-	-	-	-	-	0.7	-	-
Mackerel	*Scomber scombrus*	-	-	-	-	-	0.7	-	-
Goby indet	Gobiidae spp	0.7	-	-	-	-	-	-	-
Sprat	*Sprattus sprattus*	0.7	-	-	-	-	-	-	-

Common name	Scientific name	CPUE (number of individuals per hour)							
		Control				Windfarm			
		EA THREE		EA FOUR		EA THREE		EA FOUR	
		Feb 2013	May 2013	Feb 2013	May 2013	Feb 2013	May 2013	Feb 2013	May 2013
Thornback ray	*Raja clavata*	0.7	-	-	-	-	-	-	-
4-Bearded Rockling	*Rhinonemus cimbrius*	-	-	-	-	-	-	0.6	-
Edible Crab	*Cancer pagurus*	-	-	-	0.6	-	-	-	-
Squid	*Loligo sp.*	-	-	-	0.6	-	-	-	-

6.1.1.3 Epibenthic Surveys

6.1.1.3.1 East Anglia THREE and former East Anglia FOUR

37. Epibenthic surveys were conducted during May 2013 in the East Anglia THREE and the former East Anglia FOUR sites to characterise the marine epifauna (i.e. animals that live on the surface of the sea bed). The surveys were conducted using a 2-metre scientific beam trawl.

38. A summary of the fish species recorded during these surveys is presented in Table 6.4. As shown, the most prevalent species caught were solenette and sand goby *Pomatoschistus minutus*.

Table 6.4 Summary of the results of the 2m Scientific Beam Trawl survey (EA THREE & EA FOUR, May 2013)

Common Name	Scientific Name	CPUE (number of individuals per hour)		
		EA THREE May 2013		EA FOUR May 2013
		Export cable	EA THREE Site	
Solenette	*Buglossidium luteum*	122.2	273.8	695.9
Sand goby	*Pomatoschistus minutus*	83	306	172.8
Lesser weever	*Echiichthys vipera*	49.2	48.3	82.8
Scaldfish	*Arnoglossus laterna*	23.8	51.9	37.9
Dab	*Limanda limanda*	10.8	17.9	28.4
Common dragonet	*Callionymus lyra*	6.1	23.3	18.9
Greater sandeel	*Hyperoplus lanceolatus*	14.6	8.9	9.5
Pogge	*Agonus cataphractus*	8.5	8.9	7.1
Spotted	Callionymus	1.5	8.9	7.1

Common Name	Scientific Name	CPUE (number of individuals per hour) EA THREE May 2013 Export cable	EA THREE Site	EA FOUR May 2013
Dragonet	maculatus			
Sprat	*Sprattus sprattus*	2.3	0	14.2
Three-bearded Rockling	Gaidropsarus vulgaris	0.8	5.4	7.1
Reticulated dragonet	*Callionymus reticulatus*	0.8	3.6	7.1
Plaice	*Pleuronectes platessa*	1.5	7.2	2.4
Whiting	*Merlangius merlangus*	0.8	1.8	7.1
Bony Fish Larvae	Osteichthyes (larvae)	3.1	1.8	4.7
Dover Sole	*Solea solea*	5.4	3.6	-
Sandeel	Ammodytes spp	6.9	1.8	-
Smooth sandeel	*Gymnammodytes semisquamatus*	1.5	5.4	-
Greater pipefish	*Syngnathus acus*	3.1	0	2.4
Small sandeel	*Ammodytes tobianus*	2.3	1.8	-
Sandeel	*Ammodytidae*	0	3.6	-
Goby indet	*Pomatoschistus sp.*	1.5	1.8	-
Lesser spotted dogfish	*Scyliorhinus canicula*	3.1	0	-
Goby indet	Gobiidae spp	1.5	0	-
Gadoid	Gadinae (juv.)	1.5	0	-
Grey Gurnard	*Eutrigla gurnardus*	1.5	0	-
Thornback Ray	*Raja clavata*	0.8	0	-
Four bearded rockling	*Enchelyopus cimbrius*	0.8	0	-

6.1.1.3.2 Former East Anglia Zone

39. Epibenthic surveys were conducted during August and September 2010 across the former East Anglia Zone to characterise the marine epifauna. The surveys were conducted using a 2-metre scientific beam trawl.

40. A summary of the fish species recorded during this survey in sampling stations that fall within study area defined for Norfolk Boreas (rectangles 34F2, 34F3, 35F2 and 35F3) is presented in Table 6.5. As shown, in line with the results recorded during surveys in the former East Anglia FOUR and East Anglia THREE the most prevalent species caught were solenette and gobies.

Table 6.5 Summary of the results of the 2m Scientific Beam Trawl survey (former East Anglia Zone, 2010)

Common Name	Scientific name	CPUE (number of individual per hour) Stations sampled during Zonal surveys for the former East Anglia Zone that fall within the Norfolk Boreas study area
Solenette	*Buglossidium luteum*	527.7
Gobies	*Gobiidae*	315.5
Lesser weever	*Echiichthys vipera*	100.1
Dab	*Limanda limanda*	86.1
Whiting	*Merlangius merlangus*	75.1
Sandeels	*Ammodytes*	57.5
Common dragonet	*Callionymus lyra*	57.5
Scaldfish	*Arnoglossus laterna*	57.2
Pogge	*Agonus cataphractus*	21.5
Plaice	*Pleuronectes platessa*	5.1
Poor cod	*Trisopterus minutus*	3.5
Solenette	*Solea solea*	3.5
Lesser pipefish	*Syngnathus rostellatus*	2.9
Horse mackerel	*Trachurus trachurus*	2.5
Red mullet	*Mullus surmuletus*	2.1
Red gurnard	*Aspitrigla cuculus*	2.0
Lesser Spotted Dogfish	*Scyliorhinus canicula*	1.5
Gurnards	*Triglidae*	1.1
Great sandeel	*Hyperoplus lanceolatus*	1.1
Fourbeard rockling	*Rhinonemus cimbrius*	0.8
Lemon sole	*Microstomus kitt*	0.5
Grey gurnard	*Eutrigla gurnardus*	0.3
Sea snail	*Liparis liparis*	0.3
Turbot	*Psetta maxima*	0.3
Sprat	*Sprattus sprattus*	0.1
Cod	*Gadus morhua*	0.1
Bull rout	*Myoxocephalus scorpius*	0.1
Butterfish	*Pholis gunnellus*	0.1
Brill	*Scophthalmus rhombus*	0.1

6.1.2 International Bottom Trawl Surveys (IBTS)

41. The average catch per unit effort (CPUE) of the 50 most common species found in the study area by ICES rectangle in IBT surveys (spring, summer, autumn, winter) for the years 2008 to 2017 is given in Table 6.6.

42. Sprat *Sprattus sprattus* was the species recording the highest CPUE in the study area (rectangles 34F1, 34F2, 34F3, 35F2 and 35F3). Similarly, CPUE for whiting was high across the study area, particularly in 34F2, where the project interconnector search

area, south western portion of the Norfolk Boreas site and eastern section of the offshore section of the offshore cable corridor are located.

43. Other species recorded in relatively high numbers by the IBTS within the study area include horse mackerel *Trachurus trachurus*, various species of sandeel, particularly greater sandeel *Hyperoplus lanceolatus* and lesser sandeel *Ammodytes marinus*, dab, herring *Clupea harengus*, mackerel *Scomber scombrus*, lesser weever, plaice and gobies (Table 6.6).

Table 6.6 Average Catch per Unit Effort CPUE (number/hour) for principal species recorded in the IBTS within each ICES rectangle relevant to Norfolk Boreas (2008-2017) (DATRAS, 2018)

Common name	Scientific name	CPUE (number of individuals per hour)				
		34F1	34F2	34F3	35F2	35F3
Sprat	*Sprattus sprattus*	1055.8	4967.0	16710.0	16974.1	51446.7
Whiting	*Merlangius merlangus*	158.6	4430.1	2939.9	1022.4	394.1
Horse mackerel	*Trachurus trachurus*	0.00	479.0	290.0	105.8	4603.8
Greater sandeel	*Hyperoplus lanceolatus*	25.8	38.6	2182.0	401.4	1247.9
Common dab	*Limanda limanda*	50.0	598.8	636.6	716.7	2665.9
Atlantic herring	*Clupea harengus*	75.0	156.6	1129.0	1154.2	948.7
Atlantic mackerel	*Scomber scombrus*	0.00	567.4	568.2	337.2	190.8
Lesser weever	*Echiichthys vipera*	6.5	203.9	523.9	773.1	153.0
Weever indet.	*Echiichthys*	0.00	265.3	517.3	0.00	0.00
Lesser sandeel	*Ammodytes marinus*	19.0	27.6	262.6	485.1	25.3
European plaice	*Pleuronectes platessa*	102.2	498.6	138.3	110.4	157.4
Small sandeel	*Ammodytes tobianus*	112.0	23.5	535.3	2.0	5.6
Common squid	*Loligo subulata*	0.00	0.00	14.5	131.8	309.3
European common squid	*Alloteuthis subulata*	0.00	29.3	12.3	129.6	267.9
Velvet swimcrab	*Necora puber*	0.00	182.0	2.0	0.00	0.00
Goby	*Pomatoschistus*	38.0	446.2	6.0	4.7	8.6
Solenette	*Buglossidium luteum*	26.7	100.1	16.7	60.7	178.1
Rock gunnel	*Pholis gunnellus*	144.1	0.00	0.00	5.0	0.00
Loligo indet.	*Loligo*	0.00	102.2	45.1	0.00	0.00
Grey gurnard	*Eutrigla gurnardus*	0.00	29.6	61.1	44.3	63.6
Smooth Sandeel	*Gymnammodytes semisquamatus*	0.00	2.0	84.0	0.00	0.00
Loligo squid	*Loligo forbesii*	0.00	5.5	12.1	100.8	67.0
European pilchard	*Sardina pilchardus*	0.00	8.0	24.0	0.00	62.9
Small-spotted catshark	*Scyliorhinus canicula*	2.5	67.2	5.2	10.7	14.4
European anchovy	*Engraulis encrasicolus*	2.0	35.9	50.7	8.2	15.0
European flounder	*Platichthys flesus*	3.0	3.3	47.0	3.6	21.5
Norway lobster	*Nephrops norvegicus*	0.00	0.00	0.00	26.0	0.00
Gobies	*Gobiidae*	9.2	12.3	2.0	10.9	76.0

Common name	Scientific name	CPUE (number of individuals per hour)				
		34F1	34F2	34F3	35F2	35F3
Gurnard	*Eutrigla sp.*	0.00	22.9	21.1	0.00	0.00
Red mullet	*Mullus barbatus*	0.00	20.0	0.00	0.00	0.00
Squid	*Teuthida*	0.00	18.0	0.00	0.00	0.00
Edible crab	*Cancer pagurus*	73.9	6.7	2.1	6.9	2.6
Smoothhound	*Mustelus mustelus*	0.00	4.5	0.00	41.0	0.00
Hooknose	*Agonus cataphractus*	18.1	18.2	2.0	16.3	10.4
Surmullet	*Mullus surmuletus*	0.00	20.7	6.5	20.0	8.7
Starry smoothhound	*Mustelus asterias*	0.00	5.3	4.0	94.1	3.3
Sandeel	*Ammodytes*	34.8	7.0	4.0	8.7	4.0
Fourbeard rockling	*Enchelyopus cimbrius*	0.00	10.9	2.0	5.0	23.3
Spotted Ray	*Raja montagui*	2.0	7.9	4.0	27.5	8.8
Fivebeard rockling	*Ciliata mustela*	28.3	4.8	0.00	3.6	0.00
Three-bearded rockling	*Gaidropsarus vulgaris*	10.0	0.00	0.00	13.2	0.00
Common seasnail	*Liparis liparis liparis*	14.0	4.0	0.00	0.00	0.00
Thornback ray	*Raja clavata*	4.7	13.1	2.0	17.5	6.1
Shorthorn sculpin	*Myoxocephalus scorpius*	26.9	3.5	2.5	18.7	2.2
Longspined bullhead	*Taurulus bubalis*	22.0	2.0	0.00	4.0	0.00
Mediterranean scaldfish	*Arnoglossus laterna*	2.0	22.6	7.9	5.0	8.8
Poor cod	*Trisopterus minutus*	10.0	12.6	6.6	11.5	2.7

6.1.3 Species Targeted by Commercial Fisheries in the Study Area

44. An indication of the principal species targeted by commercial fisheries in the study area is given in the following sections, based on analysis of annual landing weights data from the UK and other countries known to fish in the study area (primarily the Netherlands and Belgium; see Chapter 14 Commercial Fisheries).

6.1.3.1 UK MMO Landings Statistics

45. The principal species recorded in UK landings are outlined below, based on analysis of annual landing weights (average 2007-2016) by species and ICES rectangle (34F1, 34F2, 34F3, 35F2 and 35F3) (Table 6.7 and Figure 6.3).

46. In rectangles 34F2, 34F3, 35F2 and 35F3, where the majority of the offshore project arera is located, the principal species landed are plaice and Dover sole *Solea solea*. Sprat landings within this area are also of relevance, contributing 23.44% in rectangle 34F2 and 25.90% in rectangle 35F2. Cod *Gadus morhua* makes a relatively small contribution to landings weights in all the rectangles within the study area (Table 6.7 and Figure 6.3).

47. In rectangles 34F1, where the inshore section of the offshore cable corridor is located, edible crabs *Cancer pagurus*, lobster *Homarus gammarus* and whelk *Buccinum undatum* make the greatest contribution to landings weights. Although at much lower levels, fish species such as herring and cod are also landed from this rectangle (Table 6.7 and Figure 6.3).

48. The high contribution of mussels *Mytilus edulis* to landings in rectangle 34F1 is a result of unusually high landings in 2011 at 2,524.77 tonnes (Table 6.7). It is understood that 2011 was a particularly strong year for mussels owed to the opening of sub-littoral mussel seed beds between Cromer and Sea Palling, along the North Norfolk coast. Since elevated mussel landings were only observed in 2011 and not preceding or subsequent years, mussel landings data have been excluded from Figure 6.3 to allow data visualisation for other species.

Table 6.7 Percentage contribution of the principal commercial species (MMO landings data 2007-2016) within each ICES rectangle relevant to Norfolk Boreas

Species	Average contribution to catch within ICES rectangle 34F1 (%)	Average contribution to catch within ICES rectangle 34F2 (%)	Average contribution to catch within ICES rectangle 34F3 (%)	Average contribution to catch within ICES rectangle 35F2 (%)	Average contribution to catch within ICES rectangle 35F3 (%)
Mussels	52.12	0.00	0.00	0.00	0.00
Plaice	0.06	32.18	57.79	46.44	61.54
Edible Crabs	21.81	0.07	0.13	0.69	0.31
Dover Sole	0.18	23.34	16.54	14.02	12.92
Sprats	0.18	23.44	1.19	25.90	10.20
Whelks	11.49	0.12	0.09	0.44	0.01
Lobsters	5.14	0.02	0.01	0.09	0.00
Cod	1.51	5.82	5.18	0.59	3.42
Herring	3.45	0.00	0.00	0.00	0.00
Turbot	0.00	2.25	2.15	2.65	3.34
Dabs	0.03	1.69	4.19	1.53	2.90
Brill	0.00	2.42	2.06	1.51	0.88
Thornback Ray	0.38	1.68	1.06	1.04	0.86
Brown Shrimps	1.33	0.00	0.00	0.00	0.00
Tub Gurnard	0.00	2.05	1.59	0.95	0.69
Flounder or Flukes	0.03	0.48	4.87	0.09	1.08
Blonde Ray	0.15	1.91	0.36	1.33	0.08
Cockles	0.78	0.00	0.00	0.00	0.00
Spotted Ray	0.01	0.04	0.49	0.58	0.58
Bass	0.31	0.07	0.03	0.01	0.00
Other	1.03	2.40	2.27	2.14	1.19

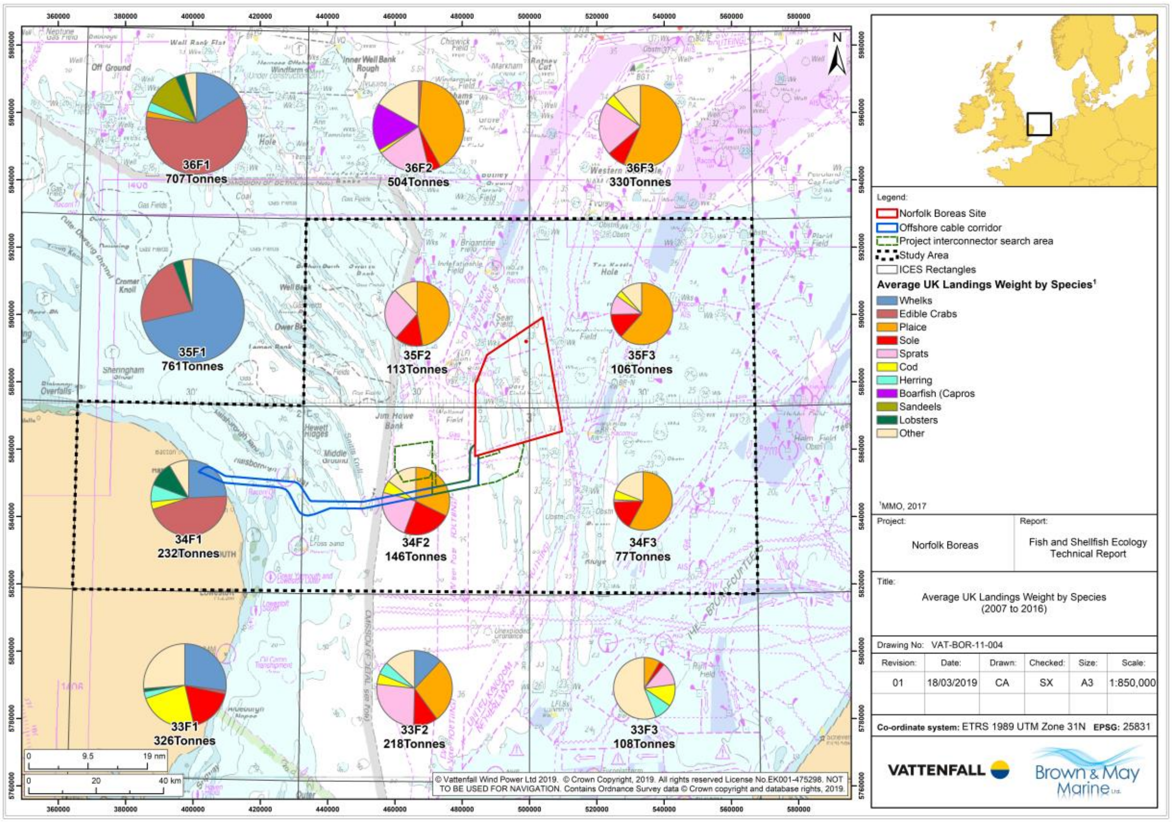


Figure 6.3 Average UK landings weight by Species (Ave. 2007-2016) (MMO, 2017)

6.1.3.2 Dutch IMARES Landings Statistics

49. Figure 6.4 shows annual Dutch landings weights (kg) in the study area (rectangles 34F1, 34F2, 34F3, 35F2 and 35F3).

50. The main species targeted by Dutch vessels are plaice and Dover sole. Landings weights for turbot *Scophthalmus maximus*, although substantially smaller than those for plaice and Dover sole, are also significant. The majority of landings come from rectangles 34F2, 34F3, 35F2 and 35F3 (where the majority of the offshore project area is located).

51. Landings weights in rectangle 34F1 (where the inshore section of the offshore cable corridor is located) are comparatively low.

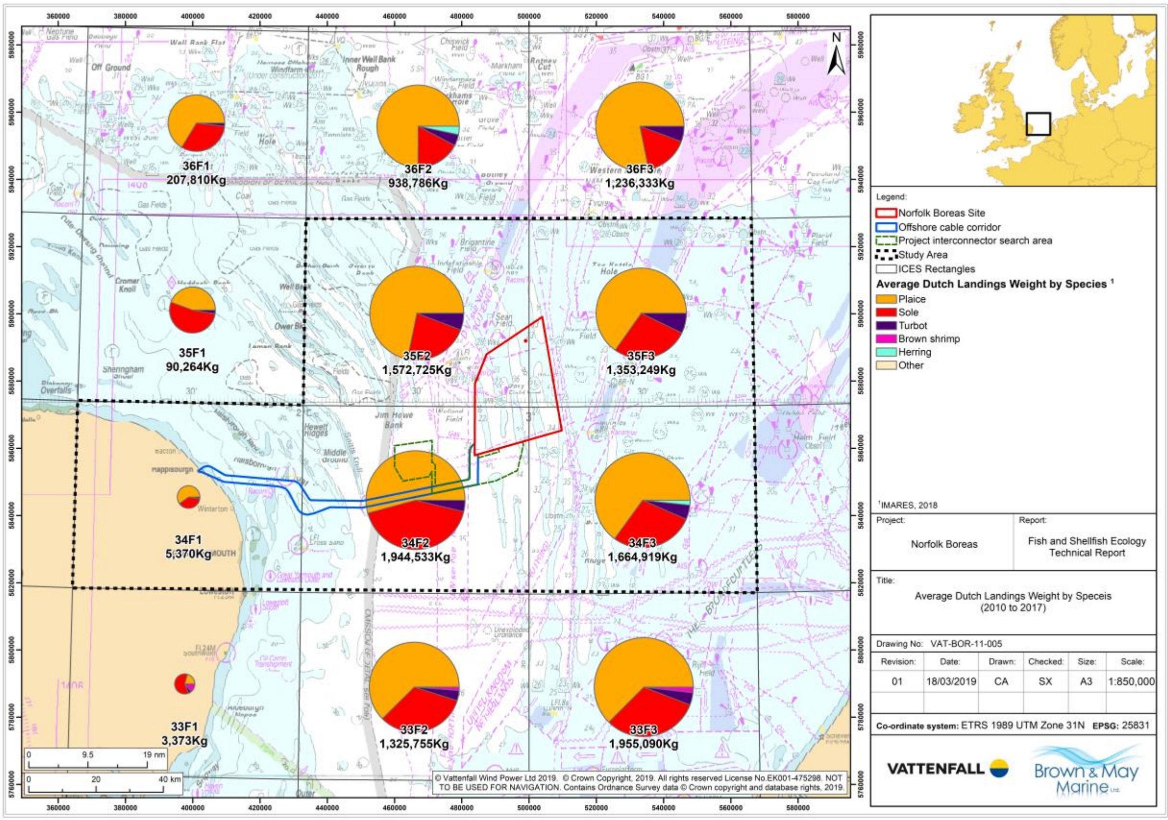


Figure 6.4 Average Dutch landings weight by species (Ave. 2010-2017) (IMARES, 2018)

6.1.3.3 Belgian ILVO Landings Statistics

52. Figure 6.5 shows annual Belgian landings weights (kg) in the study area (rectangles 34F1, 34F2, 34F3, 35F2 and 35F3) over the most recent 5-year period for which data is available (2010-2014).

53. A wide range of species are targeted by the Belgian fleet, however, plaice and Dover sole make the greatest contribution to landings by weight in the study area, notably in ICES rectangle 34F2. Other species targeted within the study area by Belgian vessels include skates and rays, cod, dab, turbot, tub gurnard *Trigla lucerna* and brill *Scophthalmus rhombus*.

54. Landings weights in 34F1, where the inshore section of the offshore cable corridor is located, are markedly lower than in 34F2, 34F3, 35F2 and 35F3, where the majority of the offshore project area is located.

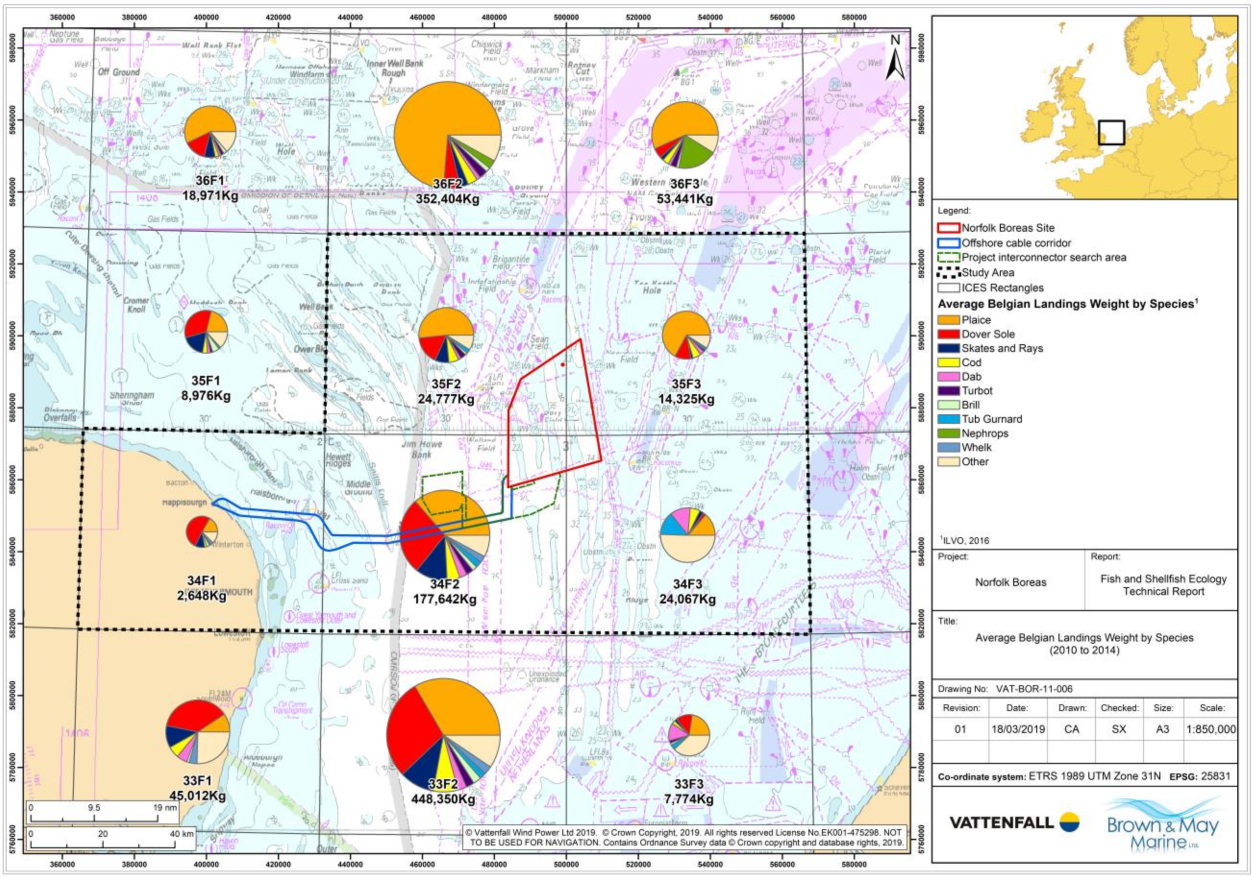


Figure 6.5 Average Belgian landings weight by species (Ave. 2010-2014) (ILVO, 2016)

6.1.4 Spawning and Nursery Grounds

55. The distribution of known spawning and nursery grounds in relation to the location of the offshore project area is discussed in this section. This has been primarily informed by data provided in Coull et al. (1998) and Ellis et al. (2012). As outlined in section 3.1.1, these papers are based on a review of published data and provide broad scale descriptions of the spatial and temporal extent of spawning grounds and spawning duration.

56. Species for which spawning or nursery grounds have been defined in areas that overlap with the Norfolk Boreas site, the project interconnector search area and/or the offshore cable corridor are listed in Table 6.8.

57. Note that both spawning and nursery grounds generally cover wide sea areas with the level of overlap between the offshore project area representing a small proportion of the overall grounds used by each species.

58. Spawning grounds for Dover sole, plaice, cod, whiting, lemon sole *Microstomus kitt*, mackerel, sprat and sandeel (Ammodytidae) have all been defined within the offshore project area.

59. Nursery grounds for all of the above species with the addition of herring, thornback ray *Raja clavata* and tope *Galeorhinus galeus* have been defined within the offshore project area. Note that in the case of thornback ray and tope, there is currently insufficient data on the occurrence of egg-cases or egg-bearing females in the spawning season with which to define spawning grounds. In the case of thornback ray, it is considered that these are likely to broadly overlap with nursery grounds (Ellis et al., 2012).

60. Most of the species listed in Table 6.8 are pelagic spawners, which release their eggs in the water column. Exceptions to this are herring and sandeel, which are substrate-specific demersal spawners. Thornback ray also lay eggs on benthic substrates although they are not known to have the same degree of substrate-specific spawning requirements as herring and sandeels.

Table 6.8 Species with spawning and/or nursery grounds in the Norfolk Boreas site, the project interconnector search area and the offshore cable corridor (Coull et al., 1998; Ellis et al., 2012)

Species	Spawning season												Spawning Intensity			Nursery Intensity		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Norfolk Boreas site	project interconnector search area	offshore cable corridor	Norfolk Boreas site	project interconnector search area	offshore cable corridor
Dover sole				●									n/a			n/a	n/a	
Plaice	●	●														n/a	n/a	
Cod		●	●															
Whiting																		
Lemon sole													n/a			n/a		
Herring													n/a	n/a	n/a			
Mackerel					●	●	●											
Sprat					●	●											n/a	n/a
Sandeel																		
Thornback ray				●	●	●	●	●					n/a			n/a	n/a	
Tope	Gravid females present year round												n/a					

(Spawning times and intensity colour key: yellow= high intensity spawning/nursery grounds, green= low intensity spawning/nursery grounds, blue= spawning/nursery intensity not defined, grey= spawning period, ● = peak spawning, n/a= no overlap with spawning/nursery grounds)

6.1.5 Species of Conservation Interest

61. Fish and shellfish species of conservation importance with potential to make use of the offshore project area are outlined in the following sections, including:

- Diadromous fish species;
- Elasmobranchs; and
- Other species.

6.1.5.1 Diadromous species

62. A number of diadromous species have the potential to transit parts of the offshore project area, during certain periods of their life cycle. These are listed in Table 6.9 together with their conservation status.

6.1.5.2 Elasmobranchs

63. The principal elasmobranch species potentially found in areas relevant to Norfolk Boreas are listed Table 6.10 together with their conservation status. Sharks, skates and rays are of conservation interest due to their slow growth rates and low reproductive output compared to other species groups (Camhi et al., 1998). This results in slow rates of stock increase (Smith et al., 1998) and a low resilience to fishing mortality (Holden, 1974). Most elasmobranch species stocks are considered to be low, and international advice and spatial management measures have been introduced to conserve the remaining stocks (ICES Advice, 2013).

6.1.5.3 Other Species of Conservation Interest

64. In addition to diadromous fish and elasmobranchs, a number of other species found in the study area are of conservation interest, being listed as species of principal importance under the UK Post-2010 Biodiversity Framework and Section 41 of the Natural Environment and Rural Communities (NERC) Act. These are presented in Table 6.11, along with other conservation designations (e.g. OSPAR and IUCN listings). It should be noted that many of these species are commercially exploited in the area, either directly or indirectly as by-catch.

Table 6.9 Conservation status of diadromous migratory species

Common name	Scientific name	Conservation Status						
		[2]IUCN Red List	[3]Species of Principal Importance	[4]OSPAR	[5]Bern Convention	[6]CITES	[7]W&C 1981	[8]Habitats Directive
European eel	*Anguilla anguilla*	Critically Endangered	✓	✓	-	✓	-	-
Allis shad	*Alosa alosa*	Least concern	✓	✓	✓	-	✓	✓
Twaite shad	*Alosa fallax*	Least concern	✓	-	✓	-	✓	✓
Sea lamprey	*Petromyzon marinus*	Least concern	✓	✓	✓	-	-	✓
River lamprey	*Lampetra fluviatilis*	Least concern	✓	-	✓	-	-	✓
Atlantic salmon	*Salmo salar*	Least concern	✓	✓	✓	-	-	✓
Sea trout	*Salmo trutta*	Least concern	✓	-	-	-	-	-
Smelt (sparling)	*Osmerus eperlanus*	Least concern	✓	-	-	-	-	-

[2] IUCN - International Union for the Conservation of Nature – Red-listed species
[3] NERC Act 2006
[4] OSPAR - Oslo and Paris Convention for the Protection of the Marine Environment of the North-East Atlantic – Threatened or declining species
[5] Bern Convention
[6] CITES
[7] Wildlife and Conservation Act 1981
[8] Habitats Directive

Table 6.10 Conservation status of elasmobranch species

Common name	Scientific name	Conservation Status: IUCN Red List	Species of Principal Importance	OSPAR	Bern Convention	CITES	W&C 1981	Habitats Directive
Sharks								
Basking shark	*Cetorhinus maximus*	Vulnerable	✓	✓	✓	✓	✓	-
Starry smoothhound	*Mustelus asterias*	Least concern	-	-	-	-	-	-
Smoothhound	*Mustelus mustelus*	Vulnerable	-	-	-	-	-	-
Spurdog	*Squalus acanthias*	Vulnerable	✓	✓	-	-	-	-
Thresher shark	*Alopias vulpinus*	Vulnerable	-	-	-	-	-	-
Tope	*Galeorhinus galeus*	Vulnerable	✓	-	-	-	-	-
Skates and rays								
Blonde ray	*Raja brachyura*	Near Threatened	-	-	-	-	-	-
Cuckoo ray	*Leucoraja naevus*	Least concern	-	-	-	-	-	-
Common Skate Complex[9]	*Dipturus intermedia/Dipturus flossada*	Critically endangered	✓	✓	-	-	-	-
Spotted ray	*Raja montagui*	Least concern	-	✓	-	-	-	-
Thornback ray	*Raja clavata*	Near Threatened	-	✓	-	-	-	-
Undulate ray[10]	*Raja undulata*	Endangered	✓	-	-	-	-	-
White skate	*Rostroraja alba*	Endangered	✓	✓	-	-	-	-

[9] A study by Iglésias *et al.* (2010) has revealed that common skate actually comprises two species: *Dipturus intermedia* and *Dipturus flossada*. Common names already in use for these species are the flapper skate and blue skate respectively, although it remains to be seen if these become widely accepted (Iglésias *et al*., 2010; Shark Trust, 2010).

