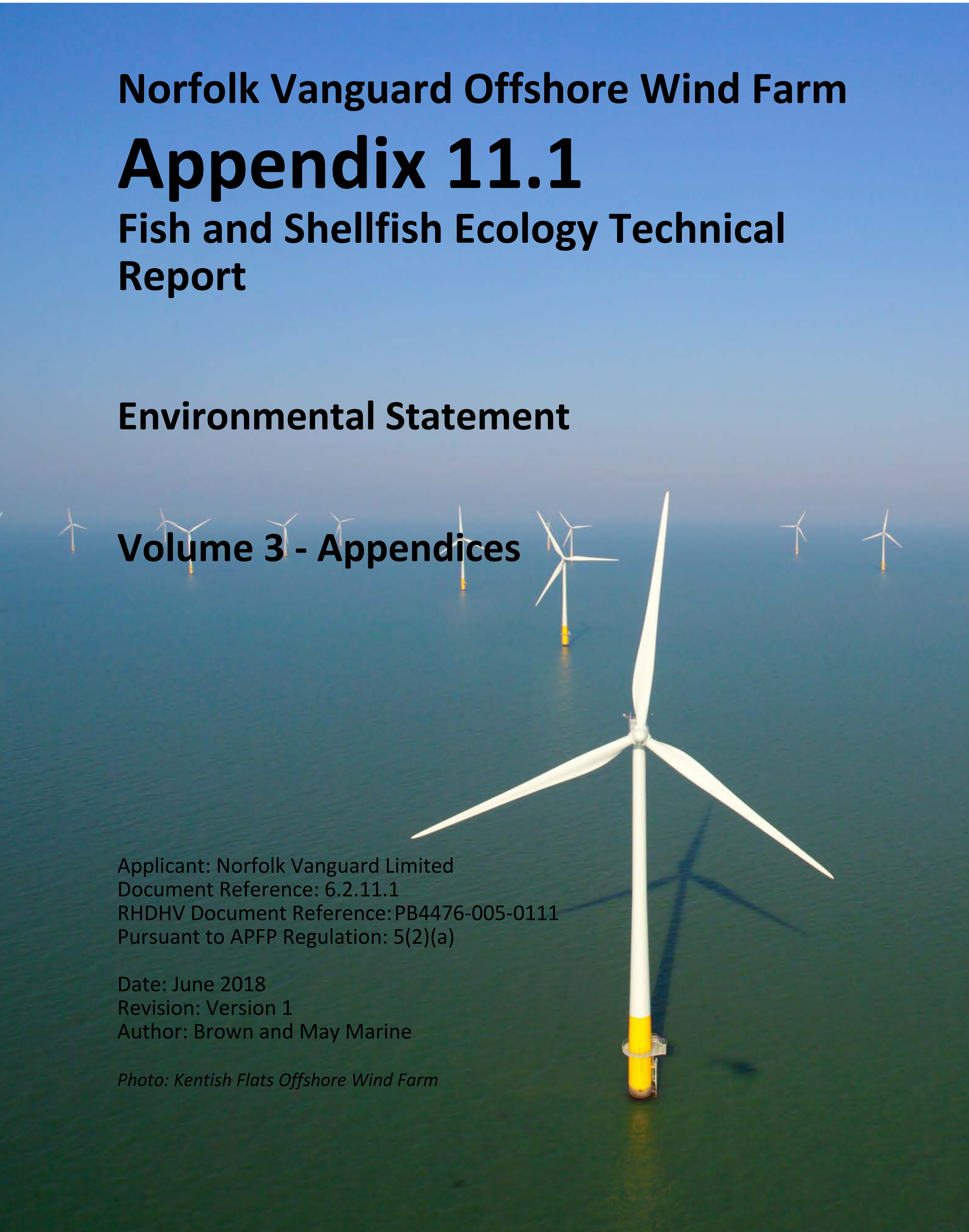
Norfolk Vanguard Offshore Wind Farm

Appendix 11.1

Fish and Shellfish Ecology Technical Report

Environmental Statement

Volume 3 - Appendices



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For and on behalf of Norfolk Vanguard Limited
Approved by: Ruari Lean, Rebecca Sherwood
Signed: [redacted]
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Norfolk Vanguard Offshore Wind Farm
Environmental Statement
Fish and Shellfish Ecology Technical Report

June 2018

Brown & May Marine Ltd.

Norfolk Vanguard Offshore Wind Farm Environmental Statement

Fish and Shellfish Ecology Technical Report

Undertaken by
Brown & May Marine Limited

Ref	Rev.	Author	Date	Checked (BMM)	Approved (Client)
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1.0 Introduction

1. The following document has been prepared by Brown and May Marine Limited (BMM) to describe the fish and shellfish ecology baseline in areas relevant to the proposed Norfolk Vanguard development ("the Project"). The areas of the Project relevant to this assessment are the Offshore Wind Farm (OWF) sites (Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West)), and the offshore cable corridor. Collectively these Project components are referred to as 'the offshore project area'.

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

3. The data sources which will be used to establish the current fish and shellfish ecology baseline environment and inform the subsequent assessment of impacts are described and key ecological receptors and potential impacts for assessment identified.

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

5. The approach outlined in this method statement also takes account of previous correspondence with the Marine Management Organisation (MMO) and Cefas, including:

- Vattenfall introduction meeting with the MMO in January 2016;
- Email and telephone correspondence with the MMO and Cefas in April 2016 regarding advice on fisheries survey requirements (Appendix 1).

2.0 Guidance

2.1 Scoping opinion and the Evidence Plan Process (EPP)

6. A Scoping Report for the Norfolk Vanguard EIA was submitted to the Planning Inspectorate on the 3rd October 2016. The recommendations and comments from the scoping opinion have been used to inform the EPP and the structure and content of this fish and shellfish baseline characterisation. Email correspondence with the MMO and Cefas regarding advice on fisheries is provided in Appendix 1.

2.2 Other guidance sources

7. The assessment of potential impacts on fish and shellfish ecology has been undertaken with specific reference to the relevant National Policy Statement (NPS). Those relevant to Norfolk Vanguard are as follows:

- Overarching NPS for Energy (EN-1) (Department of Energy and Climate Change (DECC)); and

- NPS for Renewable Energy Infrastructure (EN-3), July 2011.

8. The specific NPS (EN-3) assessment guidance relevant to fish and shellfish ecology is summarised in Table 11. 1.

Table 11. 1 NPS Assessment Requirements

NPS Requirement	NPS Reference
There is the potential for the construction and decommissioning phases, including activities occurring both above and below the sea bed, to interact with seabed sediments and therefore have the potential to impact fish communities, migration routes, spawning activities and nursery areas of particular species. In addition, there are potential noise impacts, which could affect fish during construction and decommissioning and to a lesser extent during operation.	EN-3 section 2.6.73
The applicant should identify fish species that are the most likely receptors of impacts with respect to: • spawning grounds; • nursery grounds; • feeding grounds; • over-wintering areas for crustaceans; and • migration routes.	EN-3 section 2.6.74
Where it is proposed that mitigation measures of the type set out in paragraph 2.6.76 below are applied to offshore export cables to reduce electromagnetic fields (EMF) the residual effects of EMF on sensitive species from cable infrastructure during operation are not likely to be significant. Once installed, operational EMF impacts are unlikely to be of sufficient range or strength to create a barrier to fish movement	EN-3 section 2.6.75
EMF during operation may be mitigated by use of armoured cable for interarray and export cables that should be buried at a sufficient depth. Some research has shown that where cables are buried at depths greater than 1.5m below the sea bed impacts are likely to be negligible. However, sufficient depth to mitigate impacts will depend on the geology of the sea bed.	EN-3 section 2.6.76
During construction, 24 hour working practices may be employed so that the overall construction programme and the potential for impacts to fish communities is reduced in overall time.	EN-3 section 2.6.77
The construction and operation of offshore wind farms can have both positive and negative effects on fish and shellfish stocks.	EN-3 section 2.6.122
Effects of offshore wind farms can include temporary disturbance during the construction phase (including underwater noise) and ongoing disturbance during the operational phase and direct loss of habitat. Adverse effects can be on spawning, overwintering, nursery and feeding grounds and migratory pathways in the marine area. However, the presence of wind turbines can also have positive benefits to ecology and biodiversity.	EN-3 section 2.6.63
Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed offshore wind farm and in accordance with the appropriate policy for offshore wind farm EIAs (EN-3; Paragraph 2.6.64).	EN-3 section 2.6.64

NPS Requirement	NPS Reference
Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate	EN-3 section 2.6.65
Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational offshore wind farm should be referred to where appropriate	EN-3 section 2.6.66
The assessment should include the potential for the scheme to have both positive and negative impacts on marine ecology and biodiversity	EN-3 section 2.6.67
Ecological monitoring is likely to be appropriate during the construction and operational phases to identify the actual impact so that, where appropriate, adverse effects can then be mitigated and to enable further useful information to be published relevant to future projects	EN-3 section 2.6.71

9. In addition to the NPS guidance, the following documents have been used to inform the assessment of potential impacts of Norfolk Vanguard on fish and shellfish ecology:

- 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;
- Centre for Environment, Fisheries and Aquaculture Science (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);
- Sound Exposure Guidelines for Fishes and Sea Turtles Monitoring (Popper et al., 2014)
- Renewable UK (2013) Cumulative impact assessment guidelines, guiding principles for cumulative impacts assessments in offshore wind farms;
- 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);
- Strategic Review of Offshore Windfarm Monitoring Data Associated with FEPA Licence Conditions (Cefas, 2010a);
- Blyth-Skyrme (2010) Options and opportunities for marine fisheries mitigation associated with wind farms. Final report for Collaborative Offshore Wind Research into the Environment contract FISHMITIG09. COWRIE Ltd, London; and
- Norfolk Vanguard Scoping Opinion (The Planning Inspectorate, 2016).

2.3 Data Sources

10. Key sources of data and information used to characterise the fish and shellfish ecology baseline in the study area are outlined below and in Table 11. 2:

- Results of adult and juvenile fish site specific surveys for NV East (formerly East Anglia FOUR) and East Anglia THREE in 2013;
- Results of sites specific epibenthic characterisation surveys carried out in NV East (formerly East Anglia FOUR) and East Anglia THREE in 2013;
- MMO Landings weights data by species and ICES rectangle for the period 2006 to 2015;
- ICES International Herring Larvae Survey (IHLS) results (2007-2016);
- International Bottom Trawl Survey (IBTS) results for the period 2007 to 2016.
- Channel Habitat Atlas for Marine Resource Management (CHARM) (Carpentier et al., 2009); and
- North Sea Ichthyoplankton survey data (van Damme et al., 2011).

Table 11. 2 Data Sources

Data	Year	Coverage	Notes
Results of adult and juvenile fish site specific characterisation surveys for NV East (formerly East Anglia FOUR) and East Anglia THREE	2013	ICES Rectangles 34F2 and 34F3	Fish and shellfish characterisation surveys using otter and beam trawls were undertaken within NV East (formerly East Anglia FOUR) and East Anglia THREE to provide information on fish and shellfish assemblages. The methodologies of these surveys were designed and agreed in consultation with Cefas.
Results of the site specific benthic characterisation survey (Fugro/ EMU 2013) for East Anglia THREE and NV East (Formerly East Anglia FOUR)	2013	ICES Rectangles 33F2 and 33F1	Epibenthic surveys carried out to characterise the epibenthic community, including fish and shellfish. These were carried out using a 2m scientific beam trawl.
MMO landings data (weight and value) by species (MMO, 2016)	2007-2016	ICES Rectangles 34F1, 34F2 and 34F3	Provide an indication of the principal species targeted within a given area. Not suitable for assessments of abundance and distribution of species.
International Bottom Trawl Survey (IBTS) data	2007-2016	ICES Rectangles 34F1, 34F2 and 34F3	IBTS data has been accessed via the ICES Data Portal (DATRAS, the Database of Trawl Surveys: http://datras.ices.dk). Data presented 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 2007 and 2016.

Data	Year	Coverage	Notes
ICES International Herring Larvae Survey (IHLS) data	2007-2016	Eastern and northern North Sea	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 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 between 2007 and 2016.
Channel Habitat Atlas for Marine Resource Management (CHARM) (Carpentier *et al.,* 2009);	2003 -2008	The eastern English Channel	CHARM is a collaborative Franco-British project (Interreg IIIA) initiated to support decision-making for the management of essential fish habitats (http://www.charm-project.org/en/). 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 species abundance equates to the number of eggs per 20m3 following log-transformation (log10(x+1)).
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) (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. UK territorial waters and the remainder of the North sea	Coull *et al.* (1998) and Ellis *et al.* (2010; 2012) are frequently considered the standard references to be used to provide broad scale overviews of the potential spatial extent of spawning grounds and the relative intensity and duration of spawning. Both Coull *et al.* (1998) and Ellis *et al.* (2010; 2012) are based on a compilation of a variety of data sources. In the case of Coull *et al.* (1998), many of the conclusions are based on historic research and therefore may not take account in recent changes in fish distributions and spawning behaviour. Ellis *et al.* (2010; 2012) is also constrained by the wide scale distribution of the sampling sites used for the annual international larval survey data, resulting in broad scale grids of spawning and nursery grounds. The spatial extent of the spawning grounds and the duration of spawning periods given in these publications are therefore likely to represent the maximum theoretical extent of the areas and periods within which spawning by the species is considered. It should therefore be possible that spawning grounds are likely to be smaller with shorter spawning periods

Data	Year	Coverage	Notes
			or in certain cases no longer be active spawning grounds.
North Sea Ichthyoplankton survey data (van Damme *et al.,* 2011)	April 2010 – March 2011	Southern North Sea	This report presents the results of twelve monthly ichthyoplankton surveys, on the temporal and spatial distribution of fish eggs and larvae in the Southern North Sea.

11. In addition to the data sources described above, the following resources have been accessed to inform the assessment:

- Cefas publications;
- Institute for Marine Resources and Ecosystem Studies (IMARES) publications;
- Collaborative Offshore Wind Research into the Environment (COWRIE) reports;
- International Council for the Exploration of the Sea (ICES) publications;
- Results of monitoring programmes undertaken in operational wind farms in the UK and other European countries; and
- Other relevant peer-review publications and stock assessments.

2.4 Data limitations and sensitivities

2.4.1 Spawning and nursery grounds

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

13. The spatial extent of the spawning grounds and the duration of spawning periods indicated in these studies are therefore likely to represent the maximum theoretical extent of the areas and periods within which spawning by the species is considered. Spawning grounds may therefore be smaller in extent and display shorter spawning periods. In some cases, spawning grounds may no longer be active.

2.4.2 Commercial landings data

14. Landings data derived from UK registered vessels by species and ICES rectangle have been derived from catch statistics provided by the MMO for the years 2007 to 2016.

It is acknowledged that Norfolk Vanguard supports fishing by both UK and non-UK registered vessels, principally Dutch and Belgian vessels.

15. It is important to consider that commercial fisheries data does not necessarily provide an accurate picture of community or species composition, relative abundance or biomass. This is because the species and associated quantities available for landing are determined through the system of Total Allowable Catches (TACs) and quotas (Appendix 14.1 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 effort.

16. Furthermore, vessels hold quotas for certain species and therefore focus on targeting these species whilst other species which cannot be landed due to a lack of quota are discarded at sea. Stock conservation measures, such as seasonal closures, may also influence the pattern of landings, and the absence of a species from statistics does not indicate that it is not present in a given sea area. In addition, the presence and distribution of fish and shellfish species are dependent on a number of biological and environmental factors, which interact in direct and indirect ways, and are subject to temporal and spatial seasonal and annual variations. Consequently, commercial landings data cannot be considered reflective of species composition in a given area. MMO data has therefore been used to provide an indication only of the commercial species present by ICES rectangle to identify those species to be taken forward for the assessment of impacts.

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

2.4.3.1 International Bottom Trawl Survey (IBTS)

17. IBTS data has been accessed via the ICES Data Portal (DATRAS, the Database of Trawl Surveys: http://datras.ices.dk). The DATRAS on-line 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[1] trawl 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 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 2007 and 2016.

2.4.3.2 International Herring Larval Survey (IHLS)

18. 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 refer to the number of herring larvae in the smallest reported size category (<11mm total length) caught per square metre at

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

each site sampled per fortnight in the 3rd quarter in each year between 2007 and 2016 (ICES, 2013).

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

19. 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 species abundance equates to the number of eggs per 20 m^3 following log-transformation (log10(x+1)).

2.4.4 Site specific surveys

20. Data derived from otter and beam trawl surveys carried out as part of the fisheries assessment for the East Anglia THREE EIA and the draft PEI for the former East Anglia FOUR projects, have been used to inform this characterisation report. There have been no further specific surveys carried out with respect to the Norfolk Vanguard EIA. This approach has been agreed in consultation with Cefas and the MMO (see Appendix 1). 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. The presence and abundance of some species/species groups may therefore be misrepresented in the survey results (i.e. shellfish species, clupeids and diadromous migratory fish).

2.4.5 Knowledge Gaps

21. It is acknowledged that gaps exist in understanding the distribution, behaviour and ecology of particular fish and shellfish species. This is predominantly apparent for a number of migratory species some of which are of conservation importance (e.g. lampreys and salmonids). Little is currently known about their migration routes and how they utilise the sea areas encompassed by the Norfolk Vanguard footprint.

3.0 Study area

22. The project specific study areas are shown in Figure 11. 1, with reference to the relevant ICES (International Council for the Exploration of the Sea) statistical rectangles (ICES rectangles).

23. ICES rectangles are the smallest spatial unit used to collate commercial fisheries data and the data from certain national and international fish surveys. The boundaries of each ICES rectangle aligns to 0.5° latitude by 1.0° longitude, giving whole rectangle dimensions of approximately 30 by 30 nautical miles, at UK latitudes.

24. Norfolk Vanguard is located off the Norfolk coast, in ICES Division IVc (Southern North Sea). Norfolk Vanguard comprises two distinct areas, NV East and NV West, which are located approximately, 70km and 47km from the coast of Norfolk, respectively (at the nearest points). The offshore site includes areas of sand ridges with associated peaks and troughs, dominated by slightly gravelly sand, with areas of sand, slightly gravelly muddy sand and sandy gravel. Water depths range from 25m to 47m relative to Chart Datum (CD) in NV West and from 21m to 45m (CD) in NV East. The site has a maximum tidal range of approximately 1.96m (from -0.99m mean seal level (MSL) to 0.97m MSL).

25. 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.

26. The offshore project area falls within ICES rectangles 34F1, 34F2 and 34F3 (Figure 11. 1). In this report, ICES rectangle 34F1 will be referred as the 'offshore cable corridor', whilst ICES rectangles 34F2 and 34F3 will be respectively referred to as NV West and NV East.

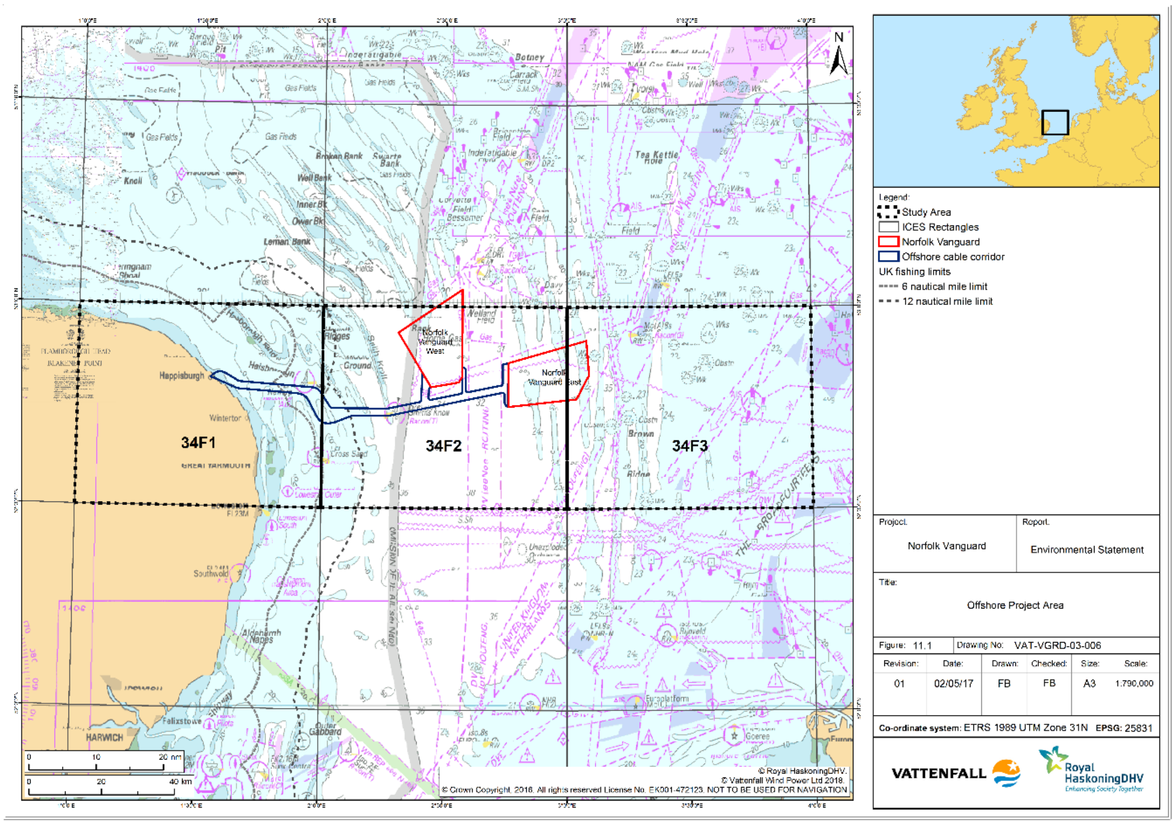


Figure 11. 1 Norfolk Vanguard OWF sites and offshore cable corridor

3.1.1 Designated Sites

27. Designated marine sites in the study area are shown in Figure 11. 2. The Norfolk Vanguard export cable corridor transects the Haisborough, Hammond and Winterton candidate Special Area of Conservation (SAC) and the northern area of the cable landfall is situated within the Cromer Shoal Chalk Beds Marine Conservation Zone (MCZ). These sites are designated based on presence of particular habitats such as sandbanks which are slightly covered by sea water all the time and *Sabellaria spinulosa* reef as opposed to any fish and shellfish species of particular conservation importance. However, both support important stocks of edible crab *Cancer pagurus* and lobster *Homarus gammarus*, which form the basis of commercially significant local fisheries.

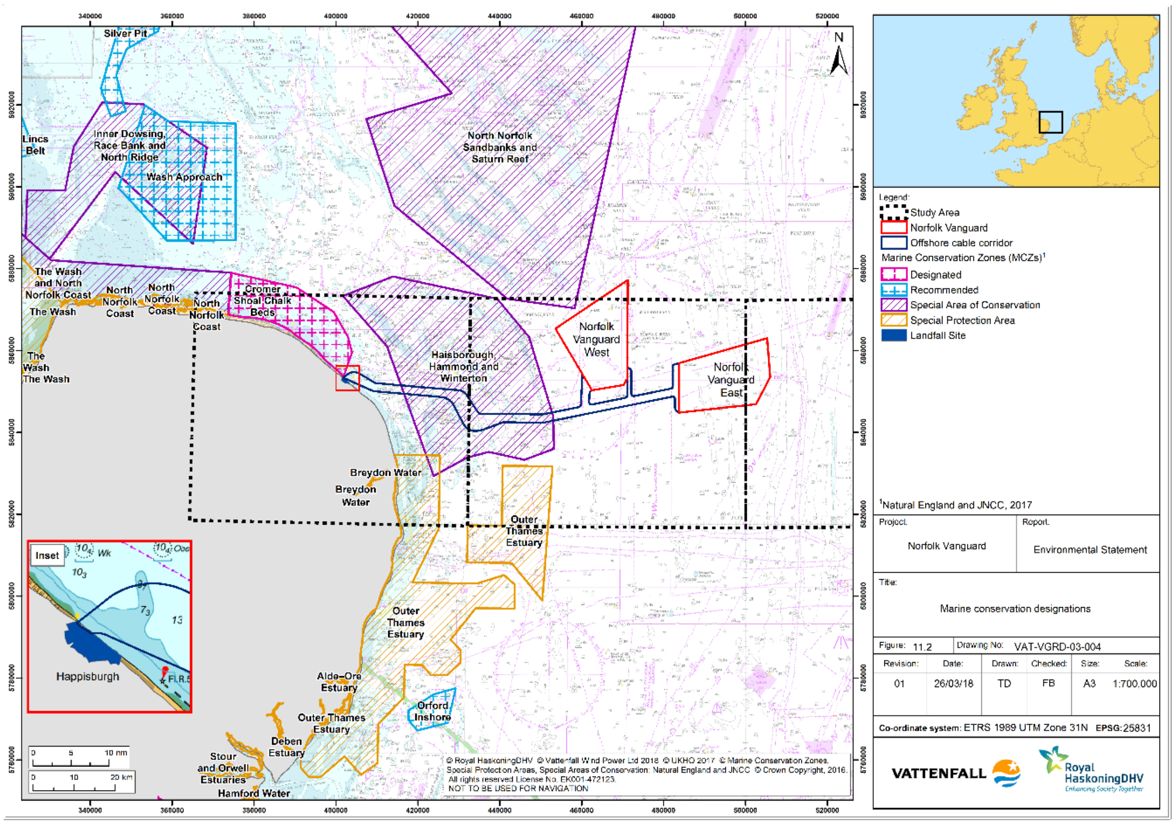


Figure 11. 2 Designated marine sites in the vicinity of Norfolk Vanguard

3.1.2 Overview

28. The Southern North Sea (ICES Division IVc) is largely shallow (<50m depth), with a greater species richness and diversity (Callaway *et al.*, 2002) in comparison to the Central and Northern North Seas (Divisions IVb and IVc, respectively). The species of greatest commercial importance in terms of landings weights and values are plaice *Pleuronectes platessa* and sole *Solea solea*, with cod *Gadus morhua,* thornback ray *Raja clavata*, and sea bass *Dicentrarchus labrax* also being of importance to local inshore fleets.

29. The fish community of the area also comprises smaller demersal species, normally allied with benthic habitats including sandeels Ammodytidae spp., dab *Limanda limanda*, solenette *Buglossidium luteum*, grey gurnard *Eutrigla gurnardus* and common dragonet *Callionymus lyra* (Callaway *et al*., 2002). The most abundant species recorded in the southern North Sea are typically dab and gurnard. Both species feed on numerous different prey taxa and possess an ability to exploit wider habitats (Sell and Kroncke, 2013), whilst also reproducing within two to three years of age when they are only 15cm long (Monroe *et al*., 2014). This early reproduction and ability to exploit a wide range of prey explains why dab and gurnard are so numerous in UK waters. Sandeels and gobies Gobiidae spp., may also be highly abundant therefore playing an important role as prey species (Teale, 2011).

30. Further species commonly found in the southern North Sea include pogge *Agonus cataphractus*, flounder *Platichthys flesus* and sand gobies *Pomatoschistus minutus*, in addition to more "southern" species including poor cod *Trisopterus minutus*, bib *Trisopterus luscus*, red mullet *Mullus surmuletus*, sardine *Sardina pilchardus*, lesser weever *Echiichthys vipera*, anchovy *Engraulis encrasicolus*, tub gurnard *Chelidonichthys lucerna*, John Dory *Zeus faber*, sea bass *Dicentrarchus labrax*, black sea bream *Spondyliosoma cantharus*, horse mackerel *Trachurus trachurus* and mackerel *Scomber scrombus* (Corten van de Kamp, 1996).

31. More than 23 different elasmobranch species (sharks, skates and rays) have been documented in the North Sea, the most common being shark species; spurdog *Squalus acanthias*, lesser spotted dogfish *Scyliorhinus canicula* and smoothhounds *Mustelus asterias,* concentrated in the western North Sea (Daan *et al*., 2005). In terms of ray species, starry rays *Amblyraja radiata* can be found offshore between 50-100m depth in the central North Sea, while thornback ray, spotted ray *Raja montagui* and blonde ray *Raja brachyura* are broadly distributed in inshore waters around much of the British Isles (Daan *et al*., 2005). In the southern North Sea along the East Anglian coastline, Thornback Ray has been shown to be highly abundant, while Spotted Ray and Blonde Ray were abundant off the North Norfolk coast (IBTS data 2007-2016). Juvenile undulate rays *Raja undulata* and egg cases have previously been recorded off the Norfolk coast and at Felixstowe (Shark Trust, 2012). Sightings or landings of other elasmobranch species, including the common skate *Dipturus batis* complex, basking shark *Cetorhinus maximus*, tope *Galeorhinus galeus*, thresher shark *Alopias vulpinus* and porbeagle *Lamna nasus* are uncommon or rare in light of their population status or spatial distribution (Ellis, 2005; NBN Gateway, 2017).

32. Diadromous species undergoing seasonal migrations between the sea and riverine environments, potentially for spawning and nursery life-history stages, have the potential to transit Norfolk Vanguard. Species with recorded presence in the southern North Sea, rivers and coastal regions off East Anglia are listed below:

- Sea lamprey *Petromyzon marinus* and river lamprey *Lampetra fluviatilis* are rarely observed in UK coastal waters, estuaries and accessible rivers (JNCC, 2013a).

- East Anglian coastal waters are believed to support feeding areas for sea trout spawned in rivers in the north east of England and in East Anglian rivers including; the Glaven, Wensum and Yare (Tingley *et al*., 1997).
- European eel *Anguilla Anguilla* are reported to migrate to local rivers including the Waveney, Yare, Bure and Deben (DEFRA, 2010);
- Shoaling smelt have been documented in estuaries including the lower tidal reaches of the Waveney and Yare (Colclough and Coates, 2013).

33. Allis shad *Alosa alosa* and twaite shad *Alosa fallax* are thought to be present elsewhere in rivers and estuaries in Eire, Wales and in the Solway Firth (King and Roche, 2008; Aprahamian, 1989; Maitland and Lyle, 2005). Despite historical spawning in several English river systems, the only recently-confirmed spawning site in England is the Tamar Estuary, Devon (Jolly, 2012). No records exist of these species in rivers in the vicinity of Norfolk Vanguard.

34. The southern North Sea (ICES Division IVc) supports commercially important shellfish species including brown crab *Cancer pagurus*, lobster *Hommarus gammarus*, velvet swimming crab *Necora puber*, brown shrimp *Crangon crangon*, pink shrimp *Pandalus montagui* and the edible common whelk *Buccinum undatum* (Walmsey and Pawson, 2007).

35. Shellfish species of lower commercial importance but of relevance to Norfolk Vanguard include common prawn *Palaemon serratus*, green crab *Carcinus maenas*, spider crab Majidae spp., cuttlefish Sepiidae spp., octopus Octopoda spp. and squid Teuthida spp.

36. Harvested at localised inshore locations including areas classified as shellfish harvesting areas, a limited number of shellfish species including blue mussel *Mytilus edulis*, native oyster *Ostrea edulis*, Pacific oyster *Crassostrea gigas*, razor clams *Ensis* spp. and cockle *Cerastoderma edule* are harvested (FSA, 2016). These fisheries are however outside of the Norfolk Vanguard OWF sites and offshore cable corridor.

3.2 Existing Environment

3.2.1 Site Specific Fish and Shellfish Surveys

37. Fish characterisation data from the fisheries assessments for East Anglia THREE and the former East Anglia FOUR EIAs, conducted in February and May 2013, have been used to inform the following sections of this report. The data are also presented in Appendix 2. As agreed by Cefas and the MMO (see Appendix 1), findings of fish and shellfish surveys undertaken for the former East Anglia Zone are highly relevant to Norfolk Vanguard due the close proximity of the sites (Figure 11. 3). Table 11. 3 summarises the surveys undertaken.

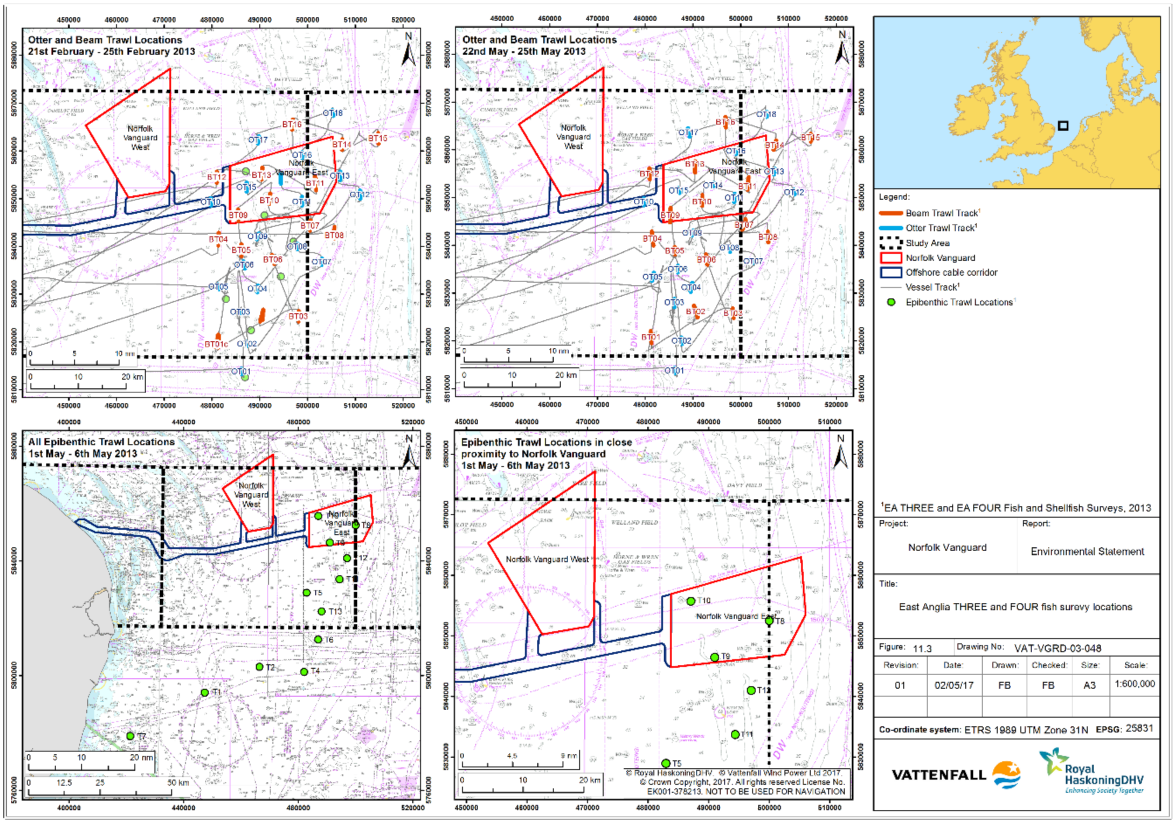


Figure 11. 3 Locations of Otter trawl, Beam trawl and Epibenthic surveys conducted during East Anglia THREE and FOUR site specific surveys in relation to Norfolk Vanguard

Table 11. 3 Summary of site specific surveys undertaken

Survey and Gear Type	Survey area	Sampling Effort	Time of Surveys
Otter trawl survey (commercial otter trawl with a 100mm mesh cod-end)	Former East Anglia FOUR and East Anglia THREE sites	• 9 x 20 minute tows (5 within East Anglia FOUR and 4 in adjacent areas at control locations) • 6 x 20 minute tows (3 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)	Former East Anglia FOUR and East Anglia THREE sites and East Anglia THREE offshore	• 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	May 2013

Survey and Gear Type	Survey area	Sampling Effort	Time of Surveys
	cable corridor	East Anglia THREE offshore cable corridor	

3.2.1.1 Otter Trawl Sampling

38. For East Anglia THREE, a total of 18 species were caught during demersal otter trawl sampling; eight at the control stations and eighteen within the East Anglia THREE site. Dab was the most abundant species in trawl samples, followed by plaice and whiting *Merlangius merlangus*. Lesser spotted dogfish was the only elasmobranch species caught at control and windfarm stations.

39. For East Anglia FOUR, a total of 22 species were recorded in the otter trawl survey; 17 at the control stations and 17 within East Anglia FOUR. Overall, dab was again the most abundant species sampled, followed by plaice and whiting respectively.

40. A summary of the results of the demersal otter trawl sampling is given in Table 11. 4.

Table 11. 4 Summary Results of the Demersal Otter Trawl Sampling (EA THREE & EA FOUR February and May 2013) (Appendix 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
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

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
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 Rockling	*Gaidropsarus vulgaris*	-	-	-	-	-	-	-	1.2
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	-	-

3.2.1.2 Beam Trawl Surveys

41. For East Anglia THREE, a total of 23 species of fish and shellfish were caught with the 4m beam trawl sampling; 17 species at control stations and 19 within the East Anglia THREE site (Table 11. 5). Plaice was the most abundant species caught, followed by dab. Whelk were not caught in the windfarm area but were caught at control stations during the May 2013 survey. Solenette, velvet crab and lesser spotted dogfish were found in moderate numbers whilst catch rates of all other species were low. As caveated in section 2.4.4., the absence of smaller species and crustaceans should be interpreted with caution due to limitations associated with the sampling gear.

42. 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 11. 5). 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 11. 5 Summary Results of 4m Beam Trawl sampling (EA THREE & EA FOUR February and May 2013) (Appendix 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
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
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

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
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	-	-	-	-	-	-	-
Thornback ray	*Raja clavata*	0.7	-	-	-	-	-	-	-
4-Bearded Rockling	*Rhinonemus cimbrius*	-	-	-	-	-	-	0.6	-
Edible Crab	*Cancer pagurus*	-	-	-	0.6	-	-	-	-
Squid	*Loligo sp.*	-	-	-	0.6	-	-	-	-

3.2.1.3 Epibenthic Surveys

43. Site specific scientific 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 (Appendix 2).

44. A summary of the fish species recorded during this sampling for both East Anglia THREE and the former East Anglia FOUR is presented in Table 11. 6. Other epifauna present in samples is described within Appendix 10.1 (benthic characterisation report). As shown, the most prevalent species caught were solenette and sand goby.

Table 11. 6 Summary of the results of the 2m Scientific Beam Trawl survey (EA THREE & EA FOUR May 2013) (Annex 2).

Common Name	Scientific Name	CPUE (number of individuals per hour)		
		EA THREE		EA FOUR
		May 2013	May 2013	May 2013
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 Dragonet	Callionymus maculatus	1.5	8.9	7.1
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

Common Name	Scientific Name	CPUE (number of individuals per hour)		
		EA THREE		EA FOUR
		May 2013	May 2013	May 2013
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	-

3.2.2 International Bottom Trawl Surveys (IBTS)

45. The 50 most common species present in the ICES rectangles where Norfolk Vanguard is located (Table 11. 7), expressed as their average relative abundance (CPUE) in IBT surveys (spring, summer, autumn, winter) for the years 2007 to 2016 are given in Table 11. 7. Whiting CPUE was highest in all three ICES rectangles spanning the offshore project area (34F1, 34F2 and 34F3). Greater sandeel was high in NV East (34F3), but comparatively low in the offshore cable corridor (34F1). Herring also showed high CPUE in NV East (34F3), in addition to dab, which had high CPUE in NV East (34F3) and NV West (34F2). However, both herring and dab were much reduced in the offshore cable corridor (34F1). In contrast, edible crab and rock

gunnel CPUE was high in the offshore cable corridor (34F1), but substantially lower in NV West and NV East (34F2 and 34F3).

Table 11. 7 Average Catch per unit effort CPUE (number/hour) for principal species recorded in the IBTS within each ICES rectangle relevant to Norfolk Vanguard (2007-2016) (DATRAS, 2017)

Common name	Scientific name	CPUE (number of individuals per hour)		
		34F1	34F2	34F3
Whiting	*Merlangius merlangus*	147.72	6,891.18	4,005.57
Greater sandeel	*Hyperoplus lanceolatus*	5.69	40.20	2,785.60
Common dab	*Limanda limanda*	36.96	1,456.41	1,201.08
Atlantic herring	*Clupea harengus*	8.70	121.25	1,505.75
Lesser weever	*Echiichthys vipera*	3.39	298.92	931.74
Weever indet.	*Echiichthys*	0.00	121.03	276.91
Solenette	*Buglossidium luteum*	7.90	170.73	19.47
Small sandeel	*Ammodytes tobianus*	0.70	4.70	106.96
Loligo indet.	*Loligo*	0.00	57.38	36.88
Lesser sandeel	*Ammodytes marinus*	0.00	2.80	68.47
European anchovy	*Engraulis encrasicolus*	0.20	18.98	47.47
Grey gurnard	*Eutrigla gurnardus*	0.00	13.46	43.19
Edible crab	*Cancer pagurus*	52.20	3.28	0.43
Surmullet	*Mullus surmuletus*	0.00	24.69	23.72
Rock gunnel	*Pholis gunnellus*	45.50	0.00	0.00
Hooknose	*Agonus cataphractus*	10.18	19.96	0.35
Atlantic cod	*Gadus morhua*	12.90	8.79	2.95
Shorthorn sculpin	*Myoxocephalus scorpius*	19.70	1.27	0.84
Lemon sole	*Microstomus kitt*	6.10	11.05	2.25
Mediterranean scaldfish	*Arnoglossus laterna*	0.10	13.89	3.22
Gurnard	*Eutrigla*	0.00	8.86	7.61
Dragonet	*Callionymus lyra*	1.20	9.80	4.89
Fivebeard rockling	*Ciliata mustela*	13.90	1.10	0.00
Velvet swimcrab	*Necora puber*	0.00	14.30	0.10
Sandeel	*Ammodytes*	11.16	1.50	0.07
European common squid	*Alloteuthis subulata*	0.00	7.09	4.94
Gobies	*Gobiidae*	1.80	4.80	0.15
Striped seasnail	*Liparis liparis*	6.10	0.30	0.00
Fourbeard rockling	*Enchelyopus cimbrius*	0.00	6.03	0.10
Tub gurnard	*Chelidonichthys lucerna*	0.00	0.20	4.70
European squid	*Loligo vulgaris*	0.00	0.40	3.60
Starry smooth-hound	*Mustelus asterias*	0.00	2.80	0.20
Twaite shad	*Alosa fallax*	0.00	2.90	0.00
Loligo squid	*Loligo forbesii*	0.00	0.90	1.44
Reticulated dragonet	*Callionymus reticulatus*	0.00	0.00	1.47
Smooth-hound	*Mustelus mustelus*	0.00	1.39	0.00
Agone	*Alosa agone*	0.30	0.90	0.00
Northern rockling	*Ciliata septentrionalis*	0.59	0.43	0.00
Three-bearded rockling	*Gaidropsarus vulgaris*	1.00	0.00	0.00

Common name	Scientific name	CPUE (number of individuals per hour)		
		34F1	34F2	34F3
Red mullet	*Mullus barbatus*	0.00	1.00	0.00
European lobster	*Homarus gammarus*	0.80	0.00	0.00
Snake pipefish	*Entelurus aequoreus*	0.00	0.00	0.77
Montagus seasnail	*Liparis montagui*	0.50	0.00	0.00
Long rough dab	*Hippoglossoides platessoides*	0.00	0.43	0.00
Ling	*Molva molva*	0.40	0.00	0.00
Spotted dragonet	*Callionymus maculatus*	0.00	0.27	0.10
Megrim	*Lepidorhombus whiffiagonis*	0.00	0.30	0.00

3.2.3 Commercial Species

3.2.3.1 UK MMO Landings Statistics

46. An indication of the principal commercially targeted species found in the study area is given below based on the analysis of annual landing weights (tonnes) by species and ICES rectangle (34F1, 34F2 and 34F3) averaged for the period 2007-2016.

47. Table 11. 8 presents the main species landed by weight in the study areas. Plaice contributes 31.59% and 56.74% of landings (tonnes) in NV West and NV East (34F2 and 34F3) respectively, whereas the contribution of this species in the offshore cable corridor (34F1) is low at 0.06%. In both the offshore cable corridor (34F1) and NV East (34F3), sprat contributes 0.18% and 1.17% of the total landings, compared to 23.01% in NV West (34F2). The highest landings of cod and sole by weight are reported within the NV West (34F2) at 5.71% and 22.91%.

48. Figure 11. 4, Figure 11. 5 and Figure 11. 6 demonstrate the UK annual landings weights (tonnes) for NV West, NV East and the offshore cable corridor between 2007 and 2016. Figure 11. 4 shows that landings of lobster and herring in the offshore cable corridor (34F1) have been fairly consistent over the 10-year period for which data is shown (2007-2016). Landings of edible crab declined by an order of magnitude between 2008 and 2009 but have increased since 2012. The recent increases in the importance of the commercial whelk fishery is evidenced by significant annual increases from 2009 to 2014. The landings weight of skates and rays have been higher in the offshore cable corridor (34F1) than in NV West and NV East (34F2 and 34F3).

49. Mussels were omitted from Figure 11. 4 because landings were unusually high within 34F1 in the year 2011 at 2,524.77 tonnes. Including the mussel data made it difficult to interpret data for other species. Personal communication with the Eastern Inshore Fisheries and Conservation Authority (EIFCA) revealed 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, mussels landings data have been excluded.

50. Figure 11. 5 shows that plaice landings largely declined until 2012 in NV West (34F2), before increasing to a 10-year peak in 2013 (139.18 tonnes). Sole landings weights were relatively consistent until 2013, at which point landings experienced a similar increase to those of plaice from 8.26 tonnes in 2012 to 92.55 tonnes in 2013. Significant landings of sprat were only recorded in 2011 within NV West (34F2) at 342.25 tonnes.

51. Figure 11. 6 illustrates that sole landings by weight in NV East (34F3) have been relatively consistent throughout the ten-year period for which data has been analysed. Plaice landings have been more variable, peaking in 2010 with landings of 173.31 tonnes, then falling to 13.41 tonnes in 2015.

52. Figure 11. 7, Figure 11. 8 and Figure 11. 9 show seasonal variation in landings weights (tonnes) for the OWFs and the western section of the offshore cable corridor. Figure 11. 7 shows seasonal variation (average 2007-2016) in landings weights for the offshore cable corridor (34F1). Edible crab landings show high seasonal variability. Landings are low during January (0.8 tonnes), reach a peak in April and May (19.2 tonnes) and then fall back to 2.2 tonnes in December. Whelk landings have remained fairly consistent between a low of 3 tonnes (June) and a high of 6.1 tonnes (April). Lobster have also made a large contribution to landings in 34F1, recording the second highest landings weights in July after edible crab, at 6.0 tonnes.

53. Figure 11. 8 demonstrates the seasonal variation in landings weights for NV West (34F2). Cod landings are highest in December and April. Landings of sole and plaice are generally consistent throughout the year, with a peak in September of 5.9 tonnes for sole and 6.6 tonnes for Plaice in October. Landings for sprat are recorded in December only at 34.2 tonnes.

54. Figure 11. 9 shows seasonal landings data for NV East (34F3). Landings of plaice are generally higher in the winter months (November to February) which correspond to the high intensity spawning period defined by Coull et al. (1998) and Ellis et al. (2010). The highest cod landings within the windfarm site also corresponds to the beginning of spawning period defined by Coull et al. (1998) and Ellis et al. (2010) (January to April). Landings of sprat are only recorded in NV East (34F3) in December (0.91 tonnes).

Table 11. 8 Average weight (tonnes) and percentage contribution of the principal commercial species (MMO landings data 2007-2016) within each ICES rectangle relevant to Norfolk Vanguard

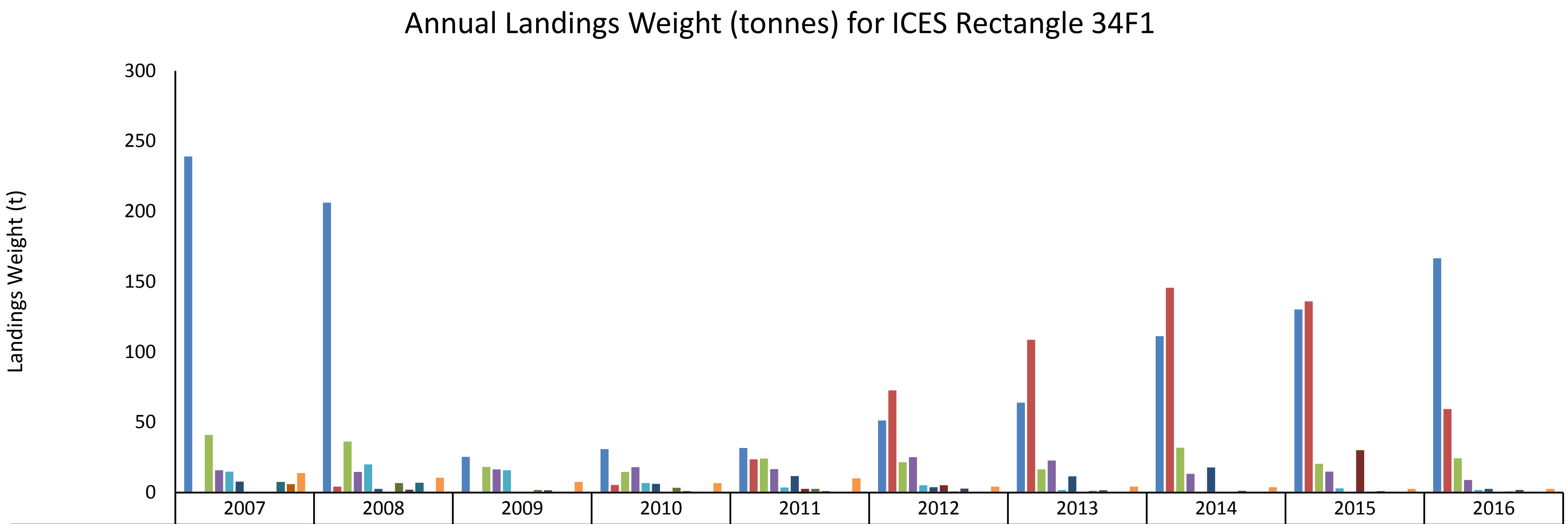
Species	Offshore cable corridor 34F1		NV West 34F2		NV East 34F3	
	Average landings (tonnes)	Average contribution to catch within ICES rectangle (%)	Average landings (tonnes)	Average contribution to catch within ICES rectangle (%)	Average landings (tonnes)	Average contribution to catch within ICES rectangle (%)
Mussels	252.48	51.96%	0.00	0.00%	0.00	0.00%
Edible Crabs	105.68	21.75%	0.10	0.06%	0.10	0.13%
Plaice	0.29	0.06%	46.99	31.59%	44.44	56.74%
Whelks	55.66	11.46%	0.18	0.12%	0.07	0.09%
Sole	0.85	0.18%	34.08	22.91%	12.72	16.24%
Sprats	0.87	0.18%	34.23	23.01%	0.91	1.17%
Lobsters	24.92	5.13%	0.03	0.02%	0.00	0.01%
Cod	7.32	1.51%	8.50	5.71%	3.98	5.09%
Herring	16.70	3.44%	0.00	0.00%	0.00	0.00%
Brown Shrimps	6.46	1.33%	0.00	0.00%	0.00	0.00%
Dabs	0.13	0.03%	2.47	1.66%	3.22	4.11%
Brill	0.01	0.00%	3.54	2.38%	1.59	2.03%
Thornback Ray	1.85	0.38%	2.46	1.65%	0.81	1.04%
Turbot	0.01	0.00%	3.29	2.21%	1.65	2.11%
Flounder/Flukes	0.15	0.03%	0.70	0.47%	3.75	4.78%
Tub Gurnard	0.00	0.00%	2.99	2.01%	1.22	1.56%
Cockles	3.80	0.78%	0.00	0.00%	0.00	0.00%
Blonde Ray	0.71	0.15%	2.80	1.88%	0.28	0.36%
Bass	1.49	0.31%	0.11	0.07%	0.02	0.03%
Velvet Crabs	1.46	0.30%	0.00	0.00%	0.00	0.00%
Mackerel	1.36	0.28%	0.01	0.01%	0.01	0.01%
Skates and Rays	0.66	0.14%	0.56	0.38%	0.13	0.16%
Whiting	0.11	0.02%	0.23	0.16%	0.55	0.71%
Other	1.48	0.30%	2.77	1.86%	1.43	1.82%

3.2.3.2 Dutch landings Statistics

55. Figure 11. 10, Figure 11. 11 and Figure 11. 12 show annual Dutch landings weights (kg) for the offshore cable corridor (34F1), NV West (34F2) and NV East (34F3) respectively. Dutch fishing activity is high within all three ICES rectangles relevant to Norfolk Vanguard, particularly NV West and NV East (34F2 and 34F3). The main species targeted by Dutch vessels are plaice and sole. Plaice landings were highest in all three rectangles in 2013, reaching 5.25 tonnes in the offshore cable corridor (34F1) (Figure 11. 10), 1,447.71 tonnes in NV West (34F2) (Figure 11. 11) and 1,434.33 tonnes in NV East (34F3) (Figure 11. 12). Sole landings were consistently highest in NV West (34F2) throughout the five-year period (2012-2016), peaking in 2013 at 947.42 tonnes (Figure 11. 11). Landings weights for Turbot in NV West and NV East (34F2 and 34F3) have generally remained consistent throughout the period 2012-2016 (Figure 11. 11 and Figure 11. 12).

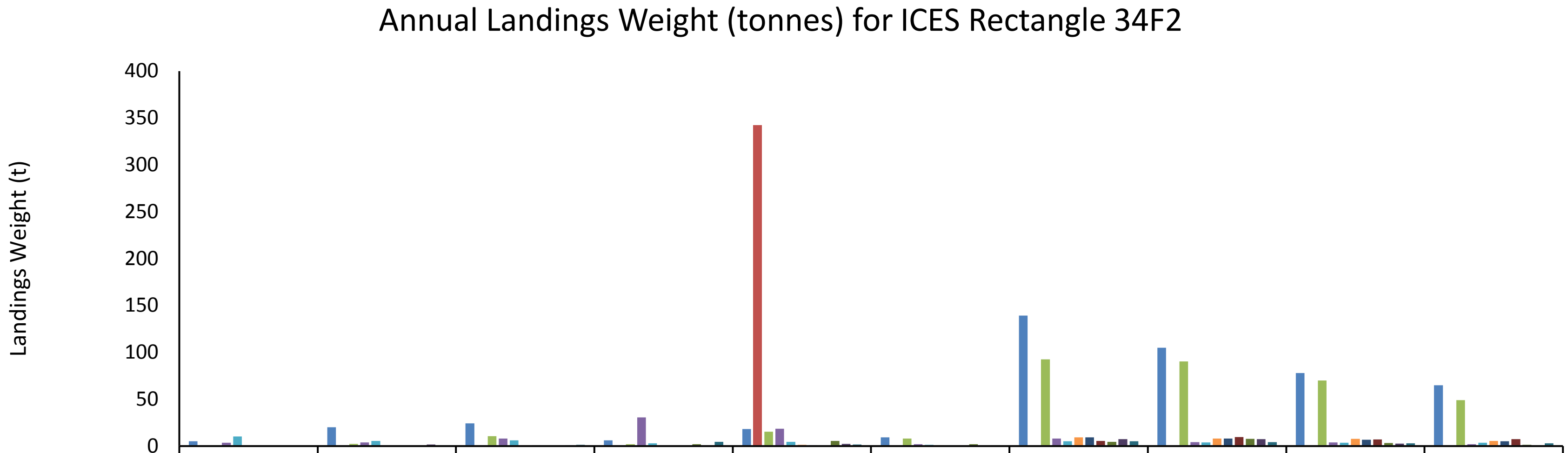
3.2.3.3 Belgian ILVO Landings statistics

56. Figure 11. 13, Figure 11. 14 and Figure 11. 15 show annual Belgian landings weights (kg) for the offshore cable corridor (34F1), NV West (34F2) and NV East (34F3) over the most recent 5-year period for which data is available (2010-2014). Within the offshore cable corridor (34F1), Belgian landings declined dramatically from 2010 to 2014, falling to zero for all species in 2014 (Figure 11. 13). Landings of plaice and sole dominate in ICES rectangle 34F2, with both species peaking in 2014 (Figure 11. 14). For Plaice, this was 94.54 tonnes, for Sole, this was 77.64 tonnes. Skates and rays showed the third highest landings for all species in ICES rectangle 34F2 (Figure 11. 14). Mackerel landings were highest in NV East (34F3), particularly in 2014, when they reached 12.89 tonnes (Figure 11. 15). Tub gurnard, plaice and dab were also landed in relatively high volume (Figure 11. 15). Fishing by Belgian vessels has been greatest overall in NV West (34F2).



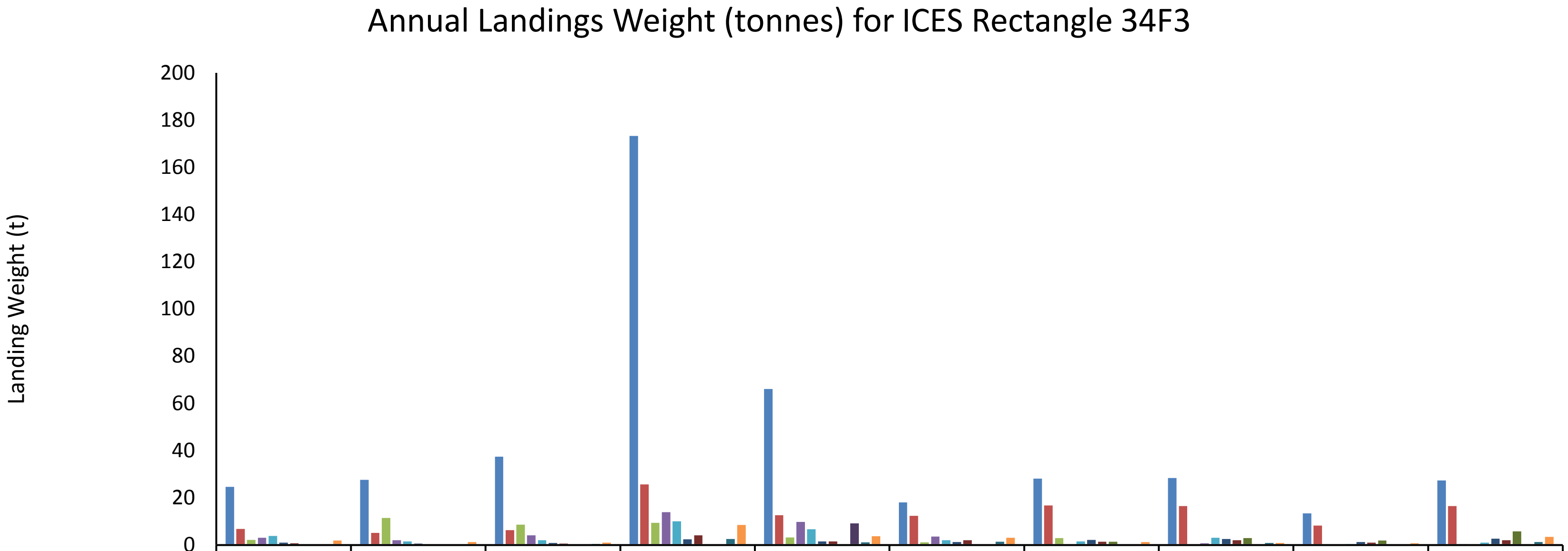
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Edible Crabs	239	206	25	31	32	51	64	111	130	167
Whelks	0	4	1	5	24	73	109	146	136	60
Lobsters	41	36	18	15	24	22	16	32	20	24
Herring	16	15	16	18	17	25	23	13	15	9
Cod	15	20	16	7	4	5	2	0	3	2
Brown Shrimps	8	3	0	6	12	4	12	18	0	3
Cockles	0	0	0	0	3	5	0	0	30	0
Thornback Ray	0	7	2	3	3	1	1	1	1	1
Bass	0	2	2	1	1	3	2	1	1	2
Velvet Crabs	8	7	0	0	0	0	0	0	0	0
Skates and Rays	6	1	0	0	0	0	0	0	0	0
Other	14	11	8	7	10	4	4	4	3	3

Figure 11. 4 Annual UK landings weight (tonnes) by species in ICES rectangle 34F1, relevant to the offshore cable corridor (2007-2016) (Source: MMO, 2017)



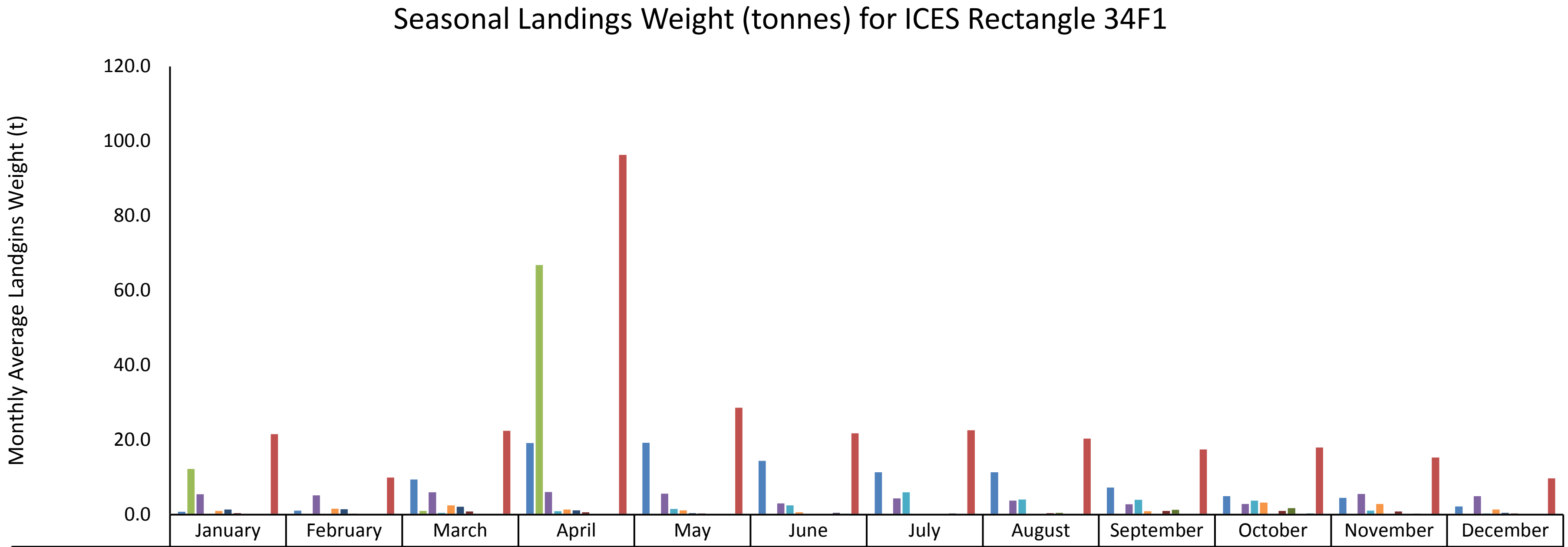
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Plaice	5	20	24	6	18	9	139	105	78	65
Sprats	0	0	0	0	342	0	0	0	0	0
Sole	1	2	11	2	15	8	93	90	70	49
Cod	4	4	8	31	19	2	8	4	4	2
Other	10	5	6	3	5	1	5	4	4	4
Brill	0	0	1	0	1	1	9	8	8	6
Turbot	0	0	1	0	1	1	9	8	7	5
Tub Gurnard	0	0	0	0	0	0	5	10	7	8
Blonde Ray	0	1	0	2	6	2	5	8	3	1
Dabs	1	2	1	0	2	0	7	7	3	1
Thornback Ray	0	1	2	5	2	1	5	4	3	3

Figure 11. 5 Annual UK landings weight (tonnes) by species in ICES rectangle 34F2, relevant to NV West (2007-2016) (Source: MMO, 2017)



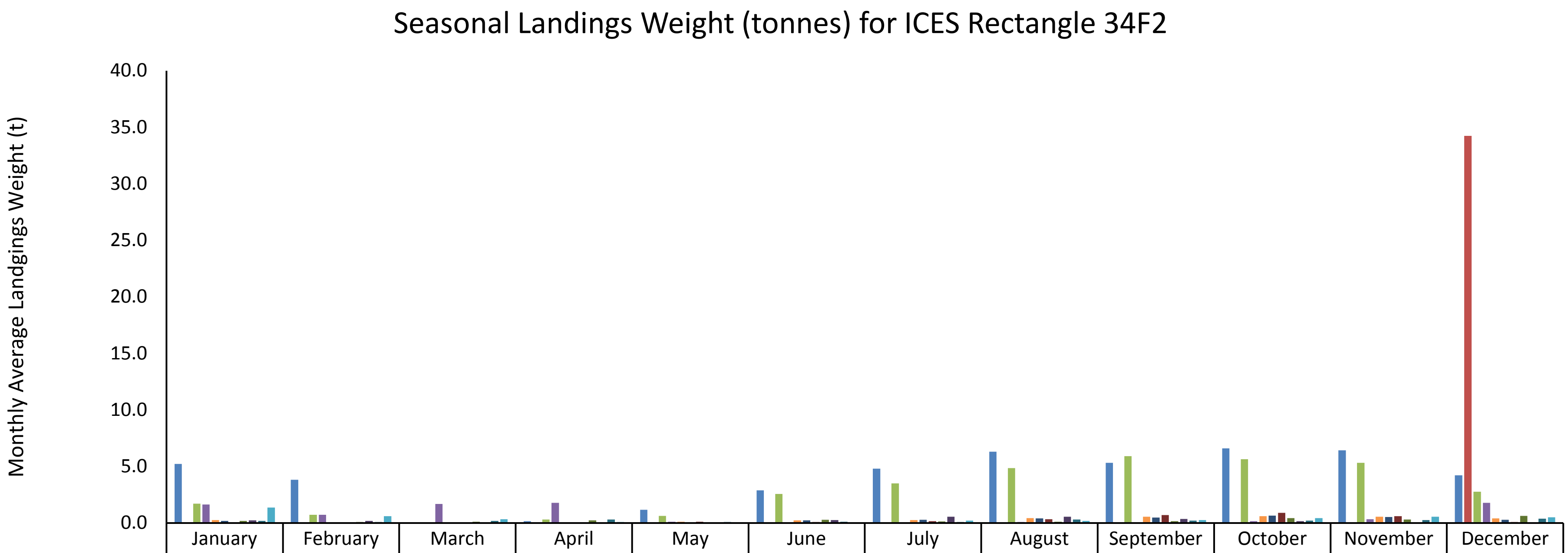
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Plaice	25	28	37	173	66	18	28	28	13	27
Sole	7	5	6	26	13	12	17	17	8	17
Cod	2	11	9	9	3	1	3	0	0	0
Flounder or Flukes	3	2	4	14	10	4	0	1	0	0
Dabs	4	2	2	10	7	2	1	3	0	1
Turbot	1	1	1	2	2	1	2	3	1	3
Brill	1	0	1	4	2	2	1	2	1	2
Tub Gurnard	0	0	0	0	0	0	1	3	2	6
Sprats	0	0	0	0	9	0	0	0	0	0
Thornback Ray	0	0	0	3	1	1	0	1	0	1
Other	2	1	1	8	4	3	1	1	1	3

Figure 11. 6 Annual UK landing weight (tonnes) by species in ICES rectangle 34F3, relevant to NV East (2007-2016) (Source: MMO, 2017)



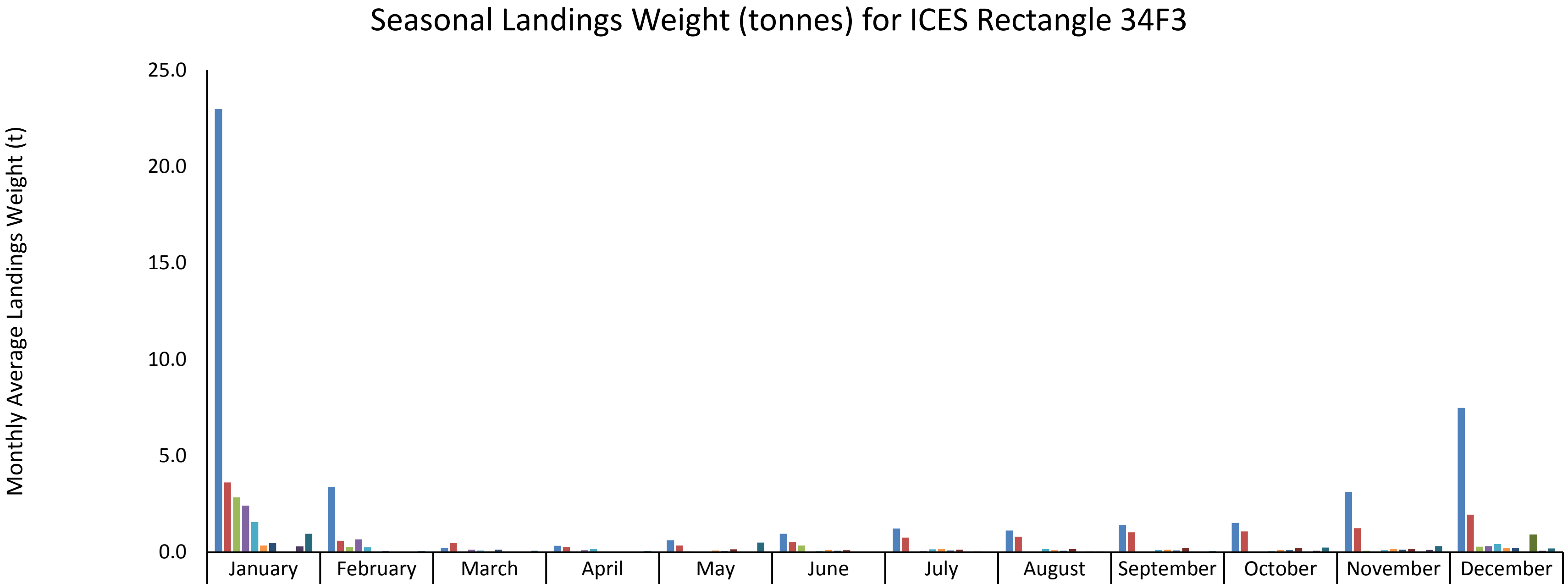
	January	February	March	April	May	June	July	August	September	October	November	December
Edible Crabs	0.8	1.1	9.4	19.2	19.2	14.4	11.4	11.3	7.3	5.0	4.5	2.2
Mussels	12.2	0.0	1.0	66.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Whelks	5.5	5.1	6.0	6.1	5.7	3.0	4.4	3.8	2.8	2.9	5.5	5.0
Lobsters	0.1	0.2	0.5	1.0	1.5	2.5	6.0	4.1	4.0	3.7	1.1	0.3
Herring	1.0	1.6	2.5	1.3	1.2	0.6	0.1	0.0	0.9	3.3	2.9	1.3
Cod	1.4	1.5	2.1	1.1	0.4	0.1	0.0	0.0	0.0	0.0	0.2	0.4
Brown Shrimps	0.4	0.3	0.8	0.6	0.3	0.2	0.2	0.4	1.0	1.0	0.8	0.3
Cockles	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.5	1.3	1.7	0.0	0.0
Thornback Ray	0.1	0.2	0.1	0.1	0.1	0.5	0.3	0.1	0.1	0.0	0.2	0.0
Bass	0.0	0.1	0.0	0.1	0.2	0.3	0.1	0.2	0.2	0.3	0.0	0.0
Other	21.5	10.0	22.4	96.3	28.7	21.8	22.6	20.3	17.4	17.9	15.3	9.7

Figure 11. 7 Average seasonal UK landings weight (tonnes) by species in ICES rectangle 34F1, relevant to the offshore cable corridor (average 2007-2016) (Source: MMO, 2017)



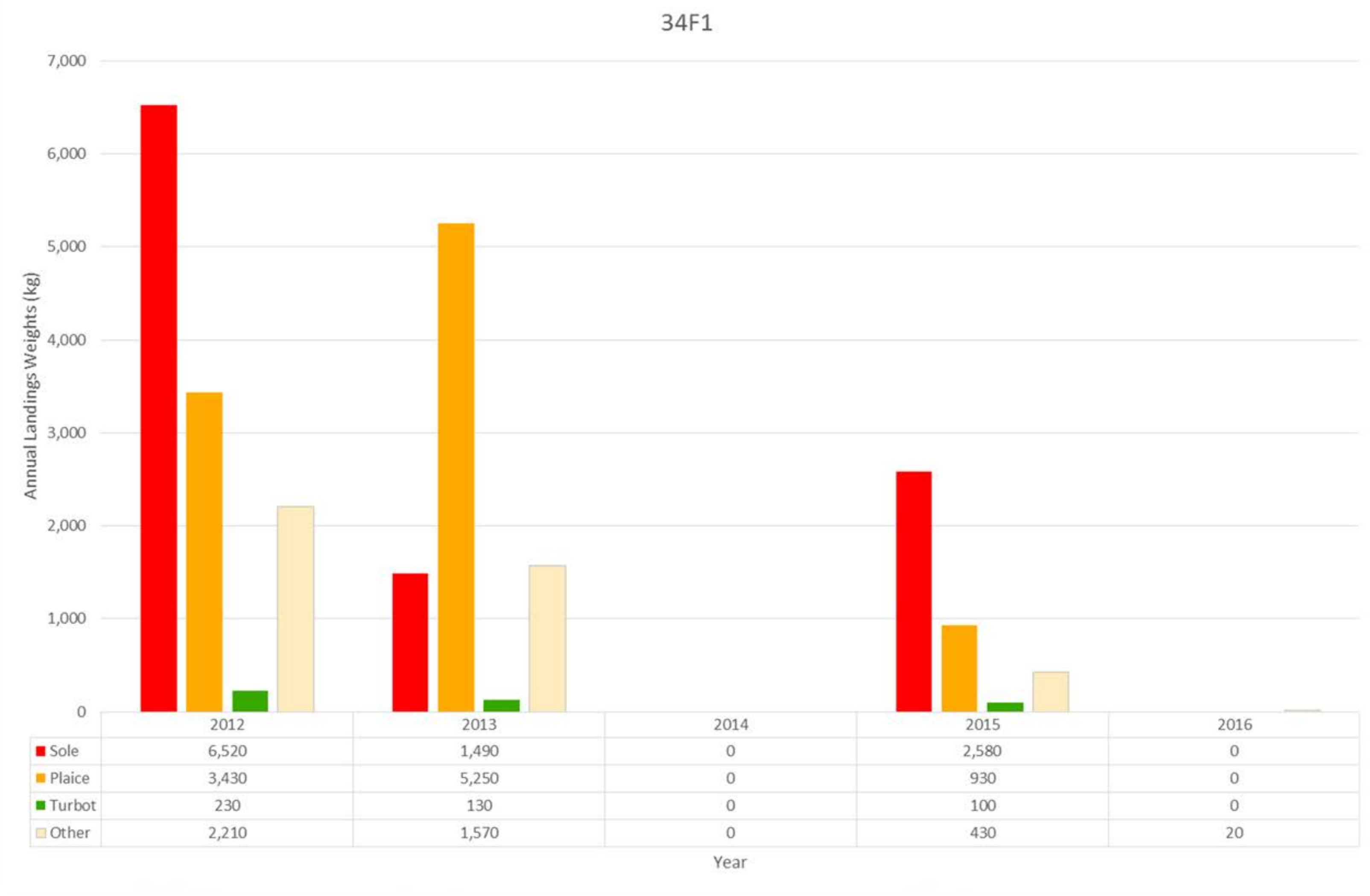
	January	February	March	April	May	June	July	August	September	October	November	December
Plaice	5.2	3.8	0.0	0.2	1.2	2.9	4.8	6.3	5.3	6.6	6.4	4.2
Sprats	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.2
Sole	1.7	0.7	0.1	0.3	0.6	2.6	3.5	4.9	5.9	5.7	5.3	2.8
Cod	1.6	0.7	1.7	1.8	0.1	0.1	0.0	0.1	0.1	0.2	0.3	1.8
Brill	0.3	0.1	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.6	0.5	0.4
Turbot	0.2	0.1	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.5	0.3
Tub Gurnard	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.7	0.9	0.6	0.1
Blonde Ray	0.2	0.1	0.1	0.2	0.1	0.3	0.1	0.1	0.2	0.4	0.3	0.6
Dabs	0.2	0.2	0.0	0.0	0.0	0.3	0.6	0.5	0.3	0.2	0.1	0.0
Thornback Ray	0.2	0.1	0.2	0.3	0.1	0.1	0.1	0.3	0.2	0.2	0.3	0.4
Other	1.4	0.6	0.3	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.6	0.5

Figure 11. 8 Average seasonal UK landings weight (tonnes) by species in ICES rectangle 34F2, relevant to NV West (average 2007-2016) (Source: MMO, 2017)



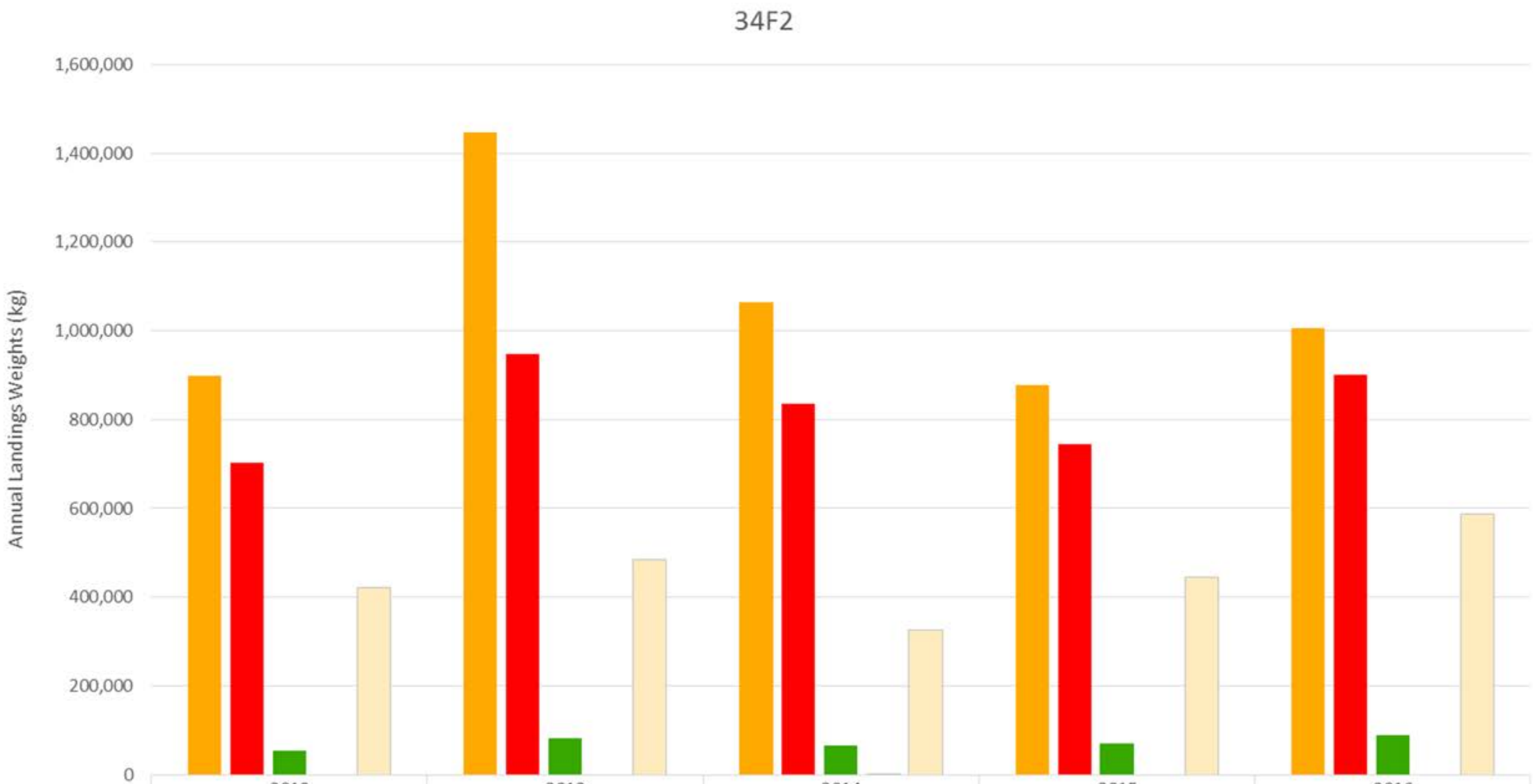
	January	February	March	April	May	June	July	August	September	October	November	December
Plaice	23.0	3.4	0.2	0.3	0.6	1.0	1.2	1.1	1.4	1.5	3.1	7.5
Sole	3.6	0.6	0.5	0.3	0.3	0.5	0.8	0.8	1.0	1.1	1.3	1.9
Cod	2.8	0.3	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.3
Flounder or Flukes	2.4	0.7	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.3
Dabs	1.6	0.3	0.1	0.2	0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.4
Turbot	0.3	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.2
Brill	0.5	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Tub Gurnard	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.0
Sprats	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Thornback Ray	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Other	1.0	0.1	0.1	0.1	0.5	0.0	0.0	0.0	0.1	0.2	0.3	0.2

Figure 11. 9 Average seasonal UK landings weight (tonnes) by species in ICES rectangle 34F3, relevant to NV East (average 2007-2016) (Source: MMO, 2017)



	2012	2013	2014	2015	2016
Sole	6,520	1,490	0	2,580	0
Plaice	3,430	5,250	0	930	0
Turbot	230	130	0	100	0
Other	2,210	1,570	0	430	20

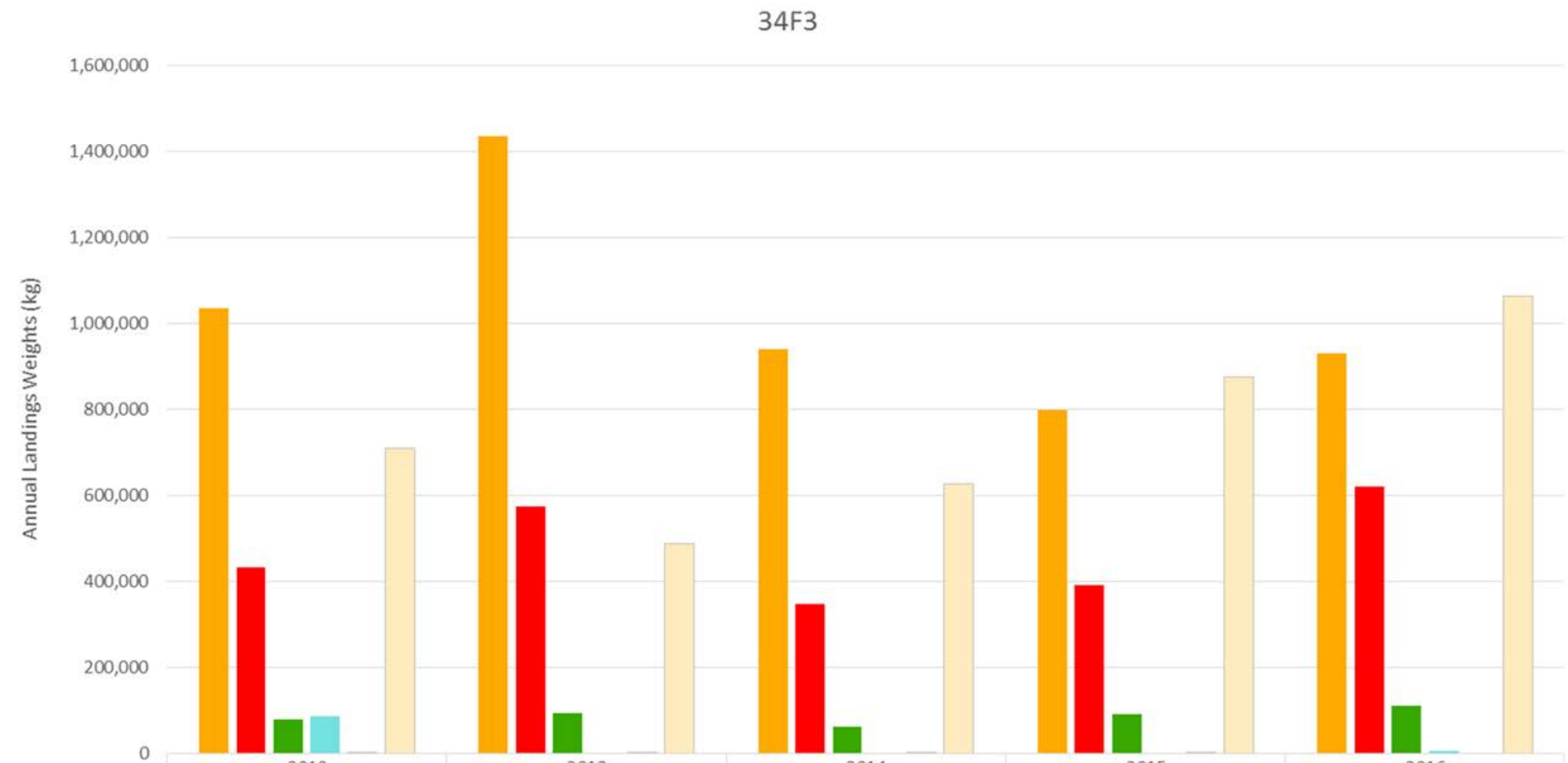
Figure 11. 10 Annual Dutch landings weight (tonnes) by species in ICES rectangle 34F1, relevant to the offshore cable corridor (average 2012-2016) (Source: IMARES, 2017)



	2012	2013	2014	2015	2016
Plaice	898,300	1,447,710	1,063,910	877,100	1,006,970
Sole	703,280	947,420	836,360	745,380	901,940
Turbot	54,780	81,260	65,160	70,720	89,170
Brown Shrimp	0	0	1600	0	0
Other	421560	483900	324870	444940	587180

Year

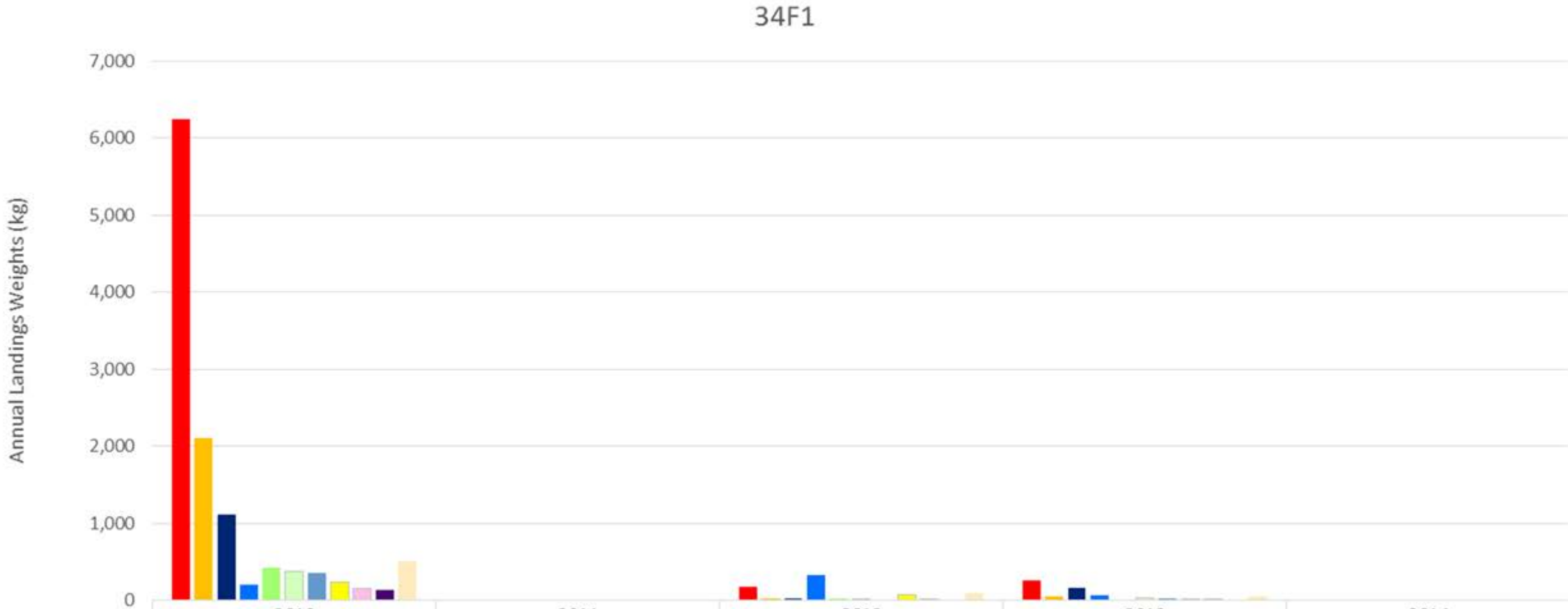
Figure 11. 11 Annual Dutch landings weight (tonnes) by species in ICES rectangle 34F2, relevant to NV West (average 2012-2016) (Source: IMARES, 2017)



	2012	2013	2014	2015	2016
Plaice	1,035,700	1,434,330	938,650	797,170	928,810
Sole	433,270	573,630	346,630	389,760	619,870
Turbot	79,790	92,920	62,190	91,100	109,760
Herring	86,070	0	0	0	5,660
Brown Shrimp	1,850	2,170	2,360	240	0
Other	708,610	487,890	625,180	876,280	1,062,220

Year

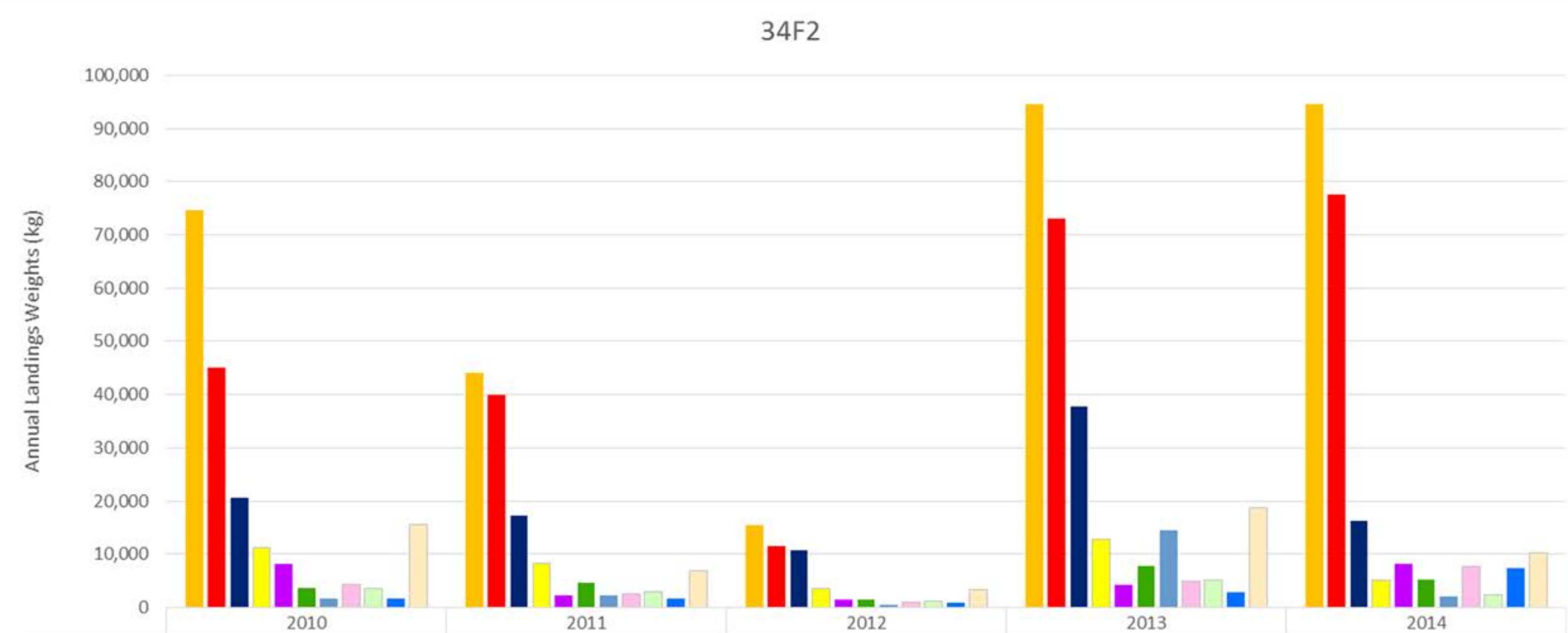
Figure 11. 12 Annual Dutch landings weight (tonnes) by species in ICES rectangle 34F3, relevant to NV East (average 2012-2016) (Source: IMARES, 2017)



	2010	2011	2012	2013	2014
Sole	6,249	0	175	260	0
Plaice	2,099	0	16	46	0
Skates & Rays	1,109	0	28	157	0
Catsharks	204	0	332	66	0
Whiting	426	0	24	3	0
Brill	373	0	5	30	0
Whelk	356	0	3	17	0
Cod	240	0	64	1	0
Tub Gurnard	153	0	10	20	0
Lemon Sole	135	0	5	3	0
Other Species	499	0	86	45	0

Year

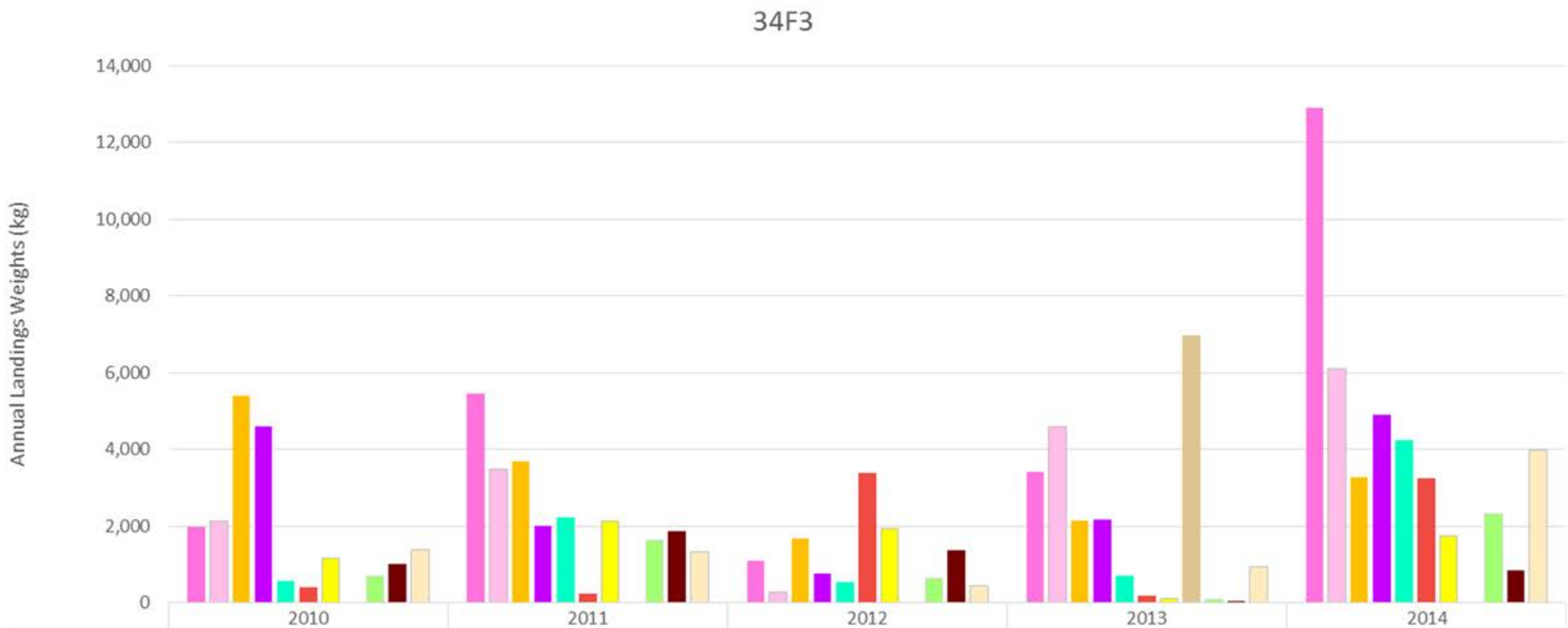
Figure 11. 13 Annual Belgian landings weight (kg) by species in ICES rectangle 34F1, relevant to the offshore cable corridor (average 2010-2014) (Source: ILVO)



	2010	2011	2012	2013	2014
Plaice	74,650	44,169	15,488	94,456	94,538
Sole	45,068	39,834	11,594	72,977	77,640
Skates & Rays	20,538	17,195	10,738	37,758	16,312
Cod	11,160	8,337	3,495	12,873	5,100
Dab	8,143	2,262	1,484	4,237	8,162
Turbot	3,707	4,593	1,401	7,733	5,249
Whelk	1,759	2,226	530	14,589	2,150
Tub Gurnard	4,350	2,526	974	4,912	7,727
Brill	3,643	3,068	1,195	5,078	2,419
Catsharks	1,679	1,601	913	2,926	7,384
Other Species	15,554	7,004	3,273	18,793	10,337

Year

Figure 11. 14 Annual Belgian landings weight (kg) by species in ICES rectangle 34F2, relevant to NV West (average 2010-2014) (Source: ILVO)



	2010	2011	2012	2013	2014
Mackerel	1,975	5,447	1,095	3,420	12,890
Tub Gurnard	2,129	3,473	283	4,577	6,091
Plaice	5,402	3,684	1,681	2,154	3,266
Dab	4,594	2,012	754	2,164	4,895
Horse Mackerel	565	2,212	551	700	4,230
Grey Gurnard	403	232	3,392	171	3,255
Cod	1,148	2,124	1,921	112	1,754
Brown Shrimp	0	0	0	6,964	0
Whiting	699	1,625	626	74	2,315
Red Mullet	998	1,865	1,378	47	838
Other Species	1,385	1,327	457	929	3,981

Year

Figure 11. 15 Annual Belgian landings weight (kg) by species in ICES rectangle 34F3, relevant to NV East (average 2010-2014 (Source: ILVO)

3.2.4 Spawning and Nursery Grounds

57. Norfolk Vanguard is in the proximity of the spawning grounds of a number of species (Coull *et al*., 1998; Ellis *et al*., 2010, 2012). The spawning periods and their relative intensities are given in Table 11. 9. The majority of the species with spawning grounds in the vicinity of the OWF sites and offshore cable corridor are pelagic spawners, releasing their eggs into the water column over wide areas. The exceptions are herring and sandeels, which deposit eggs on specific benthic substrates.

58. Coull *et al.* (1998) and latterly Ellis *et al*. (2010, 2012) have, to-date, been the main references consulted during the consideration of windfarm consent conditions regarding fish spawning. Coull *et al*. (1998) and Ellis *et al*. (2010, 2012) review and draw together a range of published research data, and as such provide comprehensive definitions of spawning areas and periods. Furthermore, since the publication of Coull *et al*., evidence suggests that the spawning grounds of certain species may have altered. For instance, since the mid-1970s, herring have not been found to have spawned on the Dogger Bank spawning grounds, which were previously considered important spawning grounds for herring (Nichols, 1999; Schmidt *et al*., 2009).

Table 11. 9 Species with spawning and/or nursery grounds in NV West, NV East and the offshore cable corridor (Coull et al., 1998; Ellis et al., 2010, 2012)

Species	Spawning season												Spawning Intensity			Nursery Intensity		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	OWF sites		Offshore Cable Corridor	OWF sites		Offshore Cable Corridor
													NV West	NV East		NV West	NV East	
Dover sole				●										n/a		n/a	n/a	
Plaice	●	●														n/a	n/a	
Cod		●	●											n/a				
Whiting																		
Lemon sole																		
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: orange= 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)

3.2.5 Species of Conservation Interest

59. A summary of fish and shellfish species with recognised conservation status requiring consideration in the Norfolk Vanguard impact assessment is presented below in Table 11. 10, Table 11. 11 and Table 11. 12.

3.2.5.1 Demersal species

60. A small number of demersal fish species have a designated conservation status under internationally recognised criteria. Cod and haddock for example are listed as 'Vulnerable' on the IUCN Red List (www.iucnredlist.org).

61. Other demersal species including whiting, plaice, sandeel and sole are 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.

3.2.5.2 Diadromous species

62. A number of diadromous species have the potential to transit parts of the Norfolk Vanguard wind farm site and offshore cable corridor, during certain periods of their life cycle. These species are listed in Table 11. 10 together with their conservation status. Despite the fact these species were not caught during site specific fish and shellfish surveys for East Anglia THREE, certain diadromous species including sea trout, European eel, smelt and river lamprey, have been confirmed in the vicinity of Norfolk Vanguard (Potter and Dare, 2003; Colclough and Coates, 2013). These species have also been recorded in IBTS samples and documented occasionally in MMO commercial landings statistics.

3.2.5.3 Elasmobranchs

63. The principal elasmobranch species and their respective conservation status are given in Table 11. 11. 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).

3.2.5.4 Other Species of Conservation Interest

64. In addition to those above, a number of species using the local area are of conservation interest, being listed as a species of principal importance. These are presented in Table 11. 12, along with other conservation designations and statuses 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.

65. Non-commercial shellfish species with listed conservation status recorded in the southern North Sea include several bivalve species. Records of these species are rare and occurred outside of the study areas.

3.2.5.5 Prey Species and Food Web Linkages

66. A number of species found in the general area of the Norfolk Vanguard site play an important role in the North Sea's food web as prey to predators such as birds, marine mammals and piscivorous fish.

67. 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. 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).

68. 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 *Pollachius virens* 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).

69. Sprat is important prey for fish species including cod, grey gurnard, herring, sandeels, spurdog, horse mackerel, mackerel, sea trout 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).

Table 11. 10 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 11. 11 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	✓	-	-	-	-	-

[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).

Common name	Scientific name	Conservation Status						
		IUCN Red List	Species of principal importance	OSPAR	Bern Convention	CITES	W&C 1981	Habitats Directive
White skate	*Rostroraja alba*	Endangered	✓	✓	-	-	-	-

Table 11. 12 Conservation status of Fish and Shellfish species relevant to the proposed Norfolk Vanguard site and the offshore cable corridor (excluding diadromous and elasmobranch species).

Common name	Scientific name	Recorded present in Site specific 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	-	-	✓ Sand goby/ common goby	-	-	-
Haddock	*Melanogrammus aeglefinus*	N	Vulnerable	-	-	-	-	-	-
Lesser sandeel	*Ammodytes marinus*	N	-	✓	-	-	-	-	-
Dover sole	*Solea solea*	Y	-	✓	-	-	-	-	-
Whiting	*Merlangius merlangus*	Y	Least Concern	✓	-	-	-	-	-

[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).

Common name	Scientific name	Recorded present in Site specific surveys Y/N	Conservation Status						
			IUCN Red List	Species of principal importance	OSPAR	Bern Convention	CITES	W&C 1981	Habitats Directive
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	-	✓	✓	-	-	-	-

4.0 Species relevant to Norfolk Vanguard

70. To reach agreement regarding which potential impacts and species would be taken forward for the Project on fish and shellfish ecology, an evidence plan was produced and consultation undertaken with Cefas and Natural England (Evidence Plan meeting, see PEI Chapter 7, Consultation). Cefas (via the MMO), have highlighted herring, sandeels and elasmobranchs as key receptors to be considered within the assessment. This is with particular reference to piling noise (herring), increased suspended sediments (herring and sandeels) and electromagnetic field (EMF) generation (elasmobranchs). It was also recommended that commercially important species such as cod, bass, sole and plaice as well as species of conservation importance were assessed in the EIA.

71. Table 11. 13 summarises the rationales for the identification of relevant species, based on consultation with statutory stakeholders and fishermen, guidance documents, information on conservation status and relevant scientific advice and research.

Table 11. 13 Fish and shellfish species relevant to the proposed Norfolk Vanguard site with basis for consideration

Relevant Fish and Shellfish Species	Rationale
Commercial demersal fish species	
Dover sole	• Abundant throughout the study area • Species of principal importance • Commercially important in the study area • Low intensity spawning area overalps with the offshore cable route and NV West • Low intensity nursery areas overlaps with the inshore section of the offshore cable corridor
Plaice	• Abundant throughout the study area • Species of principal importance • High intensity spawning area overlaps with NV West, NV East and the offshore section of the offshore cable corridor • Commercially important species in the study area • Low intensity nursery area overlaps with the inshore section of the export cable corridor
Cod	• Species of principal importance and OSPAR listed species and 'vulnerable' on the IUCN Red List • Commercially important species to local vessels in the study area • Low intensity spawning area overlaps with the export cable corridor and NV West.

Relevant Fish and Shellfish Species	Rationale
	• Low intensity nursery area overlaps with the offshore project area
Whiting	• Abundant throughout the study area • Species of principal importance • Low intensity spawning and nursery areas overlap with the offshore project area
Seabass	• Commercially important to local fisheries and relatively abundant, particularly in areas in the proximity of the export cable corridor • Recent conservation concerns have led to changes in regulation to the fishery
Lemon sole	• Present throughout the study area • Spawning and nursery grounds overlap with the offshore project area
Commercial pelagic fish species	
Herring	• Present in the study area • Species of principal importance • Low intensity nursery area overlaps with the offshore project area • Key prey species for fish, birds and marine mammals • Demersal spawner
Sprat	• Abundant in the study area • Important prey species for fish, birds and marine mammal species • Spawning area (undefined intensity) overlaps with the offshore project area • Nursery areas (undefined intensity) overlaps with NV East
Ammodytidae (Sandeels)	
Greater sandeel Lesser sandeel Smooth sandeel Small sandeel	• Species of principal importance • Low intensity spawning and nursery areas in the study area • Key prey species for fish, birds and marine mammals • Demersal spawner
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 have important local commercial value • The study area is situated within low intensity nursery area for tope and thornback ray (potential for these areas to also be used for spawning)
Diadromous fish species	
Sea trout	• Present in some East Anglian rivers

Relevant Fish and Shellfish Species	Rationale
	• Species of principal importance • Feeding grounds located in the vicinity of the offshore project area, particularly in areas relevant to the export 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
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	• Considered to be of national importance • 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 (paritcularly 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
Non commercial fish species	
Includes grey gurnard, lesser weever fish and solenette (characterising species of the fish assemblage), and small demersal species Gobiidae spp.	• Present / abundant throughout the study area • Possible prey items for fish, bird and marine mammal species
Shellfish species	
Brown (edible) crab	• Present in the study area, particularly in areas relevant to the offshore cable corridor

Relevant Fish and Shellfish Species	Rationale
	• 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 export cable corridor • Commercially important species
Brown and pink shrimp	• Present in the study area, particularly in areas relevant to the western 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.

4.1.1 Commercial Demersal Species

4.1.1.1 Dover sole

72. In the North Sea, the main Dover sole populations are found south of latitude 56°N with a wide distribution in the southern North Sea (Limpenny *et al*., 2011) (Figure 11. 16). The major factor determining the population's northern limit is sea temperature (Burt and Millner, 2008). Sole show a preference for inhabiting sandy and muddy sediments at depths up to 70m, where their favoured food source (e.g. polychaetes) are most abundant (Limpenny *et al*., 2011). In winter months, 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).

73. 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).

74. NV East and NV West are located some distance away from sole spawning grounds (Figure 11. 17). This is further supported by charts produced by CHARM Consortium (Carpentier et al., 2009) (Figure 11. 18).

74. The offshore cable corridor however coincides with spawning areas defined by Ellis et al. (2010, 2012) (Figure 11. 17). The western section of the offshore cable corridor also falls within low intensity nursery grounds as demonstrated by Coull et al. (1998), the ichthyoplankton survey results given in Ellis et al. (2010, 2012) (Figure 11. 17) and findings by van Damme et al. (2011) (Figure 11. 19)

75. The 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. Ichthyoplankton surveys (van Damme et al., 2011) discovered the highest concentrations of stage one eggs between April and June (Figure 11. 19)

76. Sole is a key species targeted by fishermen in the vicinity of Norfolk Vanguard, predominantly by Dutch beam trawlers, a number of which UK registered and flagged vessels. Therefore, although seasonal data was not available, landings recorded by the UK fleet can be expected to be representative of the fishery as a whole. As shown in Figure 11. 18 and Figure 11. 19, sole landings by UK vessels vary throughout the year, with landings in NV West (34F2) particularly high between August and November.

77. As shown in Table 11. 9 Species with spawning and/or nursery grounds in NV West, NV East and the offshore cable corridor (Coull et al., 1998; Ellis et al., 2010, 2012), sole is listed as a species of principal importance. ICES have advised that landings of sole in 2017 should not exceed 15,251 tonnes in the North Sea (subarea IV) (ICES, 2016a).

78. 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).

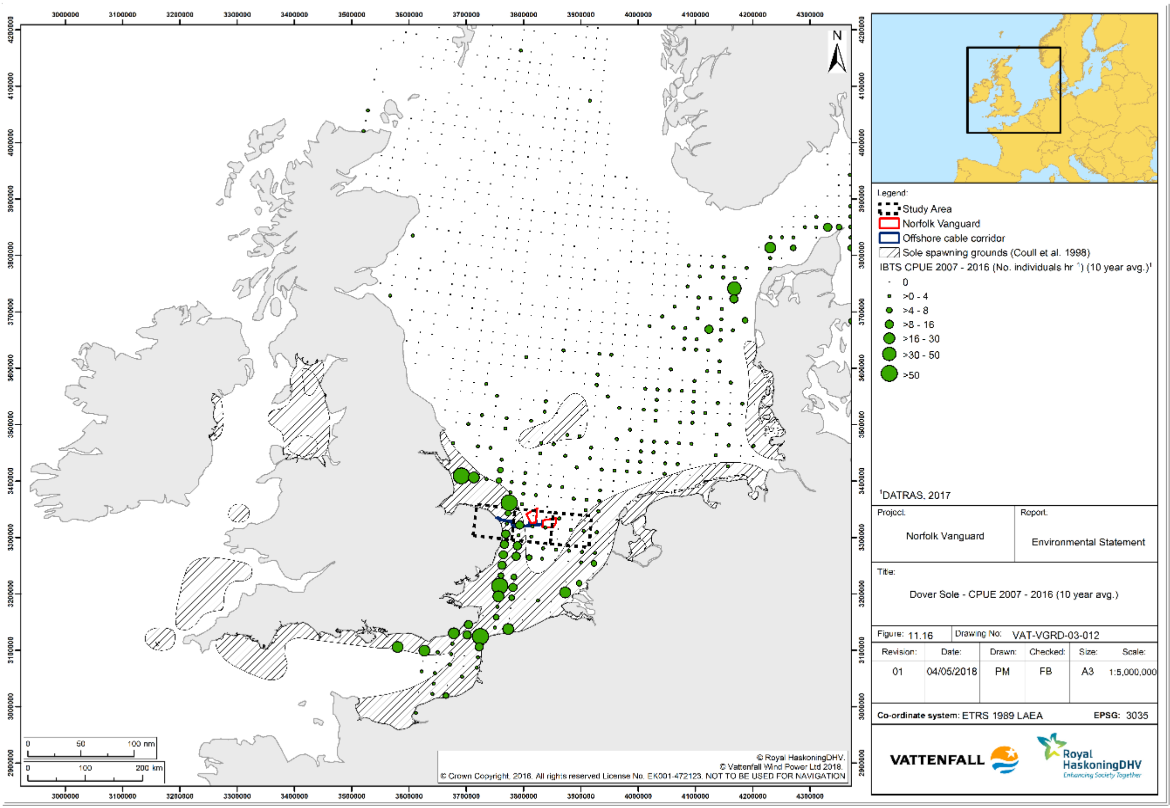


Figure 11. 16 Average number (catch per standardised haul) of Dover sole from IBTS survey data (2007-2016) (Source: DATRAS)

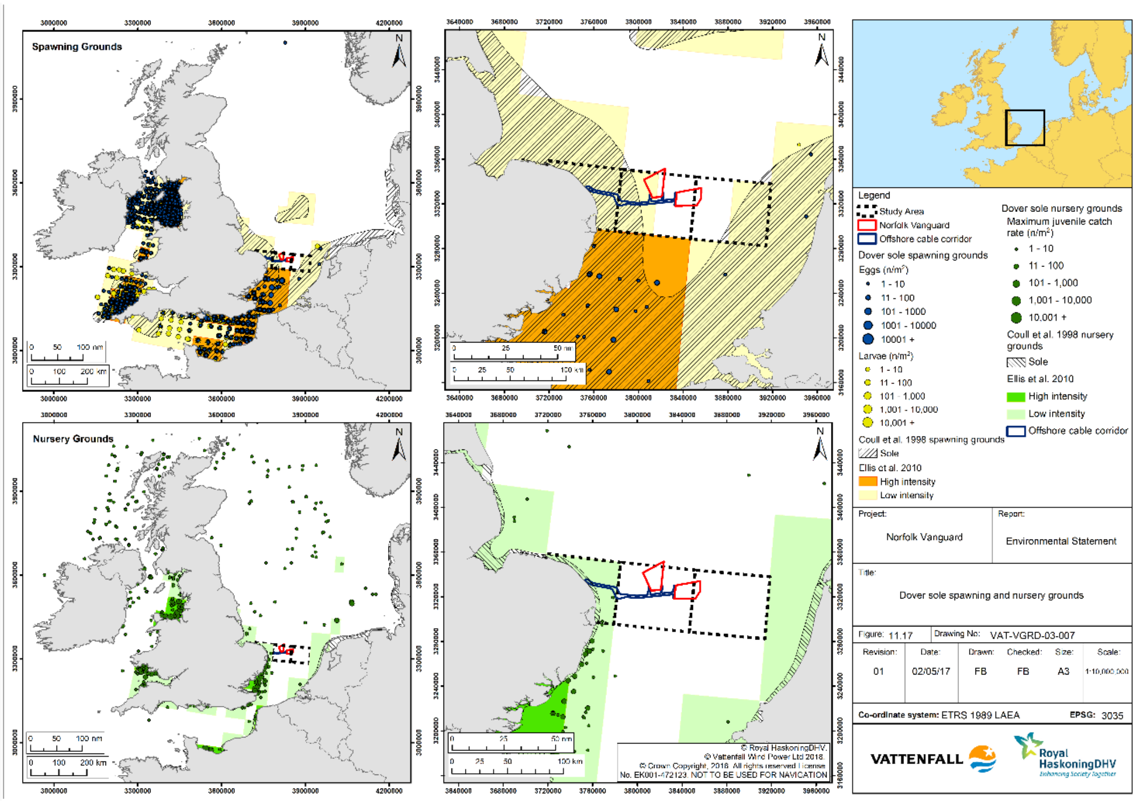


Figure 11. 17 Dover sole spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

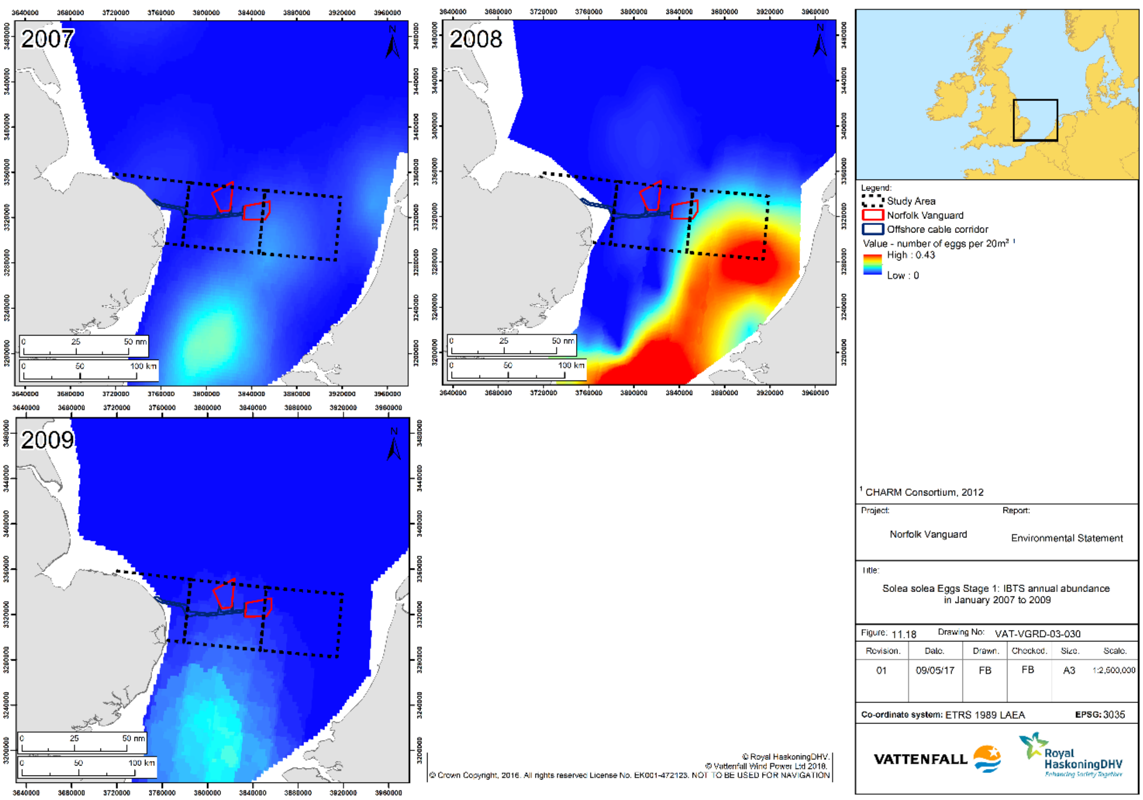


Figure 11. 18 IBTS abundance of Dover Sole eggs, stage one in January (2007-2009) (Source: CHARM Consortium). Note: CHARM Sole egg data only available 2007-2009.

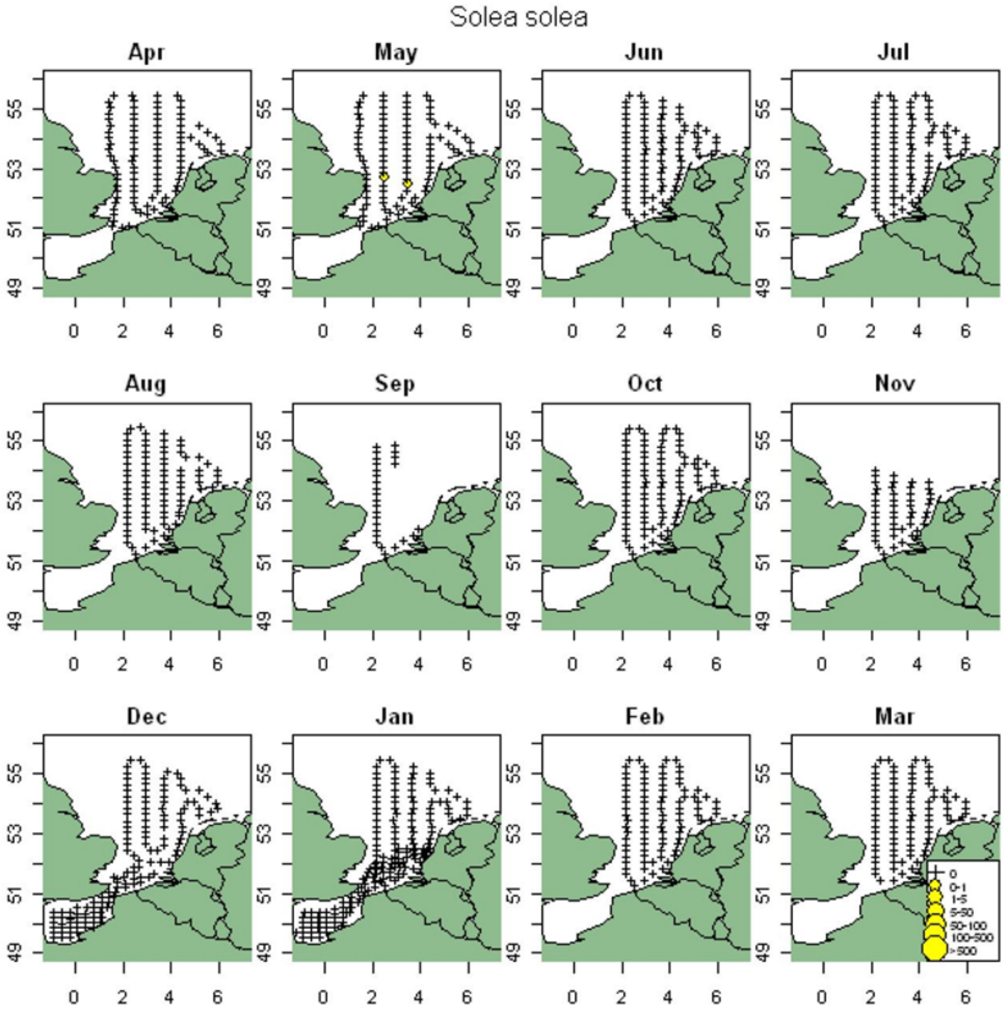


Figure 11. 19 Spatial and temporal distribution of Sole yolk sac larvae (van Damme et al., 2011)

4.1.1.2 Plaice

79. Plaice are widespread throughout the North Sea (Figure 11. 20) 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).

80. Findings of plaice tagging studies conducted in the North Sea (by Cefas and collaborators) 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).

81. Figure 11. 21 indicates that the western section of the offshore cable corridor overlaps with an area defined as a low intensity nursery ground for plaice (Ellis et al., 2010).

82. In the southern North Sea and English Channel where tides are stronger, the speed and direction of tidal flows influences plaice migratory behaviour (Creutzberg et al., 1978; Hufnag et al., 2013). Mature fish are understood to select the tidal streams flowing towards spawning grounds whilst spent fish use the reciprocal tidal stream to return to feeding grounds (Cefas, 2012).

83. Spawning in the North Sea is widespread, across most of the offshore and deeper areas of the southern North Sea, and off the UK coast from Flamborough Head to the Moray Firth with spawning areas connected to known nursery areas (Hufnag et al., 2013).

84. 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, as shown by Figure 11. 21 (Ellis et al., 2010). NV East, NV West and the eastern section of the offshore cable corridor fall within high intensity spawning grounds for plaice (Ellis et al., 2010) (Figure 11. 21). The focal centres of egg concentrations are considered to be located in the English Channel, Southern Bight and German Bight (Hufnag et al., 2013). There is considerable variation in the annual abundance and distribution of plaice stage one eggs, as the charts produced by CHARM illustrate. Highest abundances appear to concentrate for the most part to the north, south and east of the OWF sites (Figure 11. 22).

85. Ichthyoplankton surveys (Figure 11. 23) have generally found plaice stage one eggs in the southern North Sea between December and March, with the highest concentrations in the eastern southern North Sea occurring in January (van Damme et al., 2011). This concurs with other conclusions suggesting peak spawning occurs during the final two weeks of January (Simpson, 1959; Harding et al., 1978). Furthermore, tagging by Hunter et al. (2003) found individual fish return to the same spawning areas, suggesting strong spawning area fidelity.

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

87. Plaice are one of the main species targeted by commercial fishing vessels in the vicinity of the offshore project area, notably by Dutch beam trawlers (Figure 11. 10, Figure 11. 11 and Figure 11. 12). According to Beare et al. (2010) undersized plaice constitute a significant proportion of by-catch as a result of net mesh sizes. Plaice were also one of the principal species caught during the otter and beam trawl surveys undertaken in 2013 within the East Anglia THREE and former East Anglia FOUR sites (Table 11. 4, Table 11. 5).

88. 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 11. 12). ICES have advised that the TAC for plaice in Area lV (North Sea) for 2017 should not exceed 158,201 tonnes (ICES, 2016b).

89. 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).

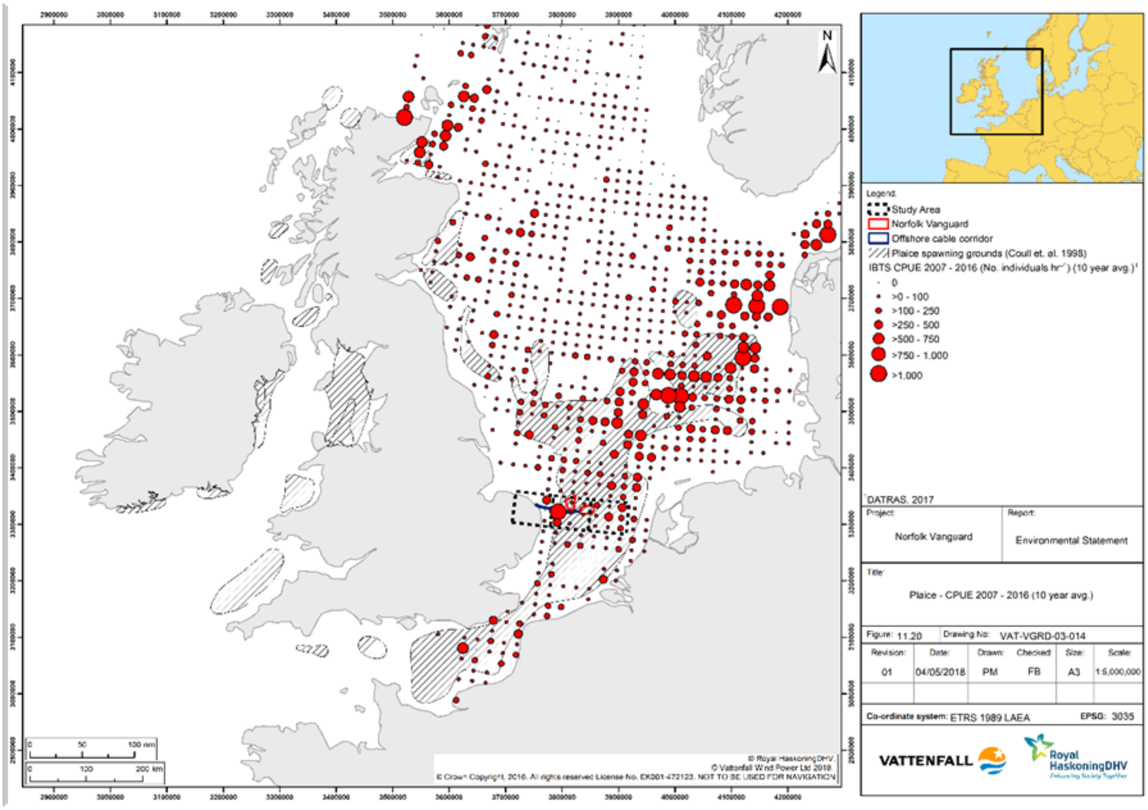


Figure 11. 20 Average number (catch per standardised haul) of Plaice from IBTS survey data (2007-2016) (Source: DATRAS)

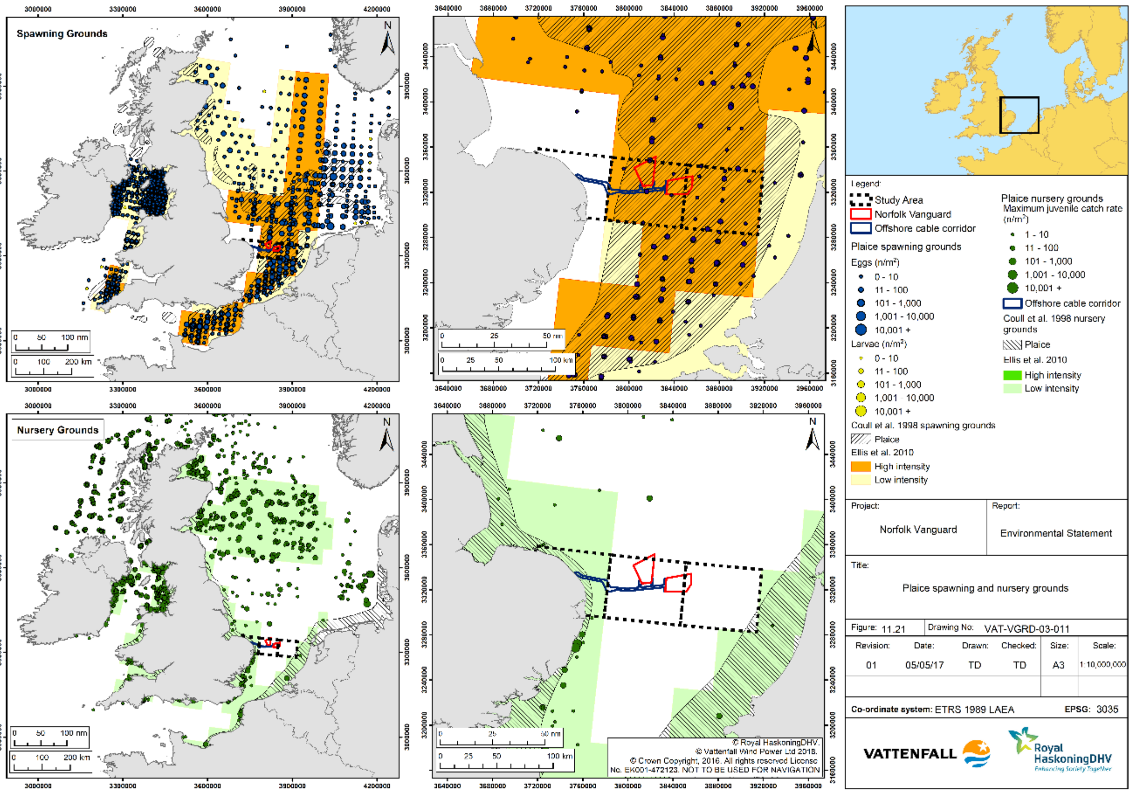


Figure 11. 21 Plaice spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

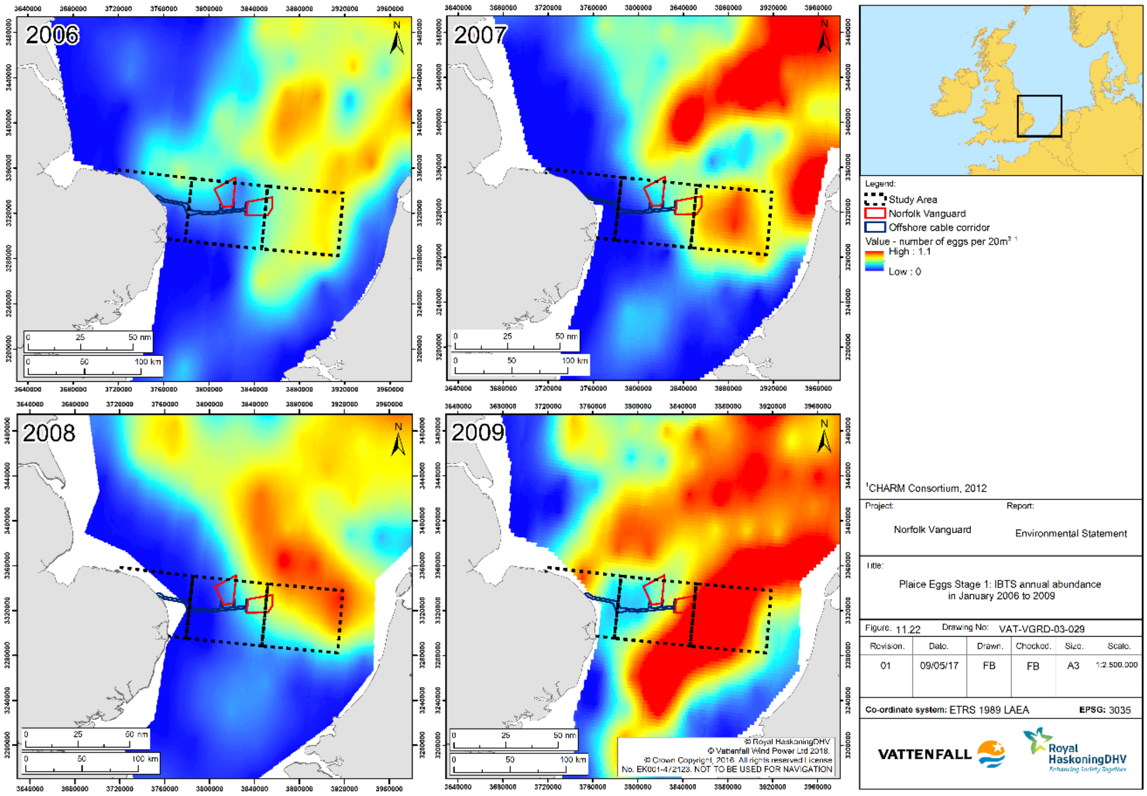


Figure 11. 22 IBTS abundance of Plaice eggs, stage one in January (2006-2009) (Source: CHARM Consortium)

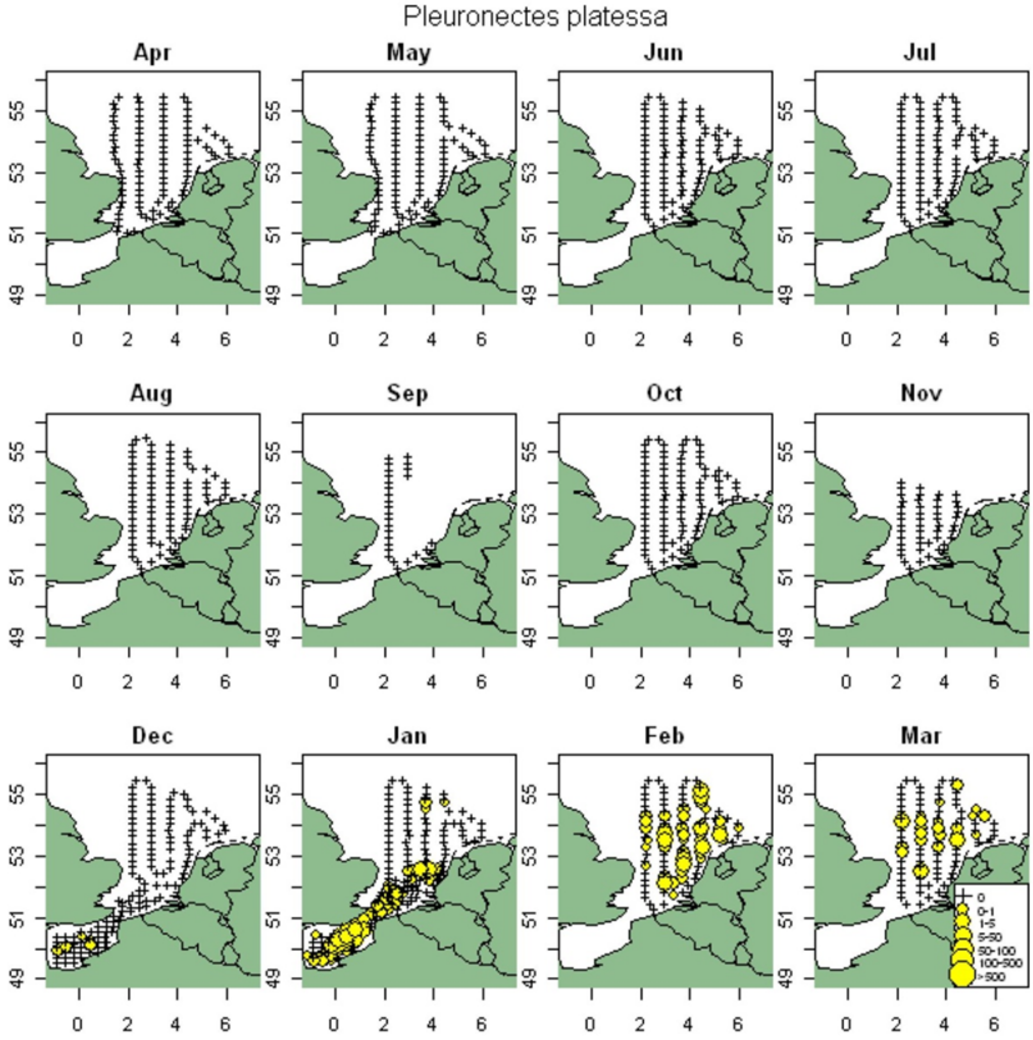


Figure 11. 23 Spatial and temporal distribution of Plaice yolk sac larvae (van Damme et al., 2011)

4.1.1.3 Cod

90. Both juvenile and adult cod are widely distributed throughout the North Sea (Figure 11. 24). Cod are a demersal species and are typically found at depths up to 500m within 30-80m of the seabed (Hedger et al., 2004). Demersal 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 IBTS 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. Cod undergo an extensive spawning migration, returning to the southern North Sea during autumn.

91. 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).

92. Hutchinson et al. (2001) have classified several genetically distinct populations within the southern and northern 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).

93. Limited information exits regarding the cod spawning areas which are currently active in the North Sea (Fox et al., 2008). Cod are pelagic spawners, hence cod spawning grounds are not substrate specific. 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). Van Damme et al. (2011) found yolk sac larvae at a limited number of sampling stations in the eastern sector of the southern North Sea in February (Figure 11. 28). 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). The low numbers of cod eggs at sites off Flamborough Head however suggests that this area can now be considered as a historical spawning ground (Fox et al., 2008).

94. NV West and the offshore cable corridor fall within an extensive low intensity spawning area defined by Ellis et al. (2010) (Figure 11. 25). 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). According to Coull et al. (1998) and Ellis et al. (2010), Norfolk Vanguard and particlarly NV East, coincide with low intensity cod nursery grounds (Figure 11. 25).

95. ICES also collects data on cod egg and larva abundance as part of the MIK (Isaacs-Kidd midwater trawl) herring larval sampling program during the annual IBTS survey. The data from MIK samples for the years 2006-2009 has been mapped by the CHARM III Project and the distribution of early stage cod eggs is presented in Figure 11. 26 and Figure 11. 27. Cod stage 1 and 2 eggs were present in comparatively low densities in the offshore project area in January for the years 2006, 2007 and 2008. As is apparent from Figure 11. 26 and Figure 11. 27, more extensive distributions of stage 1 and stage 2 cod eggs were observed to the east and north-east of the Norfolk Vanguard OWF sites.

96. 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).

97. In the central 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).

98. For management purposes, ICES currently defines three separate assessment areas for North Sea cod: Divisions IIIa (Skagerrak), VIId (English Channel) and Sub-Area IV (southern and northern North Sea). ICES have advised, on the basis of the EU-Norway management plan, that landings of cod in the North Sea should not exceed 47,431 tonnes in 2017 (ICES, 2016c). ICES reports that there has been a slow improvement in the status of the North Sea cod stock and spawning stock biomass over the last decade, with strong increases in stock abundance in more recent years (ICES, 2016c).

99. Cod is a target species of local long lining vessels in East Anglia, particularly in NV West (34F2) (Table 11. 8). In otter trawl samples at both control and windfarm stations conducted in February 2013 for East Anglia THREE and the former East Anglia FOUR, low numbers of cod were recorded overall. For East Anglia THREE, cod were only present during surveys in February, while for East Anglia FOUR cod were only present in May (Table 11. 4). It is also likely that cod, including undersized cod may form a proportion of the Dutch beam trawl catches which comprise the majority of fishing activity within the vicinity of the windfarm site.

100. 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 11. 12).

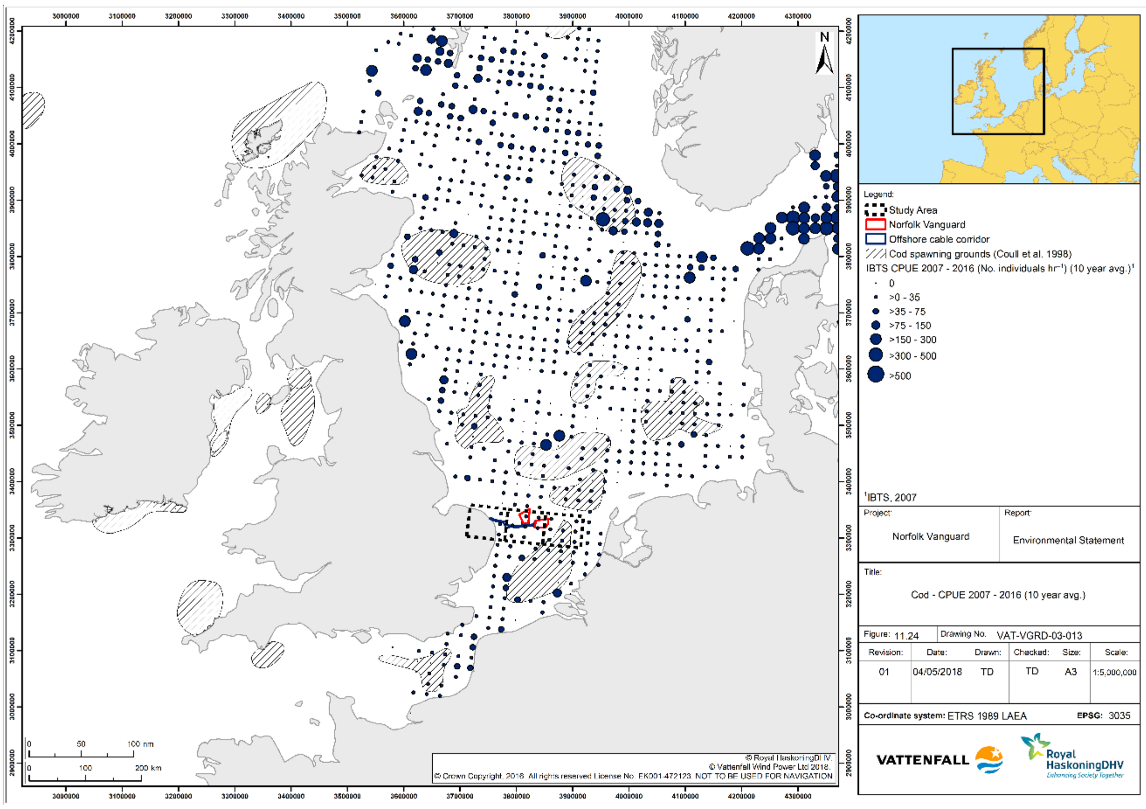


Figure 11. 24 Average number (catch per standardised haul) of Cod from IBTS survey data (2007-2016) (Source: DATRAS)

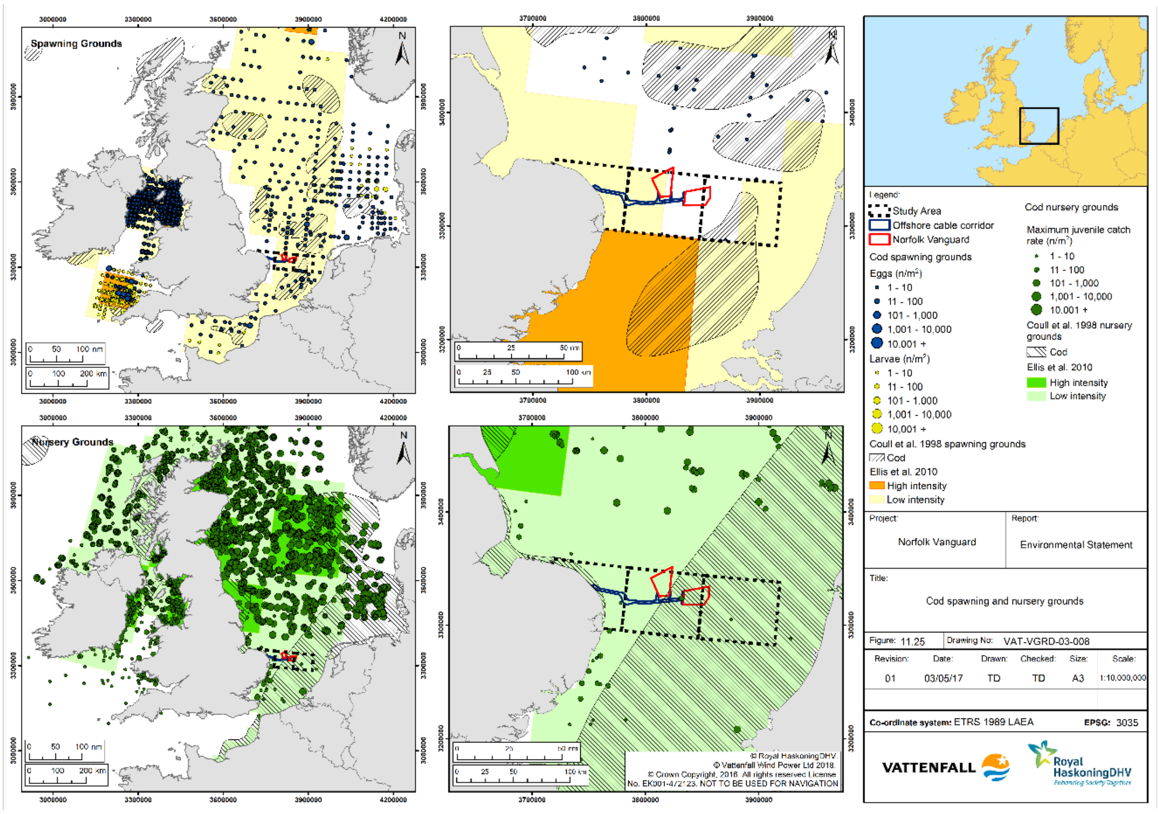


Figure 11. 25 Cod spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

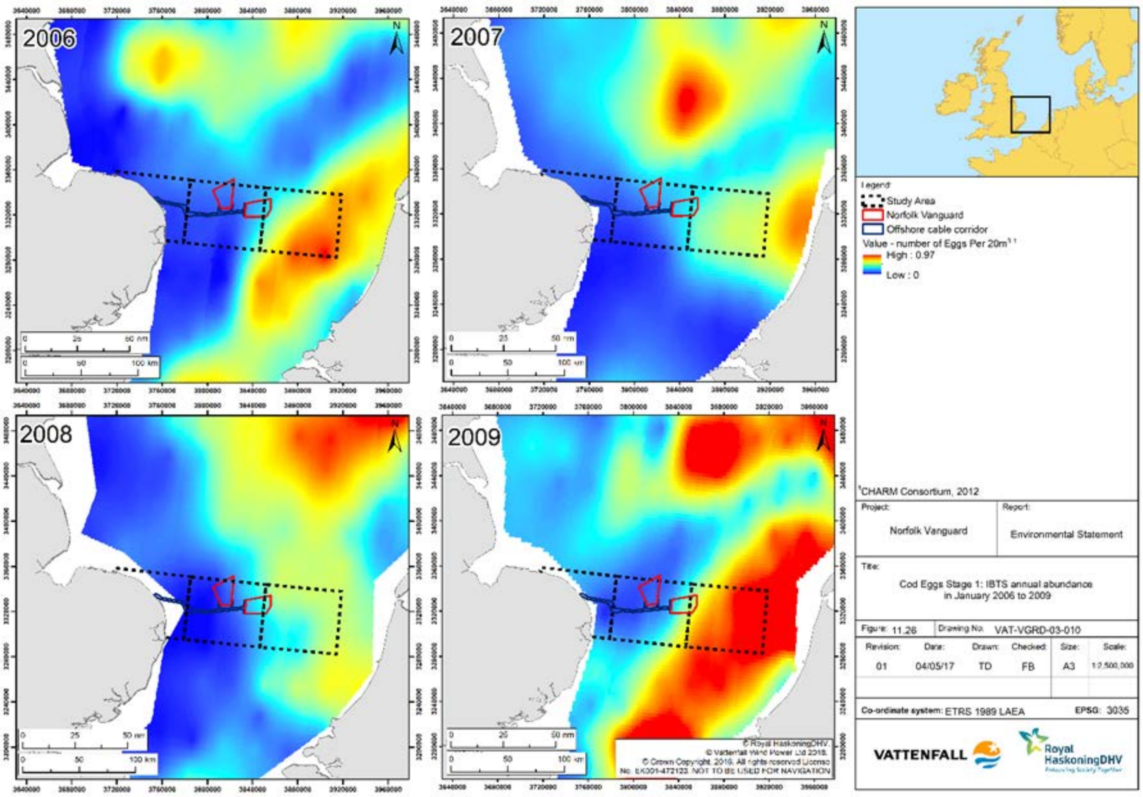


Figure 11. 26 IBTS abundance of Cod eggs stage one in January (2006-2009) (Source: CHARM Consortium, 2012)

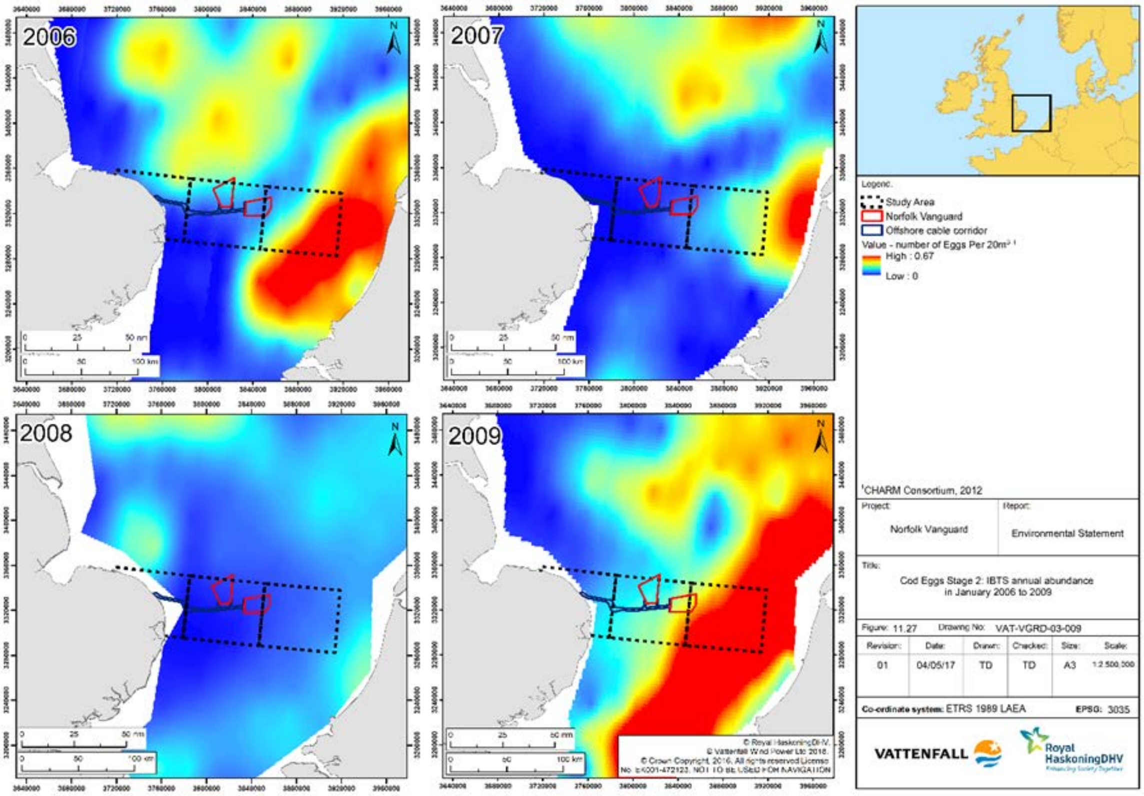


Figure 11. 27 IBTS abundance of Cod eggs stage two in January (2006-2009) (Source: CHARM Consortium, 2012)

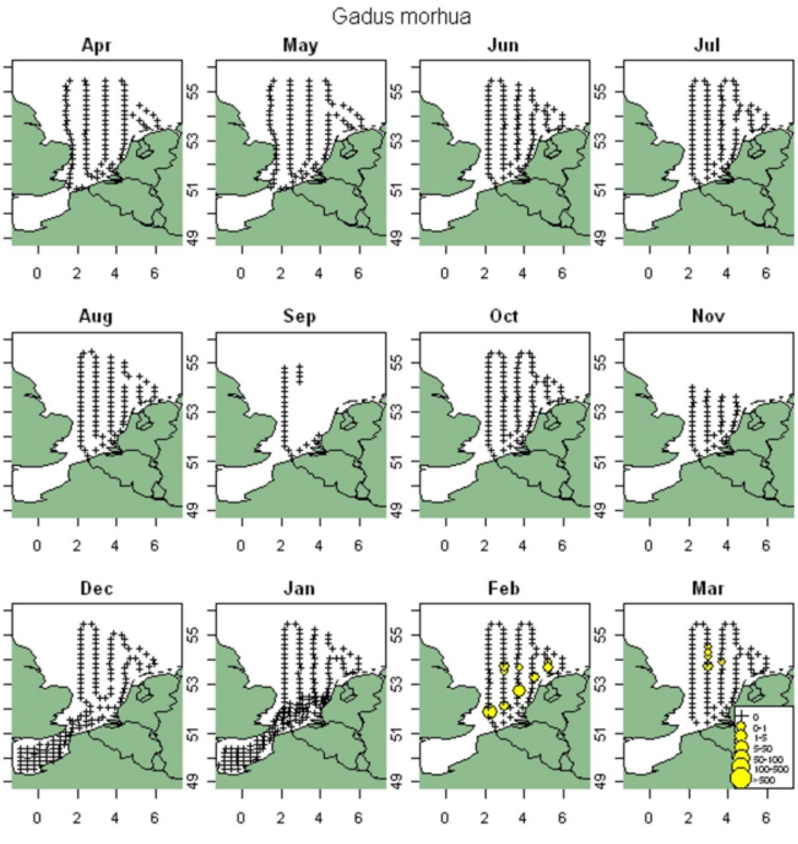


Figure 11. 28 Spatial and temporal distribution of Cod yolk sac larvae (van Damme et al., 2011)

4.1.1.4 Whiting

101. Whiting is broadly distributed throughout the North Sea and is common to inshore waters (Loots *et al*., 2011) (Figure 11. 29). Whiting is a fast-growing demersal species, considered to be most abundant between 30m and 100m inhabiting a variety of substrates such as mud, gravel, sand and rock (Barnes, 2008a). As illustrated by Figure 11. 29, whiting occur throughout the North Sea, Skagerrak and Kattegat (ICES, 2016d) with high densities of both juvenile and adult whiting found almost anywhere, with older individuals (>2yr) demonstrating a preference for deeper waters (Daan *et al*., 1990).

102. 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 11. 30, the offshore project area is located within extensive areas defined as low intensity spawning and nursery grounds for whiting (Ellis *et al*., 2010). It is of note that the distributions of eggs and larvae given in Figure 11. 30, reproduced from Ellis *et al*. (2010), do not correlate with the whiting spawning grounds depicted by Coull *et al*. (1998).

103. 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 between 50 and 100m (Limpenny et al., 2011).

104. Whiting spawn 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 period.

105. Stage one whiting eggs have been found in the vicinity of the offshore project areas in June (van Damme et al., 2011) (Figure 11. 33) coinciding with the later spawning period given in Ellis et al., (2012). Whiting yolk sac larvae were found between January to March during previous IMARES surveys (van Damme et al., 2011) (Figure 11. 33)

106. Fishermen target whiting throughout the North Sea, although substantial quantities are also discarded from commercial catches (ICES, 2016d). Landings by weight for whiting are comparatively low in the offshore cable corridor (34F1), NV West (34F2) and NV East (34F3) (Table 11. 9). However, during the otter trawl fish sampling undertaken in East Anglia THREE and former East Anglia FOUR sites in 2013, whiting was one of the top three species caught (Table 11. 4).

107. According to charts produced by the CHARM Consortium (Figure 11. 31 and Figure 11. 32) there is large variation in the annual abundance and distribution of whiting eggs in the proximity of the offshore project areas. During January 2009 in the English Channel and southern North Sea, the data suggest an increase in egg abundance in comparison to previous years, particularly for stage 2 eggs. However, this pattern may be as a consequence of the IBTS surveys only having been conducted during January, in addition to their limited spatial coverage.

108. As shown in Table 11. 12, 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 23,527 tonnes in the North Sea and Eastern Channel for whiting for 2017 (ICES, 2016d).

109. 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).

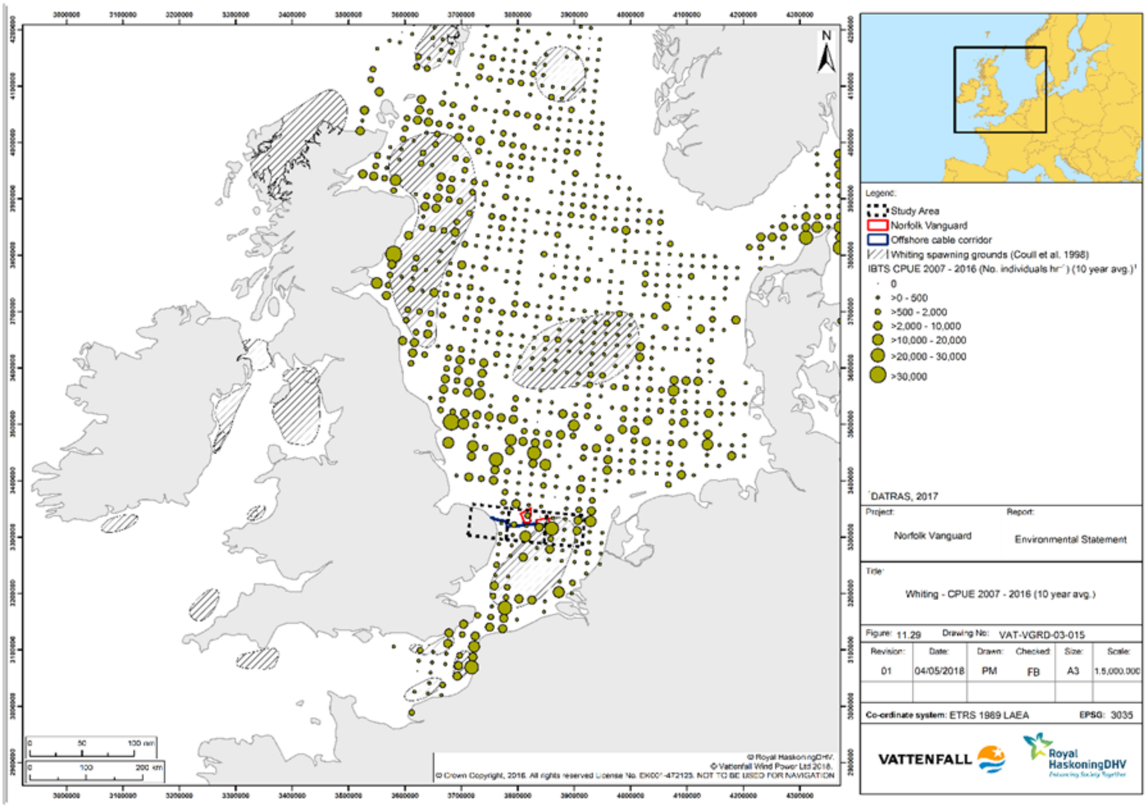


Figure 11. 29 Average number (catch per standardised haul) of Whiting from IBTS survey data (2007-2016) (Source: DATRAS)

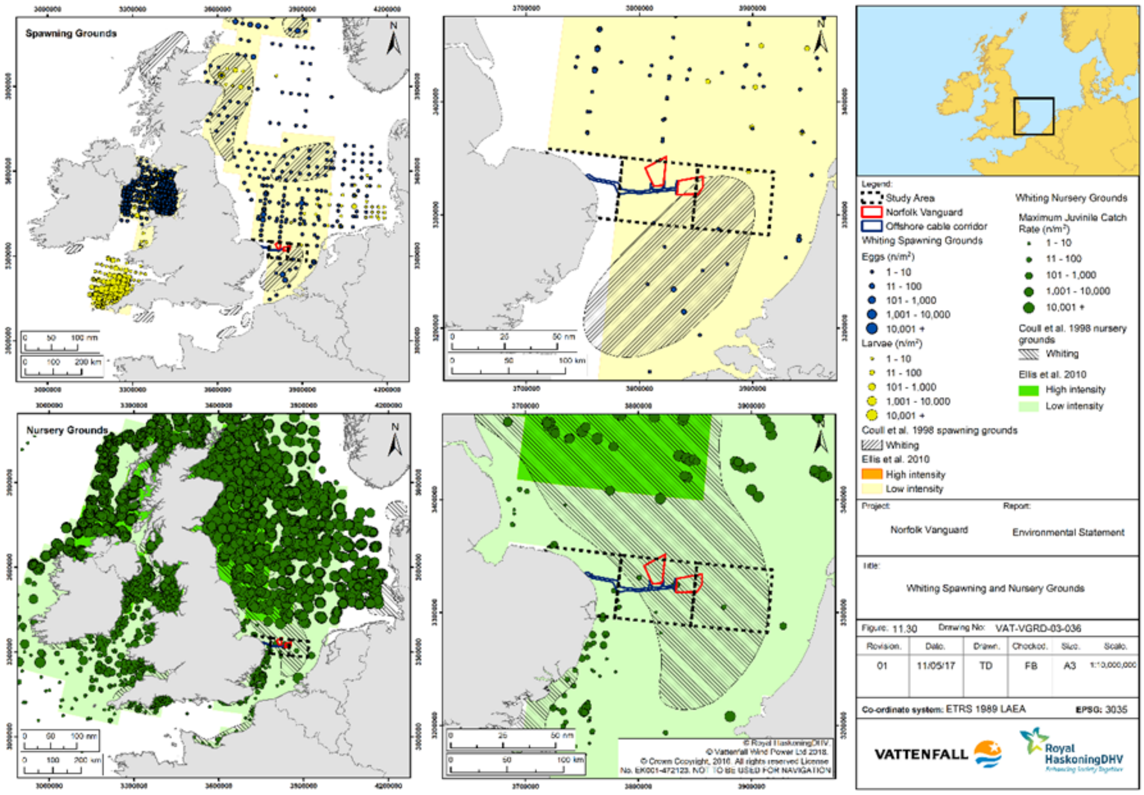


Figure 11. 30 Whiting spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

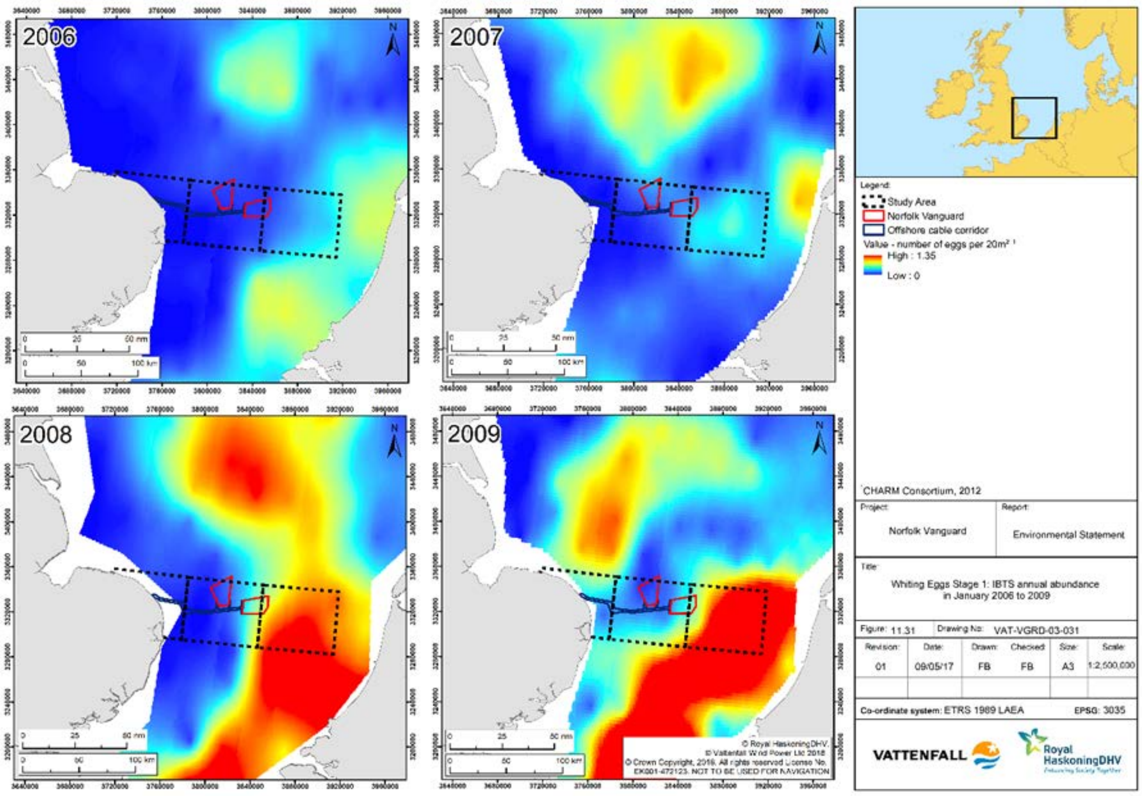


Figure 11. 31 IBTS abundance of Whiting Eggs Stage one in January (2006-2009) (source: CHARM Consortium, 2012)

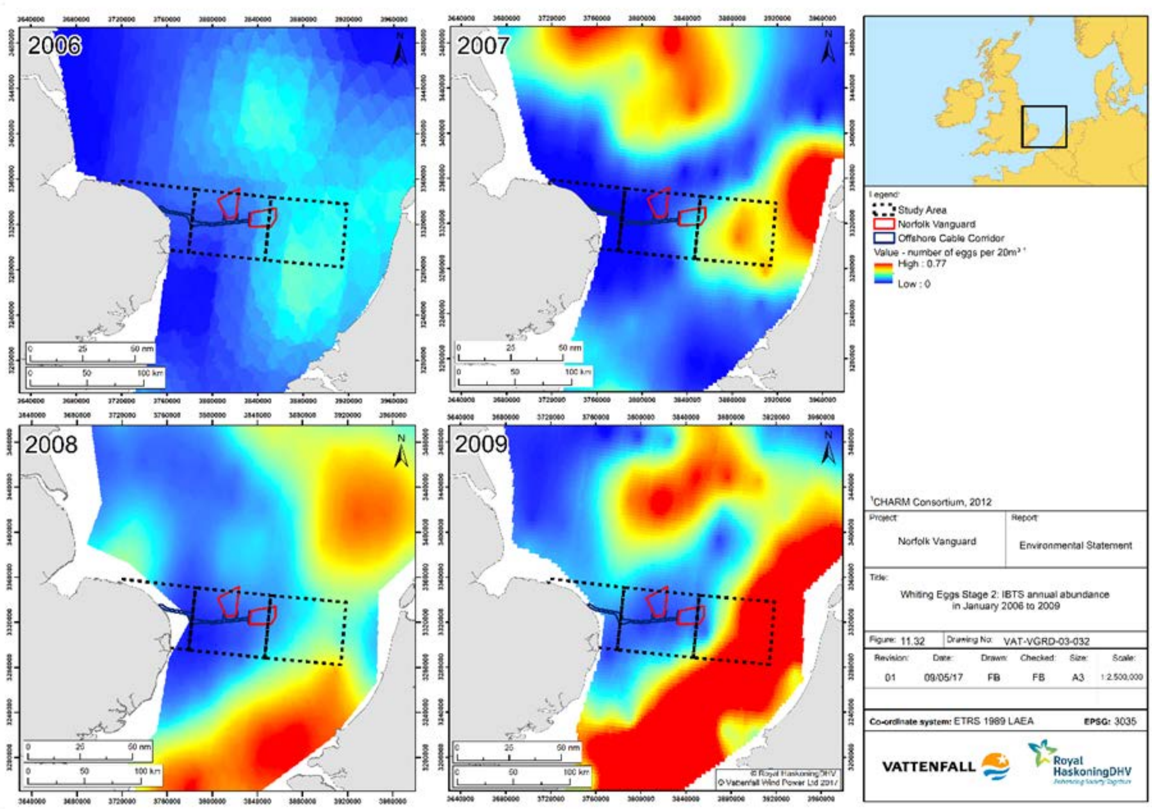


Figure 11. 32 IBTS abundance of Whiting Eggs Stage two in January (2006-2009) (source: CHARM Consortium, 2012)

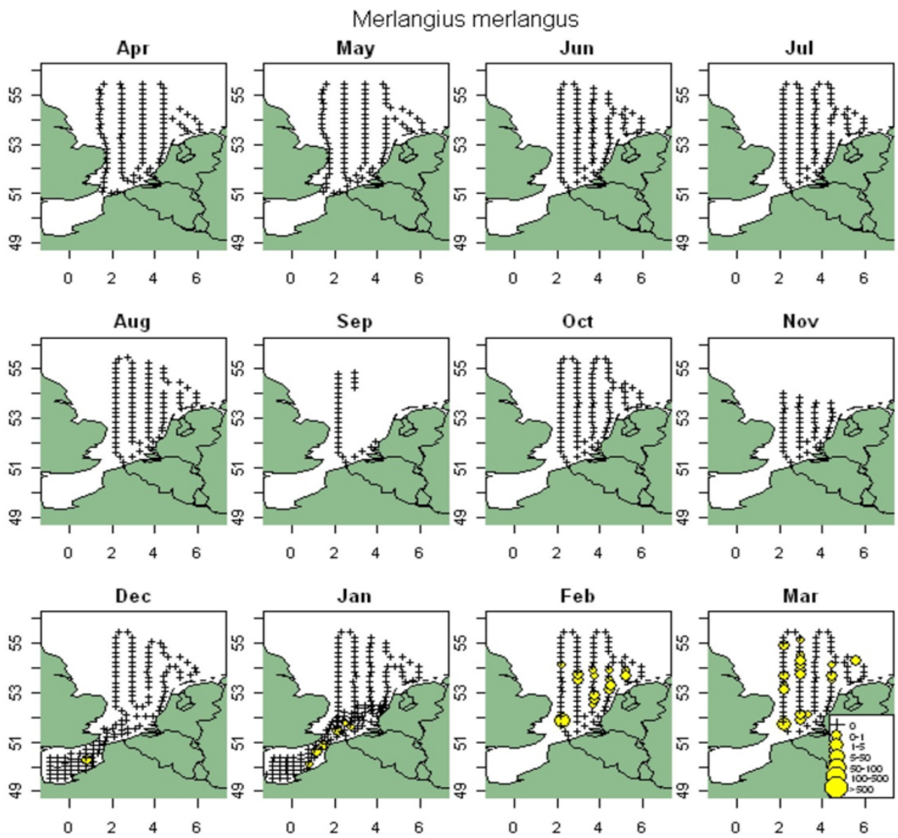


Figure 11. 33 Spatial and temporal distribution of whiting yolk sac larvae (van Damme et al., 2011)

4.1.1.5 Sea bass

110. 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).

111. Sea bass are group spawners, releasing pelagic eggs into the water column once a year, usually in spring. The juvenile stage occurs approximately 2 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). Bass can tolerate brackish water habitats such as those in estuaries and river mouths where they spend much of their juvenile stage (Kennedy and Fitzmaurice, 1972). Sea bass reach maturity between 4 and 7 years of age (~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.

112. Fully mature 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 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).

113. 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.

114. 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, 2016e). 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).

115. As of 1st January 2017, new bass fishing regulations came into play throughout the UK. In the North Sea, commercial fisheries are only permitted to catch and retain bass with fixed gillnets, hooks and lines, demersal trawls and seines. Use of any other gears to catch or retain bass, including drift nets, are prohibited.

116. Figure 11. 34 shows the extent of the historical sea bass fishery in the vicinity of Norfolk Vanguard.

117. Seabass is classified as of ‘Least Concern’ in the IUCN Red List of Threatened Species (Table 11. 12). Chartable data for sea bass is limited.

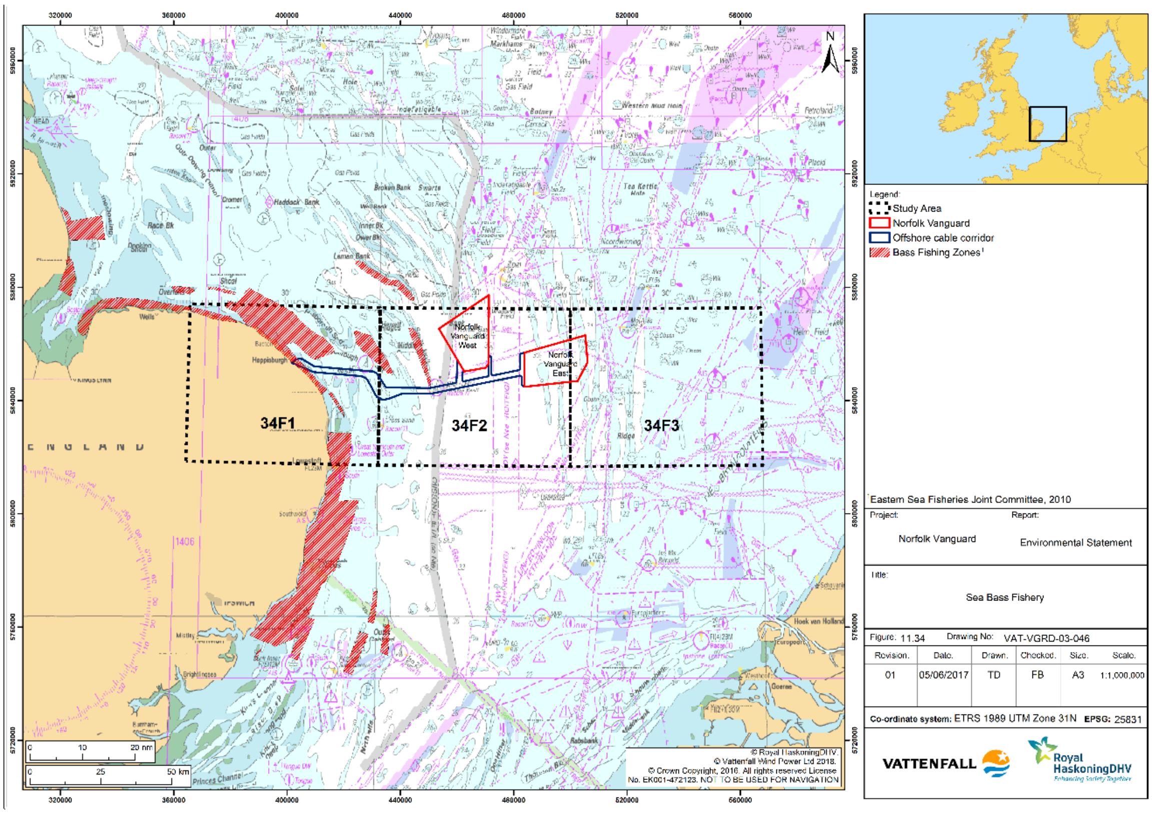


Figure 11. 34 Sea Bass Fishing areas (Source: Eastern Sea Fisheries Joint Committee, 2010)

4.1.1.6 Lemon Sole

118. Lemon sole Microstomus *kitt* 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 common in the central region of the North Sea and off the east coast of Scotland, as shown in Figure 11. 35. 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).

119. Lemon sole may be found over a variety of substrate types between 40 to 200m depth (Wheeler, 1969). Lemon sole appear to prefer sandy and gravelly substrates, living deeper and at higher salinity and lower temperature than plaice or sole (Cotter *et al*, 2004).

120. 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, in addition to NV West (Figure 11. 36).

121. The lemon sole does not have well-defined spawning grounds, but simply spawns 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.

122. Lemon soles 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).

123. There is no formal or analytical assessment of lemon sole in EU waters (ICES, 2015b). However, survey information available for the North Sea subarea IV and Divisions IIIa and VIId indicates stable biomass at a high level, although landings data show a declining long-term trend (ICES, 2015b). ICES advice for 2016 and 2017 is that catches of Lemon Sole should be no more than 5,655 tonnes (ICES, 2015b). Provided discard rates do not change (30% of the total catch) this implies landings of no more than 3,959 tonnes

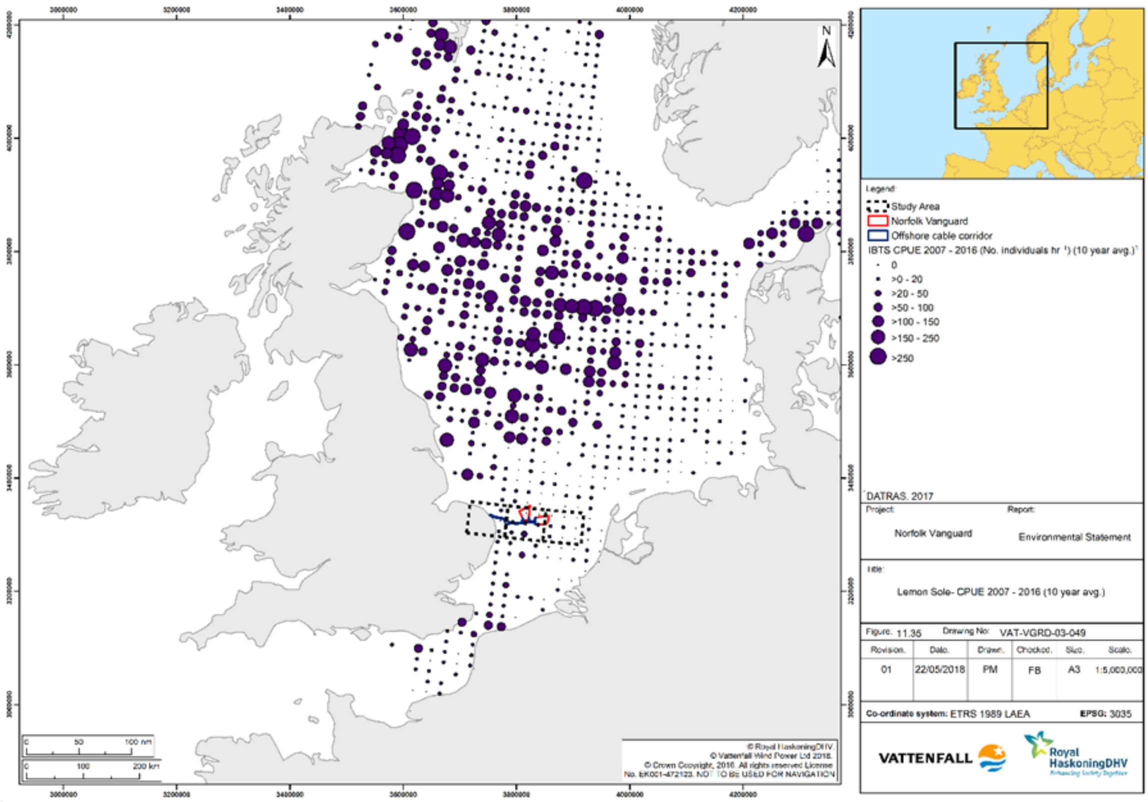


Figure 11. 35 Average number (catch per standardised haul) of Lemon sole from IBTS survey data (2007-2016) (Source: DATRAS)

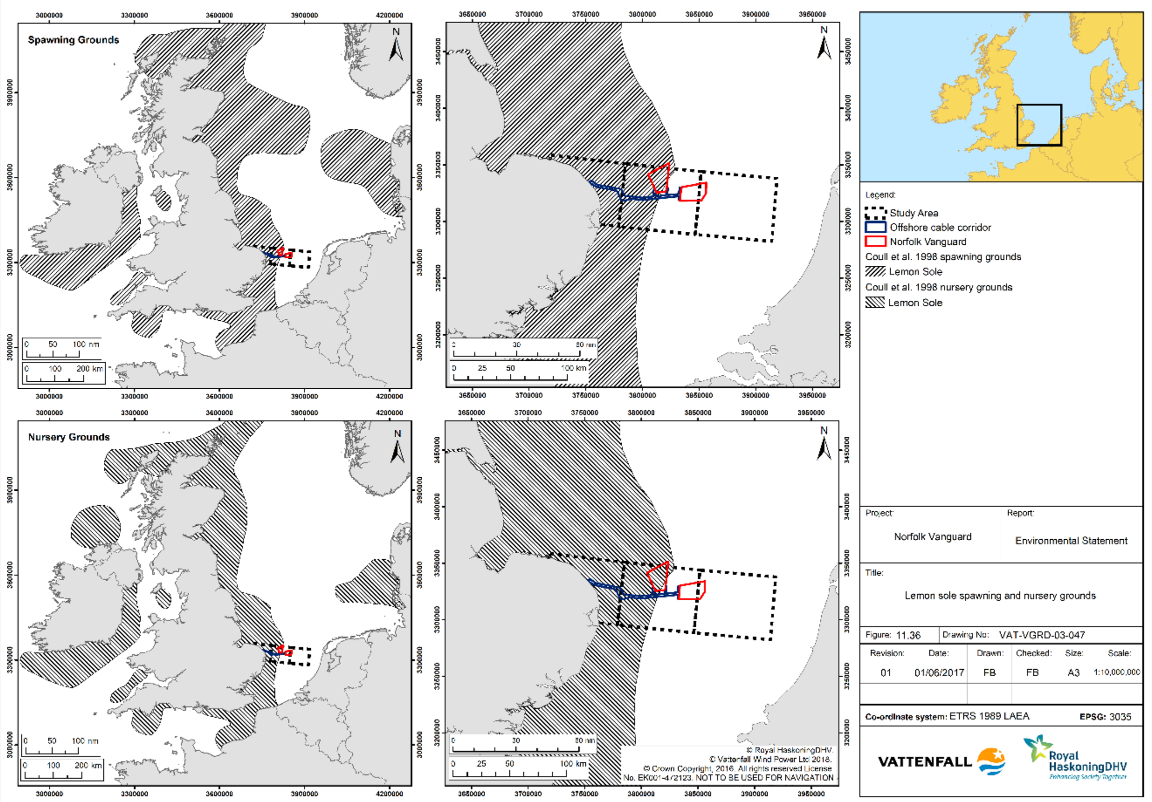


Figure 11. 36 Lemon sole spawning and nursery grounds (Source: Coull et al., 1998)

4.1.2 Commercial Pelagic Species

4.1.2.1 Herring

124. Herring are prevalent throughout the North Sea (Figure 11. 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).

125. The North Sea autumn-spawning herring stock is understood to consist 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) (Figure 11. 39). The Downs sub-population is of relevance to Norfolk Vanguard. The Downs herring 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) (Figure 11. 38). In the spring, the Downs herring move to the central and northern North Sea to feed (Corten, 2001).

126. The Downs herring typically spawn in high energy environments at depths 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).

127. The Downs herring sub-population is less fecund than the other three spawning components within the North Sea (i.e. produce fewer eggs). However, Downs herring produce larger eggs (Baxter, 1959 and 1963; Cushing, 1958; Almatar and Bailey, 1989) thus hatched larvae are larger than their northern counterparts (Heath *et al*., 1997). Depending on the 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).

128. 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). Dickey-Collas et al. (2009) propose that herring larvae can travel up to 100km in the first 15 days after hatching. High numbers of drifting larvae from the Downs component are dispersed along the Dutch coastline during transportation towards the German Bight and Skagerrak.

129. The OWF sites are located a considerable distance from the spawning grounds of the Downs component as demonstrated by Coull *et al*. (1998) and Ellis *et al*. (2010) (Figure 11. 38). Figure 11. 38 also demonstrates that the offshore project areas fall with broadly defined low intensity nursery grounds for hering (Ellis *et al*., 2010). Herring larvae densities in the immediate vicinity of the OWF sites are low, according to the results of the IHLS conducted in the area in recent years (Figure 11. 41, Figure 11. 42 and Figure 11. 43).

130. The southern limit of the central North Sea survey occurs at ICES rectangles 36F0 and 36F1; some distance to the north of Norfolk Vanguard. There is a low abundance of Banks larvae at sites in ICES rectangles 36F0 and 36F1. This indicates that Banks herring are not moving further south beyond the spawning areas mapped by Coull et al. (1998) and that Banks herring are not spawning in the locality of the offshore project area.

131. Monthly ichthyoplankton surveys encompassing the offshore project area did not find yolk sac herring larvae in the vicinity of the Norfolk Vanguard site; larvae were found in the Strait of Dover and the English Channel in November, December and January (van Damme et al., 2011) (Figure 11. 40). IHLS southern North Sea surveys conducted between 2007 and 2016 however recorded some small larvae (<11mm) at stations surrounding, but outside of Norfolk Vanguard (Figure 11. 41, Figure 11. 42 and Figure 11. 43). It cannot be ruled out, therefore that on occasions, currents may carry some planktonic larvae through the Norfolk Vanguard site, from spawning grounds in the eastern English Channel to the nursery areas along the Dutch coast and into the German Bight (Maurcops, 1969; Munro *et al*., 1998; Hodgson, 1957; ICES, 2010b).

132. Herring is of limited commercial importance within the study area (Table 11. 7 and Table 11. 8). Clupeids (herring and sprat) were present, albeit in relatively low numbers, at sites sampled in the East Anglia THREE and former East Anglia FOUR surveys (Table 11. 4, Table 11. 5 and Table 11. 6).

133. Herring is of conservation interest, being listed as a Species of principal importance (Table 11. 12). 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 is 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).

134. Overall in recent years, herring recruitment in the North Sea has been low. This is thought to be associated with a fall in larval survival rates during the overwintering phase, driven by increases in water temperatures in the North Sea and changes in the plankton community (Payne *et al*., 2009). ICES have advised on the basis of precautionary considerations, that total catches should be no more than 426,259 tonnes in the North Sea and Eastern Channel for herring for 2017 (ICES, 2016f).

135. 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).