[10] *Raja undulata* is considered to be occasionally present off the East Anglian coast (Shark Trust, 2010) and occurs locally in the Eastern English Channel (Coelho *et al*., 2009).

Table 6.11 Conservation status of fish and shellfish species relevant to the proposed Norfolk Boreas site, project interconnector search area and the offshore cable corridor (excluding diadromous and elasmobranch species)

Common name	Scientific name	Recorded present in EA3 and EA4 surveys Y/N	Conservation Status						
			IUCN Red List	Species of Principal Importance	OSPAR	Bern Convention	CITES	W&C 1981	Habitats Directive
Demersal species									
Cod	*Gadus morhua*	Y	Vulnerable	✓	✓	-	-	-	-
Plaice	*Pleuronectes platessa*	Y	Least concern	✓	-	-	-	-	-
Gobiidae - sand goby/common goby	*Pomatoschistus minutus/ Pomatoschistus microps*	Y	Least concern	-	-	✓	-	-	-
Haddock	*Melanogrammus aeglefinus*	N	Vulnerable	-	-	-	-	-	-
Lesser sandeel	*Ammodytes marinus*	N	-	✓	-	-	-	-	-
Dover sole	*Solea solea*	Y	-	✓	-	-	-	-	-
Whiting	*Merlangius merlangus*	Y	Least Concern	✓	-	-	-	-	-
Ling	*Molva molva*	N	-	✓	-	-	-	-	-
European Hake	*Merluccius merluccius*	N	Least concern	✓	-	-	-	-	-
Sea bass	*Dicentrarchus labrax*	N	Least concern	-	-	-	-	-	-
Pelagic species									
Herring	*Clupea harengus*	Y	Least concern	✓	-	-	-	-	-
Horse mackerel	*Trachurus trachurus*	Y	Vulnerable	✓	-	-	-	-	-
Mackerel	*Scomber scombrus*	Y	Least concern	✓	-	-	-	-	-
Shellfish									
Horse mussel	*Modiolus modiolus*	N	-	-	-	-	-	-	-
Blue mussel	*Mytilus edulis*	N	-	-	-	-	-	-	-
Dog whelk	*Nucella lapillus*	N	-	-	✓	-	-	-	-
Crawfish	*Palinurus elephas*	N	Vulnerable	✓	-	✓	-	-	-
Fan mussel	*Atrina fragilis*	N	-	✓	-	-	-	✓	-
Ocean quahog	*Arctica islandica*	N	-	-	✓	-	-	-	-
Native oyster	*Ostrea edulis*	N	-	✓	✓	-	-	-	-

6.1.6 Prey Species and Food Web Linkages

65. Various of the species found in the study area play an important role in the North Sea's food web as prey to predators such as birds, marine mammals and piscivorous fish.

66. Sandeels are preyed upon by a broad range of predators. They are a component of the diet of birds, such as kittiwakes, razorbills, puffins and terns (Wright and Bailey, 1996; Furness, 1990; Wanless et al. 1998; Wanless et al., 2005). Sandeels also provide prey to other fish species such as herring, sea trout, cod, whiting, grey gurnard and saithe *Pollachius virens*. In addition, marine mammals such as seals Phoca spp. and harbour porpoises *Phocoena phocoena* are known to feed on sandeels (ICES, 2012; Santos and Pierce, 2003). Predation can occur when sandeels are buried in the sediment but they are more commonly taken during transit to, or feeding in, the water column (Van der Kooij et al., 2008; Furness, 2002; Hobson, 1986).

67. Herring is preyed upon by a variety of bird species and fish species such as whiting, cod, mackerel and horse mackerel (ICES, 2008; ICES, 2005a; ICES, 2005b). Predation mortality of one-year old herring in the North Sea is considered to be largely driven by consumption by cod, whiting, saithe and seabirds, whilst younger herring (0-group herring) are mostly preyed upon by horse mackerel (ICES, 2008). Herring egg mats are also known to attract a number of predators such as spurdog, mackerel, lemon sole and other herring (Richardson et al., 2011).

68. Sprat is important prey for fish species including cod, grey gurnard, herring, sandeels, spurdog *Squalus acanthias*, horse mackerel, mackerel, sea trout *Salmo trutta* and whiting (ICES, 2005b; ICES, 2009), as well as seabirds (Wanless et al., 2005). Both herring and sprat form part of the diet of marine mammals such as seals and harbour porpoise (Santos and Pierce, 2003; Santos et al., 2004).

6.2 Key fish and shellfish species in the study area

69. The principal species identified in the study area are listed in Table 6.12. These have been selected on the basis of:

- Presence/abundance in the study area;
- Location of spawning and nursery grounds;
- Commercial importance; and
- Conservation interest.

70. In addition, in order to identify key species, due regard has been given to the Scoping Opinion and the feedback received during consultation on the Fish and Shellfish Ecology Method Statement carried out as part of the EPP for Norfolk Boreas.

Similarly, feedback received from consultees in respect of the neighbouring Norfolk Vanguard project has also be taken into account where relevant.

Table 6.12 Principal fish and shellfish species in the study area

Relevant Fish and Shellfish Species	Rationale
Principal demersal fish species	
Dover sole	• Abundant throughout the study area • Species of principal importance • Commercially important in the study area • Low intensity spawning area overlaps with the offshore cable corridor and project interconnector search area • Low intensity nursery area overlaps with the inshore section of the offshore cable corridor
Plaice	• Abundant throughout the study area • Species of principal importance • Commercially important species in the study area • High intensity spawning area overlaps with the Norfolk Boreas site, offshore cable corridor and project interconnector search area • Low intensity nursery area overlaps with the inshore section of the offshore cable corridor
Cod	• Species of principal importance and OSPAR listed species and 'vulnerable' on the IUCN Red List • Commercially important in the study area • Low intensity spawning and nursery areas overlap with the Norfolk Boreas site, offshore cable corridor and project interconnector search area
Whiting	• Abundant throughout the study area • Of commercial importance in the Southern North Sea • Species of principal importance • Low intensity spawning and nursery areas overlap with the Norfolk Boreas site, offshore cable corridor and project interconnector search area
Seabass	• Commercially important to local fisheries and relatively abundant, particularly in areas in the proximity of the offshore cable corridor • conservation concerns have led to changes in regulation to the fishery
Lemon sole	• Present throughout the study area • Spawning and nursery grounds (undefined intensity) overlap with the offshore cable corridor and project interconnector search area
Turbot and Brill	• Present throughout the study area • Commercially important in the study area
Other species: Gurnards, lesser weever, dab solenette and small demersal species (Gobiidae spp.)	• Other species characteristic of the Southern North Sea fish assemblage • Present/abundant throughout the study area • Possible prey items for fish, bird and marine mammal species
Ammodytidae (Sandeels)	
Greater sandeel Lesser sandeel	• Species of principal importance • Key prey species for fish, birds and marine mammals, including Annex II species.

Relevant Fish and Shellfish Species	Rationale
Smooth sandeel Small sandeel	• Demersal spawning species • Low intensity spawning and nursery areas overlap with the Norfolk Boreas site, offshore cable corridor and project interconnector search area
Principal pelagic fish species	
Herring	• Present in the study area • Species of principal importance • Key prey species for fish, birds and marine mammals • Targeted in inshore araes within the study area by local fishermen • Demersal spawning species • Low intensity nursery area overlaps with the Norfolk Boreas site, offshore cable corridor and project interconnector search area • No spawning grounds in the offshore project area. Closest spawning areas are located to the south of the Boreas site (Downs herring) and in a discrete inshore areas off Great Yarmouth, to the south of the offshore cable corridor.
Sprat	• Abundant in the study area • Of commercial importance in the study area • Important prey species for fish, birds and marine mammal species • Spawning area (undefined intensity) overlaps with the Norfolk Boreas site, offshore cable corridor and project interconnector search area • Nursery area (undefined intensity) overlaps with the Norfolk Boreas site
Mackerel	• Relatively abundant in the study area • Of commercial importance in the North Sea • Spawning area (undefined intensity) overlaps with the Norfolk Boreas site and project interconnector search area • Nursery grounds (low intesntiy) overlap with the offshore cable corridor, project interconnector search area and the south west corner of the Norfolk Boreas site • Species of principal importance
Elasmobranchs	
Rays, Skates and Sharks	• Present in the vicinity of the study area • Some species are Species of Principal Importance or OSPAR listed and several are classified on the IUCN Red-List with landings restricted or prohibited • Some species are of commercial importance in the study area • Low intensity nursery area for thornback ray overlaps with the offshore cable corridor (potential for these areas to also be used for spawning) • Low intensity nursery area for tope overlaps with the Norfolk Boreas site, offshore cable corridor and project interconnector search area
Diadromous fish species	
Sea trout	• Present in some East Anglian rivers • Species of principal importance • Feeding grounds located in the vicinity of the offshore project area, particularly in areas relevant to the offshore cable corridor off the Norfolk coast • May transit/feed in the study area during marine migration
Atlantic salmon	• Species of principal importance • May occasionally transit/feed in the study area during marine migration

Relevant Fish and Shellfish Species	Rationale
European eel	• Present in almost all East Anglian rivers • Species of principal importance and listed as 'critically endangered' on the IUCN Red List • May transit/feed in the study area during marine migration
European smelt	• Species of principal importance • Spawning populations present in some East Anglian rivers • May transit/feed in vicinity of the inshore section of offshore cable corridor
River lamprey Sea lamprey	• Present in some East Anglian Rivers • Species of principal importance and sea lamprey listed by OSPAR as declining and/or threatened. • May transit/feed in vicinity of the study area during marine migration, more likely in areas relevant to the inshore offshore cable corridor (particularly in the case of river lamprey)
Twaite shad Allis shad	• Species of principal importance • Potential (rarely) transit/feed in vicinity of the study area during marine phase. If present at times most likely in areas relevant to the inshore section of the offshore cable corridor
Shellfish species	
Edible crab	• Present in the study area, particularly in areas relevant to the offshore cable corridor • Commercially important species • May overwinter within the study area and the wider area
Lobster	• Present in the study area, particularly in areas relevant to the inshore section of the offshore cable corridor • Commercially important species
Brown and pink shrimp	• Present in the study area, particularly in areas relevant to the inshore section of the offshore cable corridor • Important prey species for fish • Commercially important
Whelk	• Commercially important species in the study area, particularly in areas relevant to the offshore cable corridor

6.2.1 Demersal Fish Species

6.2.1.1 Dover sole

71. In the North Sea, Dover sole is generally found south of latitude 56°N with a wide distribution in the Southern North Sea (Limpenny et al., 2011) (Figure 6.6). The major factor determining the population's northern limit is sea temperature (Burt and Millner, 2008). Dover sole show a preference for inhabiting sandy and muddy sediments at depths of up to 70m, where their favoured food source (e.g. polychaetes) are most abundant (Limpenny et al., 2011). In winter months, Dover sole are known to move further offshore and can be found living in deeper water, up to depths of 150m (Kay and Dipper, 2009; Reeve, 2007).

72. In spring, mature fish return to shallow inshore waters to spawn. Spawning areas, such as at the mouths of estuaries, possess relatively higher water temperatures e.g. the Wash and Thames Estuaries, and shallow waters such as sand banks, which also act as juvenile nursery areas (Limpenny et al., 2011). Juveniles inhabit shallow inshore waters whereas fish in their first year of life (0-groups) are generally abundant at all depths (Rogers et al., 1998).

73. Defined spawning and nursery grounds of Dover sole (Coull et al., 1998; Ellis et al., 2010; 2012) are located at some distance from the Norfolk Boreas site (Figure 6.7). However, low intensity spawning and nursery grounds for this species overlap with the inshore section of the offshore cable corridor (Figure 6.7). The distribution of Dover sole stage one eggs from charts produced by the CHARM Consortium (Carpentier et al., 2009) (Figure 6.8) further suggest low probability of Dover sole spawning across the offshore project area (Figure 6.8).

74. The Dover sole spawning season is considered to commence in March in the English Channel and Southern North Sea once sea temperatures rise to approximately 7°C (Burt and Millner, 2008; Limpenny et al., 2011; Fonds, 1979). Spawning continues until May, peaking in April with sporadic spawning until June.

75. As shown in Table 6.11, Dover sole is listed as a species of principal importance. In addition, Dover sole is of key importance as a commercial species to the fisheries active in the study area. ICES have advised that landings of Dover sole in 2018 should not exceed 15,726 tonnes in the North Sea (subarea 4) (ICES, 2017a).

76. Dover sole prey upon small crustaceans, small molluscs and fish (Wheeler, 1978). In Dutch coastal waters polychaete worms are documented to be a key staple of their diet, whilst small echinoderms (e.g. brittle stars), also represent important prey for adults in some areas (ICES, 2012b).

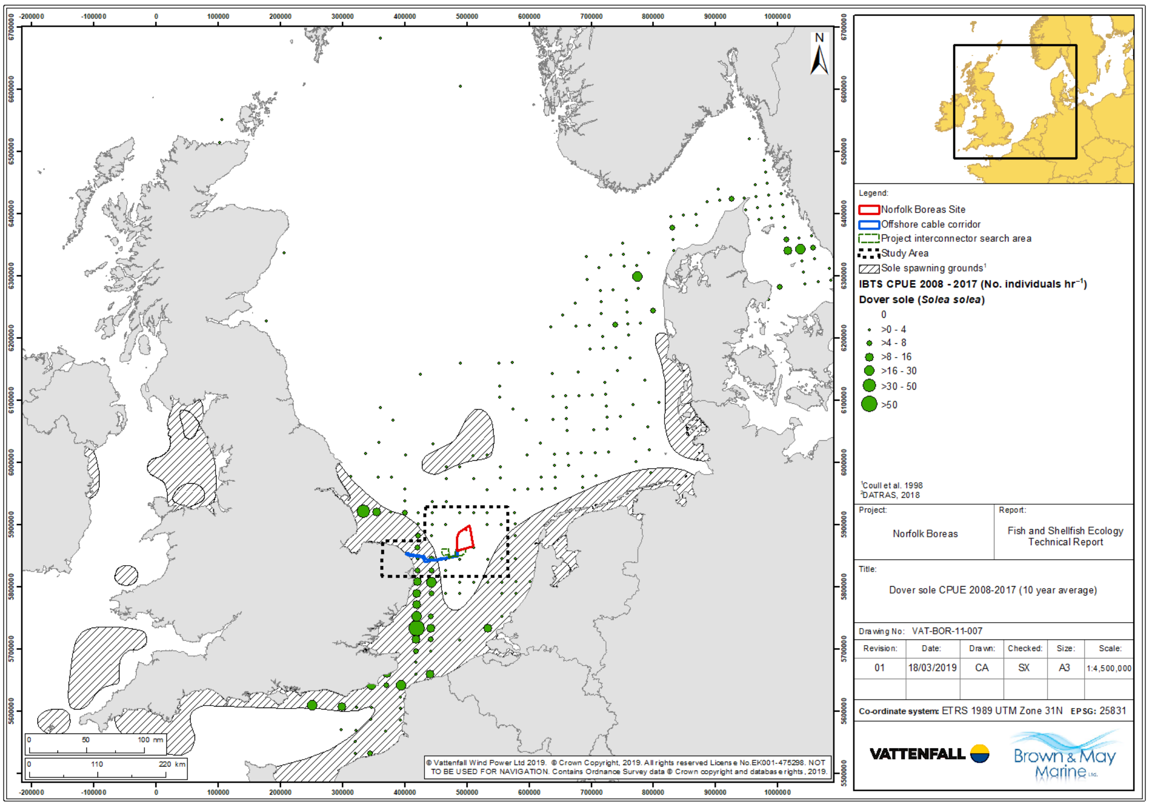


Figure 6.6 Average number (catch per standardised haul) of Dover sole from IBTS data (2008-2017) (Source: DATRAS, 2018)

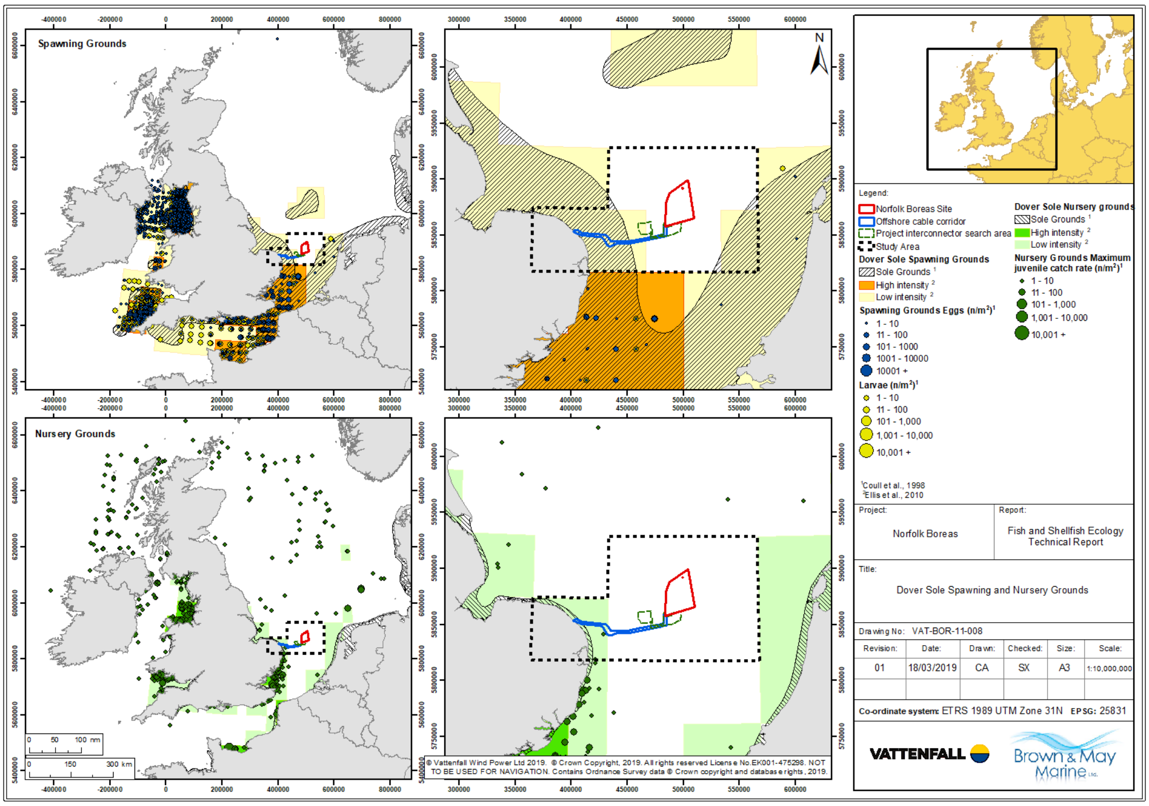


Figure 6.7 Dover sole spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

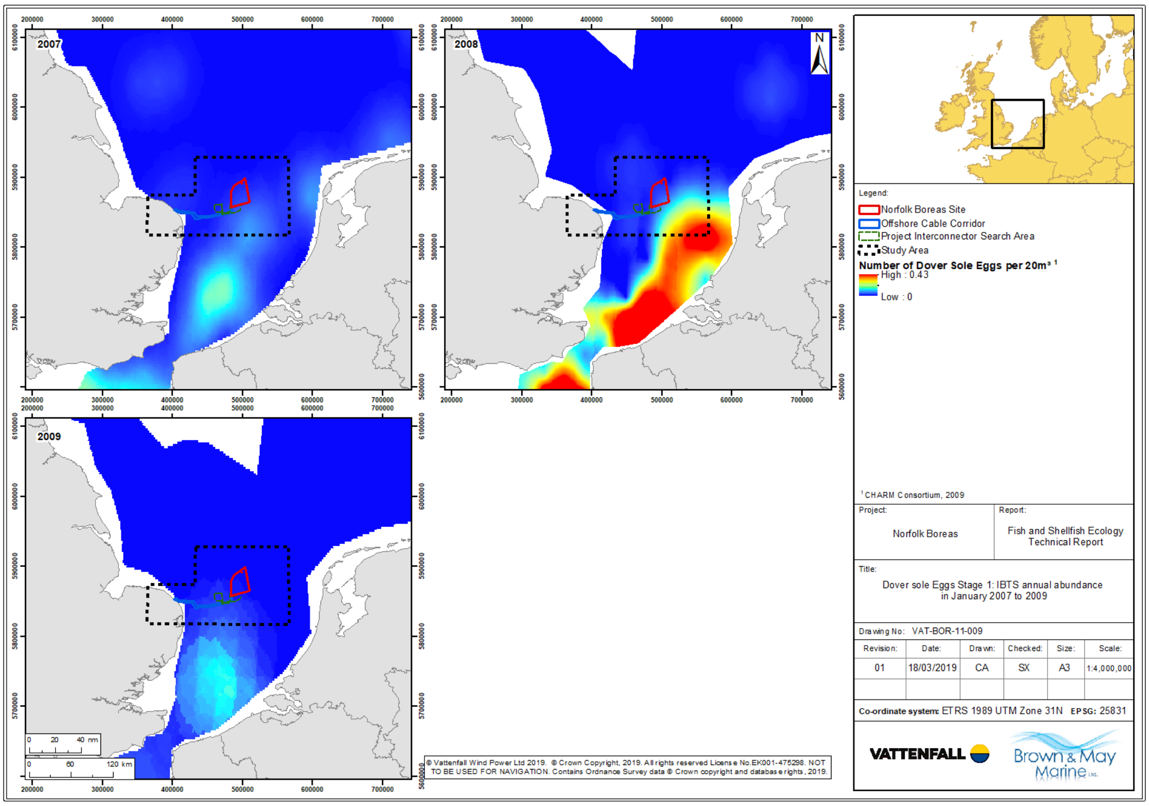


Figure 6.8 IBTS abundance of Dover sole eggs, stage one in January (2007-2009) (Source: CHARM Consortium, 2009). Note: CHARM Dover sole egg data only available 2007-2009.

6.2.1.2 Plaice

77. Plaice are widespread throughout the North Sea (Figure 6.9) and are generally found between depths of 10 and 50m (Kay and Dipper, 2009). They exhibit a preference for sand and gravel substrates, but are also found on muds (Ruiz, 2007).

78. Tagging studies carried out in the North Sea indicate that plaice divide into sub-populations during summer months for feeding in the Southern and German Bights, along the east coast of the UK and in the Skagerrak and Kattegat (Hunter et al., 2004). Loots et al. (2010) described the spawning distribution of North Sea plaice, concluding high abundances in the Southern North Sea and along the east coast of the UK, and very low abundances in the Central North Sea. Shallow coastal and inshore waters of the North Sea provide juvenile plaice with nursery habitats, with the Wadden Sea off the Dutch and German coast considered the most important (Teal, 2011). One year old plaice generally exhibit a coastal distribution whilst older age classes progressively disperse offshore from nursery areas (ICES, 2012a).

79. As shown in Figure 6.10, the inshore section of the offshore cable corridor overlaps with an area defined as a low intensity nursery ground for plaice (Ellis et al., 2010).

80. Spawning of plaice is widespread across most of the deeper offshore areas of the Southern North Sea. Spawning also occurs off the UK coast from Flamborough Head

to the Moray Firth with spawning areas connected to known nursery areas (Hufnagl et al., 2013).

81. The Norfolk Boreas site, project interconnector search area and eastern section of the offshore cable corridor fall within defined high intensity spawning grounds for plaice (Ellis et al., 2010) (Figure 6.10). The focal centres of egg concentrations are however considered to be located in the English Channel, Southern Bight and German Bight (Hufnagl et al., 2013).

82. As suggested in Ellis et al. (2012) (Figure 6.10) and from data available from CHARM and the North Sea plaice egg survey (CP-EGGS) (Figure 6.11, Figure 6.12, Figure 6.13, Figure 6.14 and Figure 6.15) it is apparent that areas of egg production are extensive, ranging from the English Channel to as far north as approximately latitude 58°N off the coast of Norway (Ellis et al., 2010).

83. Juvenile nursery areas are generally in shallow (< 10m deep), sandy or muddy areas (Zijlstra, 1972; van der Veer 1986; Hufnagl et al., 2013).

84. Plaice is one of the main species targeted by commercial fihseries in the study area (Figure 6.4 and Figure 6.5) and it was one of the principal species caught during otter and beam trawl surveys undertaken within the East Anglia THREE and former East Anglia FOUR sites (Table 6.2 and Table 6.3).

85. Plaice is listed as a species of principal importance and its conservation status is defined as of 'Least Concern' in the IUCN Red List of Threatened Species (Table 6.11). ICES have advised that the TAC for plaice in subarea 4 (North Sea) for 2018 should not exceed 142,481 tonnes (ICES, 2017b).

86. Plaice feed on a wide range of benthic and epibenthic species including polychaetes, crustaceans and molluscs and occasionally on brittle stars and sandeels (Johnson et al., 2015).

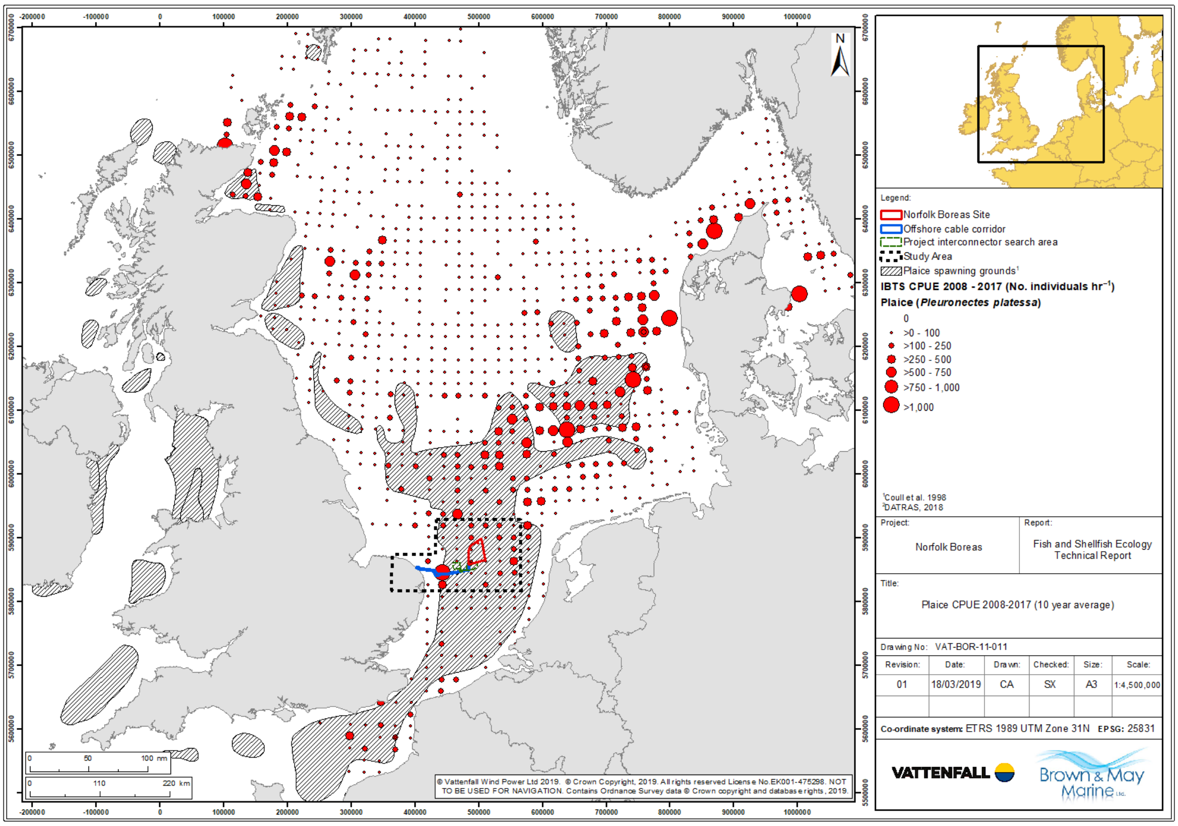


Figure 6.9 Average number (catch per standardised haul) of plaice from IBTS data (2008-2017) (Source: DATRAS, 2018)

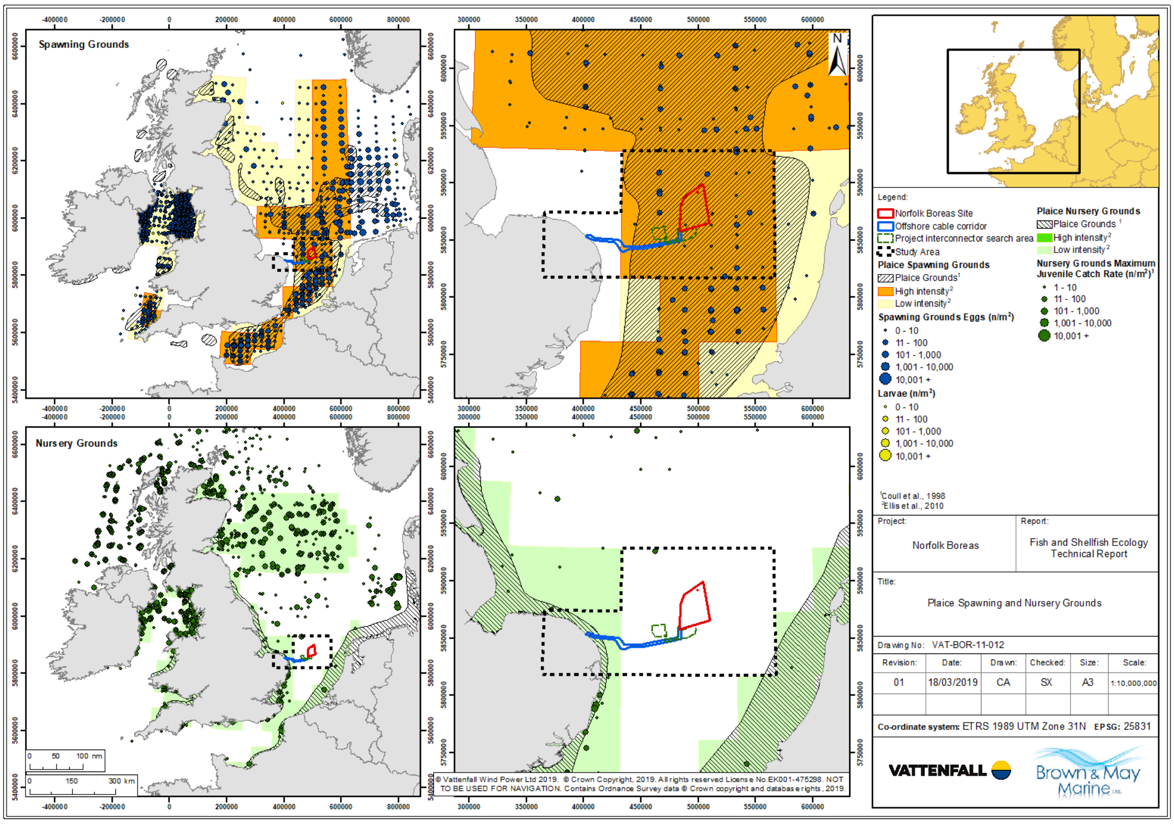


Figure 6.10 Plaice spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

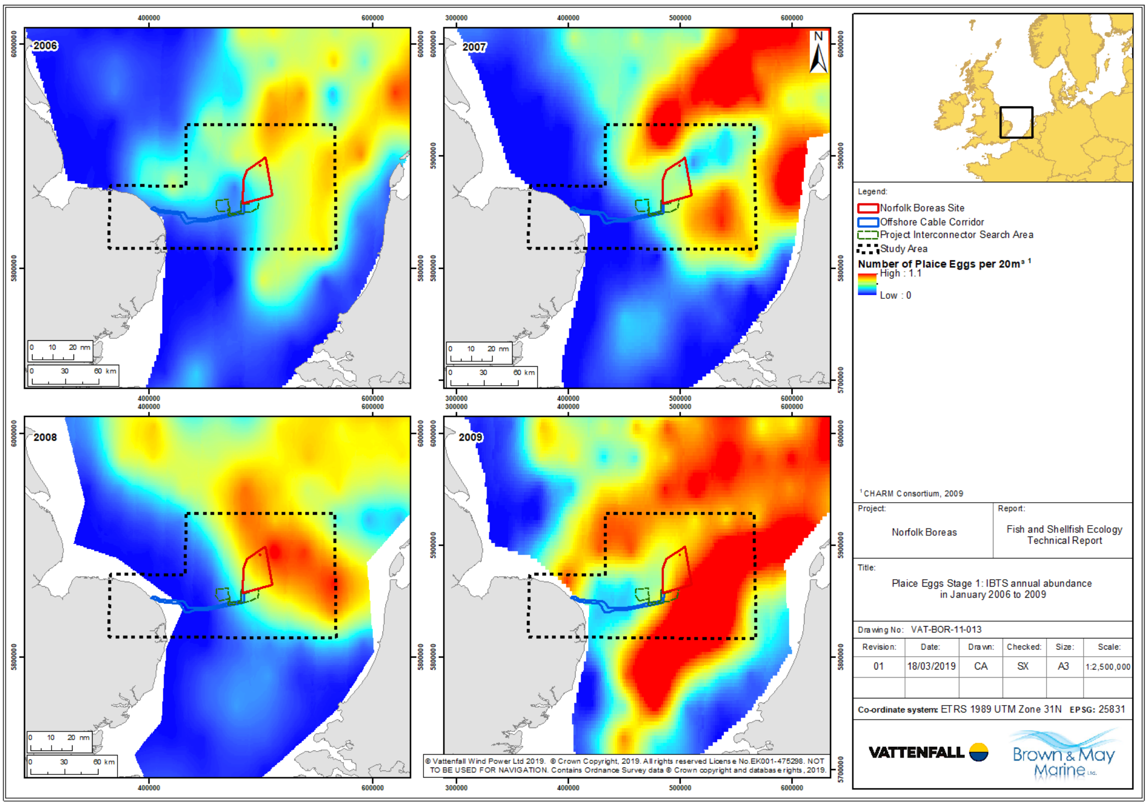


Figure 6.11 IBTS abundance of plaice eggs, stage one in January (2006-2009) (Source: CHARM Consortium, 2009)