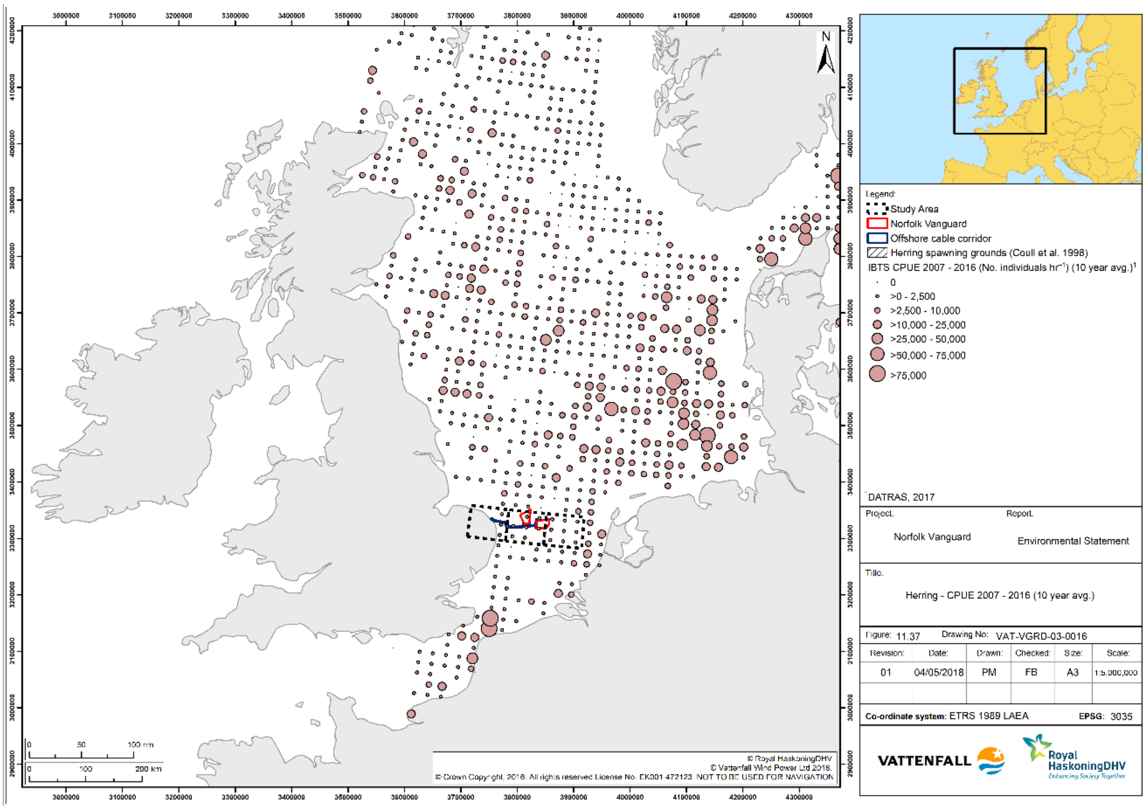


Figure 11. 37 Average number (catch per standardised haul) of Herring from IBTS survey data (2007-2016) (Source: DATRAS)

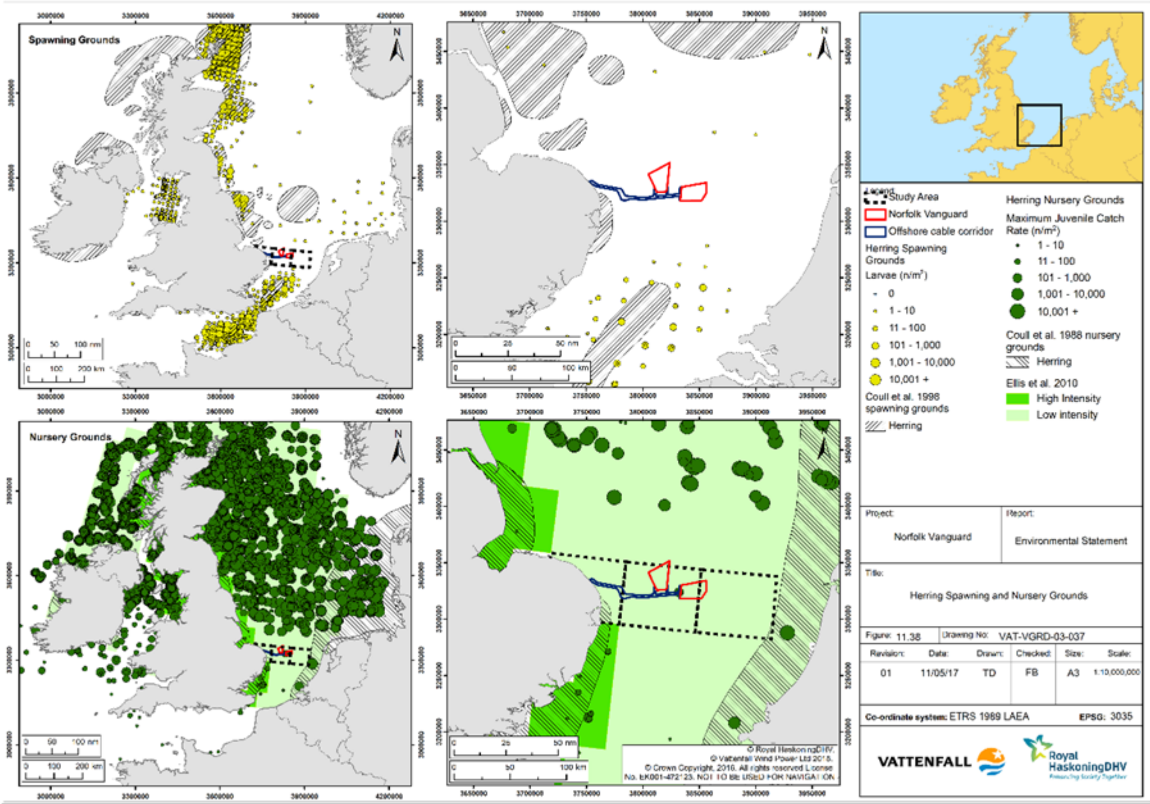


Figure 11. 38 Herring spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

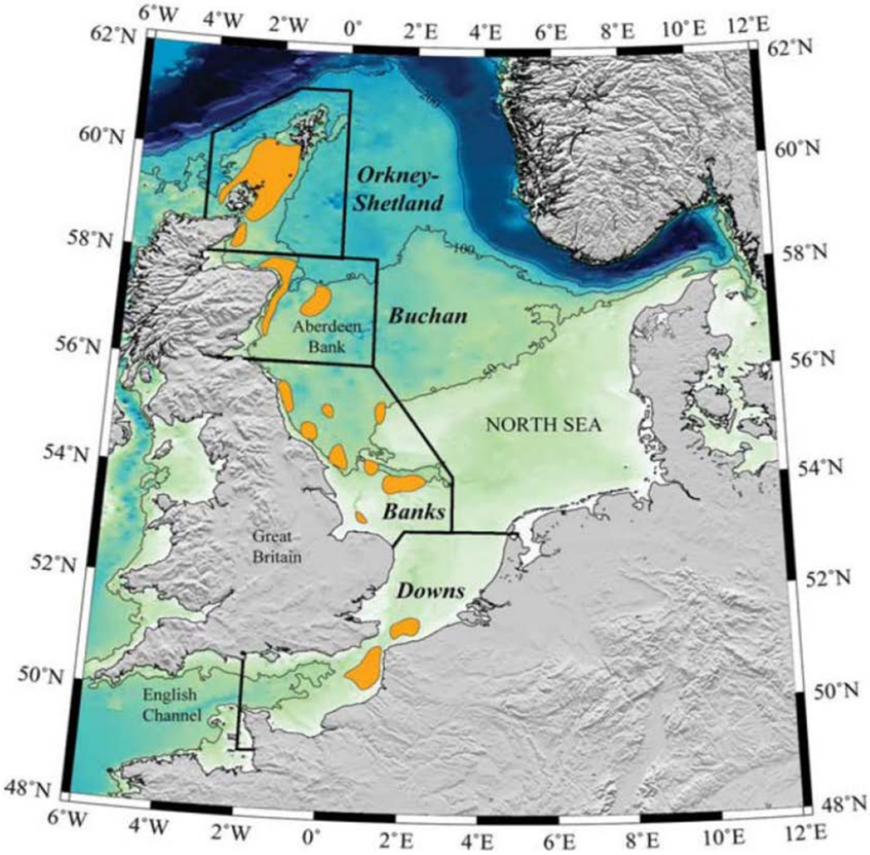


Figure 11. 39 Atlantic herring spawning sub-populations in the North Sea (From: Payne, 2010).

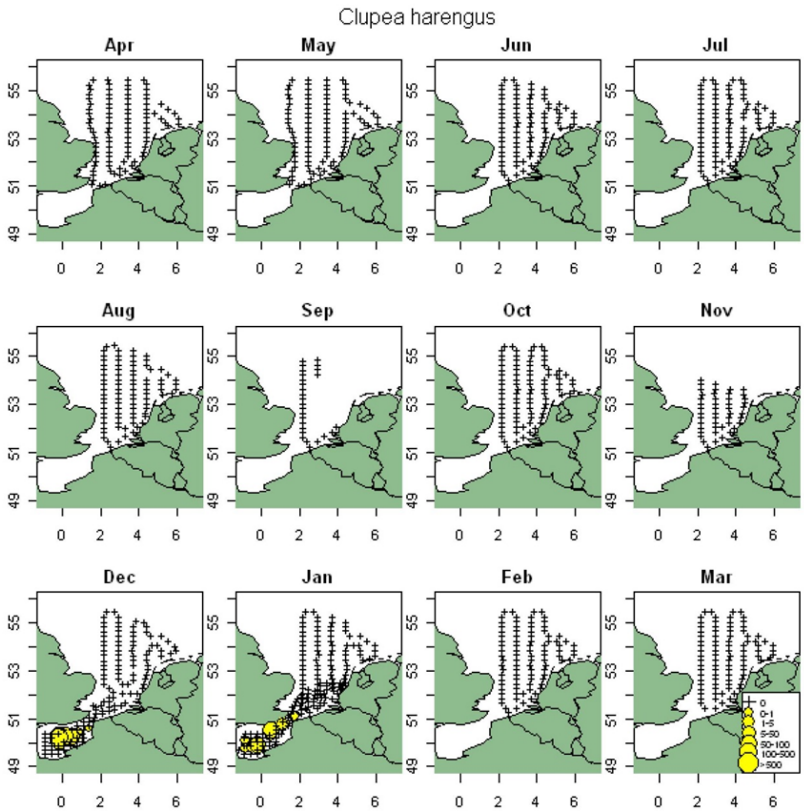


Figure 11. 40 Spatial and temporal distribution of herring yolk sac larvae (van Damme et al., 2011)

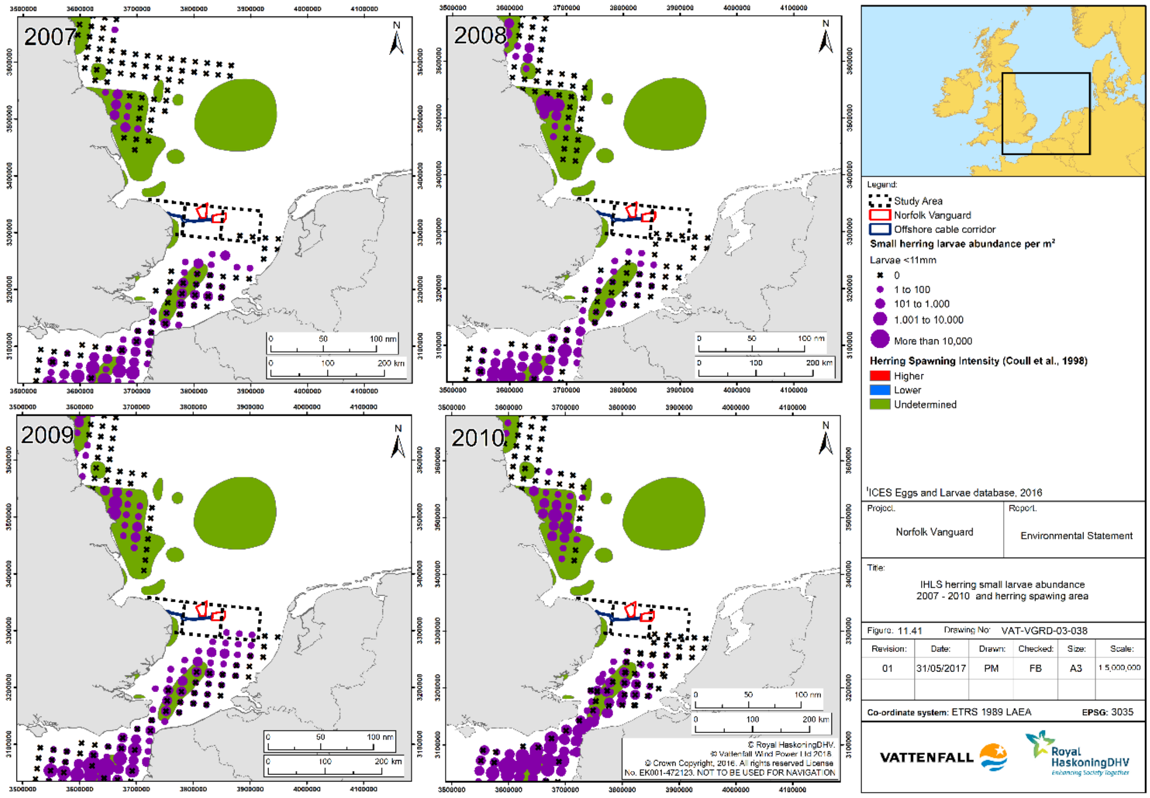


Figure 11. 41 IHLS herring small larvae abundance (2007-2010) (Source: ICES Eggs and Larvae database)

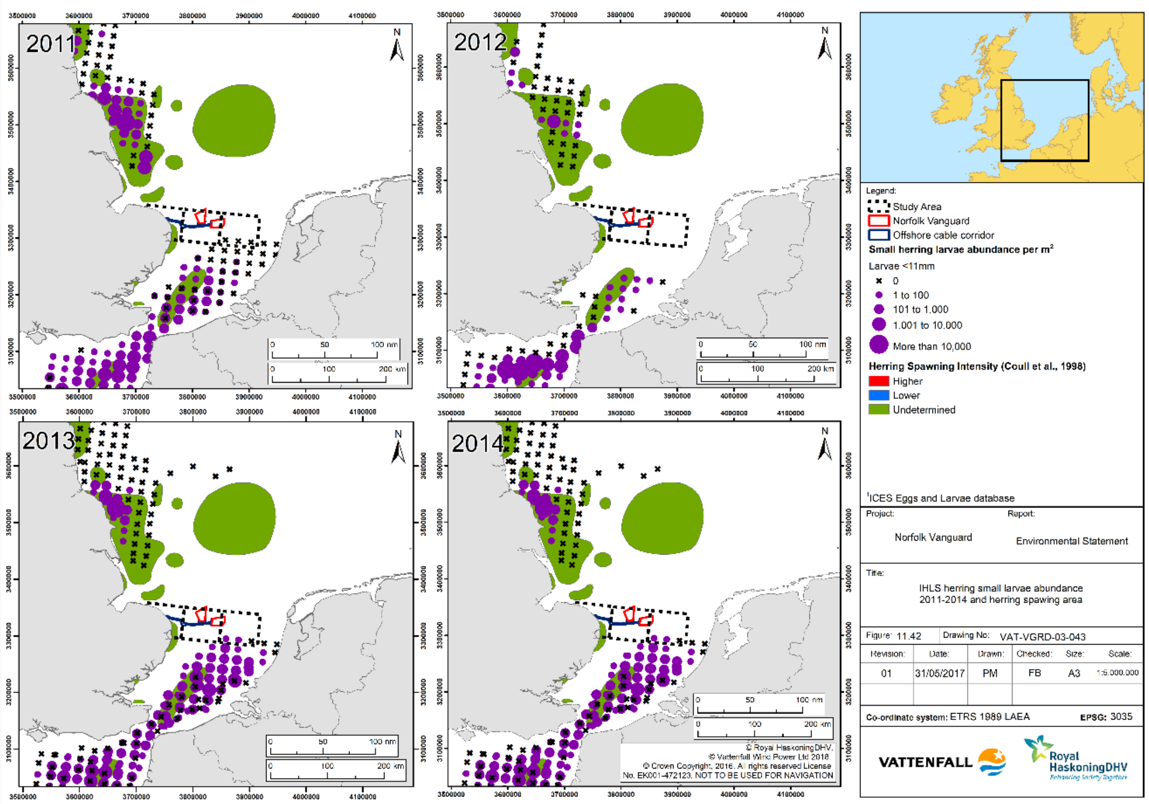


Figure 11. 42 IHLS herring small larvae abundance (2011-2014) (Source: ICES Eggs and Larvae database)

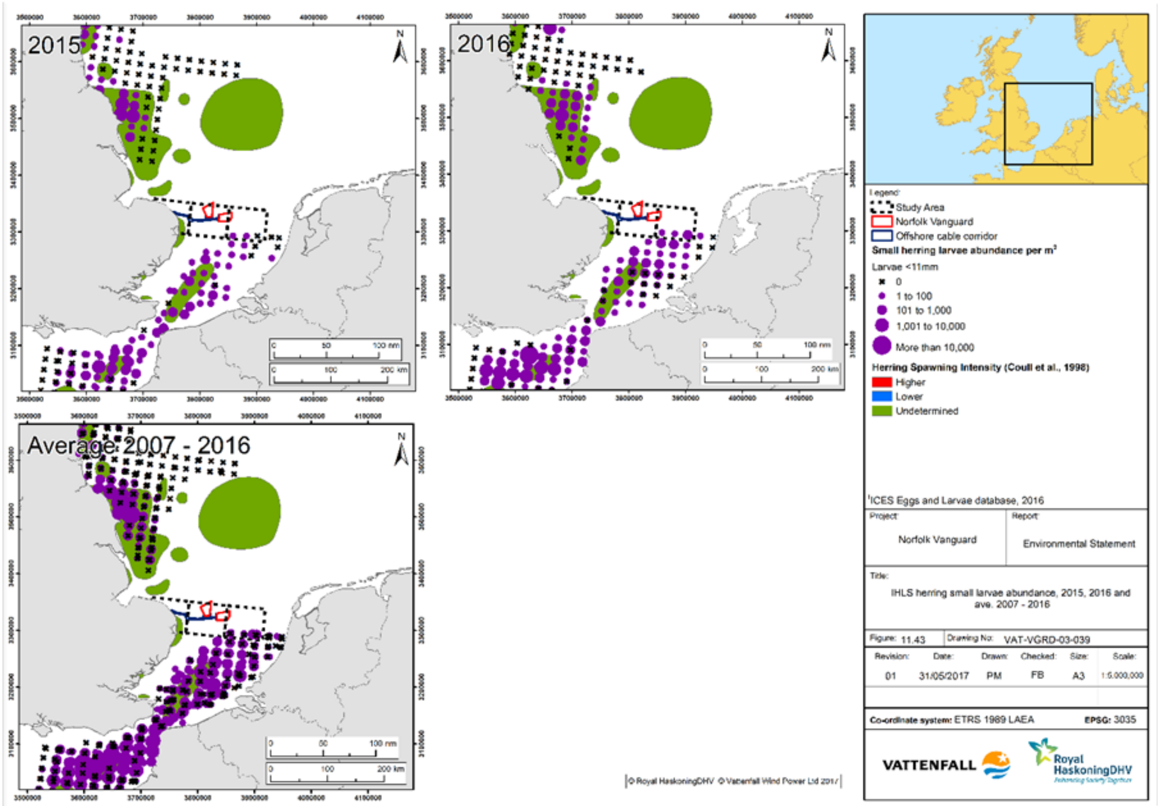


Figure 11. 43 IHLS herring small larvae abundance (2015-2016), all herring larvae (2007-2016) (Source: ICES Eggs and Larvae database)

4.1.2.2 Mackerel

136. Mackerel are distributed throughout the North Sea and demonstrate seasonal inshore and northward migrations in summer (Cefas, 2010b) (Figure 11. 44). 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).

137. NV East, a small north-eastern portion of NV West and the eastern section of the offshore cable corridor fall within defined mackerel spawning grounds (Figure 11. 45). The offshore project areas are also located within low intensity nursery grounds for this species (Figure 11. 45). In the North Sea, mackerel spawning occurs from May to August, peaking between May and July (Coull *et al*., 1998).

138. Yolk sac mackerel larvae were not found in the offshore project areas Norfolk Vanguard (Figure 11. 46 and Figure 11. 47) during previous ichthyplankton surveys (van Damme et al., 2011). Larval stages at later phases of development were found in the vicinity of the OWF sites in July, albeit at comparatively low levels.

139. Mackerel are of limited UK commercial importance in the locality of Norfolk Vanguard. Belgian ILVO data showed that mackerel landings were highest in NV East (34F3), particularly in 2014, when they reached 12.89 tonnes (Figure 11. 15).

140. Mackerel is listed as a Species of principal importance and classified as of 'Least Concern' in the IUCN Red List of Threatened Species (Table 11. 12). 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 2017 in the Northeast Atlantic should be no more than 857,185 tonnes (ICES, 2016g).

141. 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.

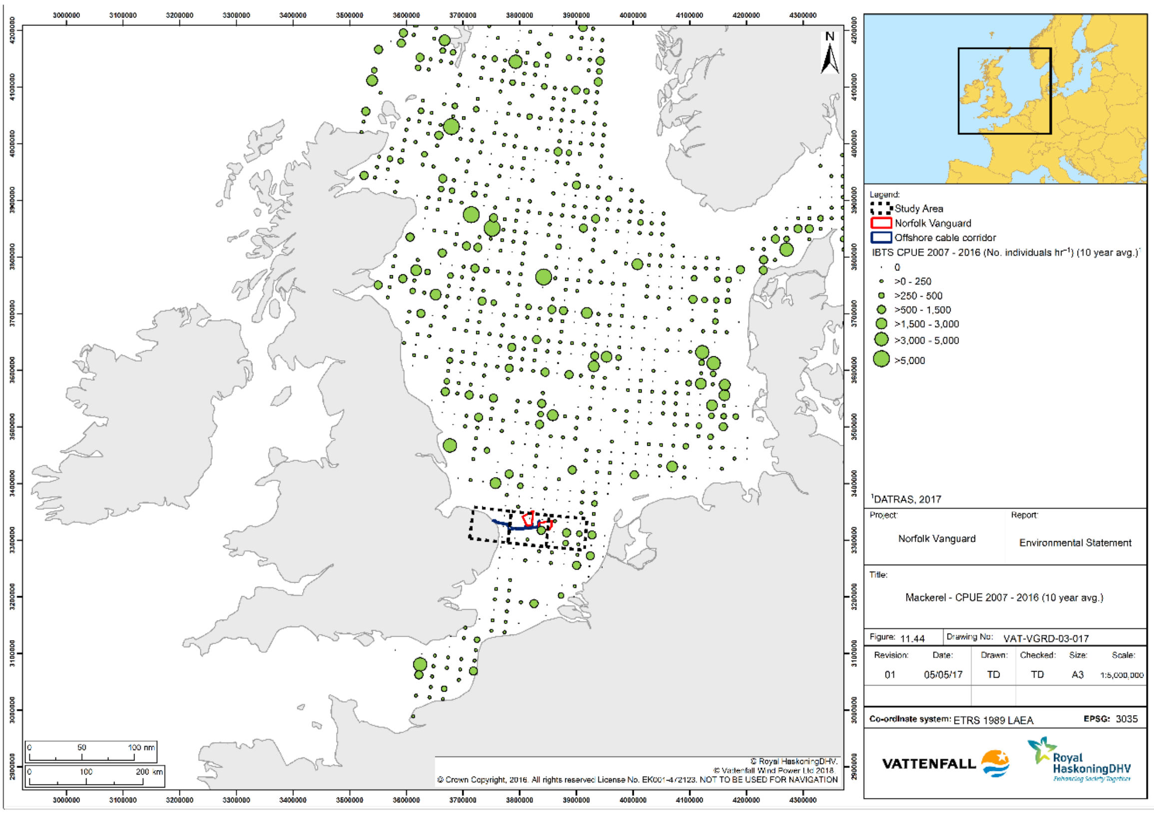


Figure 11. 44 Average number (catch per standardised haul) of Mackerel from IBTS survey data (2007-2016) (Source: DATRAS)

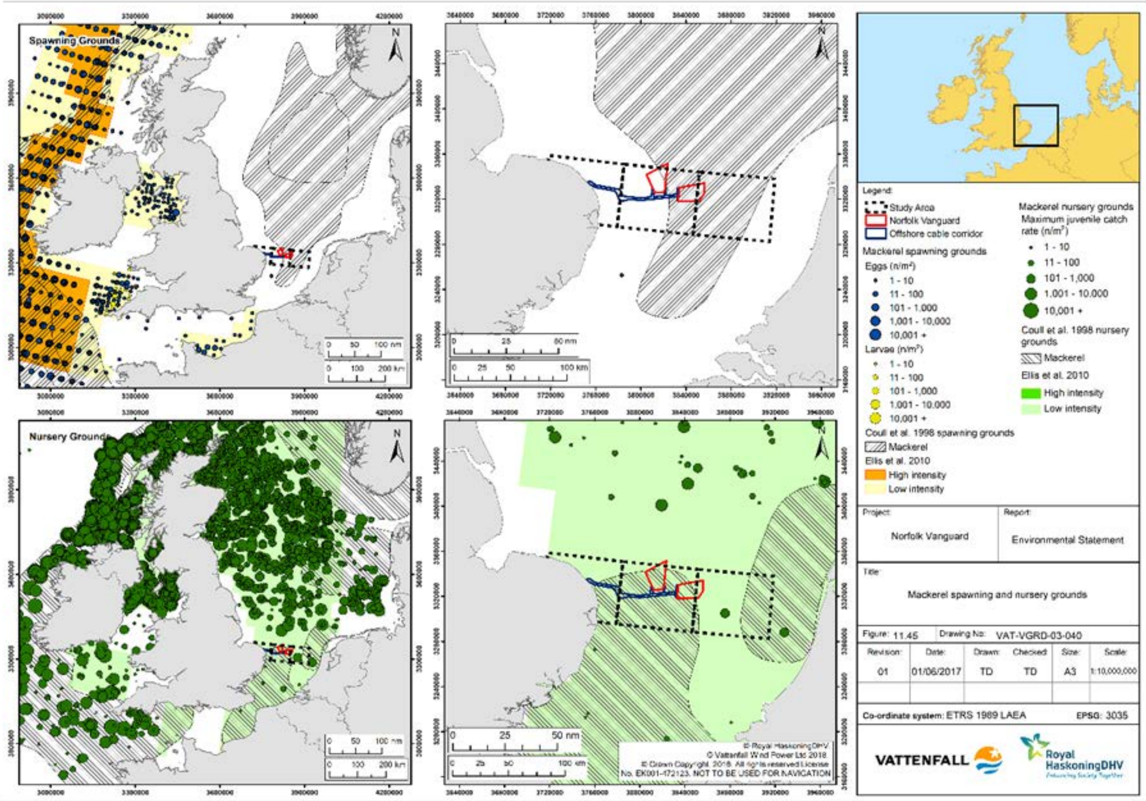


Figure 11. 45 Mackerel spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

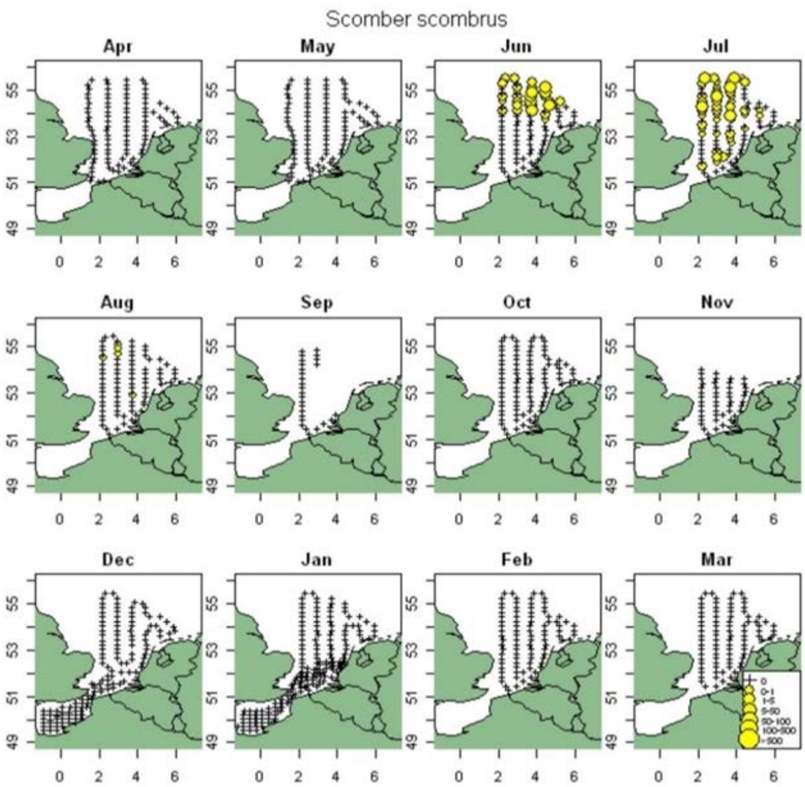


Figure 11. 46 Spatial and temporal distribution of yolk sac mackerel larvae (van Damme et al., 2011)

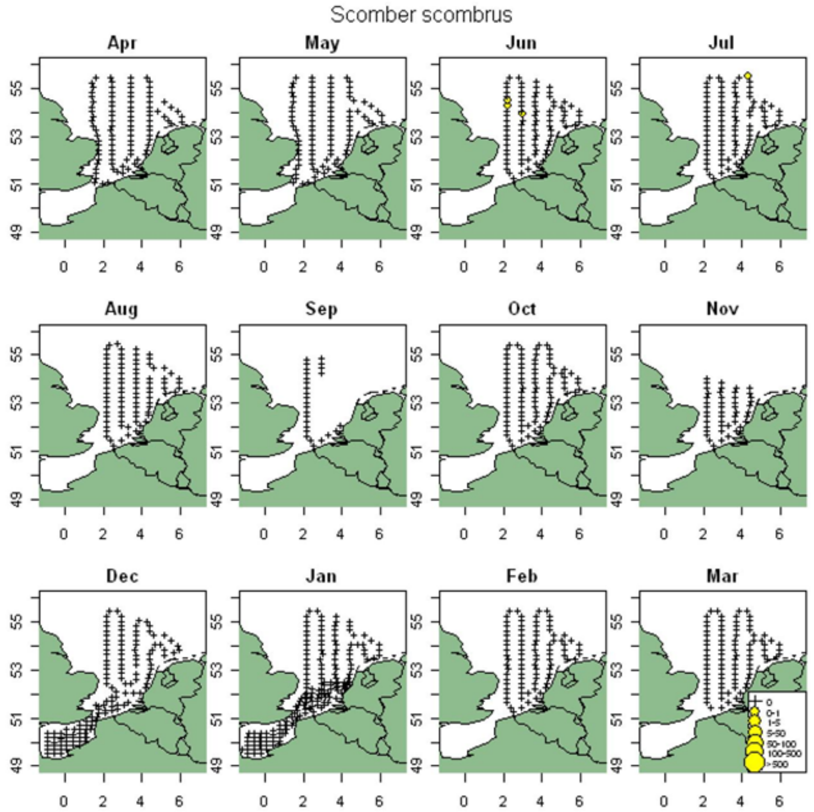


Figure 11. 47 Spatial and temporal distribution of Mackerel bent notochord stage (van Damme et al., 2011)

4.1.2.3 Sprats

142. Sprat are common throughout the North Sea, particularly in and around the Dogger Bank and German Bight (Figure 11. 48). During summer, they occur in inshore waters for spawning, and subsequently undertake migrations to winter feeding grounds (FAO, 2011).

143. As shown by Table 11. 8, landings of sprat predominantly derive from NV West (34F2), contributing 23.73% towards the total catch in ICES rectangle 34F2.

144. 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 11. 49). Females spawn repeatedly in batches throughout the spawning season (Milligan, 1986). Sprat are a pelagic spawning species. Their eggs and larvae are therefore subject to larval drift, directing movement to inshore nursery areas (Hinrichsen *et al*., 2005; Nissling *et al*., 2003). Juvenile sprat are often found close inshore in schools with juvenile herring.

145. NV East, NV West and the eastern section of the offshore cable corridor fall within broadly defined spawning grounds for sprat (Coull *et al*., 1998) (Figure 11. 49). Only a very small eastern portion of NV East coincides with the species nursery grounds (Coull *et al*., 1998) (Figure 11. 49).

146. Ichtyoplankton surveys have identified sprat stage one eggs within NV East and NV West and the wider North Sea from March to June (van Damme et al., 2011) (Figure 11. 50), however yolk sac sprat larvae were only identified in June (Figure 11. 50).

147. Sprat 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, 2017a).

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

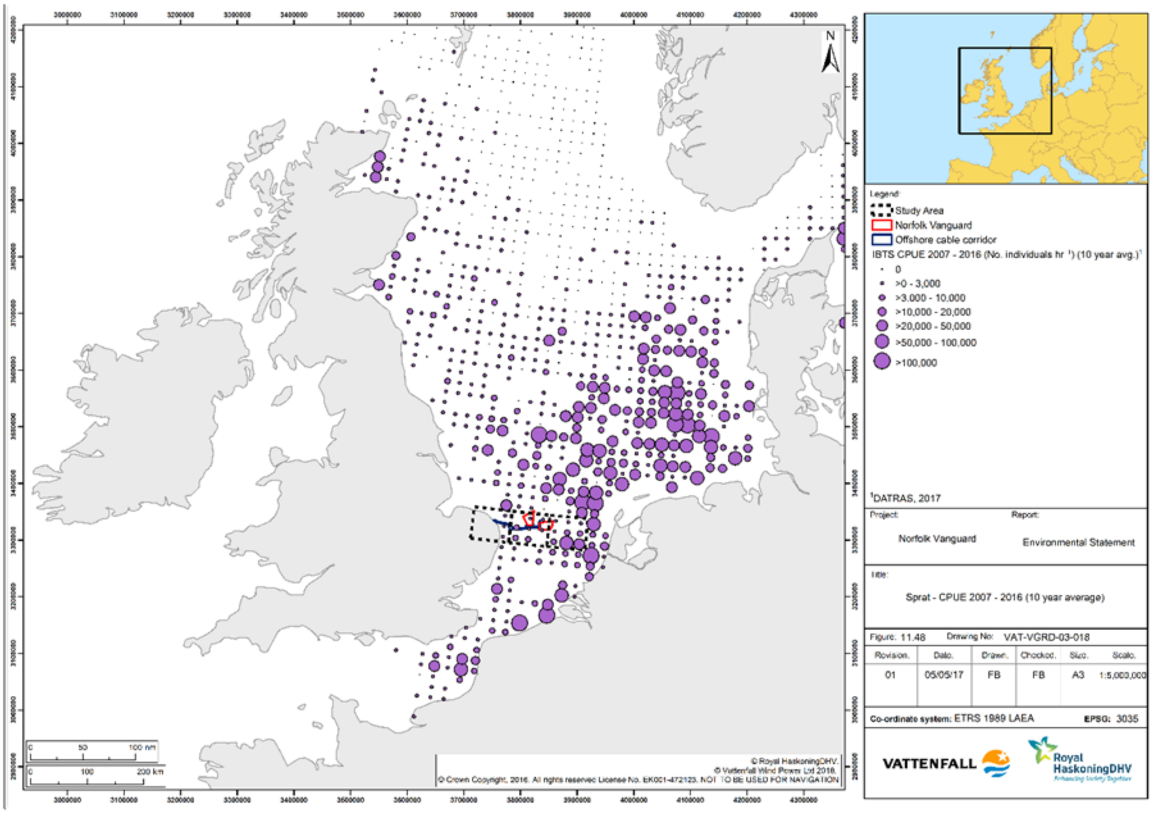


Figure 11. 48 Average number (catch per standardised haul) of Sprat from IBTS survey data (2007-2016) (Source: DATRAS)

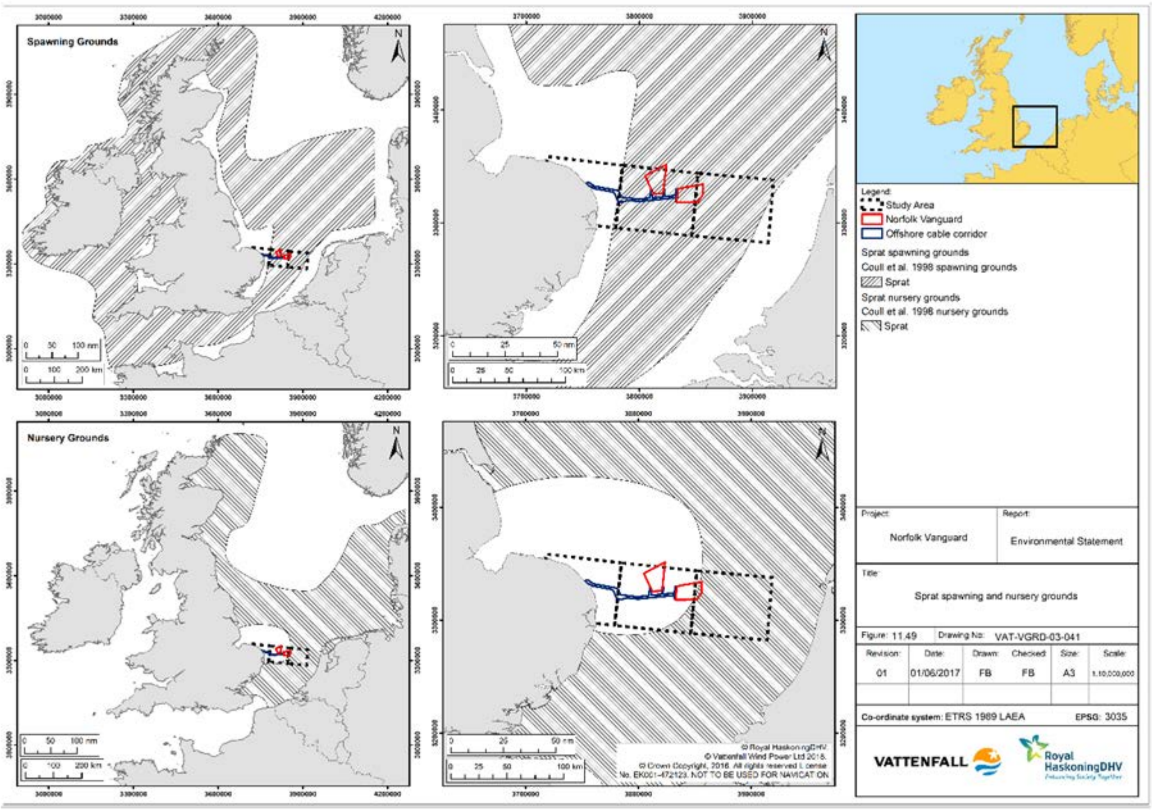


Figure 11. 49 Sprat spawning and nursery grounds (Source: Coull et al., 1998)

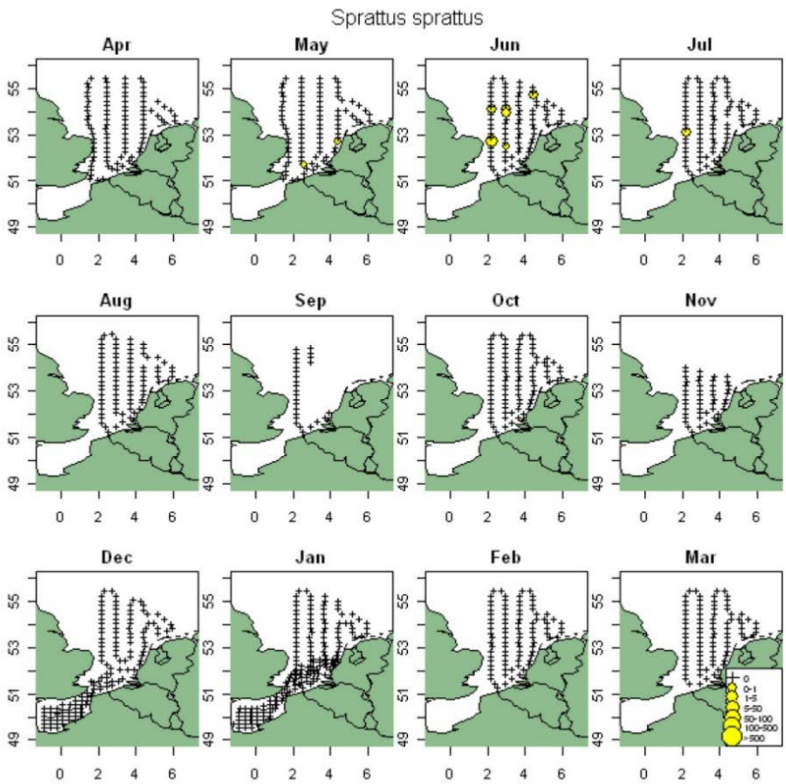


Figure 11. 50 Spatial and temporal distribution of Sprat yolk sac larvae (van Damme et al., 2011)

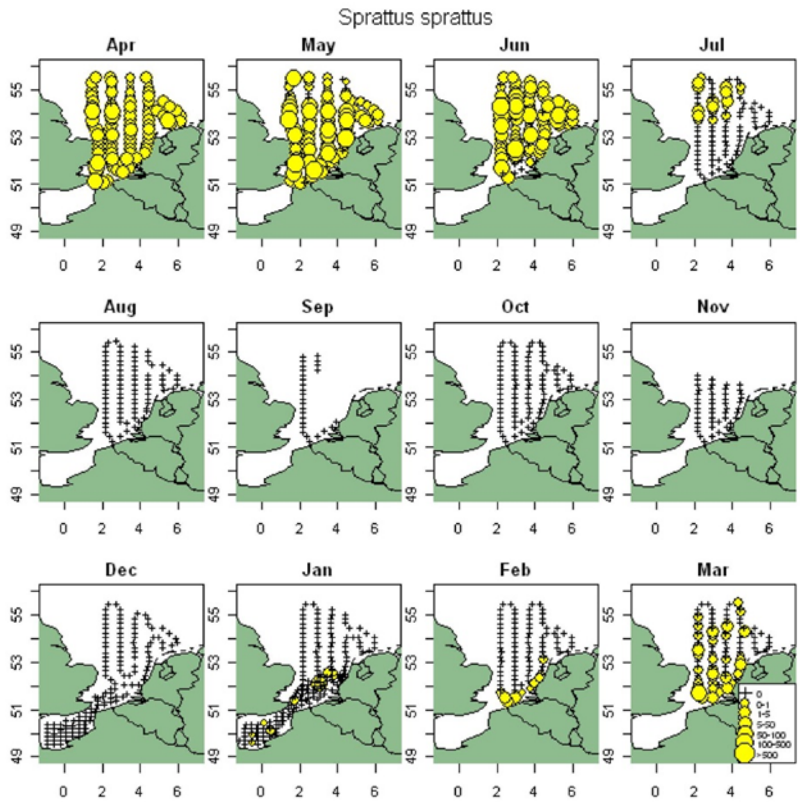


Figure 11. 51 Spatial and temporal distribution of Sprat stage one eggs (van Damme et al., 2011)

4.1.2.4 Sandeels

149. The North Sea sandeel population is considered to consist of several discrete meta-populations rather than an individual homogeneous stock (ICES, 2017b). For the purposes of stock management, ICES has divided the North Sea into four sandeel areas (SAs). The offshore project area falls within the boundaries of Sandeel Assessment Area 1r (Figure 11. 56).

150. Three species of sandeel were recorded in the site specific scientific beam trawl surveys undertaken in the East Anglia THREE and former East Anglia FOUR sites: small sandeel *Ammodytes tobianus*, greater sandeel *Hyperoplus lanceolatus* and smooth sandeel *Gymnammodytes semisquamatus* (Table 11. 6). Small sandeel, greater sandeel and lesser sandeel *Ammodytes marinus* have also been recorded in the study area by the IBTS (Table 11. 7). Within the study area, the CPUE of greater sandeel was particularly high in ICES rectangle 34F3, where the eastern section of NV East is located (Table 11. 7).

151. Analysis of IBTS data in the wider North Sea (Figure 11. 52 to Figure 11. 55), however, suggest that sandeels are found in the offshore project area in relatively low numbers, with considerably higher CPUE recorded in areas to the north and east of the export cable corridor and the OWF sites.

152. 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). Sandeel distribution is highly patchy being dependent on sediment type (Figure 11. 52, Figure 11. 53, Figure 11. 54 and

Figure 11. 55) 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).

153. 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). Where silt content is greater than 10%, sandeels have been recorded as absent (Holland *et al*., 2005; Wright *et al*., 2000). Sediment categories first proposed by Holland *et al*. (2005) and adapted by Greenstreet *et al*. (2010) define 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. Sandeel habitat preferences are shown in Table 11. 14 (as adapted from Marinespace, 2013).

154. 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). While recruitment to individual fishing banks is mainly related to the local (sub-) stock, some interchange can occur between these sub-stocks before larvae settle. Following settlement, sandeels form a complex of local (sub-) stocks in the North Sea and are largely sedentary (Heath *et al*., 2011).

155. As shown in Figure 11. 57, the offshore project areas fall within low intensity sandeel (Ammodytidae spp.) spawning and nursery grounds defined by Ellis *et al*. (2010), in addition to coinciding with spawning and nursery grounds defined by Coull *et al*. (1998).

156. 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). Known fishing grounds are considered to represent the major areas of sandeel distribution in the North Sea in recognised peer-review publications (Jensen and Christensen, 2008; Jensen *et al*., 2011). Norfolk Vanguard is located at a considerable distance from the majority of sandeel habitat areas defined by Jensen *et al*. (2011) (see Figure 11. 56).

157. Ichtyoplankton surveys (van Damme et al., 2011) found lesser sandeel yolk sac larvae throughout the offshore project area in February and March, whilst early larval stages of small sandeel, greater sandeel and smooth sandeel were not found in significant numbers (Figure 11. 58 and Figure 11. 59).

158. According to UK landings data (Table 11. 8), sandeels are of limited commercial importance in the offshore project area. Important sandeel fishing grounds are found in the Dogger Bank area, located some distance to the north of Norfolk Vanguard, as shown in Figure 11. 60. The majority of the commercial catch of

sandeels is used for fish meal, predominantly by the non-UK fleets including Denmark, Norway, Sweden and Germany.

159. Figure 11. 60 illustrates VMS fishing intensity of the Danish sandeel fleet (2009-2013), which represents the principal sandeel fishery in the North Sea. For the most part, fishing activity occurs to the north of the OWF sites, coinciding with defined high intensity spawning and nursery grounds for sandeels, areas where highest CPUEs for sandeel species have been recorded by the IBTS and known sandeel fishing grounds (Figure 11. 52 to Figure 11. 58).

160. An indication of the suitability of the substrate across the offshore project area in terms of provision of sandeel habitat, based on Marine Space (2013) sandeel habitat categorisation (Table 11. 14), and using particle size analysis (PSA) data collected during benthic surveys in Norfolk Vanguard and the wider East Anglia Zone, is shown in is Figure 11. 57. Analysis of the sediment samples across the offshore project area and the wider area suggests the presence of sub-prime sandeel habitat. However, in this context it is important to note that the presence of suitable or preferred (prime/sub-prime) habitat does not necessarily imply that sandeels are present in significant numbers. As mentioned above, spawning and nursery grounds for this species in areas relevant to the offshore project area are considered of low intensity and information from commercial fishing in terms of both, fishing grounds and fishing density does not suggest that the offshore project area is of key importance to sandeels stocks (Figure 11. 56, Figure 11. 57 and Figure 11. 61). Similarly, data from the IBTS survey (Figure 11. 52 to Figure 11. 55) does not suggest that sandeels are found in significant numbers in the area of Norfolk Vanguard, with highest catch rates generally recorded to the north and east of NV East and West.

161. ICES have advised that for the Dogger Bank stock (Sandeel Area 1r, central and southern North Sea, Dogger Bank) the sandeel catch should be no more than 255,956 tonnes (ICES, 2017b).

162. Sandeels are of conservation interest. They are listed as a species of principal importance and are designated 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).

163. 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).

Table 11. 14 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

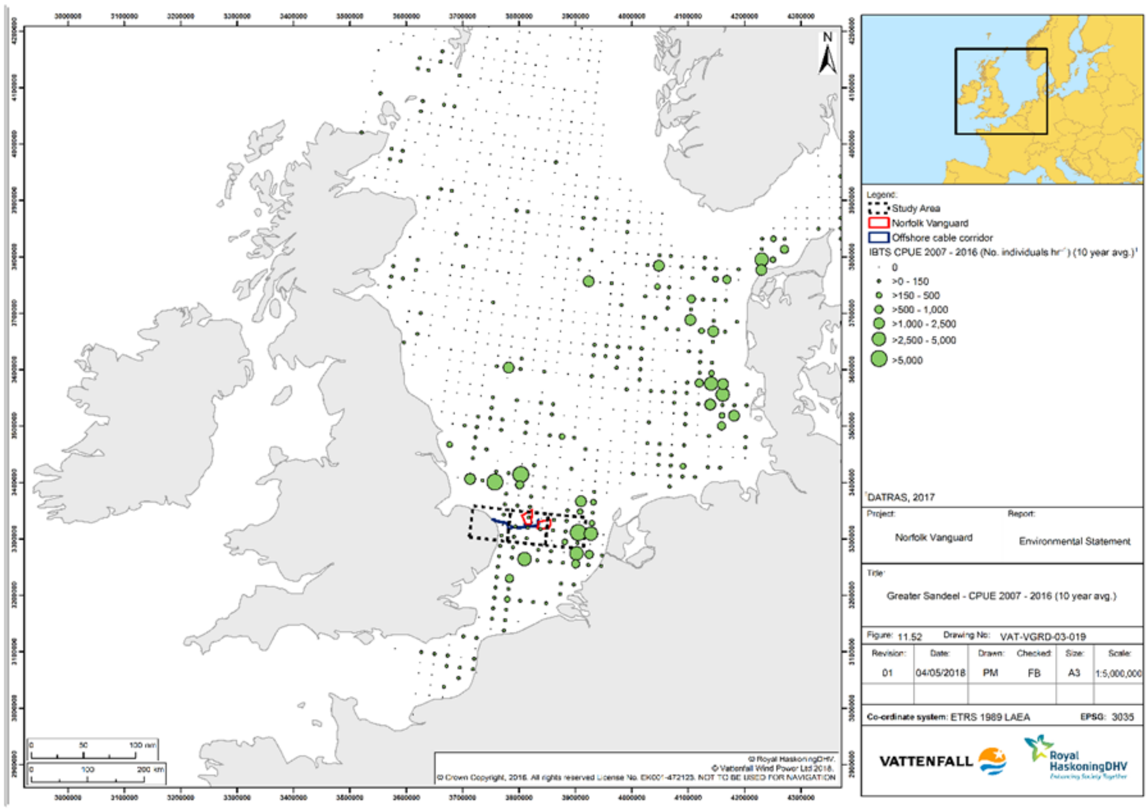


Figure 11. 52 Average number (catch per standardised haul) of Greater sandeel from IBTS survey data (2007-2016) (Source: DATRAS)

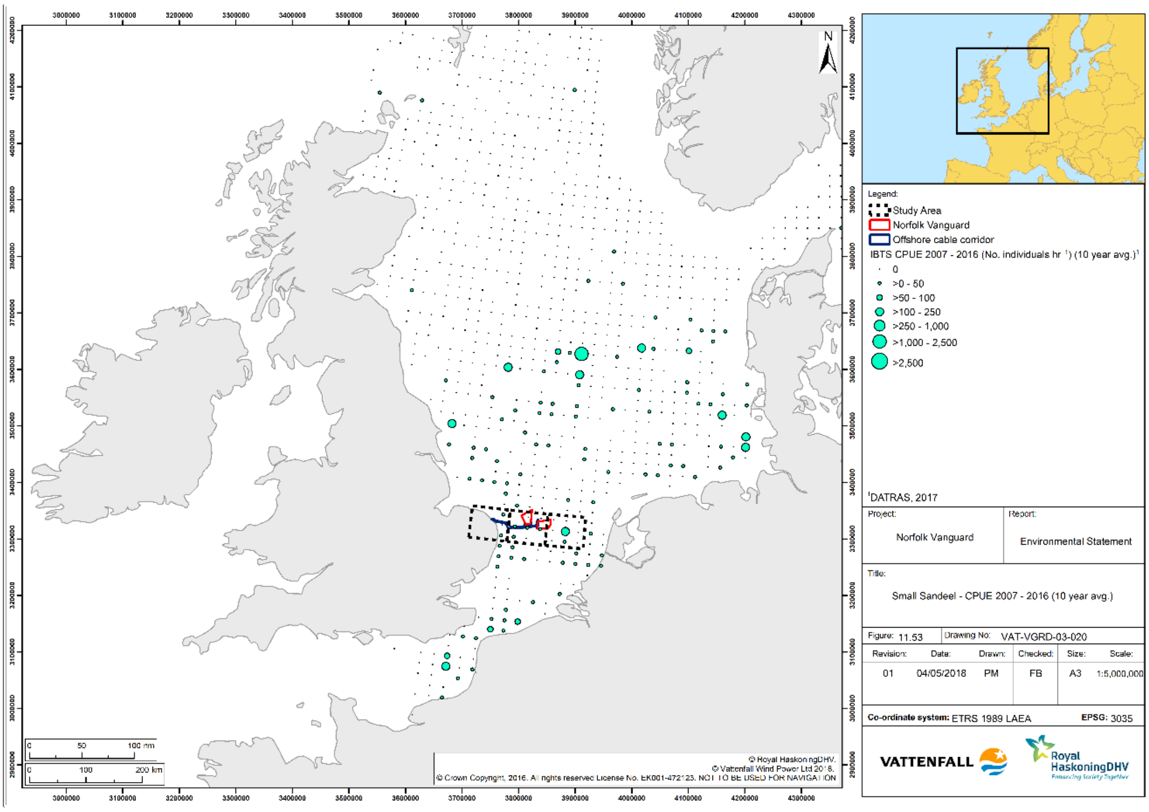


Figure 11. 53 Average number (catch per standardised haul) of Small sandeel (Ammodytes tobianus) from IBTS survey data (2007-2016)

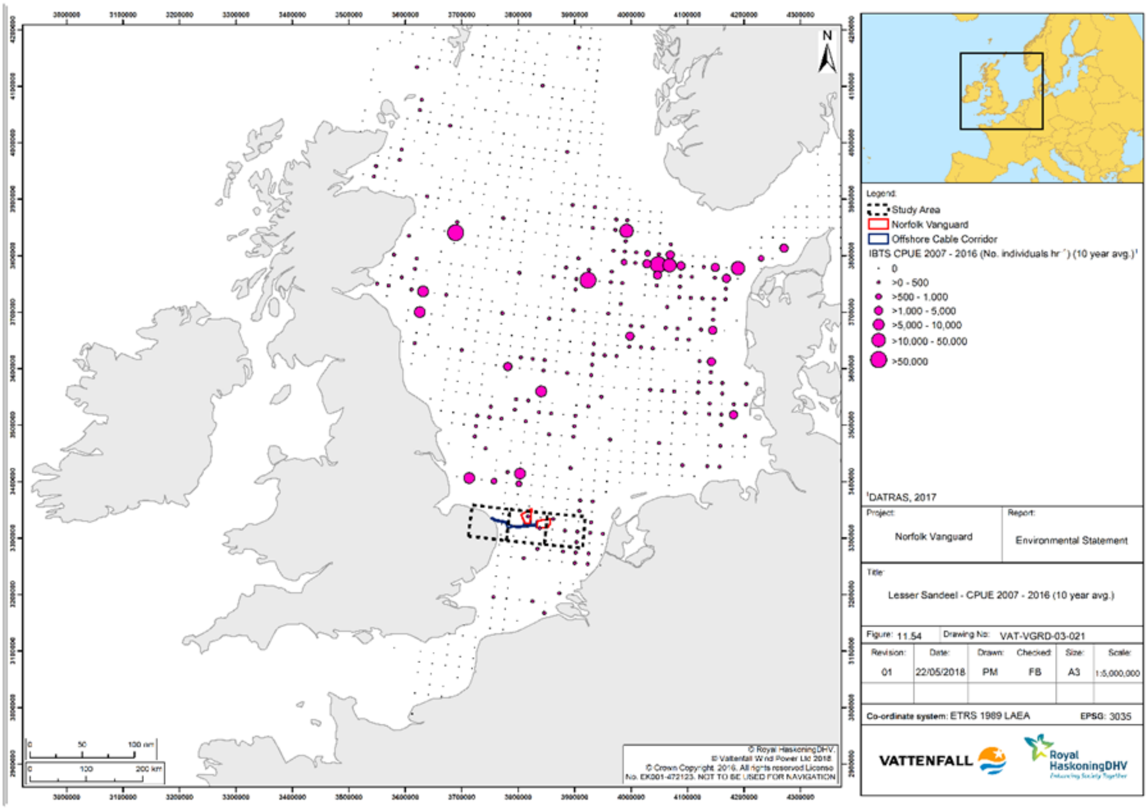


Figure 11. 54 Average number (catch per standardised haul) of Lesser sandeel (Ammodytes marinus) from IBTS survey data (2007-2016) (Source: DATRAS)

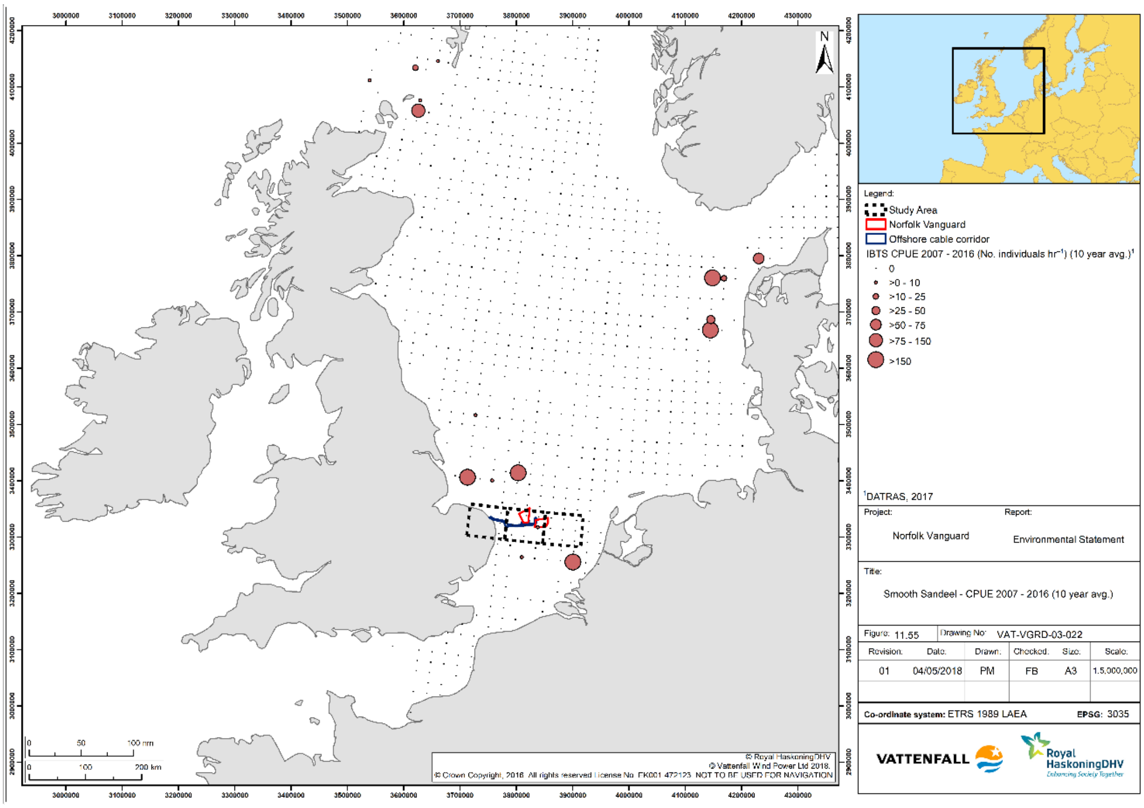


Figure 11. 55 Average number (catch per standardised haul) of Smooth sandeel from IBTS survey data (2007-2016) (Source: DATRAS)

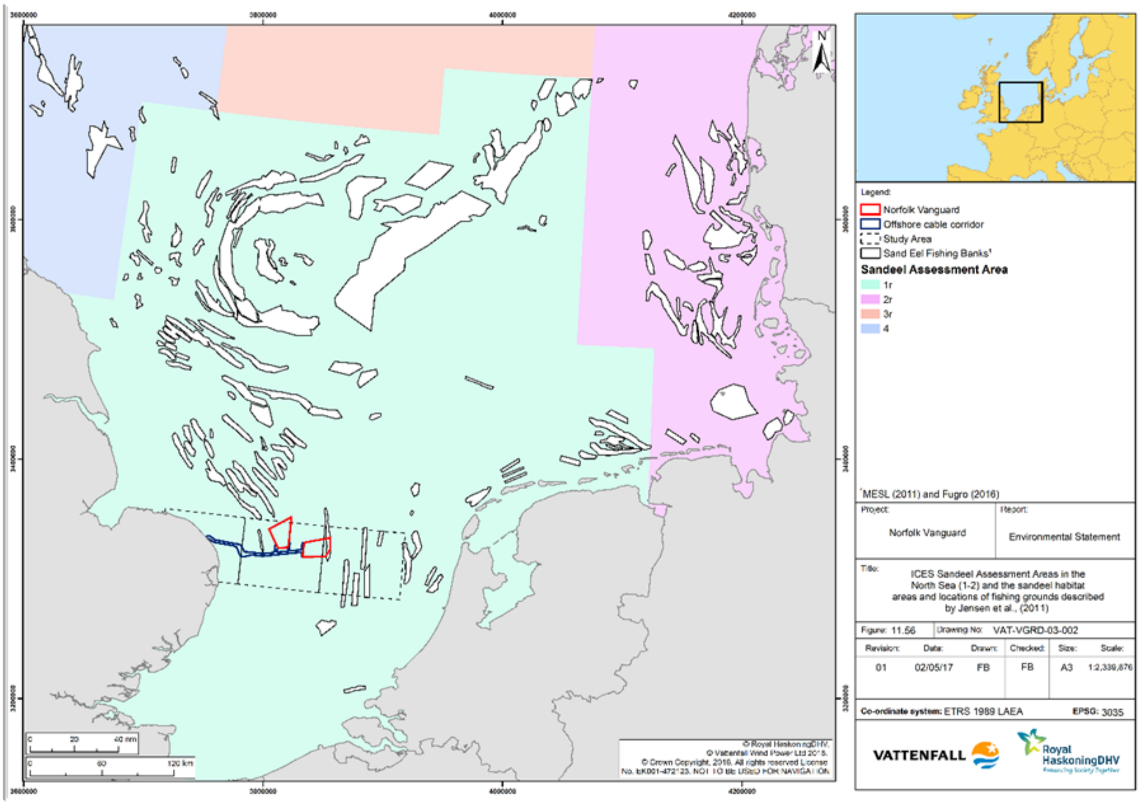


Figure 11. 56 ICES Sandeel Assessment Areas in the North Sea (1-4) and the sandeel habitat areas and locations of fishing grounds described by Jensen et al., (2011) outlined in white. SA 1r central and southern North Sea, Dogger Bank (green).

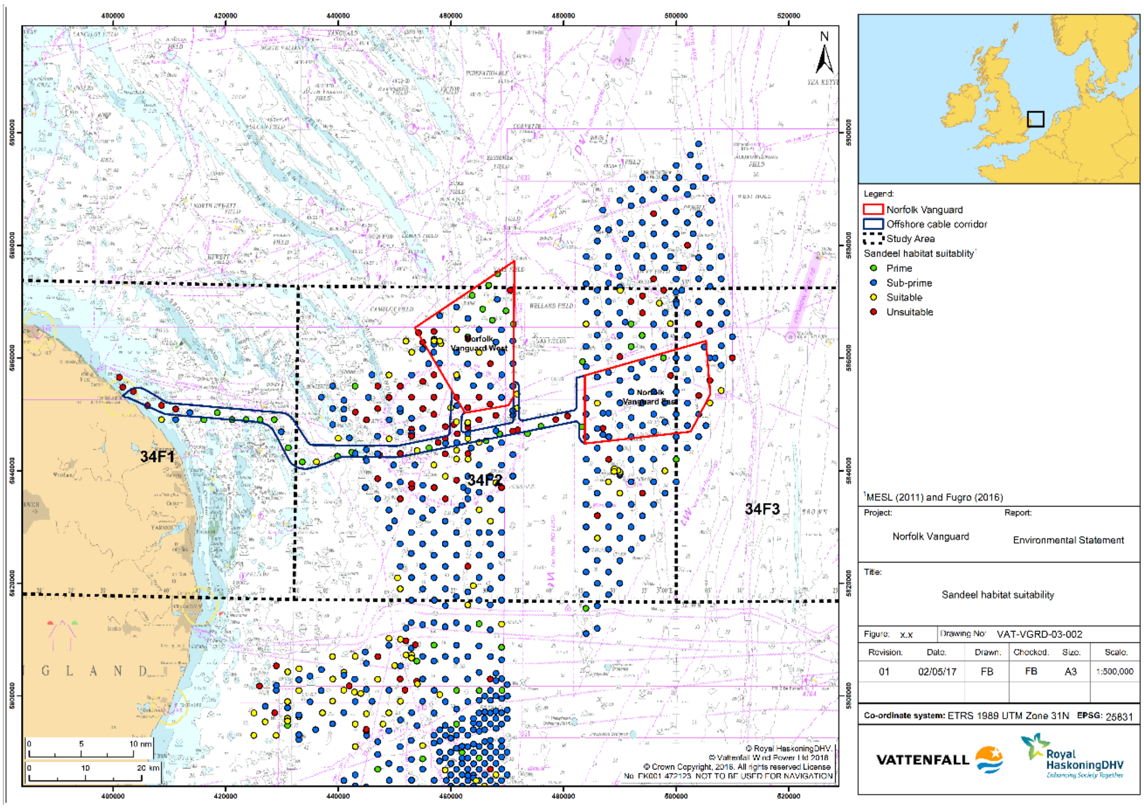


Figure 11. 57 Sandeel habitat suitability, MESL (2011) and Fugro (2016)

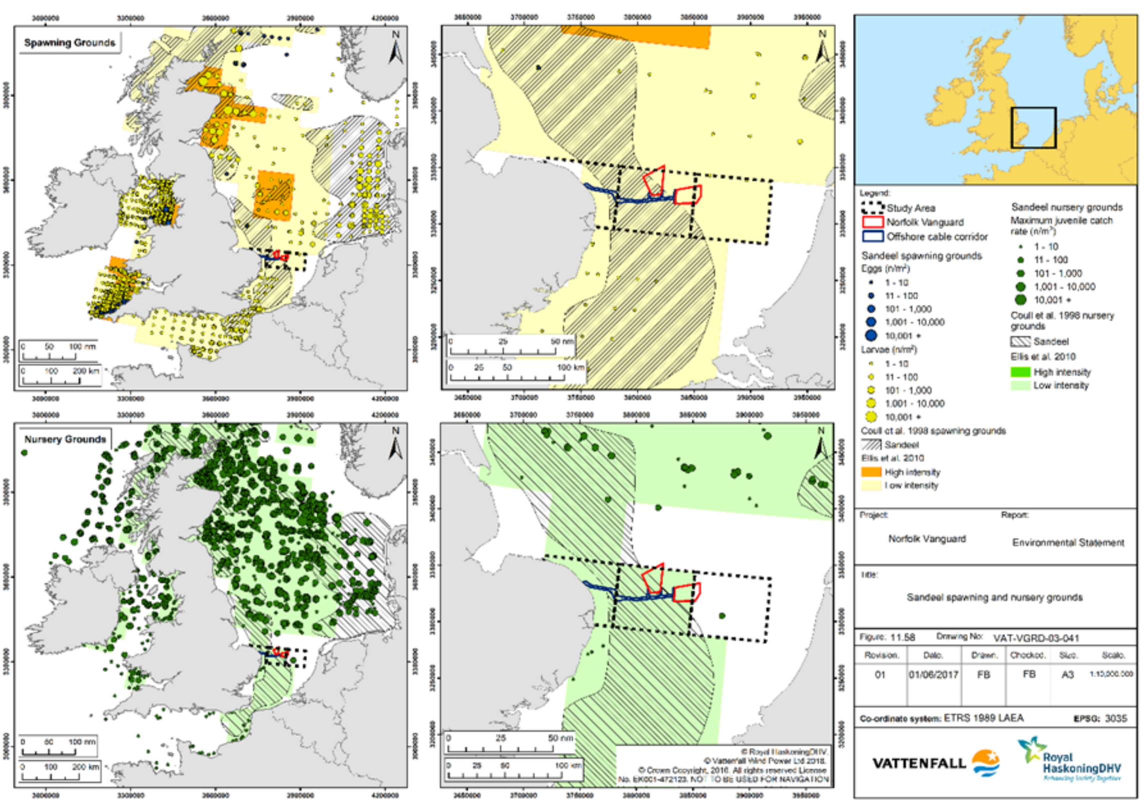


Figure 11. 58 Sandeel spawning and nursery grounds (Source: Coull et al., 1998 and Ellis et al., 2010)

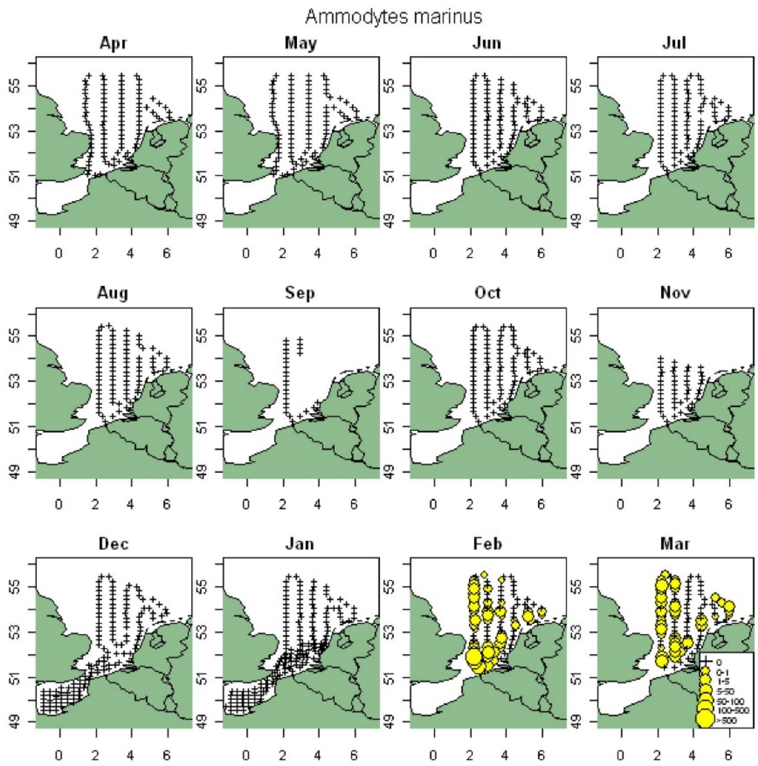


Figure 11. 59 Spatial and temporal distribution of Lesser sandeel (Ammodytes marinus) yolk sac larvae (van Damme et al., 2011)

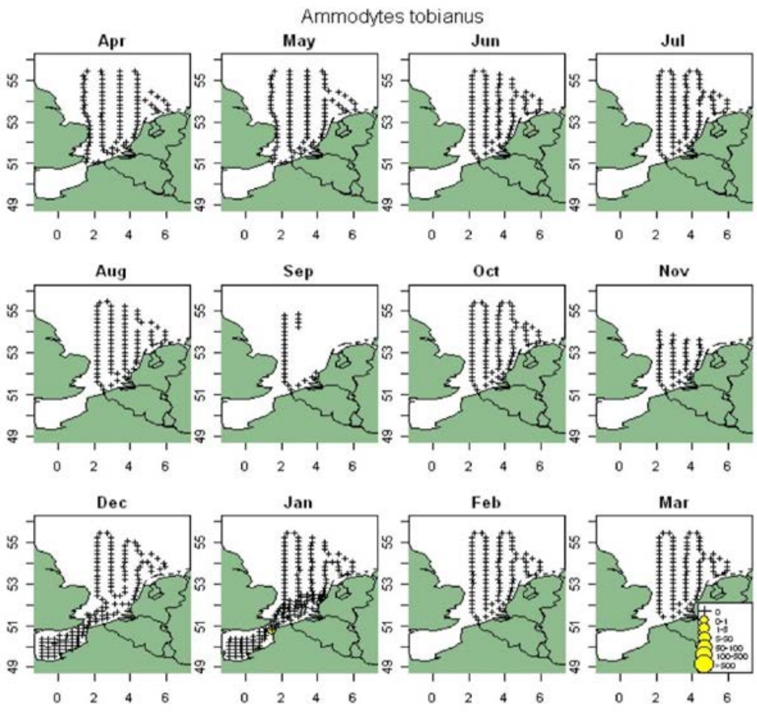


Figure 11. 60 Spatial and temporal distribution of Small sandeel (Ammodytes tobianus) yolk sac larvae (van Damme et al., 2011)

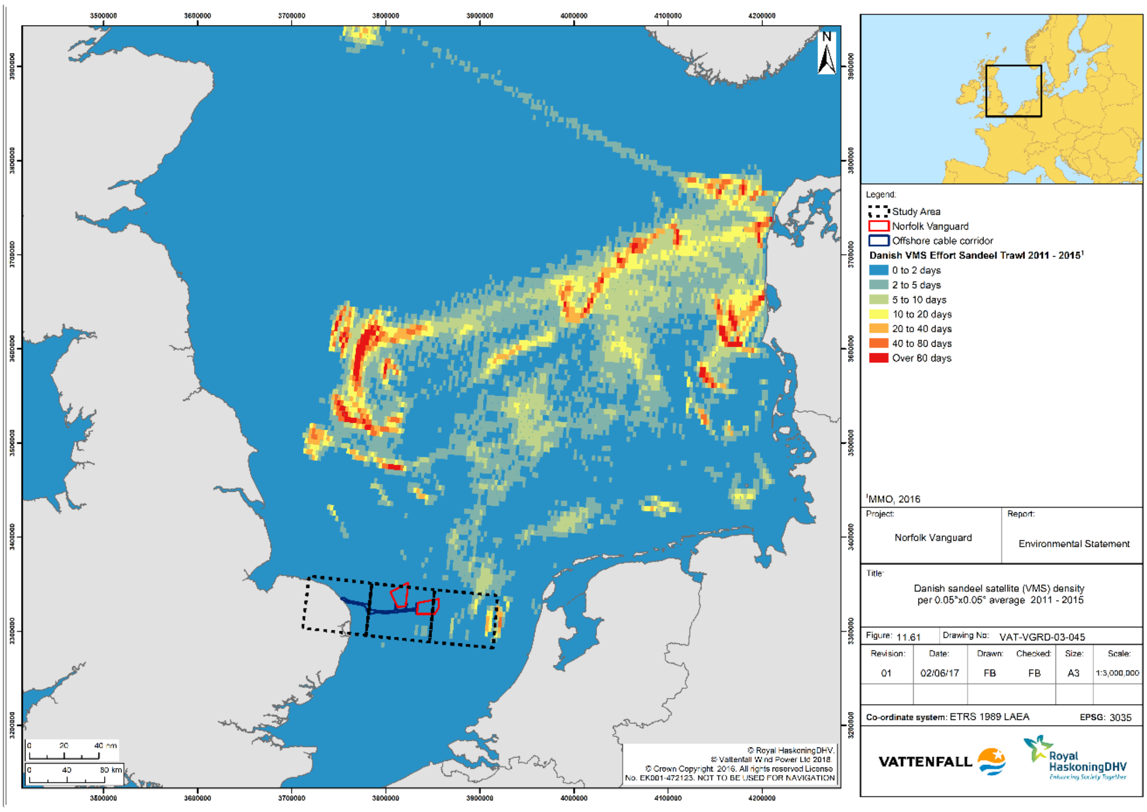


Figure 11. 61 Danish Sandeel Fishing Vessel Monitoring System (2011-2015)

4.1.3 Elasmobranchs – Skates and Rays

4.1.3.1 Thornback Ray

164. The average distribution of thornback rays in the North Sea between 2007 and 2016 is indicated in Figure 11. 62. 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).

165. 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).

166. Figure 11. 63 highlights that the western section of the offshore cable corridor coincides with defined low intensity nursery areas. Spawning and nursery grounds 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).

167. In the vicinity of Norfolk Vanguard, thornback rays are amongst the main elasmobranch species landed (Table 11. 8). Landings of thornback ray were primarily recorded in NV West (34F2), with comparatively lower landings in the offshore cable corridor (34F1) and NV East (34F3). Thornback rays were found in very low numbers in the proximity of Norfolk Vanguard during site specific beam trawl surveys for East Anglia THREE and site specific otter trawl surveys for the former East Anglia FOUR (Table 11. 4 and Table 11. 5).

168. In terms of conservation importance, thornback rays are included in the OSPAR list of threatened and/or declining species and has been classified as 'Near Threatened' by the IUCN (Table 11. 11).

169. 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).

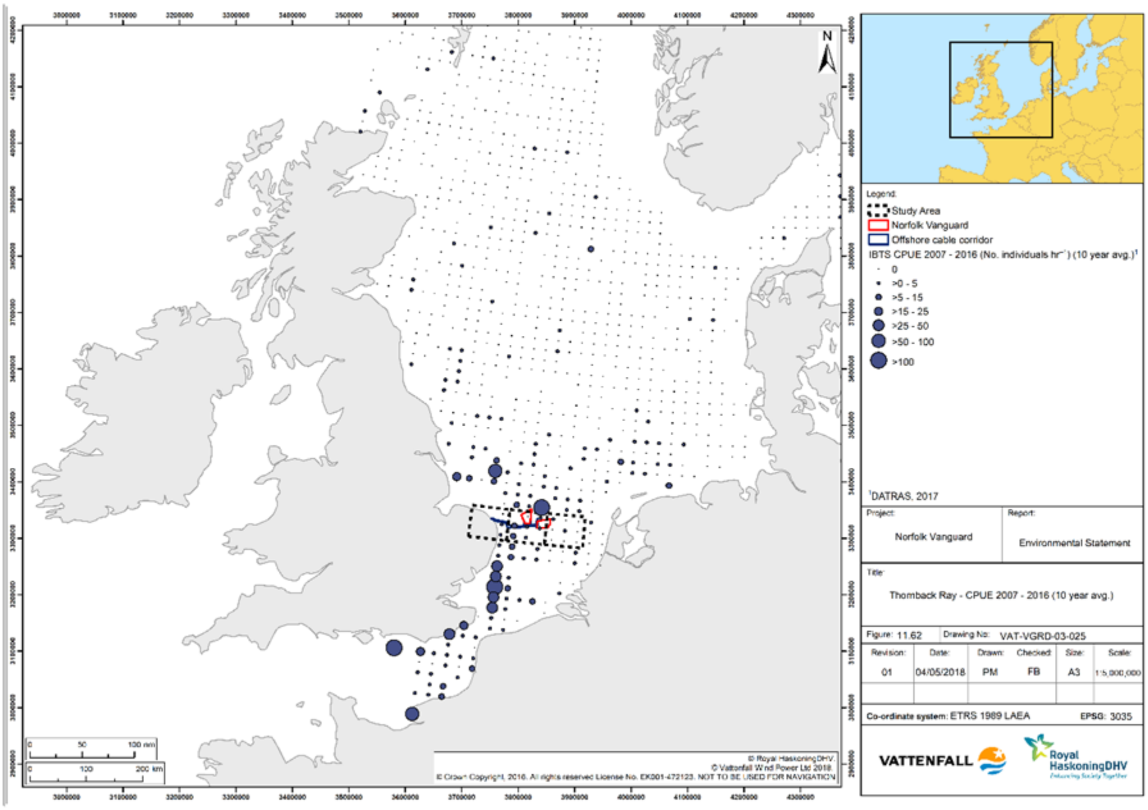


Figure 11. 62 Average number (catch per standardised haul) of Thornback ray from IBTS survey data (2007-2016) (Source: DATRAS)

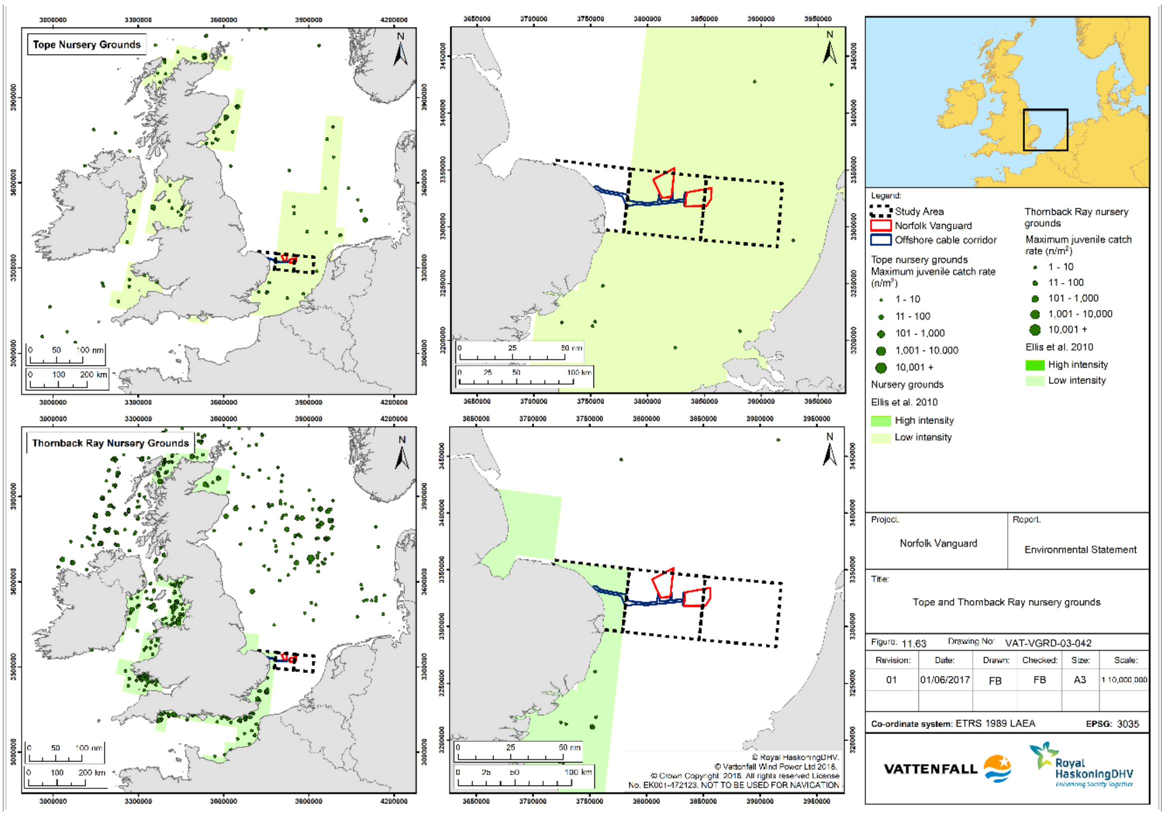


Figure 11. 63 Tope and Thornback ray nursery grounds (Source: Ellis et al., 2010)

4.1.3.2 Spotted Ray

170. 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 survey results showed that (Figure 11. 64) spotted rays are present off the East Anglian coast.

171. 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). The offshore project area does not fall within the defined nursery areas for this species (Ellis et al., 2010). In comparison to thornback rays, spotted rays are considered of secondary importance in UK landings data.

172. 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 11. 11).

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

4.1.3.3 Blonde Ray

174. Blonde rays inhabit sandy seabed areas in coastal waters (Figure 11. 65). 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 (14 to 146m) off southern and western England, than in the North Sea and Celtic Sea. Blonde rays have been located at IBTS sites in the vicinity of Norfolk Vanguard (Table 11. 7).

175. 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 sole (Wheeler, 1978).

176. Blonde rays are of less commercial importance in UK 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 11. 11).

4.1.3.4 Common Skate Complex

177. Traditionally, the common skate complex (*Dipturus intermedia* and *Dipturus flossada*) were amongst the most abundant ray species in the north-east Atlantic, demonstrating 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).

178. Common skate complex is classified as 'Critically Endangered' by the IUCN Red List of Threatened Species. In addition, they are listed as a species of principal importance and in the OSPAR list of threatened and/or declining species (Table 11. 11).

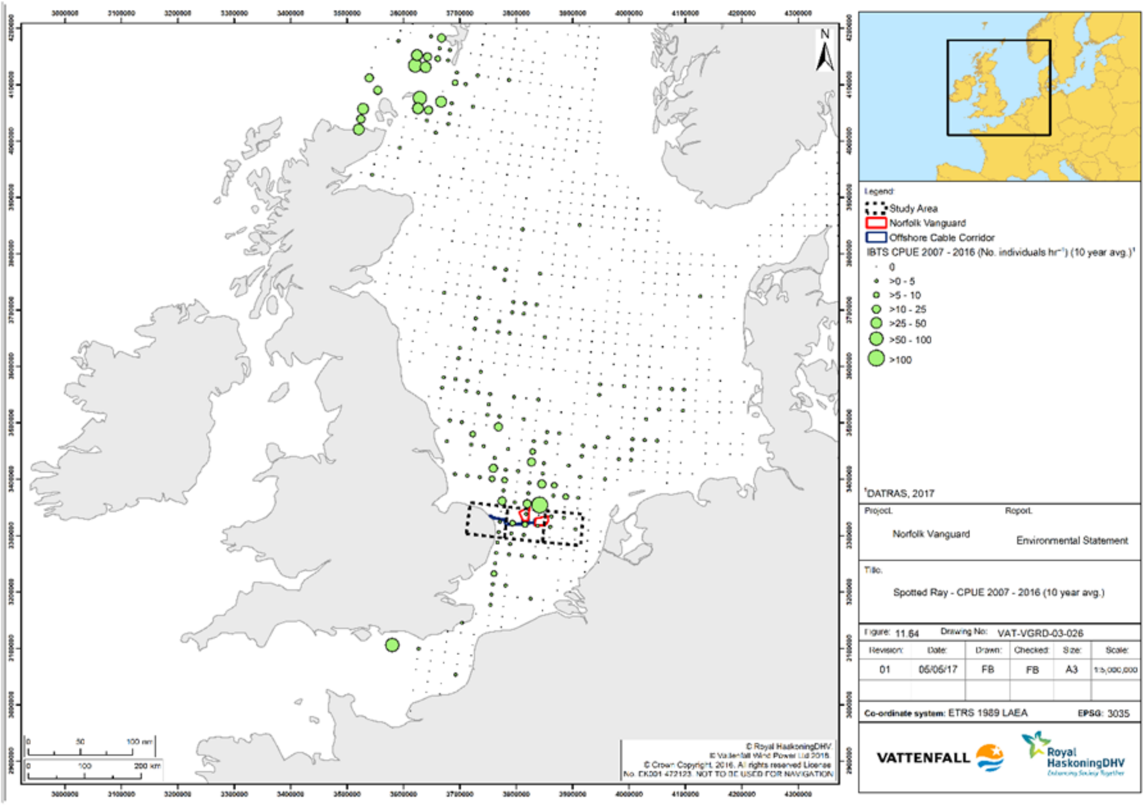


Figure 11. 64 Average number (catch per standardised haul) of Spotted ray from IBTS survey data (2007-2016) (Source: DATRAS)

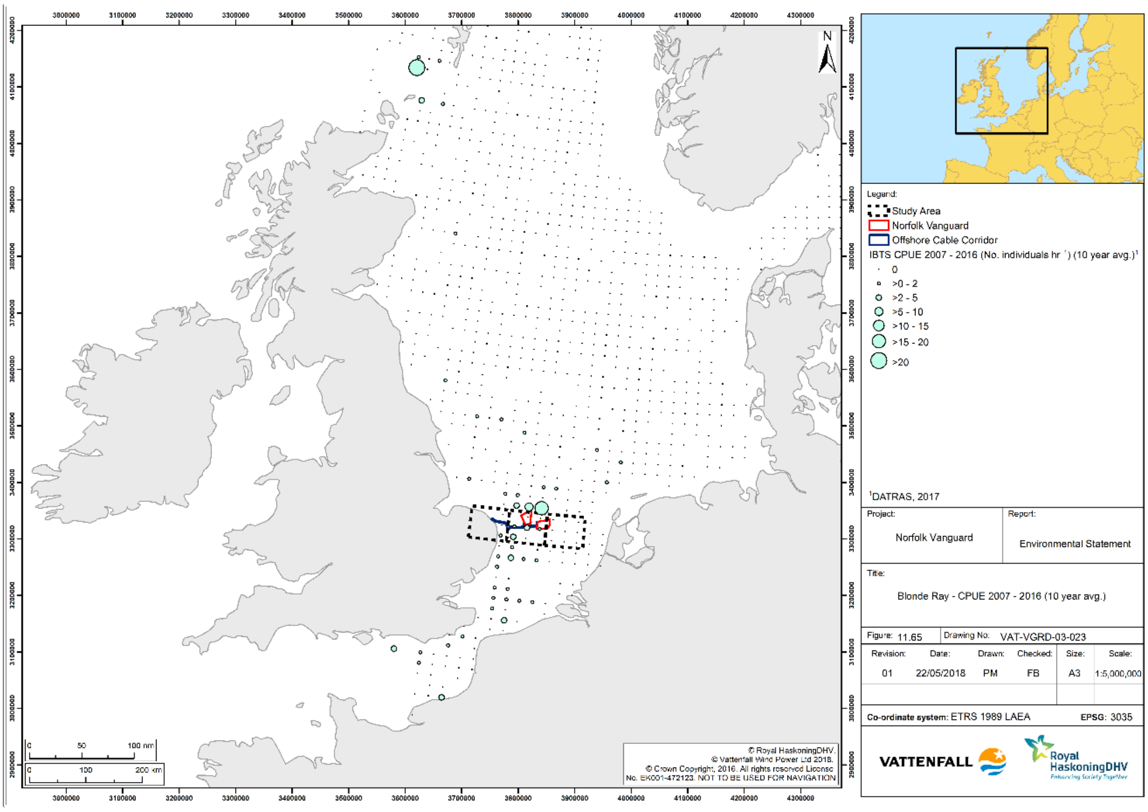


Figure 11. 65 Average number (catch per standardised haul) of Blonde ray from IBTS survey data (2007-2016) (Source: DATRAS)

4.1.4 Elasmobranchs – Sharks

4.1.4.1 Small spotted catshark/lesser spotted dogfish

179. 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 existing 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).

180. During the site specific otter trawl and beam trawl surveys (Table 11. 4 and Table 11. 5) conducted for East Anglia THREE and the former East Anglia FOUR, lesser spotted dogfish was one of the more abundant species found within the area. Commercial landings of the species are comparatively low in the vicinity of Norfolk Vanguard, contributing 0.05% and 0.23% respectively to the total catch within ICES rectangles 34F1 (offshore cable corridor) and 34F2 (NV West) (Table 11. 8).

181. 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).

4.1.4.2 Smoothhounds

182. Starry smoothhound Mustelus asterias and Smoothhound Mustelus mustelus live in depths of up to approximately 50m (Kay and Dipper, 2009). As shown by Figure 11. 66, starry smoothhounds exhibit a broad distribution across the North Sea, in contrast to the distribution of smoothhounds which is much smaller (Figure 11. 67) and they have rarely been recorded in the North Sea (Ellis et al., 2005).

183. Cefas are currently of the opinion that smoothhounds and starry smoothhounds can be considered the same species and are not distinguishable by external physiological features (pers comm. J. Ellis, M. Etherton, Cefas 2013) (see Farrell et al., 2009).

184. Starry smoothhounds and smoothhounds are occasionally recorded in the local study area by the IBTS (Table 11. 7), particularly in ICES rectangle 34F2, relevant to NV West. Starry smoothound are of ‘Least Concern’ on the IUCN Red List of Threatened Species whilst Smoothhound are assessed as ‘Vulnerable’ (Table 11. 11).

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

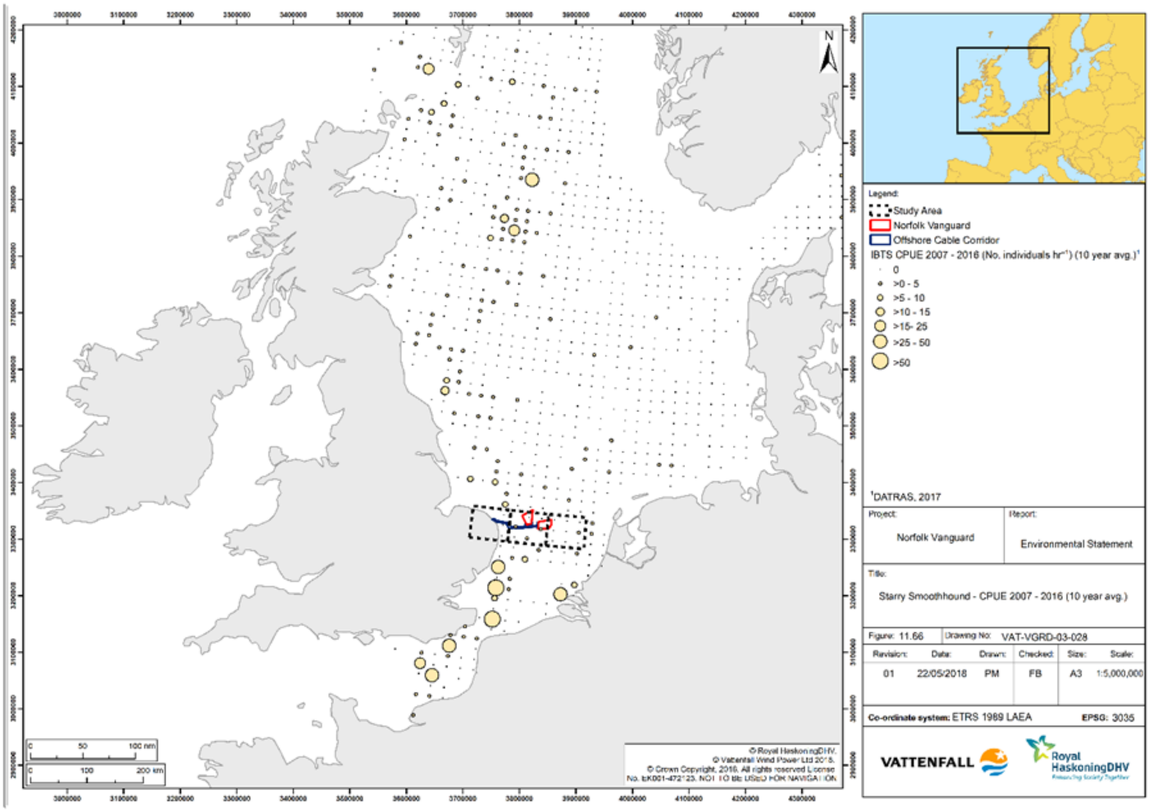


Figure 11. 66 Average number (catch per standardised haul) of Starry smoothhound from IBTS survey data (2007-2016) (Source: DATRAS)

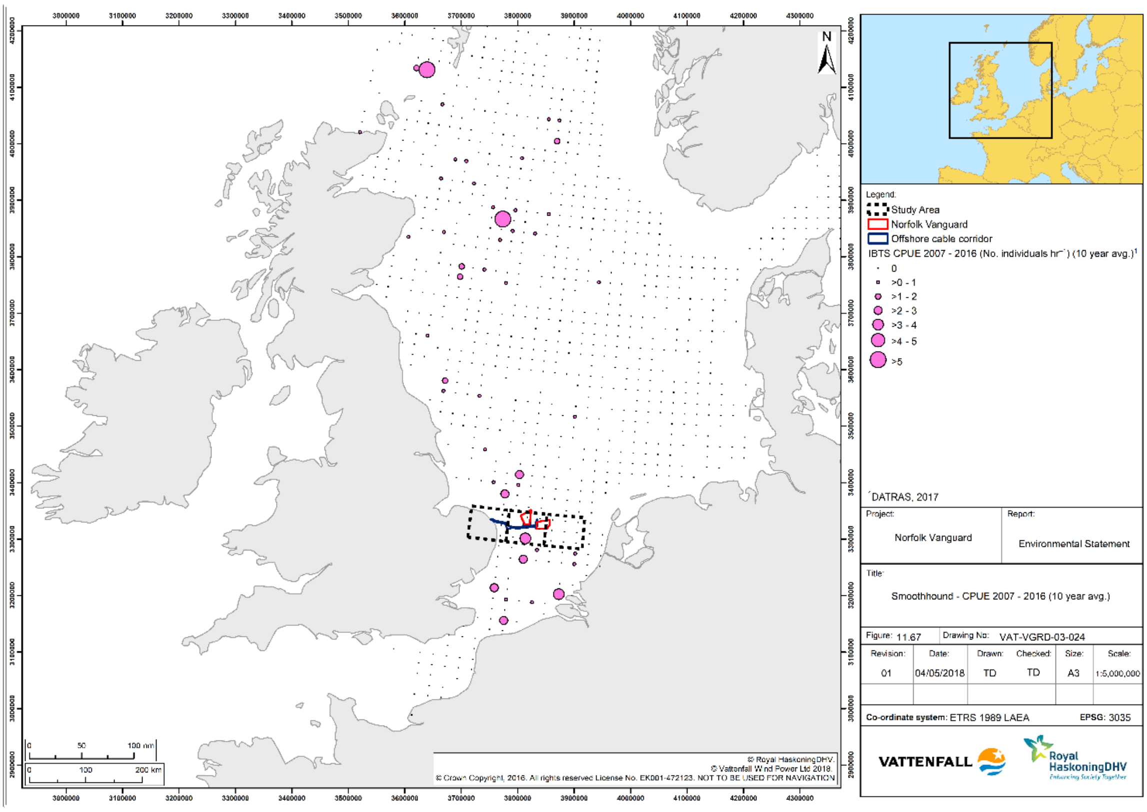


Figure 11. 67 Average number (catch per standardised haul) of Smoothhound from IBTS survey data (2007-2016) (Source: DATRAS)

4.1.4.3 Tope

186. 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.

187. Tope were not recorded in the area of the East Anglia THREE site during site specific fish surveys. The offshore project area falls within defined low intensity nursery grounds for this species (Figure 11. 63).

188. 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 11. 11).

189. Tope consume a wide variety of fish, including pilchards, herring, anchovies, smelt, hake, cod, 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).

4.1.4.4 Spurdog

190. Spurdogs are wide ranging throughout the North Sea. However, the highest densities can be found well to the north of Norfolk Vanguard (Figure 11. 68) at depths of 15 and 528m (Ellis et al., 2005).

191. Tagging studies have indicated the existence of a single North East Atlantic stock, and shown that in spring, mature males migrate to the north and east of the British Isles, only to return 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).

192. After thornback ray and blonde ray, spurdog is the third most commercially important elasmobranch species to be landed from the Norfolk Vanguard project area (Table 11. 8). This is, however, the remanants of a no longer extant commercial fishery (see below). Spurdog were not recorded during site specific fish surveys undertaken for East Anglia THREE and the former East Anglia FOUR.

193. The decision to decrease quota allocations for spurdog in recent years has resulted in the substantial reduction in fisheries targeting this species (Clarke, 2009). In 2010, the TAC for spurdog was set to zero, however landings were still permitted under a by-catch TAC, provided certain conditions were met (ICES, 2010a). In 2013, the TAC for spurdog was retained at zero and no landings (including by-catch) were permitted (ICES, 2013). 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, 2016h). Any possible provision for the landing of bycatch should be part of a management plan, including close monitoring of the stock and fisheries (ICES, 2016h).

194. CHARM consortium charts indicate that spurdog abundance is low within the vicinity of Norfolk Vanguard. Spurdog presence is higher to the north, within the central North Sea (Figure 11. 69).

195. Spurdog is listed as Species of principal importance and is included in the OSPAR list of threatened and/or declining species, thus making it a species of conservation importance. It is assessed as 'Vulnerable' in the IUCN Red List of Threatened Species (Table 11. 10).

196. Spurdog are opportunistic feeders. They consume a wide range of predominantly pelagic 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 (Shark Trust, 2010).

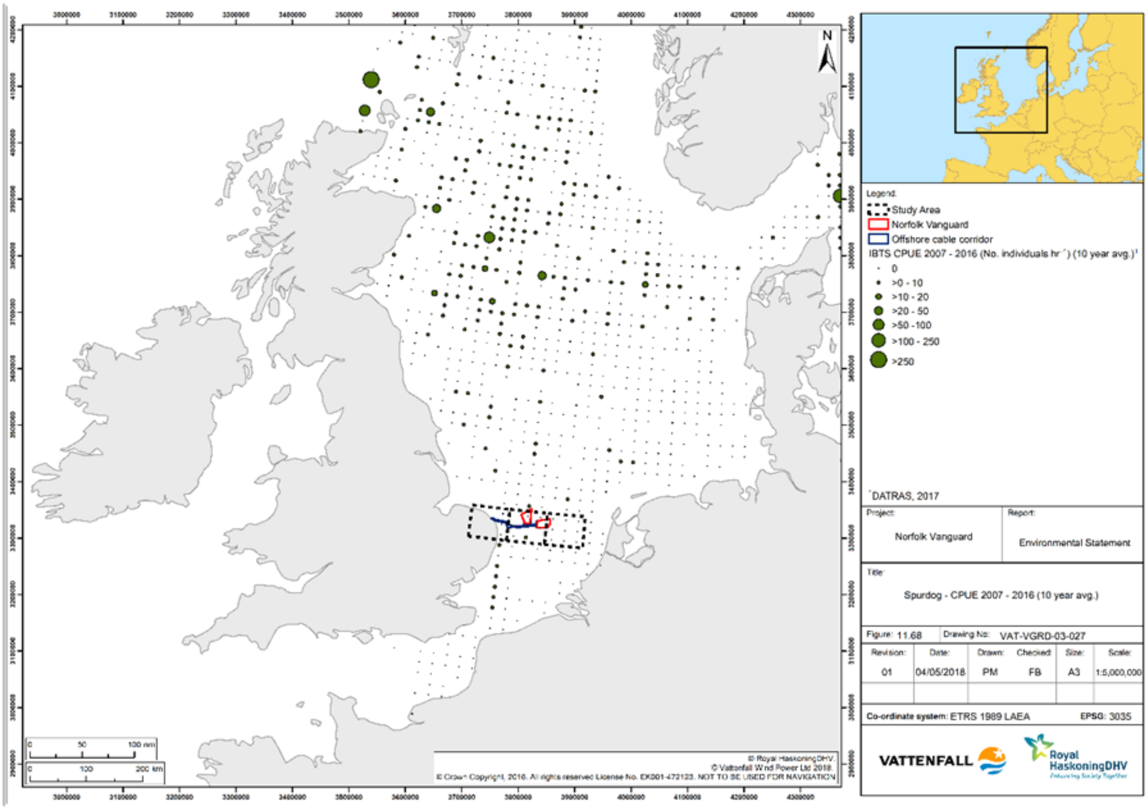


Figure 11. 68 Average number (catch per standardised haul) of Spurdog from IBTS survey data (2007-2016) (Source: DATRAS)

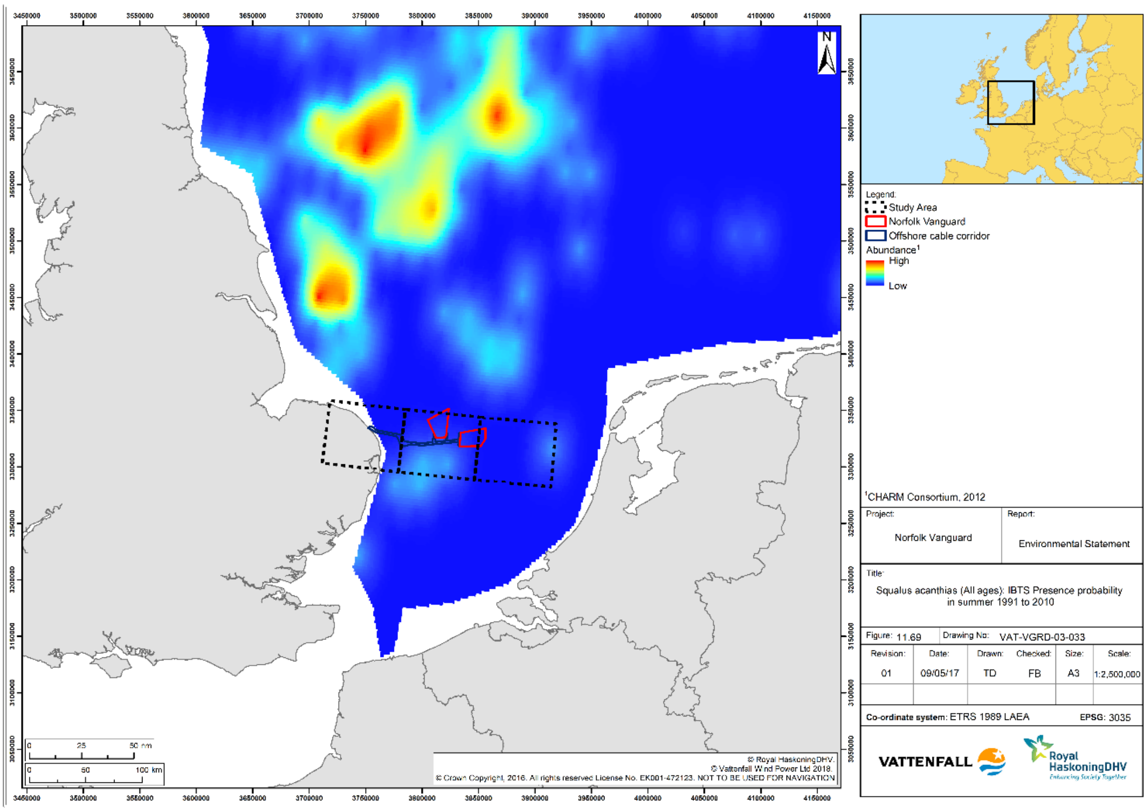


Figure 11. 69 Spurdog presence probability in summer from IBTS data (1991 to 2010) (Source: CHARM consortium)

4.1.4.5 Basking Shark

197. 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.

198. Basking sharks are of important conservation interest. They are protected under UK legislation (Wildlife and Countryside Act, 1981) as well as the Bern Convention, listed as a species of principal importance and feature on 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 11. 11).

4.1.5 Diadromous Migratory Species

4.1.5.1 River and Sea Lamprey

199. River lamprey and sea lamprey are parasitic anadromous migratory species. Figure 11. 70 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).

200. 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).

201. 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).

202. 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).

203. 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, cod, haddock 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 (4100m water depth) (Moore et al., 2003).

204. River and Sea lamprey are both of conservation interest, being listed as species of principal importance and protected under the Habitats Directive (Table 11. 10).

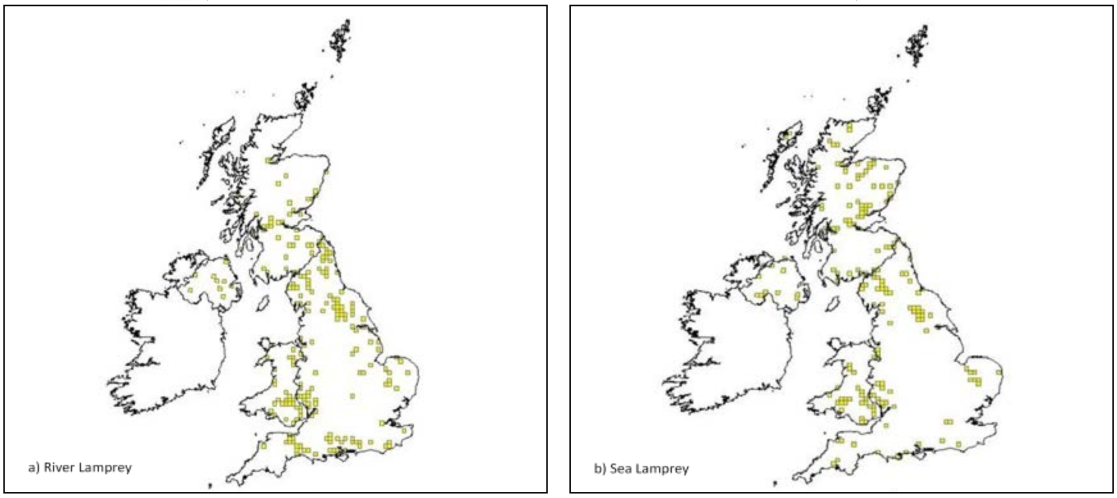


Figure 11. 70 The distribution of River Lamprey and Sea Lamprey in the UK (records 1990 to 2011) (JNCC, 2012)

4.1.5.2 Allis and Twaite Shad

205. 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.

206. The distribution of allis shad and twaite shad is presented in Figure 11. 71.

207. 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 no 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). It can therefore be assumed that allis and twaite shad are unlikely to be present and do not spawn in the vicinity of Norfolk Vanguard.

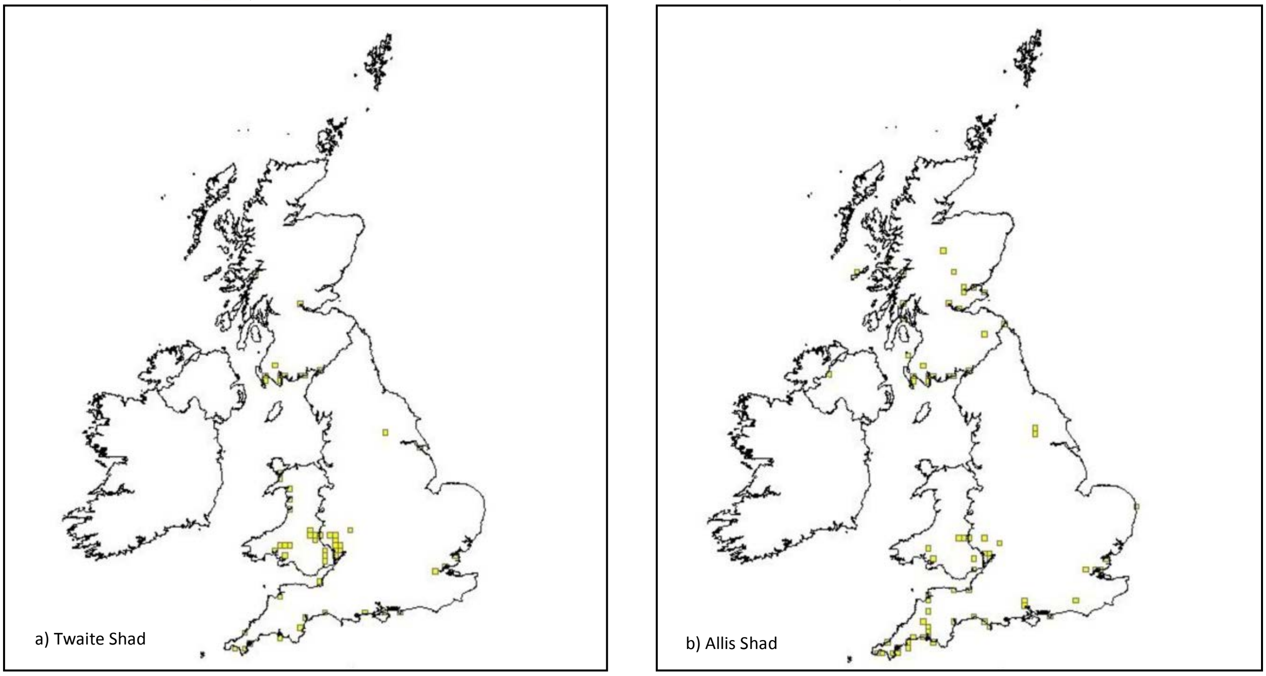


Figure 11. 71 The distribution of Twaite shad and Allis shad in the UK (records 1990 to 2011) (JNCC, 2012)

4.1.5.3 Atlantic salmon

208. 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.

209. 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.

210. 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).

211. The distribution of Atlantic salmon recorded in the UK is summarised in Figure 11. 72, highlighting that the East Anglian region does not support salmon populations.

212. Salmon have not been recorded in the regional study area during the IBTS (2007-2016), although there have been rare occurrences recorded in MMO landings data from rectangle 33F2, located directly to the south of Norfolk Vanguard (East Anglia Offshore Wind ZEA, 2012). Salmon may therefore very occasionally transit the

offshore project area, but they are not considered to be located in important migratory pathways for salmon.

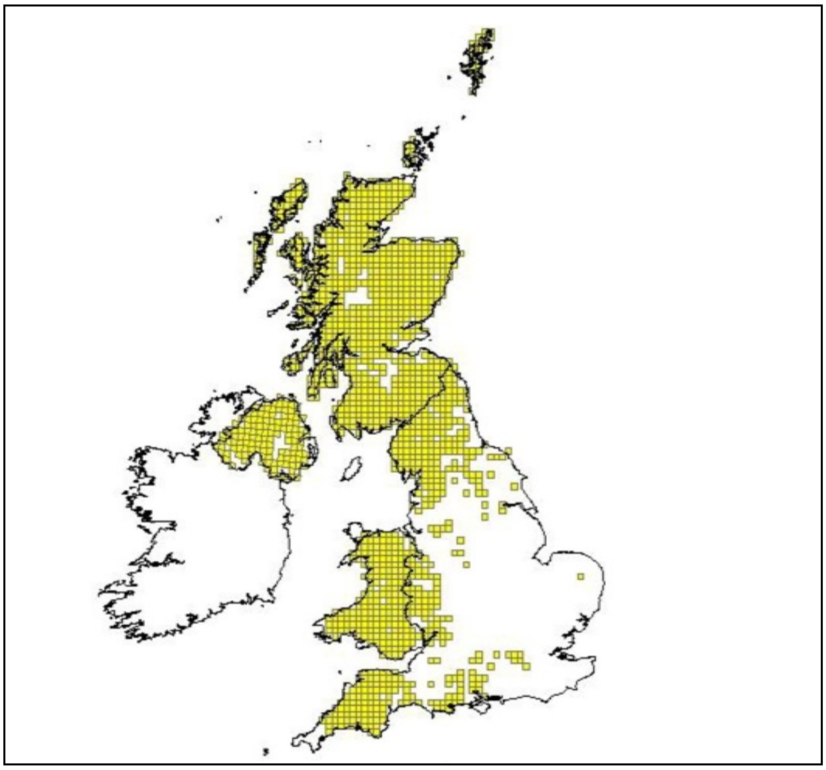


Figure 11. 72 The distribution of Atlantic salmon in the UK (records 1990-2011) (JNCC, 2012)

4.1.5.4 Sea trout

213. 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).

214. 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 including; the Glaven, Wensum and Yare (Tingley *et al*., 1997).

215. Sea trout were once targeted by local fisheries off Norfolk but underwent decline from the 1950s (Pawson, 2013). Projects have been implemented in recent years to restore and improve access for migratory trout across a number of Anglian rivers encompassing the rivers Stiffkey, Glaven, Burn, Nar, Great Eau and Welland (Everard, 2010). Despite sea trout records in each of these rivers, sea trout 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)

216. Sea trout spend at least one year maturing in the southern North Sea, before returning to their natal rivers to spawn. Sea trout fisheries are being phased out given brown/sea trout are listed as a species of principal importance (Table 11. 10).

217. This species has not been recorded within the ICES rectangles relevant to the offshore project area 34F1, 34F2 and 34F3) by the IBTS nor the MMO (Table 11. 7 and Table 11. 8).

218. The species is of important conservation interest, being listed as species of principal importance and included in the OSPAR list of threatened and/or declining species. It is 'Critically Endangered' in the IUCN Red List of Threatened Species (Table 11. 10).

4.1.6 Other Non-Commercial Fish Species

4.1.6.1 Solenette

219. 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).

220. 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).

221. 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).

222. During the East Anglia THREE and former East Anglia FOUR fish surveys, solenette was one of the more abundant non-commercial species in the catch samples (Table 11. 5 and Table 11. 6).

223. 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).

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

4.1.6.2 Sand Goby

225. 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 11. 6).

226. 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 11. 12).

227. 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.

228. 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).

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

230. 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).

4.1.6.3 Lesser Weever Fish

231. Lesser weever fish 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).

232. 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).

233. 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).

4.1.6.4 Grey Gurnard

234. 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).

235. 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).

236. Current market demand for grey gurnard is low and as a by-catch species in demersal fisheries, they are widely discarded (Mackinson and Daskalov, 2007).

237. 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 11. 4, Table 11. 5 and Table 11. 6).

4.1.7 Commercial Shellfish

4.1.7.1 Edible Brown Crab

238. Edible brown crab 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 (34F1), where they support local commercial fisheries (Table 11. 8 and Figure 11. 4).

239. 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.

240. 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).

241. Figure 11. 73 indicates a moderate to high percentage probability of the presence of edible brown crab in the vicinity of the offshore cable corridor and a low percentage probability within Norfolk Vanguard.

242. Commercial landings of edible brown crab in the offshore cable corridor (34F1) are significant at 116.99 tonnes (ave. 2006-2015), representing 23.49% of the catch within ICES rectangle 34F1 (Table 11. 8).

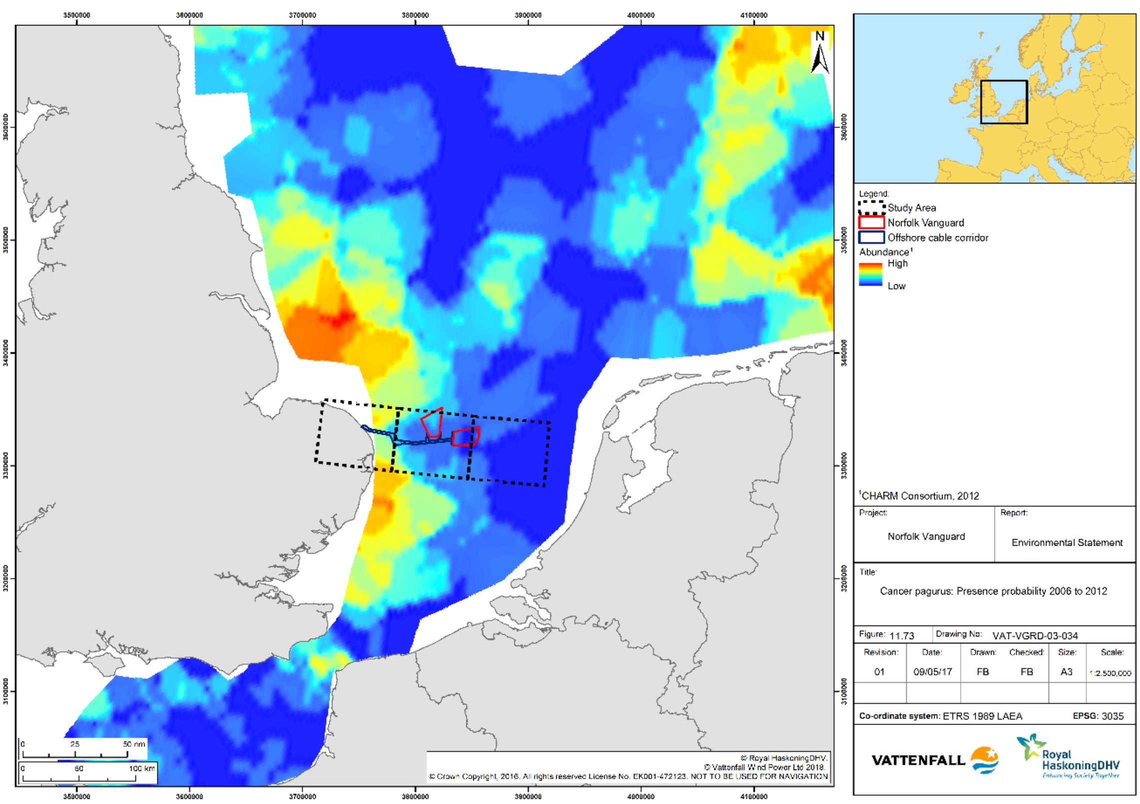


Figure 11. 73 Brown Crab presence probability. Data from IBTS (January) and CGFS (October) 2006-2012 (Source: CHARM consortium)

4.1.7.2 European Lobster

243. European lobster 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).

244. Unlike edible crabs, lobsters of both sexes are considered sedentary and have not been found to undertake extensive migrations. 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).

245. 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).

246. Larval distribution and abundance is subject to local hydrographical conditions and is therefore very variable (Cefas, 2011b). It is however, thought to be released close inshore in July to October being dependent on water temperature (Bennett and Nichols, 2007).

247. As shown in Table 11. 9, commercial landings of lobster are highest in the offshore cable corridor (34F1) but low in NV West and NV East (34F2 and 34F3).

248. The main lobster 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).

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

4.1.7.3 Whelk

250. 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). There are no known specific whelk migrations for spawning although they show aggregating behaviour and the distribution of juvenile whelks tends to be limited to areas close to the adult stock (Lockwood, 2005). Breeding occurs by copulation in late autumn following which demersal egg-cases are laid in masses from November until April (Lawler and Vause, 2009). Egg development is intracapsular whereby they do not have pelagic eggs but instead lay clumps of demersal egg-cases from which juveniles hatch as a fully formed whelk during February and March (Smith and Thatje, 2013; Hancock, 1967).

251. As shown in Table 11. 8, there is evidence of an increasingly important whelk fishery in the offshore cable corridor (34F1), with landings in 34F1 averaging 49.84 tonnes between 2006 and 2015.

252. Figure 11. 74 indicates a moderate to high percentage probability of the presence of whelk in the vicinity of Norfolk Vanguard, and a high percentage probability within the vicinity of the offshore cable corridor (data 2006 to 2012).

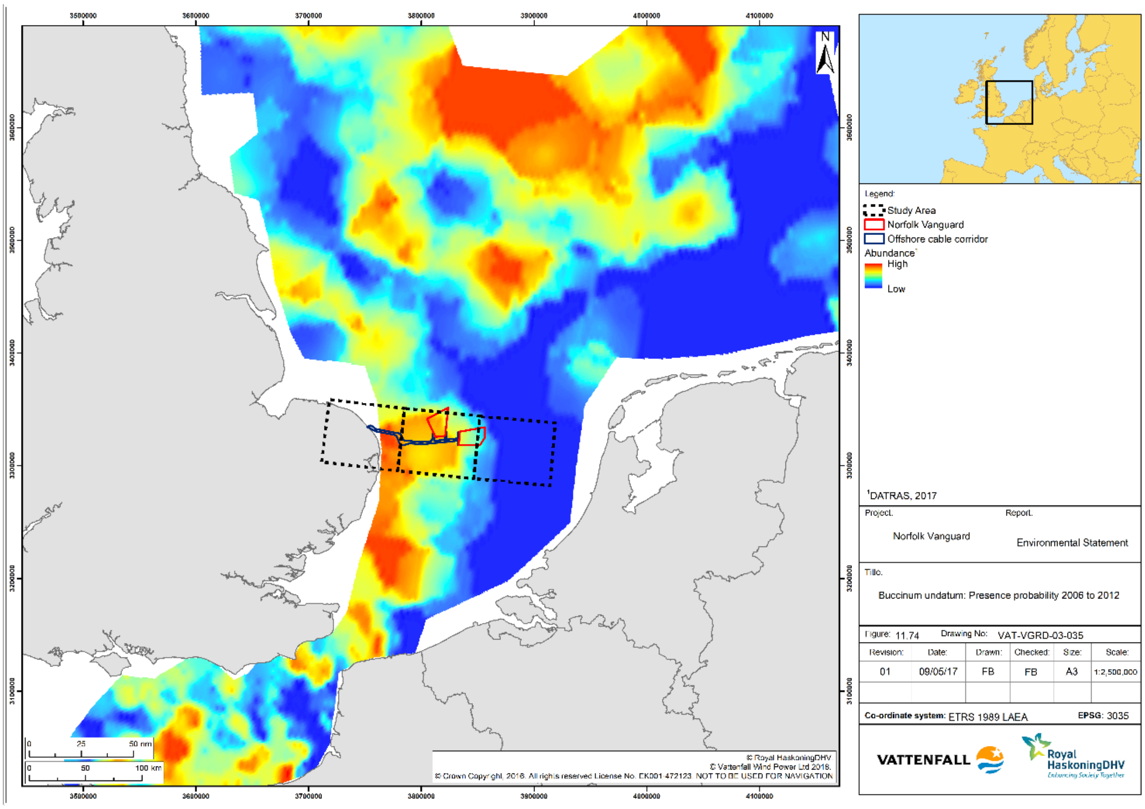


Figure 11. 74 Whelk presence probability. Data from IBTS (January) and CGFS (October) 2006-2012 (Source: CHARM consortium)

4.1.7.4 Shrimp

253. Brown shrimp has high productivity and is an important food source for many birds, fish and crustaceans. In addition, it is commercially exploited for human consumption (Neal, 2008). As suggested by landings data, shrimp do not support important fisheries in the offshore project area (Figure 11. 6). The principal fisheries for both species are located further north, within The Wash.

254. Pink shrimp *Pandulus montagui* are common at depths between 20 to 100m (Ruiz, 2008). The species 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).

255. Brown and pink shrimp have a diet consisting principally of small polycheates, hydroids, copepods and other small invertebrates (Ruiz, 2008).

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6.0 Annex 1: Evidence Plan Process Cefas fisheries advice

MARINE AND COASTAL ACCESS ACT (2009). EAST ANGLIA (NORTH) TRANCHE 1[11]
EVIDENCE PLAN PROCESS
Reference Number: DCO/2016/00002

FISHERIES ADVICE

From: Georgina Greenhalgh - Cefas, Lowestoft Laboratory
Date: 11th April 2016
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To: Frances Edwards – MMO (by e-mail)
Cc: Fisheries Advice – Cefas, Lowestoft
SEAL Case Officer – Cefas, Lowestoft

With reference to the above application for East Anglia (North) Tranche 1 Offshore Wind Farm by Vattenfall Ltd and your request for comments dated 22nd March 2016 please find my comments below in my capacity as advisor on fisheries.

Document (s) reviewed
East Anglia Tranche 1 Offshore Wind Farm, Benthic Sampling, Proposed Methodology PB4476.003.001

East Anglia Tranche 1 Offshore Wind Farm, Evidence Plan, Terms of Reference PB4476.001.004

Description of the proposed works
The Crown Estate has awarded Vattenfall Wind Power Ltd (VWPL) the right to develop the north area of the East Anglia Zone for the construction of a round three UK Offshore Wind Farm. VWPL's development of the north area, known as Tranche 1 will have a capacity of 1800MW and will be separated into East and West zones within Tranche 1.

In order to consider the requirements for an Environmental Impact Assessment (EIA), VWPL have submitted their proposed methodology for benthic sampling and collection of fisheries data with an overview of the proposed works.

Major comments 1
We note that no additional fisheries survey will be carried out prior to delivery of the EIA. Instead, data on fisheries will be established through a desk based study using previously published research resources and past survey results.
Given the previous surveys in the vicinity (undertaken as part of the East Anglia ZEA and East Anglia Three and East Anglia Four EIA's), a desk based study is likely to identify the key species present in the area together with nursery and spawning grounds, without the need for a new fisheries survey to be carried out.

We would request that any previous survey data presented in the desk based assessment and used in the EIA, includes or signposts to documents that present all relevant information such as dates and times of surveys, locations, gear used, mesh size, duration of tow / soak times. We recommend that the limitations of any data sources used in the EIA are presented and acknowledged in the report. Any inconsistencies in survey techniques from past surveys should be discussed in the report and we recommend that catch data has been standardised.

A comprehensive review of the fish and shellfish assemblages should be completed. Species of commercial importance and conservation concern in the vicinity should be sufficiently evaluated Direct impacts, cumulative and in-combination impacts should be discussed within the document.

[11] Please note that East Anglia (North) Tranche 1, is now known as Norfolk Vanguard

Major comments 2

We would recommend that the following species are considered within the EIA and that potential impacts and resulting mitigation (if required) are discussed in the report; herring, sandeels, elasmobranchs:

Herring: The main species for concern are herring; they are known to be sensitive to noise and sedimentation in relation to spawning activities. Herring are benthic spawners and require a specific substrate on which to lay their eggs. Typical spawning sites consist of gravel, coarse sand, maerl or shell with a low proportion of fine sediment and well oxygenated water. Data from the International Herring Larvae Surveys (IHLS) will provide herring larvae details for the Southern North Sea area. IHLS data can be found via the ICES Egg and Larvae data portal website; http://www.ices.dk/marine-data/data-portals/Pages/Eggs-and-larvae.aspx

Sandeels: are ecologically important and also fished commercially. Sandeels generally spawn where they are found, therefore nursery grounds are generally located in the same area as spawning grounds. Ellis et al., 2012 identifies that there may be sandeel nursery and spawning grounds around the development area. Sandeels may be present in samples collected using epibenthic trawls and benthic grabs undertaken during the benthic ecology surveys. Although these survey methods are not designed to target sandeels, if sandeels are recorded in either gear this indicates presence in the survey area and any presence in the samples should be discussed in the EIA.

Elasmobranchs: Submarine export cables from windfarms are known to produce an electromagnetic field (EMF). Electrosensitive elasmobranchs (i.e. sharks, skates and rays) may have the potential to detect and react to the EMF produced by such export cables. The National Policy Statement for Renewable Energy Infrastructure (EN-3) (Dept. of Energy & Climate Change, 2011) recommends to minimise the potential effect of EMF that cables are laid to a depth of greater than 1.5m. The effects of EMF on sensitive species e.g. elasmobranchs may be mitigated by adopting this recommendation. However, we recognise that this may be subject to local seabed geology, and other receptors in the area.

We would also recommend that commercially important species such as cod, sole and plaice as well as species of conservation concern are sufficiently assessed in the EIA.

Observations 1

In order to characterise the fish and shellfish ecology for the EIA, a variety of desk-based resources will be used e.g. Ellis et al., 2010 & Coull et al., 1998 and International Bottom Trawl Survey (IBTS) data. We agree that the information sources described in the report combined with the existing East Anglia FOUR data will allow characterisation of the Tranche 1 offshore project area for the EIA, without the need for further fish trawl surveys.

Cefas beam trawl surveys are conducted in the Eastern English Channel in ICES divisions VIId and IVc. Data from these trawls may provide an additional source of fisheries information. Information can be downloaded from the ICES DATRAS website http://datras.ices.dk/Home/Default.aspx

Observations 2

We note and endorse the Particle Size Analysis (PSA) to be carried out to determine sediment type as part of the benthic characterisation. PSA data can also provide information on site suitability for sandeel habitats and herring spawning grounds

Any additional comments

We promote and encourage good relations with fishermen and those working in the industry who may be affected by the such developments. We encourage developers to consider the impacts to shipping and commercial fishing as a result of construction activity. Impacts should be identified and appropriate mitigation measures outlined in the report to ensure minimal disruption to other sea users.

Georgina Greenhalgh
Fisheries Scientist

Quality Check	***Date***
Louise Straker Cox ***Senior Fisheries Environmental Impact Advisor***	***12/04/2016***

SEAL high level QC	***Date***
Ruth Edwards	13/04/2016

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7.0 Annex 2: East Anglia THREE Fish and Shellfish Survey 16th to 26th February 2013

East Anglia Offshore Windfarm

East Anglia THREE

Fish and Shellfish Survey

16th to 26th February 2013

Undertaken by
Brown and May Marine Ltd

Ref	Issue Date	Issue Type	Author	Checked	Approved
EA3OB01	10/09/2013	Draft 2	LS/AWG	LS/AWG/PO	SJA

7.1 Content

Figures

Tables

1.0 Summary

1.1 Otter Trawl

A total of 11 species were caught in the otter trawl survey; seven at the control stations and 10 within East Anglia THREE. Overall, dab (*Limanda limanda*) was the most abundant species caught, followed by plaice (*Pleuronectes platessa*) and then whiting (*Merlangius merlangus*). All other species were caught in relatively low numbers. The total overall catch rate was highest within East Anglia THREE. The highest catch rate for all species combined was recorded at station OT09 within East Anglia THREE. *P. platessa* and *L. limanda* represented the highest proportion of the catch at all stations, with the exception of OT09, where *M. merlangus* was most prevalent.

Four species of fish were caught with a set minimum landing size (MLS). Most of the *P. platessa* and *M. merlangus* caught in both sampling areas were below the MLS. All of the cod (*Gadus morhua*) found at the control stations and within East Anglia THREE were above the MLS, and all of the herring (*Clupea harengus*) caught within East Anglia THREE were below the set MLS.

The sex ratio of the *L. limanda* caught at the control stations and within East Anglia THREE was approximately even, with most individuals classed as maturing. The majority of *P. platessa* caught in both sampling areas were male; the highest proportion of which were maturing. Three *M. merlangus* were caught at the control stations; two of which were immature males, and one was a maturing female. Within East Anglia THREE, the sex ratio of the *M. merlangus* found was approximately even, with most individuals identified as maturing.

1.2 Beam Trawl

A total of 16 species of fish and shellfish were caught, 11 of which were found at the control stations and 12 within East Anglia THREE. Overall, *P. platessa* was the most abundant species caught, followed by *L. limanda*. All other species were caught in relatively low numbers. The total overall catch rate was highest within East Anglia THREE. The station with the greatest total catch rate was BT02 within East Anglia THREE, with *L. limanda* and *P. platessa* representing 80.9% of the catch. These species represented the highest proportion of the catch at most sampling stations.

Two fish and one shellfish species were caught with a set MLS. Most of the *P. platessa* caught at the control stations and within East Anglia THREE were below the set MLS. One whelk (*Buccinum undatum*) was caught at the control stations and was above the MLS, and one *M. merlangus* was found within East Anglia THREE and was below the set MLS.

The majority of the *P. platessa* caught at the control stations and within East Anglia THREE were male, most of which were spent. A higher proportion of the *L. limanda* caught within East Anglia THREE were female, whereas at the control stations the sex ratio was approximately even; the majority of all individuals were spent.

2.0 Introduction

The following report details the findings of the February 2013 fish and shellfish survey, undertaken within and adjacent to East Anglia THREE, located within the East Anglia Zone, between the 16th and 26th February.

The East Anglia THREE offshore windfarm is located in the North Sea, approximately 79 km off the coast of Suffolk.

The survey methodology, vessel and sampling gear detailed were agreed in consultation with Cefas and the Marine Management Organisation (MMO). A dispensation from the MMO for the Provisions of Council Regulation 850/98 to catch and retain undersize fish for scientific research and 43/2009 specifically related to days at sea was obtained prior to commencement of this survey. A summary of the health and safety performance of the survey is provided in Appendix 1.

The aim of the survey was to establish the abundance and composition of fish and shellfish species within the area of the East Anglia THREE offshore windfarm.

3.0 Scope of Works

The proposed scope of works for the February 2013 fish and shellfish survey is detailed below, and the proposed sampling stations are illustrated in Figure 3.1 overleaf.

- **Otter Trawl**
  - Six tows of approximately 20 minutes duration within East Anglia THREE and three control tows in adjacent areas

- **Beam Trawl**
  - Four tows of approximately 20 minutes duration within East Anglia THREE and four control tows in adjacent areas

- **Otter and Beam Trawl Sample Analysis**
  - Number of individuals and catch rate by species
  - Length distribution by species
    - Finfish & sharks (except *C. harengus* & sprat; *Sprattus sprattus*): individual lengths (nearest cm below)
    - *C. harengus* & *S. sprattus*: individual lengths (nearest ½ cm below)
    - Rays: individual length and wing-width (nearest cm below)
  - Sex ratio by species
  - Spawning condition
    - Finfish species (except *C. harengus*): Cefas Standard Maturity Key - Five Stage
    - *C. harengus*: Cefas Maturity Key – Nine Stage
    - Ray and shark species: Cefas Standard Elasmobranch Maturity Key - Four Stage

For the purposes of data analysis, catch rates have been calculated to allow for quantitative comparisons to be made between the numbers of individuals caught per hour at each station.

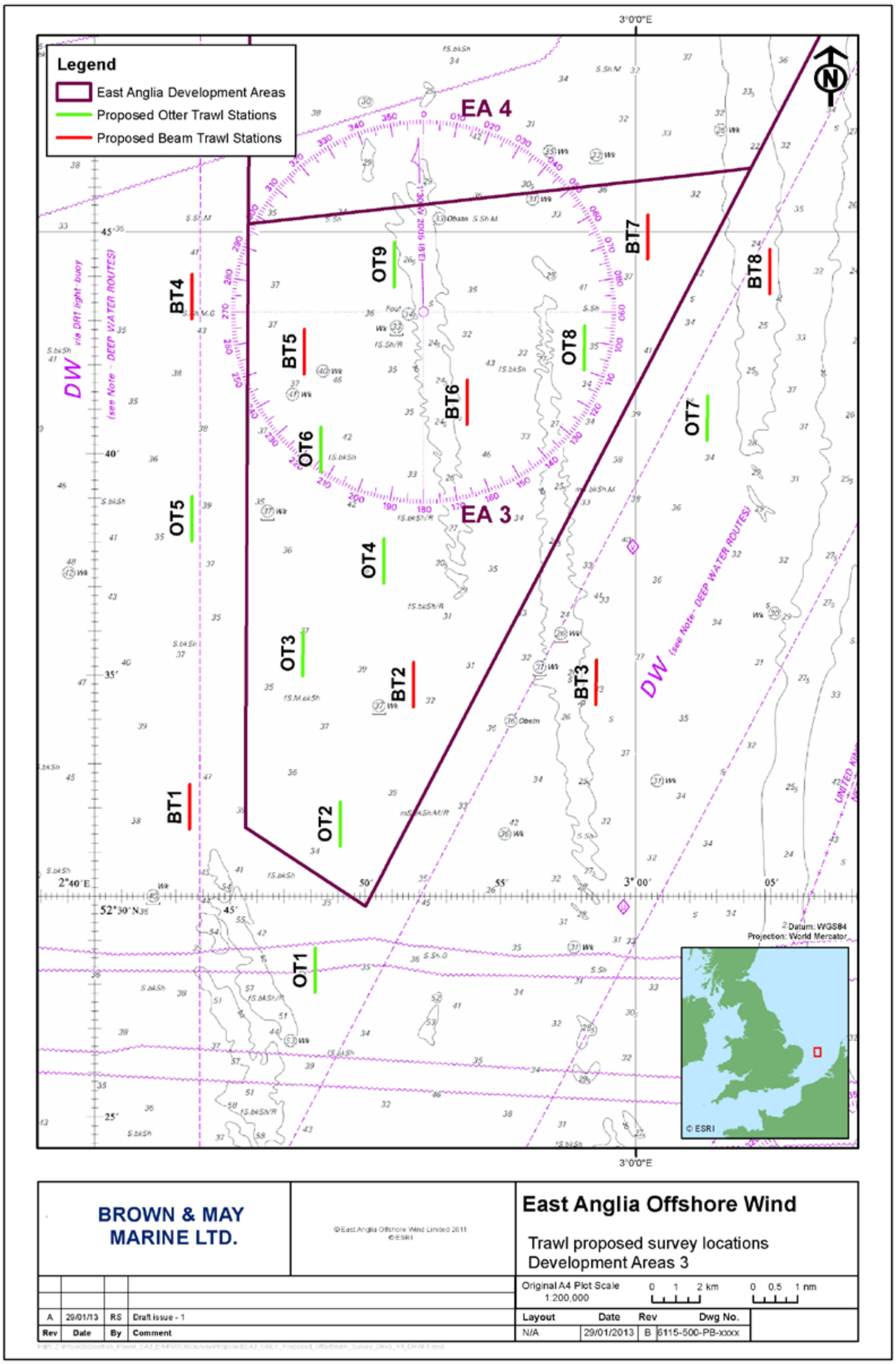


Figure 3.1 Proposed Trawl Locations

4.0 Methodology

4.1 Survey Vessel

The vessel chartered for the survey (Figure 4.1), the "Jubilee Spirit", is a Grimsby-based commercial trawler that was contracted for previous fish and shellfish surveys at East Anglia One. The specifications of the vessel are given below in Table 4.1.

Figure 4.1 Survey Vessel "Jubilee Spirit"

Table 4.1 Survey Vessel Specifications

Survey Vessel Specifications	
Length	21.2m
Beam	6.9m
Draft	2.3m
Main engine	Caterpillar Type 340TA 475 BHP
Gearbox	Hydraulic 6: reduction
Propeller	4 Blade Manganese Bronze Fixed Pitch 1.7m diameter
GPS	2-Furuno GP80
Plotters	Sodena Plotter with Electronic Charts
Sounder	Furuno Daylight Viewing

4.2 Sampling Gear

4.2.1 Commercial Otter Trawl

A commercial otter trawl (Figure 4.2) with a 100mm mesh cod-end was used for fish and shellfish sampling; the specifications of which are given in Table 4.2 below.

Figure 4.2 Otter Trawl Used

Table 4.2 Otter Trawl Specifications

Otter Trawl Specifications	
Towing Warp	18mm, 6x19+1
Depth: Payout Ratio	3:1
Trawl Doors	Perfect B 84
Net	100mm mesh cod-end
Ground line length	24.4m
Footrope	Rock-hopper with 18-inch bobbins
Est. Headline height	7.3m
Distance between doors (est.)	51m

4.2.2 Commercial 4m Beam Trawl

A commercial beam trawl (Figure 4.3) with an 80mm mesh cod end was used for fish and shellfish sampling; the specifications of which are given in Table 4.3 below.

Figure 4.3 Beam Trawl Used

Table 4.3 Beam Trawl Specifications

Beam Trawl Specifications	
Beam width	4m
Headline height	60cm
Cod-end liner	80mm (double twinned on belly and cod end)
Ground gear	5cm rubber bobbins and chain mat

4.3 Positioning and Navigation

The position of the vessel was tracked at all times using a Garmin GPSMap 60 with an EGNOS differential connected to an external Garmin GA30 antenna. Trawl start times and positions were taken when the winch stopped paying out the gear. Similarly, trawl end times and positions were taken when hauling of the gear commenced.

4.4 Sampling Operations

The survey was undertaken from the 16th to the 26th February 2013. A summarised log of events is given in Table 4.4 below.

Table 4.4 Summarised Log of Events

Thursday 14th February 2013
Vessel audited in Grimsby
Friday 15th February 2013
Vessel on standby awaiting confirmation
Saturday 16th February 2013
Vessel departs Grimsby at 0800 and steams to Lowestoft
Surveyors meet vessel at Lowestoft 2330, load and stow gear
Pre-departure H&S meeting conducted. Safety drill carried out at 2345
Vessel departs Lowestoft at 2355 and steams overnight to survey area
Overnight at sea
Sunday 17th February 2013
Beam trawls: BT01 (3 repeats), BT02 (2 repeats), BT03, BT06
Archaeological samples: BT02 (peat and wood), BT03 (peat)
Weather: BF 1/2
Overnight at sea
Tuesday 19th February 2013
Beam trawls: BT08, BT07, BT05, BT04
Weather: BF 1/2
Archaeological samples: BT07 (peat), BT05 (peat)
Steam overnight to Lowestoft for sample drop and gear changeover
Overnight at sea
Wednesday 20th February 2013

Arrive at Lowestoft at 0430
Beam trawl removed from vessel
Beam trawl and archaeological samples landed and transported to BMM
Depart Lowestoft at 1715 and steam to survey area
Weather: BF4-5, moderate
Overnight at sea
Friday 22nd February 2013
Otter trawls: OT09
Weather: BF 4
Overnight at sea
Saturday 23rd February 2013
Otter trawls: OT05, OT06, OT04, OT08, OT07
Weather: BF 5
Overnight at sea
Sunday 24th February 2013
Otter trawls: OT03, OT02, OT01
Steam to Lowestoft
Weather: BF 6
Overnight at sea
Monday 25th February 2013
Arrive into Lowestoft at 0930
Demobilise survey
Otter trawl samples landed and transported to BMM
Vessel steams to Grimsby overnight
Tuesday 26th February 2013
Vessel arrives at Grimsby at 1200

4.5 Otter Trawl Sampling

The whole catch from each otter trawl was retained. The samples were then boxed, labelled, photographed, iced and stored at +2°C before transportation to Cefas (Lowestoft) for analysis at the end of the survey, in line with the agreed scope of works.

The start and end times, co-ordinates and the duration of each otter trawl are given in Table 4.5 (control and East Anglia THREE tows highlighted green and red respectively). The vessel tracks whilst towing the otter trawl are illustrated in Figure 4.4 overleaf.

Table 4.5 Start and End Times, Co-ordinates and Duration of each Otter Trawl

Station	Date	Start				End				Duration (hh:mm:ss)
		Time (GMT)	UTM31N		Depth (m)	Time (GMT)	UTM31N		Depth (m)	
			Easting	Northing			Easting	Northing		
OT01	24/02/2013	11:29:01	486,217.90	5,813,209.15	41.6	11:49:02	486,145.75	5,814,461.27	43.8	00:20:01
OT02		09:58:50	487,422.74	5,819,196.80	42.9	10:18:52	487,230.58	5,820,000.08	43.4	00:20:02
OT03		08:20:46	485,945.24	5,826,006.23	41.4	08:40:50	485,897.42	5,826,647.08	40.3	00:20:04
OT04	23/02/2013	11:29:18	489,607.57	5,831,842.24	45.8	11:49:37	489,485.59	5,830,410.79	45.8	00:20:19
OT05		08:06:19	481,455.17	5,831,077.08	41.8	08:26:30	481,258.74	5,832,147.59	41.6	00:20:11
OT06		10:07:53	486,599.86	5,836,939.84	42.7	10:27:57	486,881.86	5,835,369.09	43.8	00:20:04
OT07		15:36:34	503,037.74	5,837,504.56	36.5	15:56:36	502,926.78	5,836,108.93	36.3	00:20:02
OT08		14:04:07	497,831.06	5,840,576.67	36.7	14:24:11	497,870.74	5,839,399.55	38.0	00:20:04
OT09	22/02/2013	08:41:06	489,412.99	5,841,534.77	37.0	09:01:12	489,761.39	5,842,740.84	36.3	00:20:06

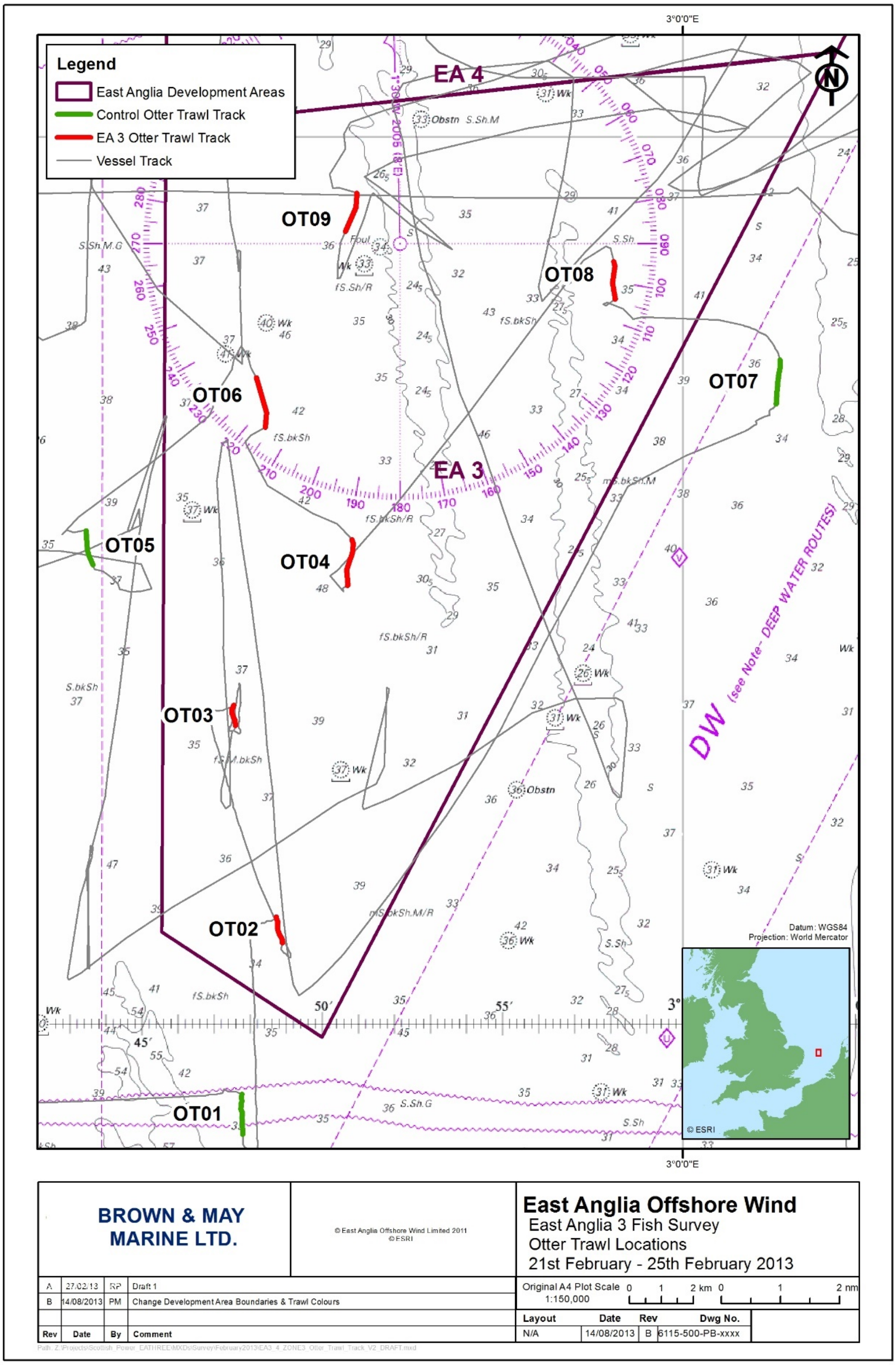


Figure 4.4 Vessel Tracks whilst Towing the Otter Trawl

4.6 Beam Trawl Sampling

The whole catch from each beam trawl was retained. The samples were then boxed, labelled, photographed, iced and stored at +2°C before transportation to Cefas (Lowestoft) for analysis at the end of the survey, in line with the agreed scope of works.

The start and end times, co-ordinates and the duration of each beam trawl are given in Table 4.6 (control and East Anglia THREE tows highlighted green and red respectively). The vessel tracks whilst towing the beam trawl are illustrated in Figure 4.5.

Table 4.6 Start and End Times, Co-ordinates and Duration of each Beam Trawl

Station	Date	Start				End				Duration (hh:mm:ss)
		Time (GMT)	UTM31N		Depth (m)	Time (GMT)	UTM31N		Depth (m)	
			Easting	Northing			Easting	Northing		
BT01	17/02/2013	10:00:44	481,268.97	5,821,478.75	47.8	10:20:51	481,356.48	5,819,026.48	47.1	00:20:07
BT02		13:28:25	490,692.00	5,826,745.83	39.6	13:48:50	490,111.69	5,824,259.11	41.4	00:20:25
BT03		15:03:16	498,178.15	5,826,496.81	37.6	15:24:22	498,102.18	5,824,307.54	33.2	00:21:06
BT04	19/02/2013	15:42:56	481,428.57	5,842,901.57	42.9	16:03:05	481,296.69	5,840,193.78	45.3	00:20:09
BT05		14:11:07	486,124.87	5,840,493.40	44.2	14:31:25	486,148.92	5,837,974.61	43.3	00:20:18
BT06	17/02/2013	16:50:20	493,048.35	5,836,314.47	35.4	17:10:21	492,545.37	5,838,282.74	34.3	00:20:01
BT07	19/02/2013	09:24:00	500,506.15	5,843,289.83	40.3	09:44:01	500,628.20	5,845,484.99	37.4	00:20:01
BT08		08:04:51	505,641.48	5,841,748.10	32.3	08:24:57	505,602.89	5,844,106.84	31.6	00:20:06

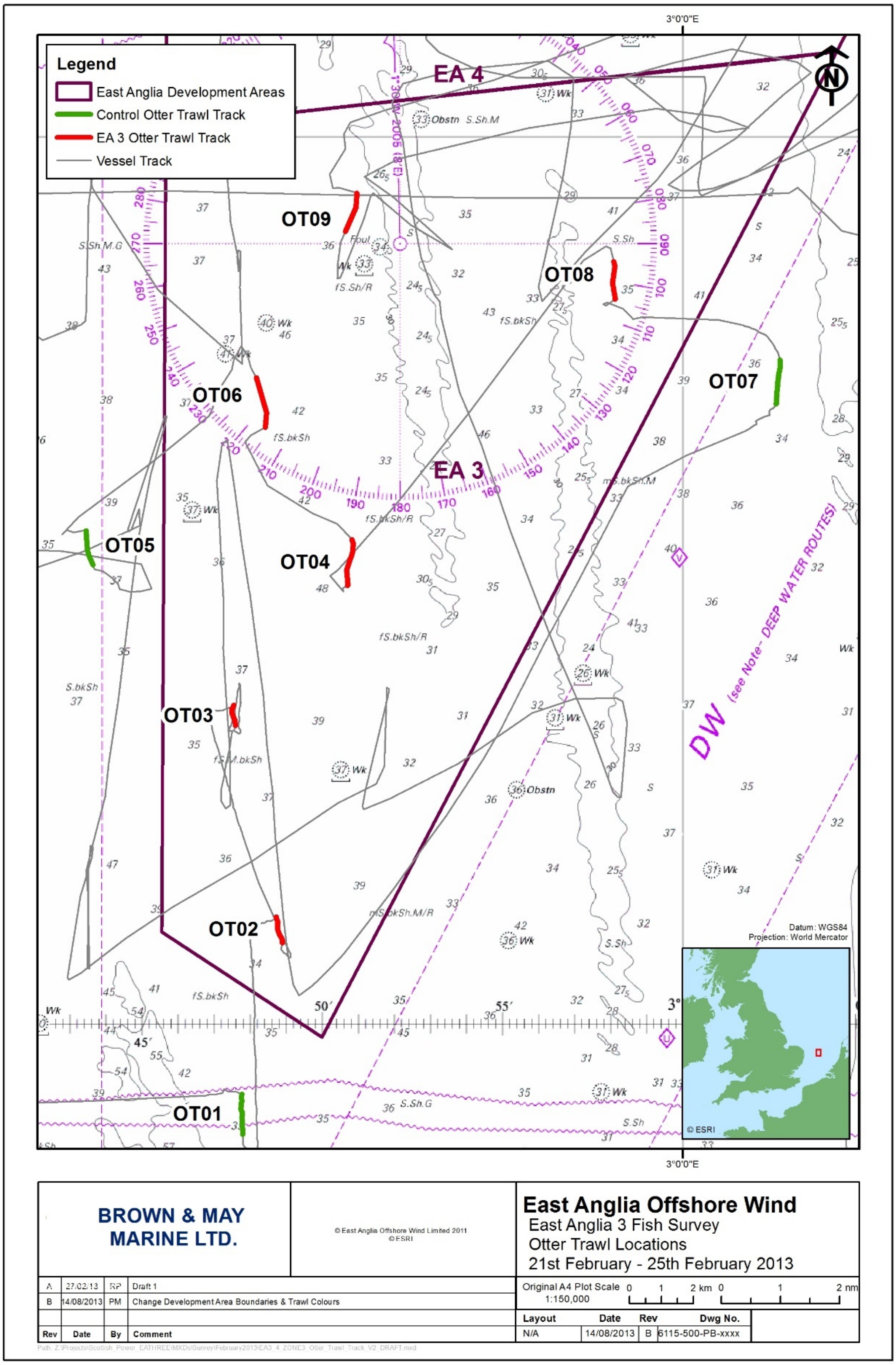


Figure 4.5 Vessel Tracks whilst Towing the Beam Trawl

5.0 Otter Trawl Results

5.1 Catch Rates and Species Distribution

The total number of individuals caught and the catch rate (number of individuals caught per hour) for fish and shellfish species by sampling area (control and East Anglia THREE) are given in Table 5.1 and are illustrated in Figure 5.1. The catch rates by sampling station are illustrated in Figure 5.2 (red boxes denote stations within East Anglia THREE).

Spatial distribution plots for the most abundant species are given in Figure 5.3 to Figure 5.5, showing the percentage distribution by catch rate of *L. limanda*, *P. platessa* and *M. merlangus*. The circle size corresponds to the catch rate i.e. larger circles indicate greater catch rates.

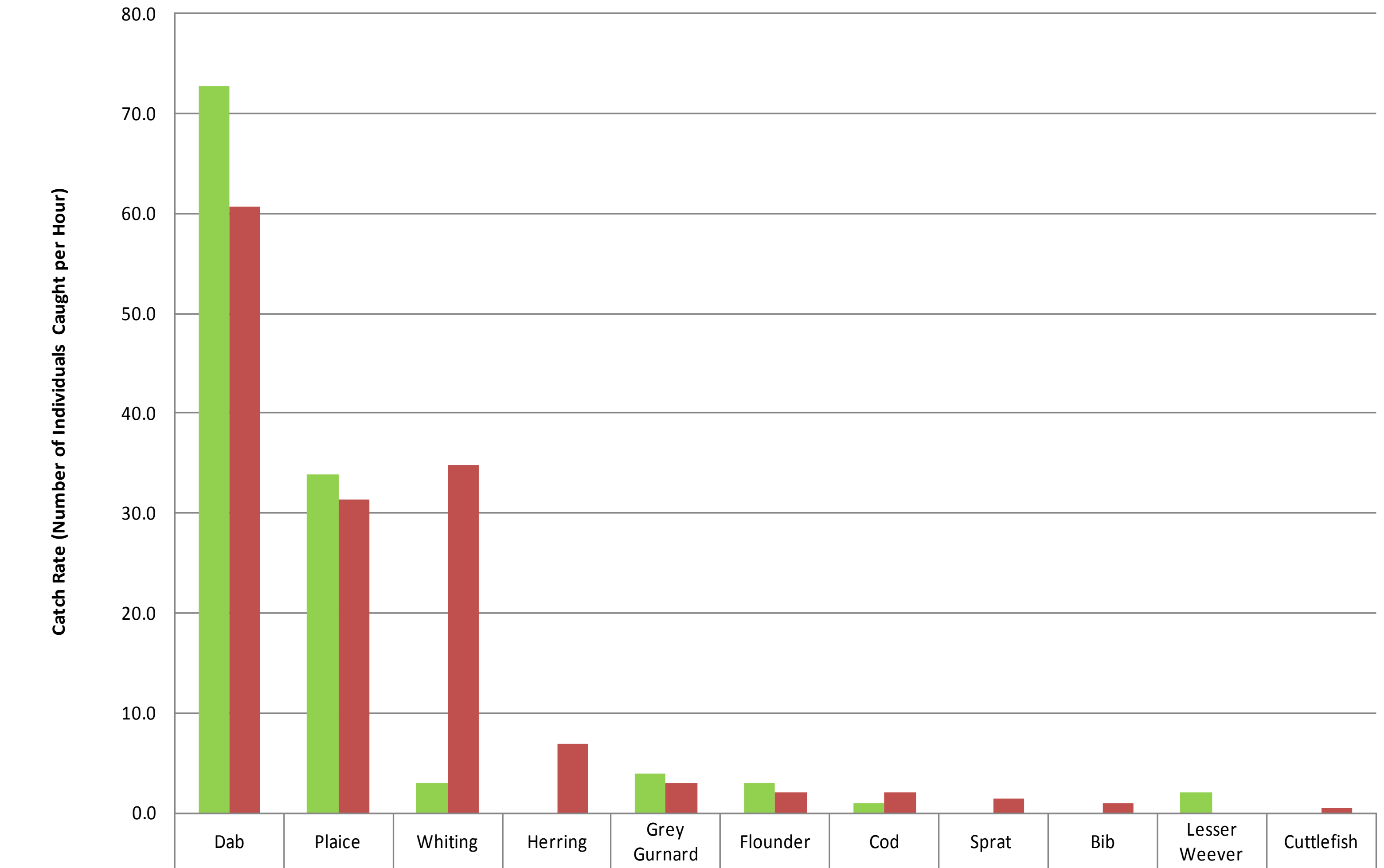
A total of 11 species were caught; seven at the control stations and 10 within East Anglia THREE. Overall, *L. limanda* was the most abundant species caught, followed by *P. platessa* and then *M. merlangus*. All other species were caught in relatively low numbers.

The highest catch rate for all species combined was recorded at station OT09 (289.6/hr) within East Anglia THREE, with *M. merlangus* accounting for 62.9% of the catch. *P. platessa* and *L. limanda* represented the highest proportion of the catch at all stations, with the exception of OT09, where *M. merlangus* was most prevalent.

Overall, the total catch rate was higher within East Anglia THREE (143.7/hr) than at the control stations (119.5/hr).

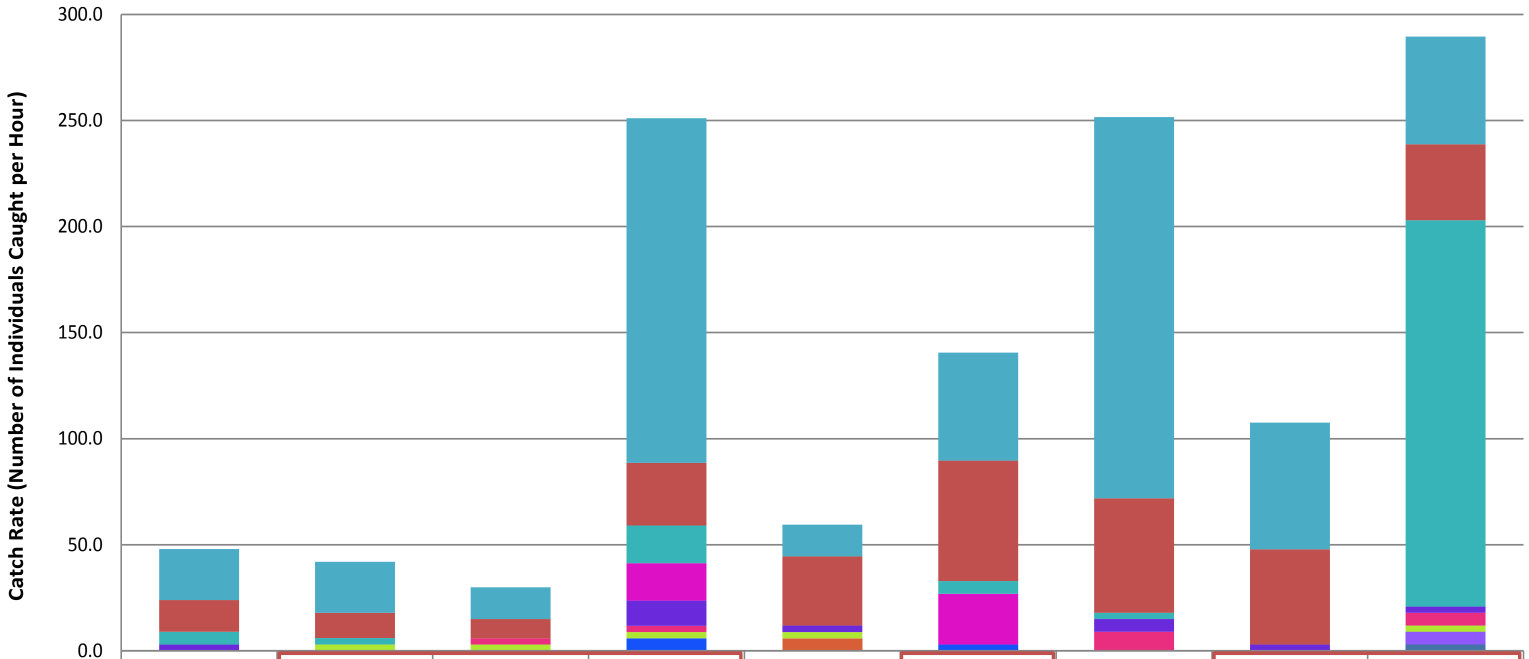
Table 5.1 Total Numbers of Individuals Caught and Catch Rate for Fish Species by Sampling Area

Species		Number of Individuals Caught			Catch Rate (Number of Individuals Caught per Hour)	
Common Name	Scientific Name	Control	East Anglia THREE	Total	Control	East Anglia THREE
Dab	*Limanda limanda*	73	122	195	72.7	60.7
Plaice	*Pleuronectes platessa*	34	63	97	33.9	31.3
Whiting	*Merlangius merlangus*	3	70	73	3.0	34.8
Herring	*Clupea harengus*	0	14	14	0.0	7.0
Grey Gurnard	*Eutrigla gurnardus*	4	6	10	4.0	3.0
Flounder	*Platichthys flesus*	3	4	7	3.0	2.0
Cod	*Gadus morhua*	1	4	5	1.0	2.0
Sprat	*Sprattus sprattus*	0	3	3	0.0	1.5
Bib	*Trisopterus luscus*	0	2	2	0.0	1.0
Lesser Weever	*Echiichthys vipera*	2	0	2	2.0	0.0
Cuttlefish	*Sepia officinalis*	0	1	1	0.0	0.5
Total No. of Individuals		120	289			
Total No. of Species		7	10			
Catch Rate (No. of Individuals Caught per Hour)		119.5	143.7			



	Dab	Plaice	Whiting	Herring	Grey Gurnard	Flounder	Cod	Sprat	Bib	Lesser Weever	Cuttlefish
Control	72.7	33.9	3.0	0.0	4.0	3.0	1.0	0.0	0.0	2.0	0.0
East Anglia THREE	60.7	31.3	34.8	7.0	3.0	2.0	2.0	1.5	1.0	0.0	0.5

Figure 5.1 Catch Rate by Species and Sampling Area



	OT01	OT02	OT03	OT04	OT05	OT06	OT07	OT08	OT09
Dab	24.0	24.0	15.0	162.4	14.9	50.8	179.7	59.8	50.7
Plaice	15.0	12.0	9.0	29.5	32.7	56.8	53.9	44.9	35.8
Whiting	6.0	3.0	0.0	17.7	0.0	6.0	3.0	0.0	182.1
Herring	0.0	0.0	0.0	17.7	0.0	23.9	0.0	0.0	0.0
Grey Gurnard	3.0	0.0	0.0	11.8	3.0	0.0	6.0	3.0	3.0
Flounder	0.0	0.0	3.0	3.0	0.0	0.0	9.0	0.0	6.0
Cod	0.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0
Sprat	0.0	0.0	0.0	5.9	0.0	3.0	0.0	0.0	0.0
Lesser Weever	0.0	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.0
Bib	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0
Cuttlefish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0

Station

Figure 5.2 Catch Rate by Species and Station (red boxes denote stations within East Anglia THREE)

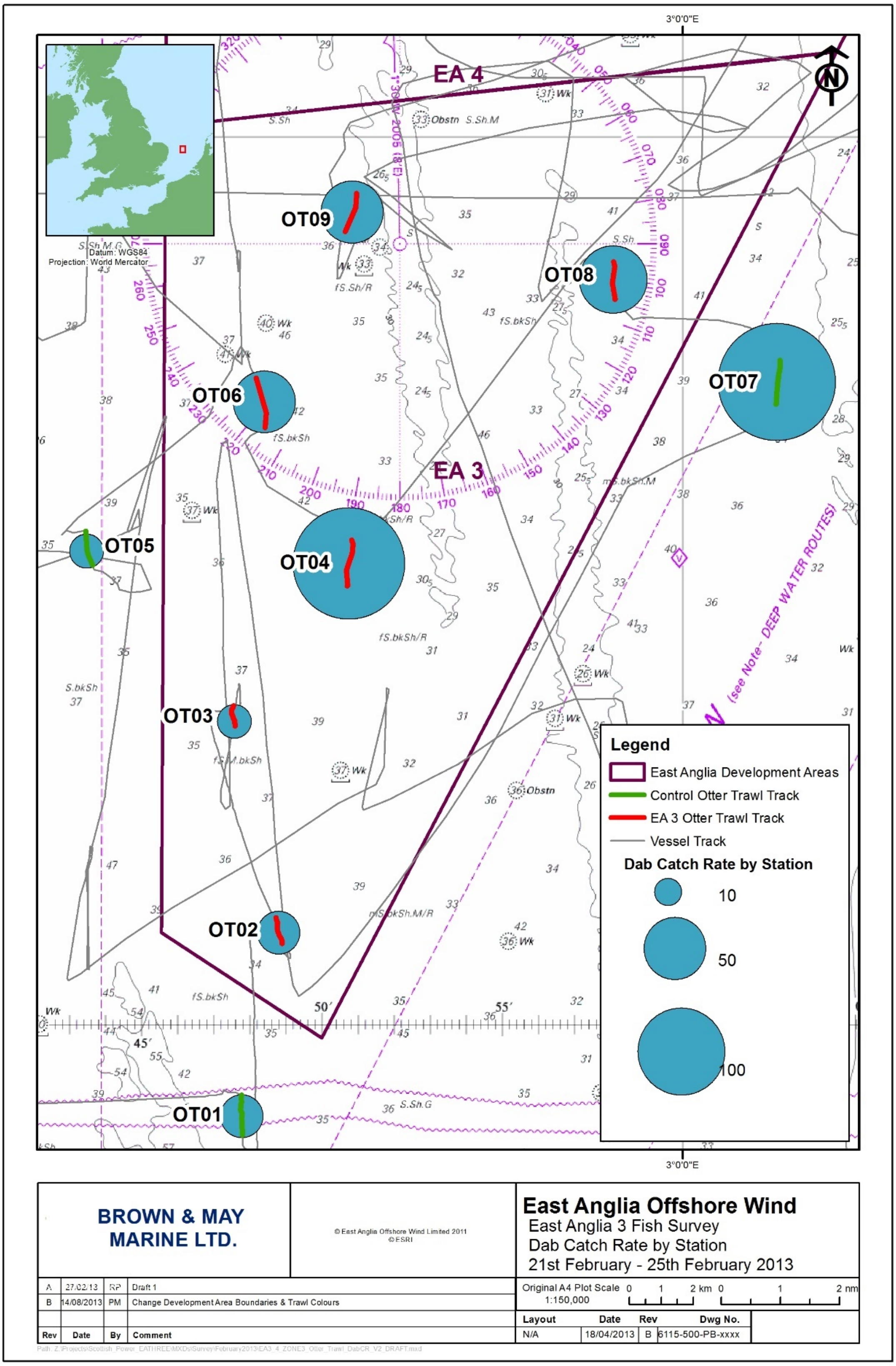


Figure 5.3 Spatial Distribution of Dab (*L. limanda*) in the Area of East Anglia THREE

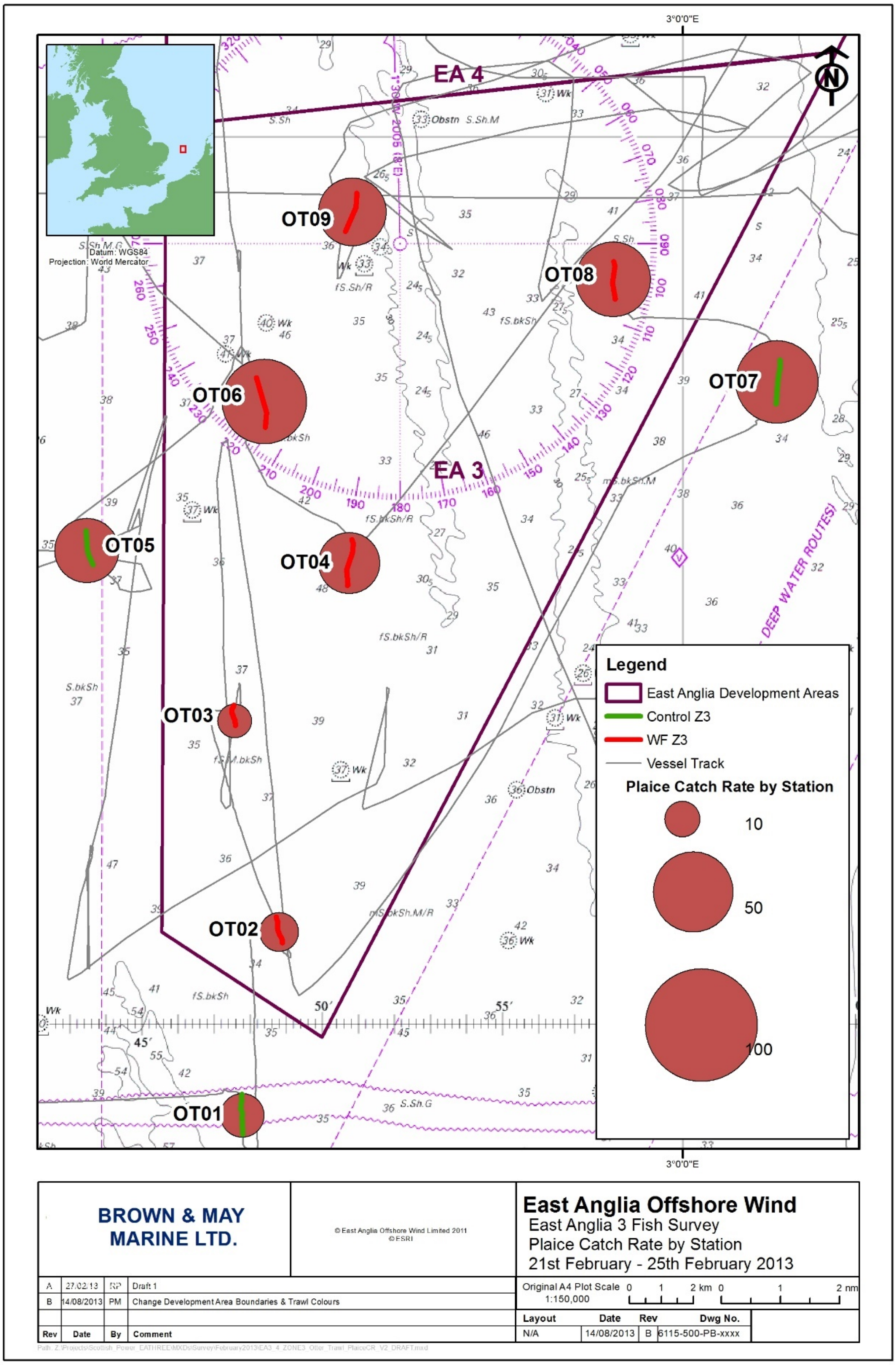


Figure 5.4 Spatial Distribution of Plaice (*P. platessa*) in the Area of East Anglia THREE

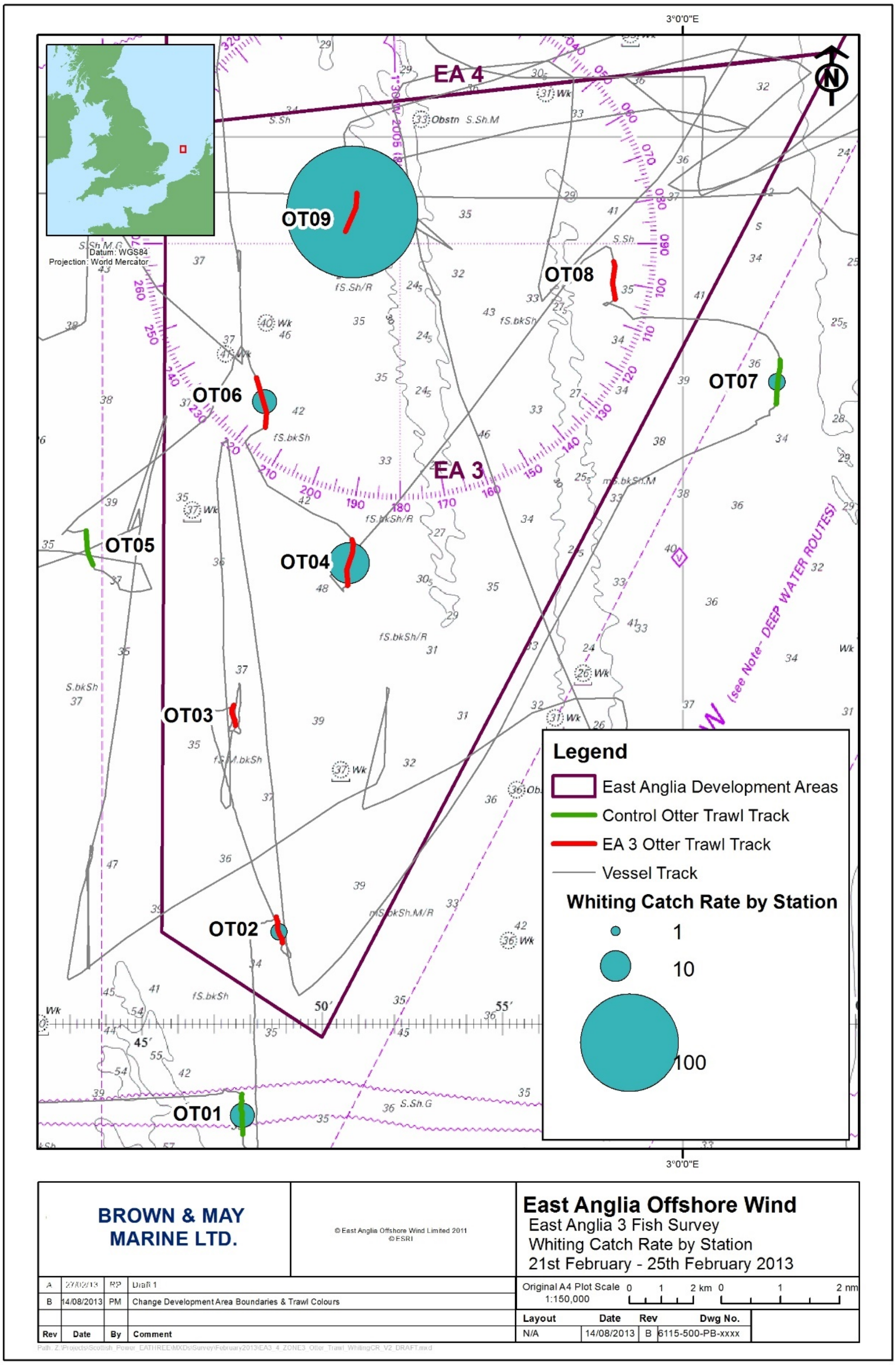


Figure 5.5 Spatial Distribution of Whiting (*M. merlangus*) in the Area of East Anglia THREE

5.2 Length Distributions

The length distributions of the three most abundant species caught during the survey, expressed as the catch rate (number of individuals caught per hour) by length (cm) and by sampling area (control and East Anglia THREE), are shown in Figure 5.6 to Figure 5.6.

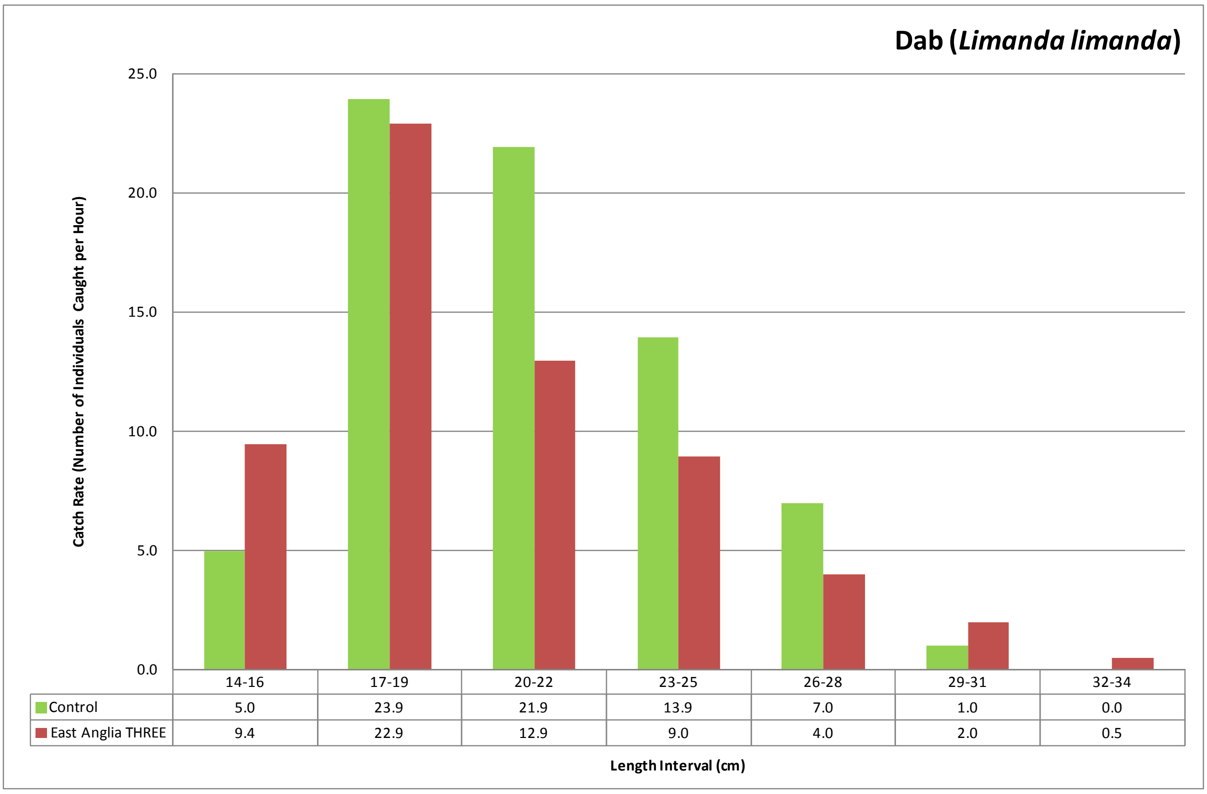


Figure 5.6 Dab (*L. limanda*) Length Distribution by Sampling Area

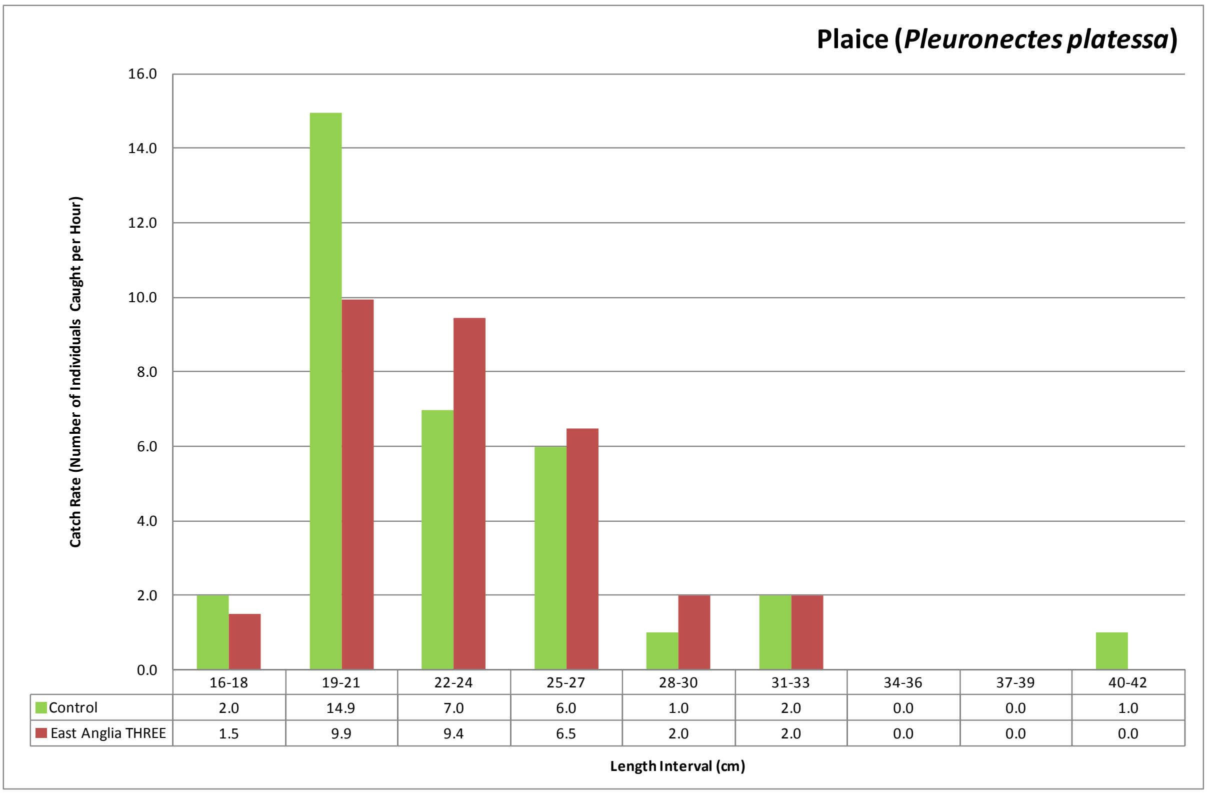


Figure 5.7 Plaice (*P. platessa*) Length Distribution by Sampling Area

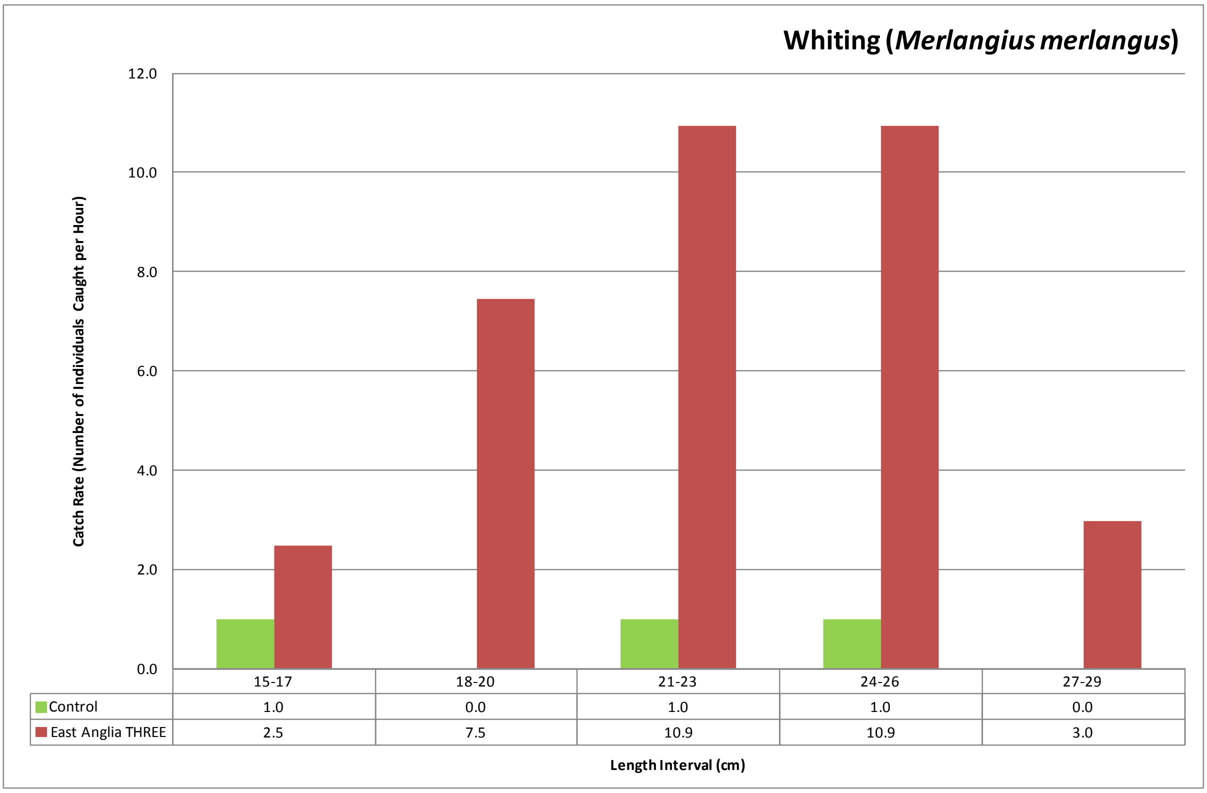


Figure 5.8 Whiting (*M. merlangus*) Length Distribution by Sampling Area

5.3 Minimum Landing Sizes

Minimum landing sizes (MLS) for fish and shellfish species are set by the EC under Regulation No. 850/98 (Annex XII).