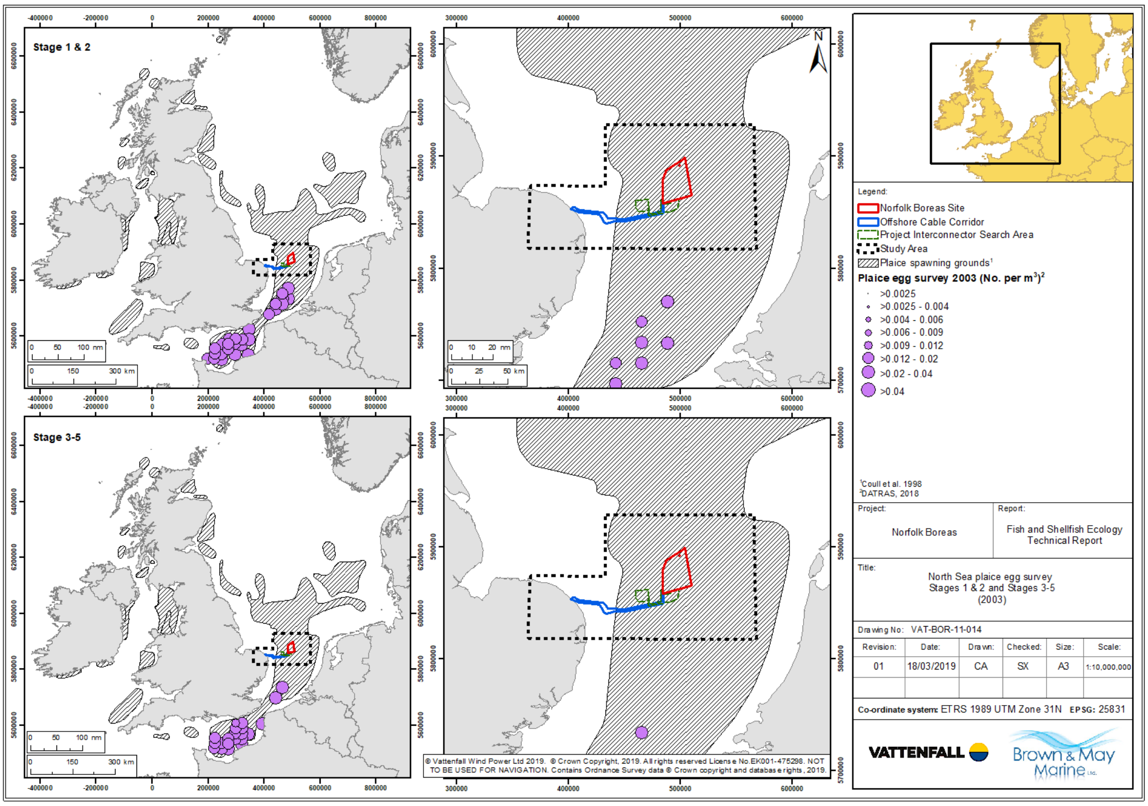


Figure 6.12 North Sea plaice egg survey (CP-EGGS) data (2003); egg stages 1, 2 and 3 to 5 (Source: DATRAS, 2018)

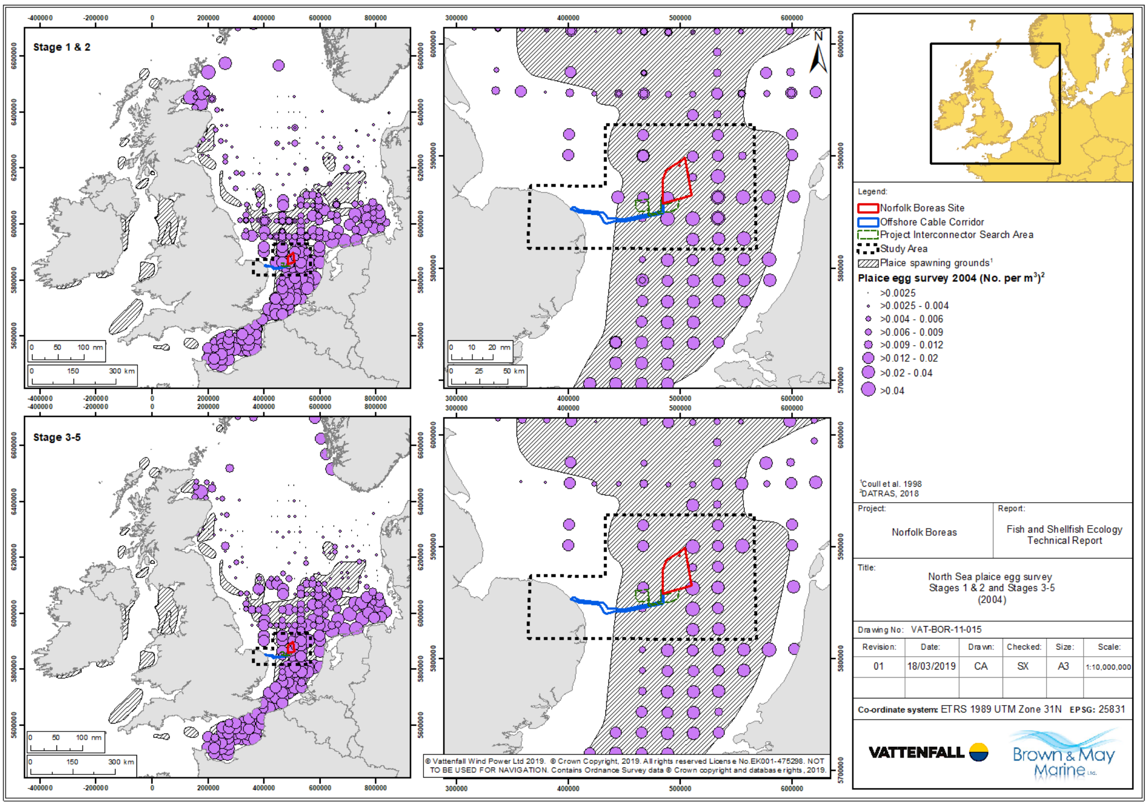


Figure 6.13 North Sea plaice egg survey (CP-EGGS) data (2004); egg stages 1, 2 and 3 to 5 (Source: DATRAS, 2018)

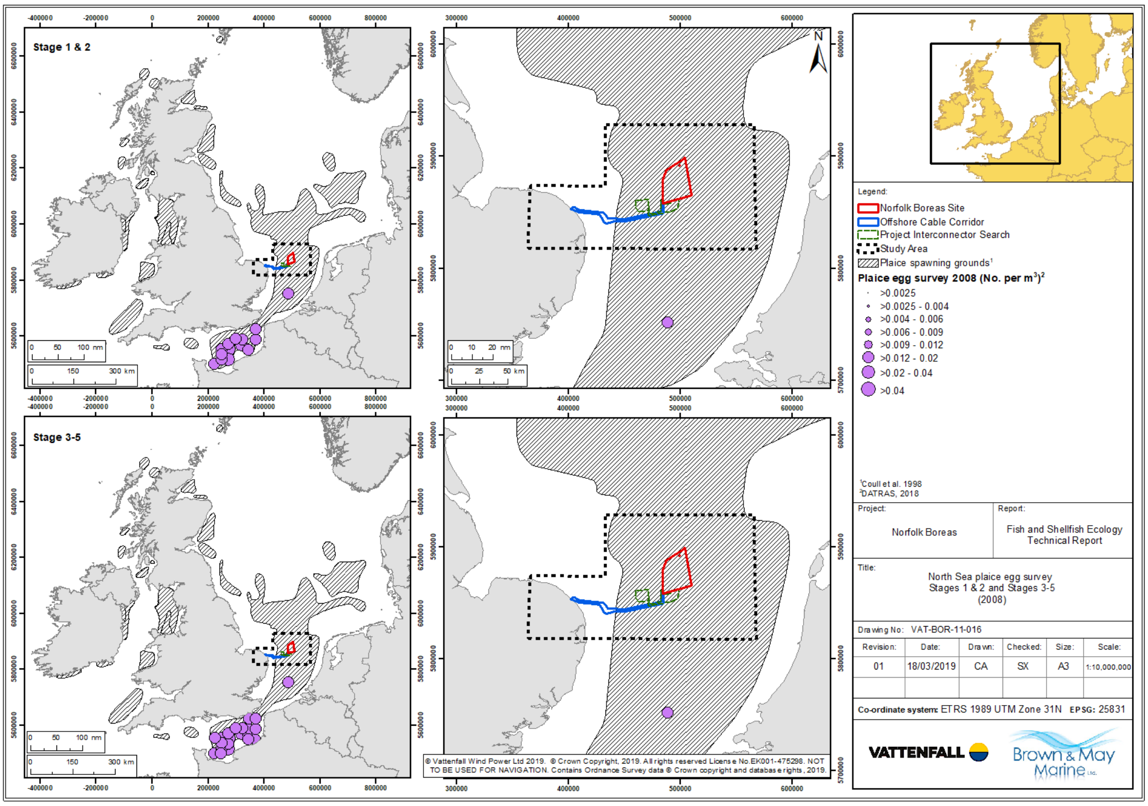


Figure 6.14 North Sea plaice egg survey (CP-EGGS) data (2008); egg stages 1, 2 and 3 to 5 (Source: DATRAS, 2018)

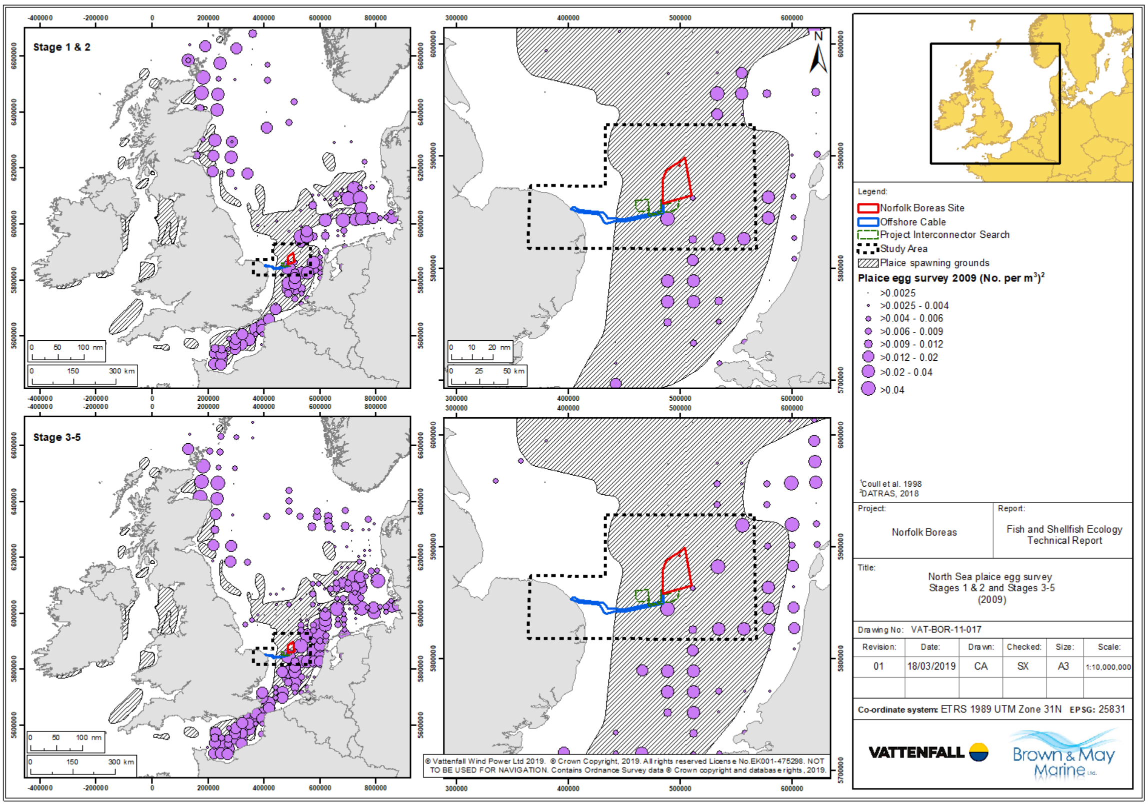


Figure 6.15 North Sea plaice egg survey (CP-EGGS) data (2009); egg stages 1, 2 and 3 to 5 (Source: DATRAS, 2018)

6.2.1.3 Cod

87. Both juvenile and adult cod are widely distributed throughout the North Sea (Figure 6.16). Cod are a demersal species and are typically found at depths of up to 500m within 30-80m of the seabed (Hedger et al., 2004). Juveniles occupy a wide range of habitat types but are often found in shallower waters than adults (Hedger et al., 2004). The results of quarterly IBT surveys show that adults occur extensively during the colder, winter months but their range contracts during spring and summer as they retreat northwards in response to increasing water temperatures in the English Channel and Southern Bight.

88. The North Sea cod stock is thought to comprise a number of sub-populations with differential rates of mixing between components, rather than a single distinct population (Blanchard et al., 2005). There is a limited influx of young cod from the eastern English Channel into the Southern North Sea, and cod in the German Bight show some limited mixing with those in the Southern Bight (Horwood et al., 2006).

89. Hutchinson et al. (2001) have classified several genetically distinct populations within North Sea at Bergen Bank, Moray Firth, Flamborough Head and the Southern Bight. These populations appear to form reproductively isolated units, which may be spatially distinct at least during the spawning season (ICES, 2005c).

90. Previous studies have documented the presence of spawning areas in the Southern Bight (Daan, 1978), in the vicinity of Flamborough (Harding and Nichols, 1987) and around the southern and eastern edges of the Dogger Bank (Heessen and Rijnsdorp, 1989). Ichthyoplankton surveys have generally confirmed the results of these spawning studies showing hot spots of egg production around the southern and eastern edges of the Dogger Bank, in the German Bight, the Moray Firth and to the east of the Shetlands (Fox et al., 2008).

91. The Norfolk Boreas site, project interconnector search area and eastern section of the offshore cable corridor fall within the wider low intensity cod spawning and nursery areas defined by Ellis et al. (2010) (Figure 6.17). In the Southern Bight, peak spawning occurs in February but in the Southern North Sea it varies from the last week of January to mid-February (Heessen and Rijnsdorp, 1989) with peak spawning occurring in the eastern English Channel in mid-February (Brander, 1994).

92. Data on the distribution of cod eggs from MIK samples (2006-2009) mapped as part of the CHARM III Project (Figure 6.18 and Figure 6.19) suggest cod stage one and two eggs are present in comparatively low densities in the offshore project area with highest egg densities found to the south-east. This pattern correlates with the results of North Sea cod egg surveys (CP-EGGS) (Figure 6.20 and Figure 6.21).

93. First-feeding cod larvae consume small organisms in the plankton including diatoms and dinoflagellates before moving onto the nauplii of small crustaceans, such as isopods and small crabs. As juvenile cod gradually move from inshore areas into deeper offshore waters they target larger, benthic prey (Demain et al., 2011).

94. In the North Sea, adult cod feed on crustaceans, molluscs, and fish including sandeels, haddock, herring and several flatfish species (Wilding and Heard, 2004; Arnett and Whelan, 2001). There is also evidence of cannibalism among adult cod (ICES, 2005c). Cod are deemed to be responsible for significant mortality on commercial stocks of clupeid, gadoid and flatfish species (Daan, 1973).

95. Cod is a target species in the study area, particularly in ICES rectangles 34F2 and 34F3 (Table 6.7). For management purposes, ICES currently defines three separate cod assessment areas for the Greater North Sea Ecoregion: Subarea 4 (North Sea), Division 7.d (eastern English Channel) and Subdivision 20 (Skagerrak). ICES have advised that landings of cod in this region should not exceed 53,058 tonnes in 2018 (ICES, 2017c). ICES reports that there has been a slow improvement in the status of cod stocks and spawning stock biomass in this region over the last decade, with indications of increased recruitment in 2017 (ICES, 2017c). Whilst cod is widely distributed throughout the North Sea, there are indications of subpopulations inhabiting different regions of the North Sea. The Southern North Sea sub-region (where Norfolk Boreas is located) has suffered a general decline in biomass, without

recovery to date (ICES, 2017c). It is unclear what the reasons for the lack of recovery are in this area; further work is required to investigate climate change, biological, and fisheries effects (ICES, 2017c).

96. During otter trawl surveys carried out in East Anglia THREE and the former East Anglia FOUR cod was recorded in relatively low numbers (Table 6.2).

97. Cod are listed as a species of principal importance and are included in the OSPAR list of threatened and/or declining species. The IUCN defines their species' status as 'Vulnerable' (Table 6.11).

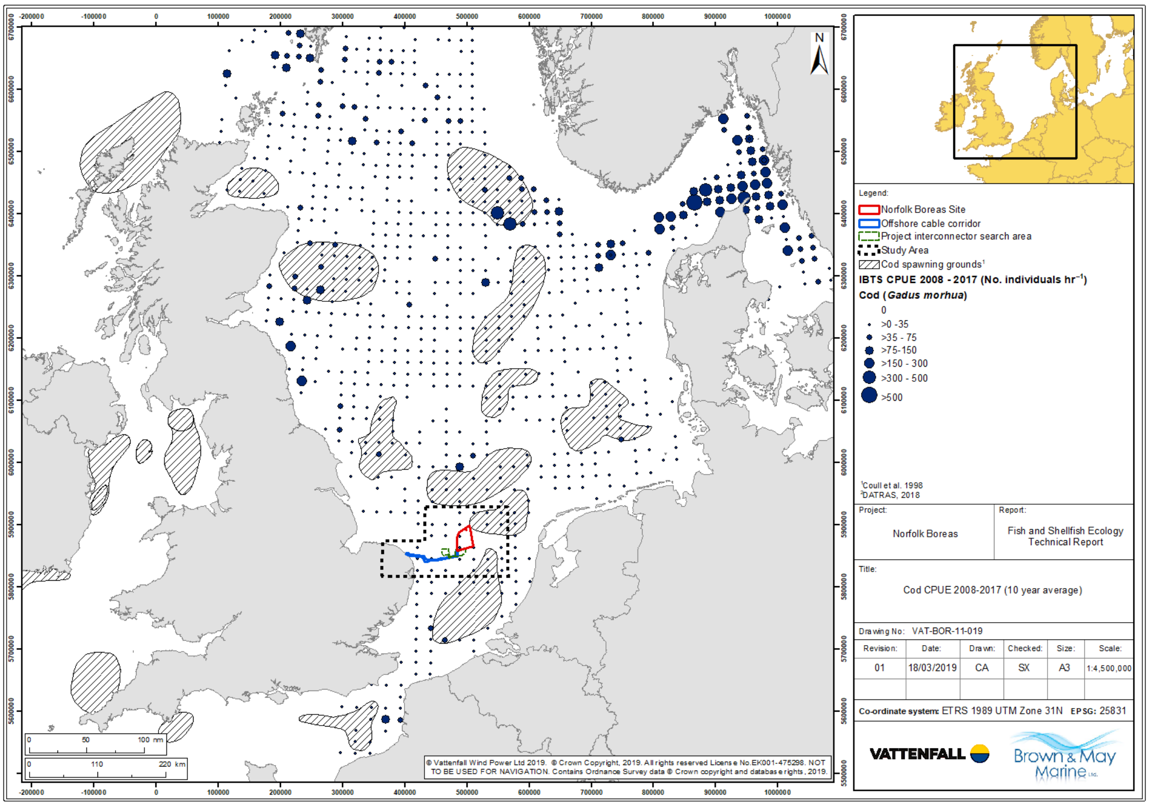


Figure 6.16 Average number (catch per standardised haul) of cod from IBTS data (2008-2017) (Source: DATRAS, 2018)

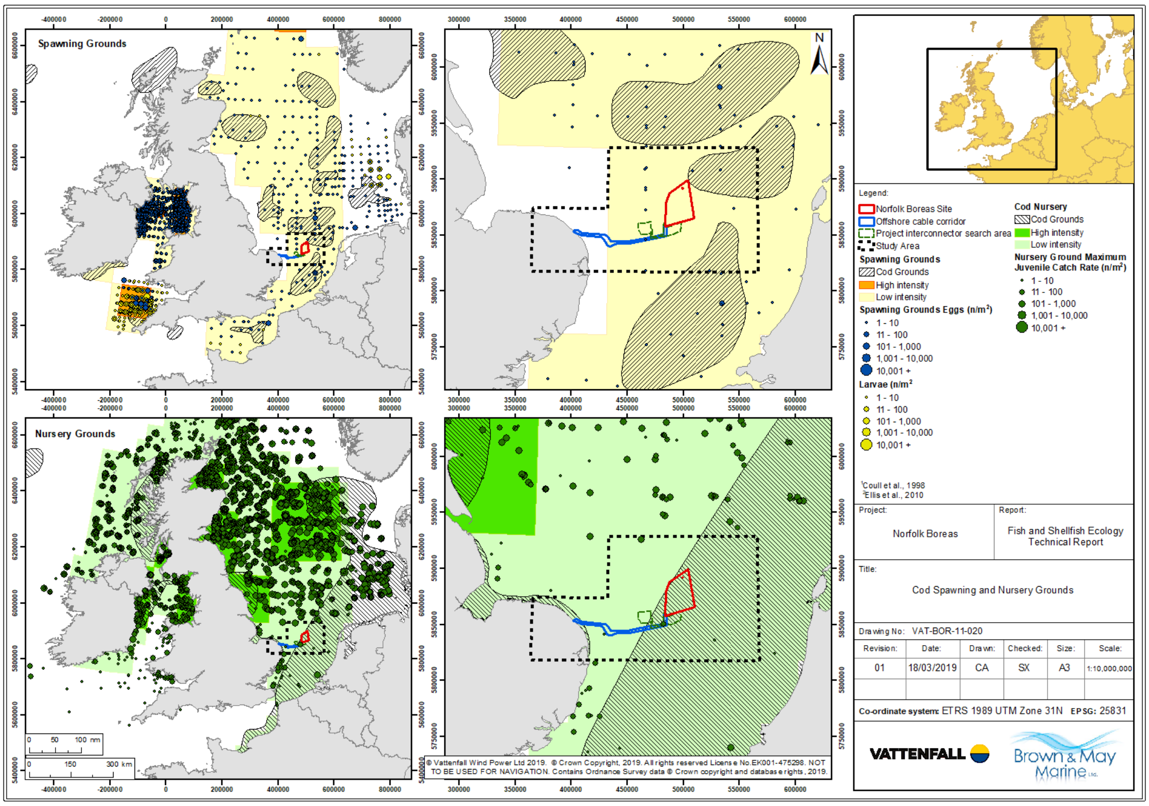


Figure 6.17 Cod spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

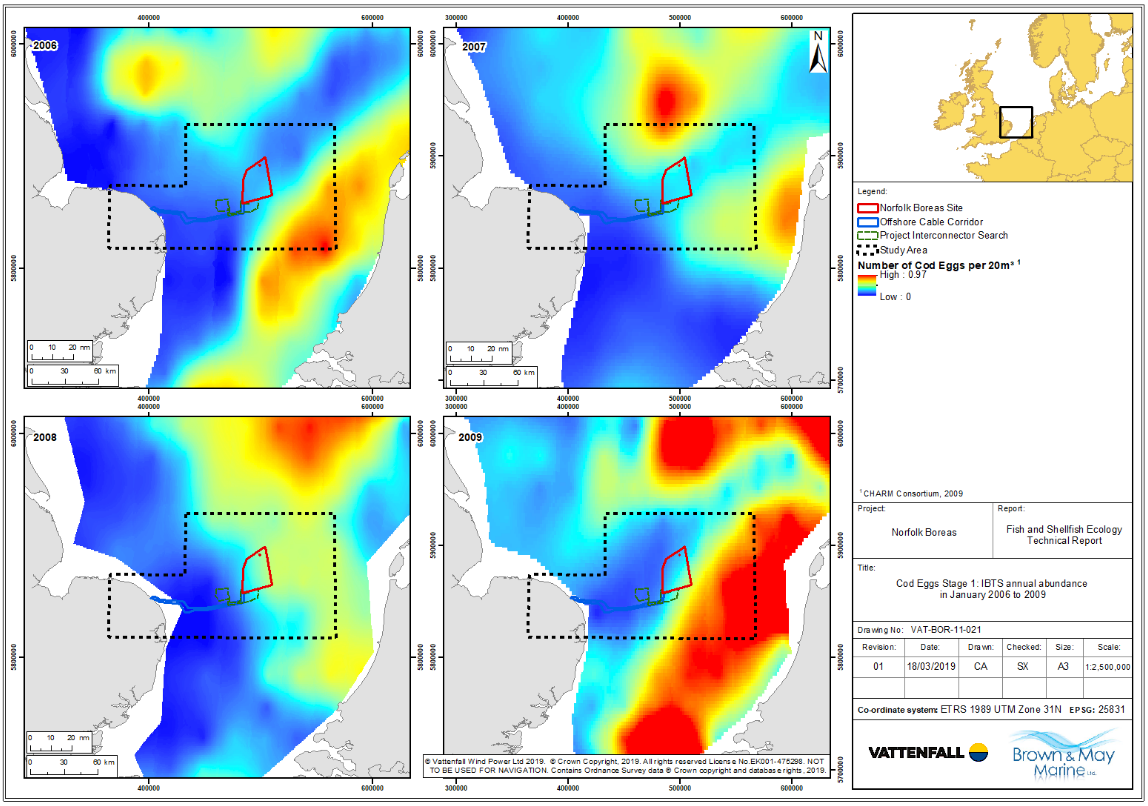


Figure 6.18 IBTS abundance of cod eggs stage one in January (2006-2009) (Source: CHARM Consortium, 2009)

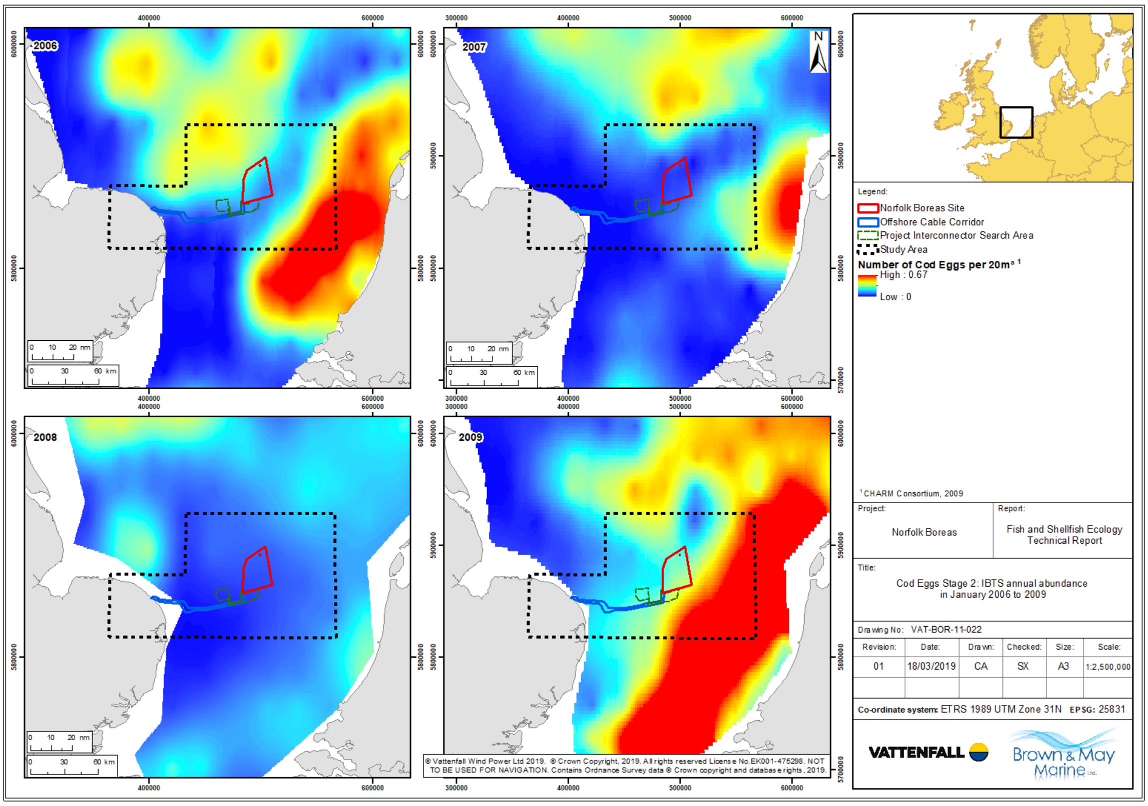


Figure 6.19 IBTS abundance of cod eggs stage two in January (2006-2009) (Source: CHARM Consortium, 2009)

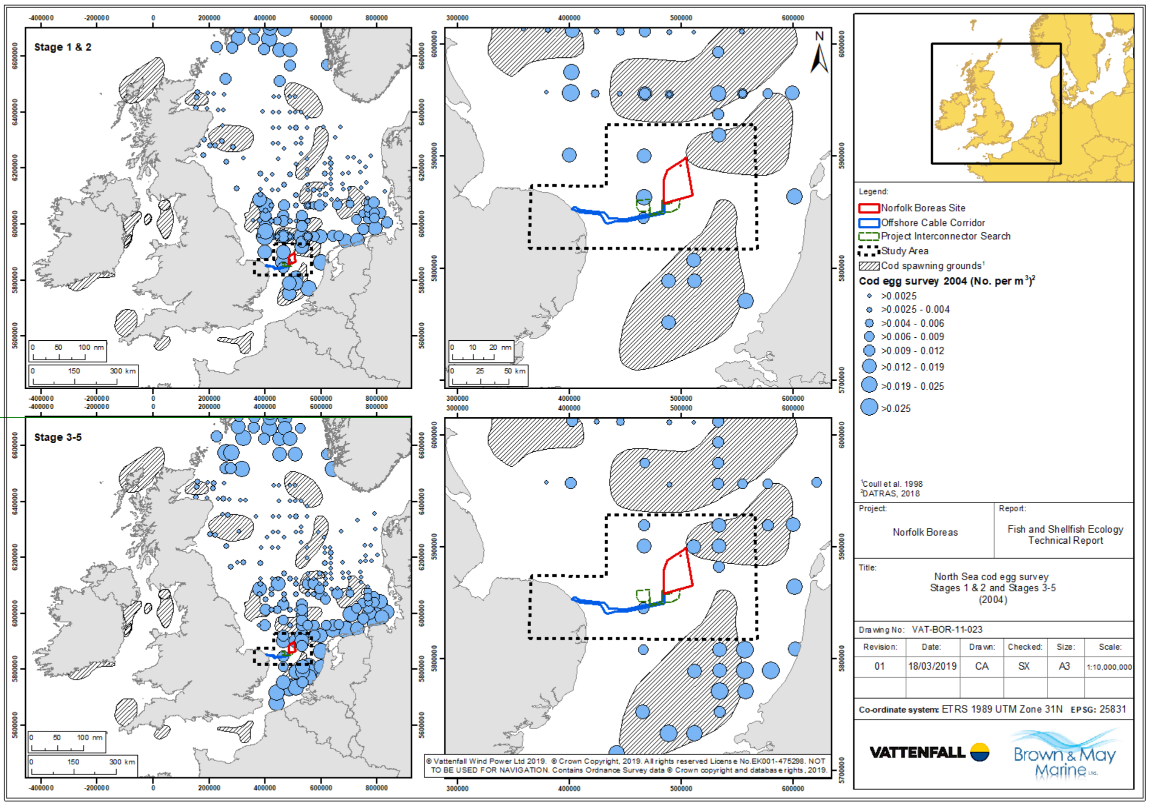


Figure 6.20 North Sea cod egg survey (CP-EGGS) data (2004); egg stages 1, 2 and 3 to 5 (Source: DATRAS, 2018)

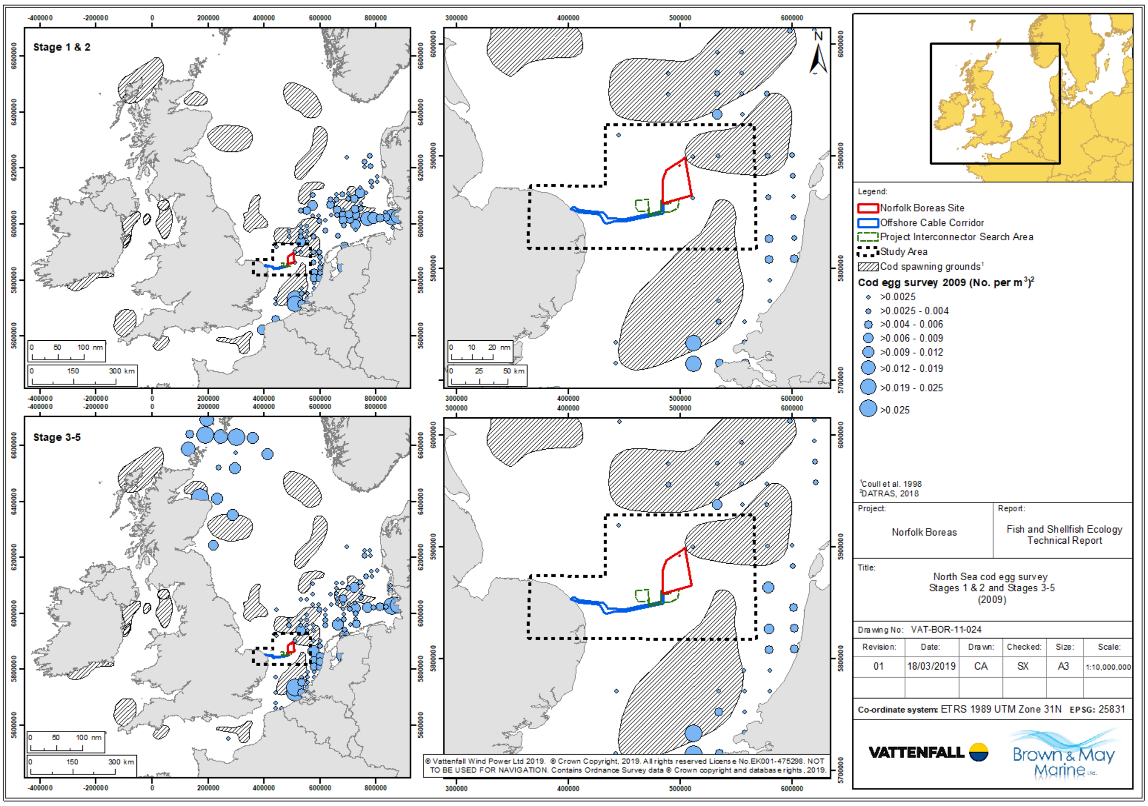


Figure 6.21 North Sea cod egg survey (CP-EGGS) data (2009); egg stages 1, 2 and 3 to 5 (Source: DATRAS, 2018)

6.2.1.4 Whiting

98. Whiting is broadly distributed throughout the North Sea and is common in inshore waters (Loots et al., 2011) (Figure 6.22). It is generally more abundant between 30m and 100m and inhabits a variety of substrates such as mud, gravel, sand and rock (Barnes, 2008a). As illustrated by Figure 6.22, whiting occur throughout the North Sea, Skagerrak and Kattegat (ICES, 2016d). High densities of both juveniles and adults are found almost anywhere, with older individuals (>2yr) demonstrating a preference for deeper waters (Daan et al., 1990).

99. During the summer, juvenile whiting are highly abundant inshore off the German Bight and the Dutch coast (Loots et al., 2011). As shown in Figure 6.23, the offshore project area is located within the wider low intensity spawning and nursery grounds defined for whiting (Ellis et al., 2010). Mapping of the distribution of whiting eggs carried out by the CHARM Consortium (Figure 6.24 and Figure 6.25) suggest highest egg densiies are generally found to the south-east and north of the offshore project area.

100. The factors determining spawning ground selection are thought to be limited, without an apparent sediment preference (Daan et al., 1990). Whiting are however reported to spawn at depths of between 50 and 100m (Limpenny et al., 2011).

101. Spawning occurs from February to June, with a peak in April (Loot et al., 2011; Coull et al., 1998). Among North Sea species, this represents one of the longest spawning periods.

102. Whiting is caught in fisheries throughout the North Sea, although substantial quantities are also discarded from commercial catches (ICES, 2017d). During the otter trawl surveys undertaken in East Anglia THREE and former East Anglia FOUR sites in 2013, whiting was one of the top three species caught (Table 6.2). Landings by weight for whiting are however negligible in the offshore project area (Table 6.7).

103. As shown in Table 6.11, whiting is listed as a species of principal importance and ICES have advised on the basis of precautionary considerations, that total catches should be no more than 26,191 tonnes in the North Sea and Eastern English Channel for whiting for 2018 (ICES, 2017d).

104. Whiting predate on a range of decapod species e.g. Crangon spp., amphipods, copepods and fish, including small species such as sprat, sandeel, herring, cod, and haddock (Derweduwen et al., 2012). The diet of immature whiting is principally small crustaceans, such as crangonid shrimp (Hislop et al., 1991).

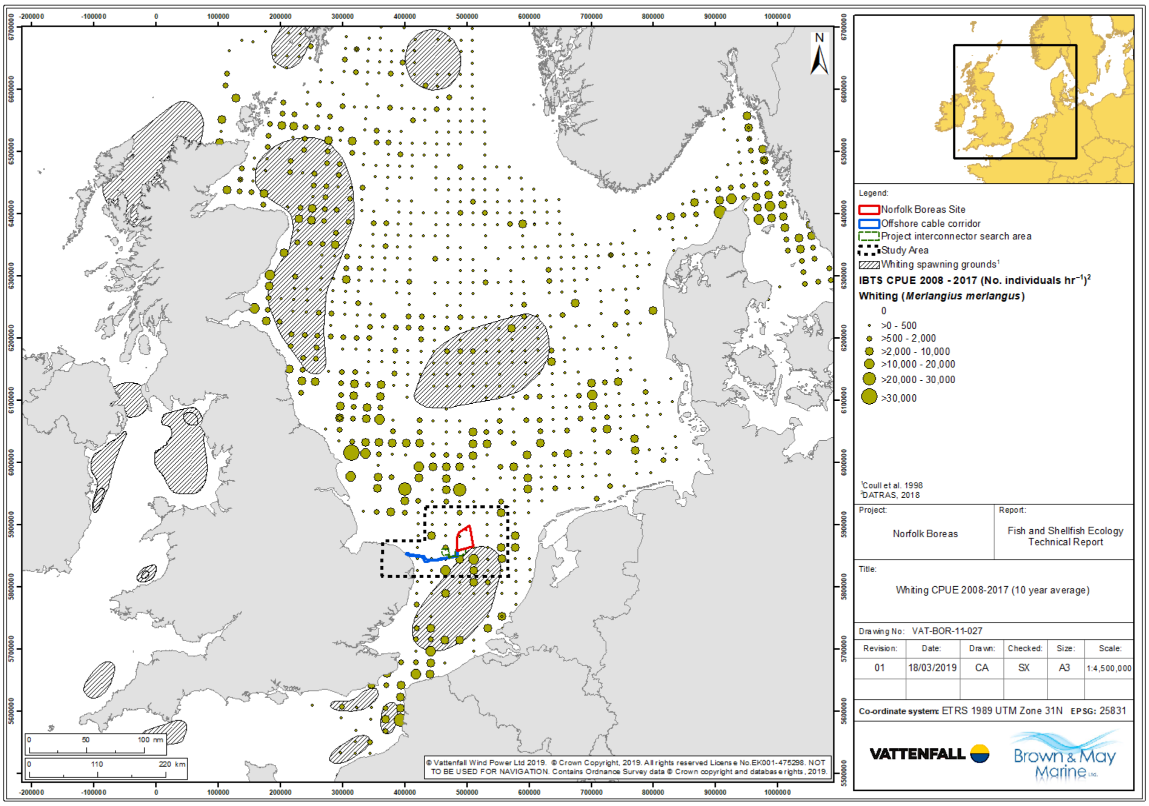


Figure 6.22 Average number (catch per standardised haul) of whiting from IBTS data (2008-2017) (Source: DATRAS, 2018)

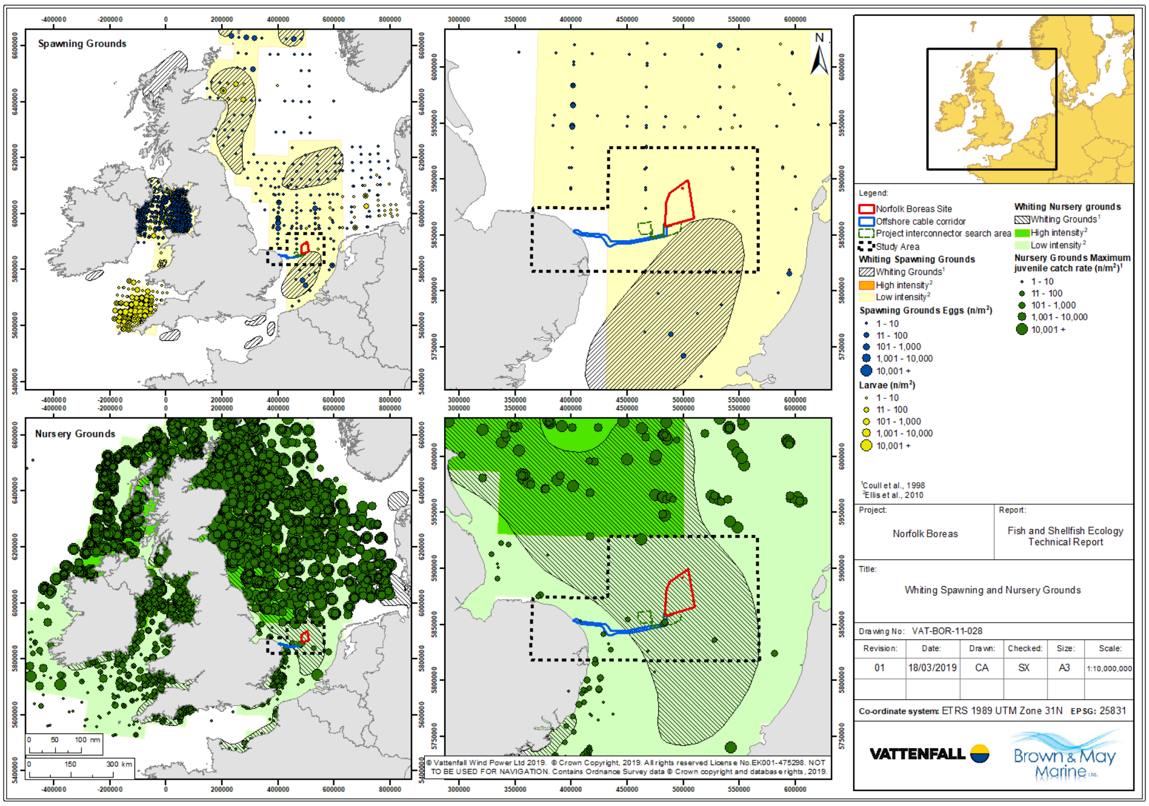


Figure 6.23 Whiting spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

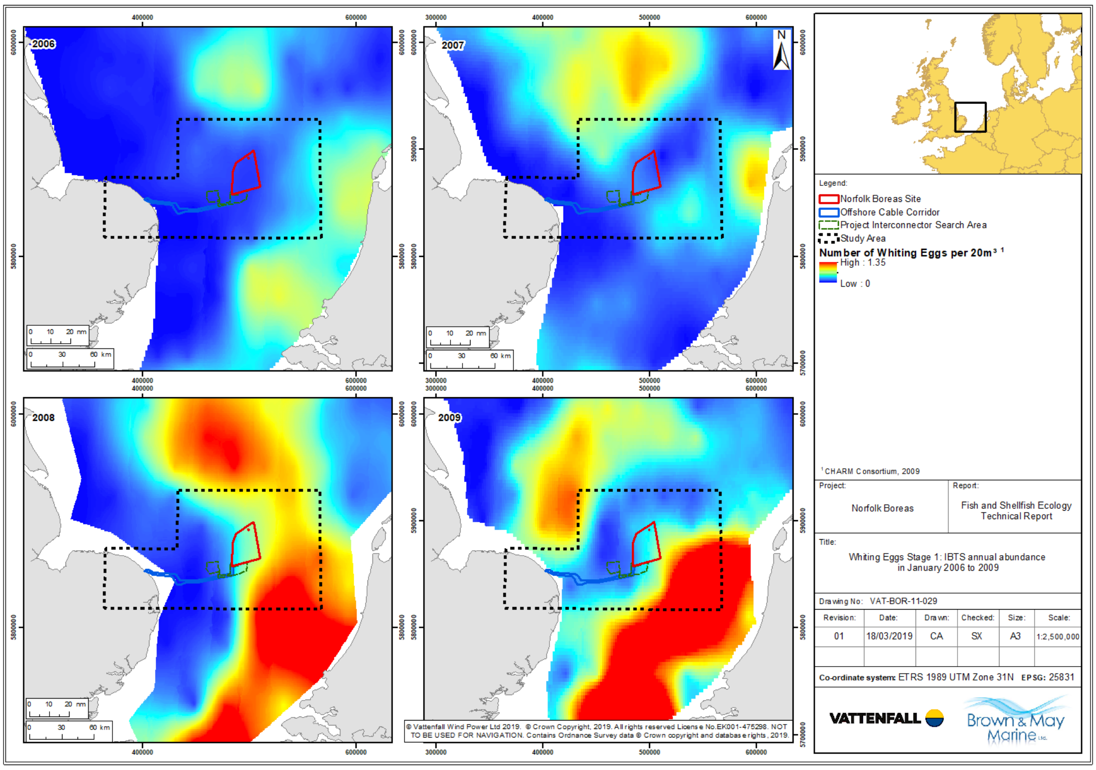


Figure 6.24 IBTS abundance of whiting eggs stage one in January (2006-2009) (source: CHARM Consortium, 2009)

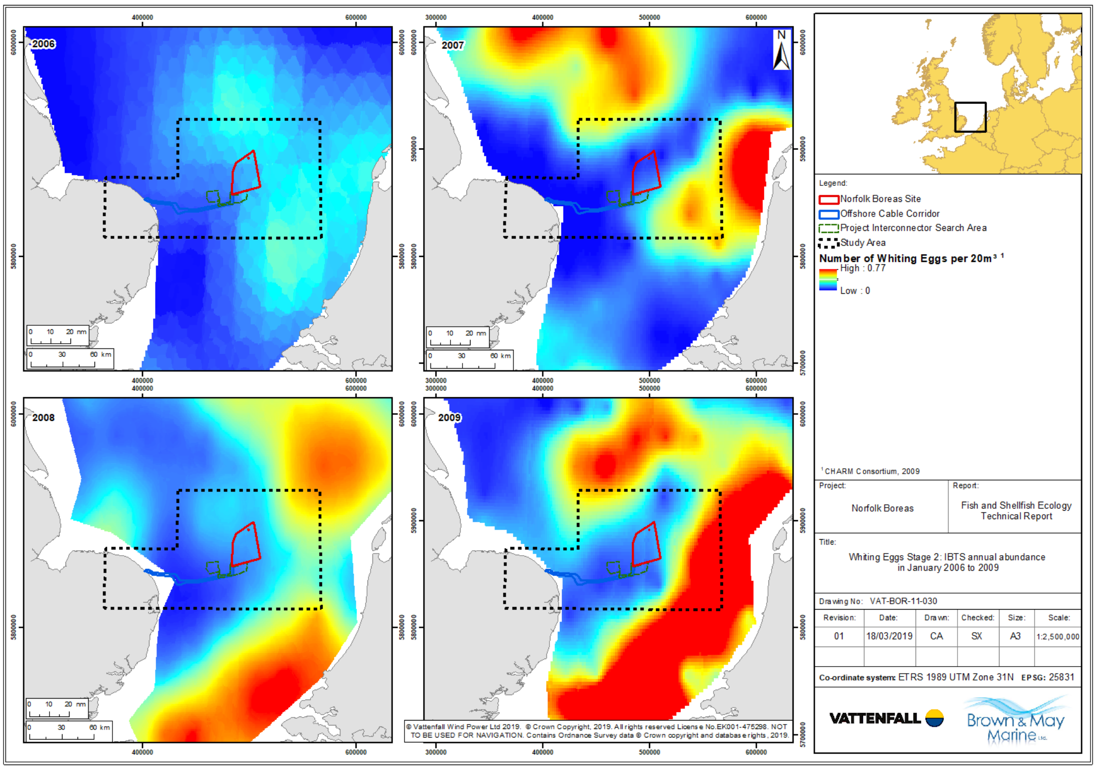


Figure 6.25 IBTS abundance of whiting eggs stage two in January (2006-2009) (source: CHARM Consortium, 2009)

6.2.1.5 Sea bass

105. The European sea bass is a predatory species of fish found throughout the Mediterranean Sea and Eastern Atlantic and increasingly within the North Sea (Fritsch et al., 2007). Adults show demersal behaviour, inhabiting coastal waters down to about 100m depth, but are more common in shallow waters (Smith, 1990). They enter coastal waters and river mouths in summer, but migrate offshore in colder weather (Fritsch et al., 2007).

106. Sea bass are group spawners, releasing pelagic eggs into the water column once a year, usually in spring. The juvenile stage occurs approximately two months after spawning (Kelley, 1988), during which time larval bass remain in the plankton and are transported inshore by currents into post-larval habitats in estuaries and shallow coastal waters (Jennings and Pawson, 1992). Juvenile bass can tolerate brackish water habitats such as those in estuaries and river mouths where they stay for four to five years (Kennedy and Fitzmaurice, 1972). Pawson et al. (2007) showed that compared to the west coasts of England and Wales where continued and extensive movement of juvenile and adult sea bass exists, in the North Sea where Norfolk Boreas is located, there is greater retainment of individuals. Juvenile sea bass off the East Anglian coast would therefore be expected to be show greater site fidelity (Pawson et al., 2007).

107. Sea bass reach maturity between four and seven years of age (approx. 35 and 42cm) and can continue to reproduce for up to 20 years (Pawson and Pickett, 1987). Sea bass exhibit sexual growth dimorphism where female bass mature at a greater size and age than males (Kennedy and Fitzmaurice, 1972). Young fish form schools, however adults appear to be less gregarious.

108. Fully mature sea bass undertake seasonal migrations from summer coastal feeding grounds to winter offshore spawning grounds (Pawson et al., 2007) coinciding with the decrease in coastal water temperature (Pawson and Pickett, 1987) that generally occurs in October. Numerous tagging studies have shown that sea bass have a strong fidelity to summer feeding grounds, where they will return year on year (Claridge and Potter, 1983; Pawson et al., 1987; Kelley, 1988; Pawson et al., 2007). The slow growing nature of sea bass along with the strong fidelity to specific locations means the species is vulnerable to over exploitation (Kelley, 1988).

109. Sea bass exhibit opportunistic feeding behaviour and consume a broad range of prey (Kelley, 1987). Adults feed chiefly on shrimps, molluscs and fishes, whilst juveniles feed on invertebrates, taking increasingly more fish with age.

110. In the 1970s, sea bass in the UK shifted from primarily a sport fish to a commercially important species (Kelley, 1988). Sea bass is an important and valuable fish stock that is fished both commercially and recreationally in the UK and by other European

Member States (e.g. France, Belgium, Netherlands, Spain and Portugal) (MRAG, 2014). ICES have reported declining total catches of sea bass, and a downward trend in the health of the stock in recent years (ICES, 2017e). This could be due to a combination of continued overfishing and numerous cold winters since 2008 reducing the survival of larval and juvenile fish (SeaFish, 2011).

111. Since 1st January 2017, bass fishing has been tightly regulated throughout the UK. In the North Sea, commercial fisheries are only permitted to catch and retain small quantities of bass with fixed gillnets, hooks and lines, demersal trawls and seine nets (MMO, 2018). For example, commercial trawl fisheries are permitted 1% by-catch of sea bass per day up to a maximum of 100 Kg per month (MMO, 2018). The taking of any sea bass is prohibited between 1 February and 31 March 2018 (inclusive) in any fishery (MMO, 2018). Use of any other gears to catch or retain sea bass, including drift nets and recreational fishing, are prohibited (MMO, 2018). ICES advises that when the precautionary approach is applied, there should be zero catch (commercial and recreational) in 2018 (ICES, 2017e).

112. An indication of sea bass fishing grounds in the study area, based on information gathered by the EIFCA (formerly known as the Eastern Sea Fisheries Joint Committee) is given in Figure 6.26.

113. Seabass is classified as of ‘Least Concern’ in the IUCN Red List of Threatened Species (Table 6.11).

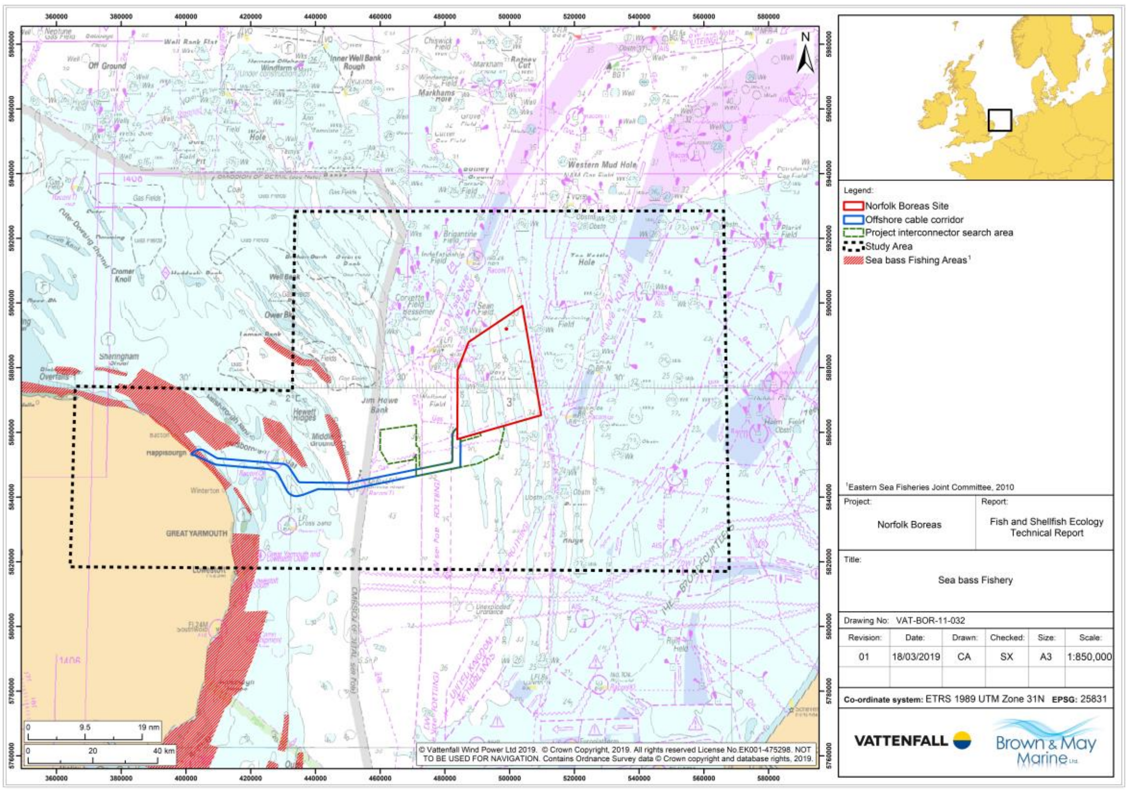


Figure 6.26 Sea bass fishing areas (Source: Eastern Sea Fisheries Joint Committee, 2010)

6.2.1.6 Lemon sole

114. Lemon sole is a commercially important flatfish found in the shelf waters of the North Atlantic from the White Sea and Iceland southwards to the Bay of Biscay (Rae, 1965; Pawson, 1995). They are however most common in the central region of the North Sea and off the east coast of Scotland (Figure 6.27). Their distribution does not extend as far south as plaice and generally favour a rougher sea bottom, but the two species often occur together (Cotter et al., 2004).

115. Sexual maturity occurs in males at 3-4 years and at 4-6 years in females. Lemon sole may live for about 17 years and can attain lengths of over 60 cm (Fish Base, 2017). They spawn in spring and summer, between April to August (Rae, 1965). Lemon sole spawning and nursery grounds coincide with the western section of the offshore cable corridor and the project interconnector search area (Figure 6.28).

116. Lemon soles do not have well-defined spawning grounds, spawning widely throughout its range, gathering in small local concentrations wherever the fish are normally found (van der Hammen and Poos, 2012). Tagging experiments have indicated a tendency for the fish to swim against the current during the period preceding spawning (Burt et al., 2012). The fish do not appear to require very precise conditions for spawning. In the North Sea spawning takes place mainly at depths between 50 and 100m when the bottom temperature is not lower than 6.5°C (Rae, 1965). Around the British Isles the earliest spawners are usually found in the English Channel in February or March, with a maximum abundance of eggs in April to June. As shown in Figure 6.28, the offshore cable corridor and project interconnector search area overlaps with the wide spawning and nursery ground described for this species in Coull et al. (1998).

117. Lemon sole feed on a wide variety of benthic and epibenthic prey, although polychaete worms, especially the eunicids *Onuphis conchylega* and *Hyalinoecia tubicola*, the terebellids *Lanice conchilega* and *Thelepus cincinnatus* and several serpulid species (Rae, 1965) frequently form a significant proportion of the diet. Their diet is restricted by the small size of the mouth. A variety of small benthic crustacea (mainly amphipods and eupagurids), molluscs (mainly chitons and small gastropods) and some ophiuroids are also consumed (Fish Base, 2017).

118. Survey information available for the North Sea subarea IV and Divisions IIIa and VIId indicates lemon sole biomass is stable and at a high level, although landings data show a declining long-term trend despite a small increase in recent years (ICES, 2017f). ICES advice for 2018 and 2019 recommends that catches of lemon sole should not exceed 5,484 tonnes (ICES, 2017f). Provided discard rates do not change from the average of the last three years (2014–2016), this implies landings of no more than 3924 tonnes in each of the years 2018 and 2019 (ICES, 2017f).

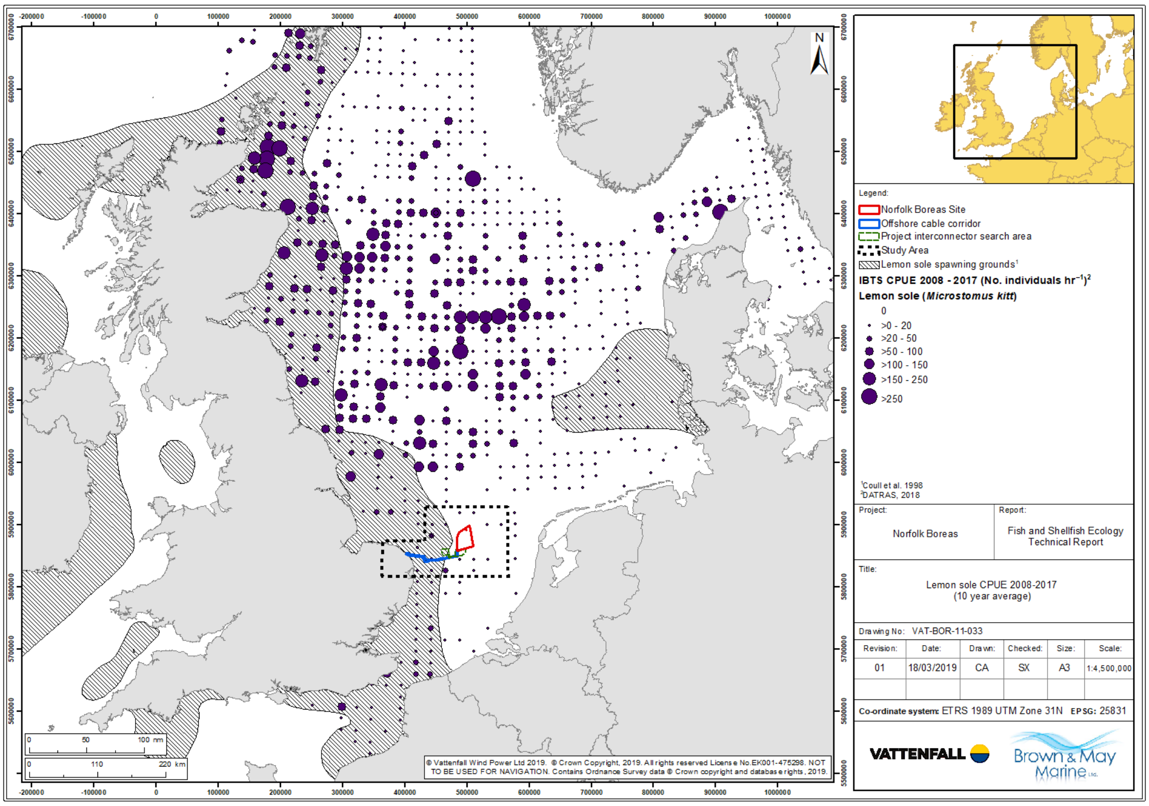


Figure 6.27 Average number (catch per standardised haul) of lemon sole from IBTS (2008-2017) (Source: DATRAS, 2018)

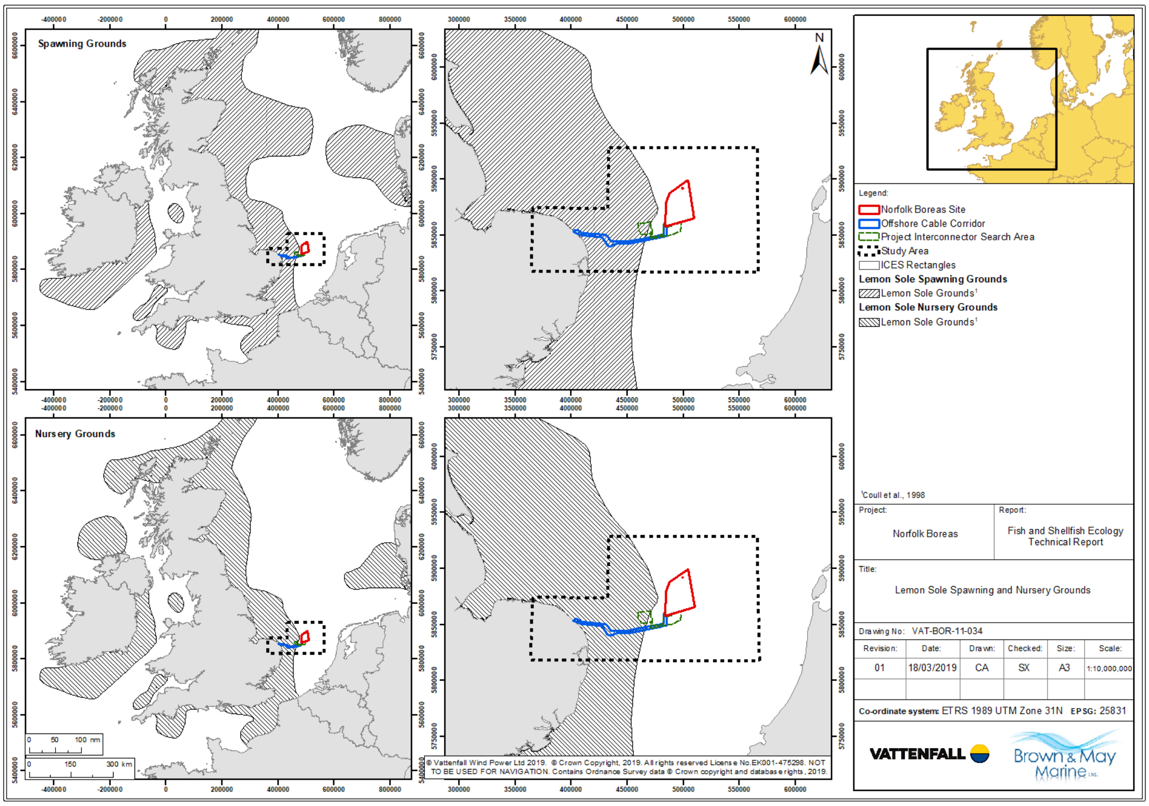


Figure 6.28 Lemon sole spawning and nursery grounds (Source: Coull et al., 1998)

6.2.1.7 Brill

119. Brill is a species of flatfish which is widely distributed throughout the North Sea (Nielsen, 1986). The species inhabits sandy and muddy bottoms in the shallower part of the continental shelf down to approximately 70 to 80m depth (Caputo et al., 2001).

120. Brill is of commercial importance to fisheries within the study area, particularly to Belgian vessels (Figure 6.5) and has been found in beam trawl surveys undertaken in East Anglia THREE and the former East Anglia FOUR (Table 6.3).

121. According to ICES advice, the species' biomass has been gradually increasing since 2000 with moderate interannual variability (ICES 2017g). Biomass has been higher in the last two years than in the three previous years. Brill is commonly a bycatch species in plaice and sole fisheries, normally caught in beam and otter trawls (ICES 2017g). ICES advises that catches should be no more than 3,170 tonnes in each of the years 2018 and 2019 (ICES 2017g).

122. Young brill principally eat shrimp, while older individuals target larger crustaceans and bottom-living fishes such as gobies and lesser sandeel, in addition to herring and young cod (Golani et al., 2011).

6.2.1.8 Turbot

123. Turbot is widespread throughout the North Sea, inhabiting sandy, rocky or mixed bottoms, and is also common in brackish waters, such as estuaries (Sparrevohn and Støttrup, 2008). Turbot predate mainly on other bottom-living fishes, such as sandeels and gobies, and to a lesser extent, on larger crustaceans and bivalves (Vinagre et al., 2011).

124. Turbot are batch spawners releasing pelagic eggs into the water column. The spawning season is between May and July. Individuals typically migrate between spawning and feeding areas (Sparrevohn and Støttrup, 2008).

125. Turbot are targeted by commercial fisheires in the study area, predominantly by Dutch and Belgain vessels (Figure 6.4 and Figure 6.5). ICES advises that catches of turbot should not to exceed 4,952 tonnes in each of the years 2017, 2018 and 2019 (ICES, 2017h). Stock recruitment in the last decade has been variable and without a trend. Fishing mortality is estimated to have decreased since the mid-1990s and remained stable for the past ten years. Spawning stock biomass has increased since the late 1990s (ICES, 2017h).

6.2.1.9 Solenette

126. Solenette is the smallest species of the Soleidae family with a distribution from the Mediterranean, along the west coast of Europe and around the British Isles (Baltus and Van der Veer, 1995). They are common on sandy sediments offshore, at depths

from 9 to 37m, and are found across the North Sea in association with their prey species (Sell and Kröncke, 2013; Callaway et al., 2002). They are rarely found inshore, do not make pronounced migrations and their abundance is not seasonal (Amara et al., 2004). In addition, there is no distinction between juveniles and adults (Baltus and Van der Veer, 1995).

127. Amara et al. (2004) suggests the species may be intolerant of the physical conditions encountered in shallow, warmer waters, inshore and at large riverine outflows. Solenette distribution therefore differs from that of sole and plaice which have a euryhaline tendency and inhabit shallow coastal and estuarine areas as nursery grounds (Amara et al., 2004).

128. The species has increased in abundance in the North Sea and has moved northwards since the late 1980s. This has been attributed to the effects of increasing temperatures from milder winters on adult habitat conditions (van Hal et al., 2010).

129. During the East Anglia THREE, former East Anglia FOUR and former East Anglia Zone surveys, solenette was one of the most abundant non-commercial species in the catch (Table 6.3, Table 6.4 and Table 6.5).

130. Spawning occurs in early summer although key spawning areas are unknown (Kay and Dipper, 2009). Once hatched, solenette larvae are present in the plankton until settlement at the seabed at around 12mm (Kay and Dipper, 2009).