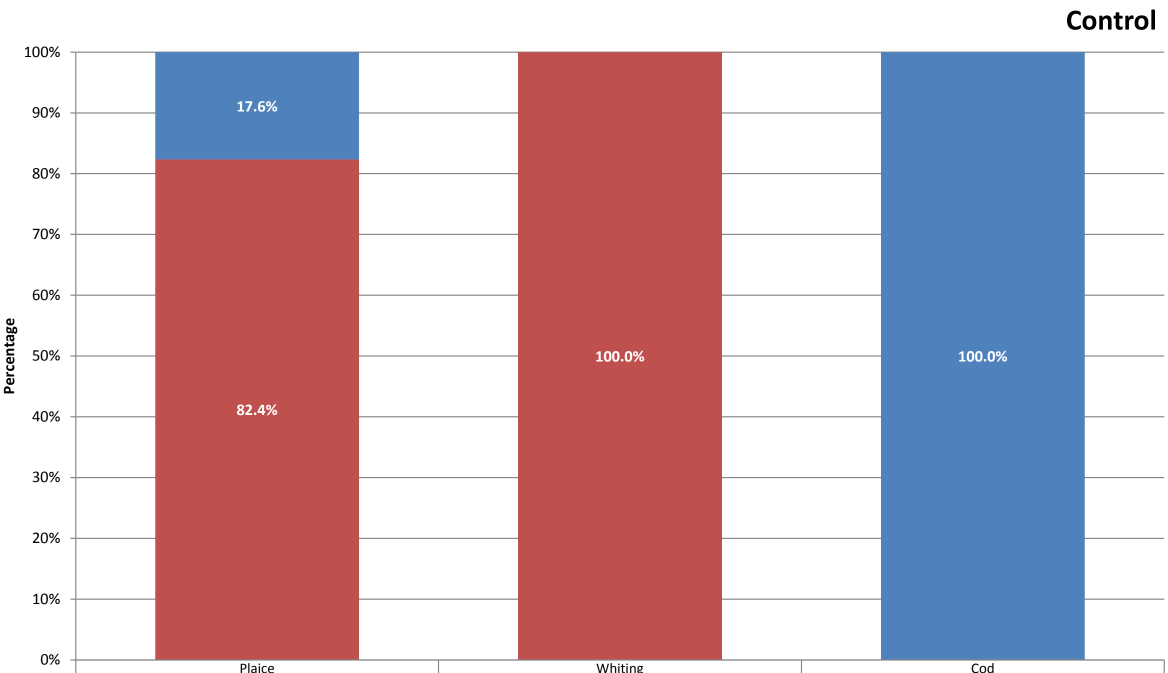
Table 5.2 shows the four species of fish caught for which a MLS has been set and denotes their presence or absence by sampling area (control and East Anglia THREE).

Table 5.2 MLS Set by EC

Species		EC MLS (cm)	Presence	
Common Name	Scientific Name		Control	East Anglia THREE
Cod	*Gadus morhua*	35	✓	✓
Herring	*Clupea harengus*	20	-	✓
Plaice	*Pleuronectes platessa*	27	✓	✓
Whiting	*Merlangius merlangus*	27	✓	✓

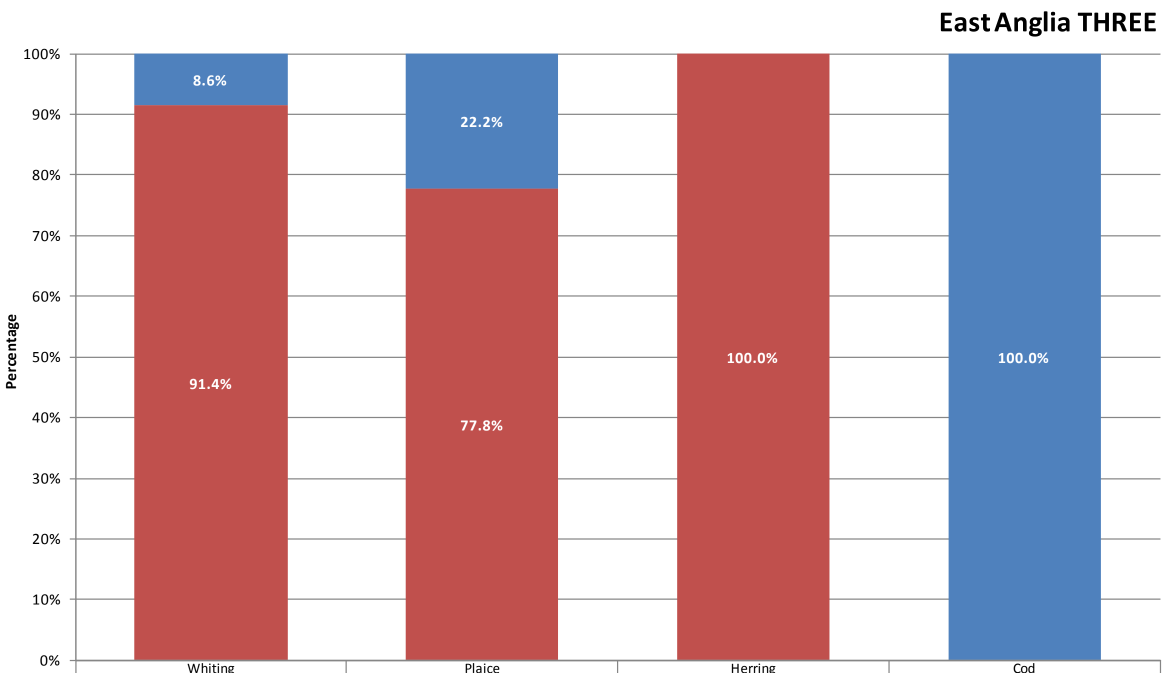
The percentage of individuals caught above and below their set MLS by species is shown in Figure 5.7 and Figure 5.8 for control and East Anglia THREE stations respectively.

Most of the *P. platessa* (control, 82.4%; East Anglia THREE, 77.8%) and *M. merlangus* (100.0% and 91.4%) caught in both sampling areas were below the MLS. All of the *G. morhua* found at the control stations and within East Anglia THREE were above the MLS, and all of the *C. harengus* caught within East Anglia THREE were below the set MLS.



	Plaice	Whiting	Cod
Above	6	0	1
Below	28	3	0

Figure 5.9 Percentage of the Catch Above and Below the MLS by Species at the Control Stations



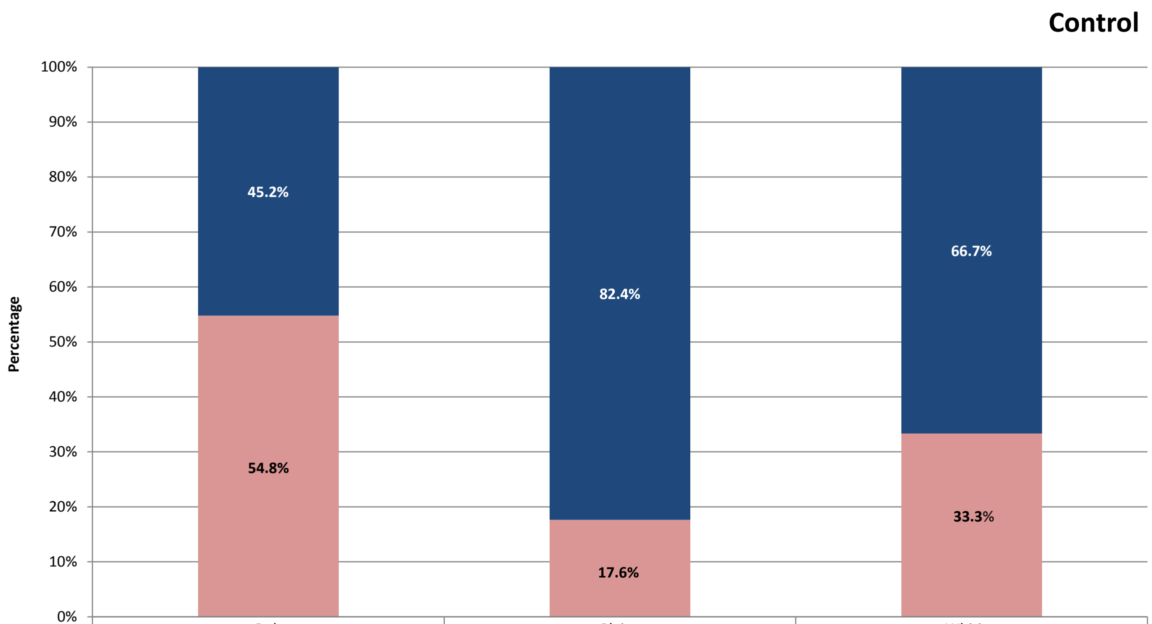
	Whiting	Plaice	Herring	Cod
Above	6	14	0	4
Below	64	49	14	0

Figure 5.10 Percentage of the Catch Above and Below the MLS by Species within East Anglia THREE

5.4 Sex Ratios

The sex ratios of the three most abundant species caught during the survey are shown in Figure 5.9 and Figure 5.10 for control and East Anglia THREE stations respectively.

The sex ratio of the *L. limanda* caught at the control stations and within East Anglia THREE was approximately even. The majority of *P. platessa* caught in both sampling areas were male (control, 82.4%; East Anglia THREE, 87.3%). Low numbers of *M. merlangus* were caught at the control stations, most of which were male (66.7%), whereas within East Anglia THREE the sex ratio was approximately even.



	Dab	Plaice	Whiting
Male	33	28	2
Female	40	6	1

Figure 5.11 Sex Ratio by Species at the Control Stations

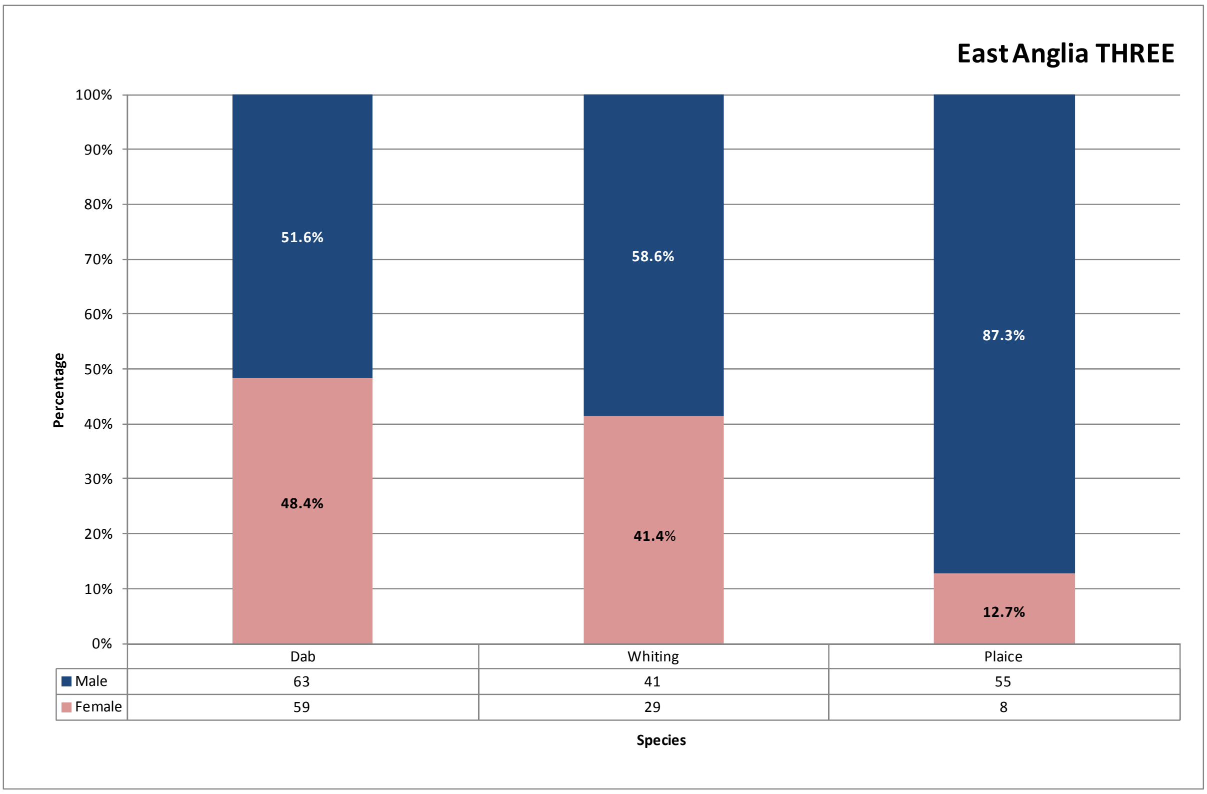


Figure 5.12 Sex Ratio by Species within East Anglia THREE

5.5 Spawning Condition

The spawning condition, sex and length range (nearest cm below) for the three most abundant species caught during the survey are given below in Table 5.3 to Table 5.5.

Most of the *L. limanda* caught at the control stations (95.9%) and within East Anglia THREE (89.3%) were maturing individuals. Approximately half of the *P. platessa* caught in both sampling areas were maturing males. The majority of the *M. merlangus* caught within East Anglia THREE were maturing individuals (74.3%). Three *M. merlangus* were caught at the control stations; two of which were immature males, and one was a maturing female.

Table 5.3 Dab (*L. limanda*) Spawning Condition

Dab							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia THREE	Total		Min.	Max.
Female	Maturing	37	54	91	46.7%	15	34
	Spent	3	5	8	4.1%	19	31
Male	Immature	0	6	6	3.1%	14	16
	Maturing	33	55	88	45.1%	14	22
	Spent	0	2	2	1.0%	18	20

Table 5.4 Plaice (*P. platessa*) Spawning Condition

Plaice							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia THREE	Total		Min.	Max.
Female	Immature	3	6	9	9.3%	19	26
	Hyaline	0	1	1	1.0%	28	28
	Spent	3	1	4	4.1%	27	42
Male	Immature	8	18	26	26.8%	16	25
	Maturing	16	35	51	52.6%	18	33
	Spent	4	2	6	6.2%	23	31

Table 5.5 Whiting (*M. merlangus*) Spawning Condition

Whiting							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia THREE	Total		Min.	Max.
Female	Immature	0	2	2	2.7%	19	21
	Maturing	1	27	28	38.4%	21	29
Male	Immature	2	16	18	24.7%	15	22
	Maturing	0	25	25	34.2%	16	28

6.0 Beam Trawl Results

6.1 Catch Rates and Species Distribution

The total number of individuals caught and the catch rate (number of individuals caught per hour) for fish and shellfish species by sampling area (control and East Anglia THREE) are given in Table 6.1 below and are illustrated in Figure 6.1. The catch rates by sampling station are shown in Figure 6.2 (red boxes denote stations within East Anglia THREE).

Spatial distribution plots for *P. platessa* and *L. limanda* are given in Figure 6.3 and Figure 6.4. Spatial plots show the percentage distribution by catch rate of *P. platessa* and *L. limanda*. The circle size corresponds to the catch rate i.e. larger circles indicate greater catch rates.

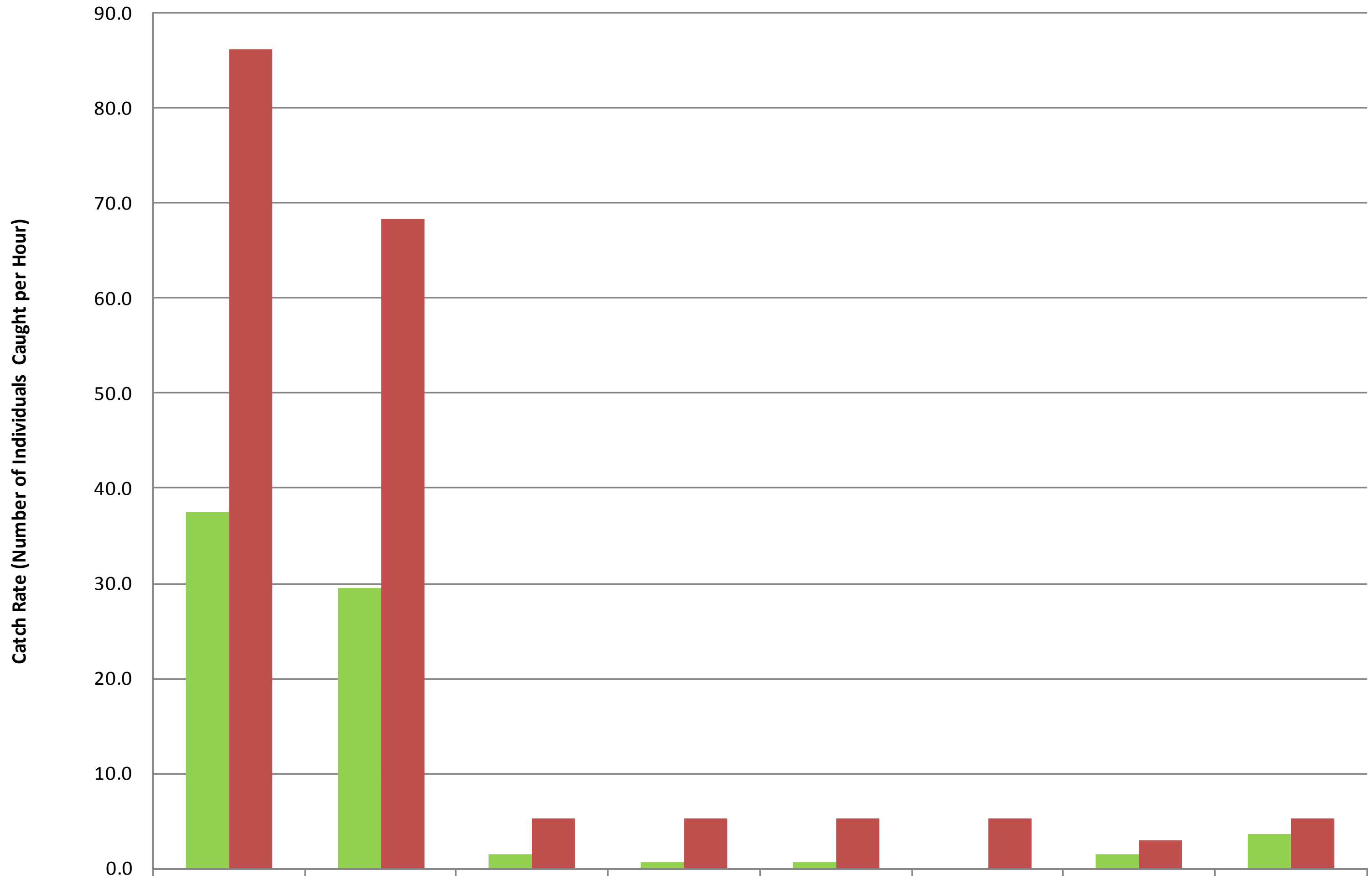
A total of 16 species of fish and shellfish were caught, 11 of which were found at the control stations and 12 within East Anglia THREE. Overall, *P. platessa* was the most abundant species caught, followed by *L. limanda*. All other species were caught in relatively low numbers.

The station with the greatest total catch rate was BT02 within East Anglia THREE (261.6/hr), with *L. limanda* and *P. platessa* representing 80.9% of the catch. *L. limanda* and *P. platessa* represented the highest proportion of the catch at most sampling stations.

Overall, catch rates were greater within East Anglia THREE (183.5/hr) than at the control stations (75.1/hr).

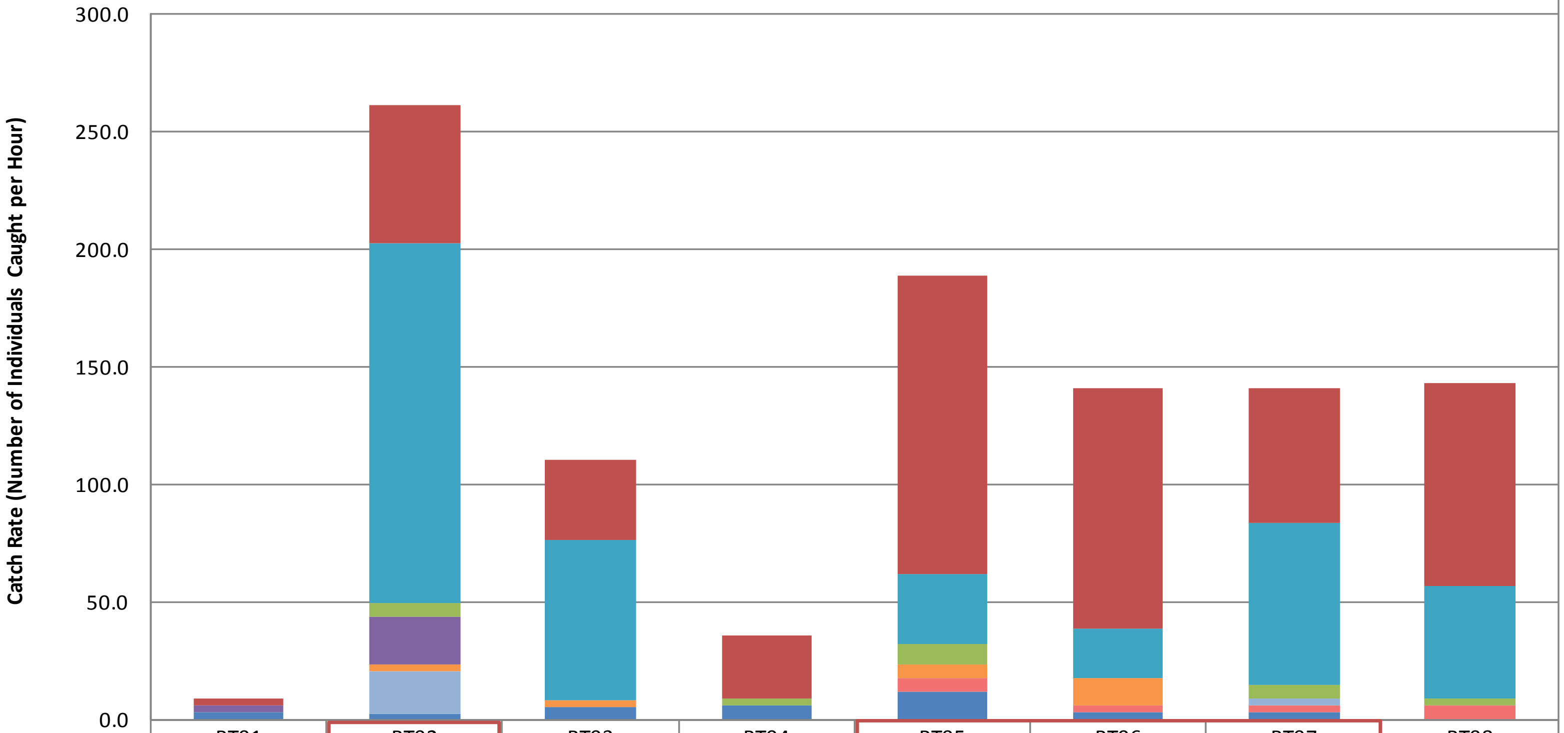
Table 6.1 Number of Individuals Caught and the Catch Rate for Fish and Shellfish Species by Sampling Area

Species		Number of Individuals Caught			Catch Rate (Number of Individuals Caught per Hour)	
Common Name	Scientific Name	Control	East Anglia THREE	Total	Control	East Anglia THREE
Plaice	*Pleuronectes platessa*	51	116	167	37.6	86.2
Dab	*Limanda limanda*	40	92	132	29.5	68.4
Cuttlefish	*Sepia officinalis*	2	7	9	1.5	5.2
Solenette	*Buglossidium luteum*	1	7	8	0.7	5.2
Velvet Crab	*Necora puber*	1	7	8	0.7	5.2
Bullrout	*Myoxocephalus scorpius*	0	7	7	0.0	5.2
Scaldfish	*Arnoglossus laterna*	2	4	6	1.5	3.0
Grey Gurnard	*Eutrigla gurnardus*	1	2	3	0.7	1.5
Lesser Spotted Dogfish	*Scyliorhinus canicula*	0	2	2	0.0	1.5
Brill	*Scophthalmus rhombus*	0	1	1	0.0	0.7
Common Dragonet	*Callionymus lyra*	0	1	1	0.0	0.7
Goby (indet.)	*Pomatoschistus sp.*	1	0	1	0.7	0.0
Sprat	*Sprattus sprattus*	1	0	1	0.7	0.0
Thornback Ray	*Raja clavata*	1	0	1	0.7	0.0
Whelk	*Buccinum undatum*	1	0	1	0.7	0.0
Whiting	*Merlangius merlangus*	0	1	1	0.0	0.7
Total No. of Individuals		102	247			
Total No. of Species		11	12			
Catch Rate (No. of Individuals Caught per Hour)		75.1	183.5			



	Plaice	Dab	Cuttlefish	Solenette	Velvet Crab	Bullrout	Scaldfish	Other Species
Control	37.6	29.5	1.5	0.7	0.7	0.0	1.5	3.7
East Anglia THREE	86.2	68.4	5.2	5.2	5.2	5.2	3.0	5.2

Figure 6.1 Catch Rates for Fish and Shellfish Species by Sampling Area



	BT01	BT02	BT03	BT04	BT05	BT06	BT07	BT08
Plaice	3.0	58.8	34.1	26.8	127.1	101.9	57.0	86.6
Dab	0.0	152.8	68.2	0.0	29.6	21.0	68.9	47.8
Cuttlefish	0.0	5.9	0.0	3.0	8.9	0.0	6.0	3.0
Velvet Crab	3.0	20.6	0.0	0.0	0.0	0.0	0.0	0.0
Solenette	0.0	2.9	2.8	0.0	5.9	12.0	0.0	0.0
Bullrout	0.0	17.6	0.0	0.0	0.0	0.0	3.0	0.0
Scaldfish	0.0	0.0	0.0	0.0	5.9	3.0	3.0	6.0
Other Species	3.0	2.9	5.7	6.0	11.8	3.0	3.0	0.0

Station

Figure 6.2 Catch Rates for Fish and Shellfish Species by Station (red box denotes East Anglia THREE stations)

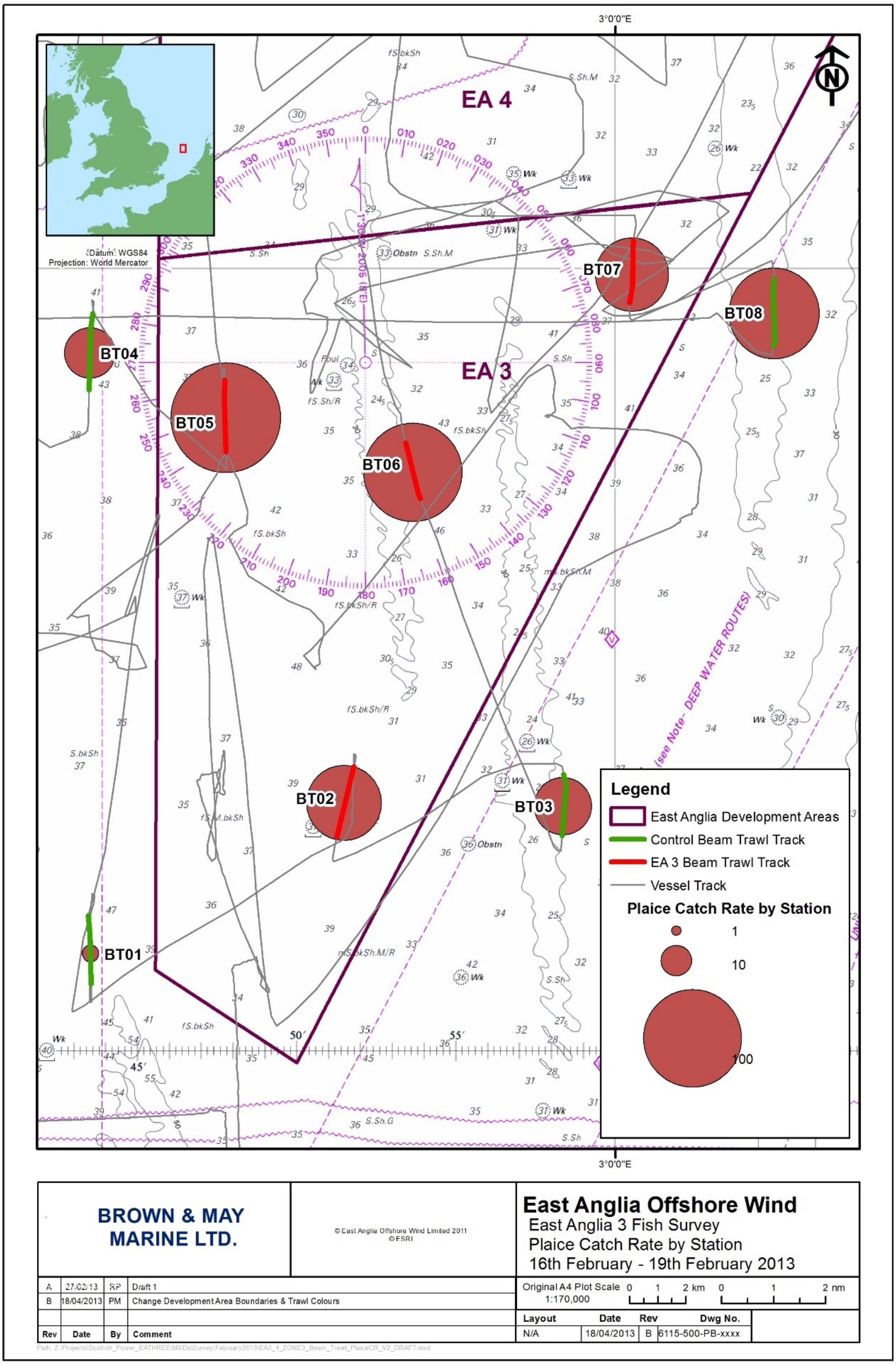


Figure 6.3 Spatial Distribution of Plaice (*P. platessa*) in the Area of East Anglia THREE

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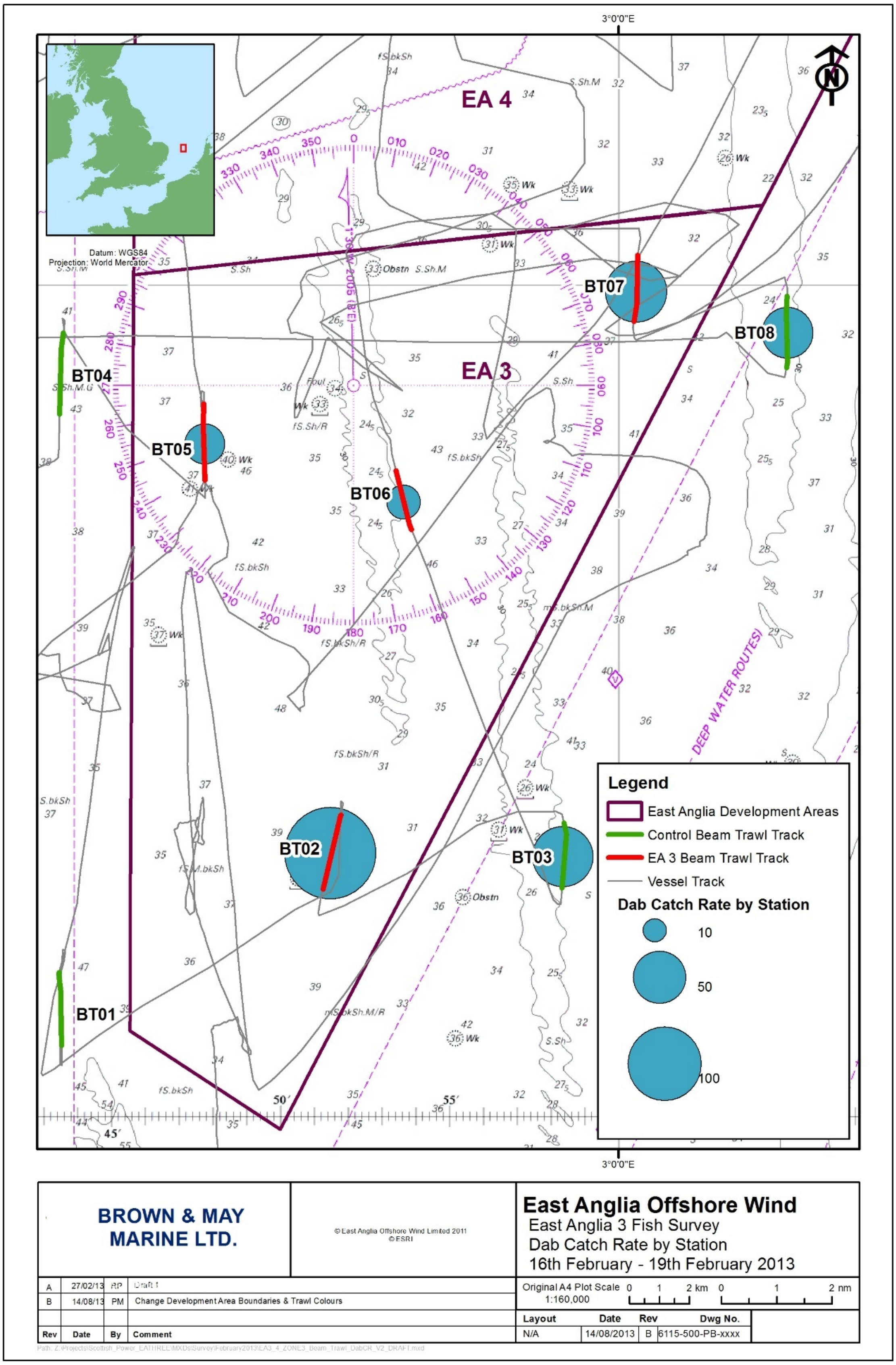


Figure 6.4 Spatial Distribution of Dab (*L. limanda*) in the Area of East Anglia THREE

6.2 Length Distributions

The length distributions of the two most abundant species caught during the survey, expressed as the catch rate (number of individuals caught per hour) by length (cm) and by sampling area (control and East Anglia THREE), are shown in Figure 6.5 and Figure 6.6 below.

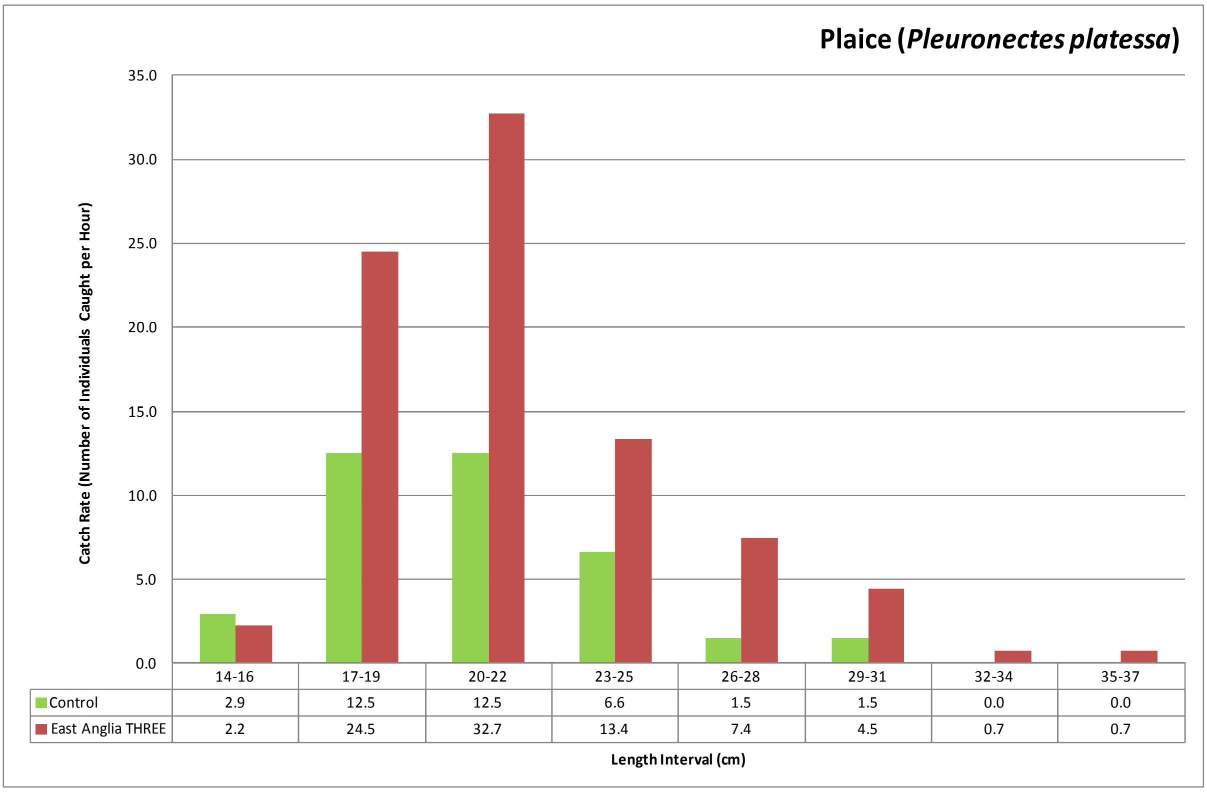


Figure 6.5 Plaice (*P. platessa*) Length Distribution by Sampling Area

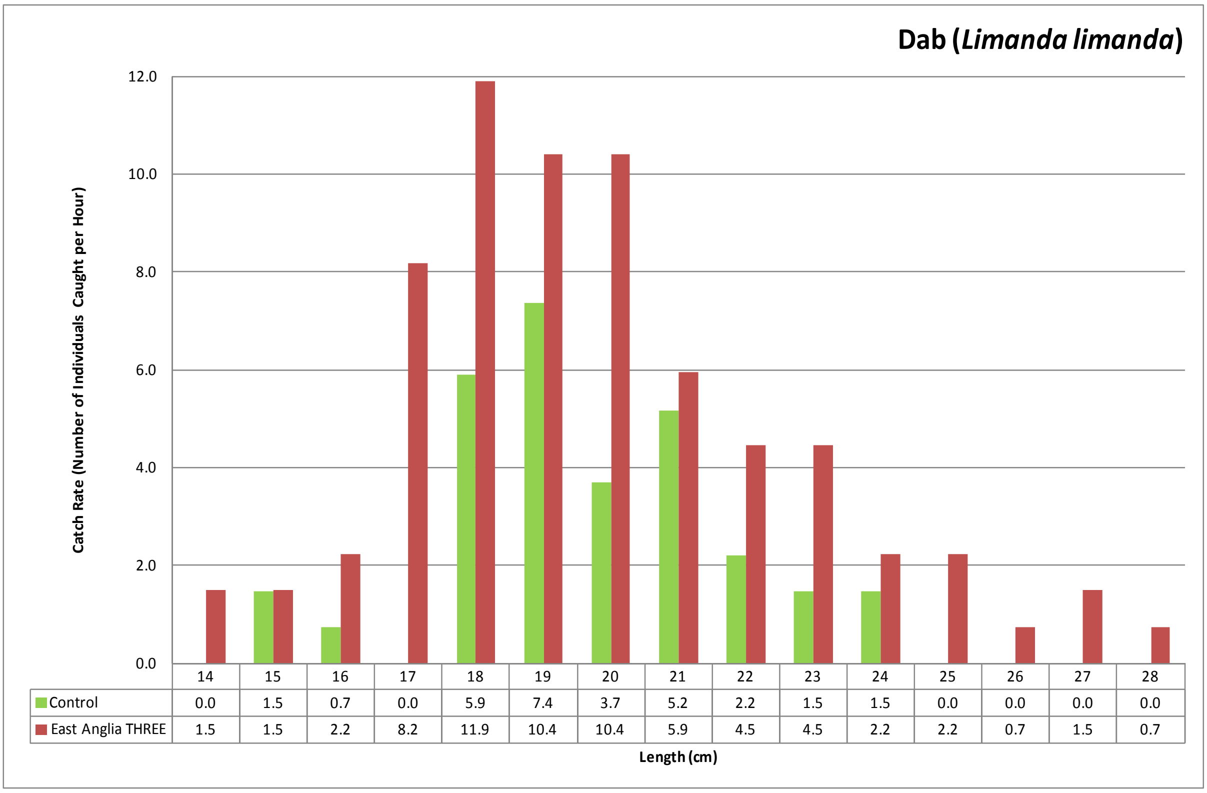


Figure 6.6 Dab (*L. limanda*) Length Distribution by Sampling Area

6.3 Minimum Landing Sizes

Minimum landing sizes (MLS) for fish and shellfish species are set by the EC under Regulation No. 850/98 (Annex XII).

Table 6.2 shows the three species of fish and shellfish caught for which a MLS has been set and denotes their presence or absence by sampling area (control and East Anglia THREE).

Table 6.2 MLS Set by EC

Species		EC MLS (cm)	Presence	
Common Name	Scientific Name		Control	East Anglia THREE
Plaice	*Pleuronectes platessa*	27	✓	✓
Whiting	*Merlangius merlangus*	27		✓
Whelk	*Buccinum undatum*	4.5	✓	

The percentage of individuals caught above and below their set MLS by species is shown in Figure 6.7 and Figure 6.8 for control and East Anglia THREE stations respectively.

Most of the *P. platessa* caught at the control stations (92.2%) and within East Anglia THREE (87.9%) were below the set MLS. One *B. undatum* was caught at the control stations and was above the MLS, and one *M. merlangus* was found within East Anglia THREE and was below the set MLS.

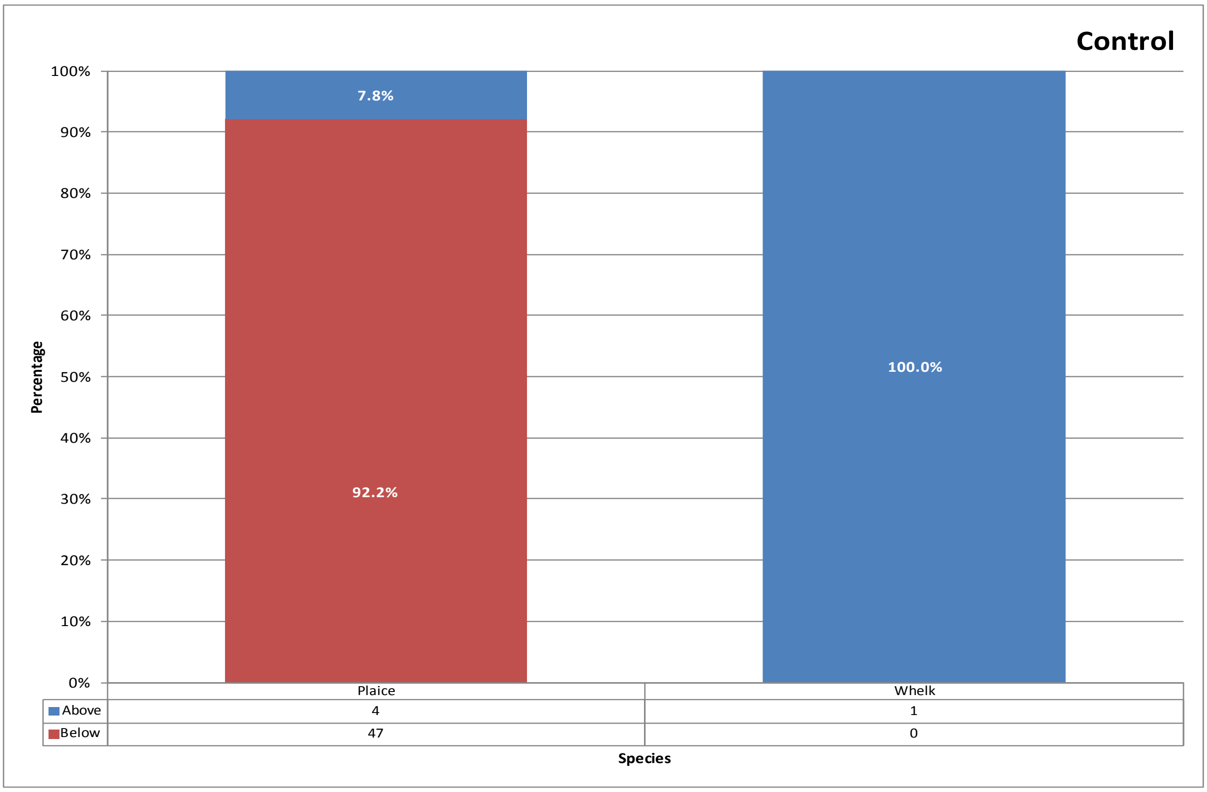


Figure 6.7 Percentage of the Catch Above and Below the MLS by Species at the Control Stations

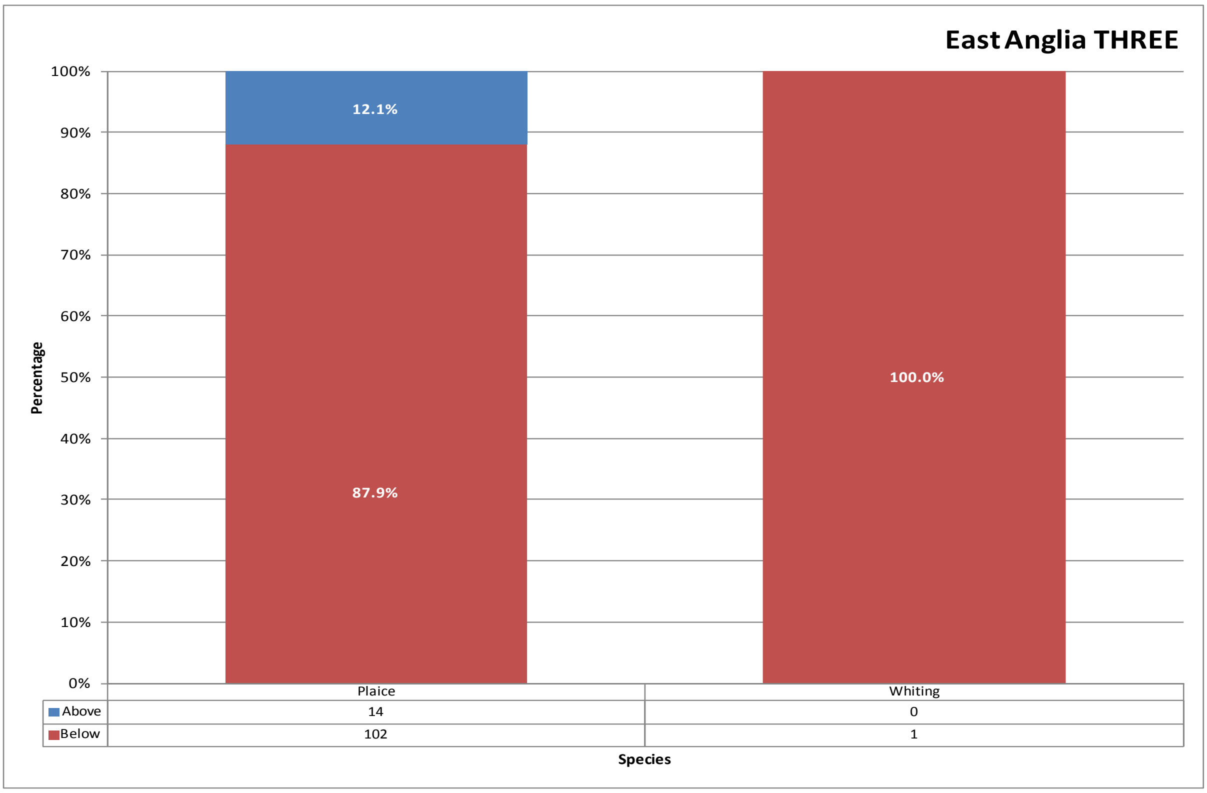


Figure 6.8 Percentage of the Catch Above and Below the MLS by Species within East Anglia THREE

6.4 Sex Ratios

The sex ratios of the two most abundant species caught during the beam trawl survey are shown in Figure 6.9 and Figure 6.10 for control and East Anglia THREE stations respectively.

The majority of the *P. platessa* caught at the control stations (78.4%) and within East Anglia THREE (81.0%) were male. A higher proportion of the *L. limanda* caught within East Anglia THREE were female (64.1%), whereas at the control stations the sex ratio was approximately even.

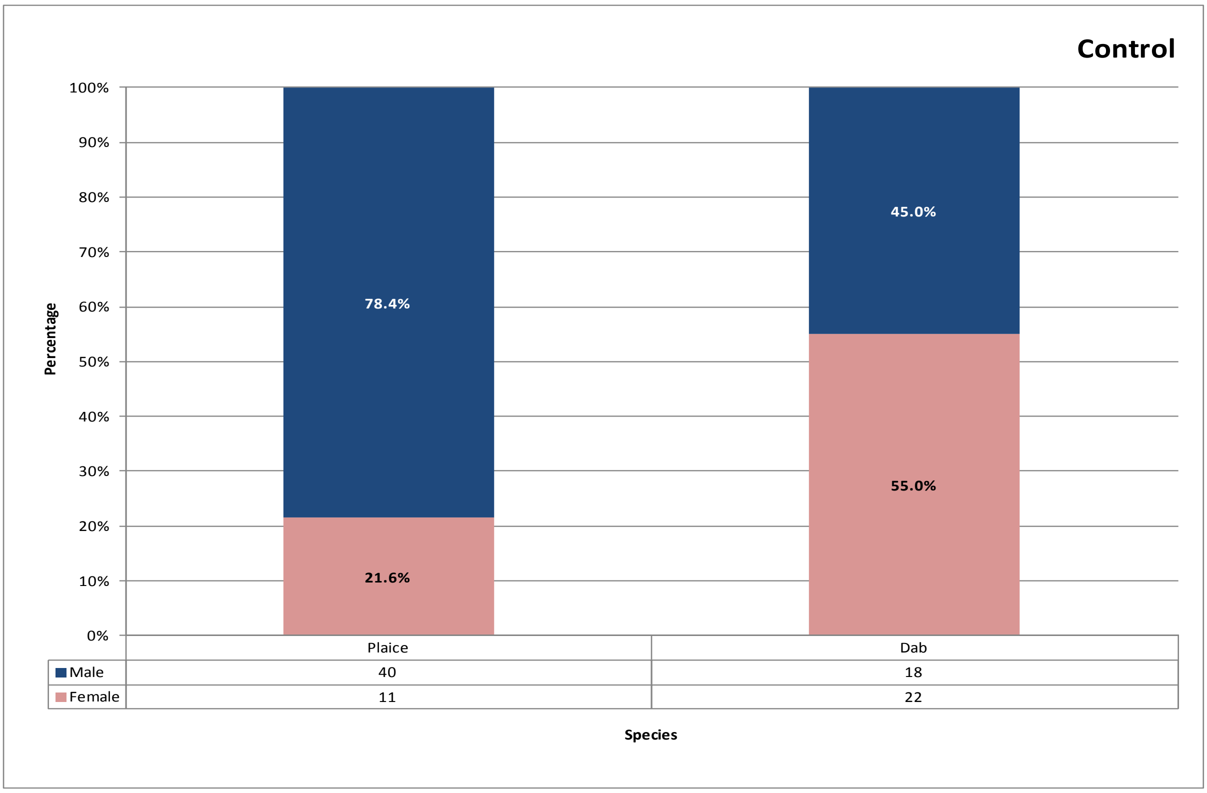


Figure 6.9 Sex Ratio by Species at the Control Stations

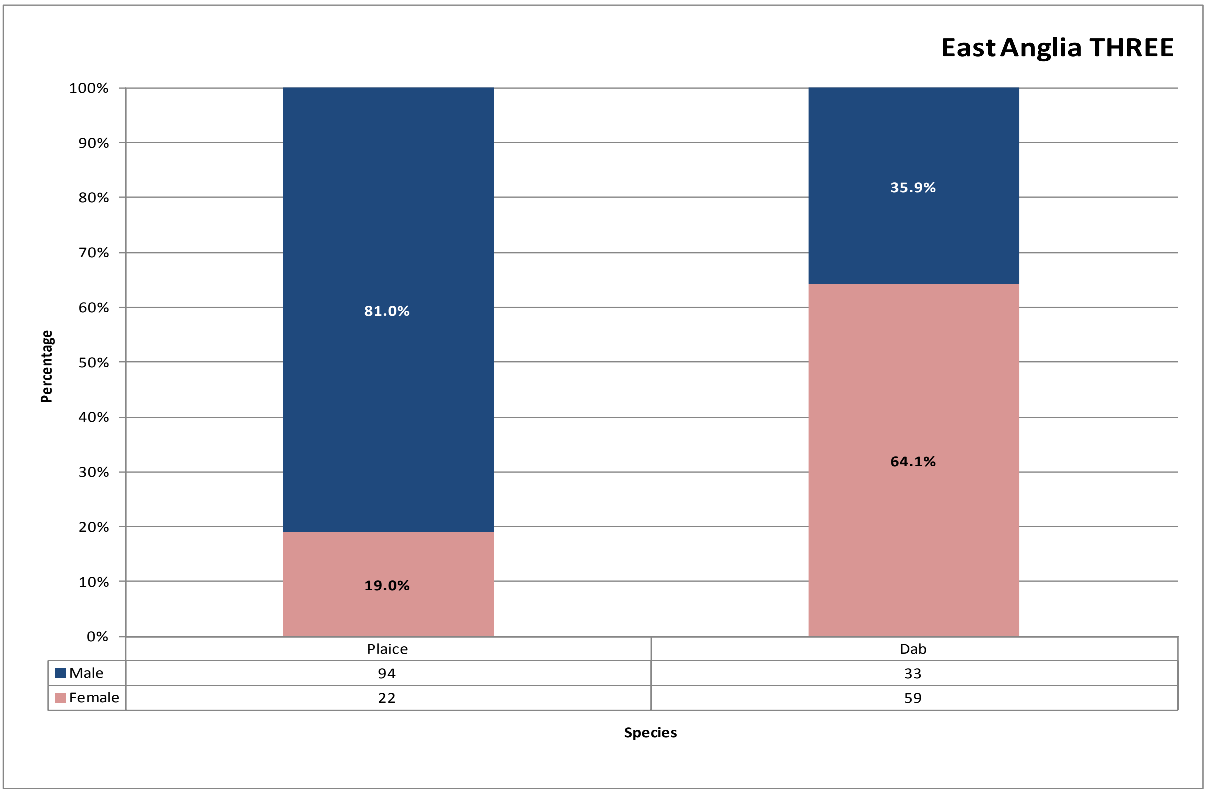


Figure 6.10 Sex Ratio by Species within East Anglia THREE

6.5 Spawning Condition

The spawning condition, sex and length range (nearest cm below) for the two most abundant species caught during the beam trawl survey are given below in Table 6.3 and Table 6.4.

The highest proportion of the *P. platessa* (control, 56.9%; East Anglia THREE, 62.9%) and *L. limanda* (85.0% and 93.5%) caught in both sampling areas were spent.

Table 6.3 Plaice (*P. platessa*) Spawning Condition

Plaice							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia THREE	Total		Min.	Max.
Female	Immature	9	15	24	14.4%	14	24
	Spent	2	7	9	5.4%	22	36
Male	Immature	13	29	42	25.1%	16	23
	Spent	27	65	92	55.1%	16	31

Table 6.4 Dab (*L. limanda*) Spawning Condition

Dab							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia THREE	Total		Min.	Max.
Female	Immature	5	4	9	6.8%	15	22
	Spent	17	55	72	54.5%	17	28
Male	Immature	1	2	3	2.3%	14	16
	Spent	17	31	48	36.4%	14	21

7.0 Appendix (of Annex 2)

7.1 Appendix 1 – Health and Safety

7.1.1 Personnel

Brown and May Marine (BMM) staff protocol followed the standard health and safety protocol outlined in the BMM "Offshore Operational Procedures for Surveys using Commercial Fishing Vessels".

All BMM staff have completed a Sea Survival course approved by the Maritime and Coastguard Agency, meeting the requirements laid down in: **STCW 95 Regulation VI/1 para 2.1.1 and STCW Code section A- VI/1** before boarding any vessel conducting works for the company. Employees are also required to have valid medical certificates (ENG1 or ML5), Seafish Safety Awareness, Seafish Basic First Aid and Seafish Basic Fire Fighting and Fire Prevention certificates before participating in offshore works.

7.1.2 Vessel Induction

Before boarding, the survey team were shown how to safely board and disembark the vessel. Prior to departure the skipper briefed the BMM staff on the whereabouts of the safety equipment, including the life raft, emergency flares and fire extinguishers, and also the location of the emergency muster point. The safe deck areas, man-overboard procedures and emergency alarms were also discussed. The survey team were warned about the possible hazards, such as slippery decks and obstructions whilst aboard. The BMM staff were briefed about trawling operations and the need to keep clear of all winch's when operational and a safety drill was conducted. All hazards were assessed prior to the survey in the BMM health and safety risk assessment.

7.1.3 Daily Safety Checks

The condition of the life jackets, EPIRB's, and life raft were inspected daily. Also checked were the survey team working areas, including the fish room and the wheelhouse to ensure these areas were clear of hazards such as clutter and obstructions.

7.1.4 Post Trip Survey review

Upon completion of the survey a "Post Trip Survey Review" was filed, see Table 7.1 overleaf.

Table 7.1 Post Trip Survey Review

Project: East Anglia THREE	**Vessel:** Jubilee Spirit
Surveyors: Alex Winrow-Giffin, Richard Preston	**Skipper:** Ross Crookes
Survey Area: East Anglia THREE, southern North Sea	**Total Time at Sea:** 11 Days
Dates at Sea: 16/02/2013 – 26/02/2013	

	Comments	Actions
Did vessel comply with pre-trip safety audits?	Yes Passed audit by LOC on 14/02/2013	N/A
Skipper and crew attitude to safety?	Good	N/A
Vessel machinery failures?	None	N/A
Safety equipment failures?	None	N/A
Accidents?	None	N/A
Injuries?	None	N/A

8.0 Annex 3: East Anglia FOUR Fish and Shellfish Survey 16th to 26th February 2013

East Anglia Offshore Windfarm

East Anglia FOUR

Fish and Shellfish Survey

16th to 26th February 2013

Undertaken by
Brown and May Marine Ltd

Ref	Issue Date	Issue Type	Author	Checked	Approved
EA4OB01	10/09/13	Draft 2	LS/AWG	LS/AWG/JK/PO	SJA

Contents

Figures

Tables

1.0 Summary

1.1 Otter Trawl

A total of 13 species were caught in the otter trawl survey; 10 at the control stations and 11 within East Anglia FOUR. Dab (*Limanda limanda*) was the most abundant species caught, followed by plaice (*Pleuronectes platessa*); all other species were caught in relatively low numbers. The total overall catch rates were similar at the control stations and within East Anglia FOUR. The highest catch rate for all species combined was recorded at control station OT18, with *L. limanda* accounting for 79.0% of the catch. *L. limanda* and *P. platessa* represented the greatest proportion of the catch at most sampling stations.

Four fish and one shellfish species were caught with set minimum landing size (MLS). Most of the *P. platessa*, whiting (*Merlangius merlangus*) and herring (*Clupea harengus*) caught at the control stations and within East Anglia FOUR were below the MLS. One edible crab (*Cancer pagurus*) was caught at the control stations and one Dover sole (*Solea solea*) was found within East Anglia FOUR, both of which were below the set MLS.

The sex ratios for the *L. limanda* caught at the control stations and within East Anglia FOUR were approximately even; most of which were maturing. The highest proportion of the *P. platessa* found in both sampling areas was represented by spent males.

1.2 Beam Trawl

A total of 17 species of fish were caught in the beam trawl survey, 13 of which were found at the control stations and 13 within East Anglia FOUR. Overall, *P. platessa* was the most abundant species caught, followed by *L. limanda*; all other species were caught in relatively low numbers. The total overall catch rate was highest within East Anglia FOUR. The station with the greatest total catch rate was BT14 within East Anglia FOUR, with *L. limanda* and *P. platessa* representing 93.0% of the catch. *P. platessa* and *L. limanda* represented the highest proportion of the catch at most sampling stations.

Three fish and one shellfish species were caught with a set MLS. The majority of the *P. platessa* caught at the control stations and within East Anglia FOUR were below the MLS. The percentage of *S. solea* found at the control stations was equally divided above and below the MLS. All of the whelk (*Buccinum undatum*) caught at the control stations and within East Anglia FOUR were above the set MLS, as was the one *M. merlangus* found within East Anglia FOUR.

The majority of the *P. platessa* caught at the control stations and within East Anglia FOUR were male; the highest proportion of all of the *P. platessa* found in both sampling areas were spent. A higher proportion of the *L. limanda* caught at the control stations were female, whereas within East Anglia FOUR the sex ratio was approximately even, the greatest proportion of which were spent.

2.0 Introduction

The following report details the findings of the February 2013 fish and shellfish survey, undertaken within and adjacent to development area Four (East Anglia FOUR) of the East Anglia offshore windfarm between the 16th and 26th February.

The East Anglia FOUR offshore windfarm is located in the North Sea, approximately 91 km off the coast of Suffolk.

The survey methodology, vessel and sampling gear detailed were agreed in consultation with Cefas and the Marine Management Organisation (MMO). A dispensation from the MMO for the Provisions of Council Regulation 850/98 to catch and retain undersize fish for scientific research and 43/2009 specifically related to days at sea was obtained prior to commencement of this survey. A summary of the health and safety performance of the survey is provided in Appendix 1.

The aim of the survey was to establish the abundance and composition of fish and shellfish species within the area of the East Anglia FOUR offshore windfarm.

3.0 Scope of Works

The proposed scope of works for the February 2013 fish and shellfish survey is detailed below, and the proposed sampling stations are illustrated in Figure 3.1 overleaf.

- **Otter Trawl**
  - Five tows of approximately 20 minutes duration within East Anglia FOUR and four control tows in adjacent areas

- **Beam Trawl**
  - Five tows of approximately 20 minutes duration within East Anglia FOUR and three control tows in adjacent areas

- **Otter and Beam Trawl Sample Analysis**
  - Number of individuals and catch rate by species
  - Length distribution by species
    - Finfish & sharks (except *C. harengus* & sprat; *Sprattus sprattus*): individual lengths (nearest cm below)
    - *C. harengus* & *S. sprattus*: individual lengths (nearest ½ cm below)
    - Rays: individual length and wing-width (nearest cm below)
  - Sex ratio by species
  - Spawning condition
    - Finfish species (except *C. harengus*): Cefas Standard Maturity Key - Five Stage
    - *C. harengus*: Cefas Maturity Key – Nine Stage
    - Ray and shark species: Cefas Standard Elasmobranch Maturity Key - Four Stage

For the purposes of data analysis, catch rates have been calculated to allow for quantitative comparisons to be made between the numbers of individuals caught per hour at each station.

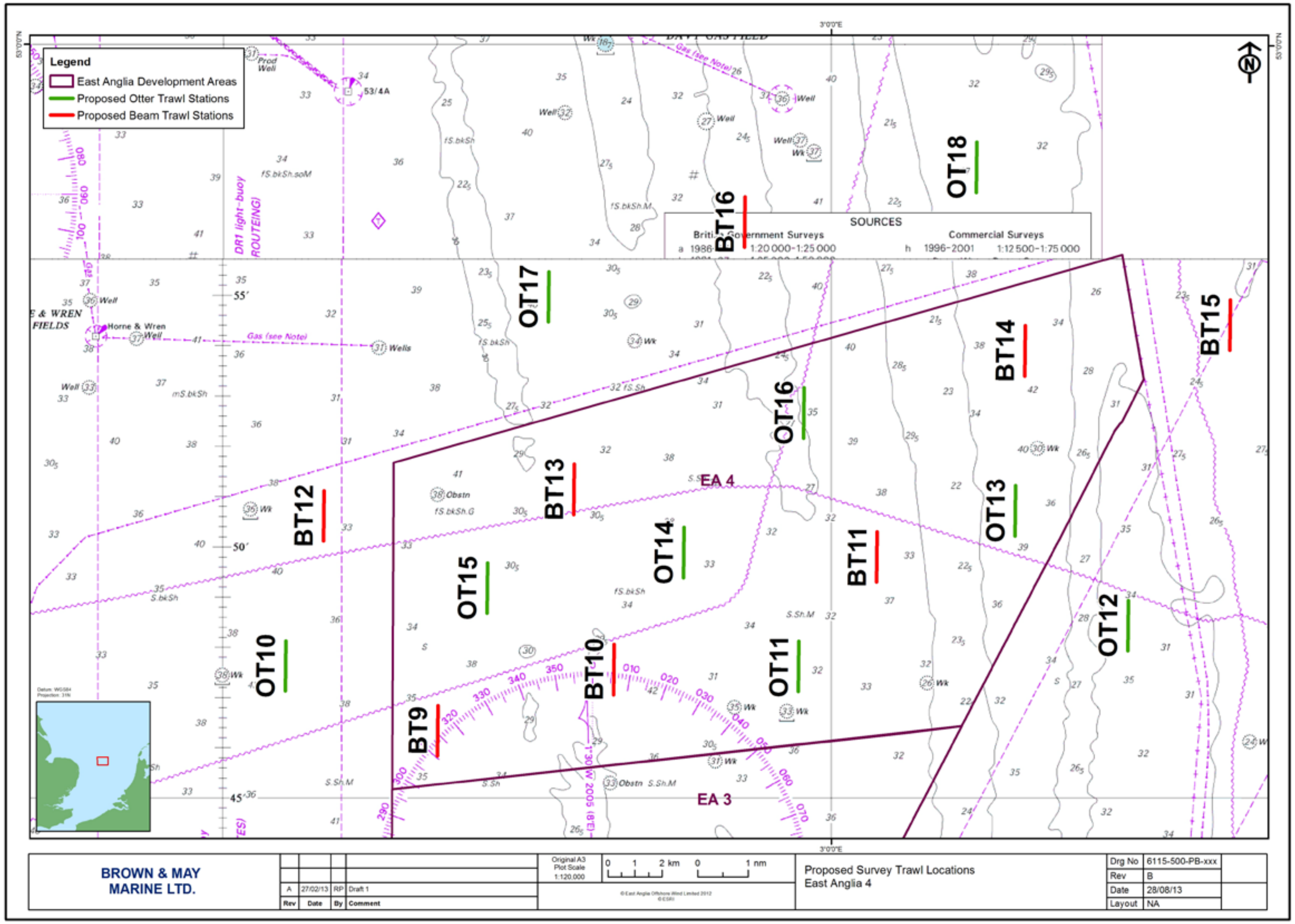


Figure 3.1 Proposed Otter and Beam Trawl Locations

4.0 Methodology

4.1 Survey Vessel

The vessel chartered for the survey (Figure 4.1), the "Jubilee Spirit", is a Grimsby-based commercial trawler that was contracted for previous fish and shellfish surveys at East Anglia One. The specifications of the vessel are given below in Table 4.1.

Figure 4.1 Survey Vessel "Jubilee Spirit"

Table 4.1 Survey Vessel Specifications

Survey Vessel Specifications	
Length	21.2m
Beam	6.9m
Draft	2.3m
Main engine	Caterpillar Type 340TA 475 BHP
Gearbox	Hydraulic 6: reduction
Propeller	4 Blade Manganese Bronze Fixed Pitch 1.7m diameter
GPS	2-Furuno GP80
Plotters	Sodena Plotter with Electronic Charts
Sounder	Furuno Daylight Viewing

4.2 Sampling Gear

4.2.1 Commercial Otter Trawl

A commercial otter trawl (Figure 4.2) with a 100mm mesh cod-end was used for fish and shellfish sampling; the specifications of which are given in Table 4.2 below.

Figure 4.2 Otter Trawl Used

Table 4.2 Otter Trawl Specifications

Otter Trawl Specifications	
Towing Warp	18mm, 6x19+1
Depth: Payout Ratio	3:1
Trawl Doors	Perfect B 84
Net	100mm mesh cod-end
Ground line length	24.4m
Footrope	Rock-hopper with 18-inch bobbins
Est. Headline height	7.3m
Distance between doors (est.)	51m

4.2.2 Commercial 4m Beam Trawl

A commercial beam trawl (Figure 4.3) with an 80mm mesh cod end was used for fish and shellfish sampling; the specifications of which are given in Table 4.3 below.

Figure 4.3 Beam Trawl Used

Table 4.3 Beam Trawl Specifications

Beam Trawl Specifications	
Beam width	4m
Headline height	60cm
Cod-end liner	80mm (double twinned on belly and cod end)
Ground gear	5cm rubber bobbins and chain mat

4.3 Positioning and Navigation

The position of the vessel was tracked at all times using a Garmin GPSMap 60 with an EGNOS differential connected to an external Garmin GA30 antenna. Trawl start times and positions were taken when the winch stopped paying out the gear. Similarly, trawl end times and positions were taken when hauling of the gear commenced.

4.4 Sampling Operations

The survey was undertaken from the 16th to the 26th February 2013. A summarised log of events is given in Table 4.4 below.

Table 4.4 Summarised Log of Events

Thursday 14th February 2013
Vessel audited in Grimsby
Friday 15th February 2013
Vessel on standby awaiting confirmation
Saturday 16th February 2013
Vessel departs Grimsby 0800 and steams to Lowestoft
Surveyors meet vessel at Lowestoft at 2330, load and stow gear
Pre-departure H&S meeting conducted. Safety drill carried out at 2345
Depart Lowestoft at 2355 and steam overnight to survey area
Overnight at sea
Sunday 17th February 2013
East Anglia THREE survey
Weather: BF 1/2
Overnight at sea
Monday 18th February 2013
Beam trawls: BT15, BT14, BT16, BT11, BT13, BT12
Weather: BF 1/2
Overnight at sea
Tuesday 19th February 2013
Beam trawls: BT10, BT09
Weather: BF 1/2
Steam overnight to Lowestoft for sample drop and gear changeover
Overnight at sea

Wednesday 20th February 2013
Arrive into Lowestoft at 0430
Beam trawl removed from vessel
Beam trawl samples landed and transported to BMM
Depart Lowestoft at 1715 and steam to survey area
Weather: BF4-5, moderate
Overnight at sea
Thursday 21st February 2013
Otter trawls:OT17, OT18, OT16, OT13, OT12
Weather: BF 4/5
Overnight at sea
Friday 22nd February 2013
Otter trawls: OT11, OT14, OT15, OT10
Weather: BF 4
Overnight at sea
Saturday 23rd February 2013
East Anglia THREE survey
Weather: BF 5
Overnight at sea
Sunday 24th February 2013
East Anglia THREE survey
Steam to Lowestoft
Weather: BF 6
Overnight at sea
Monday 25th February 2013
Arrive into Lowestoft at 0930
Demobilise survey
Otter trawl samples landed and transported to BMM
Vessel returns to Grimsby overnight
Tuesday 26th February 2013
Vessel arrives at Grimsby at 1200

4.5 Otter Trawl Sampling

The whole catch from each otter trawl was retained. The samples were then boxed, labelled, photographed, iced and stored at +2°C before transportation to Cefas (Lowestoft) for analysis at the end of the survey, in line with the agreed scope of works.

The start and end times, co-ordinates and the duration of each otter trawl are given in Table 4.5 (control and East Anglia FOUR tows highlighted green and red respectively). The vessel tracks whilst towing the otter trawl are illustrated in Figure 4.4 overleaf.

Table 4.5 Start and End Times, Co-ordinates and Duration of each Otter Trawl

Station	Date	Start				End				Duration (hh:mm:ss)
		Time (GMT)	UTM31N		Depth (m)	Time (GMT)	UTM31N		Depth (m)	
			Easting	Northing			Easting	Northing		
OT10 [green]	22/02/2013	15:35:53	479,723.51	5,850,195.32	43.4	15:55:53	479,745.51	5,848,537.09	43.3	00:20:00
OT11 [red]		11:07:35	498,858.44	5,848,551.79	37.4	11:27:39	498,828.88	5,850,415.25	37.2	00:20:04
OT12 [green]	21/02/2013	16:11:40	510,985.30	5,851,754.07	35.2	16:31:44	511,024.09	5,849,987.25	35.6	00:20:04
OT13 [red]		14:57:35	506,859.40	5,855,685.89	40.9	15:17:45	506,807.84	5,853,938.15	40.5	00:20:10
OT14 [red]	22/02/2013	12:15:48	494,422.06	5,853,181.48	38.1	12:35:59	494,424.60	5,855,094.12	39.2	00:20:11
OT15 [red]		14:13:51	487,242.94	5,851,512.02	37.2	14:34:04	487,251.58	5,853,356.90	38.1	00:20:13
OT16 [red]	21/02/2013	13:17:14	498,843.18	5,859,779.89	34.5	13:37:25	498,866.24	5,858,540.34	32.5	00:20:11
OT17 [green]		08:23:43	489,591.98	5,861,534.20	38.7	08:44:00	489,761.37	5,863,101.77	40.0	00:20:17
OT18 [green]		11:21:03	505,245.89	5,868,566.93	36.3	11:41:05	505,383.38	5,867,295.93	39.2	00:20:02

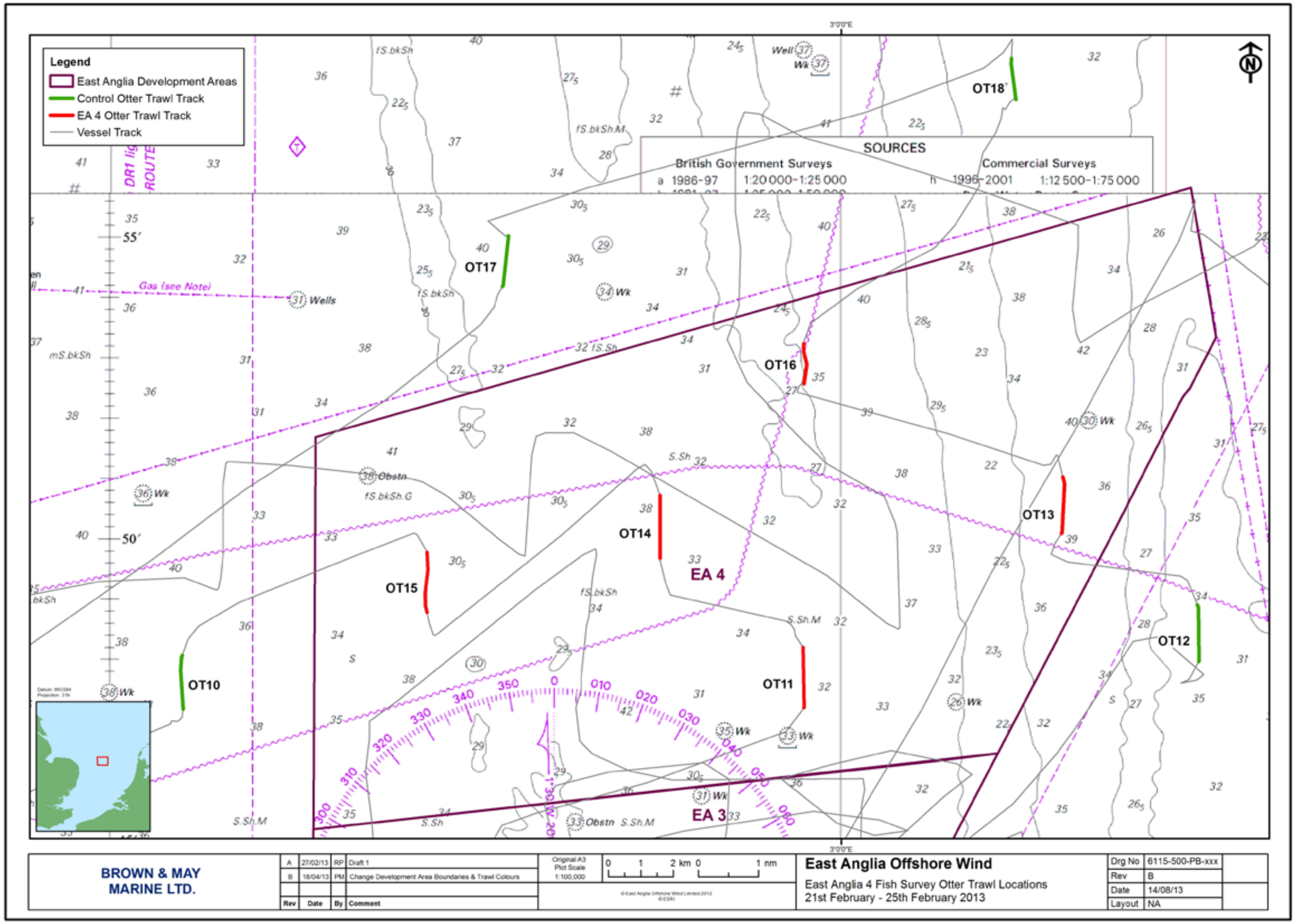


Figure 4.4 Vessel Tracks whilst Towing the Otter Trawl

4.6 Beam Trawl Sampling

The whole catch from each beam trawl was retained. The samples were then boxed, labelled, photographed, iced and stored at +2°C before transportation to Cefas (Lowestoft) for analysis at the end of the survey, in line with the agreed scope of works.

The start and end times, co-ordinates and the duration of each beam trawl are given in Table 4.6 (control and East Anglia FOUR tows highlighted green and red respectively). The vessel tracks whilst towing the beam trawl are illustrated in Figure 4.5.

Table 4.6 Start and End Times, Co-ordinates and Duration of each Beam Trawl

Station	Date	Start				End				Duration (hh:mm:ss)
		Time (GMT)	UTM31N		Depth (m)	Time (GMT)	UTM31N		Depth (m)	
			Easting	Northing			Easting	Northing		
BT09	19/02/2013	13:01:11	485,495.09	5,847,800.79	38.0	13:21:21	485,514.89	5,845,325.90	39.2	00:20:10
BT10		11:07:19	491,950.32	5,848,894.38	33.9	11:27:19	492,164.54	5,851,137.71	35.6	00:20:00
BT11	18/02/2013	12:43:28	501,479.47	5,854,654.52	39.2	13:03:27	501,774.51	5,851,840.39	38.7	00:19:59
BT12		16:03:48	481,001.82	5,855,705.19	37.2	16:23:52	480,978.16	5,853,367.01	38.1	00:20:04
BT13		14:40:14	490,512.69	5,856,557.88	37.2	15:00:36	490,338.09	5,853,982.15	35.9	00:20:22
BT14		09:34:36	507,230.83	5,860,200.64	42.9	09:54:38	507,260.33	5,862,422.60	42.2	00:20:02
BT15		08:00:17	514,830.93	5,861,448.09	31.7	08:20:24	514,780.71	5,863,793.89	34.3	00:20:07
BT16		11:13:40	496,903.26	5,866,624.47	26.6	11:33:58	496,755.32	5,864,447.48	27.5	00:20:18

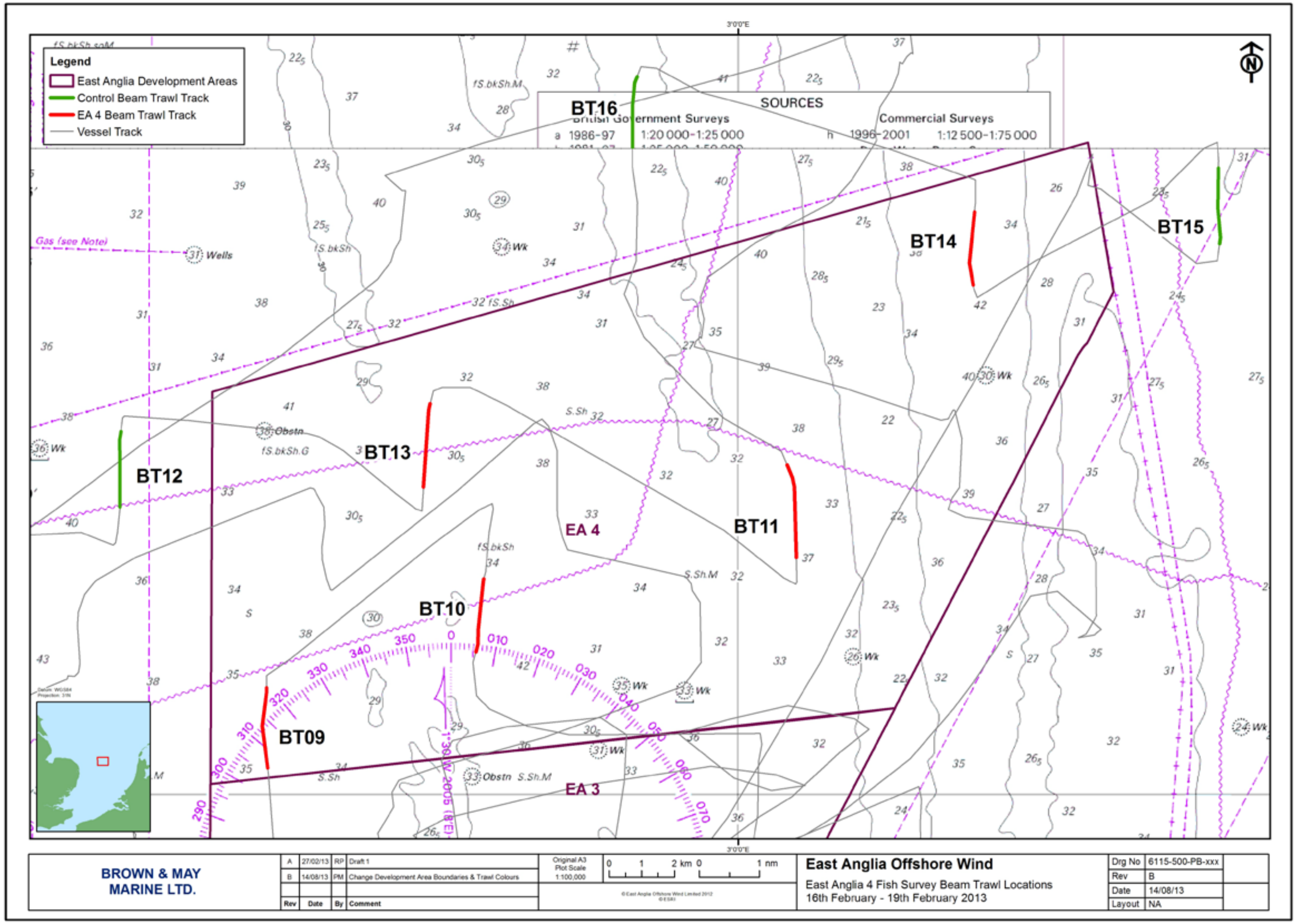


Figure 4.5 Vessel Tracks whilst Towing the Beam Trawl

5.0 Otter Trawl Results

5.1 Catch Rates and Species Distribution

The total number of individuals caught and the catch rate (number of individuals caught per hour) for fish and shellfish species by sampling area (control and East Anglia FOUR) are given in Table 5.1 and are illustrated in Figure 5.1. The catch rates by sampling station are illustrated in Figure 5.2 (red boxes denote stations within East Anglia FOUR).

Spatial distribution plots for *L. limanda* and *P. platessa* are given in Figure 5.3 and Figure 5.4, showing the percentage distribution by catch rate. The circle size corresponds to the catch rate i.e. larger circles indicate greater catch rates.

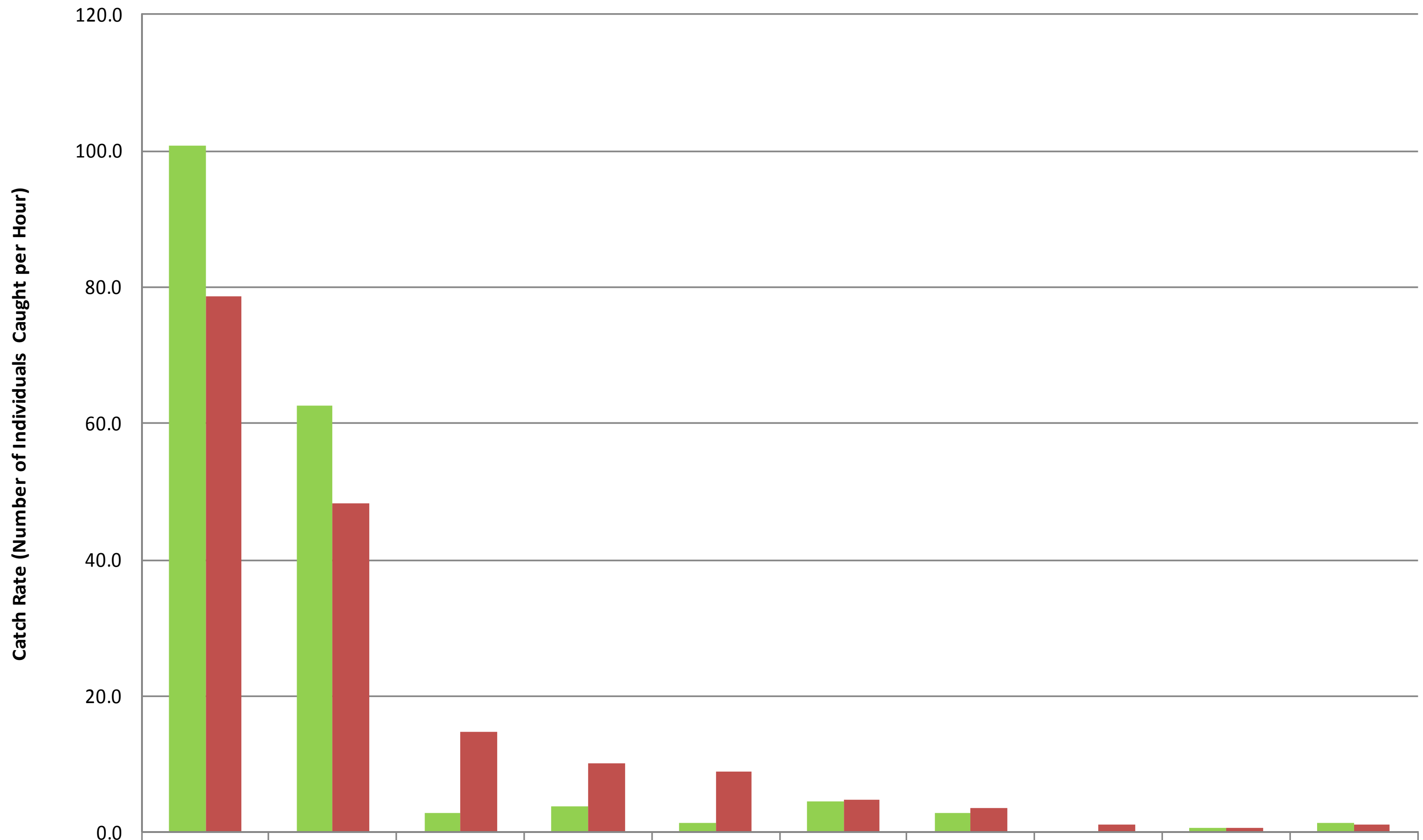
A total of 13 species were caught; 10 at the control stations and 11 within East Anglia FOUR. Overall, *L. limanda* was the most abundant species caught, followed by *P. platessa*. All other species were caught in relatively low numbers.

The highest catch rate for all species combined was recorded at control station OT18 (356.4/hr), with *L. limanda* accounting for 79.0% of the catch. *L. limanda* and *P. platessa* represented the greatest proportion of the catch at most sampling stations.