131. Solenette have a varied diet including small benthic crustaceans, polychaetes, molluscs and fish (Derweduwen et al., 2012; Amara et al., 2004).

6.2.1.10 Gobies

132. Sand goby are a common short-lived species of the Gobiidae family, living on inshore sandy grounds from the mid-tide level to 20m (Maitland and Herdson, 2009). As repeat spawners, males guard the eggs that females deposit under rocks or bivalve shells (Riley, 2007). Males guard approximately 2 egg batches at the same time, belonging to different females, and females respawn with an interval of about 1 to 2 weeks. Sand goby were the second most abundant species caught in East Anglia THREE and former East Anglia FOUR 2m Scientific Beam Trawl surveys (Table 6.4).

133. Life history information for the species is limited, although Maitland and Herdson (2009) suggest it may move to deeper water to commence breeding between March and July. Sand gobies are important prey for a number of demersal fish species (Riley, 2007) and are protected under the Bern Convention (Table 6.11).

134. Of the 19 species of Gobiidae found in UK waters (Wheeler, 1978), the other Gobiidae species represented in the site-specific otter and beam trawl survey catches included common goby *Pomatoschistus microps*, two-spotted goby

Gobiusculus flavescens, Couch's goby *Gobius couchi*; Giant goby *Gobius cobitis* and transparent goby *Aphia minuta*.

135. Common goby prefer low salinities and are abundant on sandy and muddy shores in pools to MHW, low salinity pools, coastal ditches and estuaries (Kay and Dipper, 2009).

136. Painted gobies are often found in lower shore pools in stony areas or near rocks on sandy shores (Kay and Dipper, 2009).

137. The giant goby and Couch's goby (listed under Schedule 5 of the Wildlife and Countryside Act) are rare in British coastal waters and have not been recorded from the offshore waters of the North Sea (Rogers and Stocks, 2001).

6.2.1.11 Lesser weever

138. Lesser weever are common to inshore areas off the east of England and abundant on sandy substrates in shallower, warmer waters from less than 5m depth, down to 50m (Rogers et al., 1998).

139. Weever fish spawn in summer and both eggs and larvae float in the plankton (Maitland and Herdson, 2009). Early life history stages have been associated with sandbank crests in the North Sea, suggesting that sandbanks provide suitable conditions as nursery grounds (Ellis et al., 2010). There have also been marked temporal extensions for the species attributed to the effects of increasing North Sea temperatures (Tulp, 2006).

140. Lesser weaver fish normally feed on small bottom-living organisms including decapods, mysid shrimps and fish species such as sandeels and gobies (Derweduwen et al., 2012).

6.2.1.12 Gurnards

141. Grey gurnard is one of the more abundant demersal species in the North Sea with a wide distribution to depths of 140m, on a variety of sediment and in rocky areas, both inshore and offshore (Barnes, 2008; Floeter et al., 2005; Kay and Dipper, 2009). The species shows a seasonal shift in distribution forming local aggregations in the western part of the Central North Sea and north-west of the Dogger Bank in winter months, before widespread summer dispersal (Mackinson and Daskalov, 2007; Floeter et al., 2005).

142. Tub gurnard are the biggest of the gurnard species and are distributed widely throughout the North Sea (Nunoo et al., 2015). Like grey gurnard, tub gurnards inhabit sand, muddy sand or gravel bottoms and feed on fish, crustaceans and mollusks. They exhibit distinct pairing during breeding.

143. Gurnards are generalist feeders with a diet including bottom-dwelling fish, crustaceans and invertebrates, including shrimp *Crangon* spp. and sandeels (Weinert et al., 2010). As a key predator of juvenile fish, gurnard have a significant top-down effect on other species including the gadoids; whiting and cod (Floeter et al., 2005). Regional differences in diet are reported (Sell and Krocke, 2013).

144. Market demand for grey gurnard is low and as a by-catch species in demersal fisheries and they are widely discarded (Mackinson and Daskalov, 2007). Tub gurnard are landed from the study area (primarily from rectangle 34F3) at relatively low levels (Figure 6.5).

145. Grey gurnard were recorded in both the otter and beam trawl surveys carried out for East Anglia THREE and the former East Anglia FOUR (Table 6.2, Table 6.3 and Table 6.4), whilst tub gurnard was only recorded in demersal otter trawls in the former East Anglia FOUR site in May 2013 (Table 6.2). Grey gurnard has also been recorded by the IBTS in the study area, particularly in ICES rectangle 34F3 where the south east corner of the Norfolk Boreas site is located and in rectangle 35F3, where the north east section of the Norfolk Boreas site is located.

6.2.1.13 Sandeels

146. The North Sea sandeel population is considered to consist of several discrete meta-populations rather than an individual homogeneous stock (ICES, 2017l). For the purposes of stock management, ICES has divided the North Sea into four Sandeel Assessment Areas. The offshore project area falls within the boundaries of Sandeel Assessment Area 1r (Figure 6.3).

147. Sandeels spend a large proportion of the year buried in the sediment, emerging into the water column to spawn briefly in winter and for an extended feeding period in spring and summer (Van der Kooij et al., 2008). Females lay demersal eggs on the sea bed and following several weeks, planktonic larvae hatch, typically in February or March (Macer, 1965; Wright and Bailey, 1996). Spawning is thought to occur between November and February (Coull et al., 1998).

148. Sandeel distribution is highly patchy being dependent on sediment type with a preference for shallow, turbulent sandy areas at depths of 20 to 70m, including the sloping edges of sandbanks (Greenstreet et al., 2010; Jensen et al., 2011).

149. Research on the lesser sandeel suggests sandeels require a very specific substratum, favouring sea bed habitats containing a high proportion of medium and coarse sand and low silt content (Holland et al., 2005). Sandeels have rarely been recorded in sediments where the silt content (particle size <0.63µm) is greater than approximately 4% (Holland et al., 2005; Wright et al., 2000) and are generally absent where silt content is greater than 10% (Holland et al., 2005; Wright et al., 2000).

Sediment categories first proposed by Holland et al. (2005) and adapted by Greenstreet et al. (2010) defined suitable sandeel substrate in terms of "coarse sands" (with a particle size between 250μm to 2mm) and "silt and fine sands" (with particles between 0.1 μm and 250μm). The greater the percentage of "coarse sands" relative to the percentage of ''silt and fine sands'', the greater the potential for the substrate in a given area to constitute a preferred sandeel habitat.

150. The suitability of the substrate in areas relevant to the project in terms of potential provision of sandeel habitat, based on Marine Space (2013) sandeel habitat categorisation (Table 6.13), is illustrated in Figure 6.30. This has been derived from Particle Size Analysis (PSA) data from sediment samples collected across the offshore project area. As shown, the majority of samples correspond with sediments categorised as preferred and marginal sandeel habitat. In this context it is important to note that the presence of suitable habitat does not necessarily imply that sandeels are present in significant numbers in a given area.

Table 6.13 The partition of sandeel species (ammodytidae) potential spawning habitat sediment classes (Source: Folk, 1954; adapted from Marine Space, 2013)

% Particle contribution (Muds = clays and silts <63 µm)	Habitat sediment preference	Folk sediment unit	Habitat sediment classification
<1% muds, >85% Sand	Prime	Part Sand, Part slightly gravelly Sand and part gravelly Sand	Preferred
<4% muds, >70% Sand	Sub-prime	Part Sand, Part slightly gravelly Sand and part gravelly Sand	Preferred
<10% muds, >50% Sand	Suitable	Part gravelly Sand and part sandy Gravel	Marginal
>10% muds, <50% Sand	Unsuitable	Everything excluding Gravel, part sandy Gravel and part gravelly Sand	Unsuitable

151. As shown in Table 6.4 and Table 6.5, sandeels have been found in the study area during epibenthic surveys in some numbers. Their presence was also noted in two stations in seabed video footage collected as part of the benthic surveys carried out for Norfolk Boreas (Appendix 10.1 Benthic Characterisation Report). Similarly, small sandeel, greater sandeel and lesser sandeel have been recorded in the study area by the IBTS (Table 6.6). However, analysis of IBTS data for the wider North Sea, suggests that sandeels are found in relatively low numbers in this area, with considerably higher CPUE recorded to the north and east of the offshore project area (Figure 6.31 to Figure 6.34).

152. As shown in Figure 6.35, the offshore project area overlaps with the wide low intensity sandeel (Ammodytidae spp.) spawning and nursery grounds defined by Ellis et al. (2010). However, high intensity spawning grounds are found at considerable distance from the project, the closest being located around the Dogger Bank.

153. An overview of the location of sandeel grounds in the North Sea based on fisheries information (Jensen et al. 2011) is provided in Figure 6.30. Fishing grounds are considered to provide reliable information on the distribution of sandeel habitat (Jensen, 2001) and are thus used as an indicator of the distribution of sandeels (van der Kooij et al., 2008). As shown, sandeel grounds are widespread throughout the North Sea an in areas relevant to Sandeel Assessment Area 1r (within which the project is located), they concentrate for the most part around the Dogger Bank).

154. Similarly, analyis of VMS data for the Danish sandeel fishery indicates that fishing activity for the most part concentrates around the Dogger Bank with very limited fishing activity recorded in the proximity of Norfolk Boreas (Figure 6.36).

155. Sandeels are of conservation interest being listed as a species of principal importance and designated as a nationally important marine feature because they provide a component part in the diets of fish, marine mammal and seabird species (Furness, 1990; Hammond et al., 1994; Tollit and Thompson, 1996; Wright and

Tasker, 1996; Greenstreet et al., 1998; Engelhard et al., 2013). ICES have advised that for Sandeel Area 1r (Central and Southern North Sea) the sandeel catch should be no more than 134,461 tonnes in 2018 (ICES, 2017l).

156. Zooplankton (particularly copepods) provides the staple prey of sandeels, in addition to certain large diatoms, worms, small crustaceans, fish larvae and small fish (Rowley and Wilding, 2008; Wheeler, 1978). Fluctuations in the abundance of copepod prey species (especially *Calanus finmarchicus*) in the North Sea, has been linked to the survival of sandeel larvae (ICES Advice, 2012). Sandeels are recognised for their susceptibility to declining Calanus abundance, changes in sea surface temperature and variations to the plankton community (Frederiksen et al., 2004).

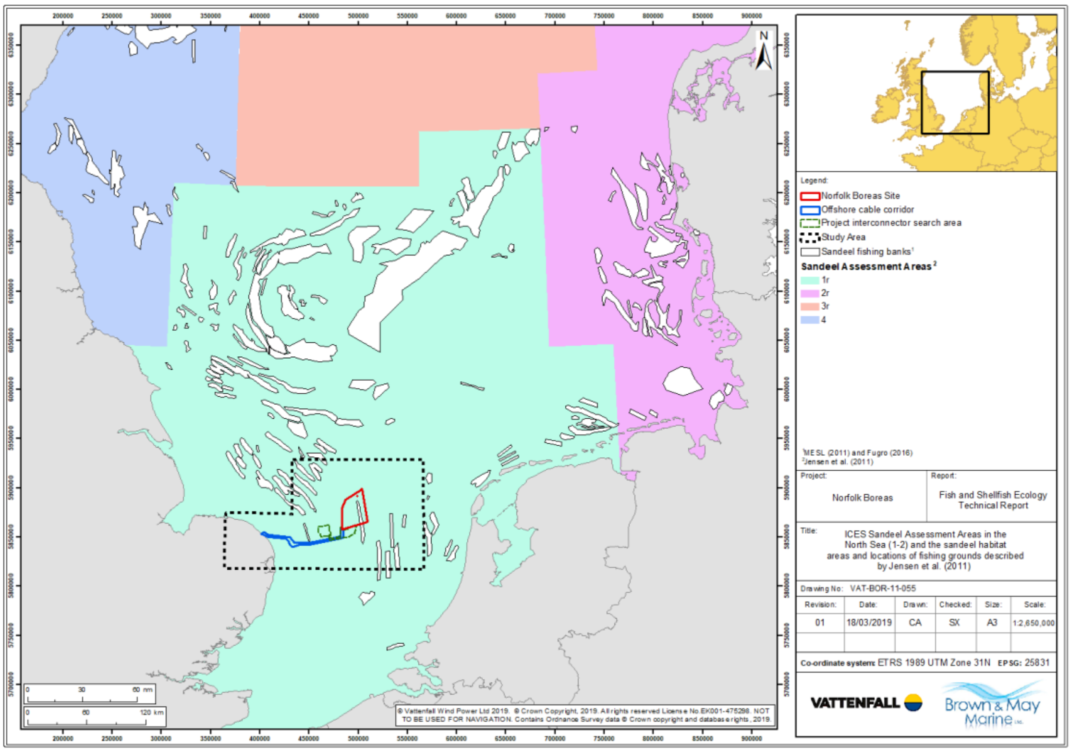


Figure 6.29 ICES Sandeel Assessment Areas in the North Sea (1-4) and the sandeel habitat areas and locations of fishing grounds described by Jensen et al. (2011) outlined in white. SA 1r central and Southern North Sea, Dogger Bank (pale green).

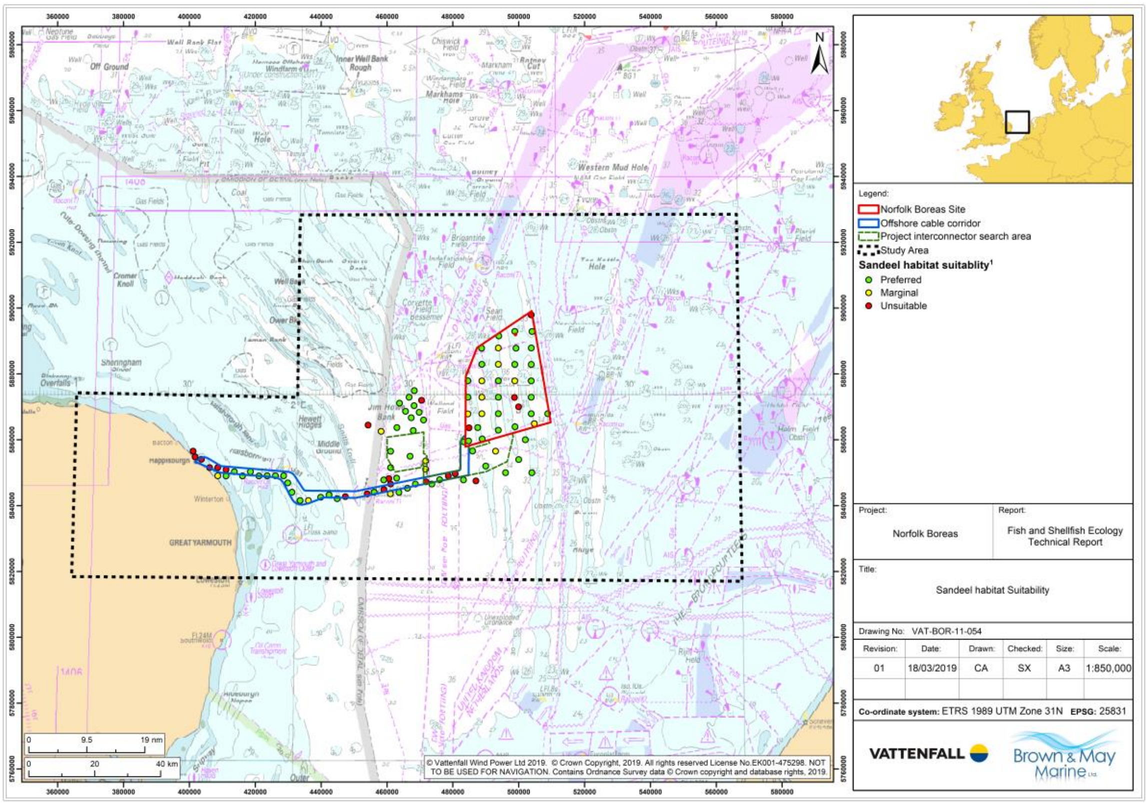


Figure 6.30 Sandeel habitat suitability (Source: Fugro, 2017)

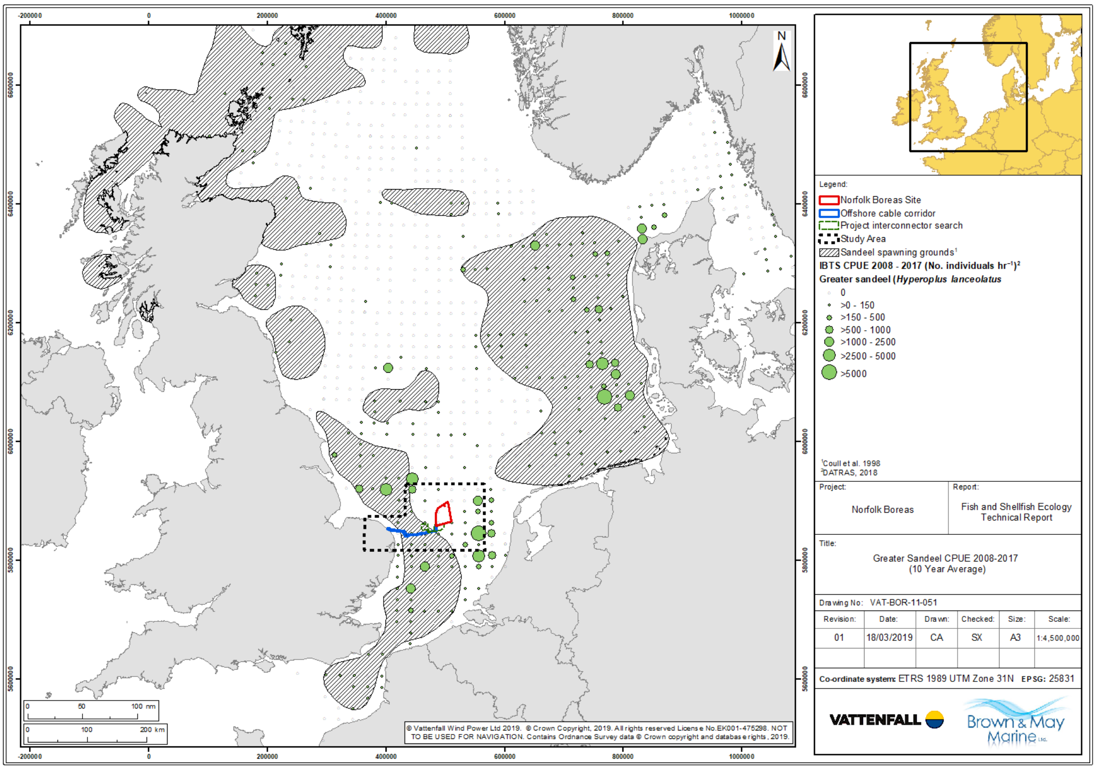


Figure 6.31 Average number (catch per standardised haul) of greater sandeel from IBTS data (2008-2017) (Source: DATRAS, 2018)

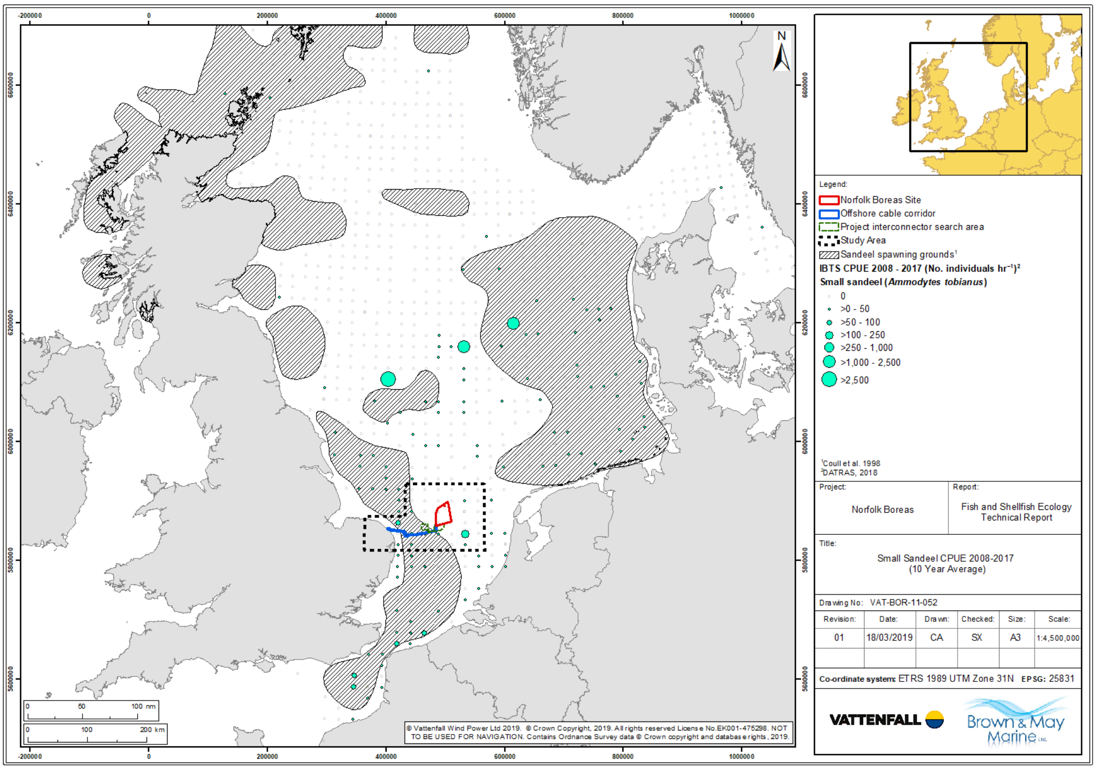


Figure 6.32 Average number (catch per standardised haul) of small sandeel from IBTS data (2008-2017) (Source: DATRAS, 2018)

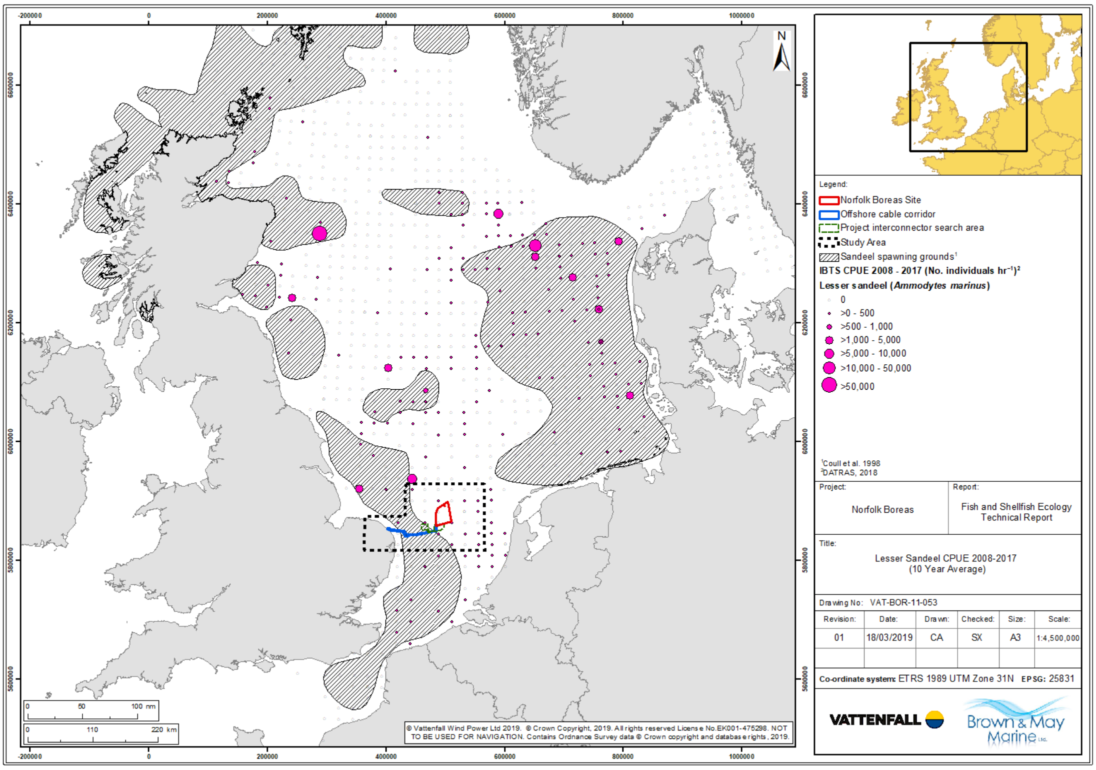


Figure 6.33 Average number (catch per standardised haul) of lesser sandeel from IBTS data (2008-2017) (Source: DATRAS, 2018)

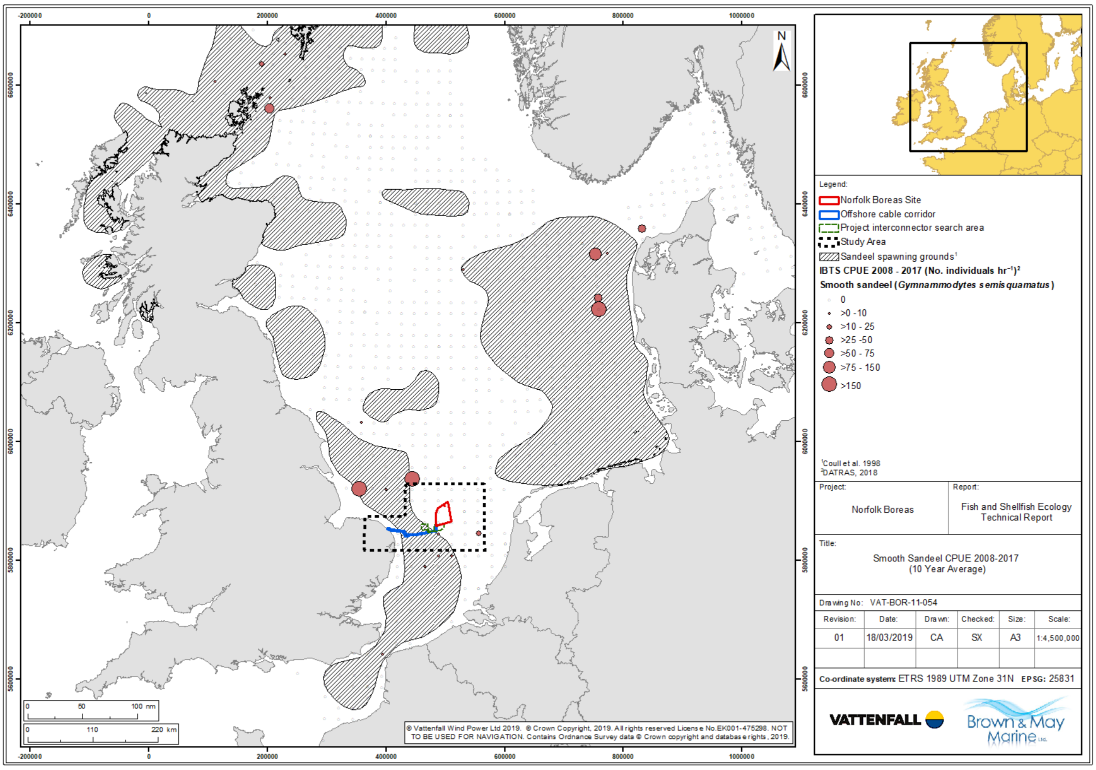


Figure 6.34 Average number (catch per standardised haul) of smooth sandeel from IBTS data (2008-2017) (Source: DATRAS, 2018)

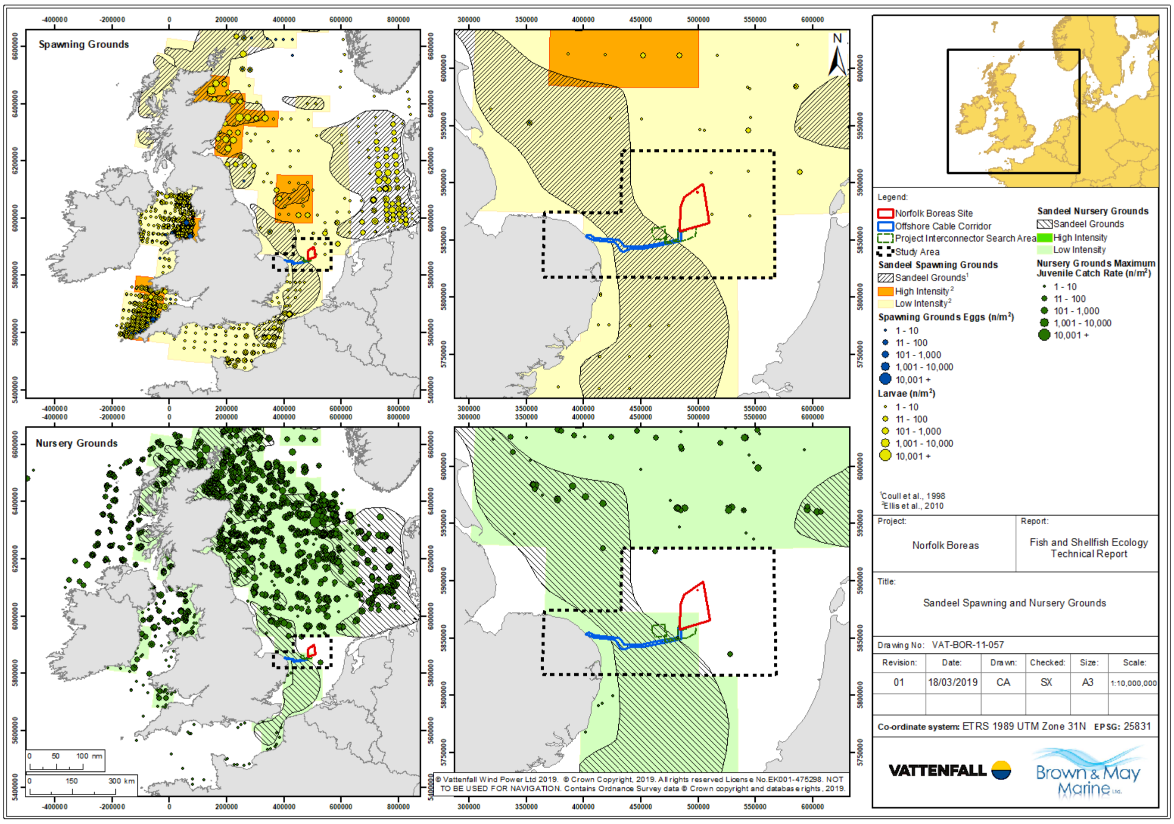


Figure 6.35 Sandeel spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

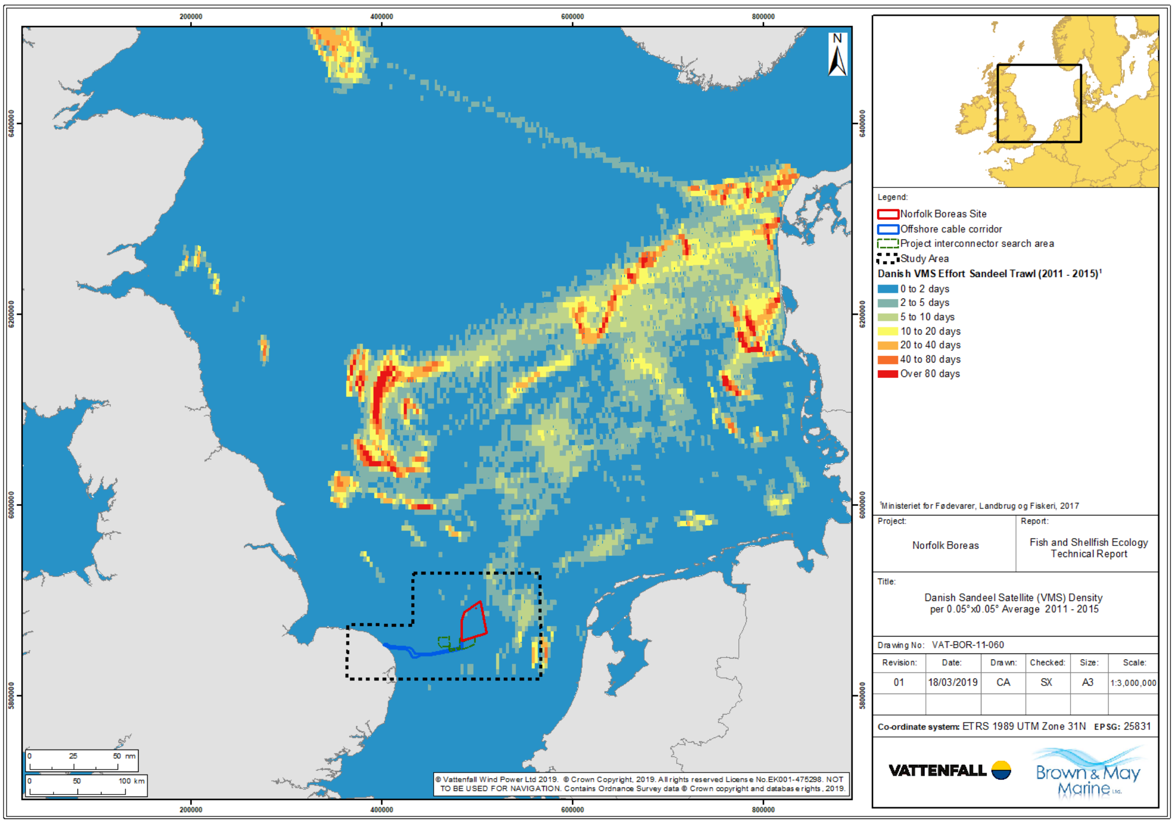


Figure 6.36 Danish sandeel fishing vessel satellite tracking (VMS) data (Average 2011-2015)

6.2.2 Pelagic Fish Species

6.2.2.1 Herring

157. Herring are found throughout the North Sea (Figure 6.37), from the sea surface to a depth of 200m. They have a broad distribution in the North Atlantic and migrate considerable distances in large shoals to reach their feeding and spawning grounds (Munro et al., 1998). Nursery areas generally support juvenile herring for up to two years before individuals join adult fish migrations (ICES, 2010b). The migration of herring is divided into three phases, the over-wintering phase, the feeding phase and the spawning phase (Maurcops, 1969).