The total overall catch rates were similar at the control stations (181.4/hr) and within East Anglia FOUR (172.0/hr)

Table 5.1 Total Numbers of Individuals Caught and Catch Rate for Fish and Shellfish Species by Sampling Area

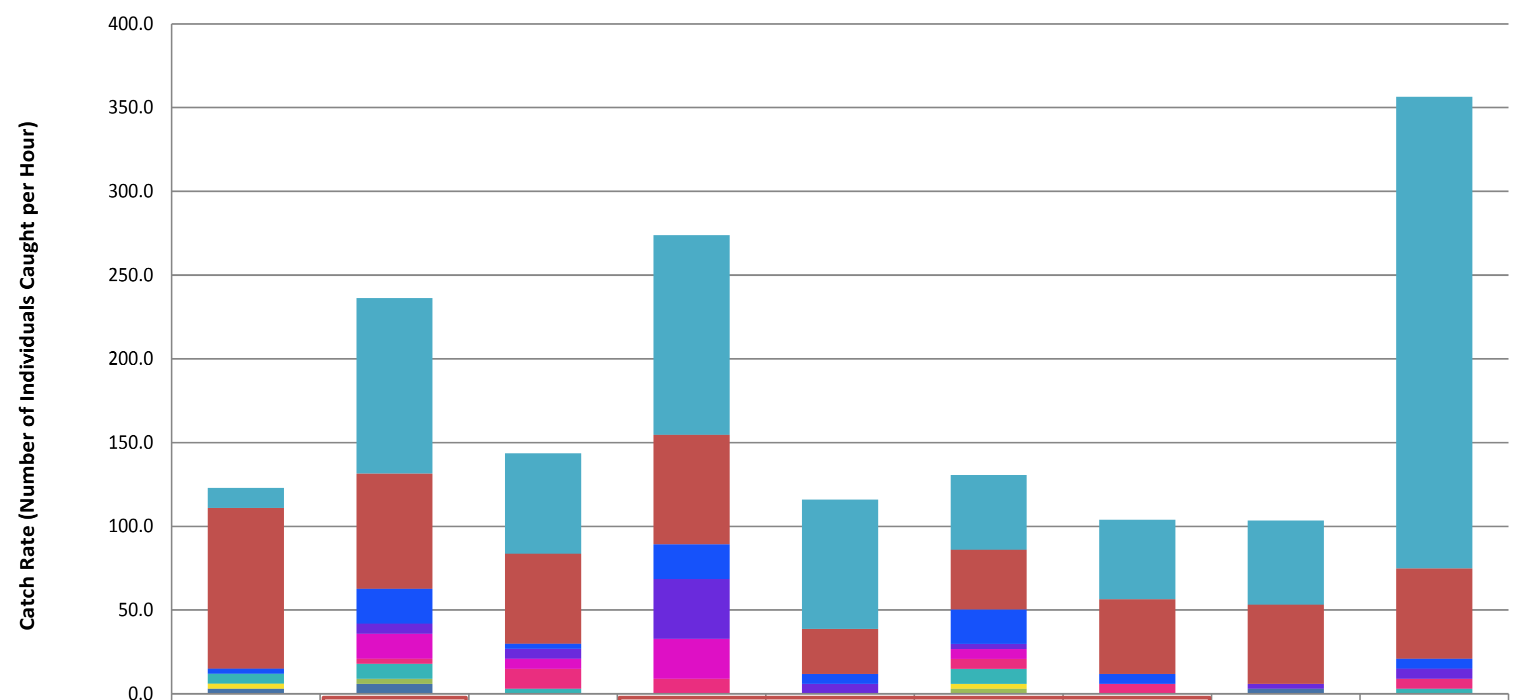
Species		Number of Individuals Caught			Catch Rate (Number of Individuals Caught per Hour)	
Common Name	Scientific Name	Control	East Anglia FOUR	Total	Control	East Anglia FOUR
Dab	*Limanda limanda*	135	132	267	100.8	78.6
Plaice	*Pleuronectes platessa*	84	81	165	62.7	48.2
Sprat	*Sprattus sprattus*	4	25	29	3.0	14.9
Grey Gurnard	*Eutrigla gurnardus*	5	17	22	3.7	10.1
Herring	*Clupea harengus*	2	15	17	1.5	8.9
Flounder	*Platichthys flesus*	6	8	14	4.5	4.8
Whiting	*Merlangius merlangus*	4	6	10	3.0	3.6
Cuttlefish	*Sepia officinalis*	0	2	2	0.0	1.2
Lesser Spotted Dogfish	*Scyliorhinus canicula*	1	1	2	0.7	0.6
Dover Sole	*Solea solea*	0	1	1	0.0	0.6
Edible Crab	*Cancer pagurus*	1	0	1	0.7	0.0
Lesser Weever	*Echiichthys vipera*	0	1	1	0.0	0.6
Starry Smoothhound	*Mustelus asterias*	1	0	1	0.7	0.0
Total No. of Individuals		243	289			
Total No. of Species		10	11			
Catch Rate (No. of Individuals Caught per Hour)		181.4	172.0			



	Dab	Plaice	Sprat	Grey Gurnard	Herring	Flounder	Whiting	Cuttlefish	Lesser Spotted Dogfish	Other Species
Control	100.8	62.7	3.0	3.7	1.5	4.5	3.0	0.0	0.7	1.5
East Anglia FOUR	78.6	48.2	14.9	10.1	8.9	4.8	3.6	1.2	0.6	1.2

Species

Figure 5.1 Catch Rate by Species and Sampling Area



	OT10	OT11	OT12	OT13	OT14	OT15	OT16	OT17	OT18
Dab	12.0	104.7	59.8	119.0	77.3	44.5	47.6	50.3	281.5
Plaice	96.0	68.8	53.8	65.5	26.8	35.6	44.6	47.3	53.9
Sprat	3.0	20.9	3.0	20.8	5.9	20.8	5.9	0.0	6.0
Grey Gurnard	0.0	6.0	6.0	35.7	5.9	3.0	0.0	3.0	6.0
Herring	0.0	15.0	6.0	23.8	0.0	5.9	0.0	0.0	0.0
Flounder	0.0	3.0	12.0	8.9	0.0	5.9	5.9	0.0	6.0
Whiting	6.0	9.0	3.0	0.0	0.0	8.9	0.0	0.0	3.0
Lesser Spotted Dogfish	3.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0
Cuttlefish	0.0	3.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0
Other Species	3.0	6.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0

Station

Figure 5.2 Catch Rate by Species and Station (red boxes denote East Anglia FOUR stations)

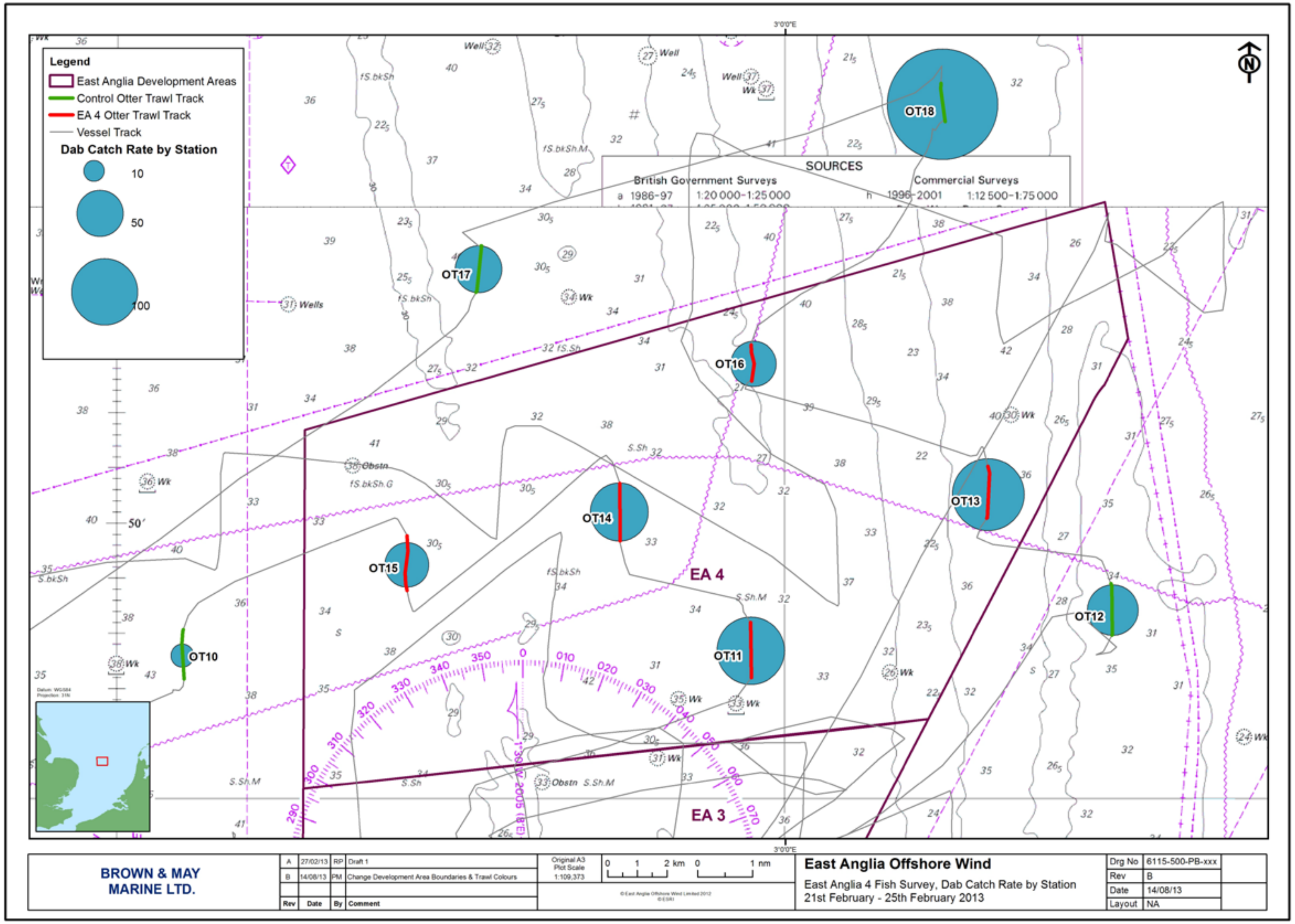


Figure 5.3 Spatial Distribution of Dab (*L. limanda*) in the Area of East Anglia FOUR

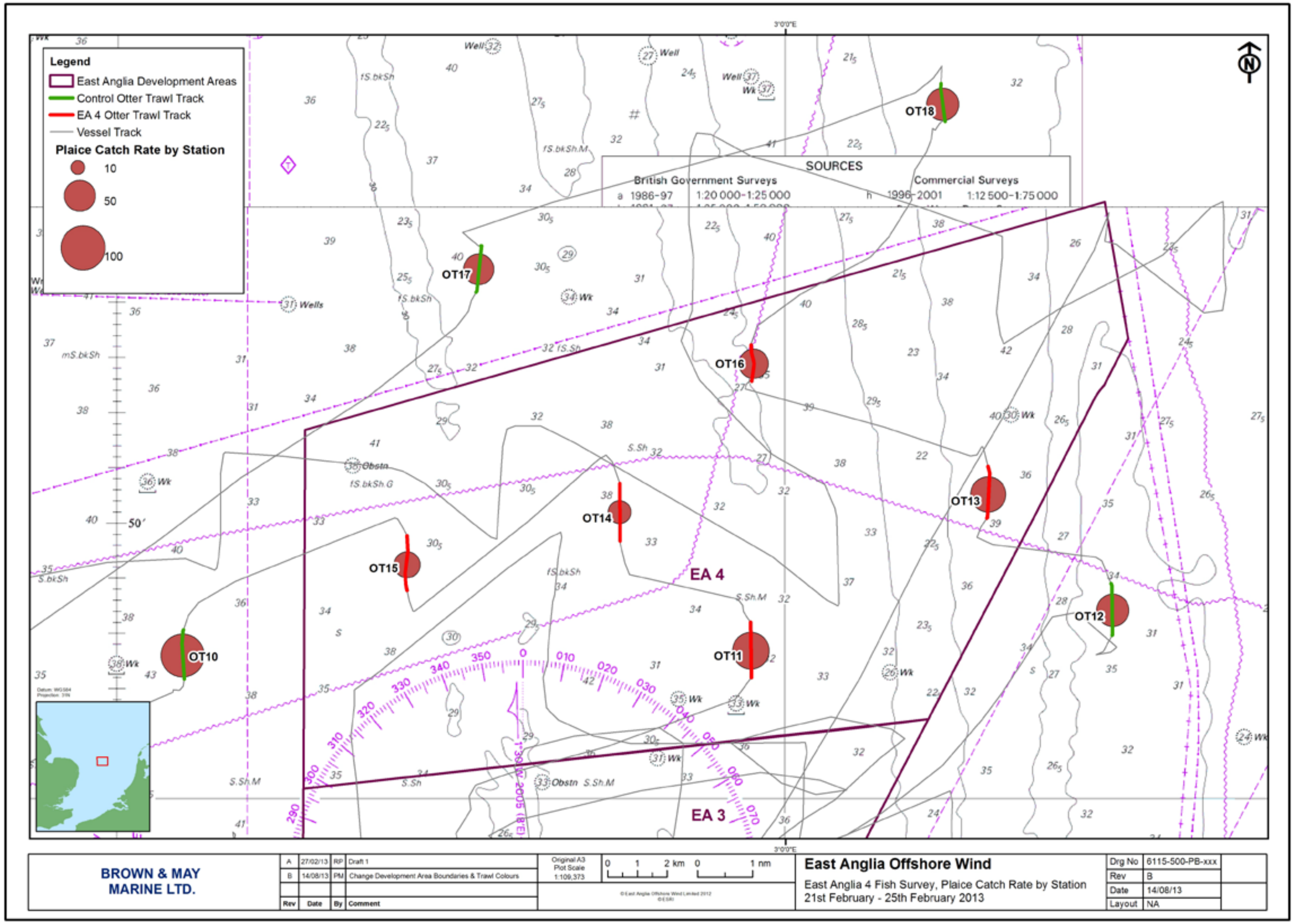
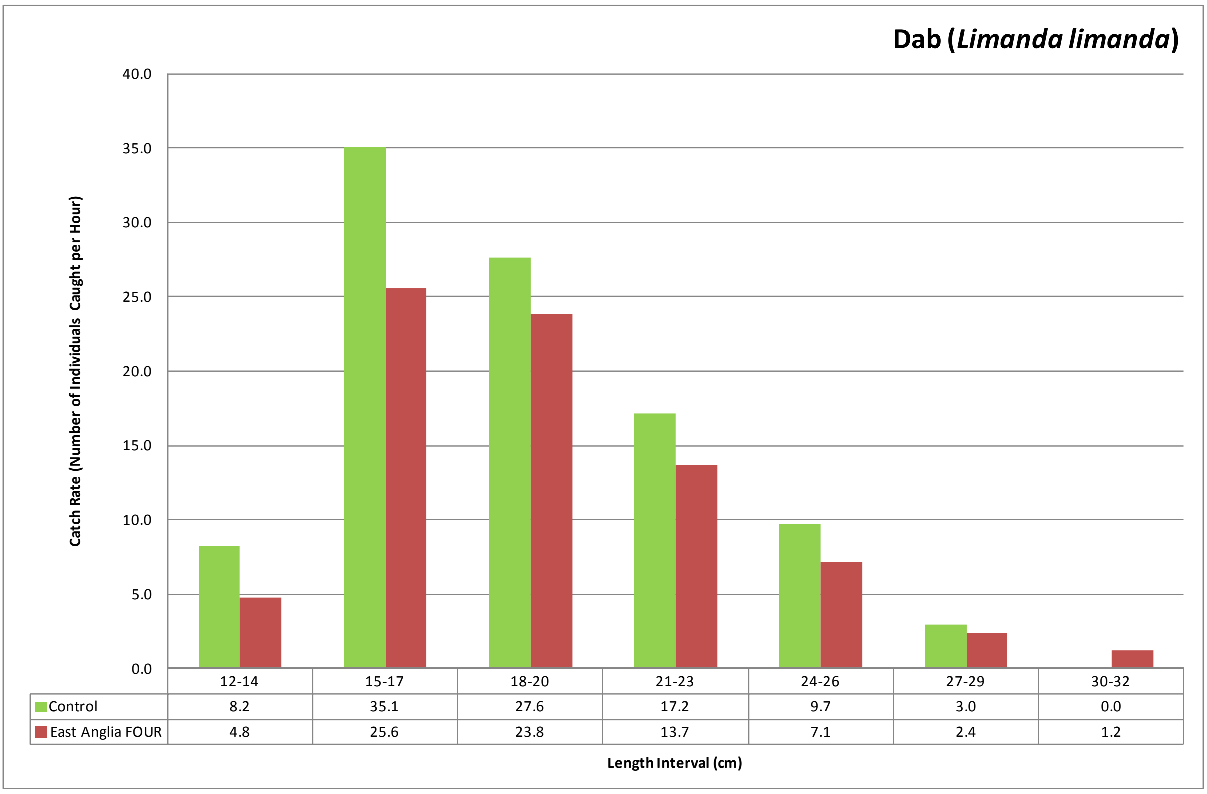


Figure 5.4 Spatial Distribution of Plaice (*P. platessa*) in the Area of East Anglia FOUR

5.2 Length Distributions

The length distributions of the two most abundant species caught during the survey, expressed as the catch rate (number of individuals caught per hour) by length (cm) and by sampling area (control and East Anglia FOUR), are shown in Figure 5.5 and Figure 5.6 below.



	12-14	15-17	18-20	21-23	24-26	27-29	30-32
Control	8.2	35.1	27.6	17.2	9.7	3.0	0.0
East Anglia FOUR	4.8	25.6	23.8	13.7	7.1	2.4	1.2

Figure 5.5 Dab (*L. limanda*) Length Distribution by Sampling Area

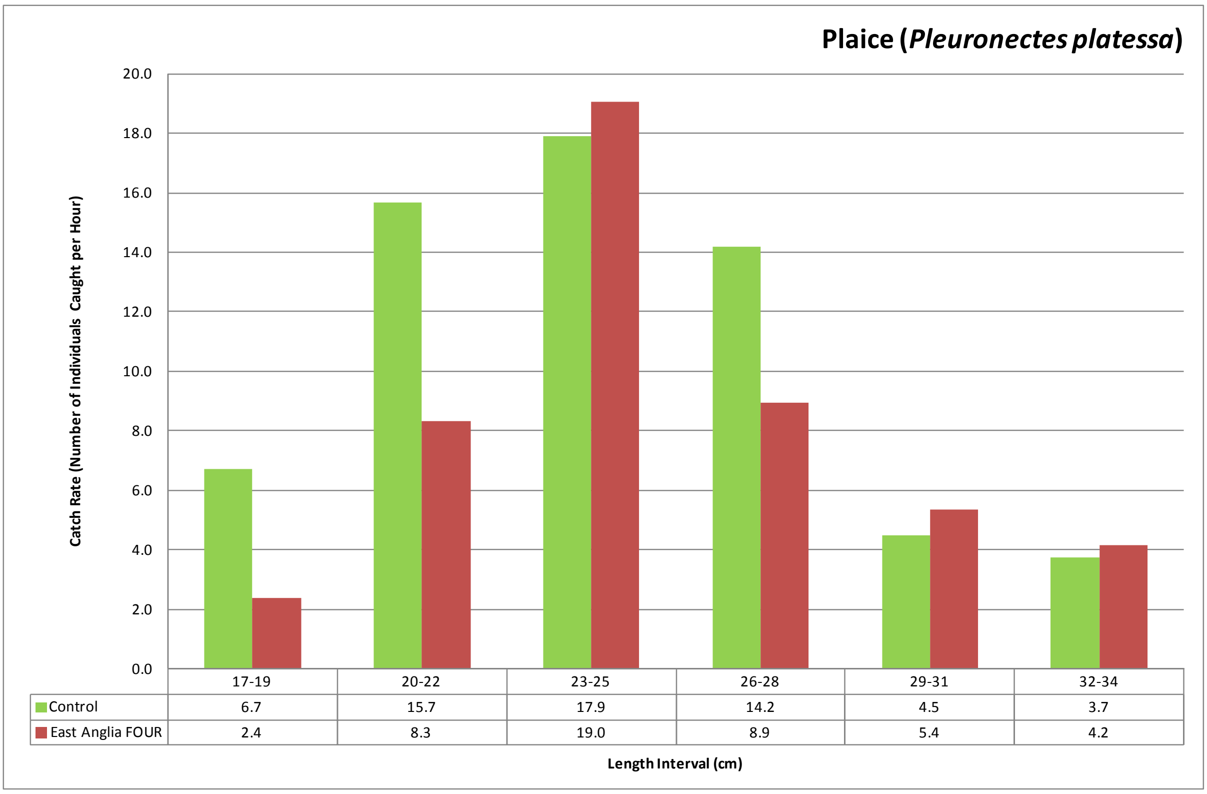


Figure 5.6 Plaice (*P. platessa*) Length Distribution by Sampling Area

5.3 Minimum Landing Sizes

Minimum landing sizes (MLS) for fish and shellfish species are set by the EC under Regulation No. 850/98 (Annex XII).

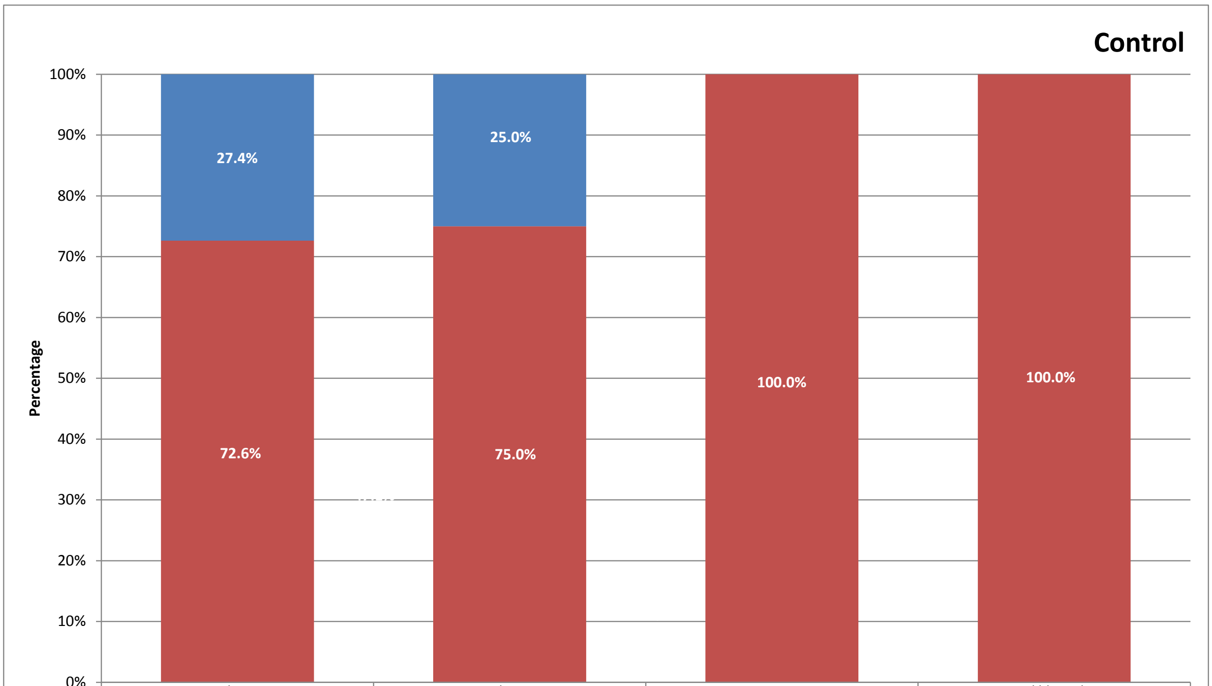
Table 5.2 shows the four fish and one shellfish species caught for which a MLS has been set, and denotes their presence or absence by sampling area (control and East Anglia FOUR).

Table 5.2 MLS Set by EC

Species		EC MLS (cm)	Presence	
Common Name	Scientific Name		Control	East Anglia FOUR
Dover Sole	*Solea solea*	24	–	✓
Herring	*Clupea harengus*	20	✓	✓
Plaice	*Pleuronectes platessa*	27	✓	✓
Whiting	*Merlangius merlangus*	27	✓	✓
Edible Crab	*Cancer pagurus*	13	✓	-

The percentage of individuals caught above and below their set MLS by species is shown in Figure 5.7 and Figure 5.8 for control and East Anglia FOUR stations respectively.

Most of the *P. platessa* (control, 72.6%; East Anglia FOUR, 70.4%), *M. merlangus* (75.0% and 66.7%) and *C. harengus* (100.0% and 86.7%) caught at the control stations and within East Anglia FOUR were below the set MLS. One *C. pagurus* was caught at the control stations and one *S. solea* was found within East Anglia FOUR, both of which were below the set MLS.



	Plaice	Whiting	Herring	Edible Crab
Above	23	1	0	0
Below	61	3	2	1

Figure 5.7 Percentage of the Catch Above and Below the MLS by Species at the Control Stations

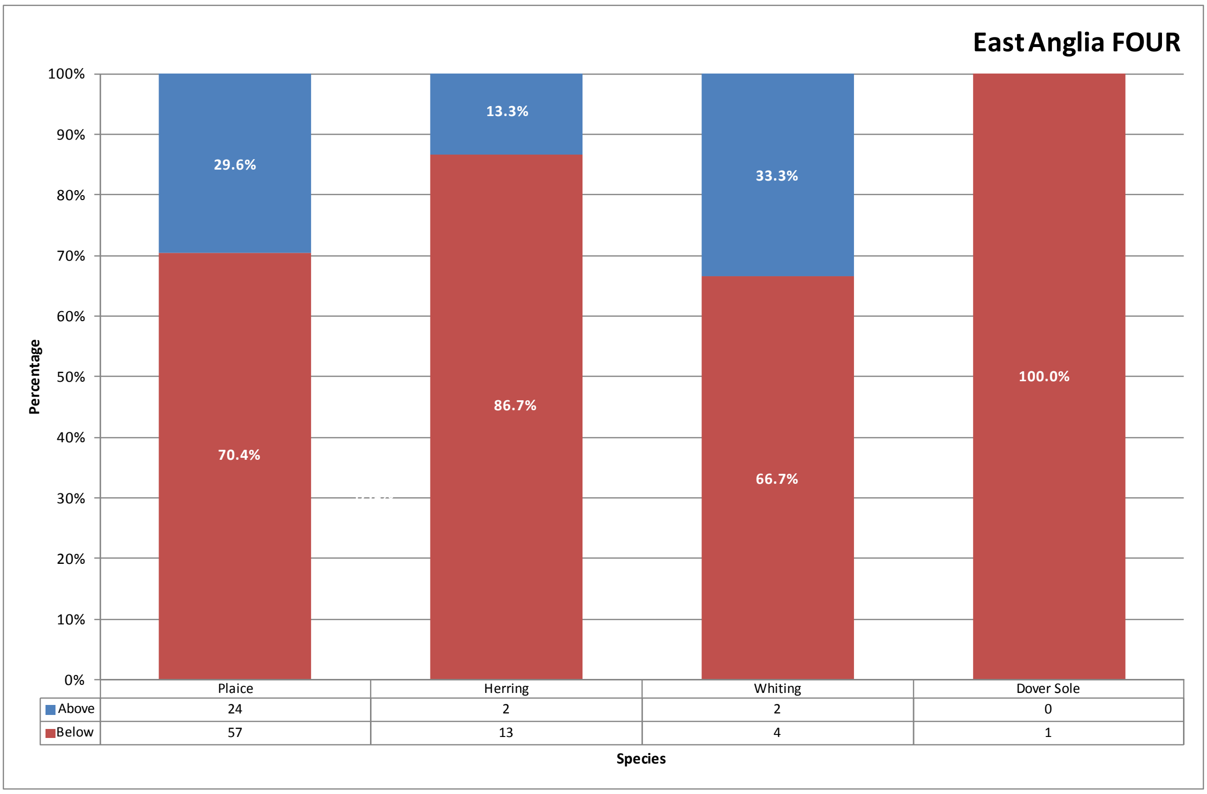
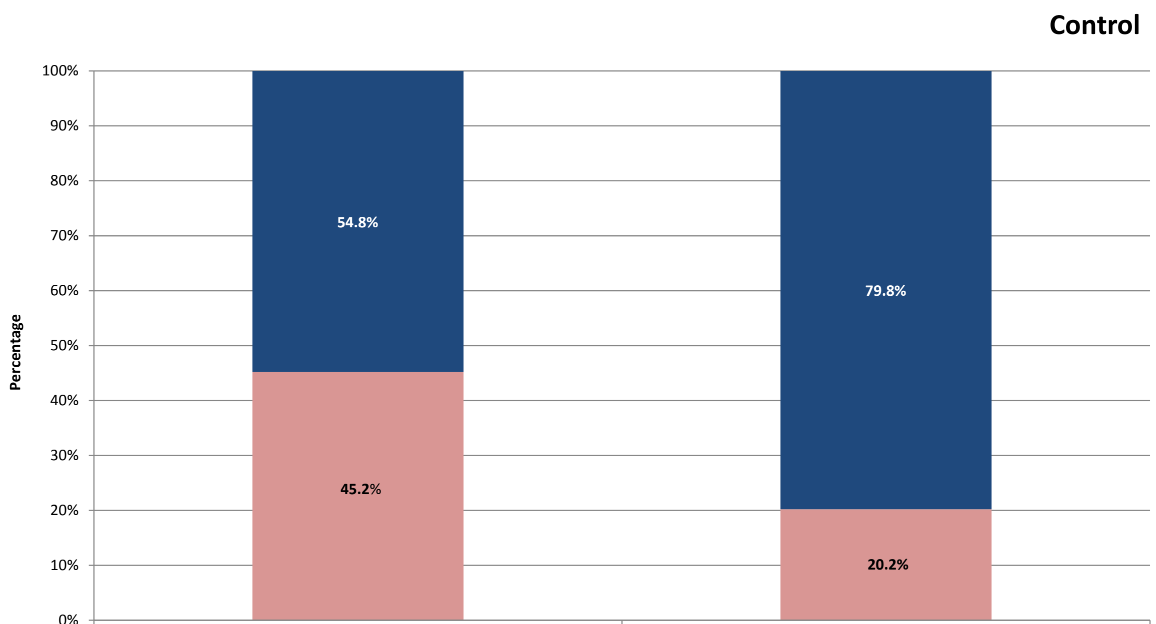


Figure 5.8 Percentage of the Catch Above and Below the MLS by Species within East Anglia FOUR

5.4 Sex Ratios

The sex ratios of the two most abundant species caught during the survey are shown in Figure 5.9 and Figure 5.10 for control and East Anglia FOUR stations respectively.

The sex ratios for the *L. limanda* caught at the control stations and within East Anglia FOUR were approximately even, whereas most of the *P. platessa* found in both sampling areas were male (79.8% and 74.1%).



	Dab	Plaice
Male	74	67
Female	61	17

Figure 5.9 Sex Ratio by Species at the Control Stations

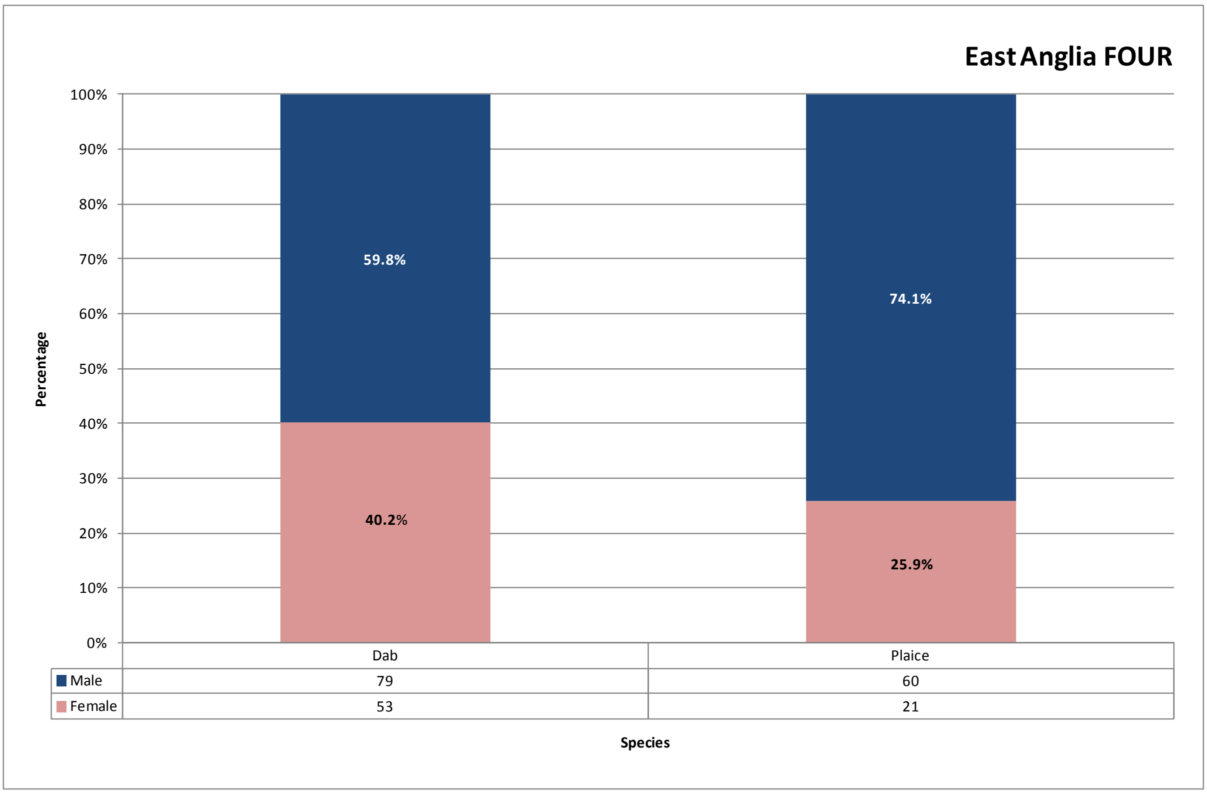


Figure 5.10 Sex Ratio by Species within East Anglia FOUR

5.5 Spawning Condition

The spawning condition, sex and length range (nearest cm below) for the two most abundant species caught during the survey are given below in Table 5.3 and Table 5.4.

Most of the *L. limanda* caught at the control stations (94.1%) and within East Anglia FOUR (87.9%) were maturing individuals. The highest proportion of the *P. platessa* found in both sampling areas was represented by maturing males (52.4% and 51.9%).

Table 5.3 Dab (*L. limanda*) Spawning Condition

Dab							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia FOUR	Total		Min.	Max.
Female	Maturing	58	49	107	40.1%	14	31
	Spent	3	4	7	2.6%	18	25
Male	Immature	5	11	16	6.0%	12	17
	Maturing	69	67	136	50.9%	13	25
	Spent	0	1	1	0.4%	14	14

Table 5.4 Plaice (*P. platessa*) Spawning Condition

Plaice							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia FOUR	Total		Min.	Max.
Female	Immature	13	10	23	13.9%	18	27
	Maturing	0	2	2	1.2%	26	31
	Hyaline	0	2	2	1.2%	33	34
	Spent	4	7	11	6.7%	23	33
Male	Immature	23	16	39	23.6%	17	27
	Maturing	44	42	86	52.1%	20	33
	Spent	0	2	2	1.2%	24	26

6.0 Beam Trawl Results

6.1 Catch Rates and Species Distribution

The total number of individuals caught and the catch rate (number of individuals caught per hour) for fish and shellfish species by sampling area (control and East Anglia FOUR) are given in Table 6.1 below and are illustrated in Figure 6.1. The catch rates by sampling station are shown in Figure 6.2 (red boxes denote stations within East Anglia FOUR).

Spatial distribution plots for *P. platessa* and *L. limanda* are given in **Figure 6.3** and Figure 6.4, showing the percentage distribution by catch rate. The circle size corresponds to the catch rate i.e. larger circles indicate greater catch rates.

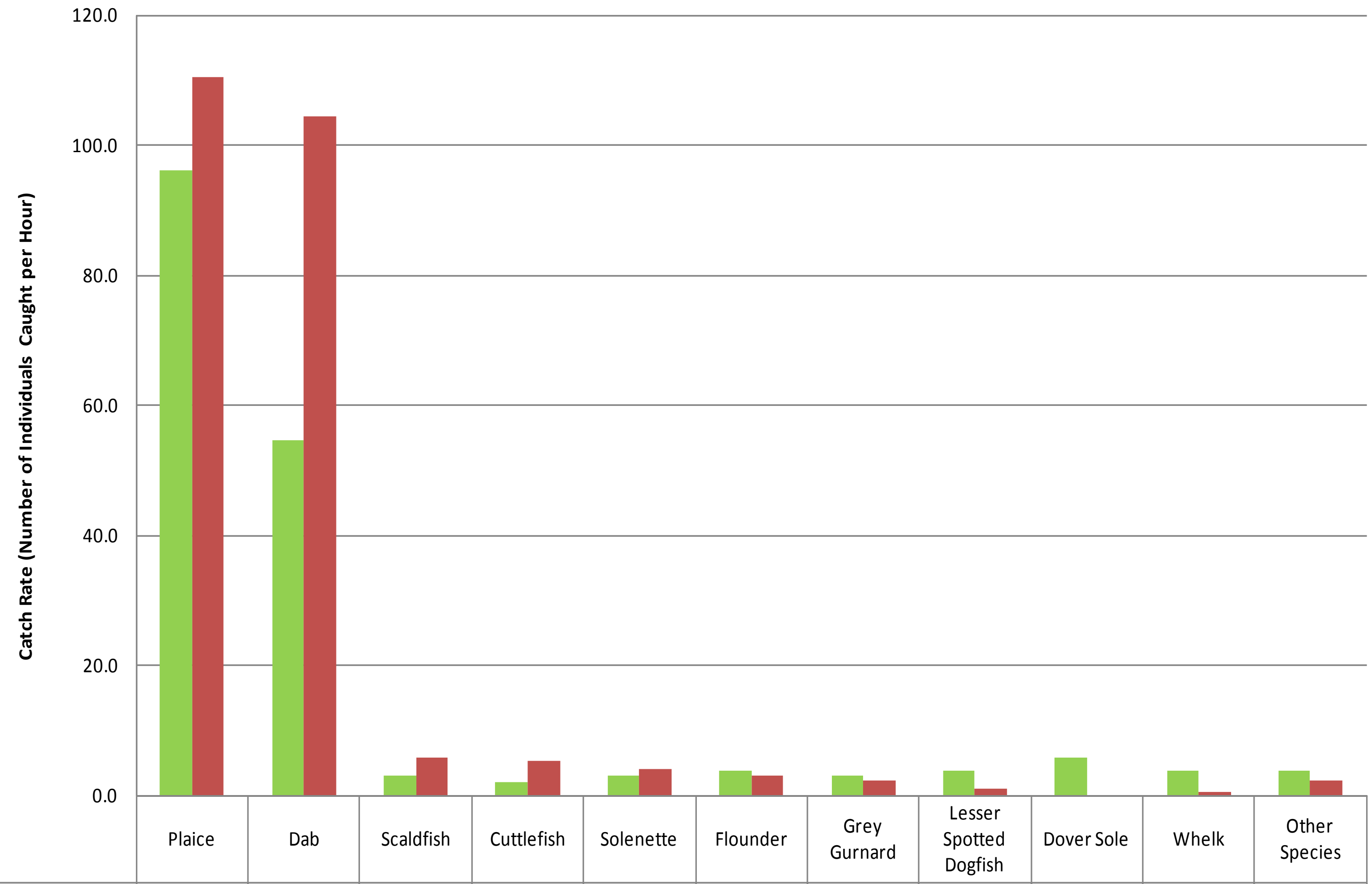
A total of 17 species of fish were caught, 13 of which were found at the control stations and 13 within East Anglia FOUR. Overall, *P. platessa* was the most abundant species caught, followed by *L. limanda*. All other species were caught in relatively low numbers.

The station with the greatest total catch rate was BT14 within East Anglia FOUR (467.2/hr), with *L. limanda* and *P. platessa* representing 93.0% of the catch. *P. platessa* and *L. limanda* represented the highest proportion of the catch at most sampling stations.

Overall, the total catch rate was higher within East Anglia FOUR (239.9/hr) than at the control stations (183.5/hr).

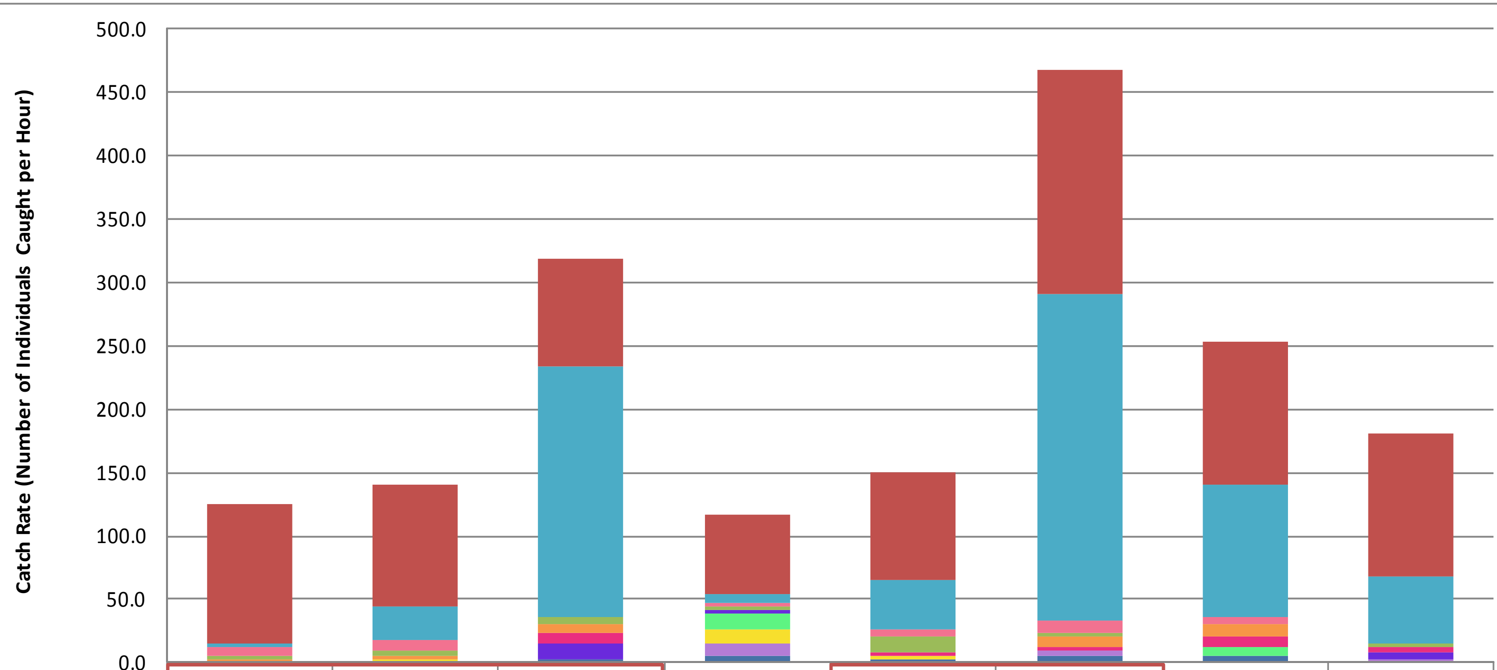
Table 6.1 Number of Individuals Caught and the Catch Rate for Fish and Shellfish Species by Sampling Area

Species		Number of Individuals Caught			Catch Rate (Number of Individuals Caught per Hour)	
Common Name	Scientific Name	Control	East Anglia FOUR	Total	Control	East Anglia FOUR
Plaice	*Pleuronectes platessa*	97	185	282	96.2	110.4
Dab	*Limanda limanda*	55	175	230	54.6	104.4
Scaldfish	*Arnoglossus laterna*	3	10	13	3.0	6.0
Cuttlefish	*Sepia officinalis*	2	9	11	2.0	5.4
Solenette	*Buglossidium luteum*	3	7	10	3.0	4.2
Flounder	*Platichthys flesus*	4	5	9	4.0	3.0
Grey Gurnard	*Eutrigla gurnardus*	3	4	7	3.0	2.4
Lesser Spotted Dogfish	*Scyliorhinus canicula*	4	2	6	4.0	1.2
Dover Sole	*Solea solea*	6	0	6	6.0	0.0
Whelk	*Buccinum undatum*	4	1	5	4.0	0.6
Bullrout	*Myoxocephalus scorpius*	2	0	2	2.0	0.0
4-Bearded Rockling	*Rhinonemus cimbrius*	0	1	1	0.0	0.6
Brill	*Scophthalmus rhombus*	1	0	1	1.0	0.0
Lemon Sole	*Microstomus kitt*	0	1	1	0.0	0.6
Lesser Weever	*Echiichthys vipera*	0	1	1	0.0	0.6
Starry Smoothhound	*Mustelus asterias*	1	0	1	1.0	0.0
Whiting	*Merlangius merlangus*	0	1	1	0.0	0.6
Total No. of Individuals		185	402			
Total No. of Species		13	13			
Catch Rate (No. of Individuals Caught per Hour)		183.5	239.9			



	Plaice	Dab	Scaldfish	Cuttlefish	Solenette	Flounder	Grey Gurnard	Lesser Spotted Dogfish	Dover Sole	Whelk	Other Species
Control	96.2	54.6	3.0	2.0	3.0	4.0	3.0	4.0	6.0	4.0	4.0
East Anglia FOUR	110.4	104.4	6.0	5.4	4.2	3.0	2.4	1.2	0.0	0.6	2.4

Figure 6.1 Catch Rates for Fish and Shellfish Species by Sampling Area



	BT09	BT10	BT11	BT12	BT13	BT14	BT15	BT16
Plaice	110.1	96.0	84.1	62.8	85.4	176.7	113.3	112.3
Dab	3.0	27.0	198.2	6.0	38.3	257.6	104.4	53.2
Scaldfish	6.0	9.0	0.0	3.0	5.9	9.0	6.0	0.0
Cuttlefish	3.0	3.0	6.0	3.0	11.8	3.0	0.0	3.0
Solenette	3.0	3.0	6.0	0.0	0.0	9.0	8.9	0.0
Flounder	0.0	0.0	9.0	0.0	2.9	3.0	8.9	3.0
Grey Gurnard	0.0	0.0	12.0	3.0	0.0	0.0	0.0	5.9
Dover Sole	0.0	0.0	0.0	12.0	0.0	0.0	6.0	0.0
Lesser Spotted Dogfish	0.0	3.0	0.0	12.0	2.9	0.0	0.0	0.0
Whelk	0.0	0.0	0.0	9.0	0.0	3.0	0.0	3.0
Other Species	0.0	0.0	3.0	6.0	2.9	6.0	6.0	0.0

Station

Figure 6.2 Catch Rates for Fish and Shellfish Species by Station (red box denotes East Anglia FOUR stations)

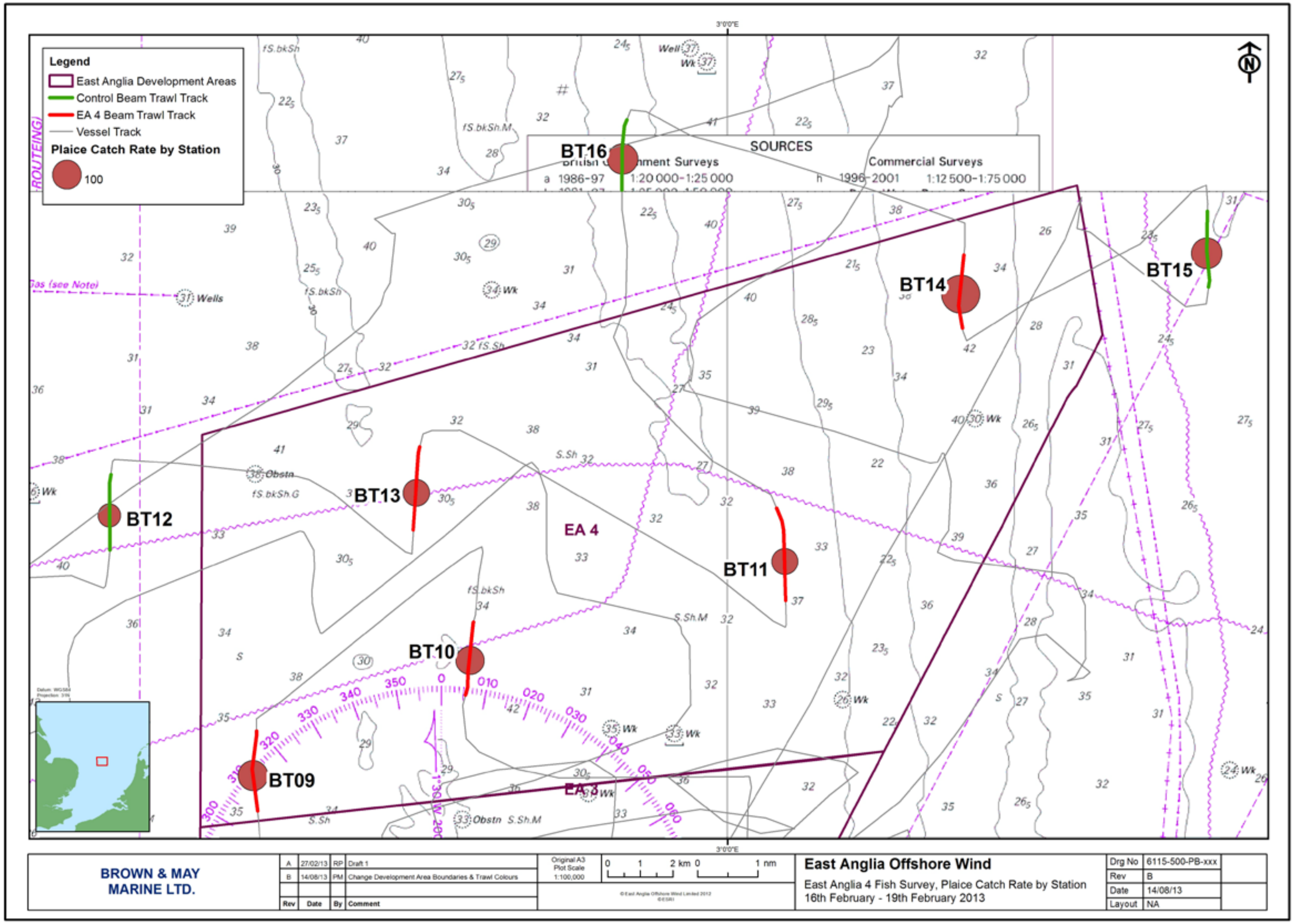


Figure 6.3 Spatial Distribution of Plaice (*P. platessa*) in the Area of East Anglia FOUR

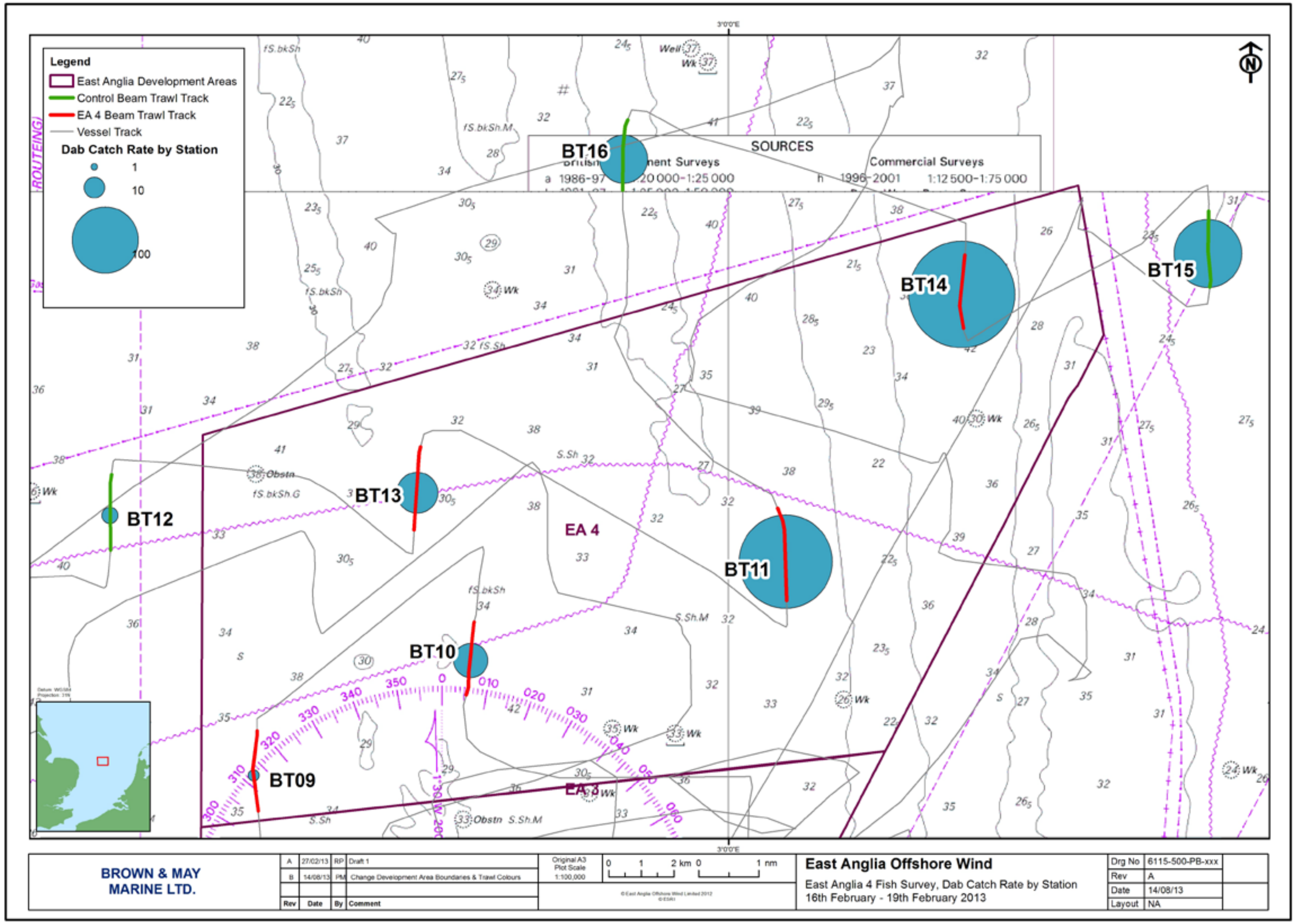
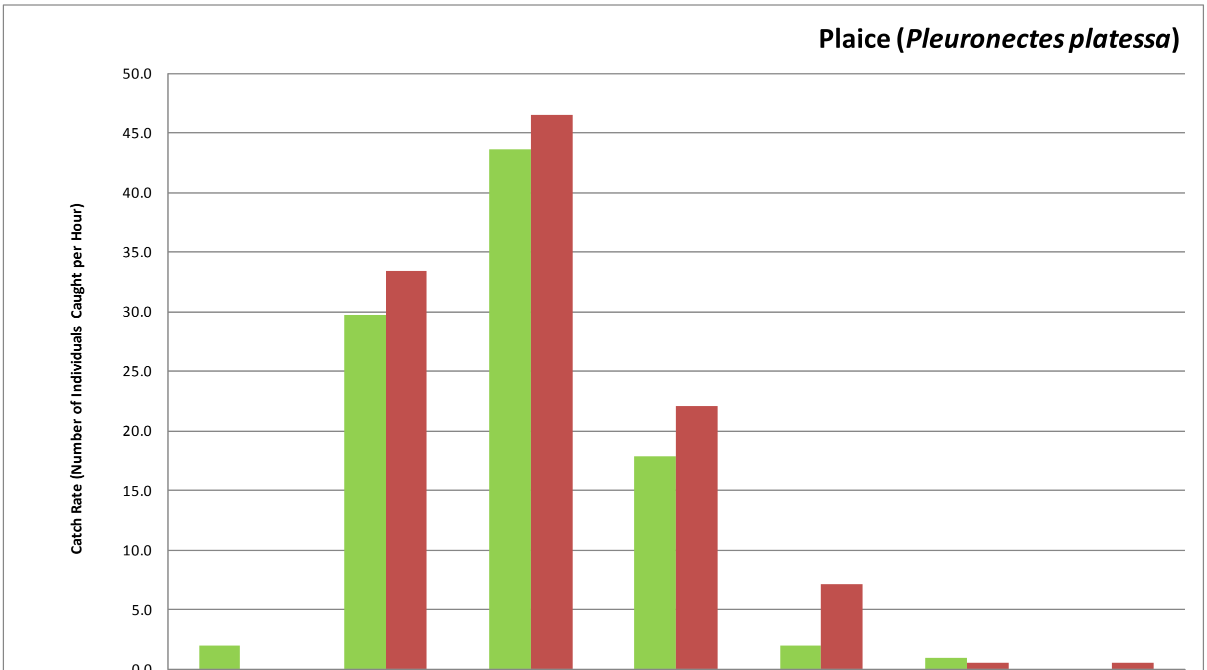


Figure 6.4 Spatial Distribution of Dab (*L. limanda*) in the Area of East Anglia FOUR

6.2 Length Distributions

The length distributions of the two most abundant species caught during the survey, expressed as the catch rate (number of individuals caught per hour) by length (cm) and by sampling area (control and East Anglia FOUR), are shown in Figure 6.5 and Figure 6.6 below.



	10-14	15-19	20-24	25-29	30-34	35-39	40-44
Control	2.0	29.8	43.6	17.9	2.0	1.0	0.0
East Anglia FOUR	0.0	33.4	46.5	22.1	7.2	0.6	0.6

Figure 6.5 Plaice (*P. platessa*) Length Distribution by Sampling Area

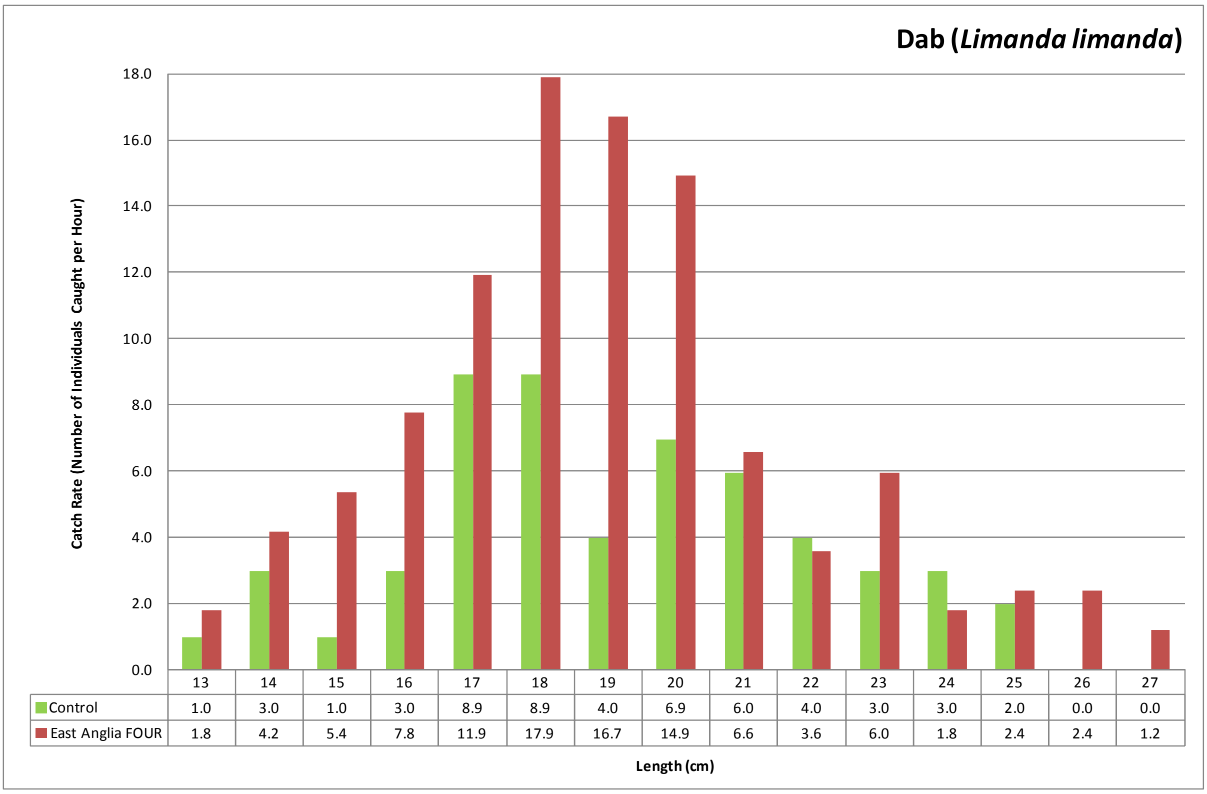


Figure 6.6 Dab (*L. limanda*) Length Distribution by Sampling Area

6.3 Minimum Landing Sizes

Minimum landing sizes (MLS) for fish and shellfish species are set by the EC under Regulation No. 850/98 (Annex XII).

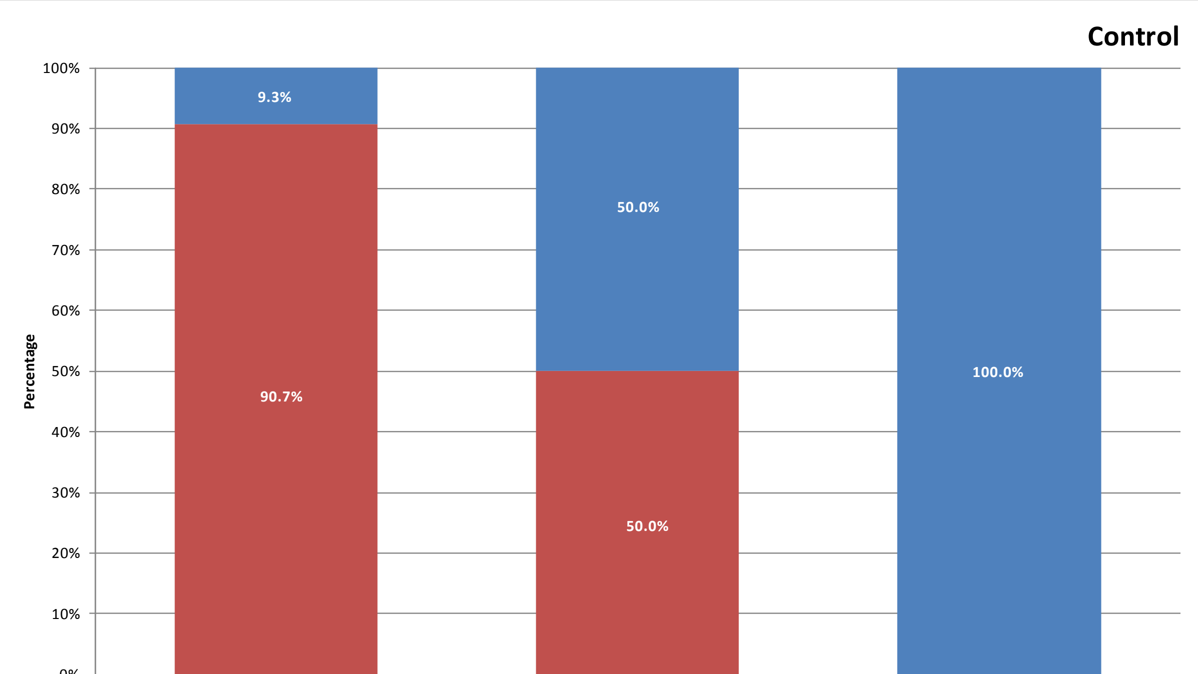
Table 6.2 shows the three fish and one shellfish species caught for which a MLS has been set and denotes their presence or absence by sampling area (control and East Anglia FOUR).

Table 6.2 MLS Set by EC

Species		EC MLS (cm)	Presence	
Common Name	Scientific Name		Control	East Anglia FOUR
Dover Sole	*Solea solea*	24	✓	-
Plaice	*Pleuronectes platessa*	27	✓	✓
Whiting	*Merlangius merlangus*	27	-	✓
Whelk	*Buccinum undatum*	4.5	✓	✓

The percentage of individuals caught above and below their set MLS by species is shown in Figure 6.7 and Figure 6.8 for control and East Anglia FOUR stations respectively.

The majority of the *P. platessa* caught at the control stations (90.7%) and within East Anglia FOUR (83.2%) were below the MLS. The percentage of *S. solea* caught at the control stations were equally divided above and below the MLS. All of the *B. undatum* caught at the control stations and within East Anglia FOUR were above the set MLS, as was the one *M. merlangus* found within East Anglia FOUR.



	Plaice	Dover Sole	Whelk
Above	9	3	4
Below	88	3	0

Figure 6.7 Percentage of the Catch Above and Below the MLS by Species at the Control Stations

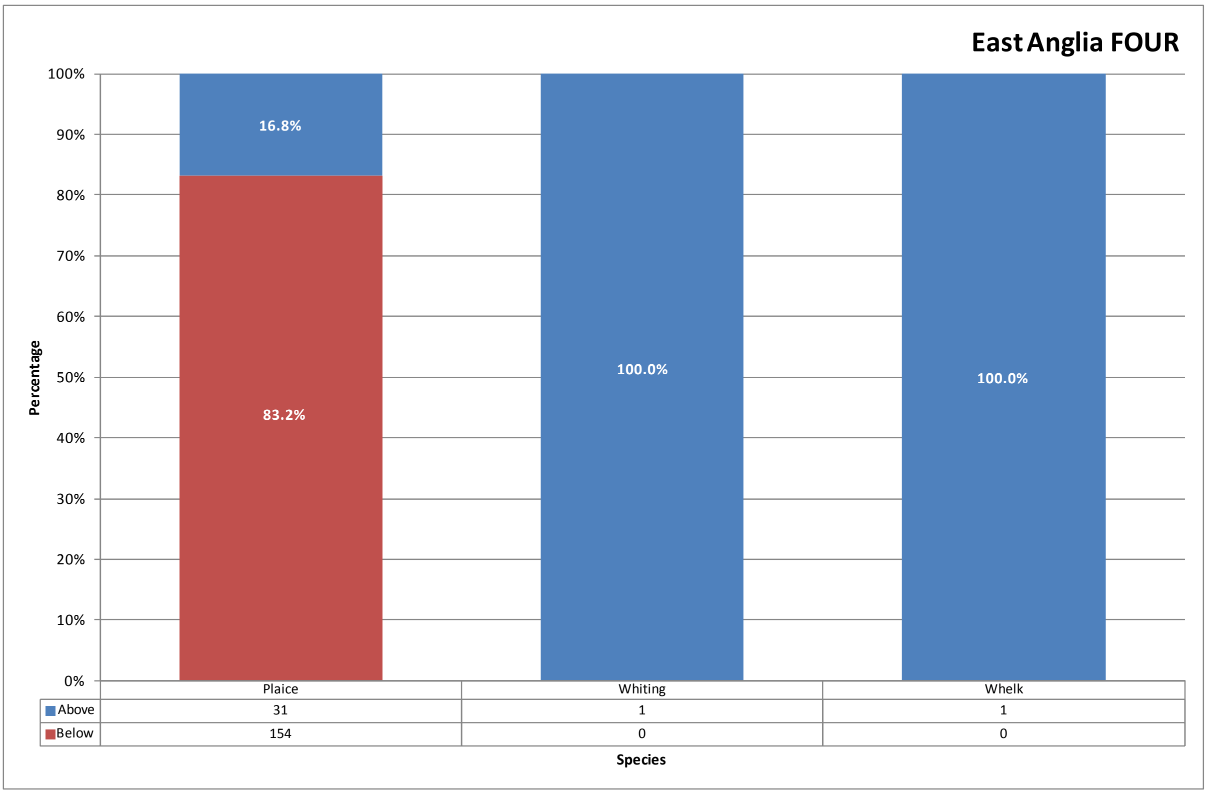


Figure 6.8 Percentage of the Catch Above and Below the MLS by Species within East Anglia FOUR

6.4 Sex Ratios

The sex ratios of the most abundant species caught during the beam trawl survey are shown in Figure 6.9 and Figure 6.10 for control and East Anglia FOUR stations.

The majority of the *P. platessa* caught at the control stations (81.4%) and within East Anglia FOUR (87.6%) were male. A higher proportion of the *L. limanda* caught at the control stations were female (63.6%), whereas within East Anglia FOUR the sex ratio was approximately even.

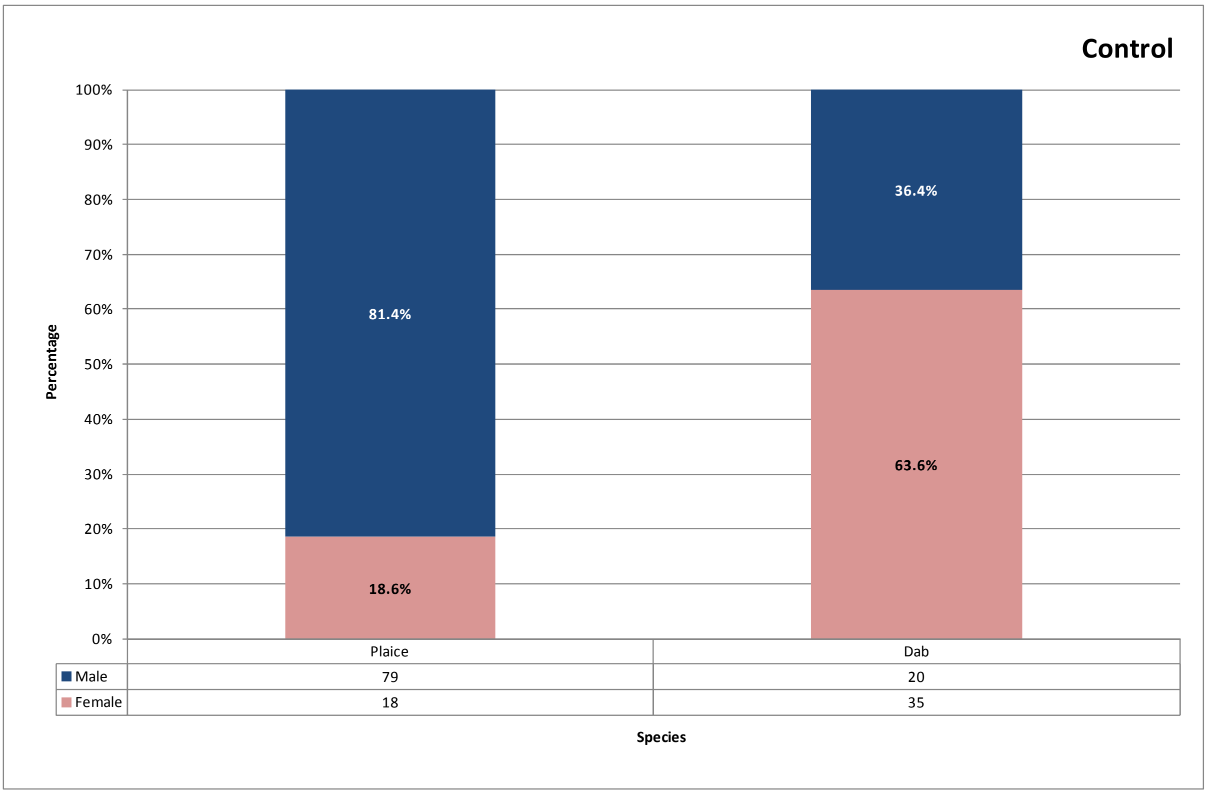


Figure 6.9 Sex Ratio by Species at the Control Stations

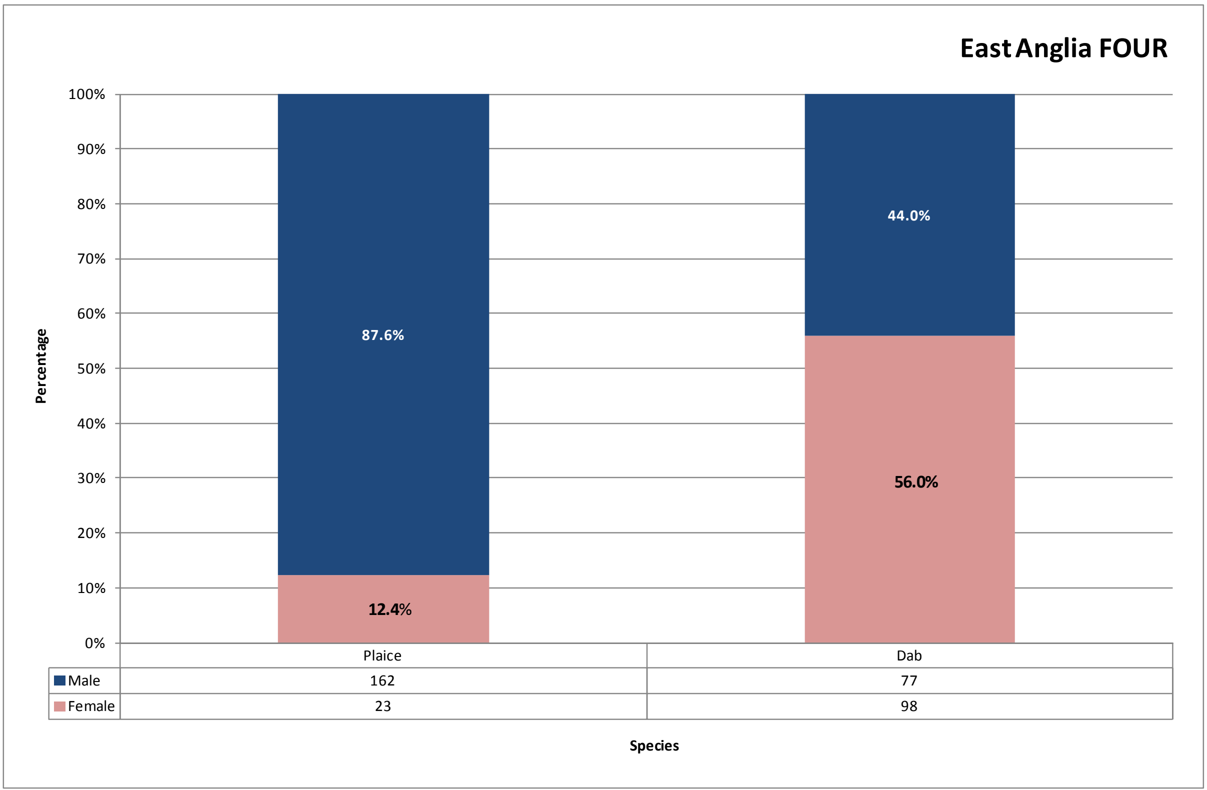


Figure 6.10 Sex Ratio by Species within East Anglia FOUR

6.5 Spawning Condition

The spawning condition, sex and length range (nearest cm below) for the most abundant species caught during the beam trawl survey are given below in Table 6.3 and Table 6.4.

The highest proportion of the *P. platessa* (control, 55.7%; East Anglia FOUR, 68.6%) and *L. limanda* (76.4% and 80.6%) caught in both sampling areas were spent.

Table 6.3 Plaice (*P. platessa*) Spawning Condition

Plaice							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia FOUR	Total		Min.	Max.
Female	Immature	14	18	32	11.3%	16	29
	Spent	4	5	9	3.2%	21	43
Male	Immature	27	39	66	23.4%	14	27
	Maturing	2	1	3	1.1%	15	20
	Spent	50	122	172	61.0%	14	36

Table 6.4 Dab (*L. limanda*) Spawning Condition

Dab							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia FOUR	Total		Min.	Max.
Female	Immature	5	24	29	12.6%	13	20
	Maturing	0	2	2	0.9%	19	20
	Spent	30	72	102	44.3%	16	27
Male	Immature	8	6	14	6.1%	13	20
	Maturing	0	1	1	0.4%	17	17
	Running	0	1	1	0.4%	19	19
	Spent	12	69	81	35.2%	15	24

7.0 Appendix (of Annex 3)

7.1 Appendix 1 – Health and Safety

7.1.1 Personnel

Brown and May Marine (BMM) staff protocol followed the standard health and safety protocol outlined in the BMM "Offshore Operational Procedures for Surveys using Commercial Fishing Vessels".

All BMM staff have completed a Sea Survival course approved by the Maritime and Coastguard Agency, meeting the requirements laid down in: **STCW 95 Regulation VI/1 para 2.1.1 and STCW Code section A- VI/1** before boarding any vessel conducting works for the company. Employees are also required to have valid medical certificates (ENG1 or ML5), Seafish Safety Awareness, Seafish Basic First Aid and Seafish Basic Fire Fighting and Fire Prevention certificates before participating in offshore works.

7.1.2 Vessel Induction

Before boarding, the survey team were shown how to safely board and disembark the vessel. Prior to departure the skipper briefed the BMM staff on the whereabouts of the safety equipment, including the life raft, emergency flares and fire extinguishers, and also the location of the emergency muster point. The safe deck areas, man-overboard procedures and emergency alarms were also discussed. The survey team were warned about the possible hazards, such as slippery decks and obstructions whilst aboard. The BMM staff were briefed about trawling operations and the need to keep clear of all winches when operational and a safety drill was conducted. All hazards were assessed prior to the survey in the BMM health and safety risk assessment.

7.1.3 Daily Safety Checks

The condition of the life jackets, EPIRBs, and life raft were inspected daily. Also checked were the survey team working areas, including the fish room and the wheelhouse to ensure these areas were clear of hazards such as clutter and obstructions.

7.1.4 Post Trip Survey review

Upon completion of the survey a "Post Trip Survey Review" was filed, see Table 7.1 overleaf.

Table 7.1 Post Trip Survey Review

Project: East Anglia FOUR	**Vessel:** Jubilee Spirit
Surveyors: Alex Winrow-Giffin, Richard Preston	**Skipper:** Ross Crookes
Survey Area: East Anglia FOUR, southern North Sea	**Total Time at Sea:** 11 Days
Dates at Sea: 16/02/2013 – 26/02/2013	

	Comments	Actions
Did vessel comply with pre-trip safety audits?	Yes Passed audit by LOC on 14/02/2013	N/A
Skipper and crew attitude to safety?	Good	N/A
Vessel machinery failures?	None	N/A
Safety equipment failures?	None	N/A
Accidents?	None	N/A
Injuries?	None	N/A

9.0 Annex 4: East Anglia THREE Fish and Shellfish Survey 15th to 27th May 2013

East Anglia Offshore Wind Farm

East Anglia THREE

Fish and Shellfish Survey

15th to 27th May 2013

Undertaken by
Brown and May Marine Ltd

Ref	Issue Date	Issue Type	Author	Checked	Approved
EA3OB02	10/09/2013	Draft 2	LS/AWG	AWG/JP	SJA

Figures

Tables

1.0 Summary

1.1 Otter Trawl

A total of 12 species of fish and shellfish were caught in the otter trawl survey; six at the control stations and 12 within East Anglia THREE. Overall, whiting (*Merlangius merlangus*) was the most abundant species caught, followed by plaice *(Pleuronectes platessa*), dab (*Limanda limanda*) and then lesser spotted dogfish (*Scyliorhinus canicula*). All other species were caught in relatively low numbers. The highest catch rate for all species combined was recorded at station OT08 within East Anglia THREE, with *P.* platessa and *L. limanda* accounting for 75.0% of the catch.

Three species of fish were caught for which there is a set minimum landing size (MLS). Most of the *P. platessa* and *M. merlangus* caught in both sampling areas were below the MLS. One horse mackerel (*Trachurus trachurus*) was caught within East Anglia THREE and was above the MLS.

At the control stations the sex ratio of the *M. merlangus* caught was approximately even, whereas within East Anglia THREE a large proportion of individuals were female; high numbers of which were running females in both sampling areas. The sex ratio of the *L. limanda* caught at the control stations was approximately equal with the highest proportion of individuals identified as immature males, whereas most of those caught with East Anglia THREE were maturing males. At the control stations the highest proportion of the *P. platessa* caught were immature and running males, whereas within East Anglia THREE most of which were maturing males.

1.2 Beam Trawl

Of the 18 species caught in the commercial beam trawl survey, 13 were found at the control stations and 13 within East Anglia THREE. Overall, *P. platessa* was the most abundant species caught, followed by *L. limanda*. The total catch rate was highest at the control stations. Control station BT01 had the highest catch rate overall; this is attributed to the high numbers of whelk (*Buccinum undatum*) recorded.

Most of the *P. platessa* caught in both sampling areas were below the set MLS. All of the *B. undatum*, caught within East Anglia THREE were below the MLS. All other species were caught in low numbers.

The highest proportion of the *P. platessa* caught in both sampling areas were maturing males. Most of the *L. limanda* caught at the control stations were immature males, whereas within East Anglia THREE the majority were maturing females.

1.3 Scientific 2-metre Beam Trawl

A total of 28 species of fish were caught in the East Anglia THREE scientific beam trawl survey; 20 within East Anglia THREE, and 27 along the export cable. Solenette (*Buglossidum luteum*) was the most abundant species along the export cable whereas sand goby (*Pomatoschistus minutus*) was more abundant within East Anglia THREE, followed by lesser weever (*Echiichthys vipera*) and scaldfish (*Arnoglossus laterna*). All other species were caught in relatively low numbers. Station T12 within East Anglia THREE yielded the highest catch rate (1,222.6/hr), with *B. luteum* and *P. minutus* representing the majority of the catch (43.7% and 42.9% respectively).

2.0 Introduction

The following report details the findings of the May 2013 fish and shellfish survey, undertaken within and adjacent to the East Anglia THREE offshore windfarm between the 15th and 27th May.

The East Anglia THREE offshore windfarm is located in the North Sea, approximately 79 km off the coast of Suffolk.

The survey methodology, vessel and sampling gear detailed were agreed in consultation with Cefas and the Marine Management Organisation (MMO). A dispensation from the MMO for the Provisions of Council Regulation 850/98 to catch and retain undersize fish for scientific research and 43/2009 specifically related to days at sea was obtained prior to commencement of this survey. A summary of the health and safety performance of the survey is provided in Appendix 1.

The aim of the survey was to establish the abundance and composition of fish and shellfish species within the area of the East Anglia THREE offshore windfarm.

The results of the epi-benthic survey undertaken by Fugro Emu Limited are also detailed in Section 0. Please refer to the epi-benthic survey report for information regarding the vessel and sampling gear specifications.

3.0 Scope of Works

The proposed scope of works for the May 2013 fish and shellfish survey replicates that of the February 2013 survey, and is detailed below. The methodology is in line with the Terms of Reference, as agreed with Cefas prior to the commencement of sampling. The proposed sampling stations are illustrated in Figure 3.1 overleaf.

- **Otter Trawl**
  - Six tows of approximately 20 minutes duration within East Anglia THREE and three control tows in adjacent areas

- **Beam Trawl**
  - Four tows of approximately 20 minutes duration within East Anglia THREE, four control tows in adjacent areas

- **Otter and Beam Trawl Sample Analysis**
  - Number of individuals and catch rate by species
  - Length distribution by species
    - Finfish and sharks (except herring and sprat): individual lengths (nearest cm below)
    - Herring and sprat: individual lengths (nearest ½ cm below)
    - Rays: individual length and wing-width (nearest cm below)
  - Sex ratio by species
  - Spawning condition
    - Finfish species (except herring and sprat): Cefas Standard Maturity Key - Five Stage
    - Herring and sprat: Cefas Maturity Key – Nine Stage
    - Ray and shark species: Cefas Standard Elasmobranch Maturity Key - Four Stage

- **2-metre Scientific Beam Trawl**
  - Six tows of approximately 400 to 700 metres distance along the export cable route and three tows within East Anglia THREE (undertaken by Fugro Emu Limited between 1st and 8th May 2013)

- **2-metre Scientific Beam Trawl Sample Analysis**
  - Number of individuals and catch rate by species
  - Length distribution by species
    - Finfish and sharks (except herring and sprat): individual lengths (nearest cm below)
    - Herring and sprat: individual lengths (nearest ½ cm below)
    - Rays: individual length and wing-width (nearest cm below)

For the purposes of data analysis, catch rates have been calculated to allow for quantitative comparisons to be made between the numbers of individuals caught per hour at each station.

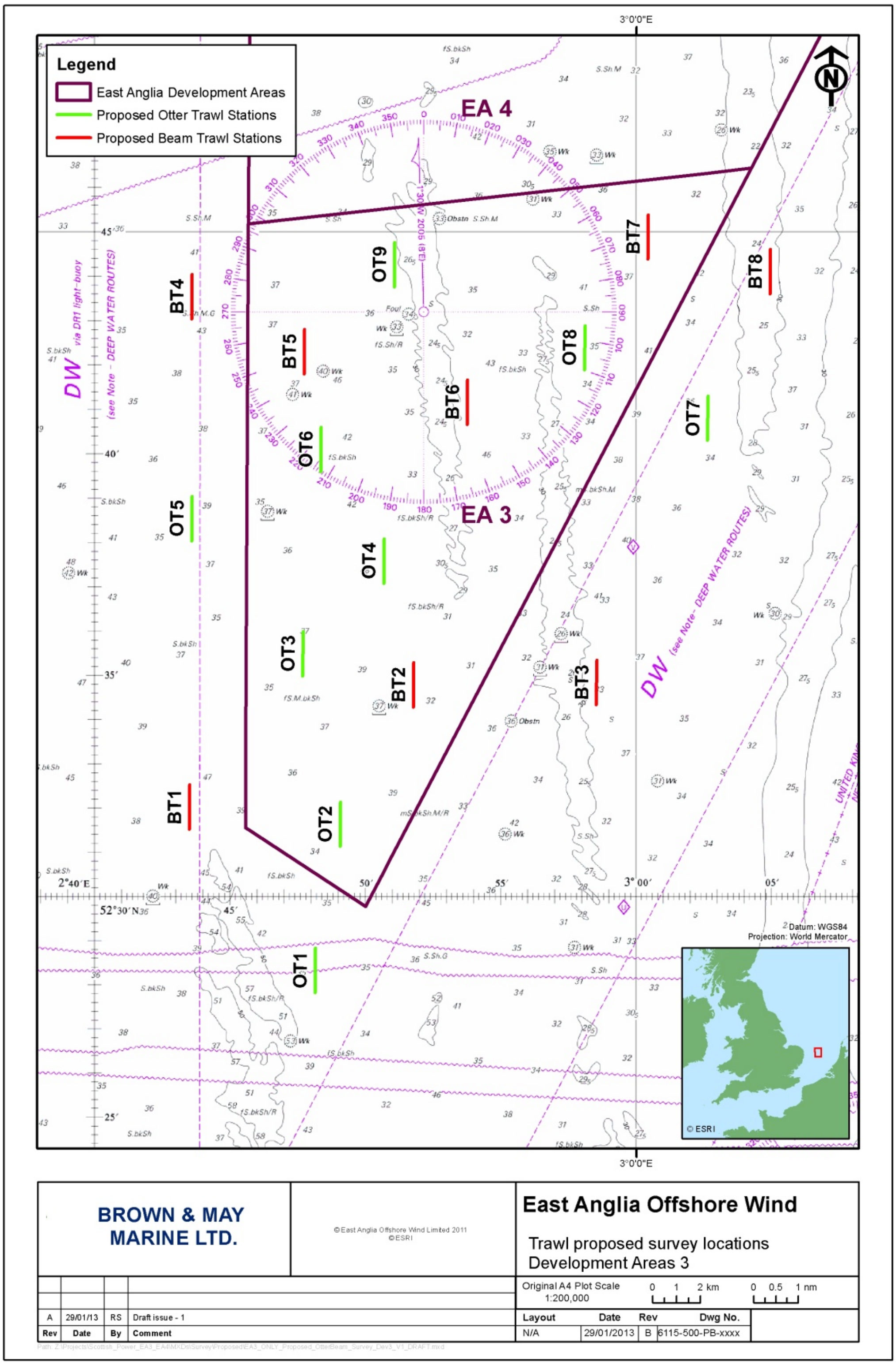


Figure 3.1 Proposed Trawl Locations

4.0 Methodology

4.1 Survey Vessel

The vessel chartered for the survey (Figure 4.1), the "Jubilee Spirit", is a Grimsby-based commercial trawler that was contracted for previous fish and shellfish surveys at East Anglia One. The specifications of the vessel are given below in Table 4.1.

Figure 4.1 Survey Vessel "Jubilee Spirit"

Table 4.1 Survey Vessel Specifications

Survey Vessel Specifications	
Length	21.2m
Beam	6.9m
Draft	2.3m
Main engine	Caterpillar Type 340TA 475 BHP
Gearbox	Hydraulic 6: reduction
Propeller	4 Blade Manganese Bronze Fixed Pitch 1.7m diameter
GPS	2-Furuno GP80
Plotters	Sodena Plotter with Electronic Charts
Sounder	Furuno Daylight Viewing

4.2 Sampling Gear

4.2.1 Commercial Otter Trawl

A commercial otter trawl (Figure 4.2) with a 100mm mesh cod end was used for fish and shellfish sampling; the specifications of which are given in Table 4.2 below.

Figure 4.2 Otter Trawl Used

Table 4.2 Otter Trawl Specifications

Otter Trawl Specifications	
Towing Warp	18mm, 6x19+1
Depth: Payout Ratio	3:1
Trawl Doors	Perfect B 84
Net	100mm mesh cod-end
Ground line length	24.4m
Footrope	Rock-hopper with 18-inch bobbins
Est. Headline height	7.3m
Distance between doors (est.)	51m

4.2.2 Commercial 4m Beam Trawl

A commercial beam trawl (Figure 4.3) with an 80mm mesh cod end was used for fish and shellfish sampling; the specifications of which are given in Table 4.3 below.

Figure 4.3 Beam Trawl Used

Table 4.3 Beam Trawl Specifications

Beam Trawl Specifications	
Beam width	4m
Headline height	60cm
Cod-end liner	80mm (double twinned on belly and cod end)
Ground gear	5cm rubber bobbins and chain mat

4.3 Positioning and Navigation

The position of the vessel was tracked at all times using a Garmin GPSMap 278 with an EGNOS differential connected to an external Garmin GA30 antenna. Trawl start times and positions were taken when the winch stopped paying out the gear. Similarly, trawl end times and positions were taken when hauling of the gear commenced.

4.4 Sampling Operations

The survey was undertaken from the 15th to the 27th May 2013. A summarised log of events is given in Table 4.4 below.

Table 4.4 Summarised Log of Events

Wednesday 15th May 2013
Depart Scarborough at 0600 hrs (BST)
Vessel in transit from Scarborough to Lowestoft
Thursday 16th May 2013
Arrive into Lowestoft at 0230 hrs (BST)
Load beam trawl and survey gear aboard
Friday 17th May 2013
Depart Lowestoft at 0200 hrs (BST)
Beam Trawls: BT04
Overnight at sea
Saturday 18th May 2013
Beam Trawls: BT01, BT02, BT03, BT06, BT05
Overnight at sea
Monday 20th May 2013
Beam Trawls: BT08, BT07
Overnight at sea
Tuesday 21st May 2013
Arrive into Lowestoft at 0720 hrs (BST)
Land beam trawl samples, unload beam trawl
Depart Lowestoft at 2020 hrs (BST) to commence otter trawl survey
Wednesday 22nd May 2013
Otter Trawls: OT01, OT02, OT03, OT04, OT05, OT06, OT09
Overnight at sea

Thursday 23rd May 2013
Otter Trawls: OT07, OT08
Overnight at sea
Sunday 26th May 2013
Arrive into Lowestoft at 1030 hrs (BST)
Land otter trawl samples
Vessel departs Lowestoft at 1130 hrs (BST)
Monday 27th May 2013
Vessel in transit from Lowestoft to Grimsby
Vessel arrives into Grimsby at 0930 hrs (BST)
Survey vessel demobilised

4.5 Otter Trawl Sampling

The whole catch from each otter trawl was retained. The samples were then boxed, labelled, photographed, iced and stored at +2°C before transportation to Cefas (Lowestoft) for analysis at the end of the survey, in line with the agreed scope of works.

The start and end times, co-ordinates and the duration of each otter trawl are given in Table 4.5 (control and East Anglia THREE tows highlighted green and red respectively). The vessel tracks whilst towing the otter trawl are illustrated in Figure 4.4 overleaf.