158. The North Sea autumn-spawning herring stock consists of multiple spawning components (sub-populations) (Payne, 2010). There are considered to be four major components, each defined by distinct spawning times and sites (Payne, 2010). The sub-population of relevance to Norfolk Boreas is the “Downs herring”. (Figure 6.40). This sub-population spawn during December and January in the eastern English Channel and overwinter in the Southern North Sea (Corten, 2001). The other three sub-populations spawn in the North Sea in August/September (the Orkney–Shetland, the Buchan and the Banks components). In addition to the above, there is a discrete inshore herring spawning ground off Great Yarmouth, south of the offshore cable corridor (Figure 6.38).

159. Herring typically spawn in high energy environments at depths of between 20-40m (Cushing and Burd, 1957; Parrish et al., 1959) on coarse substrates including gravel, sandy gravel and small stones or rocks (Keltz and Bailey, 2010; Munro et al., 1998; Hodgson, 1957). Herring spawn benthic eggs in single batches, often several eggs deep (Maitland and Herdson, 2009) forming large mats and clumps that tend to hatch synchronously (Harden Jones, 1968; Burd, 1978; Blaxter and Hunter, 1982).

160. Figure 6.39. provides an indication of the suitability of the substrate across the offshore project area in terms of provision of herring spawning habitat using aggregate industry spawning habitat criteria for herring (Reach et al., 2013) (Table 6.14). As shown, analysis of the sediment samples across the offshore project area indicate that apart from a limited number of samples collected in the inshore section of the offshore cable corridor close to shore, the sediment across the majority of the offshore project area is unsuitable for herring spawning.

Table 6.14 The partition of Atlantic herring potential spawning habitat sediment classes (Source: Folk, 1954; adapted from Reach et al., 2013)

% Particle contribution (Muds = clays and silts <63 µm)	Habitat sediment preference	Folk sediment unit	Habitat sediment classification
<5% muds, >50% gravel	Prime	Gravel and part sandy Gravel	Preferred
<5% muds, >25% gravel	Sub-prime	Part sandy Gravel and part gravelly Sand	Preferred
<5% muds, >10% gravel	Suitable	Part gravelly Sand	Marginal
>5% muds, <10% gravel	Unsuitable	Everything excluding Gravel, part sandy Gravel and part gravelly Sand	Unsuitable

161. The Downs herring sub-population is less fecund than the other three spawning components within the North Sea (i.e. produce fewer eggs), however, this sub-population produces larger eggs (Baxter, 1959 and 1963; Cushing, 1958; Almatar and Bailey, 1989) and hatched larvae are larger than their northern counterparts (Heath et al., 1997). Depending on sea temperature, herring larvae hatch after approximately three weeks and become planktonic (Craik and Harvey, 1984, 1987; Ying and Craik, 1993). The Downs larvae hatch between 7.5 and 9.5mm in length (Dickey-Collas, 2005) and have faster escape responses than the smaller northern larvae (Batty et al., 1993).

162. Almost all stocks in Western Europe are understood to drift in an easterly direction (Dickey-Collas, 2005). Larval transport in the Southern North Sea is from the Wadden Sea towards juvenile nursery grounds in the Skagerrak and Kattegat (Wallace, 1924; Burd, 1978).

163. The Norfolk Boreas site is located a considerable distance from the defined spawning grounds of the Downs herring (Figure 6.38). This is also evident from analysis of IHLS data for recent years, which suggests that that the offshore project area does not support herring spawning (Figure 6.41 to Figure 6.43). The offshore project area, however, overalps with the extensive nursery areas defined for this species (Coull et al., 1998; Ellis et al., 2010) (Figure 6.38).

164. Herring is of limited commercial importance in the study area (Figure 6.3 to Figure 6.5). As described in Appendix 14.1 (Commercial Fisheries Technical Report) herring is targeted in inshore areas off the East Anglian coast by some local vessels, however, the fishery in this area is for the most part focused on shellfish species such as edible crab, lobster and whelk.

165. Herring were present, albeit in relatively low numbers, at sites sampled in the East Anglia THREE and former East Anglia FOUR surveys (Table 6.2, Table 6.3 and Table 6.4). The limitations of the gear used in these surveys in respect of pelagic species, however, are fuly recognised.

166. Herring is of conservation interest, being listed as a Species of Principal Importance (Table 6.11). Fishing over-exploitation during the 1960s caused Downs herring to be the first North Sea component to collapse, and it was subsequently the component that took the longest time to recover. However, since 2001, the Downs component has consistently increased making it the largest component of the North Sea stock of late. In line with this, the relative contribution of the Downs component to the total stock has risen since the start of the IHLS survey in the early 1970s (Schmidt et al., 2009). Over time, the Downs component has varied from almost negligible in the 1970s, to 40% of the total stock in recent times (Payne, 2010).

167. ICES have advised on the basis of precautionary considerations, that total catches should be no more than 517,891 tonnes in the North Sea and Eastern Channel for herring for 2018 (ICES, 2017i).

168. Herring are prey to piscivorous fish, marine mammals and seabirds. Herring feed on zooplankton, particularly Calanoid copepods during their early juvenile life, although they also feed on euphausids, hyperiid amphipods, juvenile sandeels, sea-squirts (Oikopleura spp.) and fish eggs. Other dietary items include small fish, arrow worms and ctenophores (ICES, 2010b).

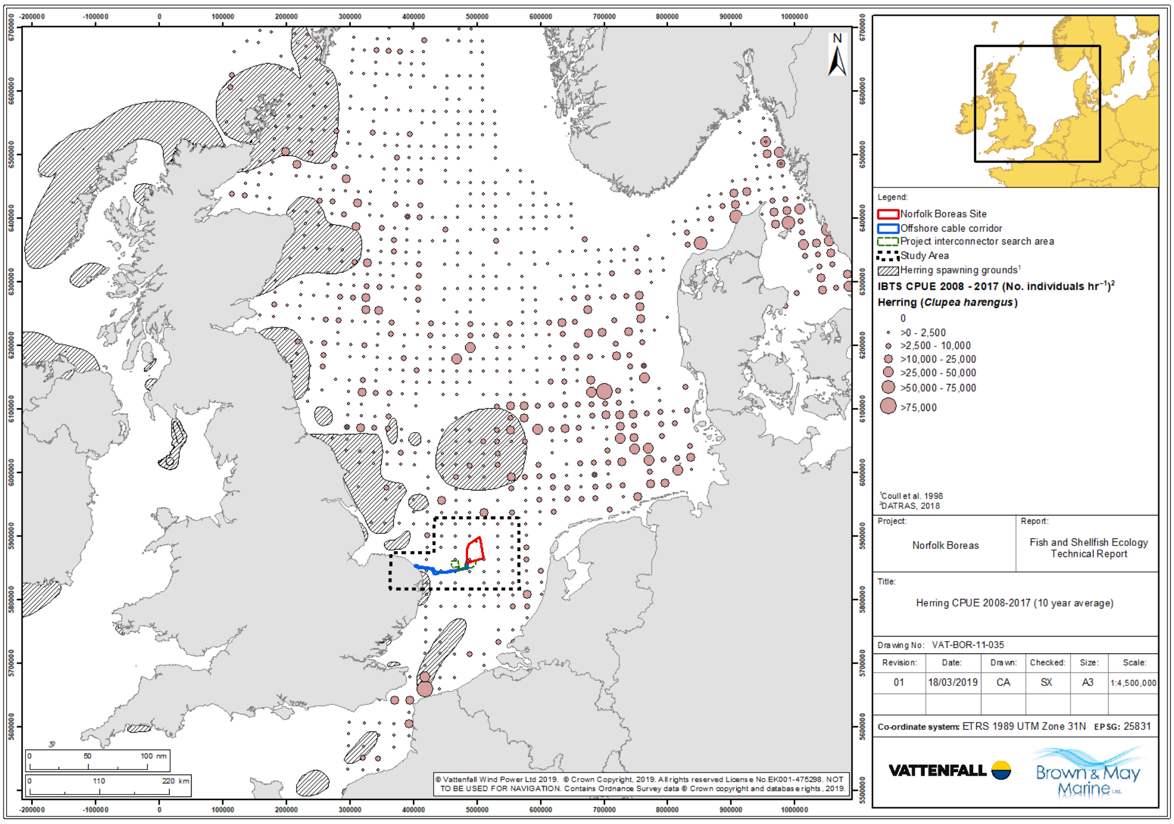


Figure 6.37 Average number (catch per standardised haul) of herring from IBTS data (2008-2017) (Source: DATRAS, 2018)

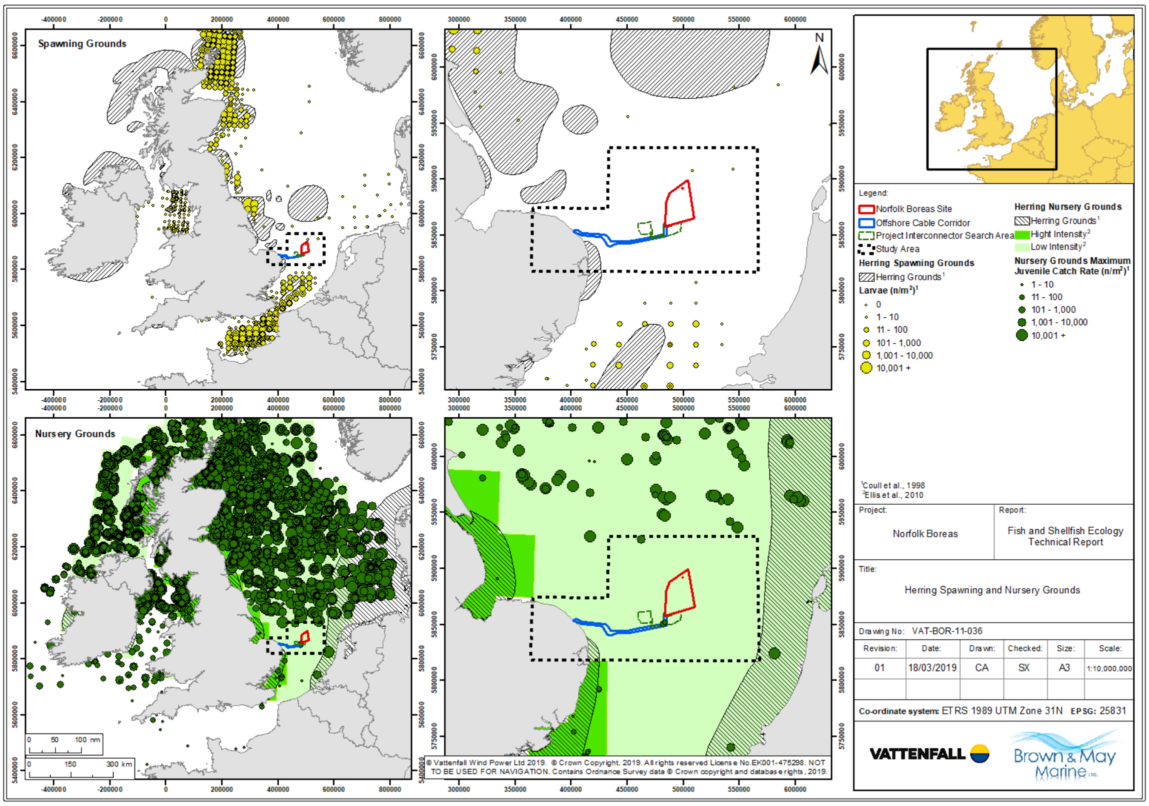


Figure 6.38 Herring spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

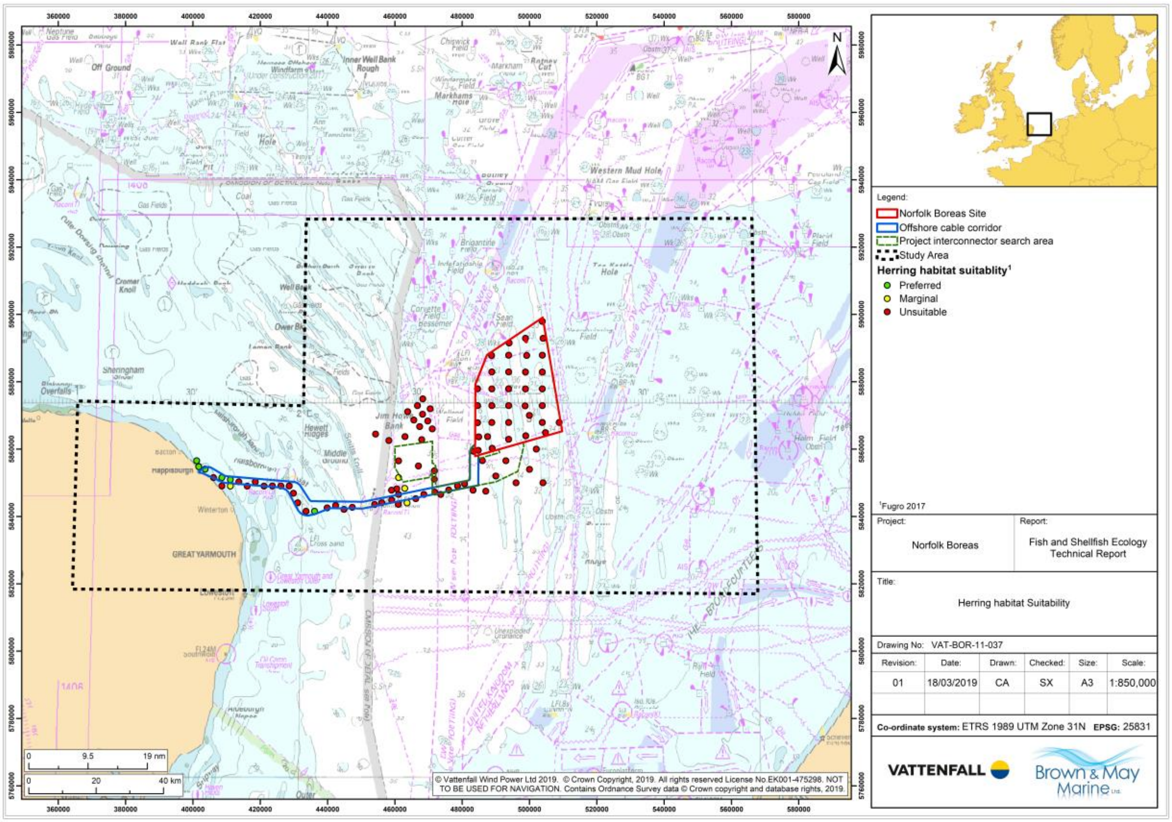


Figure 6.39 Herring habitat suitability (Source: Fugro, 2017)

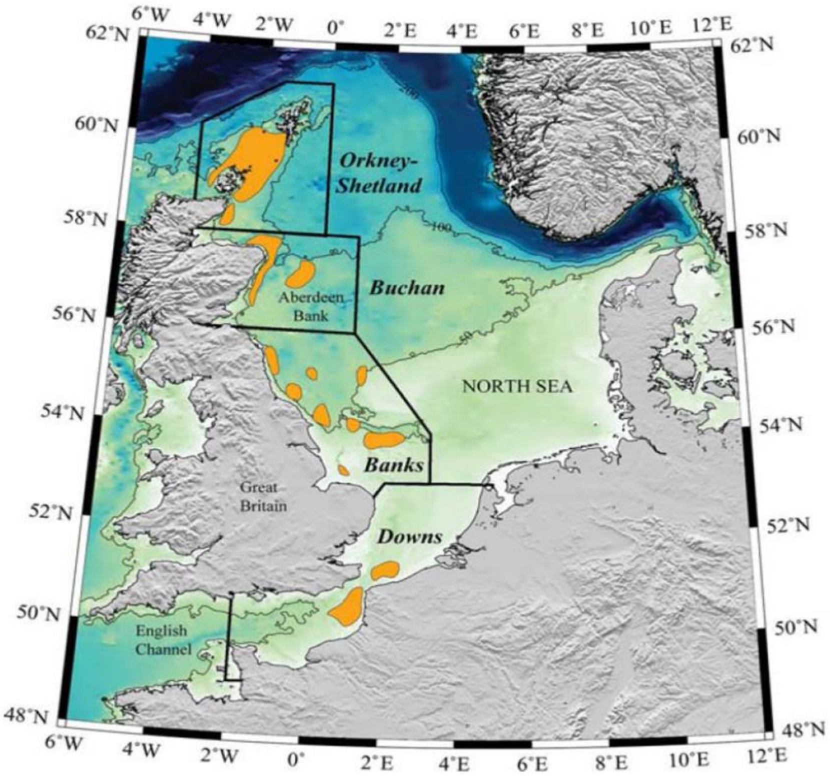


Figure 6.40 Atlantic herring spawning sub-populations in the North Sea (Source: Payne, 2010)

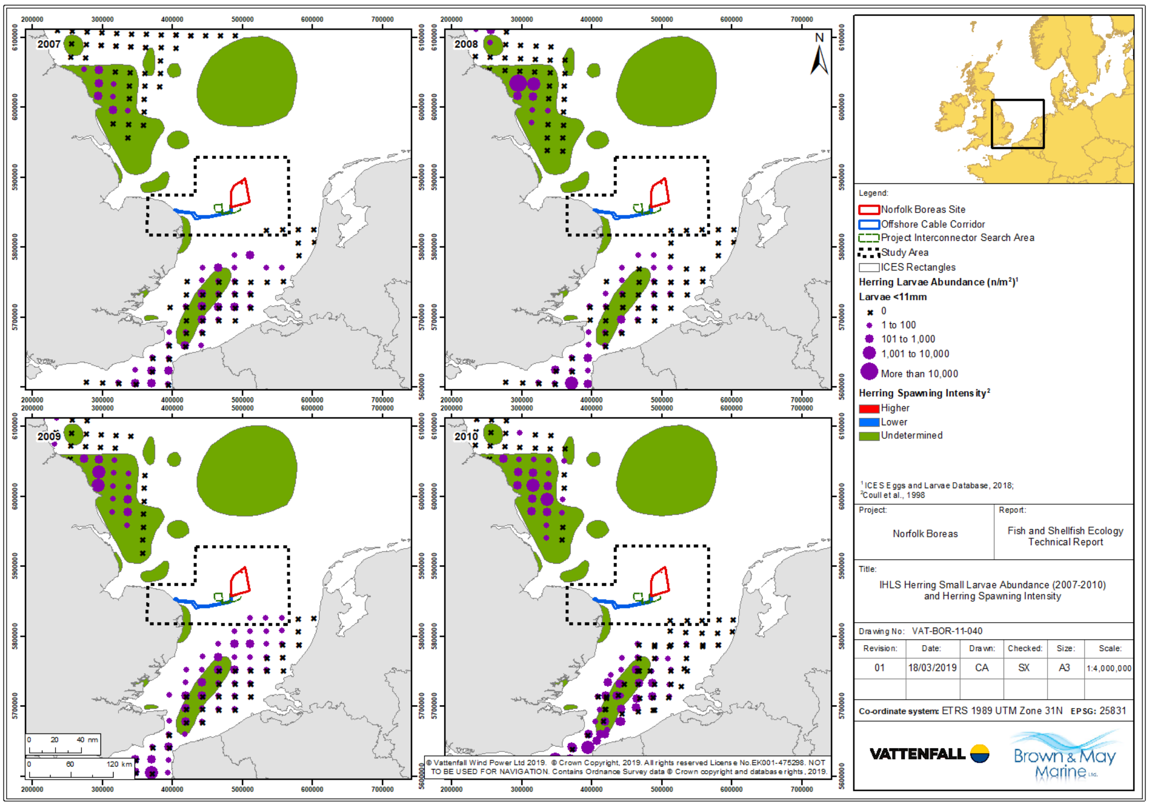


Figure 6.41 IHLS herring small larvae abundance (2007-2010) (Source: ICES Eggs and Larvae database, 2018)

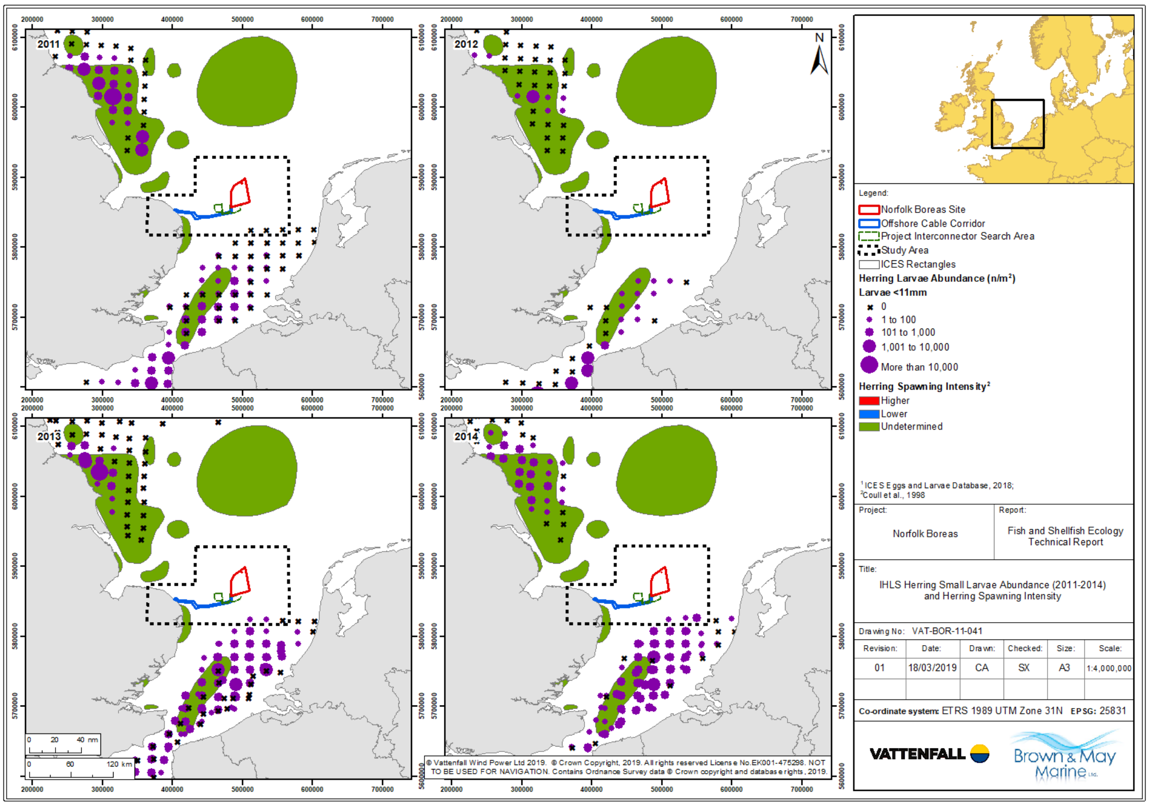


Figure 6.42 IHLS herring small larvae abundance (2011-2014) (Source: ICES Eggs and Larvae database, 2018)

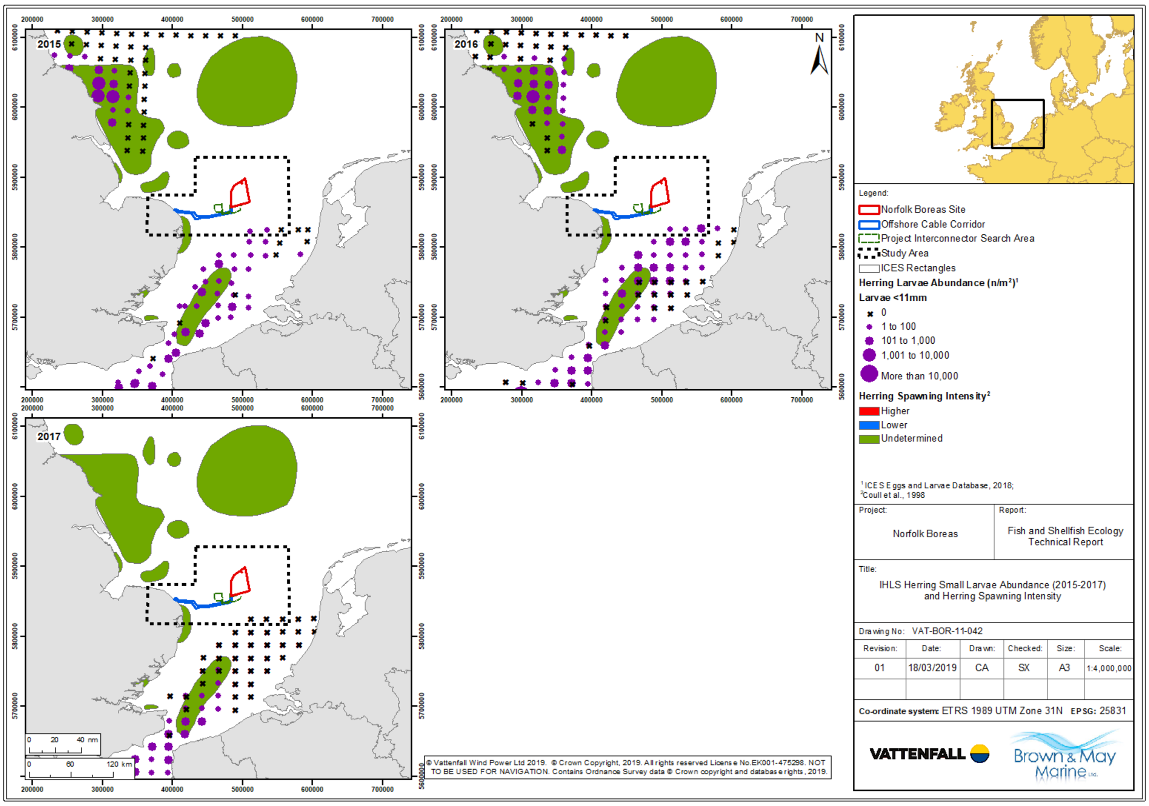


Figure 6.43 IHLS herring small larvae abundance (2015-2017) (Source: ICES Eggs and Larvae database, 2018)

6.2.2.2 Mackerel

169. Mackerel are distributed throughout the North Sea (Figure 6.44) and undertake seasonal inshore and northward migrations in summer (Cefas, 2010b). A relationship is thought to exist between the timing of spawning and sea surface temperature. Mackerel spawning in the North Sea migrate north in June and July, and by late summer disperse to feed in the Central North Sea and Skagerrat (Macer, 1974). In October, some of these fish migrate to western Shetland and some to the Norwegian Trench, where they overwinter. The following spring they return south to spawning grounds (Pawson, 1995).

170. The Norfolk Boreas site, project interconnector search area fall within defined mackerel spawning grounds (Figure 11. 45). The offshore cable corridor, project interconnector search area and the south west corner of the Norfolk Boreas site are also located within low intensity nursery grounds for this species (Figure 6.45). In the North Sea, mackerel spawning occurs from May to August, peaking between May and July (Coull et al., 1998).

171. Mackerel are of limited commercial importance in the inmediate area of Norfolk Boreas. This species has however been found in relatively high numbers in IBTS within the study area, particularly in rectangles 34F2 and 34F3 (Table 6.6).

172. Mackerel is listed as a Species of principal importance and classified as of 'Least Concern' in the IUCN Red List of Threatened Species (Table 6.11). The spawning stock biomass is estimated to have increased since the early 2000s and has been above MSY since 2009. There has been a succession of large year classes since the early 2000s (2002, 2006, 2011, and 2014) and all year classes since 2005 (except for the 2013 year class) are estimated to be above average. ICES advises that catches in 2018 in the Northeast Atlantic should be no more than 550,948 tonnes (ICES, 2017j).

173. Mackerel have a varied diet. Adults consume large quantities of pelagic crustaceans, as well as schools of smaller fish, notably sprat, herring and sandeels (Wheeler, 1978). Juvenile mackerel prey on fish larvae, crustacean larvae and their own larvae (Maitland and Herdson, 2009). Mackerel also play an important role as a food resource for sharks, marine mammals and a range of seabirds.

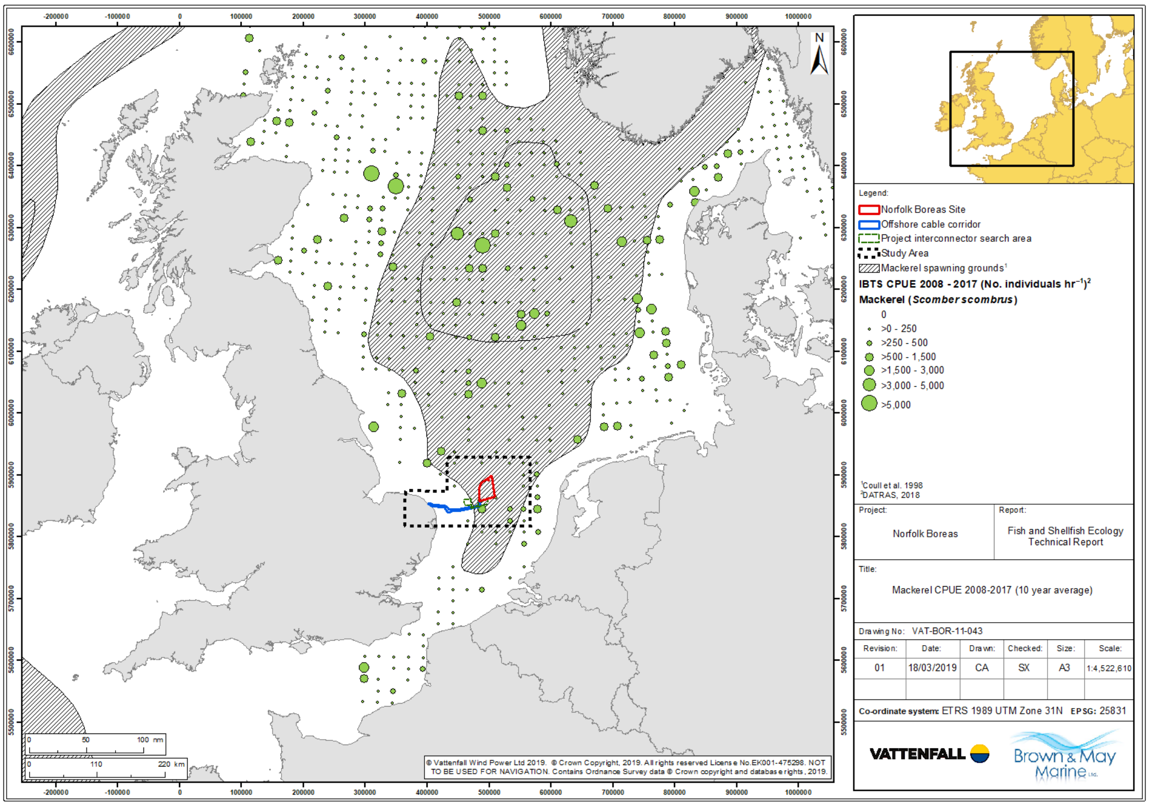


Figure 6.44 Average number (catch per standardised haul) of mackerel from IBTS data (2008- 2017) (Source: DATRAS, 2018)

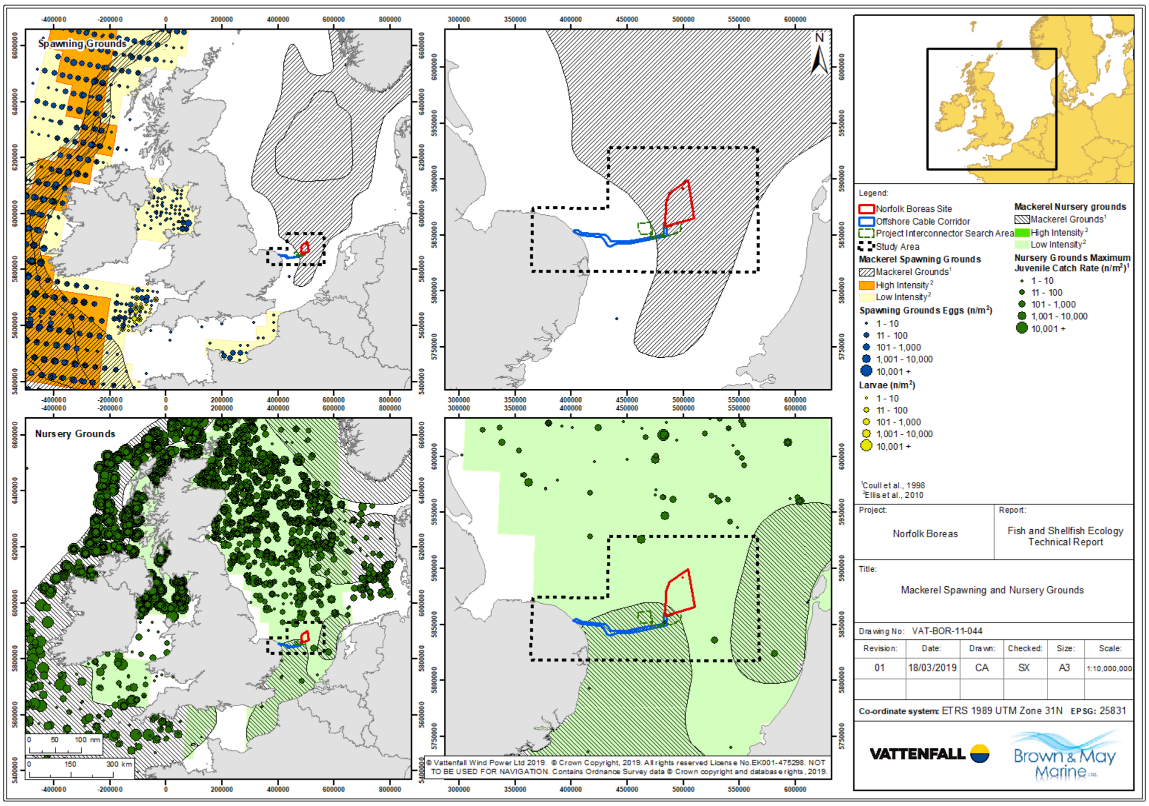


Figure 6.45 Mackerel spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

6.2.2.3 Sprats

174. Sprats are common throughout the North Sea, particularly in and around the Dogger Bank and German Bight (Figure 6.46). During summer, they occur in inshore waters for spawning, and subsequently undertake migrations to winter feeding grounds (FAO, 2011).

175. Spawning is thought to take place in both coastal waters and in deep basins up to 100km offshore (Whitehead et al., 1986; FAO, 2011; Nissling et al., 2003) between May and August, with a peak between May and June (Coull et al., 1998; Voss et al., 2009) (Figure 6.47). Females spawn repeatedly in batches throughout the spawning season (Milligan, 1986). Sprats are pelagic spawners. Their eggs and larvae are therefore subject to larval drift, directing movement to inshore nursery areas (Hinrichsen et al., 2005; Nissling et al., 2003). Juveniles are often found close inshore in schools with juvenile herring.

176. The offshore project area falls within the broad spawning grounds defined for sprat (Coull et al., 1998) (Figure 6.47). Only the eastern boundary of the Norfolk Boreas site coincides with the species nursery grounds (Coull et al., 1998) (Figure 6.47).

177. Sprats are not listed as a species of conservation importance. The spawning stock biomass has been at or above MSY since 2013. Recruitment in 2016 was estimated to be the highest on record, but with substantial uncertainty. ICES have advised, on the basis of precautionary considerations, that catches of sprat in the period from 1 July 2017 to 30 June 2018 should be no more than 170,387 tonnes (ICES, 2017k).

178. Sprats are of commercial importance in the study area, particularly in rectangles 34F2, 35F2 and 35F3 (Figure 6.3).

179. Sprats primarily feed on small planktonic crustaceans including copepod nauplii and bivalve larvae (Maes and Ollevier, 2002) and constitute an important prey for a number of species, including pisicivorous fish, marine mammals and seabirds (Maes and Ollevier, 2002).

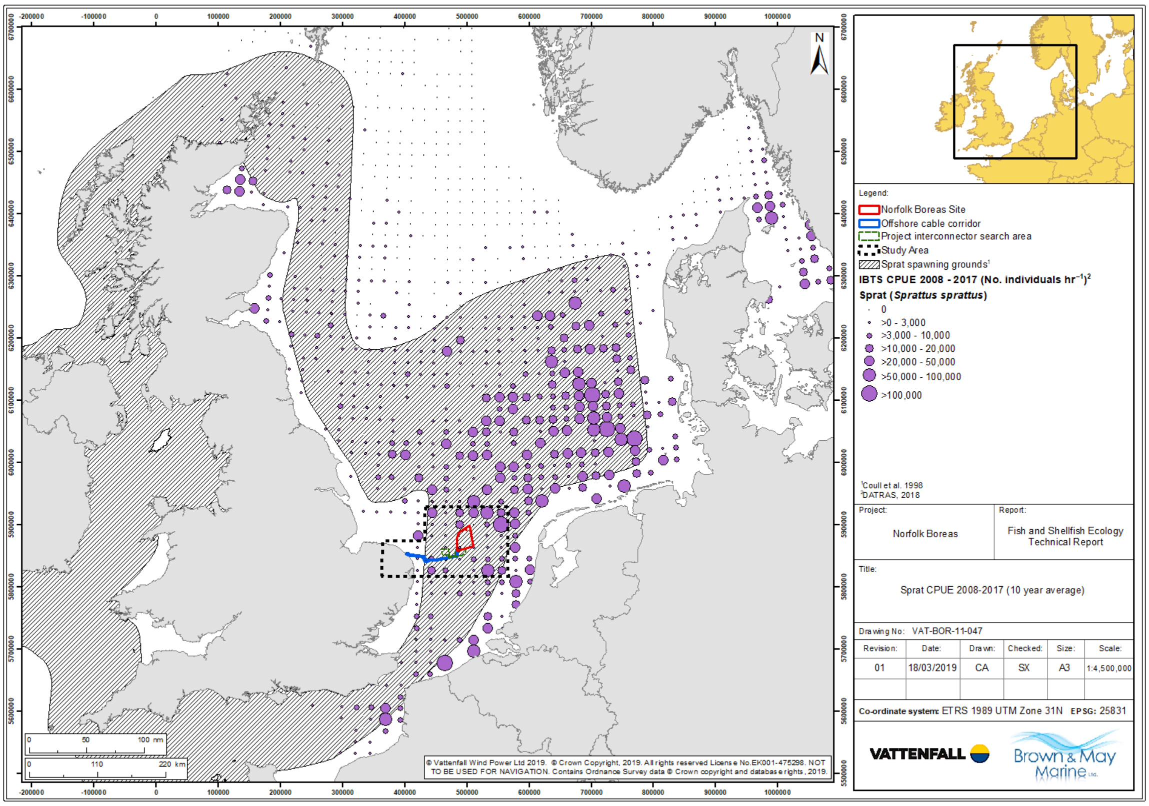


Figure 6.46 Average number (catch per standardised haul) of sprat from IBTS data (2008-2017) (Source: DATRAS, 2018)

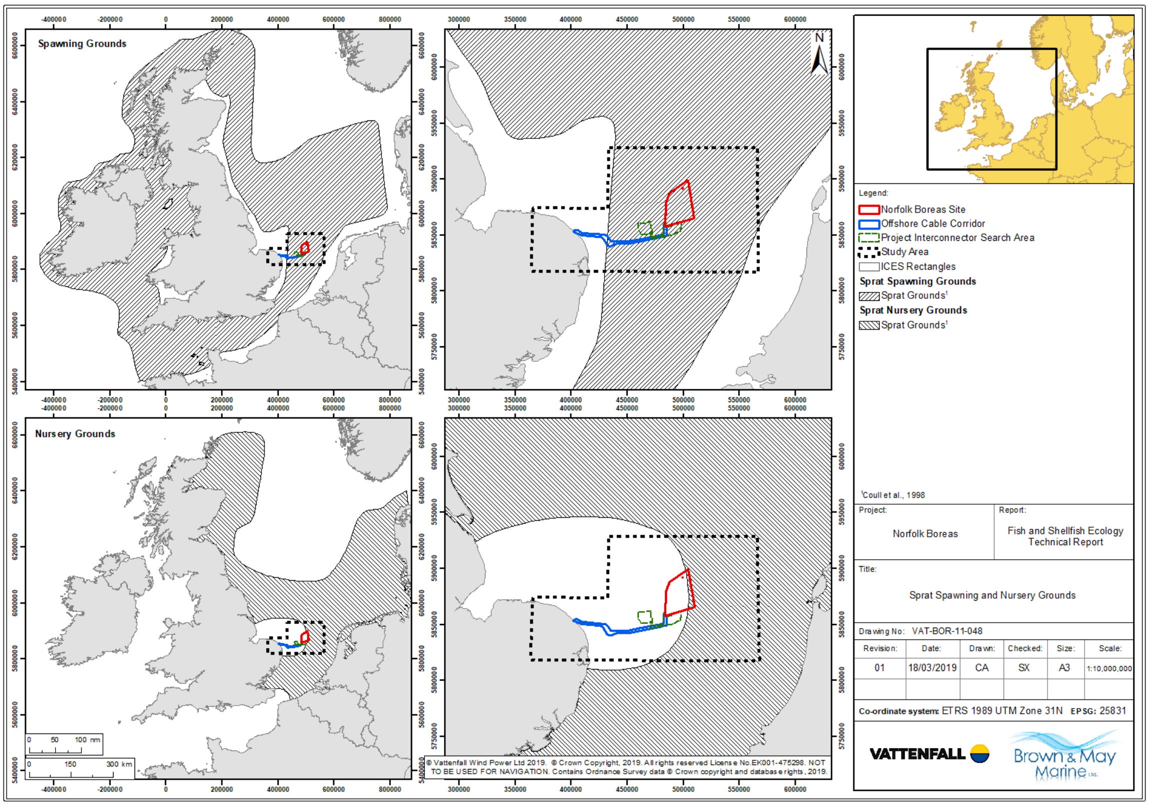


Figure 6.47 Sprat spawning and nursery grounds (Source: Coull et al., 1998)

6.2.3 Elasmobranchs – Skates and Rays

6.2.3.1 Thornback ray

180. Prior to the 1950s, thornback rays were widespread and abundant in the North Sea. However, their slow growth rate, late maturity and low fecundity rendered them vulnerable to fishing over-exploitation. Since then, thornback ray abundance and range has decreased (Chevolot et al., 2006). Thornback rays can inhabit a broad range of softer sediment types including mud, sand, shingle and gravel. They are less frequently documented on coarser sediments (Wilding and Snowden, 2008). The average distribution of thornback rays in the North Sea between 2008 and 2017 as derived from the IBTS is provided in Figure 6.48.

181. Tagging experiments in the Thames Estuary (Hunter et al., 2005) showed that mature thornback rays remain in deeper waters between 20 and 35m depth and demonstrate seasonal autumn and winter movements to shallower waters (less than 20m depth) in early spring to spawn. Rays appear to be more widely distributed in the Southern North Sea during autumn and winter. Fertilised egg cases are deposited on the seabed, followed by a 4 to 5 month incubation period. After incubation, juveniles emerge as fully formed rays (Chevolot et al., 2006).

182. The inshore section of the export cable corridor overlaps with defined low intensity nursery areas (Figure 6.49). Spawning and nursery grounds for this species are considered to broadly overlap, although data on the occurrence of egg-bearing females during the spawning season is insufficient at present (Ellis et al., 2012). Spawning occurs over an extensive period from February to October, peaking from April to August (Ellis et al., 2012). Low intensity spawning areas coincide with the inshore section of the offshore cable corridor (Figure 6.49).

183. Thornback ray is of commercial importance in the, being amongst the main elasmobranch species landed from the study area particularly from rectangle 34F2 (Table 6.7 and Figure 6.5).

184. In terms of conservation importance, thornback ray is included in the OSPAR list of threatened and/or declining species and has been classified as ‘Near Threatened’ by the IUCN (Table 6.10).

185. Small crustaceans (amphipods, mysids and crangonid shrimps) form the basis of juvenile diets, whilst larger crustaceans (e.g. swimming crabs) and fish (e.g. sandeels, small gadoids and dragonet) are preyed upon by mature rays (Morato et al., 2003).

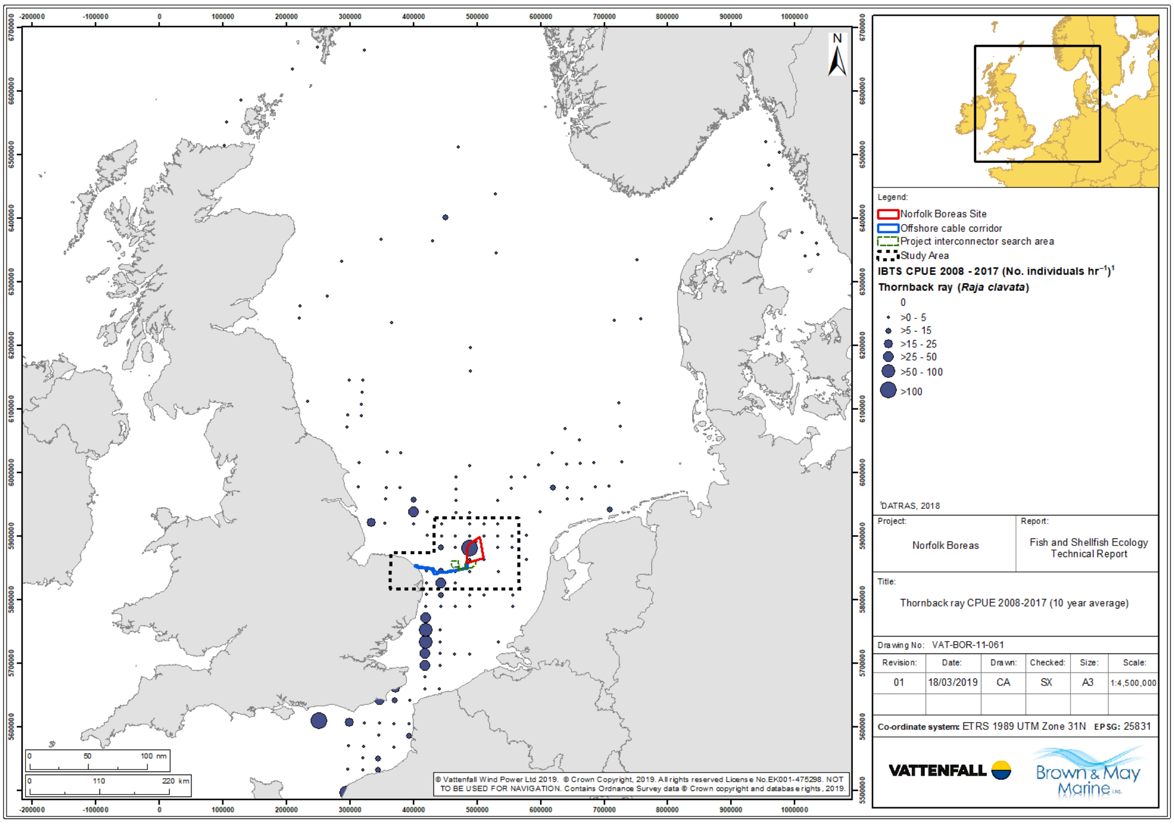


Figure 6.48 Average number (catch per standardised haul) of thornback ray from IBTS data (2008-2017) (Source: DATRAS, 2018)

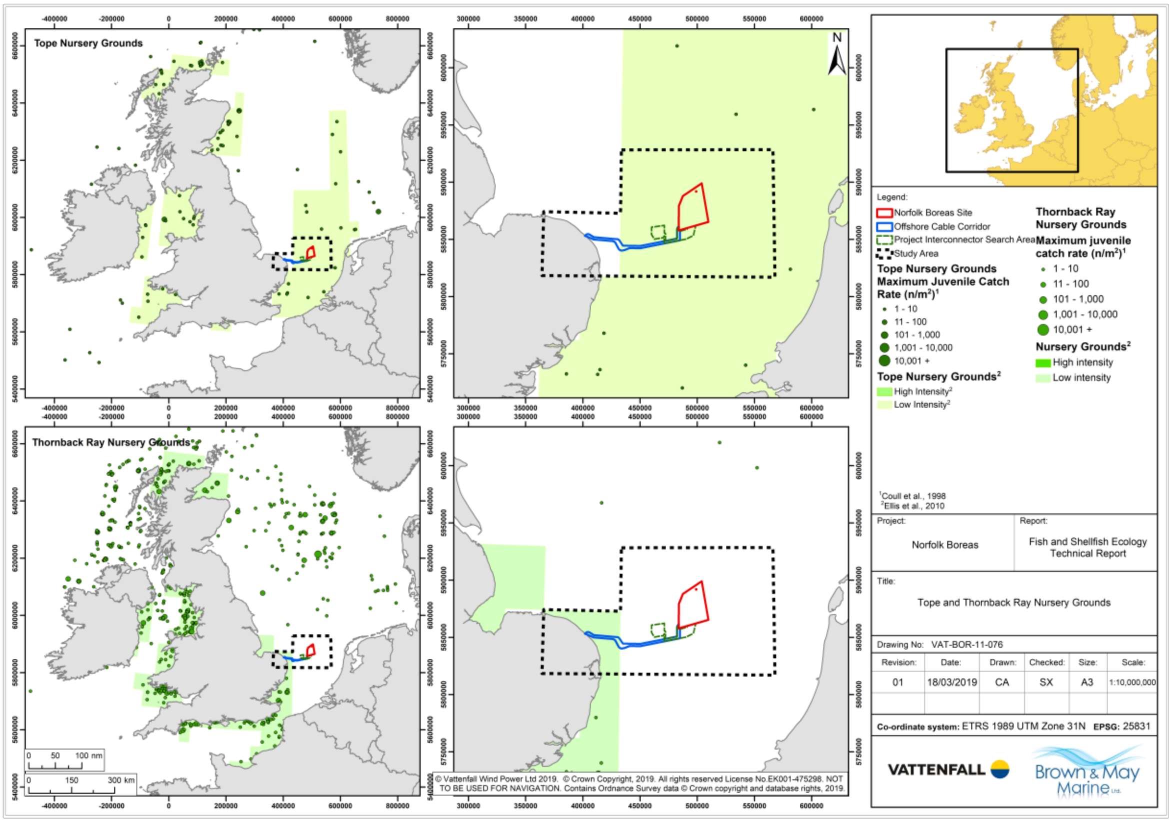


Figure 6.49 Tope and thornback ray nursery grounds (Source: Ellis et al., 2010)

6.2.3.2 Spotted ray

186. Spotted rays are most commonly found on sandy and muddy sediment in moderately deep waters, ranging between depths of 8 and 283m (Ellis et al., 2005). The distribution of spotted ray around the British Isles is believed to be similar to that of thornback ray (Ellis et al., 2005). IBTS results showed that spotted rays are present off the East Anglian coast (Figure 6.50; Table 6.6).

187. Spotted ray nursery grounds are also broadly similar to those of thornback rays, normally being located in shallower waters (Ellis et al., 2005). During the spawning season, spotted rays lay between 24 and 60 eggs cases on the sea bed. After a period of 4-5 months, the juveniles emerge (Kay and Dipper, 2009). Within the Greater Thames Estuary however, juvenile spotted rays have been found to be less abundant than their juvenile thornback counterparts (Ellis et al., 2012).

188. In comparison to thornback rays, spotted rays are considered of secondary importance in landings data. Spotted rays are included in the OSPAR list of threatened and/or declining species and have been classified as of 'Least Concern' by the IUCN (Table 6.10).

189. Spotted rays primarily feed on crustaceans, amphipods, isopods and shrimps. Fish are also consumed but are of lesser importance in their diet (Wheeler, 1978).

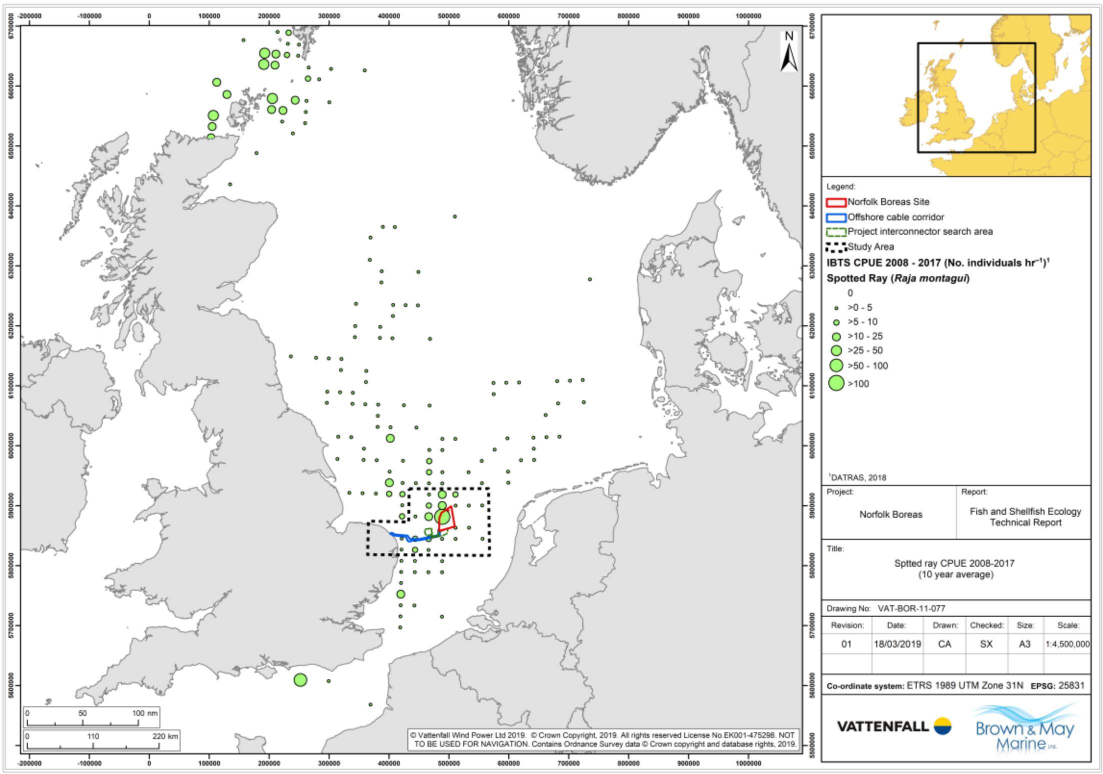


Figure 6.50 Average number (catch per standardised haul) of spotted ray from IBTS data (2008-2017) (Source: DATRAS, 2018)

6.2.3.3 Blonde ray

190. Blonde rays inhabit sandy seabed areas largely in coastal waters (Figure 6.51). They have been recorded living at depths of 100m, but are most abundant at approximately 40m (Wheeler, 1978). They are more common in inshore waters off southern and western England, than in the North Sea and Celtic Sea.

191. Blonde rays lay approximately 30 eggs cases per year, with a 7-month incubation period (Kay and Dipper, 2009). They predate on a wide range of crustaceans, worms and fish, particularly herring, sprat, pouting, sandeels and Dover sole (Wheeler, 1978).

192. Blonde rays are of less commercial importance in terms of overall landings in comparison to thornback rays. Nevertheless, Dutch beam trawl fleets often land blonde ray together with thornback ray and spotted ray (ICES, 2007). The species is classified as 'Near Threatened' in the IUCN Red List of threatened species (Table 6.10).

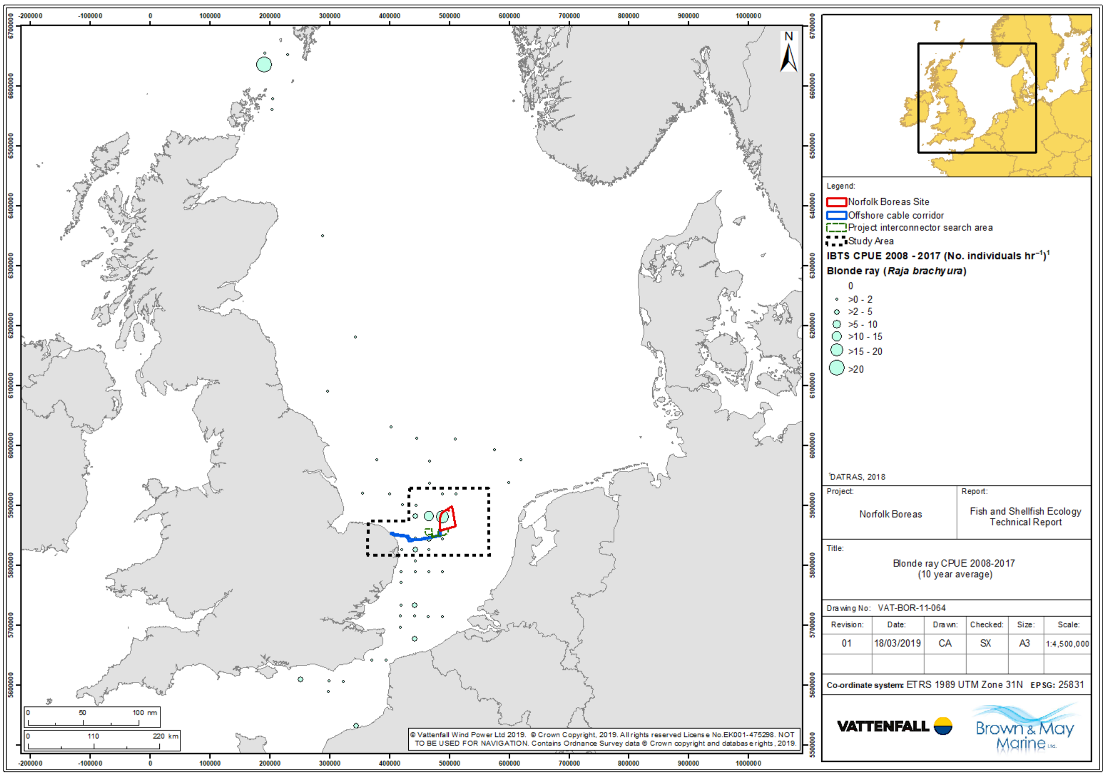


Figure 6.51 Average number (catch per standardised haul) of blonde ray from IBTS survey data (2007-2016) (Source: DATRAS)

6.2.3.4 Common skate complex

193. Traditionally, the common skate complex *(Dipturus intermedia* and *Dipturus flossada*) were amongst the most abundant ray species in the north-east Atlantic, with a broad distribution around the British Isles. Today however, they have largely disappeared from the Irish Sea, English Channel and the southern and Central North Sea. Individual specimens are reported occasionally from these areas, however, they are now only regularly observed off northern and north-western Scotland, Celtic Sea and along the edge of the continental shelf (more than 150m deep) (Dulvy et al., 2000).

194. The common skate complex is classified as 'Critically Endangered' by the IUCN Red List of Threatened Species. In addition, it is listed as a species of principal importance and in the OSPAR list of threatened and/or declining species (Table 6.10).

6.2.4 Elasmobranchs – Sharks

6.2.4.1 Small spotted catshark/lesser spotted dogfish

195. Small spotted catsharks, more commonly known as lesser spotted dogfish, inhabit rocky reefs and a range of mixed sediment. They possess a broad distribution around the British Isles, and are frequently found at depths of around 3 to 110m (Kay and Dipper, 2009). Within this extent however, their distribution is considered to be patchy (Ellis et al., 2005).

196. During the otter and beam trawl surveys conducted for East Anglia THREE and the former East Anglia FOUR (Table 6.2 and Table 6.3), lesser spotted dogfish was the elasmobranch species found in highest numbers.

197. Live egg cases are normally laid between November and July but can be found throughout the year. The species primarily feeds on crustaceans, including a variety of crab and shrimp species, molluscs and polychaete worms. Benthic fish species also form part of their diet (Wheeler, 1978).

6.2.4.2 Smoothhounds

198. Starry smoothhound *Mustelus asterias* and Smoothhound *Mustelus mustelus* live in depths of up to approximately 50m (Kay and Dipper, 2009). An indication of the distribution of these species across the North Sea is given in Figure 6.52 and Figure 6.53 based on the results of the IBTS. Smoothhounds have been occasionally recorded in the study area by the IBTS (Table 6.6), particularly in ICES rectangle 35F2.

199. Smoothhounds (*Mustelus* spp.) feed primarily on crustaceans, including hermit crabs, edible crabs, shore crabs, small lobsters and squat crabs (Wheeler, 1978).

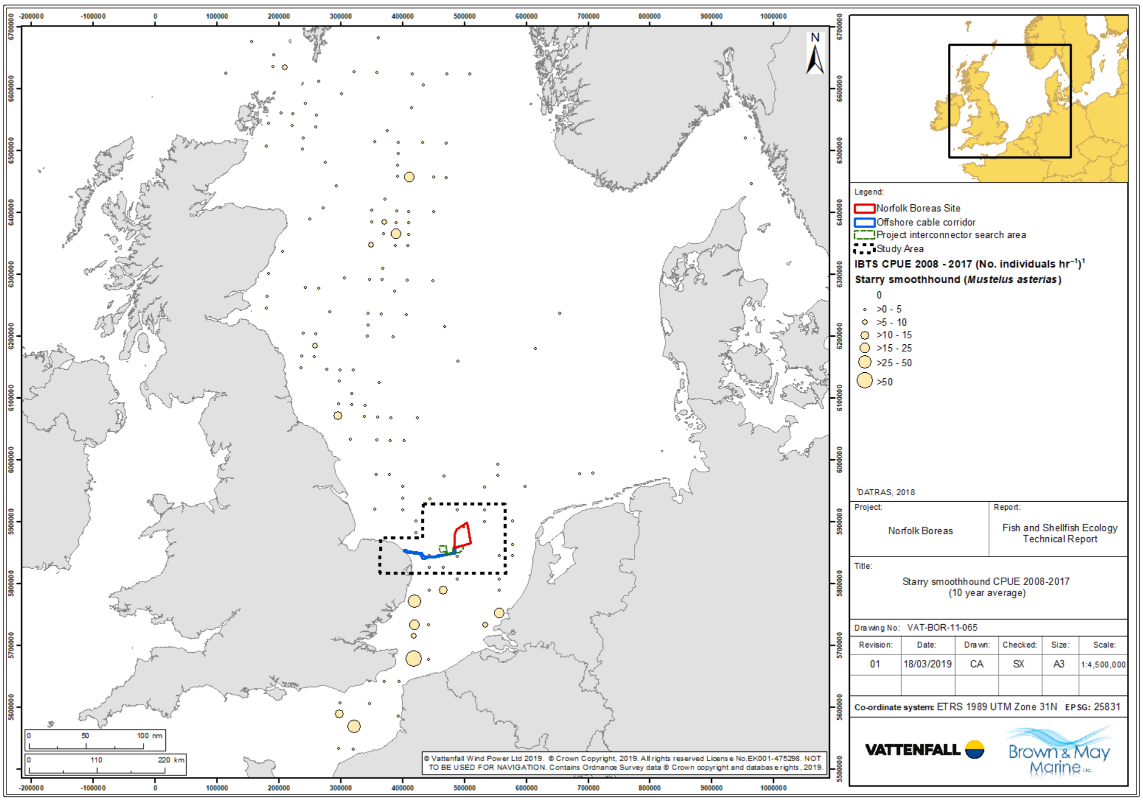


Figure 6.52 Average number (catch per standardised haul) of starry smoothhound from IBTS data (2008-2017) (Source: DATRAS, 2018)

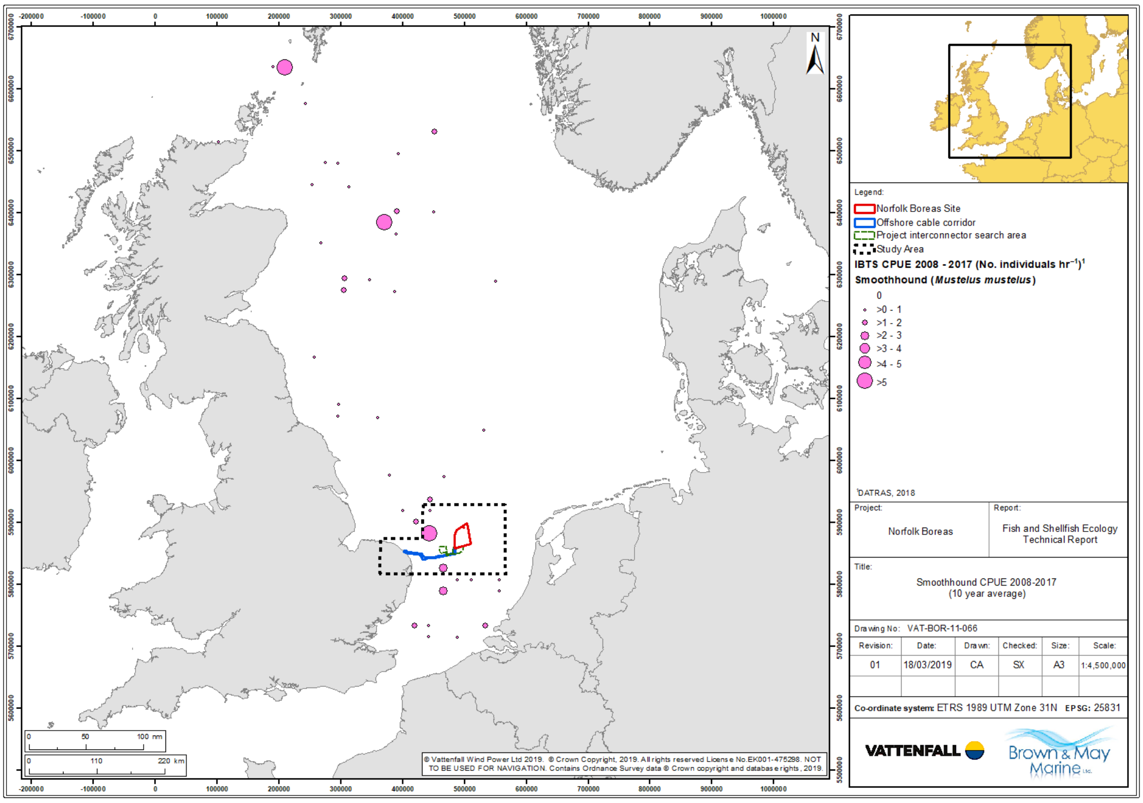


Figure 6.53 Average number (catch per standardised haul) of smoothhound from IBTS data (2008-2017) (Source: DATRAS, 2018)

6.2.4.3 Tope

200. Tope possess a geographic range of 70° N to 55° S and are frequently documented around the British Isles (Morato et al., 2003; Ellis et al., 2005). Tope usually show aggregation behaviour, thus forming schools of similarly sized individuals, often segregated by sex (Kay and Dipper, 2009). Larger individuals maybe occasionally solitary.

201. Tope were not recorded during survey undertaken in East Anglia THREE and the former East Anglia FOUR. The offshore project area, however, falls within defined low intensity nursery grounds for this species (Figure 6.49).

202. Tope are of conservation interest, being listed as a species of principal importance. The species is assessed as 'Vulnerable' in the IUCN Red List of Threatened Species (Table 6.10).

203. Tope consume a wide variety of fish, including pilchards, herring, anchovies, smelt, hake, cod, Dover sole, mackerel and gobies. They also prey on a number of crustacean and cephalopod species such as squid, octopus, crabs and whelk (Morato et al., 2003; Shark Trust, 2010).

6.2.4.4 Spurdog

204. Spurdog has a wide distribution range across the North Sea. However, highest densities are generally found in the Central and Northern North Sea (Figure 6.54) (Ellis et al., 2005).

205. Tagging studies have shown the existence of a single North East Atlantic stock. In spring, mature males migrate to the north and east of the British Isles, returning to the south-west in autumn. Immature females appear to be evenly distributed in all sea areas throughout the year, moving year by year in a clockwise direction around the British Isles. Fisheries data indicates that in winter and spring, adult females gather in the eastern Celtic Sea to spawn, and subsequently vacate rapidly in late spring (Pawson, 1995).

206. The decision to decrease quota allocations for spurdog in recent years has resulted in the substantial reduction in fisheries targeting this species (Clarke, 2009). ICES advice published in 2016 for spurdog in the Northeast Atlantic advised there should be no targeted fisheries on this stock in 2017 and 2018 (ICES, 2016a). Any possible provision for the landing of bycatch should be part of a management plan, including close monitoring of the stock and fisheries (ICES, 2016a).