Table 4.5 Start and End Times, Co-ordinates and Duration of each Otter Trawl

Station	Date	Start				End				Duration (mm:ss)
		Time (GMT)	UTM31N		Depth (m)	Time (GMT)	UTM31N		Depth (m)	
			Easting	Northing			Easting	Northing		
OT01	22/05/2013	07:14:07	486,263.4	5,813,235.2	39.6	07:34:13	486,120.9	5,814,384.1	40.7	20:06
OT02		09:36:01	487,703.2	5,819,326.4	44.2	09:56:03	487,609.9	5,820,714.7	42.2	20:02
OT03		10:57:26	486,135.0	5,827,048.2	44.0	11:17:30	486,146.4	5,828,806.0	45.3	20:04
OT04		12:05:35	489,508.5	5,830,236.2	46.9	12:26:02	489,865.0	5,832,156.9	44.9	20:27
OT05		13:47:39	481,411.1	5,832,537.2	43.6	14:07:40	481,788.0	5,834,270.4	37.6	20:01
OT06		15:01:27	486,790.3	5,834,321.7	42.7	15:21:31	486,888.5	5,835,717.1	44.5	20:04
OT07	23/05/2013	07:27:12	502,533.6	5,836,319.9	36.5	07:47:18	502,830.3	5,837,096.6	36.5	20:06
OT08		09:24:06	497,742.2	5,838,635.2	39.4	09:44:08	497,667.5	5,839,694.3	37.8	20:02
OT09	22/05/2013	16:26:58	489,761.8	5,842,044.5	37.2	16:47:05	489,980.3	5,843,104.4	33.4	20:07

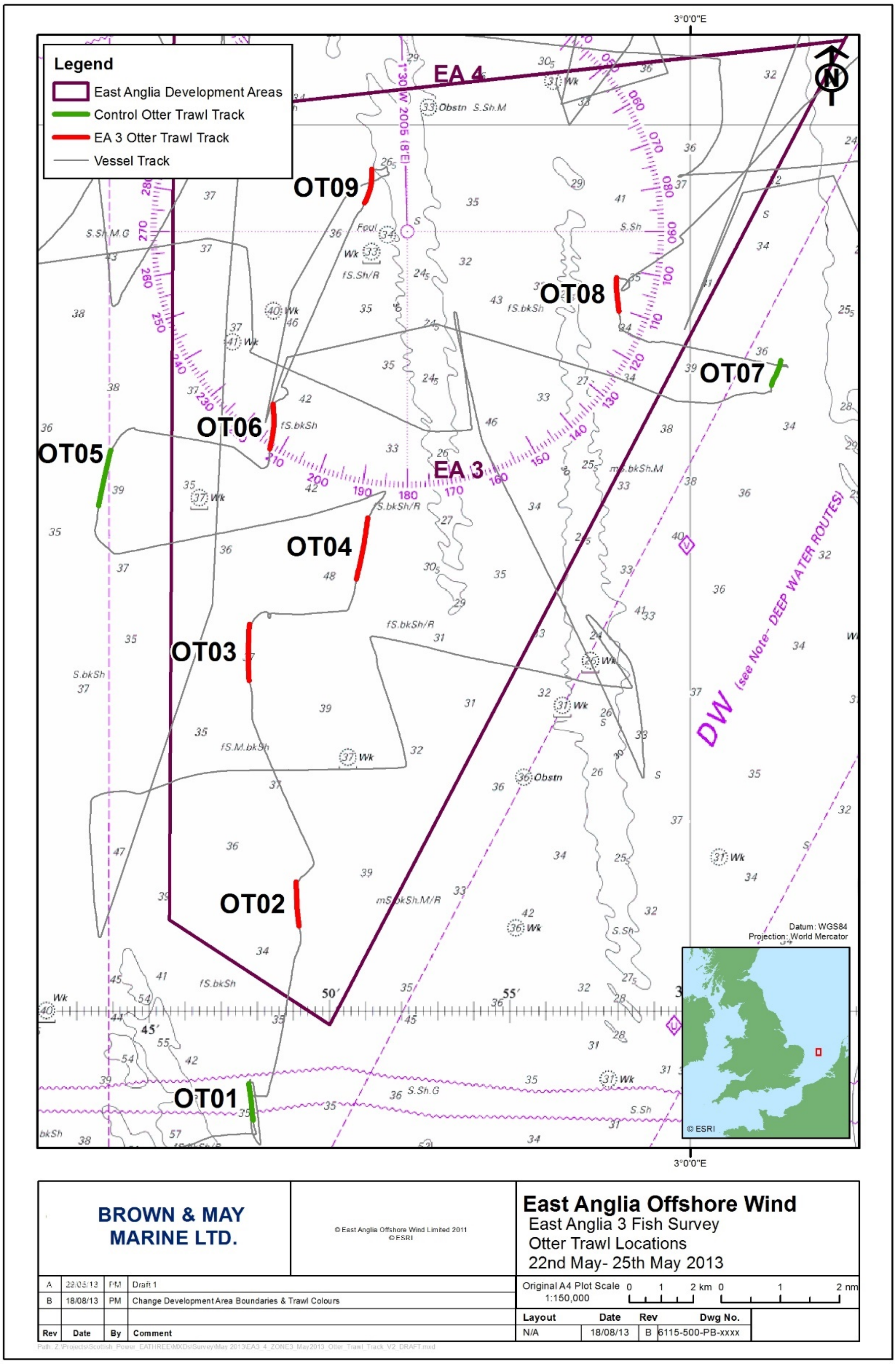


Figure 4.4 Vessel Tracks whilst Towing the Otter Trawl

4.6 Beam Trawl Sampling

The whole catch from each beam trawl was retained. The samples were then boxed, labelled, photographed, iced and stored at +2°C before transportation to Cefas (Lowestoft) for analysis at the end of the survey, in line with the agreed scope of works.

The start and end times, co-ordinates and the duration of each beam trawl are given in Table 4.6 (control and East Anglia THREE tows highlighted green and red respectively). The vessel tracks whilst towing the beam trawl are illustrated in Figure 4.5.

Table 4.6 Start and End Times, Co-ordinates and Duration of each Beam Trawl

Station	Date	Start				End				Duration (mm:ss)
		Time (GMT)	UTM31N		Depth (m)	Time (GMT)	UTM31N		Depth (m)	
			Easting	Northing			Easting	Northing		
BT01	18/05/2013	07:54:42	481,349.0	5,819,551.7	48.6	08:14:43	481,129.0	5,822,428.9	48.0	20:01
BT02		09:27:35	490,971.4	5,824,880.6	37.2	09:47:34	490,191.4	5,827,394.3	44.7	19:59
BT03		11:38:36	498,297.9	5,826,798.9	37.6	11:58:36	498,499.9	5,824,755.6	38.3	20:00
BT04	17/05/2013	11:24:27	481,406.4	5,842,896.5	43.8	11:44:27	481,735.1	5,839,951.8	44.2	20:00
BT05	18/05/2013	15:42:45	486,242.4	5,838,087.9	42.5	16:02:45	486,152.6	5,839,934.7	43.8	20:00
BT06		14:00:16	492,727.3	5,838,118.9	34.5	14:20:17	493,013.5	5,835,932.0	38.0	20:01
BT07	20/05/2013	08:55:20	500,298.7	5,843,254.3	39.8	09:15:20	500,976.3	5,845,485.2	38.1	20:00
BT08		07:42:20	505,798.6	5,840,595.2	34.3	08:02:20	505,689.5	5,842,827.3	31.9	20:00

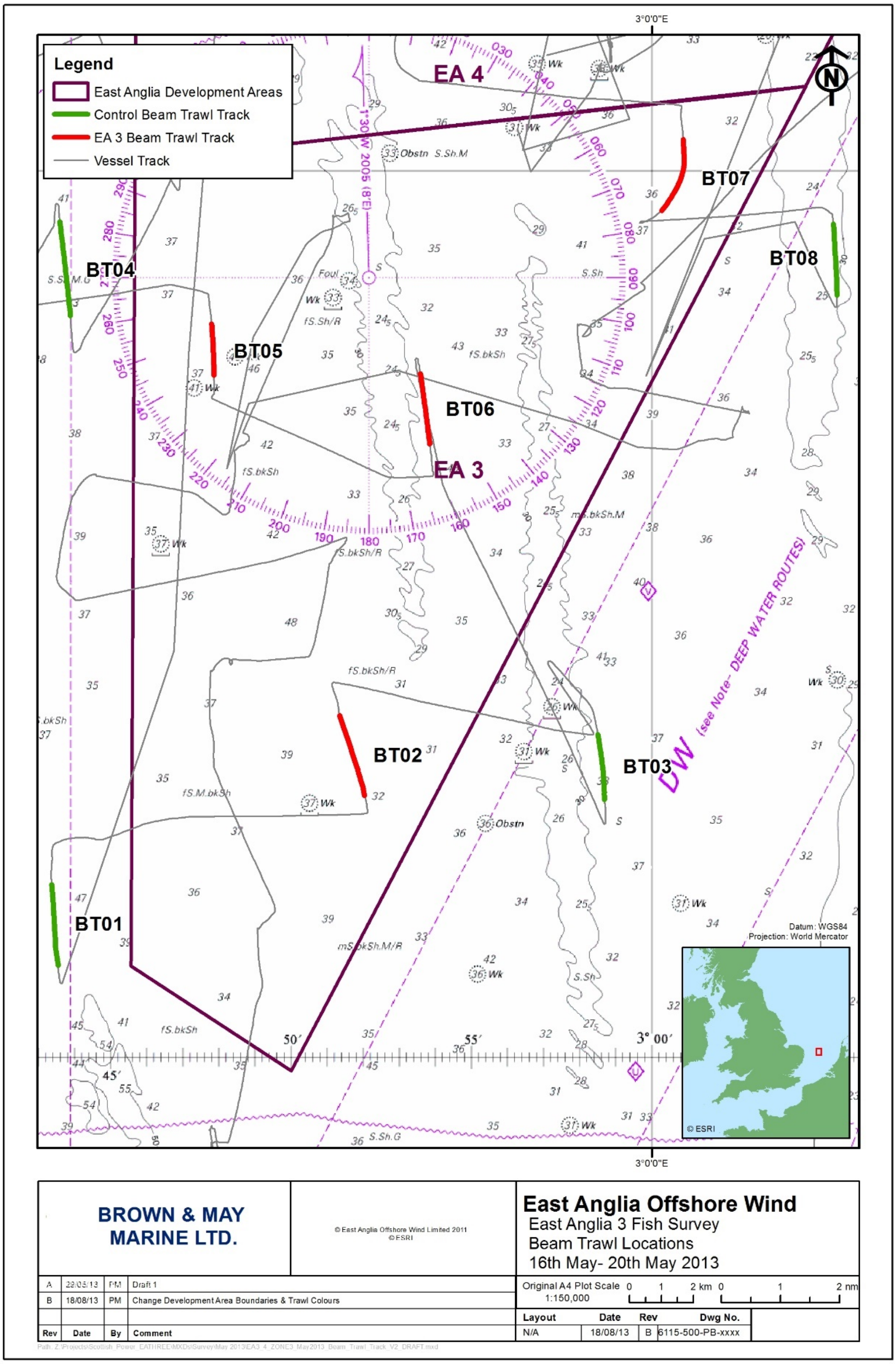


Figure 4.5 Vessel Tracks whilst Towing the Beam Trawl

4.7 Scientific 2-metre Beam Trawl Sampling

The start and end times, co-ordinates and the duration of each 2-metre scientific beam trawl are given in **Table 4.7** (export cable and East Anglia THREE tows highlighted blue and red respectively). The start and end points of each 2-metre scientific beam trawl tow are illustrated in Figure 4.6 and Figure 4.7 for the export cable and East Anglia THREE respectively.

Table 4.7 Start and End Times, Co-ordinates and Duration of each 2-metre Scientific Beam Trawl

Station	Date	Start				End				Duration (hh:mm)
		Time (GMT)	UTM31N		Depth (m)	Time (GMT)	UTM31N		Depth (m)	
			Easting	Northing			Easting	Northing		
T1	06/05/2013	19:14	447327	5794118	45.3	19:28	447636	5794499	49.9	00:14
T2	03/05/2013	11:31	466510	5803073	44.5	11:49	466403	5802553	42.7	00:18
T4	06/05/2013	11:08	482069	5801344	45.7	11:24	481969	5800803	44.9	00:16
T5	05/05/2013	21:51	482930	5828944	41.5	22:02	482858	5828502	42.5	00:11
T6	06/05/2013	09:07	486956	5812571	40.2	09:15	487020	5813084	38.5	00:08
T7	08/05/2013	00:13	421359	5778923	29.3	00:24	420957	5778623	31.8	00:11
T11	01/05/2013	22:48	494424	5833705	37.4	23:04	494649	5834151	37.3	00:16
T12		08:08	497024	5840979	33.4	08:14	497140	5841459	38.3	00:06
T13	06/05/2013	07:41	488145	5822430	43.3	07:53	488234	5822880	44.3	00:12

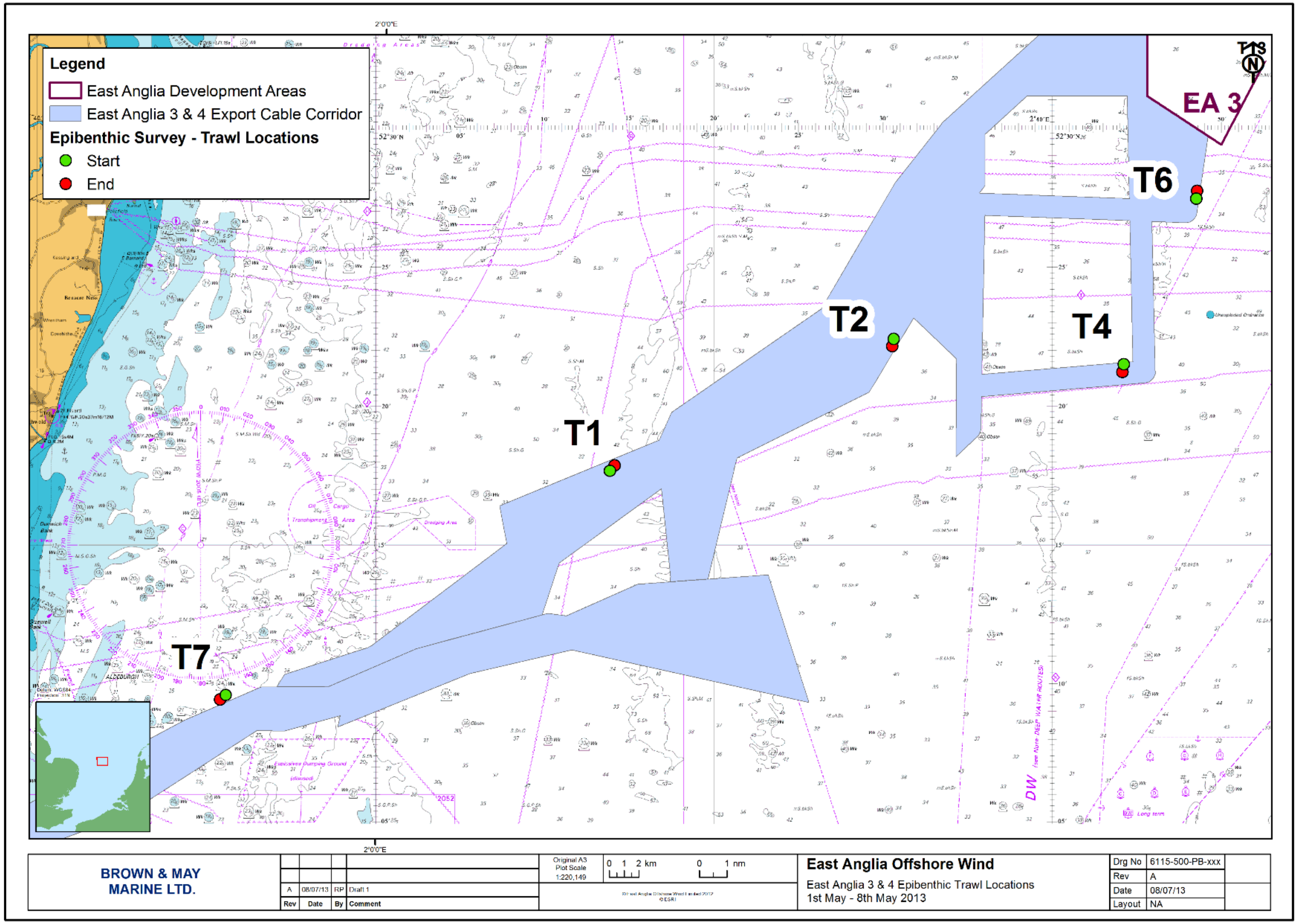


Figure 4.6 Start and End Points of each 2-metre Scientific Beam Trawl Tow along the Export Cable

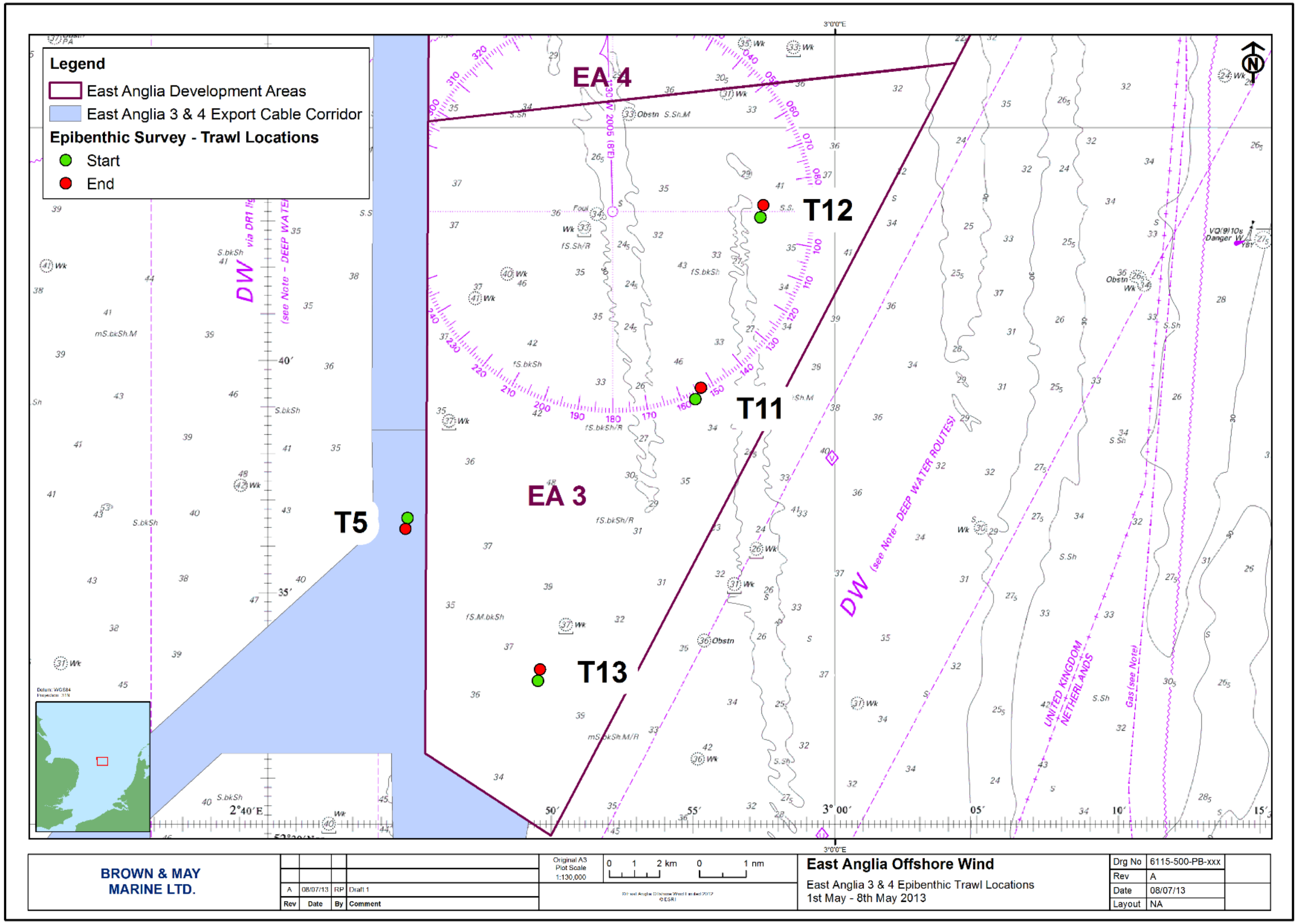


Figure 4.7 Start and End Points of each 2-metre Scientific Beam Trawl Tow within East Anglia THREE

5.0 Otter Trawl Results

5.1 Catch Rates and Species Distribution

The total number of individuals caught and the catch rate (number of individuals caught per hour) for fish and shellfish species by sampling area (control and East Anglia THREE) are given in Table 5.1 and are illustrated in Figure 5.1. The catch rates by sampling station are illustrated in Figure 5.2.

Spatial distribution plots for the most abundant species are given in Figure 5.3 to Figure 5.5, showing the percentage distribution by catch rate of *M. merlangus*, *P. platessa* and *L. limanda*. The circle size corresponds to the catch rate i.e. larger circles indicate greater catch rates.

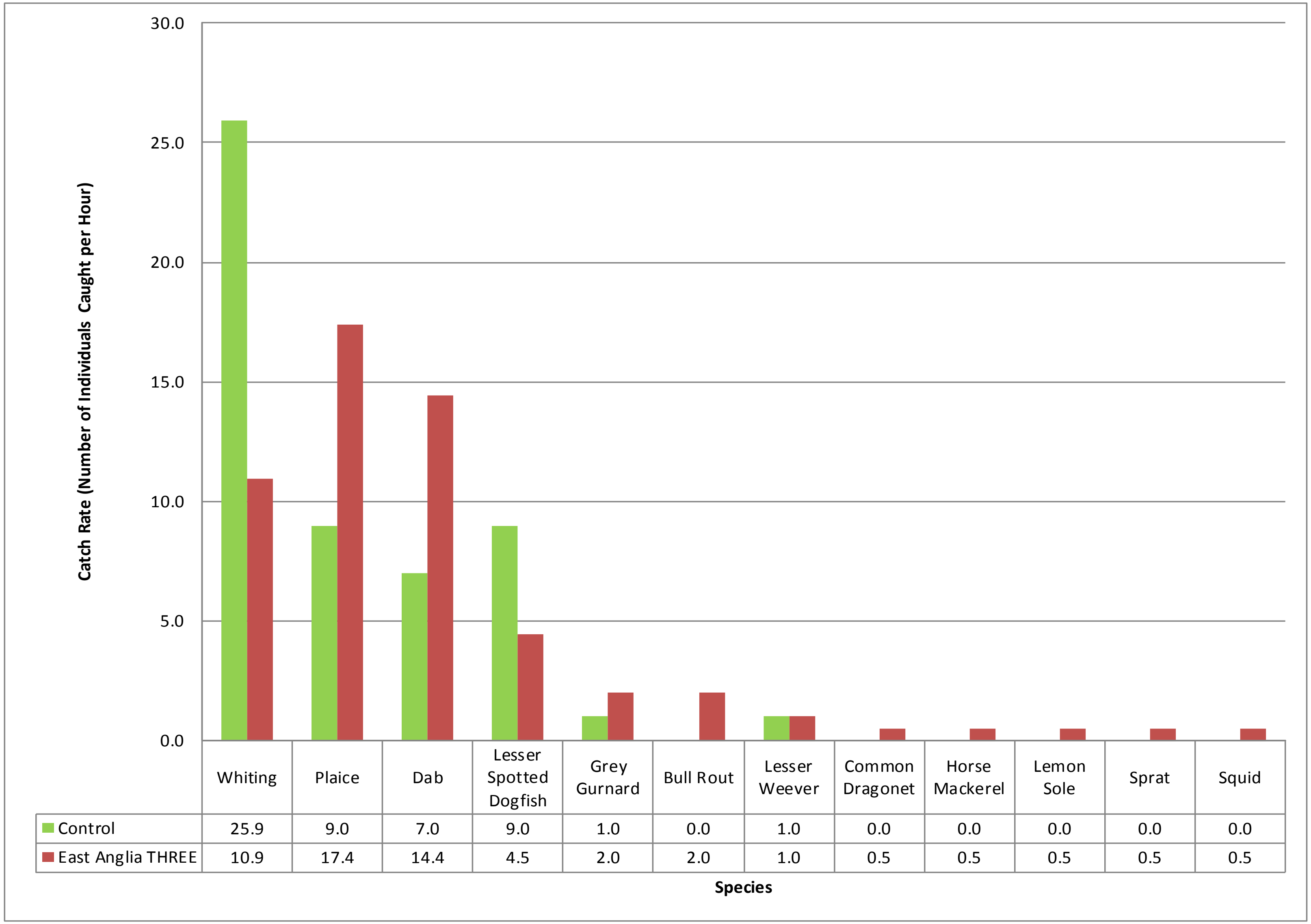
A total of 12 species were caught; six at the control stations and 12 within East Anglia THREE. Overall, *M. merlangus* was the most abundant species caught, followed by *P. platessa, L. limanda* and then *S. canicula*. All other species were caught in relatively low numbers.

The highest catch rate for all species combined was recorded at station OT08 (95.8/hr) within East Anglia THREE, with *P.* platessa and *L. limanda* accounting for 75.0% of the catch.

The total catch rate was approximately equal in both sampling areas.

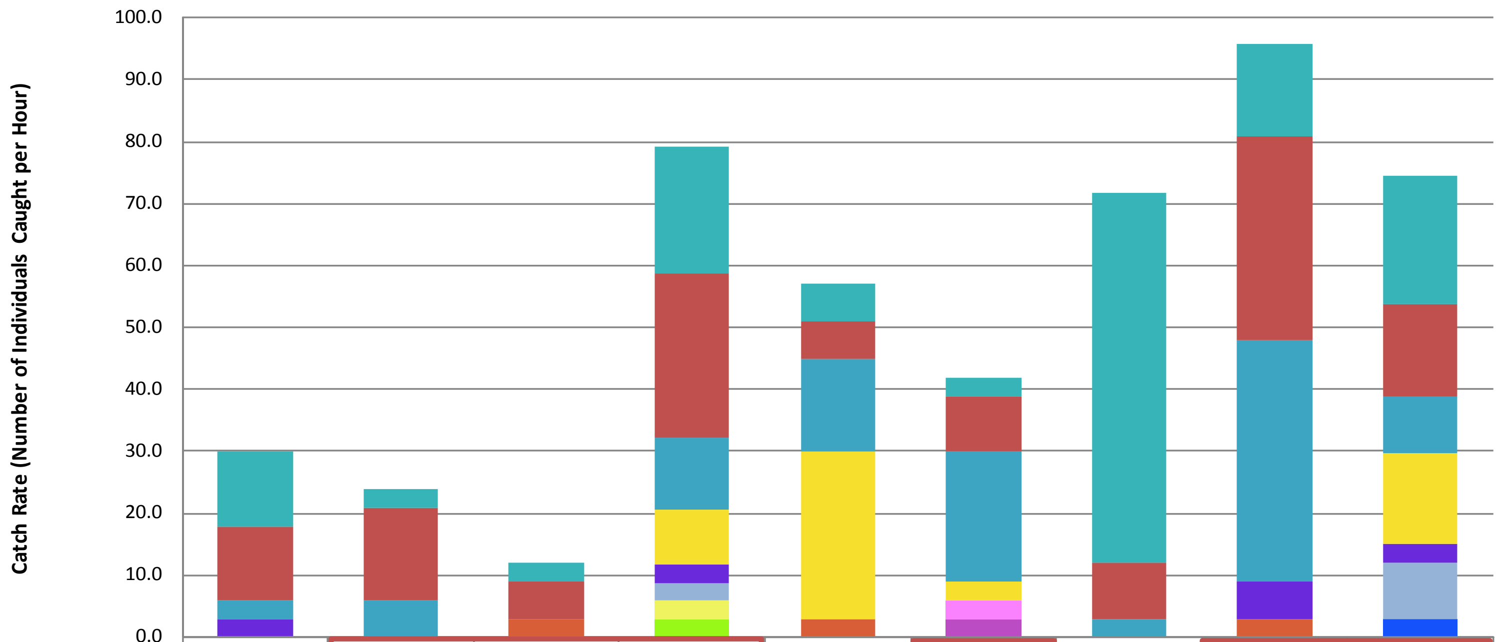
Table 5.1 Total Numbers of Individuals Caught and Catch Rate for Fish Species by Sampling Area

Species		Number of Individuals Caught			Catch Rate (Number of Individuals Caught per Hour)	
Common Name	Scientific Name	Control	East Anglia THREE	Total	Control	East Anglia THREE
Whiting	*Merlangius merlangus*	26	22	48	25.9	10.9
Plaice	*Pleuronectes platessa*	9	35	44	9.0	17.4
Dab	*Limanda limanda*	7	29	36	7.0	14.4
Lesser Spotted Dogfish	*Scyliorhinus canicula*	9	9	18	9.0	4.5
Grey Gurnard	*Eutrigla gurnardus*	1	4	5	1.0	2.0
Bullrout	*Myoxocephalus scorpius*	0	4	4	0.0	2.0
Lesser Weever	*Echiichthys vipera*	1	2	3	1.0	1.0
Common Dragonet	*Callionymus lyra*	0	1	1	0.0	0.5
Horse Mackerel	*Trachurus trachurus*	0	1	1	0.0	0.5
Lemon Sole	*Microstomus kitt*	0	1	1	0.0	0.5
Sprat	*Sprattus sprattus*	0	1	1	0.0	0.5
Squid	*Alloteuthis sp.*	0	1	1	0.0	0.5
Total No. of Individuals		53	110			
Total No. of Species		6	12			
Catch Rate (No. of Individuals Caught per Hour)		52.8	54.7			



	Whiting	Plaice	Dab	Lesser Spotted Dogfish	Grey Gurnard	Bull Rout	Lesser Weever	Common Dragonet	Horse Mackerel	Lemon Sole	Sprat	Squid
Control	25.9	9.0	7.0	9.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
East Anglia THREE	10.9	17.4	14.4	4.5	2.0	2.0	1.0	0.5	0.5	0.5	0.5	0.5

Figure 5.1 Catch Rate by Species and Sampling Area



	OT01	OT02	OT03	OT04	OT05	OT06	OT07	OT08	OT09
Whiting	11.9	3.0	3.0	20.5	6.0	3.0	59.7	15.0	20.9
Plaice	11.9	15.0	6.0	26.4	6.0	9.0	9.0	32.9	14.9
Dab	3.0	6.0	0.0	11.7	15.0	20.9	3.0	38.9	8.9
Lesser Spotted Dogfish	0.0	0.0	0.0	8.8	27.0	3.0	0.0	0.0	14.9
Grey Gurnard	3.0	0.0	0.0	2.9	0.0	0.0	0.0	6.0	3.0
Bull Rout	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	8.9
Lesser Weever	0.0	0.0	3.0	0.0	3.0	0.0	0.0	3.0	0.0
Common Dragonet	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0
Horse Mackerel	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0
Lemon Sole	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0
Sprat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
Squid	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0

Station

Figure 5.2 Catch Rate by Species and Station (red boxes denote stations within East Anglia THREE)

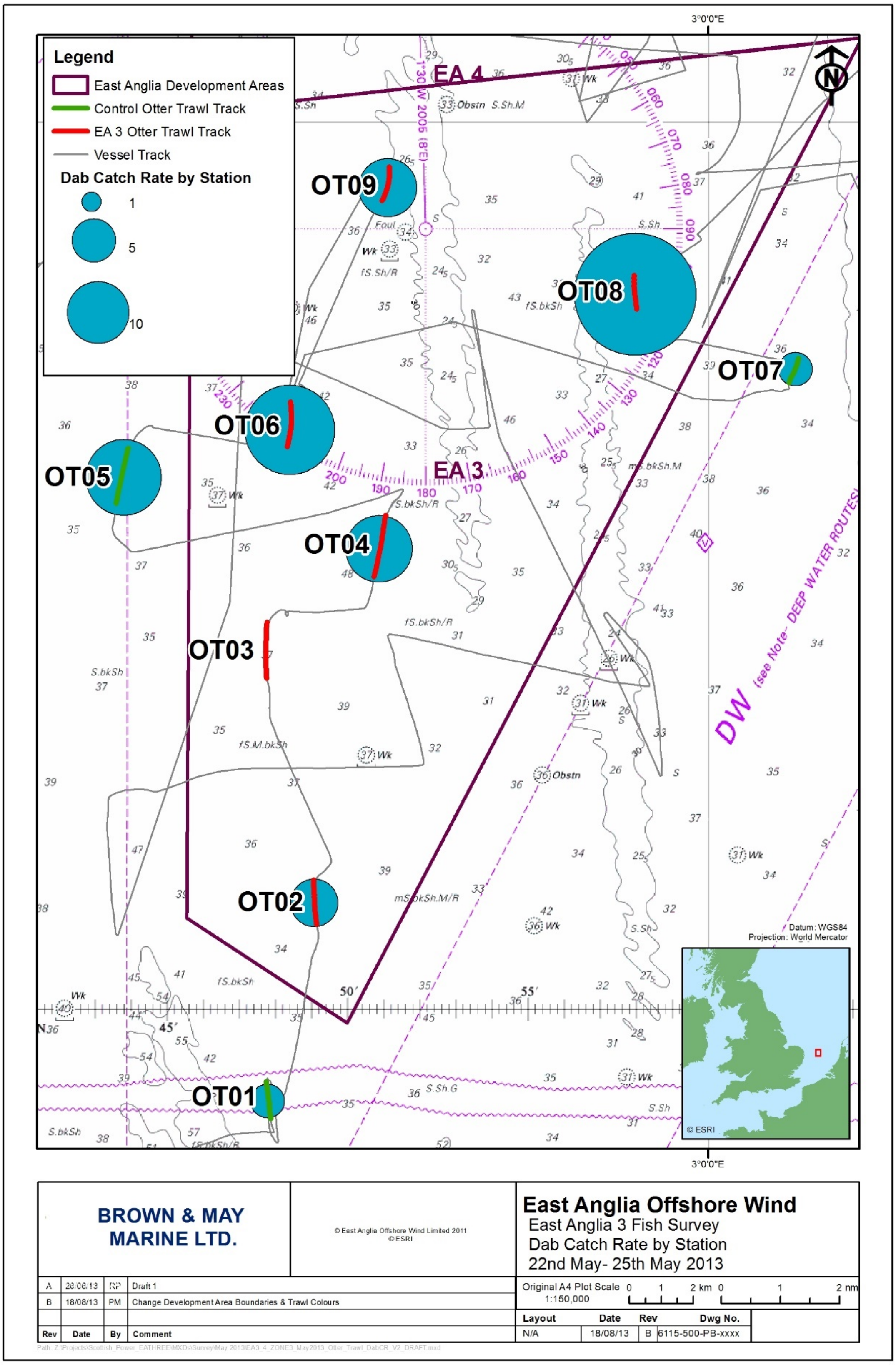


Figure 5.3 Spatial Distribution of Dab (*L. limanda*) in the Area of East Anglia THREE

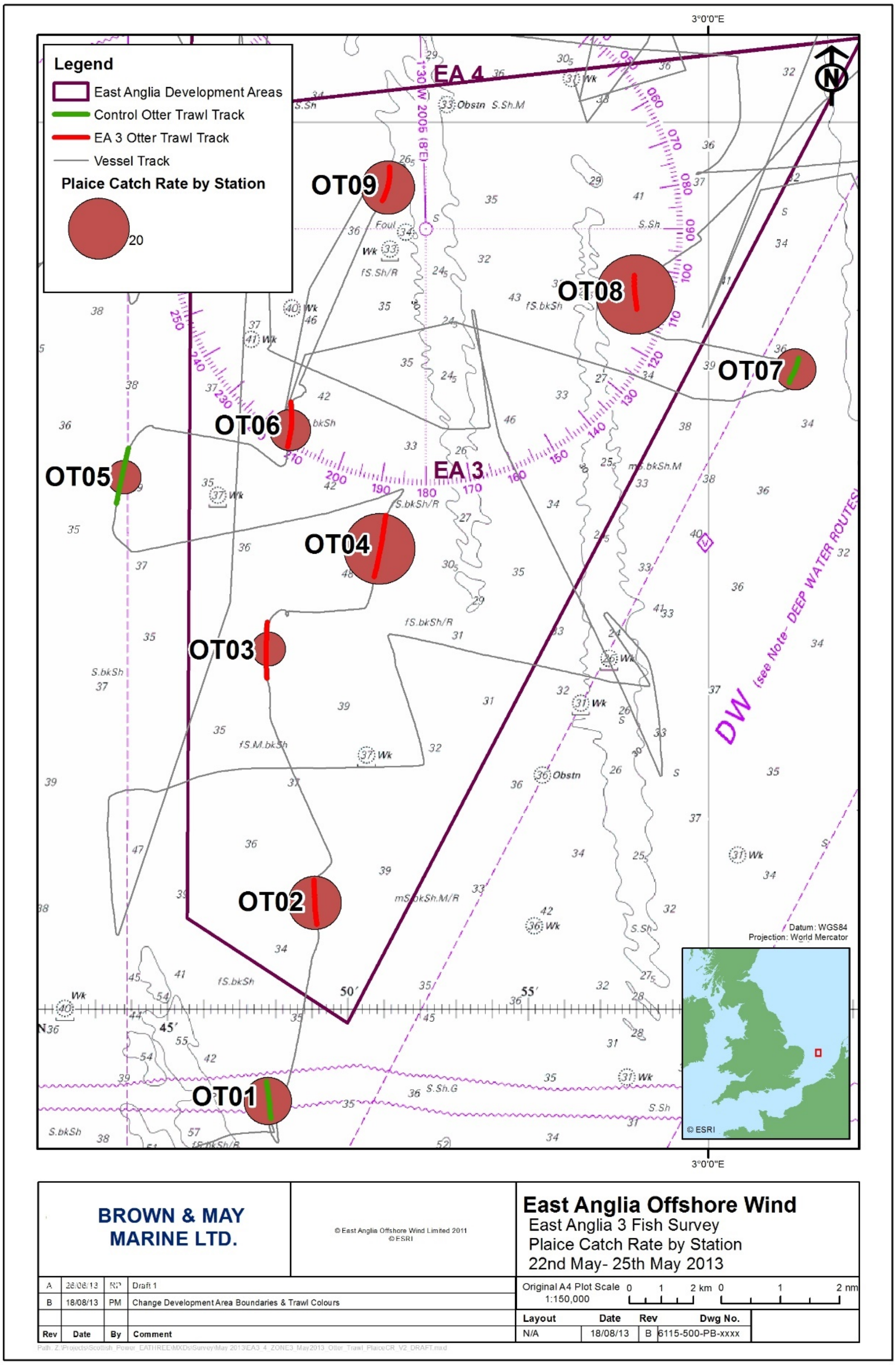


Figure 5.4 Spatial Distribution of Plaice (*P. platessa*) in the Area of East Anglia THREE

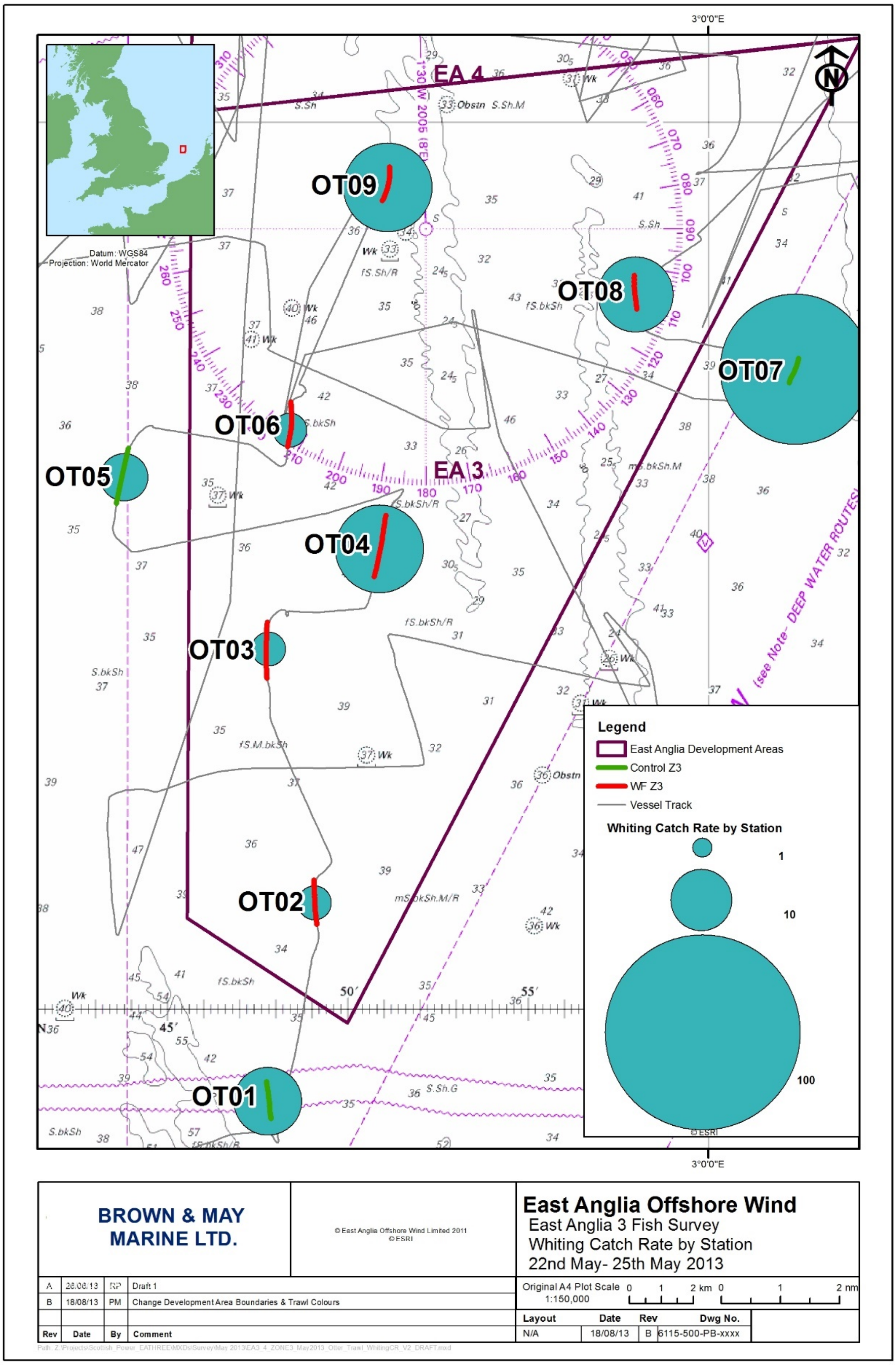


Figure 5.5 Spatial Distribution of Whiting (*M. merlangus*) in the Area of East Anglia THREE

5.2 Length Distributions

The length distributions of the three most abundant species caught during the survey, expressed as the catch rate (number of individuals caught per hour) by length (cm) and by sampling area (control and East Anglia THREE), are shown in Figure 5.6 to Figure 5.6.

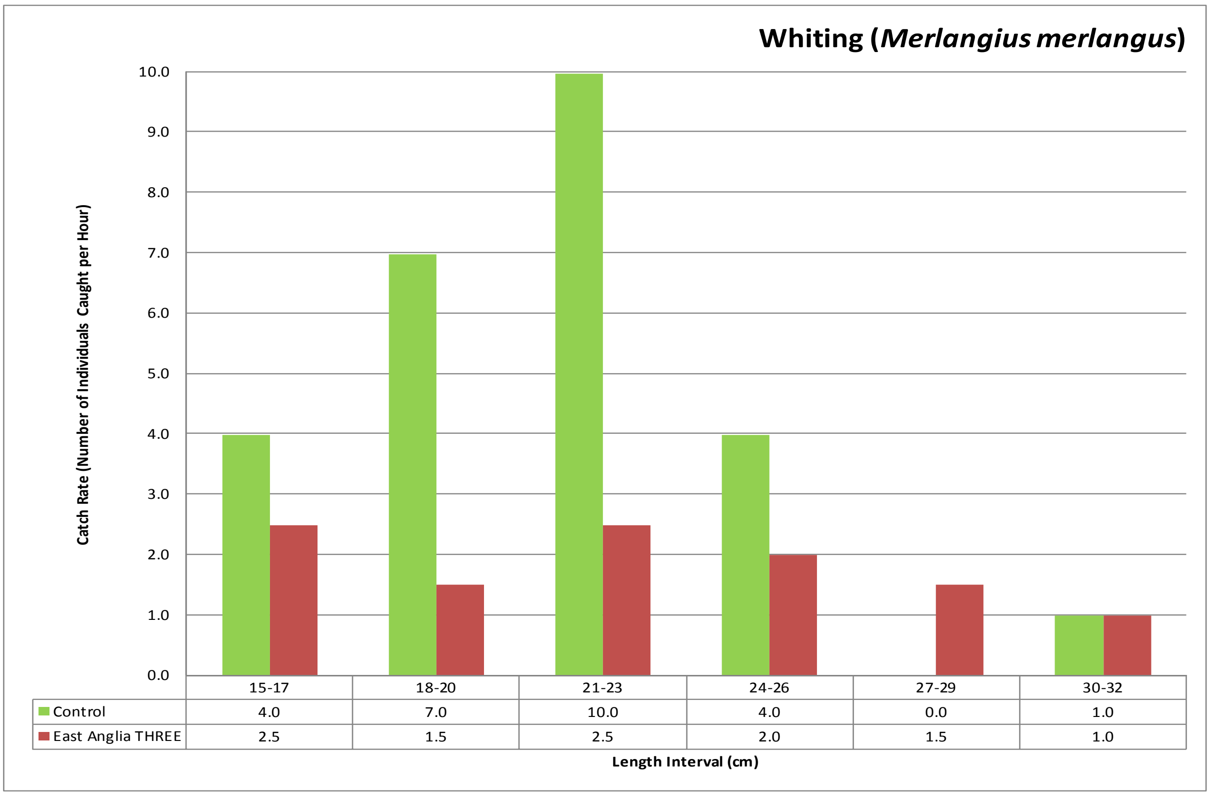
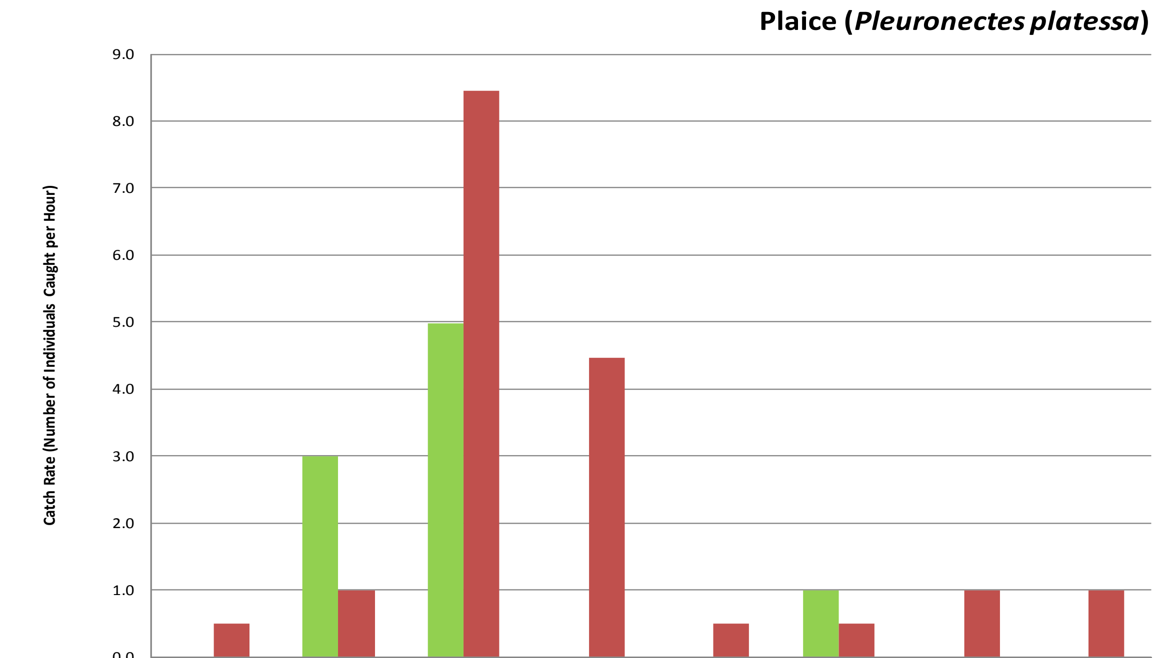
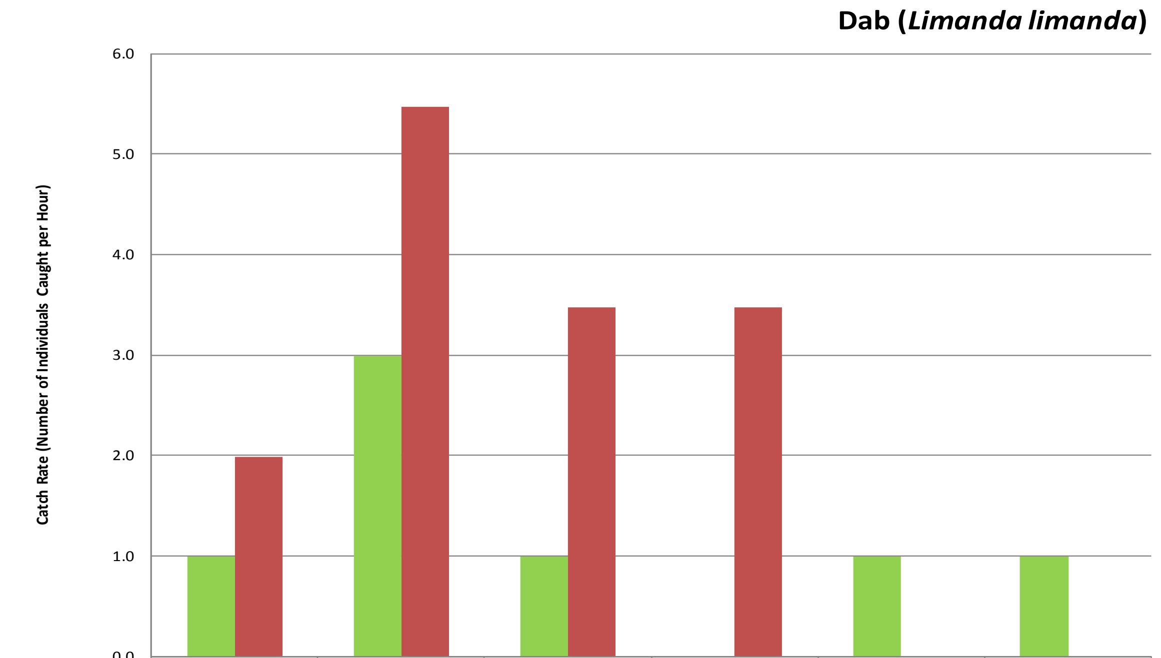


Figure 5.6 Whiting (*M. merlangus*) Length Distribution by Sampling Area



	16-18	19-21	22-24	25-27	28-30	31-33	34-36	37-39
Control	0.0	3.0	5.0	0.0	0.0	1.0	0.0	0.0
East Anglia THREE	0.5	1.0	8.4	4.5	0.5	0.5	1.0	1.0

Figure 5.7 Plaice (*P. platessa*) Length Distribution by Sampling Area



	12-14	15-17	18-20	21-23	24-26	27-29
Control	1.0	3.0	1.0	0.0	1.0	1.0
East Anglia THREE	2.0	5.5	3.5	3.5	0.0	0.0

Figure 5.8 Dab (*L. limanda*) Length Distribution by Sampling Area

5.3 Minimum Landing Sizes

Minimum landing sizes (MLS) for fish and shellfish species are set by the EC under Regulation No. 850/98 (Annex XII).

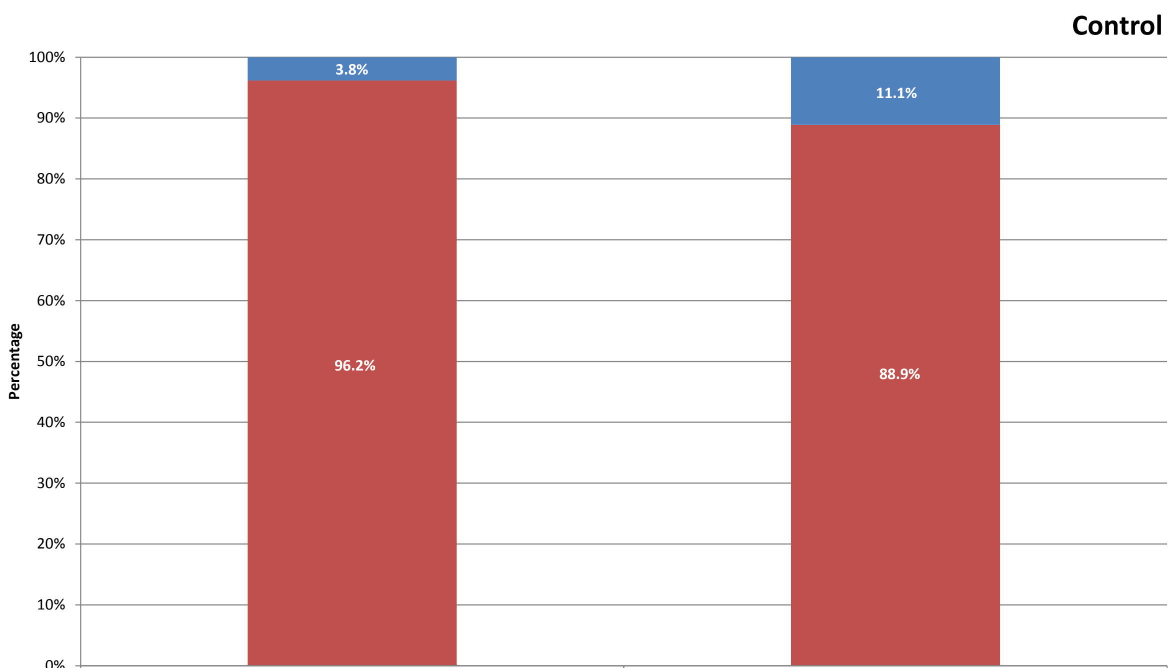
Table 5.2 shows the three species of fish caught for which a MLS has been set and denotes their presence or absence by sampling area (control and East Anglia THREE).

Table 5.2 MLS Set by EC

Species		EC MLS (cm)	Presence	
Common Name	Scientific Name		Control	East Anglia THREE
Horse Mackerel	*Trachurus trachurus*	15	–	✓
Plaice	*Pleuronectes platessa*	27	✓	✓
Whiting	*Merlangius merlangus*	27	✓	✓

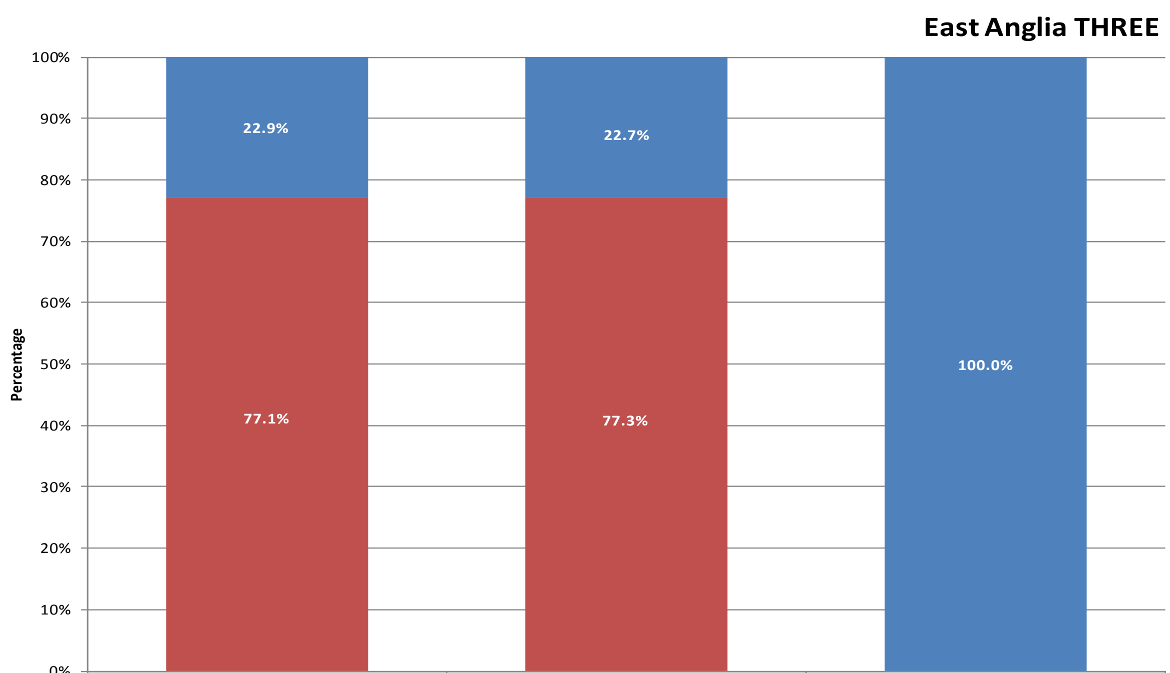
The percentage of individuals caught above and below their set MLS by species is shown in Figure 5.7 and Figure 5.8 for control and East Anglia THREE stations respectively.

Most of the *P. platessa* (control, 88.9%, East Anglia THREE, 77.1%) and *M. merlangus* (96.2% and 77.3%) caught in both sampling areas were below the MLS. One *T. trachurus* was caught within East Anglia THREE and was above the MLS.



	Whiting	Plaice
Above	1	1
Below	25	8

Figure 5.9 Percentage of the Catch Above and Below the MLS by Species at the Control Stations



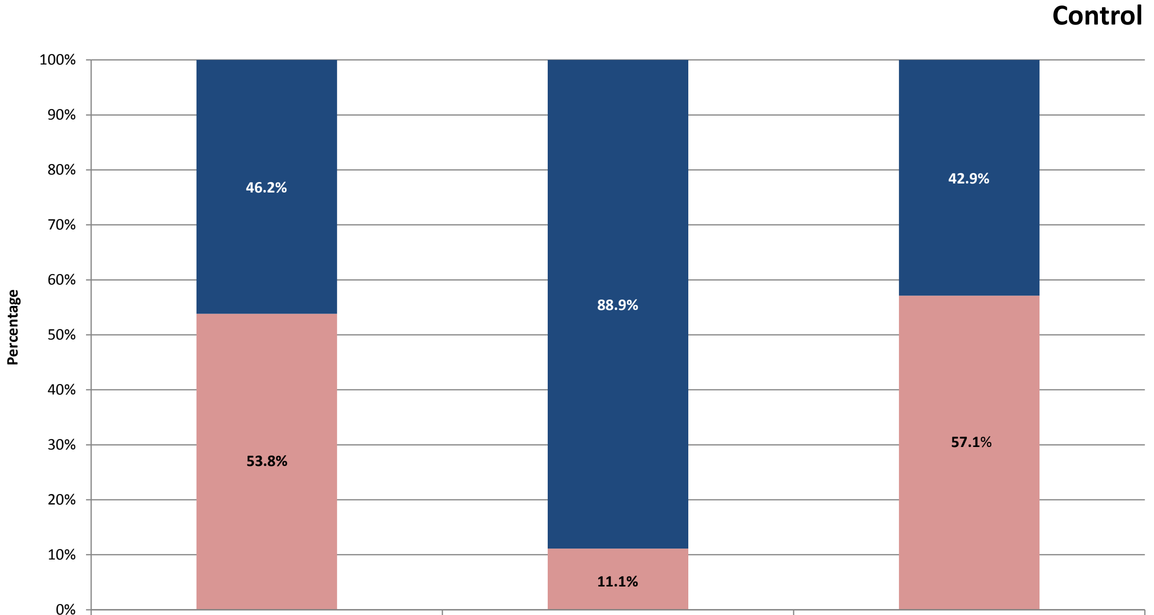
	Plaice	Whiting	Horse Mackerel
Above	8	5	1
Below	27	17	0

Figure 5.10 Percentage of the Catch Above and Below the MLS by Species within East Anglia THREE

5.4 Sex Ratios

The sex ratios of the three most abundant species caught during the survey are shown in Figure 5.9 and Figure 5.10 for control and East Anglia THREE stations respectively.

At the control stations the sex ratio of the *M. merlangus* and *L. limanda* caught was approximately equal, whereas most of the *P. platessa* found in this sampling area were male (88.9%). The majority of the *P. platessa* (80.0%) and *L. limanda* (93.1%) caught within East Anglia THREE were male, whereas the highest proportion of the *M. merlangus* caught were female (63.6%).



	Whiting	Plaice	Dab
Male	12	8	3
Female	14	1	4

Figure 5.11 Sex Ratio by Species at the Control Stations

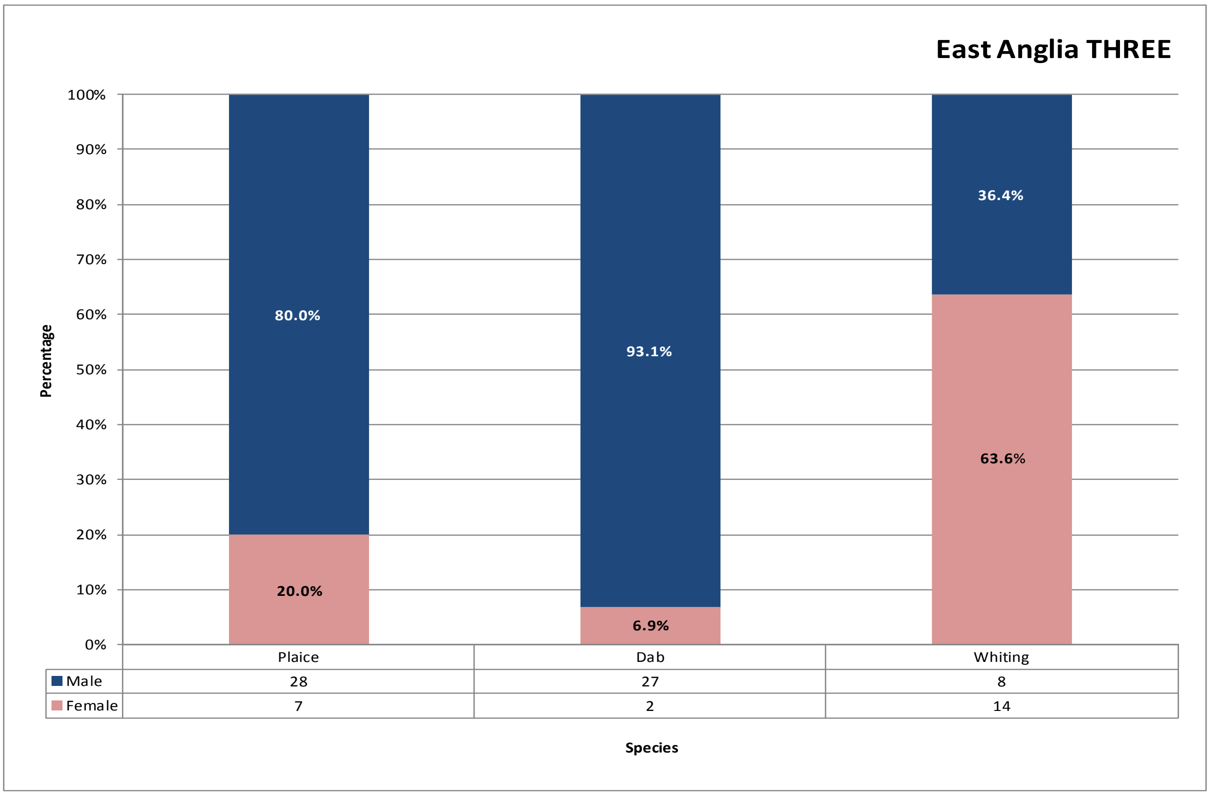


Figure 5.12 Sex Ratio by Species within East Anglia THREE

5.5 Spawning Condition

The spawning condition, sex and length range (nearest cm below) for the three most abundant species caught during the survey are given below in Table 5.3 to Table 5.5.

The highest proportion of the *M. merlangus* caught at the control stations and within East Anglia THREE were running females (control 30.8% and East Anglia THREE 54.5%) and maturing males (23.1% and 36.4%). At the control stations the highest proportion of the *P. platessa* caught were immature (44.4%) and running (33.3%) males, whereas within East Anglia THREE most of which were maturing males (65.7%). The highest proportion of the *L. limanda* caught at the control stations were immature males (42.9%) whereas within East Anglia THREE most individuals were identified as maturing males (65.5%).

Table 5.3 Whiting (*M. merlangus*) Spawning Condition

Whiting							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia THREE	Total		Min.	Max.
Female	Immature	3	1	4	8.3%	15	24
	Maturing	3	1	4	8.3%	20	23
	Running	8	12	20	41.7%	18	31
Male	Immature	3	0	3	6.3%	17	18
	Maturing	6	8	14	29.2%	16	26
	Spent	3	0	3	6.3%	19	25

Table 5.4 Plaice (*P. platessa*) Spawning Condition

Plaice							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia THREE	Total		Min.	Max.
Female	Immature	0	1	1	2.3%	24	24
	Maturing	0	1	1	2.3%	25	25
	Running	1	2	3	6.8%	22	33
	Spent	0	3	3	6.8%	34	38
Male	Immature	4	0	4	9.1%	20	22
	Maturing	0	23	23	52.3%	16	28
	Running	3	1	4	9.1%	21	24
	Spent	1	4	5	11.4%	23	39

Table 5.5 Dab (*L. limanda*) Spawning Condition

Dab							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia THREE	Total		Min.	Max.
Female	Immature	1	0	1	2.8%	18	18
	Maturing	1	1	2	5.6%	16	21
	Running	1	0	1	2.8%	26	26
	Spent	1	1	2	5.6%	19	27
Male	Immature	3	7	10	27.8%	12	16
	Maturing	0	19	19	52.8%	15	23
	Running	0	1	1	2.8%	20	20

6.0 Beam Trawl Results

6.1 Catch Rates and Species Distribution

The total number of individuals caught and the catch rate (number of individuals caught per hour) for fish and shellfish species by sampling area (control and East Anglia THREE) are given in Table 6.1 below and are illustrated in Figure 6.1. The catch rates by sampling station are shown in Figure 6.2.

Spatial distribution plots for *P. platessa* and *L. limanda* are given in Figure 6.3 and Figure 6.4. Spatial plots show the percentage distribution by catch rate of *P. platessa* and *L. limanda*. The circle size corresponds to the catch rate i.e. larger circles indicate greater catch rates.

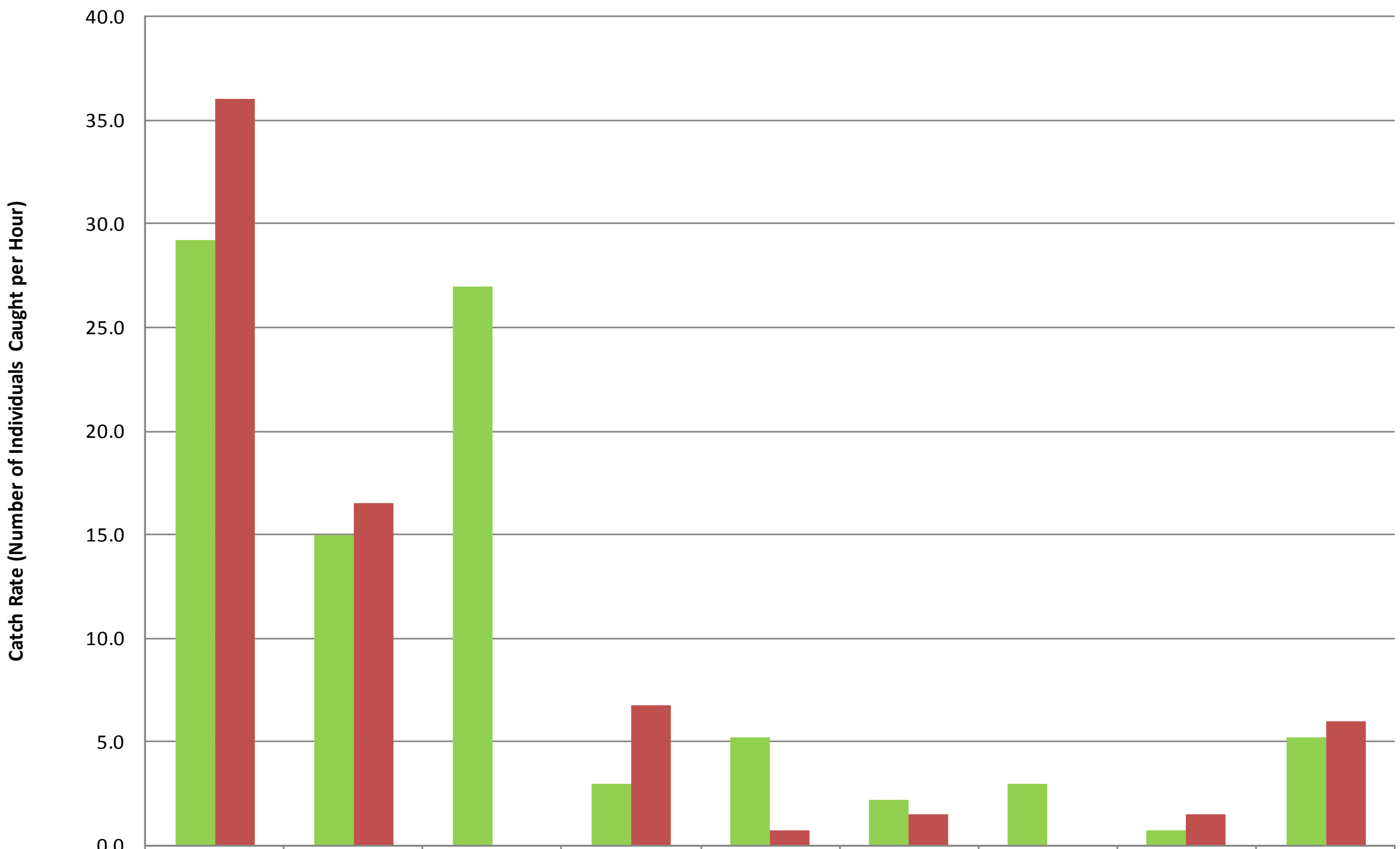
A total of 18 species of fish and shellfish were caught, 13 of which were found at the control stations and 13 within East Anglia THREE. Overall, *P. platessa* was the most abundant species caught, followed by *L. limanda*.

The station with the greatest total catch rate was control station BT01 (188.8/hr); this can be attributed to the high numbers of *B. undatum* caught, representing 57.1% of the catch. *P. platessa* represented the highest proportion of the catch at half of the sampling stations.

Overall, the total catch rate was higher at the control stations (90.7/hr) than within East Anglia THREE (69.0/hr).

Table 6.1 Number of Individuals Caught and the Catch Rate for Fish and Shellfish Species by Sampling Area

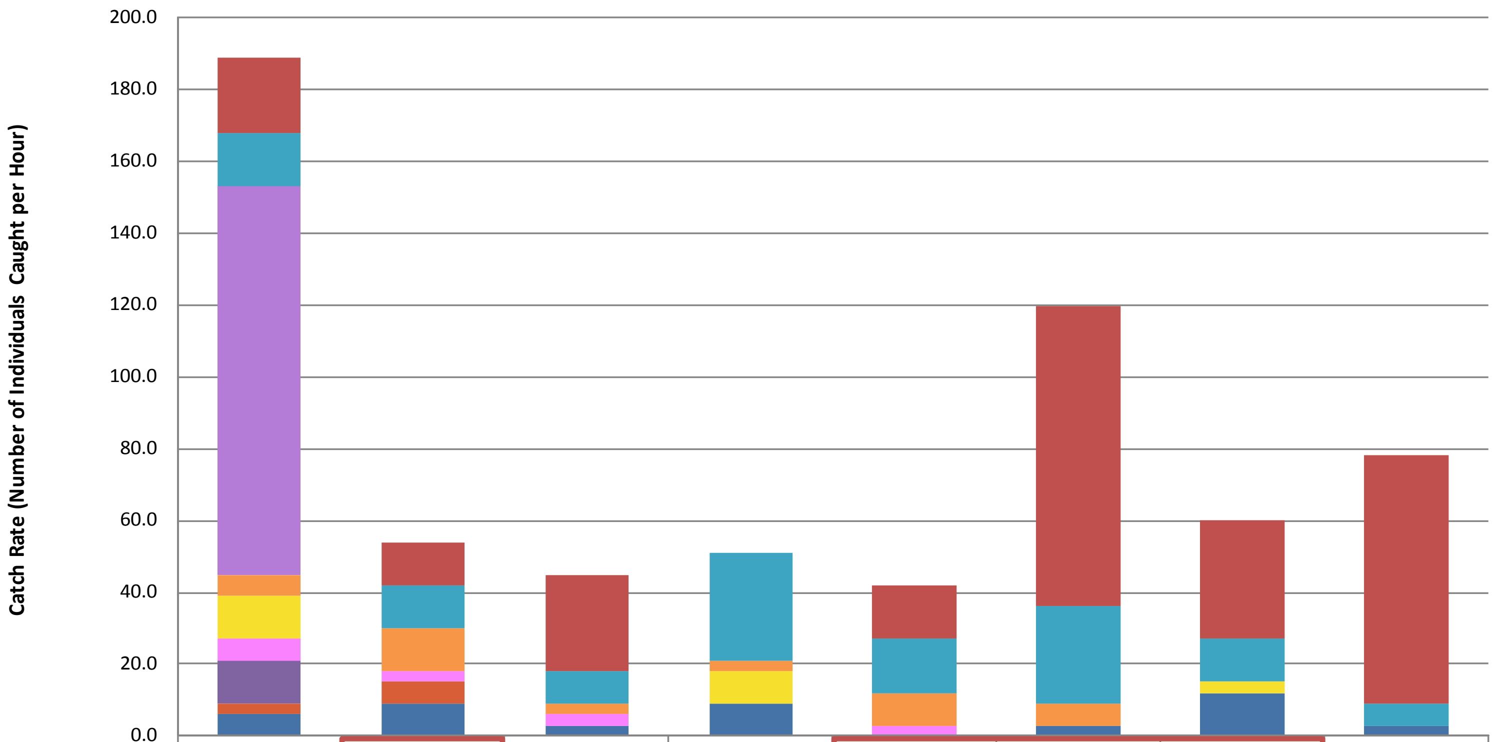
Species		Number of Individuals Caught			Catch Rate (Number of Individuals Caught per Hour)	
Common Name	Scientific Name	Control	East Anglia THREE	Total	Control	East Anglia THREE
Plaice	*Pleuronectes platessa*	39	48	87	29.2	36.0
Dab	*Limanda limanda*	20	22	42	15.0	16.5
Whelk	*Buccinum undatum*	36	0	36	27.0	0.0
Solenette	*Buglossidium luteum*	4	9	13	3.0	6.8
Lesser Spotted Dogfish	*Scyliorhinus canicula*	7	1	8	5.2	0.8
Common Dragonet	*Callionymus lyra*	3	2	5	2.2	1.5
Velvet Crab	*Necora puber*	4	0	4	3.0	0.0
Lesser Weever	*Echiichthys vipera*	1	2	3	0.7	1.5
Bullrout	*Myoxocephalus scorpius*	0	2	2	0.0	1.5
Dover Sole	*Solea solea*	1	1	2	0.7	0.8
Grey Gurnard	*Eutrigla gurnardus*	2	0	2	1.5	0.0
Pogge	*Agonus cataphractus*	1	1	2	0.7	0.8
Scaldfish	*Arnoglossus laterna*	2	0	2	1.5	0.0
John Dory	*Zeus faber*	0	1	1	0.0	0.8
Mackerel	*Scomber scombrus*	0	1	1	0.0	0.8
Sea Scorpion	*Taurulus bubalis*	0	1	1	0.0	0.8
Turbot	*Psetta maxima*	0	1	1	0.0	0.8
Whiting	*Merlangius merlangus*	1	0	1	0.7	0.0
Total No. of Individuals		121	92			
Total No. of Species		13	13			
Catch Rate (No. of Individuals Caught per Hour)		90.7	69.0			



	Plaice	Dab	Whelk	Solenette	Lesser Spotted Dogfish	Common Dragonet	Velvet Crab	Lesser Weever	Other Species
Control	29.2	15.0	27.0	3.0	5.2	2.2	3.0	0.7	5.2
East Anglia THREE	36.0	16.5	0.0	6.8	0.8	1.5	0.0	1.5	6.0

Species

Figure 6.1 Catch Rates for Fish and Shellfish Species by Sampling Area



	BT01	BT02	BT03	BT04	BT05	BT06	BT07	BT08
Plaice	21.0	12.0	27.0	0.0	15.0	83.9	33.0	69.0
Dab	15.0	12.0	9.0	30.0	15.0	27.0	12.0	6.0
Whelk	107.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solenette	6.0	12.0	3.0	3.0	9.0	6.0	0.0	0.0
Lesser Spotted Dogfish	12.0	0.0	0.0	9.0	0.0	0.0	3.0	0.0
Common Dragonet	6.0	3.0	3.0	0.0	3.0	0.0	0.0	0.0
Velvet Crab	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lesser Weever	3.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Species	6.0	9.0	3.0	9.0	0.0	3.0	12.0	3.0

Station

Figure 6.2 Catch Rates for Fish and Shellfish Species by Station (red box denotes East Anglia THREE stations)

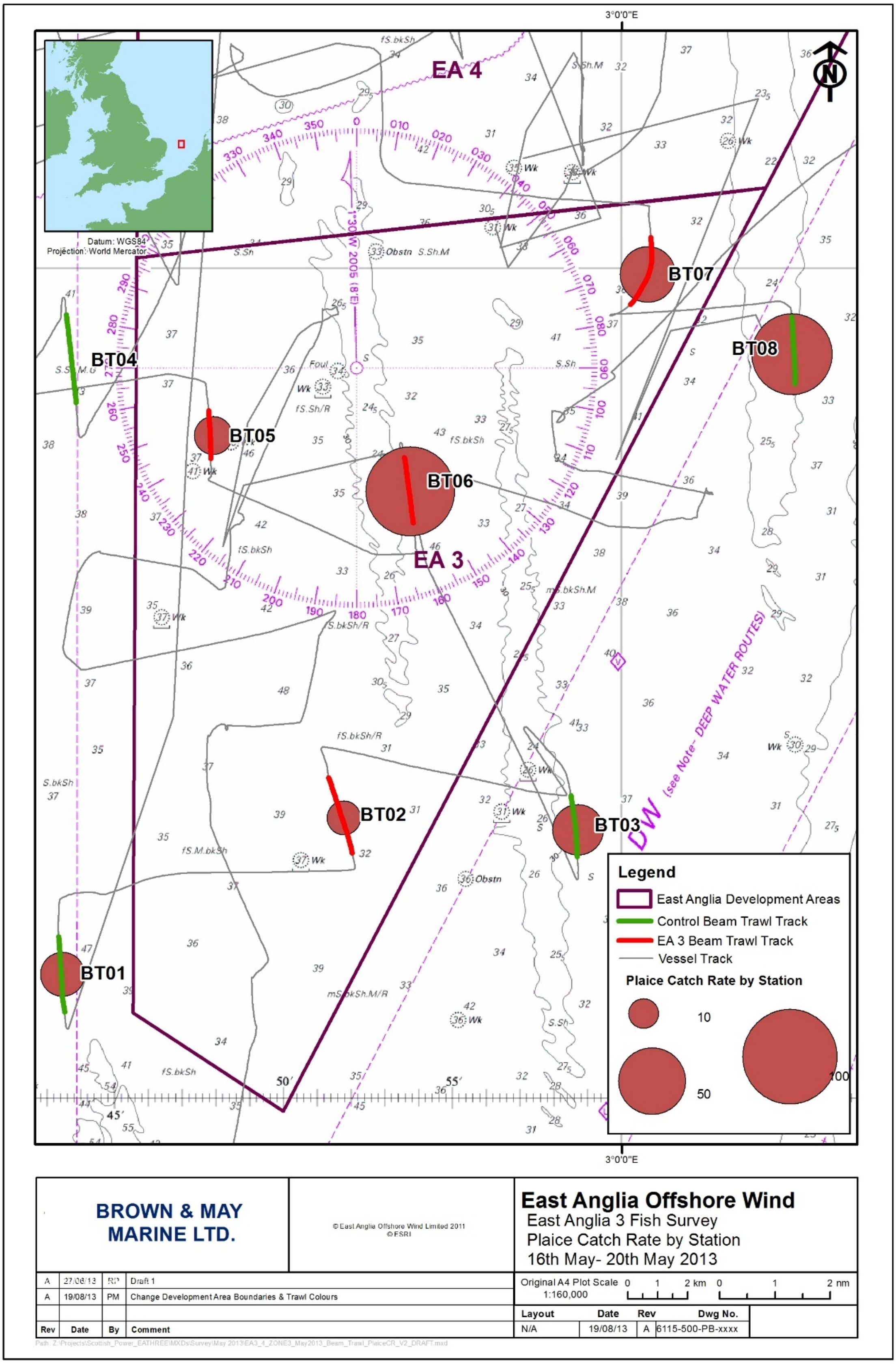


Figure 6.3 Spatial Distribution of Plaice (*P. platessa*) in the Area of East Anglia THREE

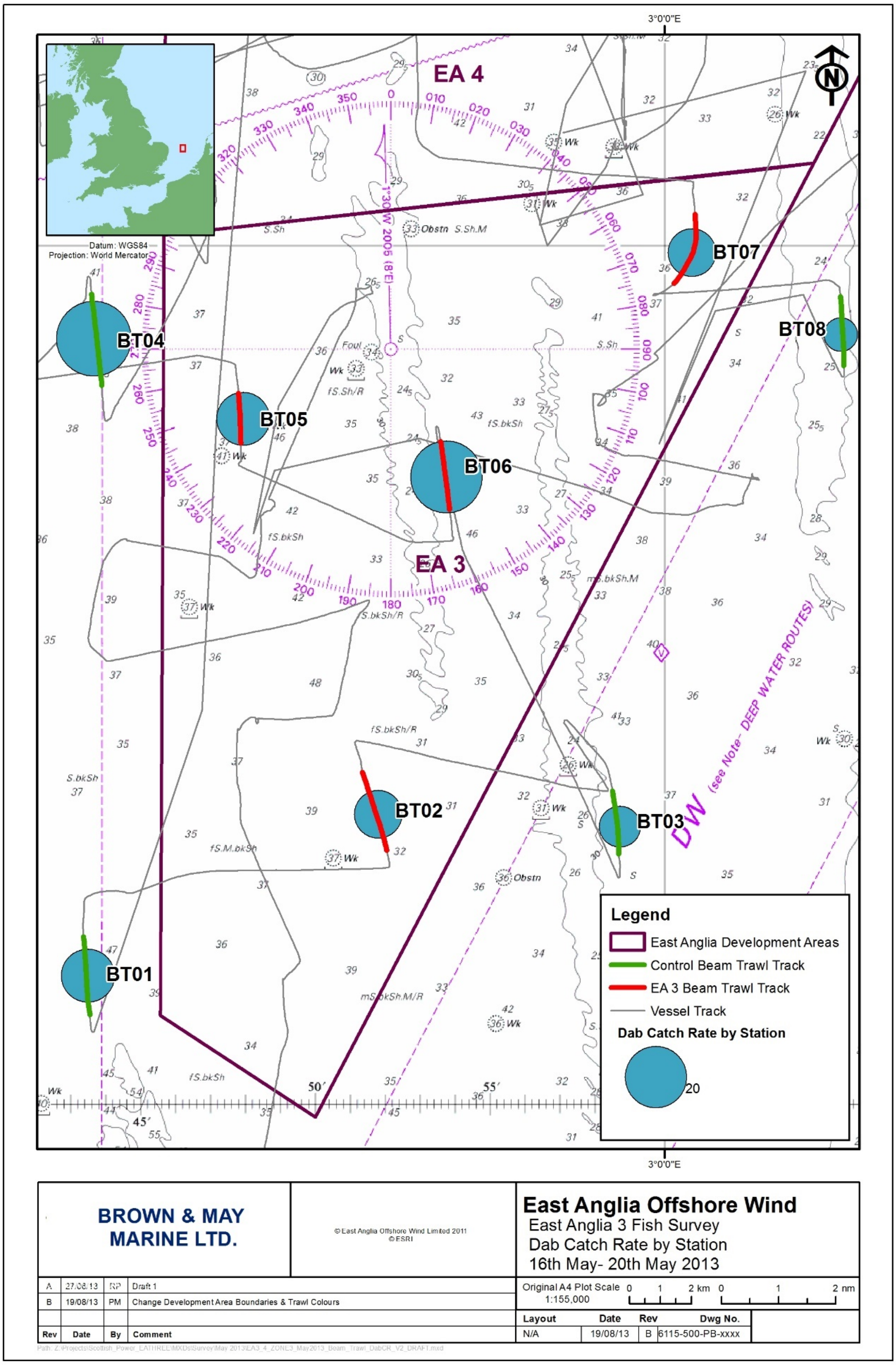
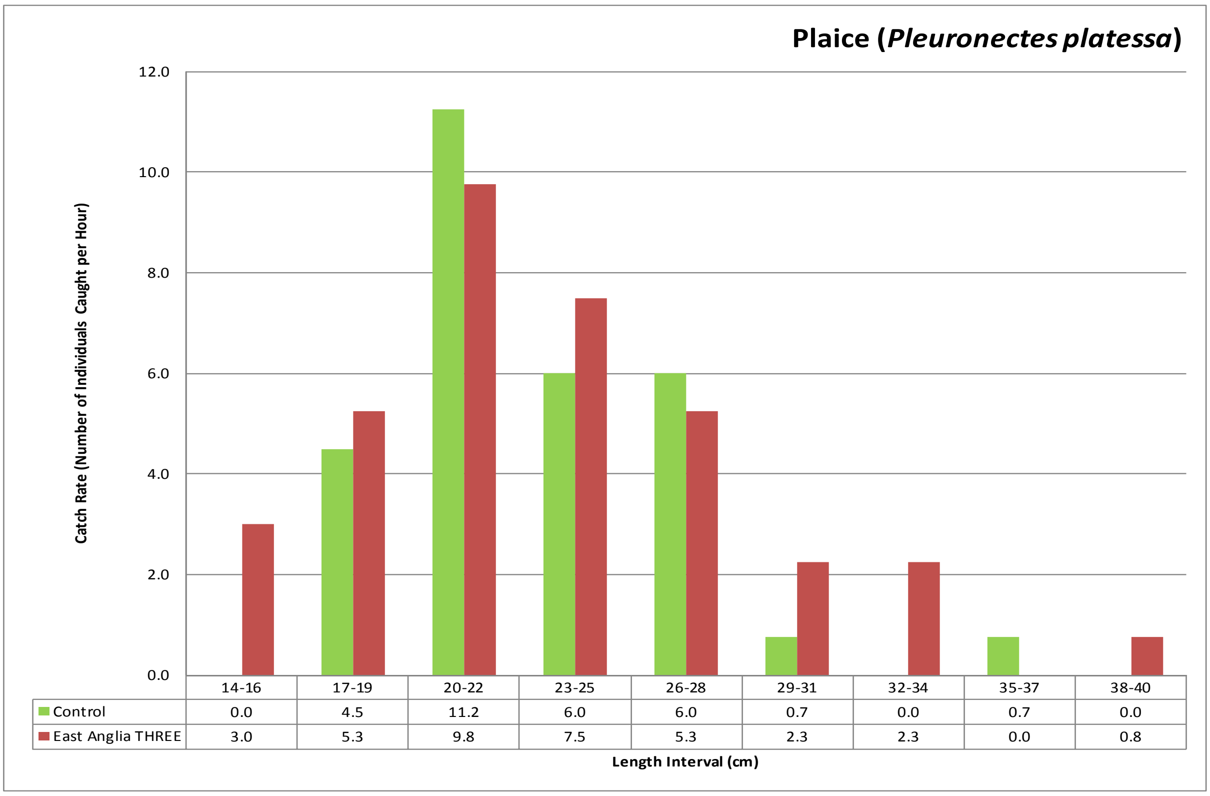


Figure 6.4 Spatial Distribution of Dab (*L. limanda*) in the Area of East Anglia THREE

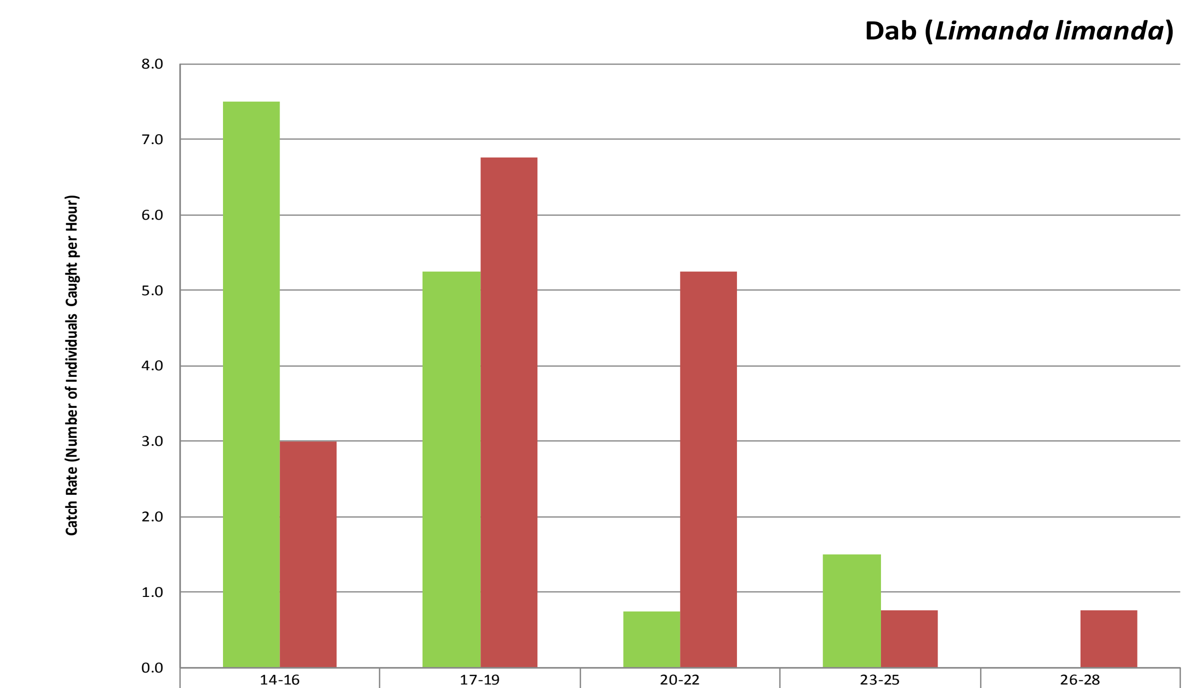
6.2 Length Distributions

The length distributions of the two most abundant species caught during the survey, expressed as the catch rate (number of individuals caught per hour) by length (cm) and by sampling area (control and East Anglia THREE), are shown in Figure 6.5 and Figure 6.6 below.



	14-16	17-19	20-22	23-25	26-28	29-31	32-34	35-37	38-40
Control	0.0	4.5	11.2	6.0	6.0	0.7	0.0	0.7	0.0
East Anglia THREE	3.0	5.3	9.8	7.5	5.3	2.3	2.3	0.0	0.8

Figure 6.5 Plaice (*P. platessa*) Length Distribution by Sampling Area



	14-16	17-19	20-22	23-25	26-28
Control	7.5	5.2	0.7	1.5	0.0
East Anglia THREE	3.0	6.8	5.3	0.8	0.8

Figure 6.6 Dab (*L. limanda*) Length Distribution by Sampling Area

6.3 Minimum Landing Sizes

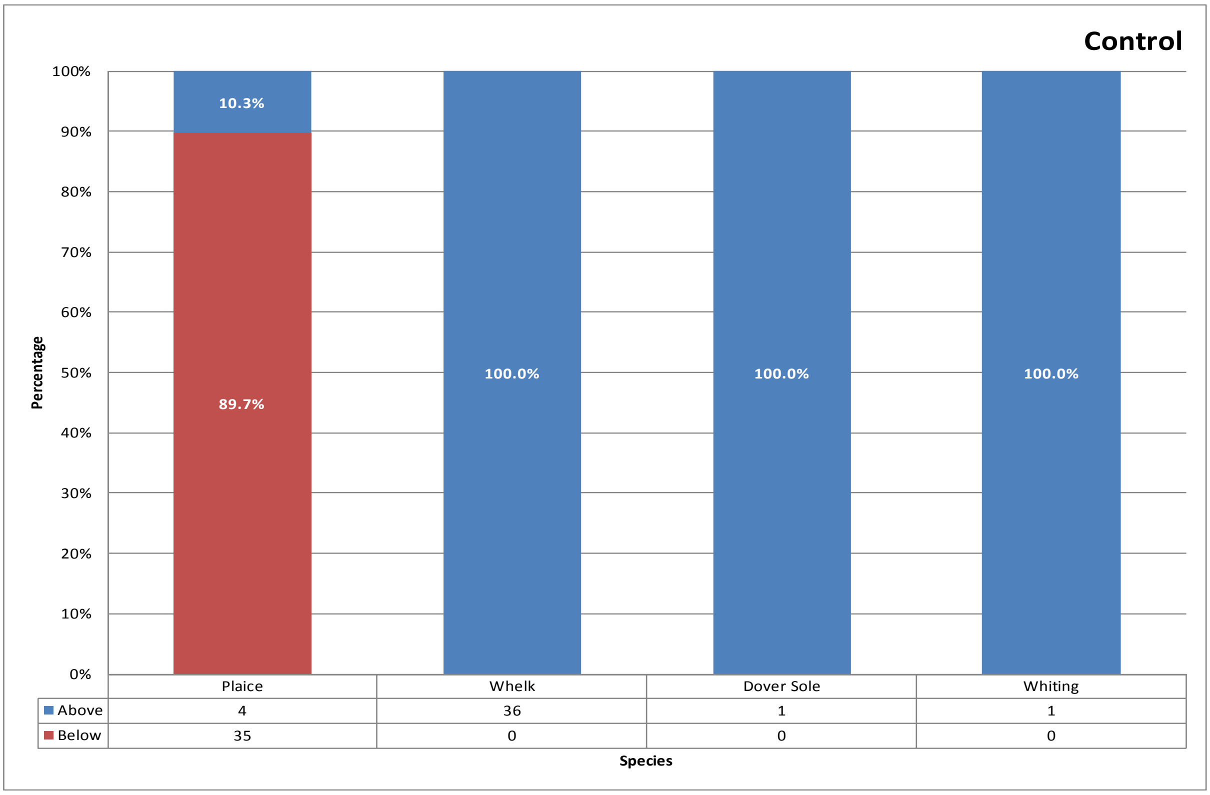
Table 6.2 shows the five species of fish and shellfish caught for which a MLS has been set and denotes their presence or absence by sampling area (control and East Anglia THREE).