207. Spurdog were not recorded during fish surveys undertaken for East Anglia THREE and the former East Anglia FOUR. Data from the CHARM consortium (Figure 6.55) indicate low probabily of presence of spurdog in the offshore project area.

208. Spurdog is of conservation importance, being listed as a species of principal importance, included in the OSPAR list of threatened and/or declining species and assessed as 'Vulnerable' in the IUCN Red List of Threatened Species (Table 6.10).

209. Spurdog are opportunistic feeders and consume a wide range of prey. Important fish species in spurdog diets include herring, sprat, small gadoids, sandeel, and mackerel. In addition, crustaceans (swimming crabs, hermit crabs and euphausids), squid and ctenophores form an important dietary component for this spsecies (Shark Trust, 2010).

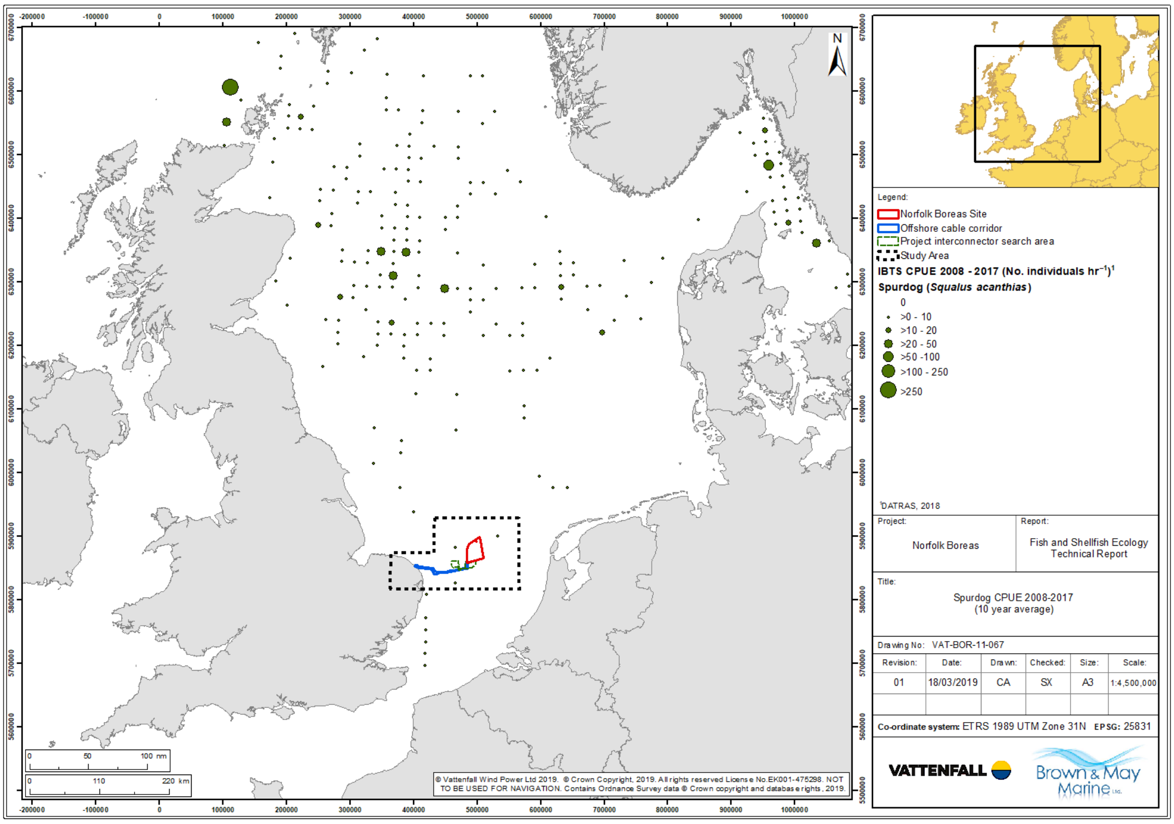


Figure 6.54 Average number (catch per standardised haul) of spurdog from IBTS data (2008-2017) (Source: DATRAS, 2018)

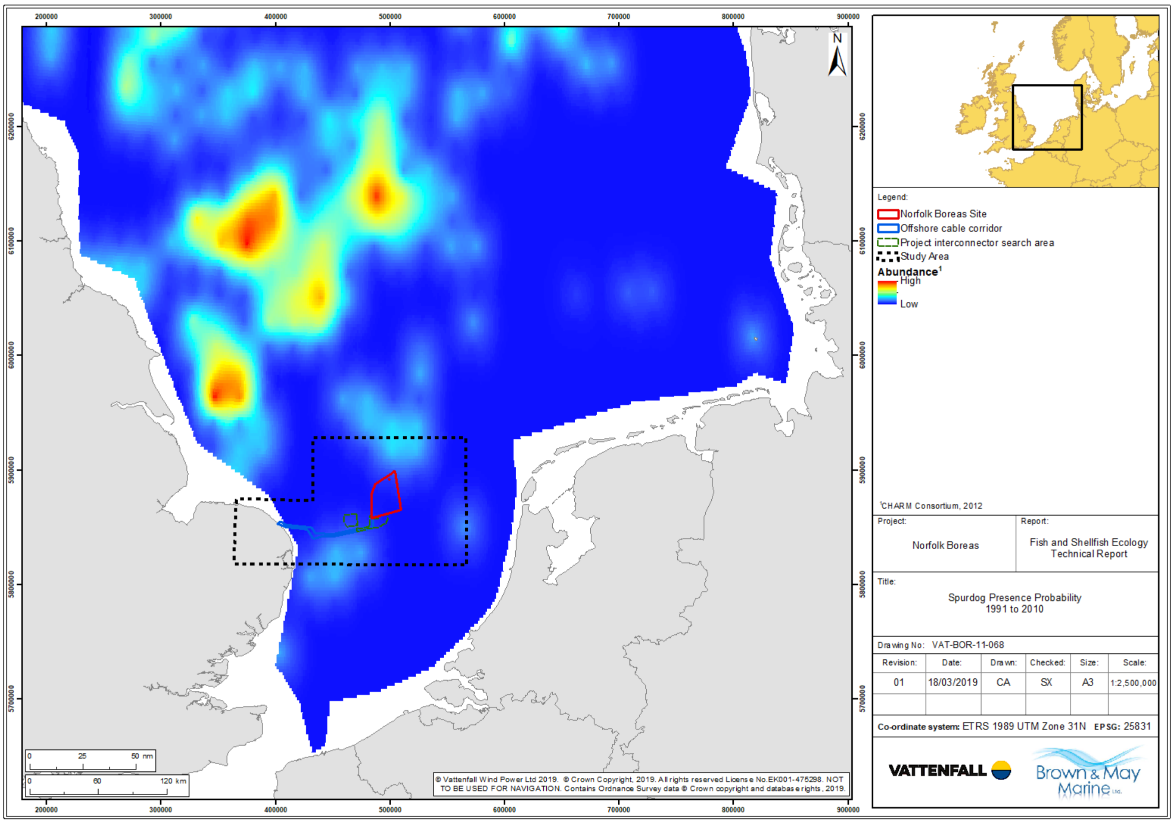


Figure 6.55 Spurdog presence probability in summer from IBTS data (1991 to 2010) (Source: CHARM Consortium, 2012)

6.2.4.5 Basking shark

210. As seasonal visitors to British waters, basking sharks *Cetorhinus maximus*, may occasionally transit the Southern North Sea between May and October. However, sightings in coastal waters off East Anglia are extremely rare (Bloomfield and Solandt, 2007), with greater prevalence off the south west of England, west Scotland and west of the Isle of Man.

211. Basking sharks are of conservation importance, being protected under UK legislation (Wildlife and Countryside Act, 1981) as well as the Bern Convention, listed as a species of principal importance and in the OSPAR list of threatened and/or declining species. In addition, they have been assessed as 'Vulnerable' on the IUCN Red List of Threatened Species (Table 6.10).

6.2.5 Diadromous Migratory Species

6.2.5.1 River and sea lamprey

212. River lamprey *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus* are parasitic anadromous migratory species. Figure 6.56 illustrates their distribution throughout the British Isles. Records of river and sea lamprey in East Anglian rivers are relatively scarce compared with other areas of the UK (Kelly and King, 2001).

213. Both species spawn in fresh water environments in spring or early summer. This is followed by a larval phase (ammocoetes) within appropriate silt beds in streams and rivers before migrating out to sea, to feed as adults (Laughton and Burns, 2003).

214. Ammocoetes can spend several years in freshwater silt beds, feeding on organic detritus before eventually transforming into adults from late summer onwards (Laughton and Burns, 2003). Transformation from larval to adult stage is characterised by the development of functional eyes and a fully formed sucker for a mouth (Waldman et al., 2008). After transformation, river and sea lampreys migrate to sea, where they use their suction cup-like mouth to attach to the skin of fish and feed (Waldman et al., 2008).

215. River lampreys generally inhabit coastal waters, estuaries and accessible rivers, feeding on a variety of fish including young herring, sprat and flounder. Following one to two years occupancy in an estuarine environment, river lampreys cease feeding in the autumn and move upstream between October and December (Waldman et al., 2008), returning to fresh water to spawn (Laughton and Burns, 2003).

216. Sea lamprey are recorded in low abundance in estuarine and inshore waters (Maitland and Herdson, 2009). In the open sea, adults attach to host species, becoming parastitic on a variety of marine mammals and fish, including basking shark and occasionally sperm whale (Maitland and Herdson, 2009), herring, salmon *Salmo salar*, cod, haddock *Melanogrammus aeglefinus* and sea bass (Kelly and King, 2001; ter Hofstede et al., 2008). Their distribution is therefore largely dictated by their hosts (Waldman et al., 2008). Homing behaviour is not apparent in this species (Waldman et al., 2008) and unlike salmonids and shads, lampreys do not have specific river populations (ter Hofstede et al., 2008). The rarity of capture in coastal and estuarine waters suggests that marine lampreys are solitary feeders and widely dispersed at sea. It is possible that sea lamprey often feed in deeper offshore waters as they have been caught at considerable depths (4,100m water depth) (Moore et al., 2003).

217. River and sea lamprey are both of conservation interest, being listed as species of principal importance and protected under the Habitats Directive (Table 6.9).

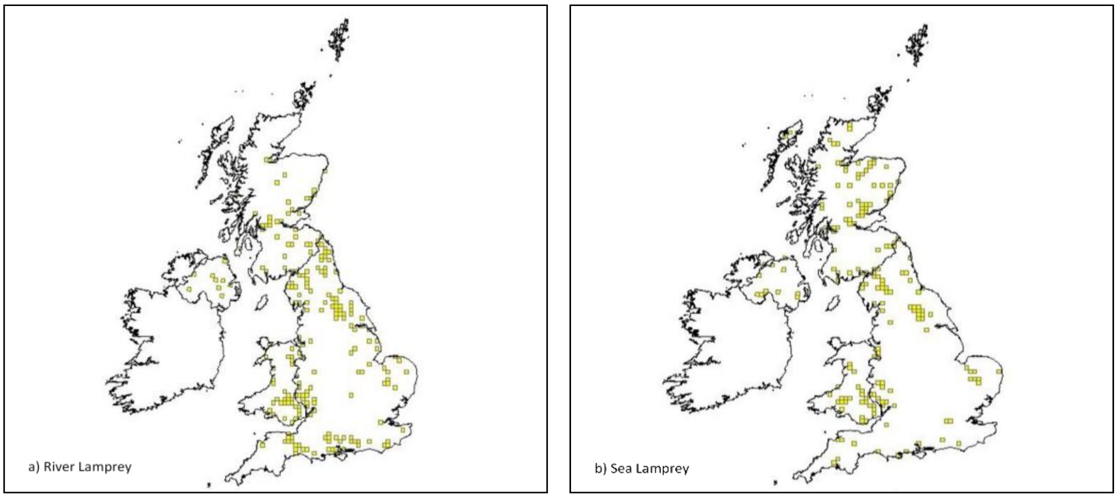


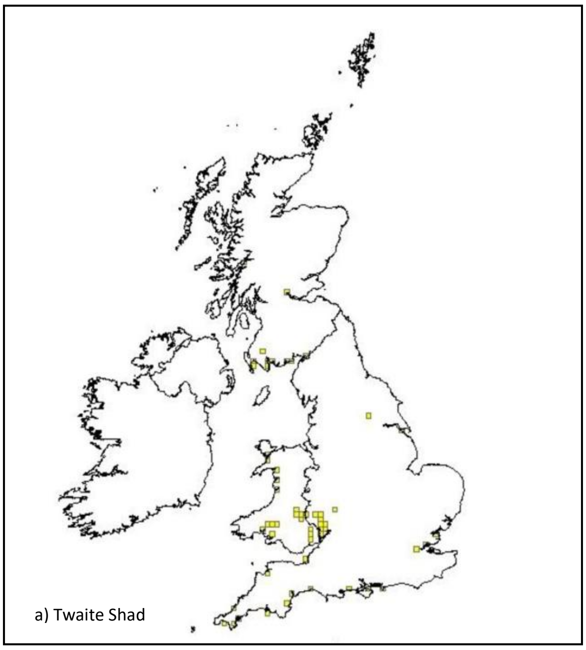
Figure 6.56 The distribution of river lamprey and sea lamprey in the UK (records 1990 to 2011) (JNCC, 2012)

6.2.5.2 Allis and twaite shad

218. Allis shad and twaite shad are anadromous migratory species which school in shallow coastal waters and estuaries at depths between 10 and 20m before entering rivers to spawn. Adults migrate from the sea to fresh water in spring and early summer (April to June), travelling to higher, middle watercourses of rivers to spawn from mid-May to mid-July (Maitland and Hatton-Ellis, 2003; Acolas et al., 2004; Patberg et al., 2005). Following spawning, adults return to the sea while juveniles remain in rivers over the summer months prior to their migration downstream in the autumn.

219. The distribution of allis shad and twaite shad is presented in Figure 6.57.

220. Spawning stocks of the twaite shad are only found in a few rivers in and around the southern Welsh border (JNCC, 2016). In contrast to twaite shad, the majority of allis shad only spawn once and then, after spawning, the adults die (ter Hofstede et al., 2008). With the exception of a recently confirmed spawning site in the Tamar Estuary (MMO, 2017), there are not known spawning sites for allis shad in the UK, although both sub-adults and sexually mature adults are still regularly found around the UK coast (Maitland and Lyle, 2005).



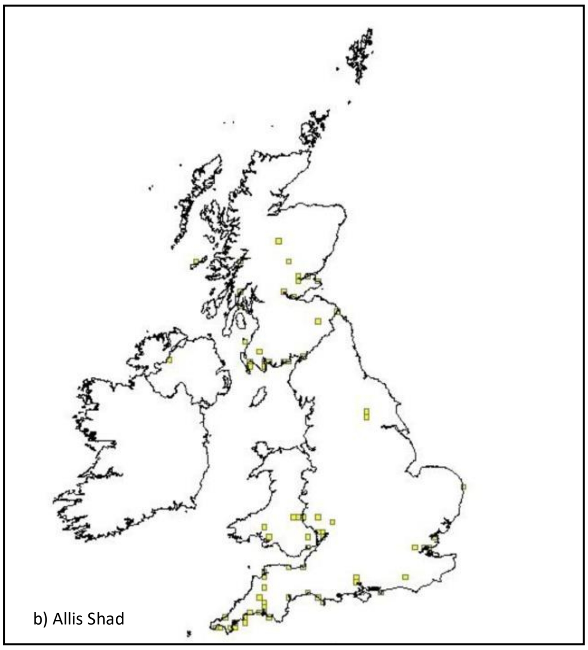


Figure 6.57 The distribution of twaite shad and allis shad in the UK (records 1990 to 2011) (JNCC, 2012)

6.2.5.3 Atlantic salmon

221. The life cycle of Atlantic salmon comprises stages in both fresh and sea water environments. Spawning occurs in rivers but individuals spend most of their life at sea.

222. Salmon return to their natal rivers after a period of up to five years at sea, although the majority spend one to three years at sea (JNCC, 2013b). Young salmon “smolts” migrate downstream from spawning areas to enter the sea. They spend one to three years feeding at sea and then return to their home rivers to spawn (JNCC, 2013b). There is scarcity of information on salmon life history at sea, although mark-recapture and salmon tagging programmes have yielded some information on migration routes.

223. Salmon are widely distributed in EU waters and the UK’s salmon population comprises a significant proportion of the total European stock. Scottish rivers are the most important in terms of spawning sites. There are 79 rivers in England and Wales that support salmon populations. The East Anglian region with rivers of low gradient do not support important salmon populations (NASCO, 2009). No rivers south of the Esk in Yorkshire or east of the Itchen in Hampshire are classified as salmon rivers (Salmon Atlas, 2011).

224. The distribution of Atlantic salmon around the UK is illustrated in Figure 6.58,

225. Salmon have not been recorded in the study area during the IBTS (2008-2017), although there have been rare occurrences recorded in MMO landings data from rectangle 33F2, located directly to the south of Norfolk Boreas (East Anglia Offshore Wind ZEA, 2012). Salmon may therefore occasionally transit the offshore project area, but the project is not considered to be located in important migratory pathways for salmon.

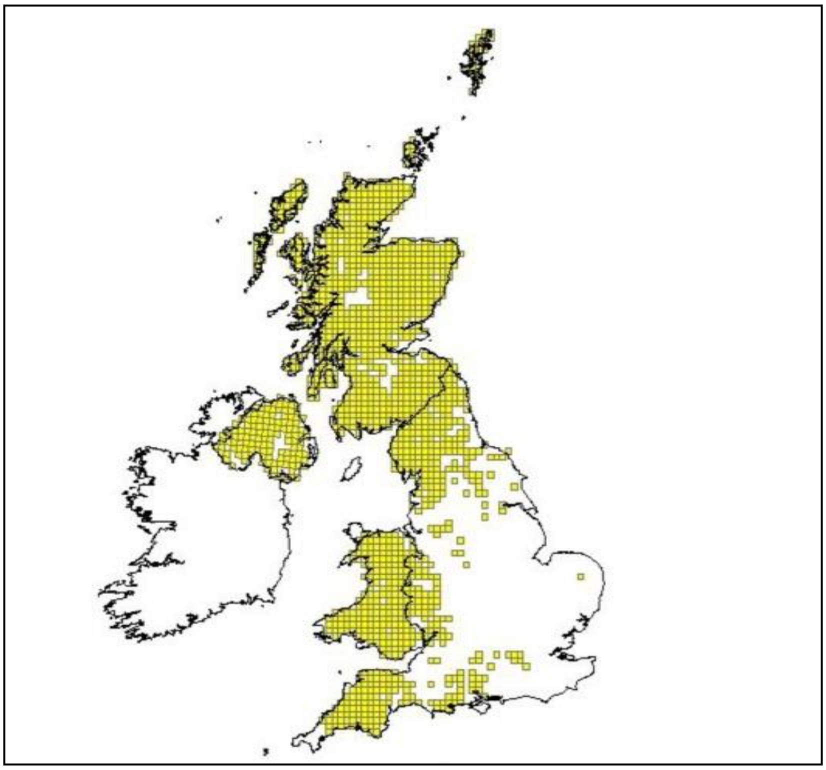


Figure 6.58 The distribution of Atlantic salmon in the UK (records 1990-2011) (JNCC, 2012)

6.2.5.4 Sea trout

226. Sea trout are the migratory counterpart of the common and widely distributed brown trout. Their life cycle, similar to that of Atlantic salmon, includes juvenile stages in freshwater, migration out to sea (as smolts), maturation at sea, and a return migration to freshwater for spawning (Pawson, 2013).

227. The East Anglian coast is thought to be a feeding area for sea trout post-smolts from rivers in the north east coast of England. Populations are also present in East Anglian rivers such as the Glaven, Wensum and Yare (Tingley et al., 1997).

228. Sea trout were once targeted by local fisheries off Norfolk but underwent decline from the 1950s (Pawson, 2013). Sea trout fisheries are being phased out given brown/sea trout are listed as a species of principal importance (Table 6.9).

229. Projects have been implemented in recent years to restore and improve access for migratory trout across a number of Anglian rivers (Everard, 2010). Despite sea trout

records Anglian rivers, sea trout generally found off the East Anglian coast are thought to originate from the rivers in north-east England and south-east Scotland such as the Esk, Wear, Coquet, Tyne and Tweed (Pawson, 2013).

6.2.5.5 Smelt

230. Smelt are widespread throughout the North Atlantic and European waters but populations are localised in the UK waters being more common in estuaries. As with salmon and sea trout, smelt move from the sea into rivers to spawn. Adult smelt shoal in estuaries during the winter and enter rivers in early spring to spawn (February to April). After spawning the adults return to sea whilst the juveniles remain in the estuary for the remainder of the summer. Eggs are laid in estuaries on gravel, sand and on weed and the young remain in estuaries for several years.

231. Records for the species have been made from a number of English rivers with small populations noted in the Broads, Great Yarmouth, Lowestoft, Alde, Deben, Orwell and Stour, and larger populations recorded in the Blackwater, Crouch, and Thames and catchment rivers (Maitland, 2003b).

6.2.5.6 European eel

232. European eel is a catadromous migratory species found all around the British Isles. Eels carry out long-distance migrations (over 5,000 km) from the coasts of Europe and are thought to spawn in the Sargasso Sea although evidence for this is limited (Schmidt, cited in van Ginneken and Maes, 2005; Aarestrup et al. 2009). The newly hatched larvae are transported back towards the European coast by prevailing currents and metamorphose into glass eels as they arrive on the continental shelf, and subsequently become pigmented ‘elvers’ (Aarestrup et al. 2009; Potter and Dare, 2003).

233. Adults are thought to migrate to sea from August to December. Glass eels arrive at coastal waters from February to March and migrate upstream as elvers from May until September (Environment Agency, 2011).

234. European eel are widely distributed throughout the Anglian region. The adult eel fishery was relatively strong in the past, although few records were kept. A commercial glass eel fishery has never been in operation (DEFRA, 2010).

6.2.6 Shellfish Species

6.2.6.1 Edible crab

235. Edible crabs are found on a range of intertidal and subtidal habitats, on bedrock, under boulders, mixed coarse grounds and offshore in muddy sand (Neal and Wilson, 2008). They are commercially important in the offshore cable corridor, particularly in rectangle 34F1, where brown crab represents 21.81% of the total catch (average 2007-2016) (Table 6.7 and Figure 6.3).

236. Edible crabs undertake wide-ranging migrations over considerable distances to offshore overwintering grounds where eggs are hatched (Edwards, 1979; Bennett, 1995). The findings of tagging studies suggest that mature females undertake long-distance migrations whilst the movements of males and immature females is more random, in local areas (Edwards, 1979; Bennett, 1995). The results of suture tagging experiments carried out off the Norfolk coast (Edwards, 1979) suggest a northerly long-distance movement of mature females.

237. The movement of female crabs is related to spawning activity (Cefas, 2011a). After pairing and mating (July to September) and subsequent spawning (October to December), egg bearing ("berried") females move to offshore over-wintering grounds and are largely inactive over the brooding period until their eggs hatch in the spring and summer. Adult females then return their migration inshore during spring and summer for pairing and mating to commence again. The hatched larvae remains in the plankton offshore prior to settlement on the sea bed, following which young crabs are then considered to migrate inshore (Neal and Wilson, 2008). Studies carried out in the English Channel by Thompson et al. (1995) suggest that although berried female crabs may prefer to incubate their eggs whilst overwintering in hollows of sand and gravel, they are not necessarily confined to such areas, and eggs may be hatched over a wide variety of sediment types from fine sands to pebbles. Mating activity peaks in summer following female moulting, with spawning occurring late autumn or winter in offshore areas (Cefas, 2011a).

238. The probability of edible crab presence in the offshore project area is illustrated in Figure 6.59. As show, the areas in the vicinity of the Norfolk Boreas site and project interconnector search area record very low probabily of presence, with low to medium probabilities recorded in the offshore cable corridor.

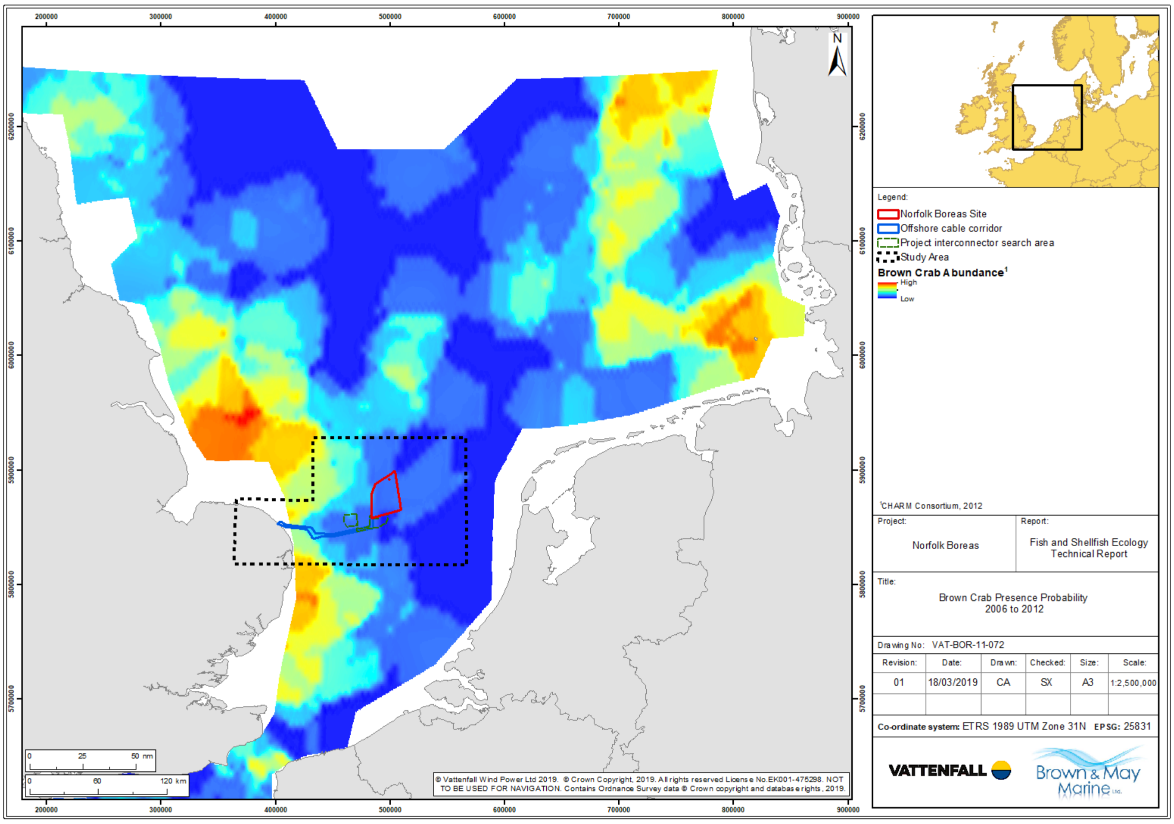


Figure 6.59 Edible crab presence probability. Data from IBTS (January) and CGFS (October) 2006-2012 (Source: CHARM consortium, 2012)

6.2.6.2 European lobster

239. European lobsters have a wide distribution along the UK and European coasts (Bennett et al., 2006). Lobsters occupy a range of habitats from rocky grounds, soft sediments and shelf areas from below MLW to depths of 150m (Buchholz et al., 2012; Bennett and Nichols, 2007).

240. Unlike edible crabs, lobsters of both sexes are considered sedentary and have not been found to undertake extensive migrations. However, localised random inshore/offshore movements and longshore migration may occur, driven by local competition for food or requirements to move to a different habitat throughout their different life-stages (Cefas, 2011b; Pawson, 1995). Tagging experiments carried out in the south coast of England found that 95% of recaptured lobsters moved less than 3.8km from their original position over periods of 862 days (Smith et al., 2001). Some individuals however moved distances up to 45km with little difference between female and male movements. Similarly, tagging experiments using hatchery reared lobsters released into the wild suggest strong site fidelity, with most recaptures being recorded within six kilometres of release sites (Bannister et al., 1994).

241. Berried females generally appear from September to December in areas where lobsters are normally present, with eggs carried externally on females until

April/May. As they do not carry out extensive migrations, hatching normally takes place in the same grounds (in spring and early summer) (Pawson, 1995). Nursery grounds are thought to occur on rocky grounds in coastal waters (Pawson, 1995) and juveniles are thought to inhabit crevices and be capable of burrowing into soft sediment (Bennett and Nichols, 2007).

242. As shown in Table 6.7 commercial landings of lobster are highest in the inshore section of offshore cable corridor (rectangle 34F1), contributing 5.14% to landings weights in 34F1. However, lobster landings weights are low in the rest of rectangles within the study area ICES rectangles (34F2, 34F3, 35F2 and 35F3).

243. As opportunistic scavengers, their diet consists of small crustaceans, molluscs and polychaetes (Cefas, 2011b).

6.2.6.3 Whelk

244. The common whelk is frequently found off all British coasts on a range of hard and soft subtidal substrates and occasionally in intertidal fringes (Ager et al., 2008; Lawler and Vause, 2009). They show aggregating behaviour and the distribution of juveniles tends to be limited to areas close to the adult stock (Lockwood, 2005). Breeding occurs by copulation in late autumn, with demersal egg-cases laid in masses from Novemberto April (Lawler and Vause, 2009). Juveniles hatch as a fully formed whelk during February and March (Smith and Thatje, 2013; Hancock, 1967).

245. As shown in Table 6.7 the whelk fishery is of importance in rectangle 34F1, where the inshore section of the offshore cable corridor is located.

246. The probability of presence of whelks in the offshore project area is illustrated in Figure 6.60. As show, whelks are anticipated to be present in low numbers in Norfolk Boreas site, with increasing increased probability of presence (medium-high) across the offshore cable corridor.

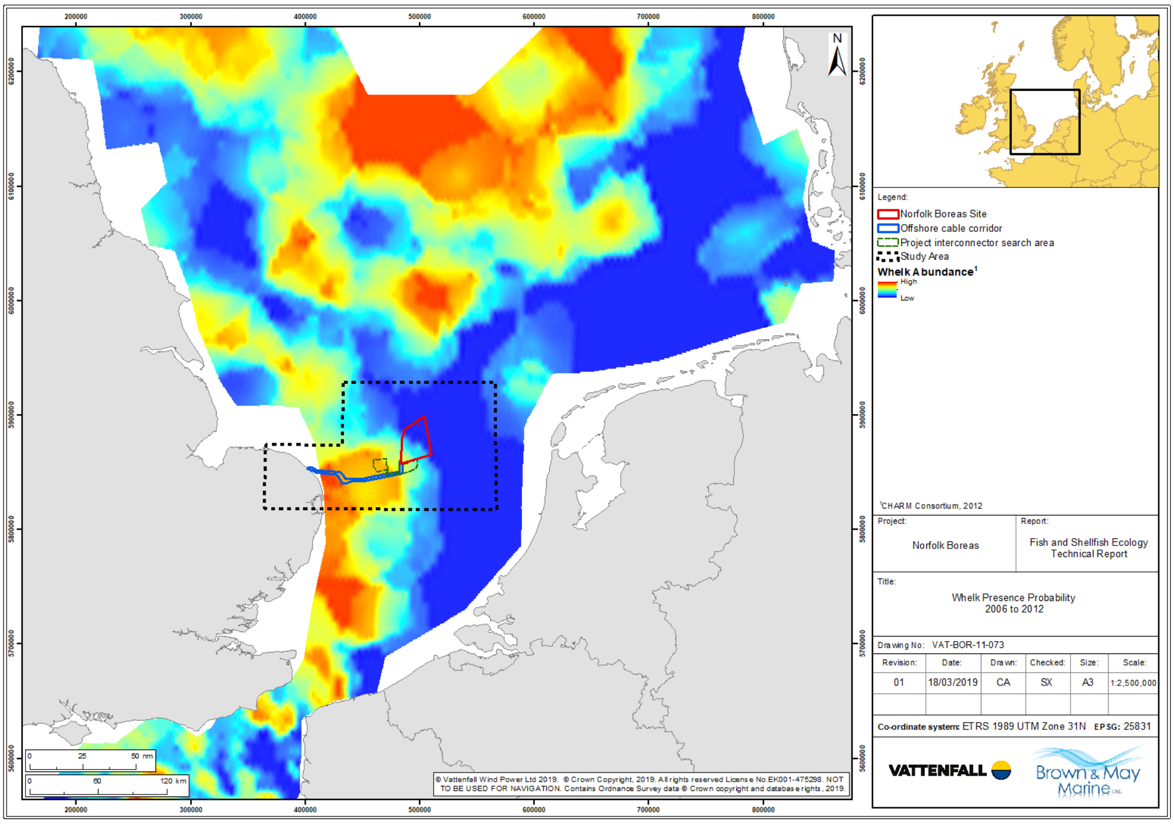


Figure 6.60 Whelk presence probability. Data from IBTS (January) and CGFS (October) 2006-2012 (Source: CHARM consortium, 2012)

6.2.6.4 Shrimp

247. Brown shrimp is one of the most abundant benthic species found in shallow soft bottom areas along the European coast. Due to their abundance they are an important food sources for other organisms including fish, crustaceans and birds (Campos et al., 2010).

248. Pink shrimp *Pandulus montagui* is typically associated with hard substrates including *Sabellaria spinulosa* reef (Warren and Sheldon, 1967) but may also occur over sand, mud and gravel substrates. In the North Sea, pink shrimp migrate to deeper offshore waters for spawning during October and November (Ruiz, 2008). Eggs are laid from November to February and hatching occurs in April/May (Ruiz, 2008).

249. As suggested by landings data, shrimps do not support significant fisheries in the study area (Table 6.7). In the vicinity of the project, the principal fisheries for both brown and pink shrimp take place around the Wash.

250. Shrimps principally feed on small polycheates, hydroids, copepods and other small invertebrates (Ruiz, 2008).

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