Table 6.2 MLS Set by EC

Species		EC MLS (cm)	Presence	
Common Name	Scientific Name		Control	East Anglia THREE
Dover Sole	*Solea solea*	24	✓	✓
Mackerel	*Scomber scombrus*	30	–	✓
Plaice	*Pleuronectes platessa*	27	✓	✓
Whiting	*Merlangius merlangus*	27	✓	-
Whelk	*Buccinum undatum*	4.5	✓	-

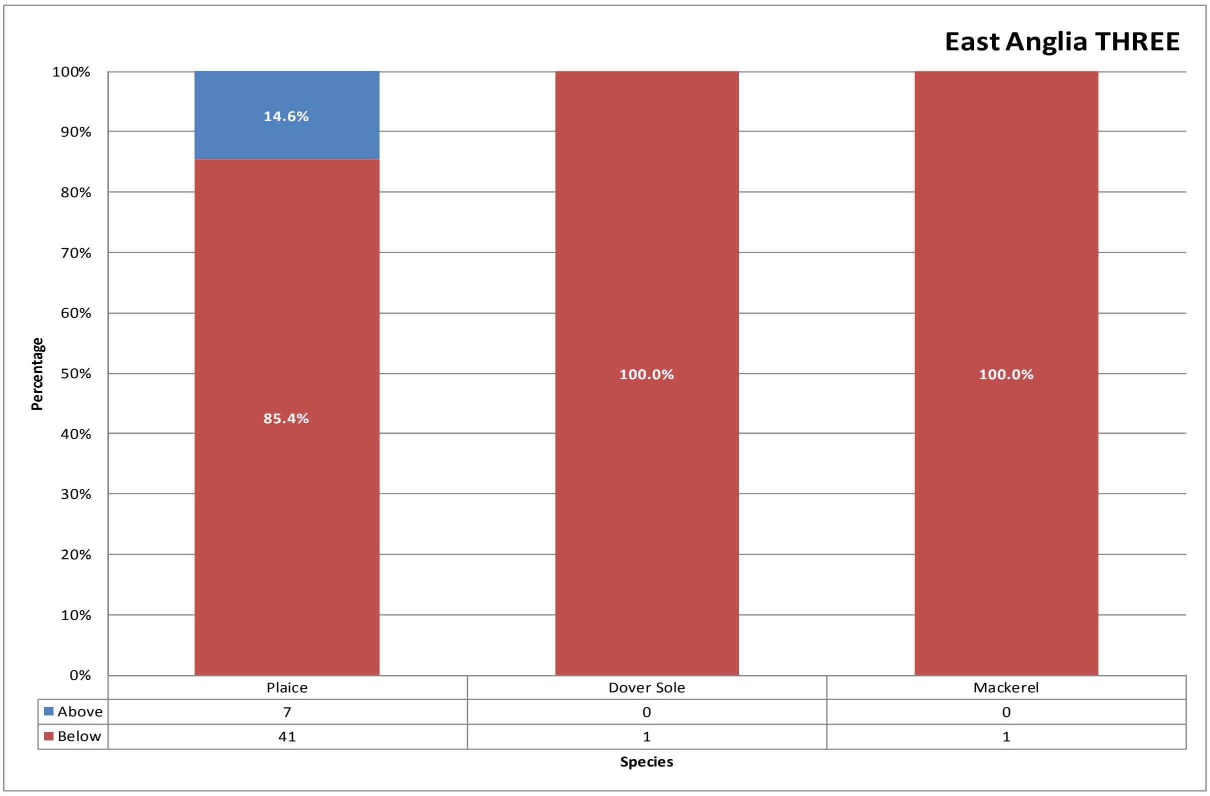
The percentage of individuals caught above and below their set MLS by species is shown in Figure 6.7 and Figure 6.8 for control and East Anglia THREE stations respectively.

Most of the *P. platessa* caught at the control stations (89.7%) and within East Anglia THREE (85.4%) were below the set MLS. All of the *B. undatum* caught at the control stations were above the MLS. All other species were caught in relatively low numbers.



	Plaice	Whelk	Dover Sole	Whiting
Above	4	36	1	1
Below	35	0	0	0

Figure 6.7 Percentage of the Catch Above and Below the MLS by Species at the Control Stations



	Plaice	Dover Sole	Mackerel
Above	7	0	0
Below	41	1	1

Figure 6.8 Percentage of the Catch Above and Below the MLS by Species within East Anglia THREE

6.4 Sex Ratios

The sex ratios of the two most abundant species caught during the beam trawl survey are shown in Figure 6.9 and Figure 6.10 for control and East Anglia THREE stations respectively.

The majority of the *P. platessa* caught at the control stations (82.1%) and within East Anglia THREE (83.3%) were male. A higher proportion of the *L. limanda* caught within East Anglia THREE were female (81.8 %), whereas at the control stations the sex ratio was approximately even.

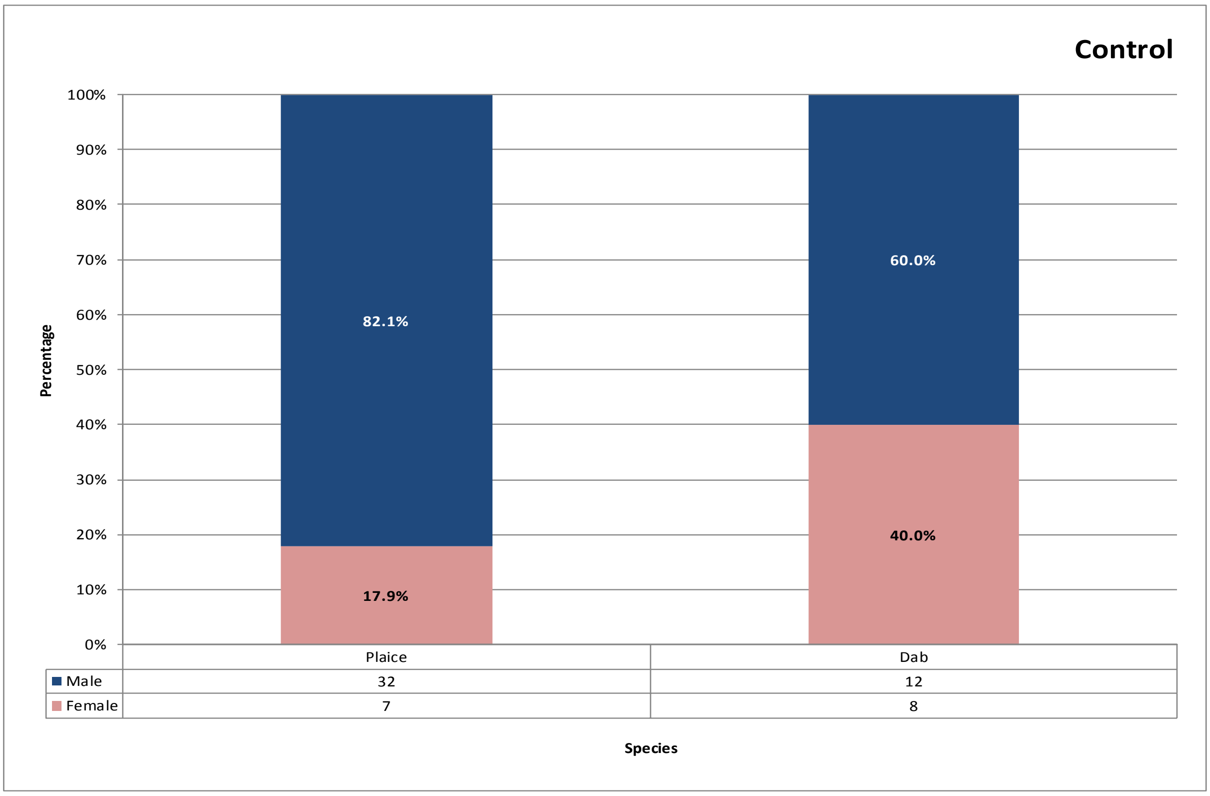


Figure 6.9 Sex Ratio by Species at the Control Stations

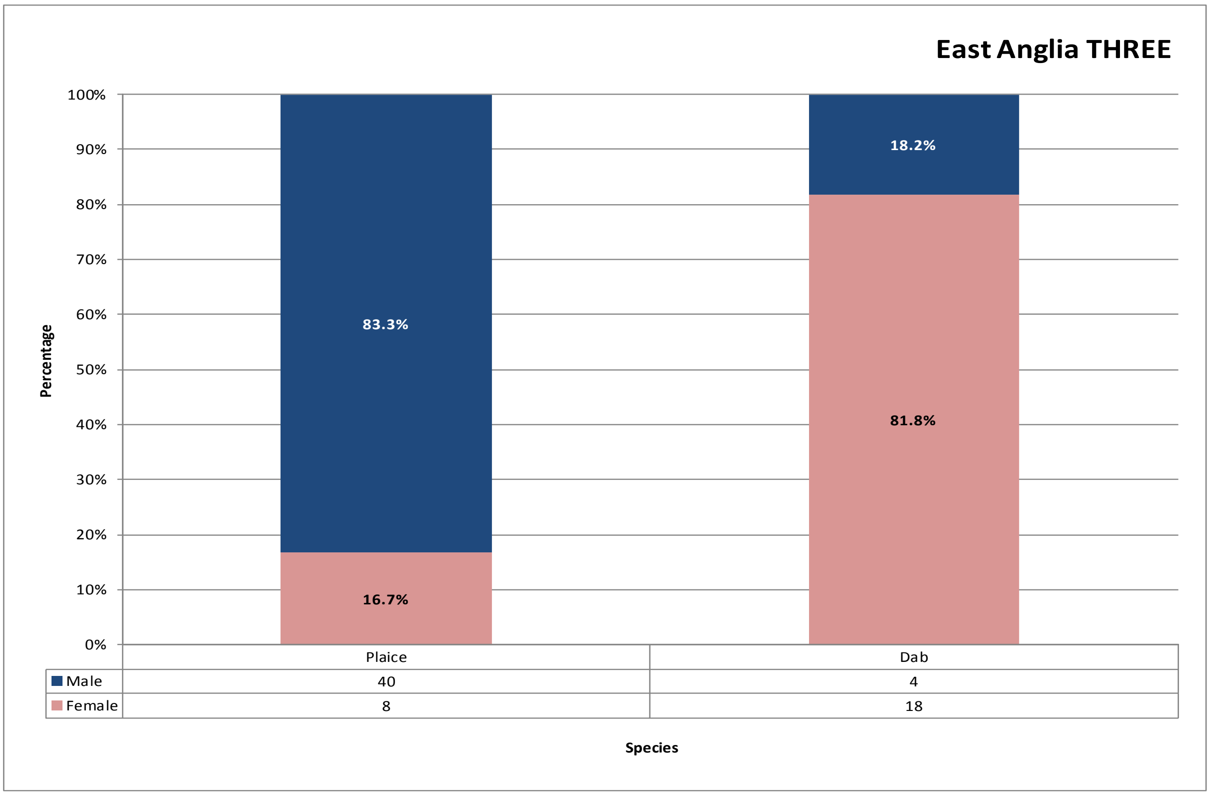


Figure 6.10 Sex Ratio by Species within East Anglia THREE

6.5 Spawning Condition

The spawning condition, sex and length range (nearest cm below) for the two most abundant species caught during the beam trawl survey are given below in Table 6.3 and Table 6.4.

The highest proportion of the *P. platessa* (control 61.5%, East Anglia THREE 43.8%) caught in both sampling areas were maturing males. Most of the *L. limanda* caught at the control stations were immature males (60.0%), whereas within East Anglia THREE the majority were maturing females (63.3%).

Table 6.3 Plaice (*P. platessa*) Spawning Condition

Plaice							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia THREE	Total		Min	Max
Female	Immature	2	0	2	2.3%	20	23
	Maturing	4	2	6	6.9%	19	26
	Running	1	2	3	3.4%	26	33
	Spent	0	4	4	4.6%	25	39
Male	Immature	4	11	15	17.2%	14	22
	Maturing	24	21	45	51.7%	17	36
	Running	0	4	4	4.6%	22	26
	Spent	4	4	8	9.2%	22	26

Table 6.4 Dab (*L. limanda*) Spawning Condition

Dab							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia THREE	Total		Min	Max
Female	Immature	3	3	6	14.3%	14	19
	Maturing	3	14	17	40.5%	15	23
	Running	1	0	1	2.4%	17	17
	Spent	1	1	2	4.8%	19	22
Male	Immature	12	1	13	31.0%	14	24
	Maturing	0	1	1	2.4%	21	21
	Running	0	2	2	4.8%	19	26

7.0 Scientific 2-metre Beam Trawl Results

7.1 Fish Catch Rates and Species Distribution

The total number of individuals caught and the catch rate (number of individuals caught per hour) by fish species and sampling area are given in Table 7.1 and illustrated overleaf in Figure 7.1. The catch rates for fish species by sampling station are given in Figure 7.2.

A total of 28 species of fish were caught in the scientific beam trawl survey; 20 within East Anglia THREE, and 27 along the export cable. *B. luteum* was the most abundant species along the export cable whereas (*P. minutus*) was more abundant within East Anglia THREE, followed by *E. vipera* and (*A. laterna*). All other species were caught in relatively low numbers.

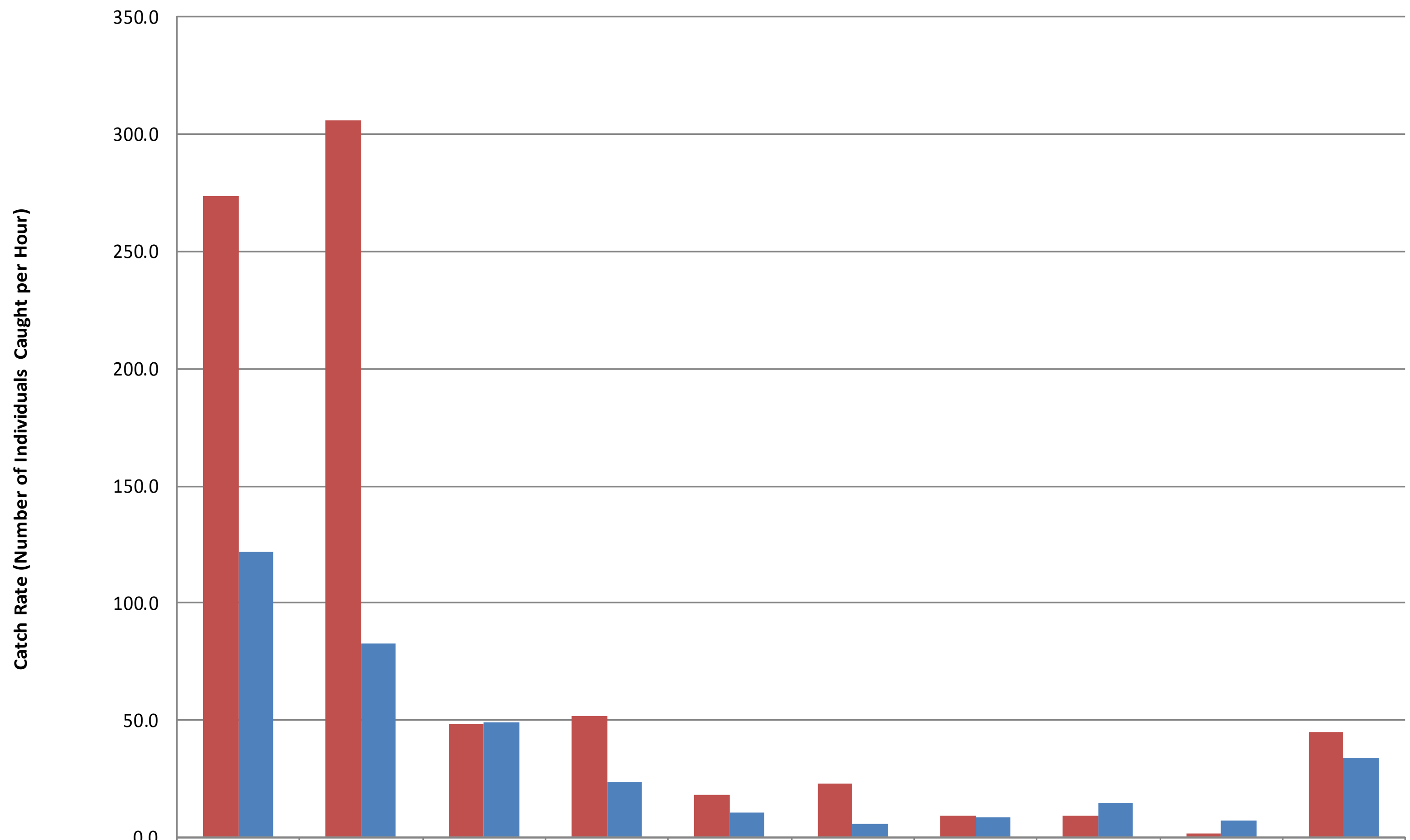
Station T12 within East Anglia THREE yielded the highest catch rate (1,222.6/hr), with *B. luteum* and *P. minutus* representing the majority of the catch (43.7% and 42.9% respectively).

The total catch rate within East Anglia THREE (785.5/hr) was approximately double that recorded along the export cable (358.8/hr).

Table 7.1 Total Numbers of Individuals Caught and the Catch Rate for Fish Species by Sampling Area

Species		Number of Individuals Caught			Catch Rate (Number of Individuals Caught per Hour)	
Common Name	Scientific Name	East Anglia THREE	Export Cable	Total	East Anglia THREE	Export Cable
Solenette	*Buglossidium luteum*	153	159	312	273.8	122.2
Sand Goby	*Pomatoschistus minutus*	171	108	279	306.0	83.0
Lesser Weever	*Echiichthys vipera*	27	64	91	48.3	49.2
Scaldfish	*Arnoglossus laterna*	29	31	60	51.9	23.8
Dab	*Limanda limanda*	10	14	24	17.9	10.8
Common Dragonet	*Callionymus lyra*	13	8	21	23.3	6.1
Pogge	*Agonus cataphractus*	5	11	16	8.9	8.5
Greater Sandeel	*Hyperoplus lanceolatus*	5	19	24	8.9	14.6
Sandeel sp.	*Ammodytes* sp.	1	9	10	1.8	6.9
Dover Sole	*Solea solea*	2	7	9	3.6	5.4
Spotted Dragonet	*Callionymus maculatus*	5	2	7	8.9	1.5
Plaice	*Pleuronectes platessa*	4	2	6	7.2	1.5

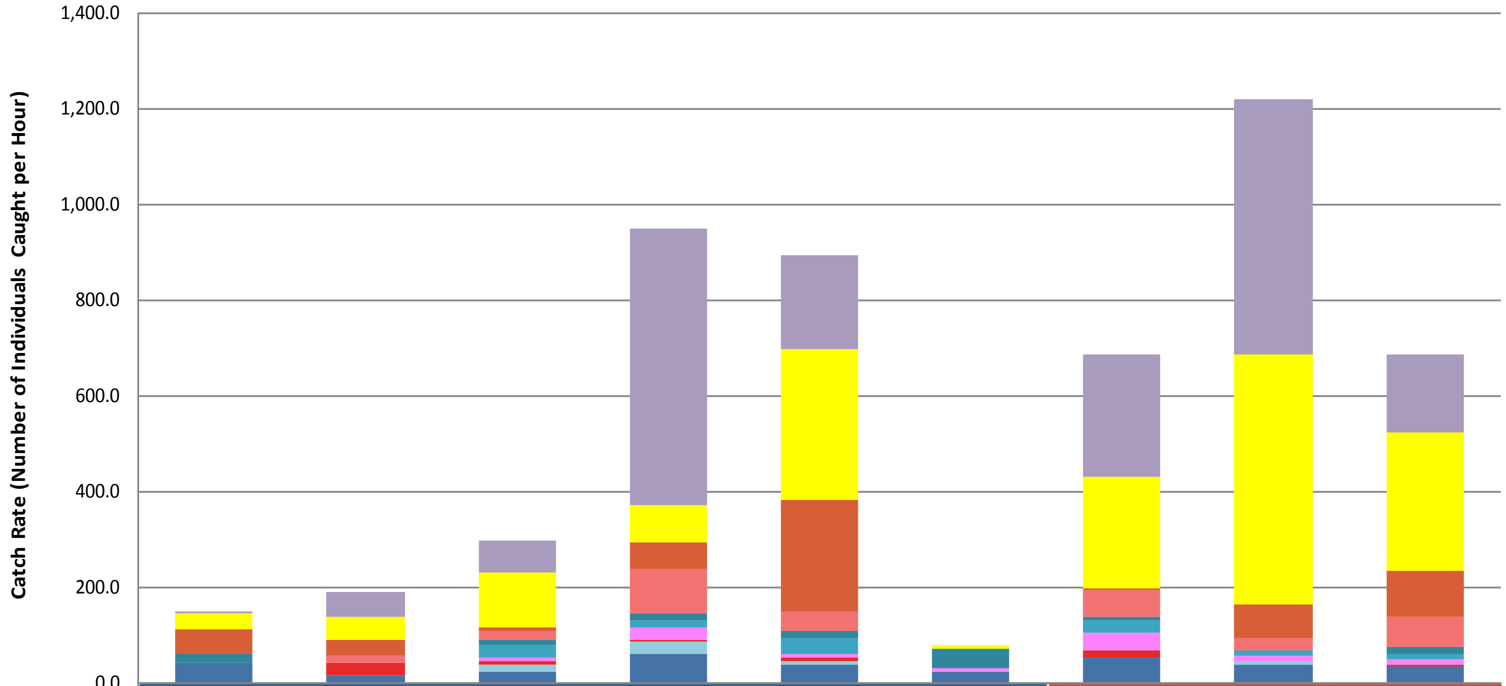
Species		Number of Individuals Caught			Catch Rate (Number of Individuals Caught per Hour)	
Common Name	Scientific Name	East Anglia THREE	Export Cable	Total	East Anglia THREE	Export Cable
Bony Fish Larvae	Osteichthyes (larvae)	1	4	5	1.8	3.1
Smooth Sandeel	*Gymnammodytes semisquamatus*	3	2	5	5.4	1.5
Three-bearded Rockling	*Gaidropsarus vulgaris*	3	1	4	5.4	0.8
Great Pipefish	*Syngnathus acus*	0	4	4	0.0	3.1
Lesser Sandeel	*Ammodytes tobianus*	1	3	4	1.8	2.3
Lesser Spotted Dogfish	*Scyliorhinus canicula*	0	4	4	0.0	3.1
Goby	*Pomatoschistus* sp.	1	2	3	1.8	1.5
Reticulated Dragonet	*Callionymus reticulatus*	2	1	3	3.6	0.8
Sprat	*Sprattus sprattus*	0	3	3	0.0	2.3
Gadoid	Gadinae (juv.)	0	2	2	0.0	1.5
Goby	Gobiidae	0	2	2	0.0	1.5
Grey Gurnard	*Eutrigla gurnardus*	0	2	2	0.0	1.5
Sandeel	Ammodytidae	2	0	2	3.6	0.0
Whiting	*Merlangius merlangus*	1	1	2	1.8	0.8
Four-bearded Rockling	*Rhinonemus cimbrius*	0	1	1	0.0	0.8
Thornback Ray	*Raja clavata*	0	1	1	0.0	0.8
Total No. of Individuals		439	467			
Total No. of Species		20	27			
Catch Rate (No. of Individuals Caught per Hour)		785.5	358.8			



	Solenette	Sand Goby	Lesser Weever	Scaldfish	Dab	Common Dragonet	Pogge	Greater Sandeel	Sandeel sp.	Other Species
East Anglia THREE	273.8	306.0	48.3	51.9	17.9	23.3	8.9	8.9	1.8	44.7
Export Cable	122.2	83.0	49.2	23.8	10.8	6.1	8.5	14.6	6.9	33.8

9

Figure 7.1 Catch Rates for Fish Species by Sampling Area



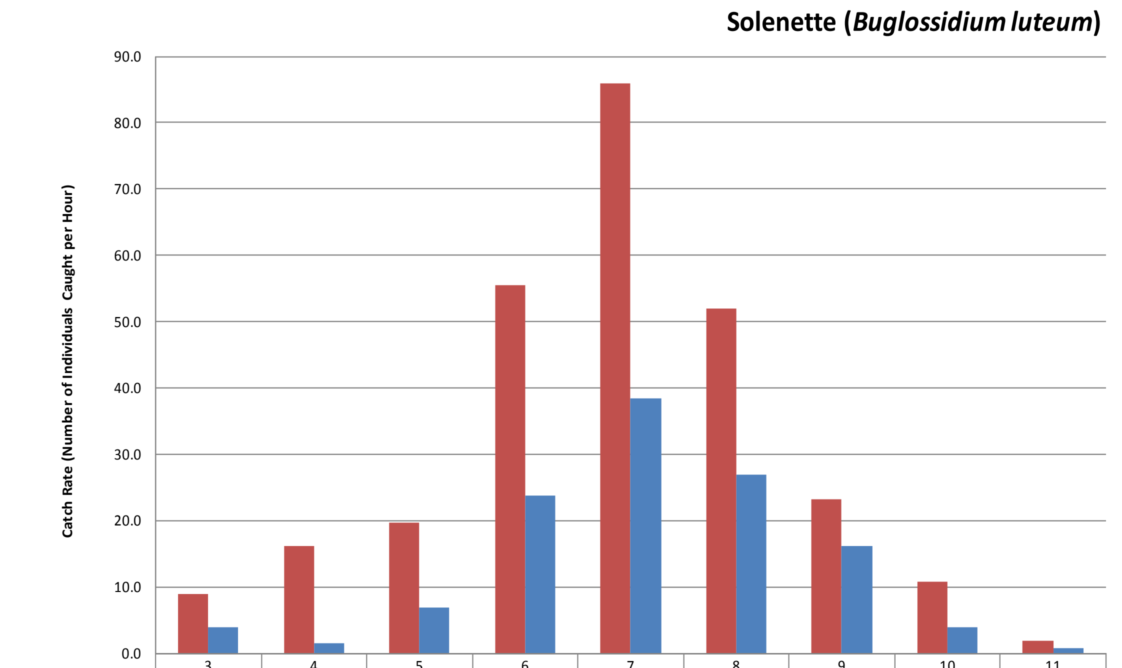
	T1	T2	T4	T5	T6	T7	T11	T12	T13
Solenette	4.3	51.6	66.2	576.7	196.5	0.0	255.5	533.7	160.1
Sand Goby	34.6	48.4	114.0	75.7	314.4	5.3	232.6	524.0	289.2
Lesser Weever	51.9	32.3	7.4	58.3	235.8	0.0	3.8	67.9	98.1
Scaldfish	0.0	16.1	18.4	93.2	39.3	0.0	53.4	29.1	62.0
Greater Sandeel	17.3	0.0	11.0	11.7	15.7	42.3	7.6	0.0	15.5
Dab	0.0	0.0	25.7	17.5	31.4	0.0	26.7	9.7	10.3
Common Dragonet	0.0	0.0	7.4	23.3	7.9	5.3	38.1	9.7	10.3
Pogge	0.0	22.6	7.4	5.8	7.9	0.0	15.3	0.0	5.2
Sandeel sp.	0.0	0.0	14.7	23.3	7.9	0.0	0.0	9.7	0.0
Other Species	43.2	19.4	25.7	64.1	39.3	26.4	53.4	38.8	36.2

Station

Figure 7.2 Catch Rates for Fish Species by Station (blue and red boxes denote stations along the export cable and within East Anglia THREE respectively)

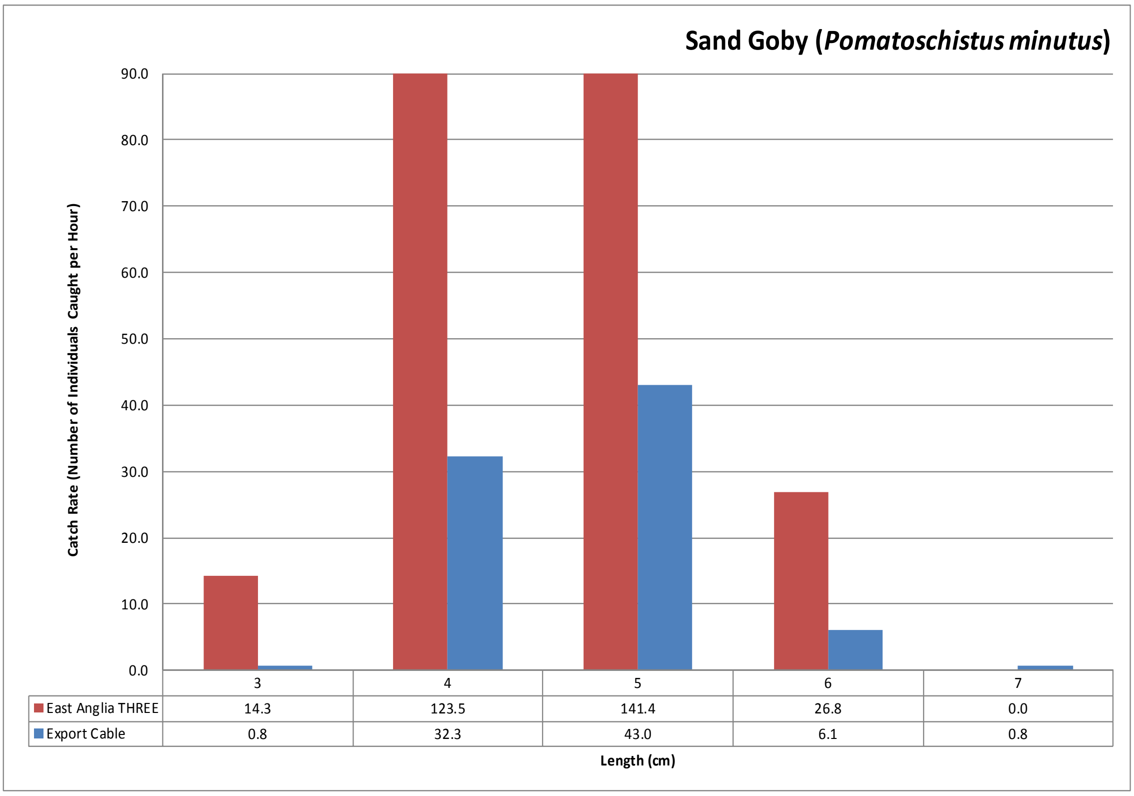
7.2 Length Distributions

The length distributions for *B. luteum*, *P. minutus* and *A. laterna*, expressed as the catch rate (number of individuals caught per hour) by length (cm) and by sampling area, is shown in Figure 7.3 to Figure 7.5. It should be noted that the poisonous *E. vipera* is not measured as a safety precaution and is therefore excluded from this section.



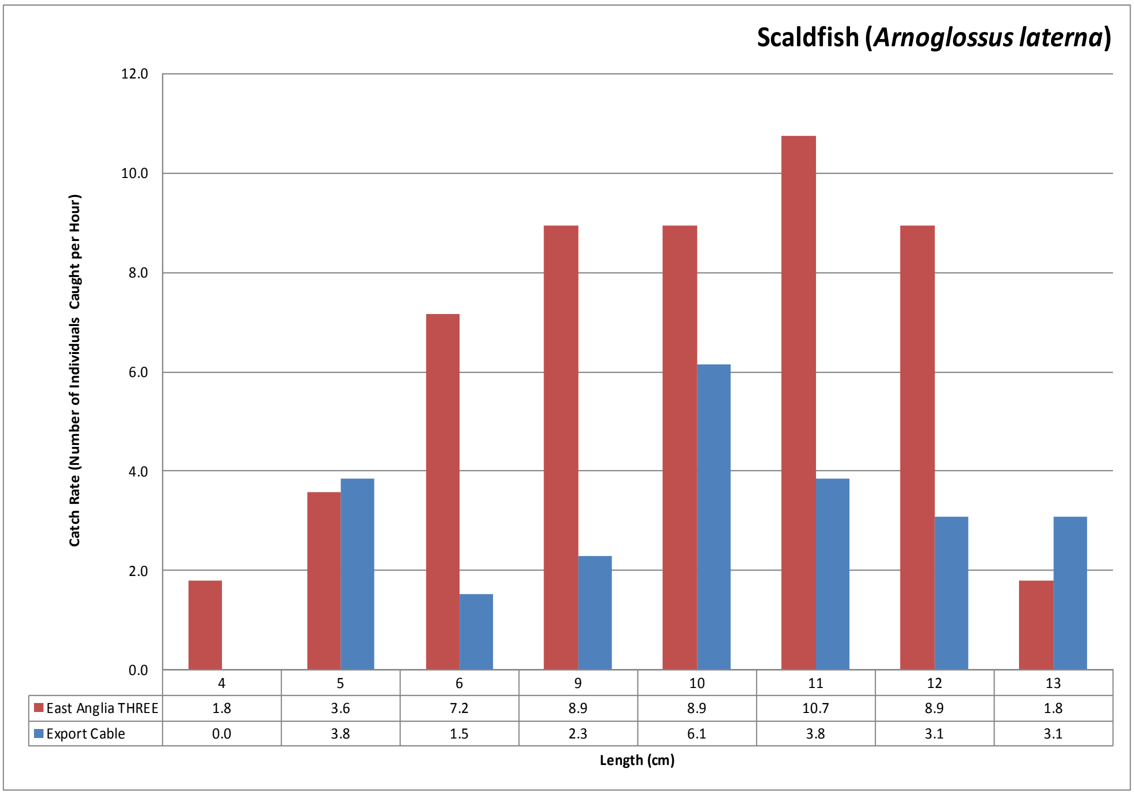
	3	4	5	6	7	8	9	10	11
East Anglia THREE	8.9	16.1	19.7	55.5	85.9	51.9	23.3	10.7	1.8
Export Cable	3.8	1.5	6.9	23.8	38.4	26.9	16.1	3.8	0.8

Figure 7.3 Solenette (*B. luteum*) Length Distribution by Sampling Area



	3	4	5	6	7
East Anglia THREE	14.3	123.5	141.4	26.8	0.0
Export Cable	0.8	32.3	43.0	6.1	0.8

Figure 7.4 Sand Goby (*P. minutus*) Length Distribution by Sampling Area



	4	5	6	9	10	11	12	13
East Anglia THREE	1.8	3.6	7.2	8.9	8.9	10.7	8.9	1.8
Export Cable	0.0	3.8	1.5	2.3	6.1	3.8	3.1	3.1

Figure 7.5 Scaldfish (*A. laterna*) Length Distribution by Sampling Area

8.0 Appendix (of Annex 4)

8.1 Appendix 1 – Health and Safety

8.1.1 Personnel

Brown and May Marine (BMM) staff protocol followed the standard health and safety protocol outlined in the BMM "Offshore Operational Procedures for Surveys using Commercial Fishing Vessels".

All BMM staff have completed a Sea Survival course approved by the Maritime and Coastguard Agency, meeting the requirements laid down in: **STCW 95 Regulation VI/1 para 2.1.1 and STCW Code section A- VI/1** before boarding any vessel conducting works for the company. Employees are also required to have valid medical certificates (ENG1 or ML5), Seafish Safety Awareness, Seafish Basic First Aid and Seafish Basic Fire Fighting and Fire Prevention certificates before participating in offshore works.

8.1.2 Vessel Induction

Before boarding, the survey team were shown how to safely board and disembark the vessel. Prior to departure the skipper briefed the BMM staff on the whereabouts of the safety equipment, including the life raft, emergency flares and fire extinguishers, and also the location of the emergency muster point. The safe deck areas, man-overboard procedures and emergency alarms were also discussed. The survey team were warned about the possible hazards, such as slippery decks and obstructions whilst aboard. The BMM staff were briefed about trawling operations and the need to keep clear of all winch's when operational and a safety drill was conducted. All hazards were assessed prior to the survey in the BMM health and safety risk assessment.

8.1.3 Daily Safety Checks

The condition of the life jackets, EPIRB's, and life raft were inspected daily. Also checked were the survey team working areas, including the fish room and the wheelhouse to ensure these areas were clear of hazards such as clutter and obstructions.

8.1.4 Post Trip Survey review

Upon completion of the survey a "Post Trip Survey Review" was filed, see Table 7.1 overleaf.

Table 8.1 Post Trip Survey Review

Project: East Anglia 3	**Vessel:** Jubilee Spirit
Surveyors: Lucy Shuff, Alex Winrow-Giffin, Jake Laws	**Skipper:** Ross Crookes
Survey Area: Southern North Sea	**Total Time at Sea:** 13 Days
Dates at Sea: 15/05/2013 – 27/05/2013	

	Comments	Actions
Did vessel comply with pre-trip safety audits?	Yes Passed audit by LOC on 14/02/2013	N/A
Skipper and crew attitude to safety?	Good	N/A
Vessel machinery failures?	Fuel pipe blockage on 17/05/2013 AIS malfunction on 20/05/2013	Repaired by crew at sea Repaired by engineer on 21/05/2013
Safety equipment failures?	None	N/A
Accidents?	None	N/A
Injuries?	None	N/A

10.0 Annex 5: East Anglia FOUR Fish and Shellfish Survey 15th to 27th May 2013

East Anglia Offshore Windfarm

East Anglia FOUR

Fish and Shellfish Survey

15^{th} to 27^{th} May 2013

Undertaken by
Brown and May Marine Ltd

Ref	Issue Date	Issue Type	Author	Checked	Approved
EA4OB02	10/09/2013	Draft 2	LS/AWG	AWG/JP	LS

Contents

Figures

Tables

1.0 Summary

1.1 Otter Trawl

A total of 15 species were caught in the otter trawl survey; 13 at the control stations and 12 within East Anglia FOUR. Overall, dab (*Limanda limanda*) was the most abundant species caught, followed by plaice (*Pleuronectes platessa*) and then whiting (*Merlangius merlangus*). The highest catch rate for all species combined was recorded at station OT13 within East Anglia FOUR, with *L. limanda* accounting for 43.4% of the catch.

Three species of fish were caught for which there is a set minimum landing size (MLS): *P. platessa*, *M. merlangus* and cod (*Gadus morhua*). Most of the *P. platessa* and *M. merlangus* caught in both sampling areas were below the MLS. Two *G. morhua* were caught; one at the control stations (above the MLS) and one within East Anglia FOUR (below the MLS).

Most of the *L. limanda* and *P. platessa* caught in both sampling areas were male, high proportions of which were maturing. Immature male *L. limanda* were also found in relatively high numbers within East Anglia FOUR. The sex ratio for the *M. merlangus* found in both sampling areas was approximately equal, with maturing males representing the greatest proportions of the catch.

1.2 Beam Trawl

Of the 18 species caught in the commercial beam trawl survey, 11 were found at the control stations and 16 within East Anglia FOUR. Overall, *P. platessa* was the most abundant species caught, followed by *L. limanda*. Station BT14 within East Anglia FOUR had the highest total catch rate, as in the previous survey, and *L. limanda* and *P. platessa* accounted for 71.8% of the catch at this station

Five fish and shellfish species were caught with a set MLS: Dover sole (*Solea solea*), *P. platessa*, *M. merlangus*, edible crab (*Cancer pagurus*) and whelk (*Buccinum undatum*). Most of the *P. platessa* caught in both sampling areas were below the MLS. All other species were caught in relatively low numbers.

The majority of the *P. platessa* caught in both sampling areas were maturing males. A higher proportion of the *L. limanda* caught at the control stations were female, and were immature, maturing, running and spent, whereas within East Anglia FOUR males were more prevalent and were mostly immature or maturing.

1.3 Scientific 2-metre Beam Trawl

A total of 16 species of fish were caught in the East Anglia FOUR scientific beam trawl survey. Overall, solenette (*Buglossidium luteum*) were the most abundant species caught followed by sand goby (*Pomatoschistus minutus*), with all other species found in relatively low numbers. The highest total catch rate was recorded at station T9 (1,741.9/hr), with *B. luteum* accounting for 60.0% of the catch.

2.0 Introduction

The following report details the findings of the May 2013 fish and shellfish survey, undertaken within and adjacent to East Anglia FOUR, located within the East Anglia Zone, between the 15th and 27th May.

The East Anglia FOUR offshore windfarm is located in the North Sea, approximately 91 km off the coast of Suffolk.

The survey methodology, vessel and sampling gear detailed were agreed in consultation with Cefas and the Marine Management Organisation (MMO). A dispensation from the MMO for the Provisions of Council Regulation 850/98 to catch and retain undersize fish for scientific research and 43/2009 specifically related to days at sea was obtained prior to commencement of this survey. A summary of the health and safety performance of the survey is provided in Appendix 1.

The aim of the survey was to establish the abundance and composition of fish and shellfish species within the area of the East Anglia FOUR offshore windfarm.

The results of the epi-benthic survey undertaken by Fugro Emu Limited are also detailed in Section 0. Please refer to the epi-benthic survey report for information regarding the vessel and sampling gear specifications.

3.0 Scope of Works

The proposed scope of works for the May 2013 fish and shellfish survey replicates that of the previous survey undertaken in February 2013 and is detailed below. The methodology is in line with the Terms of Reference, as agreed with Cefas prior to the commencement of sampling. The proposed sampling stations are illustrated in Figure 3.1 overleaf.

- **Otter Trawl**
  - Five tows of approximately 20 minutes duration within East Anglia FOUR and four control tows in adjacent areas

- **Beam Trawl**
  - Five tows of approximately 20 minutes duration within East Anglia FOUR, three control tows in adjacent areas

- **Otter and Beam Trawl Sample Analysis**
  - Number of individuals and catch rate by species
  - Length distribution by species
    - Finfish and sharks (except herring and sprat): individual lengths (nearest cm below)
    - Herring and sprat: individual lengths (nearest ½ cm below)
    - Rays: individual length and wing-width (nearest cm below)
  - Sex ratio by species
  - Spawning condition
    - Finfish species (except herring): Cefas Standard Maturity Key - Five Stage
    - Herring: Cefas Maturity Key – Nine Stage
    - Ray and shark species: Cefas Standard Elasmobranch Maturity Key - Four Stage

- **2-metre Scientific Beam Trawl**
  - Three tows of approximately 400 to 700 metres distance within East Anglia FOUR (undertaken by Fugro Emu Limited between 1st and 8th May 2013)

- **2-metre Scientific Beam Trawl Sample Analysis**
  - Number of individuals and catch rate by species
  - Length distribution by species
    - Finfish and sharks (except herring and sprat): individual lengths (nearest cm below)
    - Herring and sprat: individual lengths (nearest ½ cm below)
    - Rays: individual length and wing-width (nearest cm below)

For the purposes of data analysis, catch rates have been calculated to allow for quantitative comparisons to be made between the numbers of individuals caught per hour at each station.

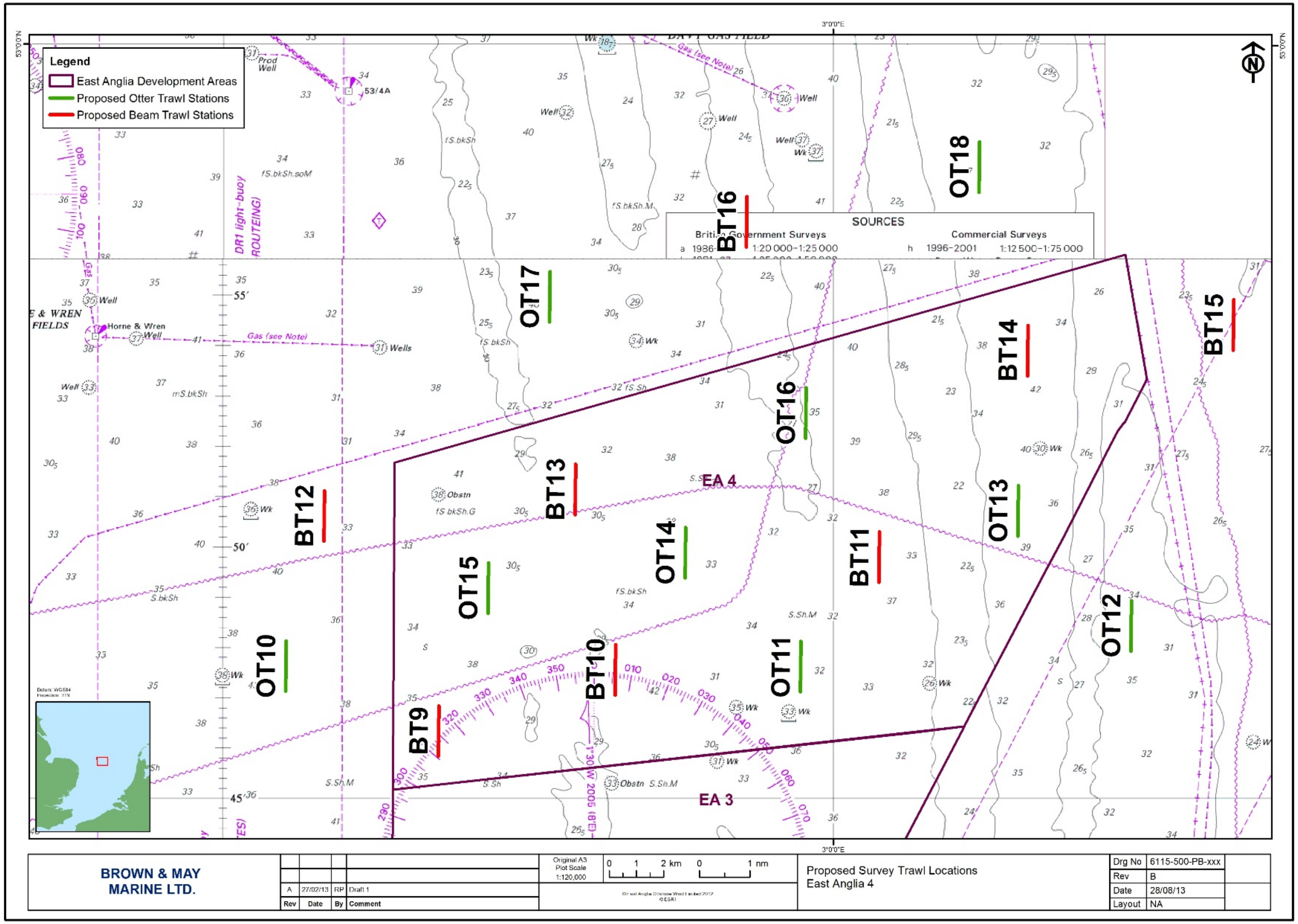


Figure 3.1 Proposed Otter and Beam Trawl Locations

4.0 Methodology

4.1 Survey Vessel

The vessel chartered for the survey (Figure 4.1), the "Jubilee Spirit", is a Grimsby-based commercial trawler that was contracted for previous fish and shellfish surveys at East Anglia ONE. The specifications of the vessel are given below in Table 4.1.

Figure 4.1 Survey Vessel "Jubilee Spirit"

Table 4.1 Survey Vessel Specifications

Survey Vessel Specifications	
Length	21.2m
Beam	6.9m
Draft	2.3m
Main engine	Caterpillar Type 340TA 475 BHP
Gearbox	Hydraulic 6: reduction
Propeller	4 Blade Manganese Bronze Fixed Pitch 1.7m diameter
GPS	2-Furuno GP80
Plotters	Sodena Plotter with Electronic Charts
Sounder	Furuno Daylight Viewing

4.2 Sampling Gear

4.2.1 Commercial Otter Trawl

A commercial otter trawl (Figure 4.2) with a 100mm mesh cod-end was used for fish and shellfish sampling; the specifications of which are given in Table 4.2 below.

Figure 4.2 Otter Trawl Used

Table 4.2 Otter Trawl Specifications

Otter Trawl Specifications	
Towing Warp	18mm, 6x19+1
Depth: Payout Ratio	3:1
Trawl Doors	Perfect B 84
Net	100mm mesh cod-end
Ground line length	24.4m
Footrope	Rock-hopper with 18-inch bobbins
Est. Headline height	7.3m
Distance between doors (est.)	51m

4.2.2 Commercial 4m Beam Trawl

A commercial beam trawl (Figure 4.3) with an 80mm mesh cod end was used for fish and shellfish sampling; the specifications of which are given in Table 4.3 below.

Figure 4.3 Beam Trawl Used

Table 4.3 Beam Trawl Specifications

Beam Trawl Specifications	
Beam width	4m
Headline height	60cm
Cod-end liner	80mm (double twinned on belly and cod end)
Ground gear	5cm rubber bobbins and chain mat

4.3 Positioning and Navigation

The position of the vessel was tracked at all times using a Garmin GPSMap 278 with an EGNOS differential connected to an external Garmin GA30 antenna. Trawl start times and positions were taken when the winch stopped paying out the gear. Similarly, trawl end times and positions were taken when hauling of the gear commenced.

4.4 Sampling Operations

The survey was undertaken from the 15th to the 27th May 2013. A summarised log of events is given in Table 4.4 below.

Table 4.4 Summarised Log of Events

Wednesday 15th May 2013
Depart Scarborough at 0600 hrs (BST)
Vessel in transit from Scarborough to Lowestoft
Thursday 16th May 2013
Arrive into Lowestoft at 0230 hrs (BST)
Load beam trawl and survey gear aboard
Friday 17th May 2013
Depart Lowestoft at 0200 hrs (BST)
Beam Trawls: BT09, BT12
Overnight at sea
Saturday 18th May 2013
East Anglia THREE survey undertaken
Overnight at sea
Sunday 19th May 2013
Beam Trawls: BT13, BT16, BT14, BT15, BT11
Overnight at sea
Monday 20th May 2013
Beam Trawls: BT10
Overnight at sea
Tuesday 21st May 2013
Arrive into Lowestoft at 0720 hrs (BST)
Land beam trawl samples, unload beam trawl
Depart Lowestoft at 2000 hrs (BST) to commence otter trawl survey

Wednesday 22nd May 2013
East Anglia THREE survey undertaken
Overnight at sea
Thursday 23rd May 2013
Otter Trawls: OT12, OT13
Overnight at sea
Friday 24th May 2013
Otter Trawls: OT18, OT17, OT16, OT11
Overnight at sea
Saturday 25th May 2013
Otter Trawls: OT14, OT15, OT10
Overnight at sea
Sunday 26th May 2013
Arrive into Lowestoft at 1030 hrs (BST)
Land otter trawl samples
Vessel departed Lowestoft at 1130 hrs (BST)
Monday 27th May 2013
Vessel in transit from Lowestoft to Grimsby
Vessel arrived into Grimsby at 0930 hrs (BST)
Survey vessel demobilised

4.5 Otter Trawl Sampling

The whole catch from each otter trawl was retained. The samples were then boxed, labelled, photographed, iced and stored at +2°C before transportation to Cefas (Lowestoft) for analysis at the end of the survey, in line with the agreed Terms of Reference.

The start and end times, co-ordinates and the duration of each otter trawl are given in Table 4.5 (control and East Anglia FOUR tows highlighted green and red respectively). The vessel tracks whilst towing the otter trawl are illustrated in Figure 4.4 overleaf.

Table 4.5 Start and End Times, Co-ordinates and Duration of each Otter Trawl

Station	Date	Start				End				Duration (mm:ss)
		Time (GMT)	UTM31N		Depth (m)	Time (GMT)	UTM31N		Depth (m)	
			Easting	Northing			Easting	Northing		
OT10	25/05/2013	11:05:05	479,745.9	5,848,391.7	42.0	11:25:06	479,668.2	5,849,859.6	43.1	20:01
OT11	24/05/2013	16:09:12	498,599.6	5,849,067.4	37.6	16:29:16	498,718.5	5,850,829.8	36.5	20:04
OT12	23/05/2013	12:28:47	511,166.3	5,851,627.6	36.7	12:48:51	511,297.8	5,850,610.6	36.9	20:04
OT13		14:29:55	507,148.3	5,856,057.9	41.4	14:50:00	506,933.3	5,854,830.2	40.2	20:05
OT14	25/05/2013	07:52:46	494,266.2	5,852,353.1	40.7	08:12:53	494,311.2	5,853,058.5	39.8	20:07
OT15		09:33:32	487,186.9	5,850,960.5	37.0	09:53:42	486,925.6	5,851,981.7	38.5	20:10
OT16	24/05/2013	13:49:40	499,018.9	5,860,060.7	36.1	14:09:45	499,042.9	5,859,087.8	35.9	20:05
OT17		11:05:07	489,311.8	5,862,771.2	38.5	11:25:09	488,974.8	5,864,535.8	39.8	20:02
OT18		07:50:59	505,415.9	5,866,887.2	39.1	08:11:03	505,445.3	5,867,966.3	37.6	20:04

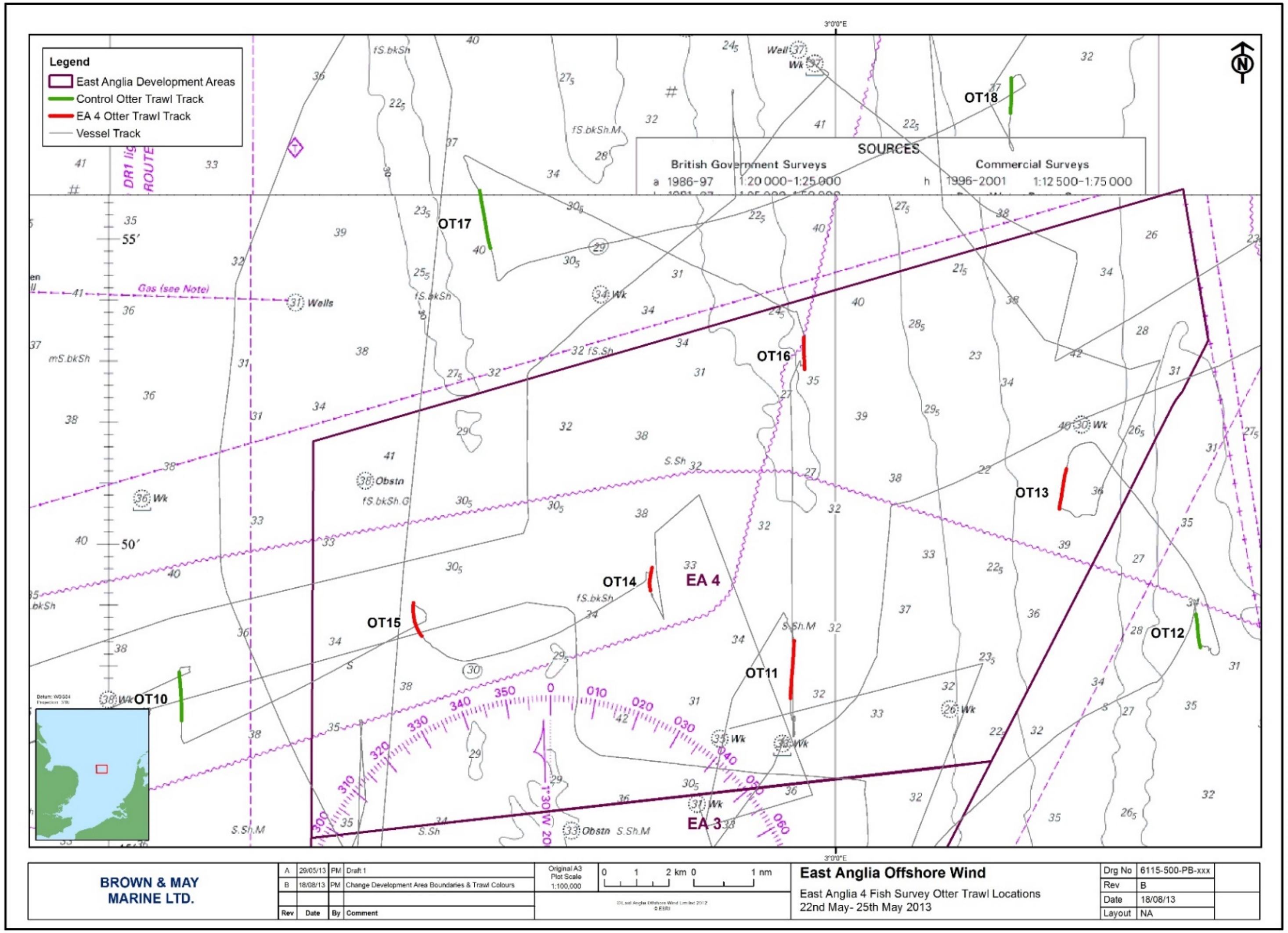


Figure 4.4 Vessel Tracks whilst Towing the Otter Trawl

4.6 Beam Trawl Sampling

The whole catch from each beam trawl was retained. The samples were then boxed, labelled, photographed, iced and stored at +2°C before transportation to Cefas (Lowestoft) for analysis at the end of the survey, in line with the agreed Terms of Reference.

The start and end times, co-ordinates and the duration of each beam trawl are given in Table 4.6 (control and East Anglia FOUR tows highlighted green and red respectively). The vessel tracks whilst towing the beam trawl are illustrated in Figure 4.5.

Table 4.6 Start and End Times, Co-ordinates and Duration of each Beam Trawl

Station	Date	Start				End				Duration (mm:ss)
		Time (GMT)	UTM31N		Depth (m)	Time (GMT)	UTM31N		Depth (m)	
			Easting	Northing			Easting	Northing		
BT09	17/05/2013	14:12:30	485,296.8	5,847,818.1	38.0	14:32:30	485,214.6	5,844,813.5	39.1	20:00
BT10	20/05/2013	10:54:08	491,916.4	5,848,279.6	35.0	11:14:08	491,958.9	5,850,568.8	35.0	20:00
BT11	19/05/2013	15:44:49	501,665.3	5,854,278.3	39.2	16:04:49	501,416.5	5,851,662.2	38.3	20:00
BT12	17/05/2013	16:22:30	480,943.6	5,853,810.4	38.1	16:42:30	480,906.3	5,856,170.1	37.2	20:00
BT13	19/05/2013	07:44:05	490,453.2	5,855,225.0	34.9	08:04:04	490,452.7	5,857,910.0	39.2	19:59
BT14	19/05/2013	12:04:40	507,395.7	5,861,997.6	42.5	12:24:40	506,898.6	5,859,953.2	41.6	20:00
BT15	19/05/2013	13:41:27	514,695.7	5,863,391.1	32.8	14:01:27	514,668.1	5,861,047.2	33.2	20:00
BT16	19/05/2013	09:24:48	496,880.8	5,864,713.6	27.5	09:44:48	496,810.0	5,866,903.3	26.6	20:00

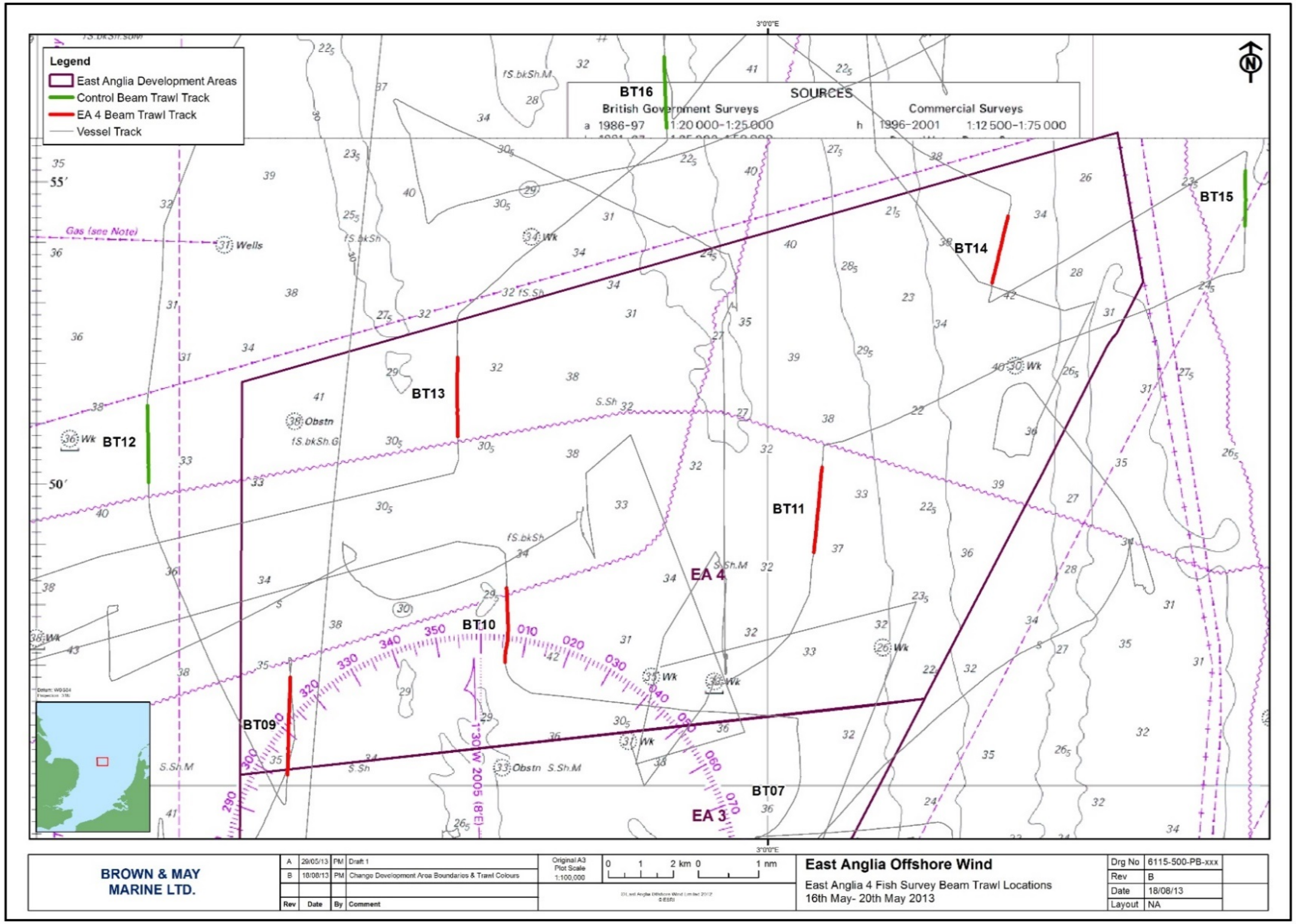


Figure 4.5 Vessel Tracks whilst Towing the Beam Trawl

4.7 2-metre Scientific Beam Trawl Sampling

The start and end times, co-ordinates and the duration of each 2-metre scientific beam trawl are given in Table 4.7 (East Anglia FOUR tows are highlighted red). The start and end points of each 2-metre scientific beam trawl tow are illustrated in Table 4.7.

Table 4.7 Start and End Times, Co-ordinates and Duration of each 2-metre Scientific Beam Trawl

Station	Date	Start				End				Duration (hh:mm)
		Time (GMT)	UTM31N		Depth (m)	Time (GMT)	UTM31N		Depth (m)	
			Easting	Northing			Easting	Northing		
T8	02/05/2013	16:42	500019	5852484	34.3	16:50	500140	5853173	32.2	00:08
T9	05/05/2013	07:58	491003	5846464	30.2	08:06	491142	5846911	30.3	00:08
T10		02:00	487071	5855703	37.5	02:10	487162	5856119	36.9	00:10

Figure 4.6 Start and End Points of each 2-metre Scientific Beam Trawl Tow within East Anglia FOUR

5.0 Otter Trawl Results

5.1 Catch Rates and Species Distribution

The total number of individuals caught and the catch rate (number of individuals caught per hour) for fish and shellfish species by sampling area (control and East Anglia FOUR) are given in Table 5.1 and are illustrated in Figure 5.1 overleaf. The catch rates by sampling station are illustrated in Figure 5.2.

Spatial distribution plots for *L. limanda, P. platessa* and *M. merlangus* are given in Figure 5.3 to Figure 5.4, showing the percentage distribution by catch rate. The circle size corresponds to the catch rate i.e. larger circles indicate greater catch rates.

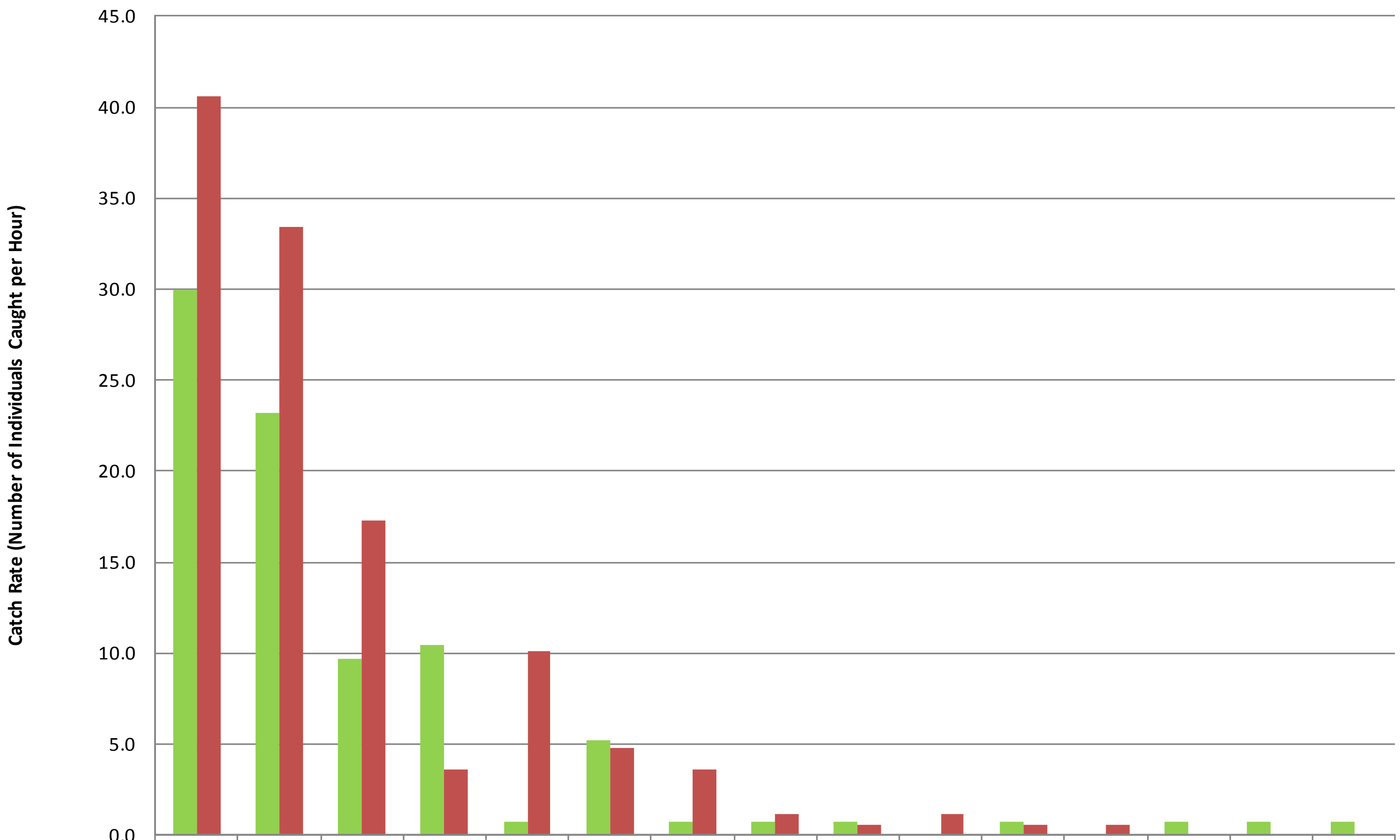
A total of 15 species were caught; 13 at the control stations and 12 within East Anglia FOUR. Overall, *L. limanda* was the most abundant species caught, followed by *P. platessa* and then *M. merlangus*. All other species were caught in relatively low numbers.

The highest catch rate for all species combined was recorded at station OT13 (227.1/hr) within East Anglia FOUR, with *L. limanda* accounting for 43.4% of the catch.

Table 5.1 Total Numbers of Individuals Caught and Catch Rate for Fish and Shellfish Species by Sampling Area

Species		Number of Individuals Caught			Catch Rate (Number of Individuals Caught per Hour)	
Common Name	Scientific Name	Control	East Anglia FOUR	Total	Control	East Anglia FOUR
Dab	*Limanda limanda*	40	68	108	29.9	40.6
Plaice	*Pleuronectes platessa*	31	56	87	23.2	33.4
Whiting	*Merlangius merlangus*	13	29	42	9.7	17.3
Lesser Spotted Dogfish	*Scyliorhinus canicula*	14	6	20	10.5	3.6
Bullrout	*Myoxocephalus scorpius*	1	17	18	0.7	10.1
Grey Gurnard	*Eutrigla gurnardus*	7	8	15	5.2	4.8
Lesser Weever	*Echiichthys vipera*	1	6	7	0.7	3.6
Lemon Sole	*Microstomus kitt*	1	2	3	0.7	1.2
Cod	*Gadus morhua*	1	1	2	0.7	0.6
Three-bearded Rockling	*Gaidropsarus vulgaris*	0	2	2	0.0	1.2
Tub Gurnard	*Trigla lucerna*	1	1	2	0.7	0.6

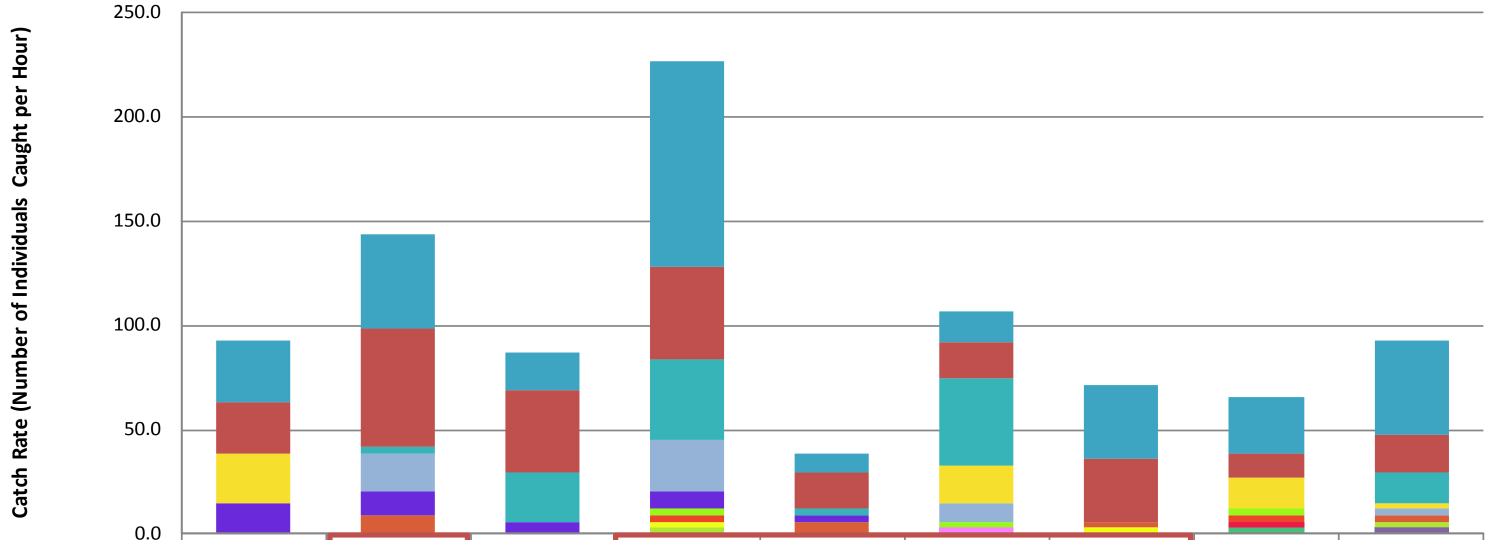
Common Dragonet	*Callionymus lyra*	0	1	1	0.0	0.6
Spotted Ray	*Raja montagui*	1	0	1	0.7	0.0
Thornback Ray	*Raja clavata*	1	0	1	0.7	0.0
Velvet Crab	*Necora puber*	1	0	1	0.7	0.0
Total No. of Individuals		113	197			
Total No. of Species		13	12			
Catch Rate (No. of Individuals Caught per Hour)		84.6	117.6			



	Dab	Plaice	Whiting	Lesser Spotted Dogfish	Bullrout	Grey Gurnard	Lesser Weever	Lemon Sole	Cod	Three-bearded Rockling	Tub Gurnard	Common Dragonet	Spotted Ray	Thornback Ray	Velvet Crab
Control	29.9	23.2	9.7	10.5	0.7	5.2	0.7	0.7	0.7	0.0	0.7	0.0	0.7	0.7	0.7
East Anglia FOUR	40.6	33.4	17.3	3.6	10.1	4.8	3.6	1.2	0.6	1.2	0.6	0.6	0.0	0.0	0.0

Species

Figure 5.1 Catch Rate by Species and Sampling Area



	OT10	OT11	OT12	OT13	OT14	OT15	OT16	OT17	OT18
Dab	30.0	44.9	17.9	98.6	8.9	14.9	35.9	27.0	44.9
Plaice	24.0	56.8	38.9	44.8	17.9	17.9	29.9	12.0	17.9
Whiting	0.0	3.0	23.9	38.8	3.0	41.7	0.0	0.0	15.0
Lesser Spotted Dogfish	24.0	0.0	0.0	0.0	0.0	17.9	0.0	15.0	3.0
Bullrout	0.0	17.9	0.0	23.9	0.0	8.9	0.0	0.0	3.0
Grey Gurnard	15.0	12.0	6.0	9.0	3.0	0.0	0.0	0.0	0.0
Lesser Weever	0.0	9.0	0.0	0.0	6.0	0.0	3.0	0.0	3.0
Lemon Sole	0.0	0.0	0.0	3.0	0.0	3.0	0.0	3.0	0.0
Tub Gurnard	0.0	0.0	0.0	3.0	0.0	0.0	0.0	3.0	0.0
Three-bearded Rockling	0.0	0.0	0.0	3.0	0.0	0.0	3.0	0.0	0.0
Cod	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	3.0
Common Dragonet	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0
Spotted Ray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0
Thornback Ray	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0
Velvet Crab	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0

Station

Figure 5.2 Catch Rate by Species and Station (red boxes denote East Anglia FOUR stations)

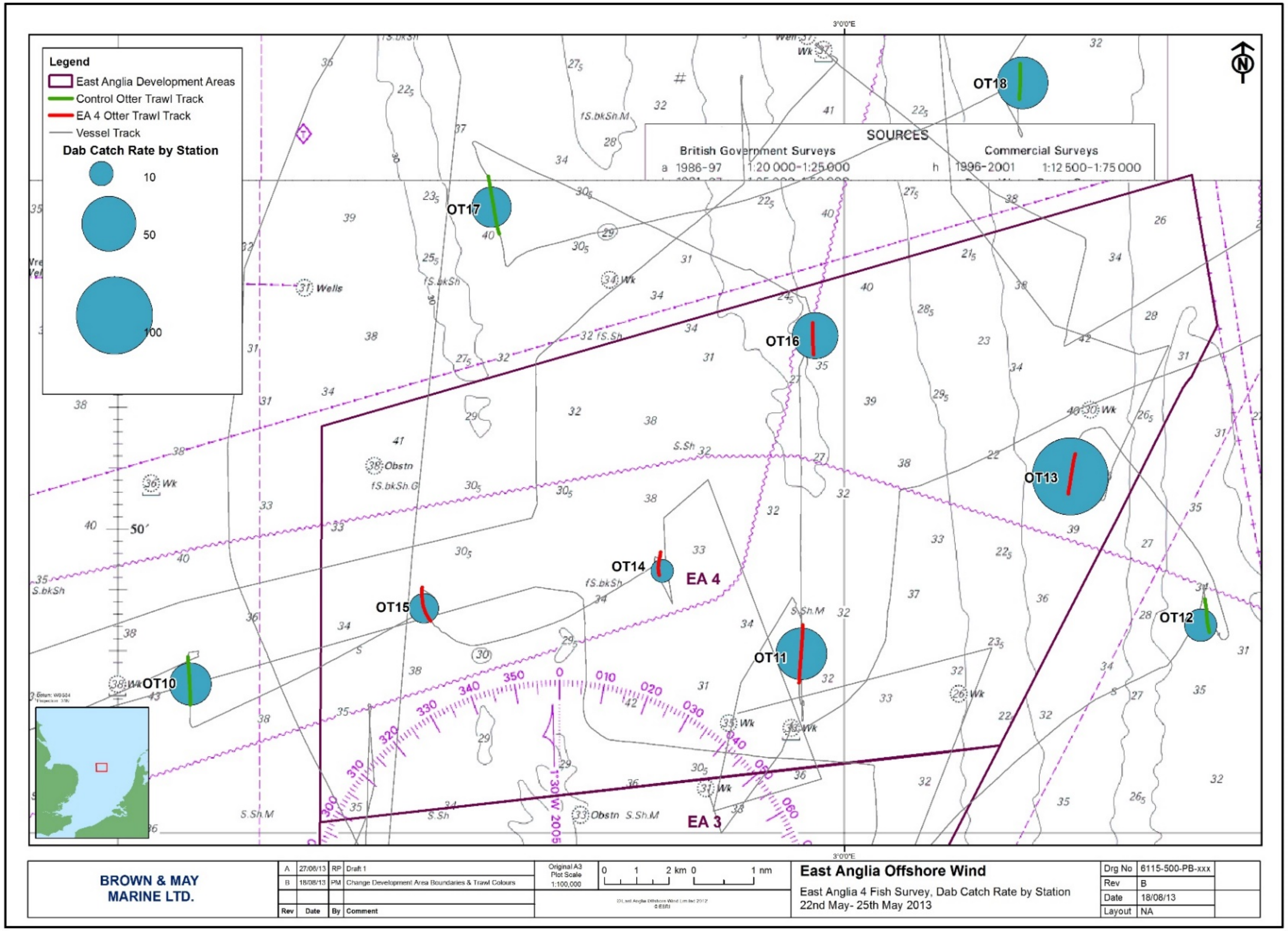


Figure 5.3 Spatial Distribution of Dab (*L. limanda*) in the Area of East Anglia FOUR

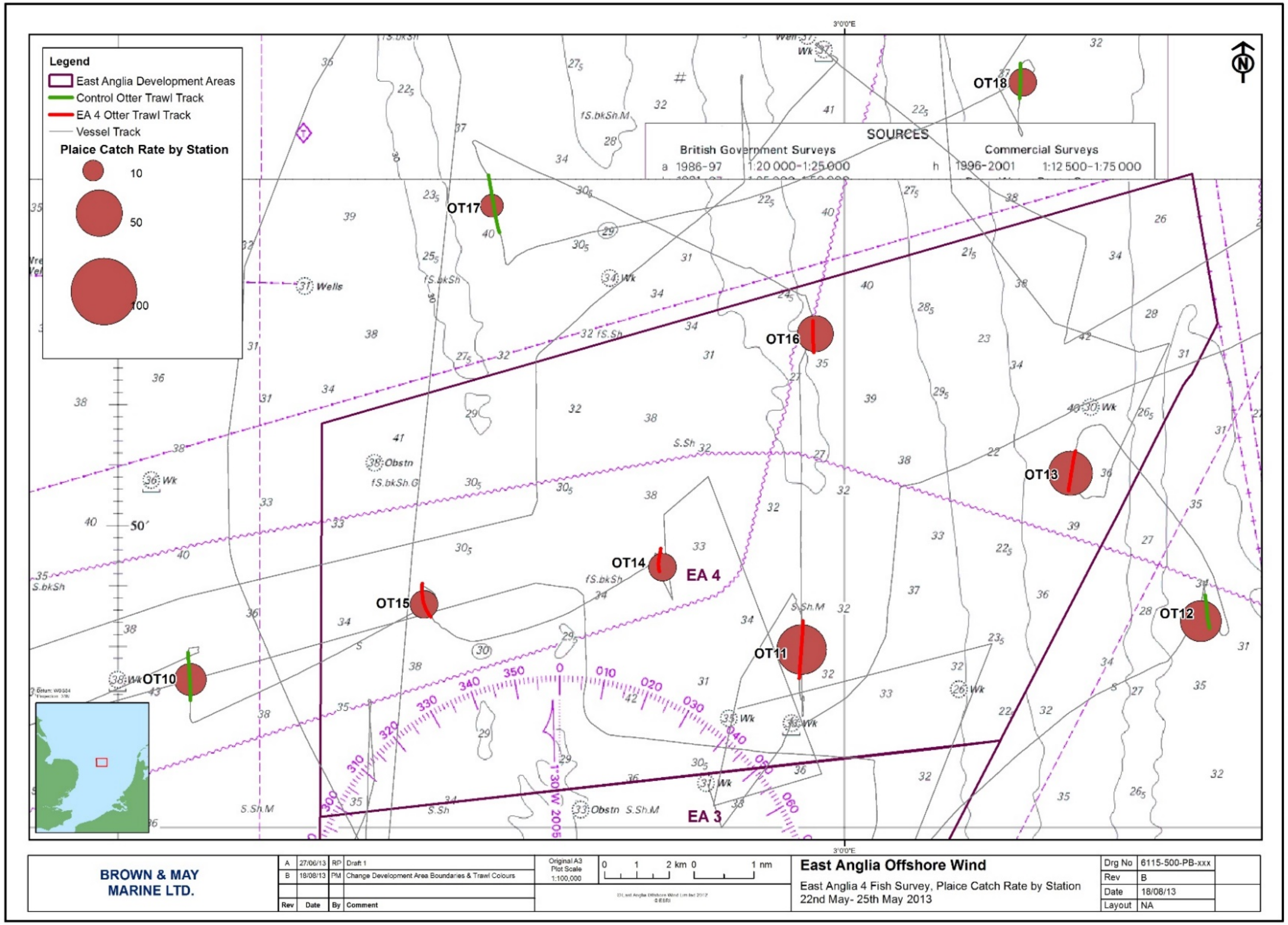


Figure 5.4 Spatial Distribution of Plaice (*P. platessa*) in the Area of East Anglia FOUR

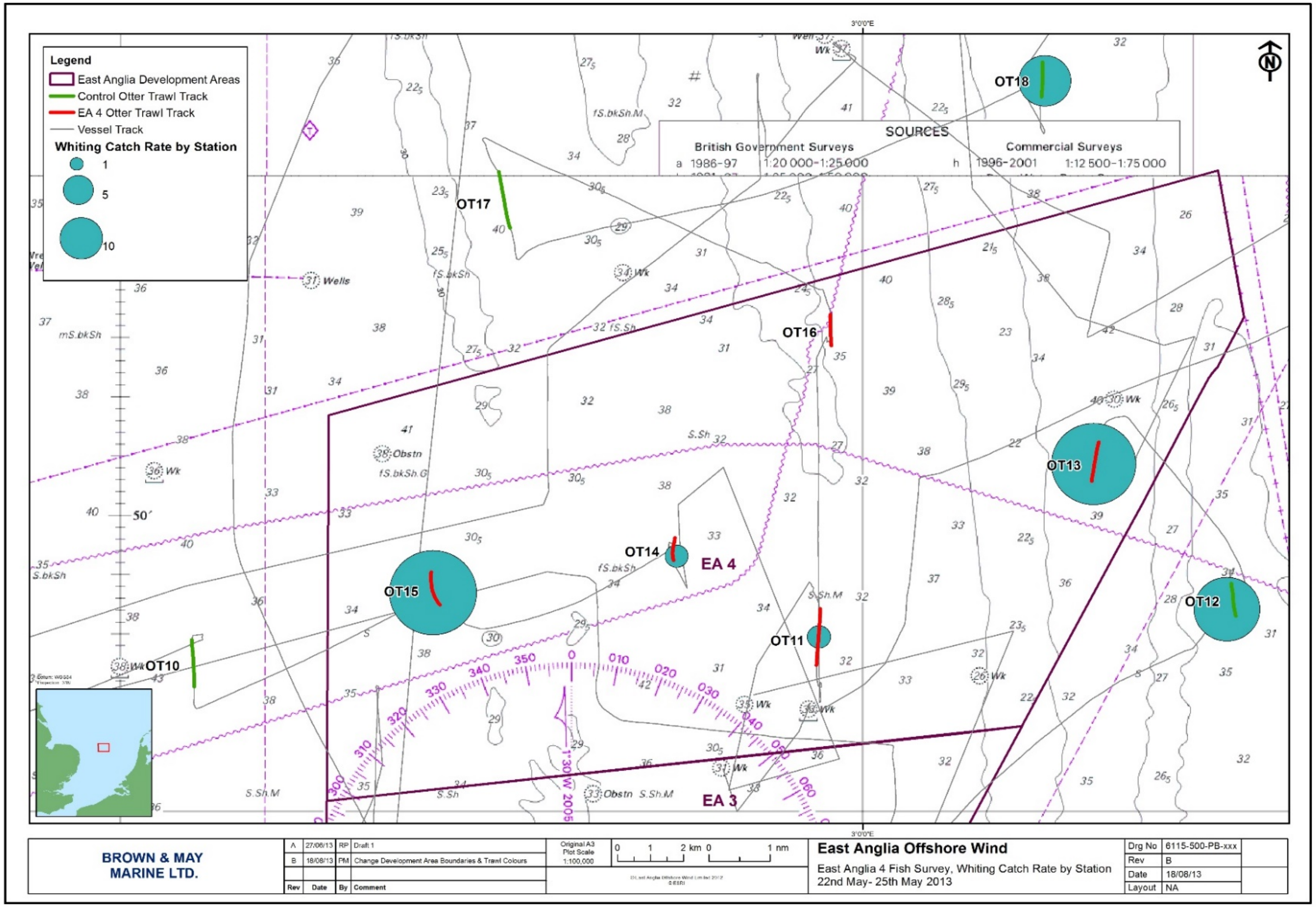


Figure 5.5 Spatial Distribution of Whiting (*M. merlangus*) in the Area of East Anglia FOUR

5.2 Length Distributions

The length distributions of the three most abundant species caught during the survey, expressed as the catch rate (number of individuals caught per hour) by length (cm) and by sampling area (control and East Anglia FOUR), are shown in Figure 5.5 to Figure 5.6 below.

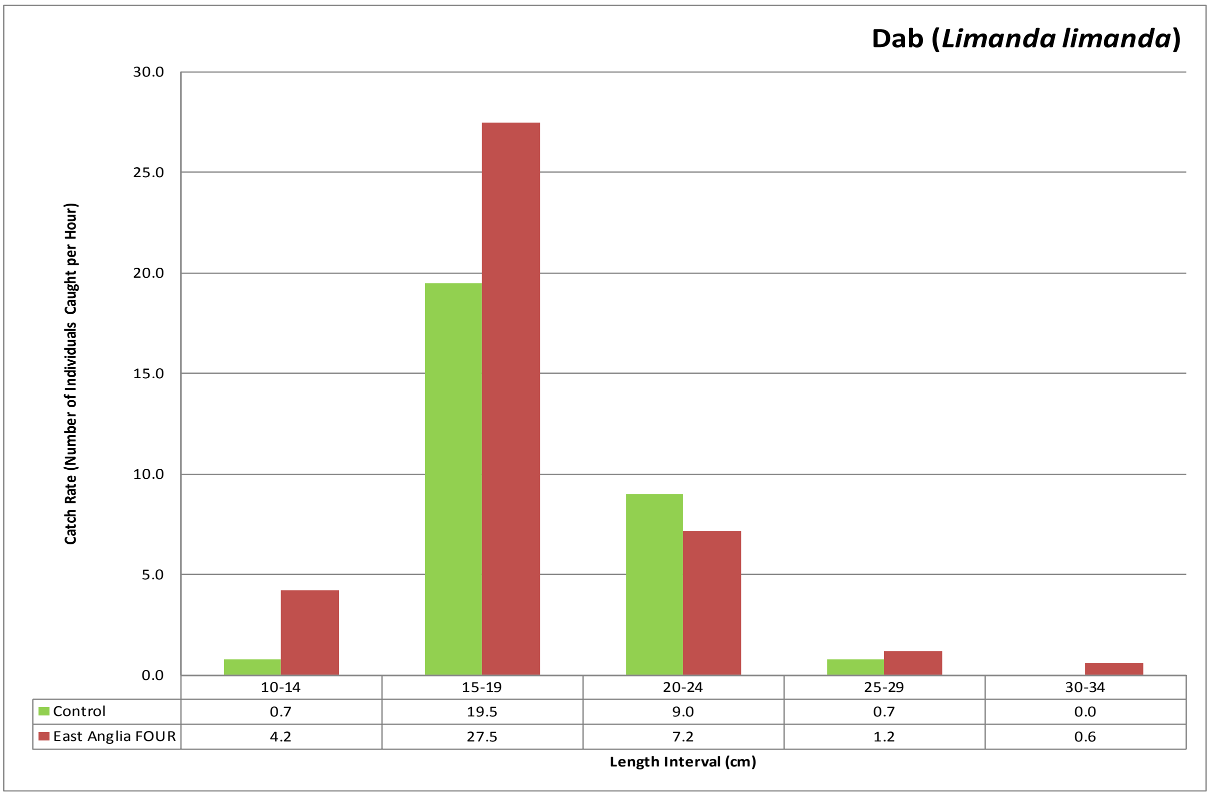


Figure 5.6 Dab (*L. limanda*) Length Distribution by Sampling Area

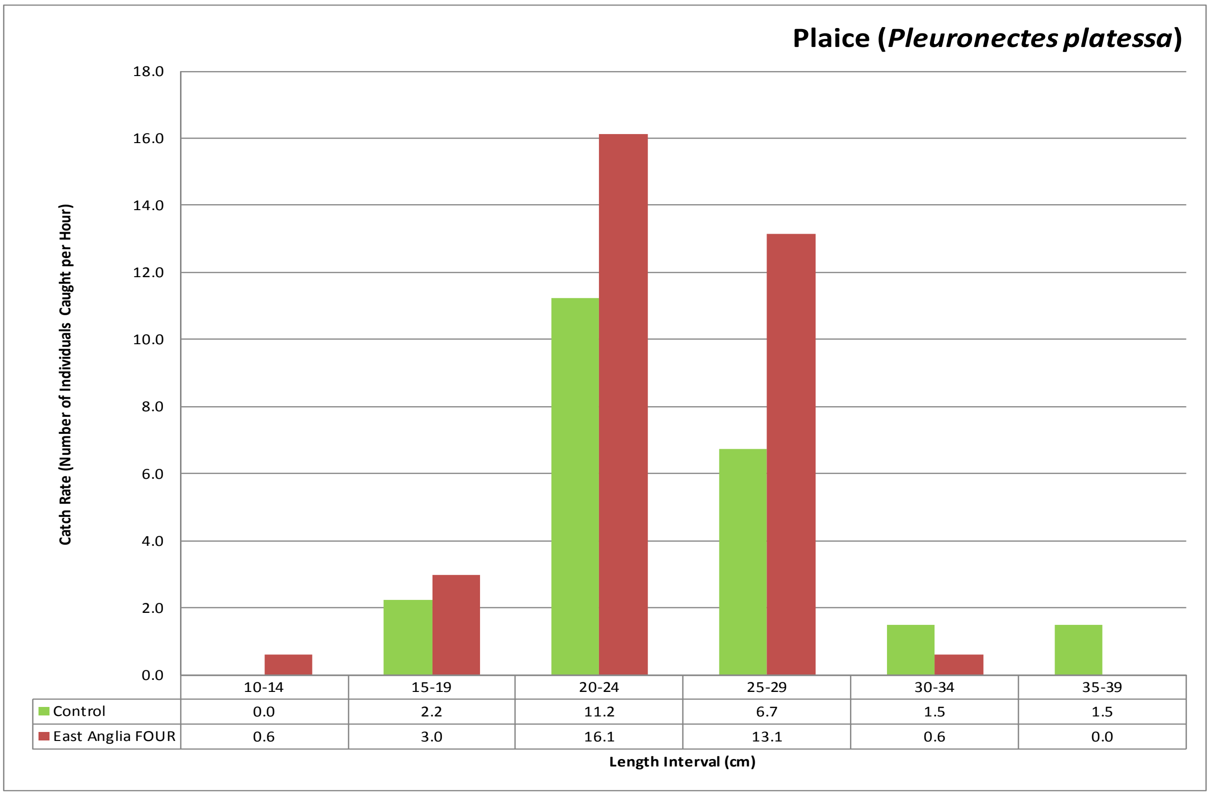


Figure 5.7 Plaice (*P. platessa*) Length Distribution by Sampling Area

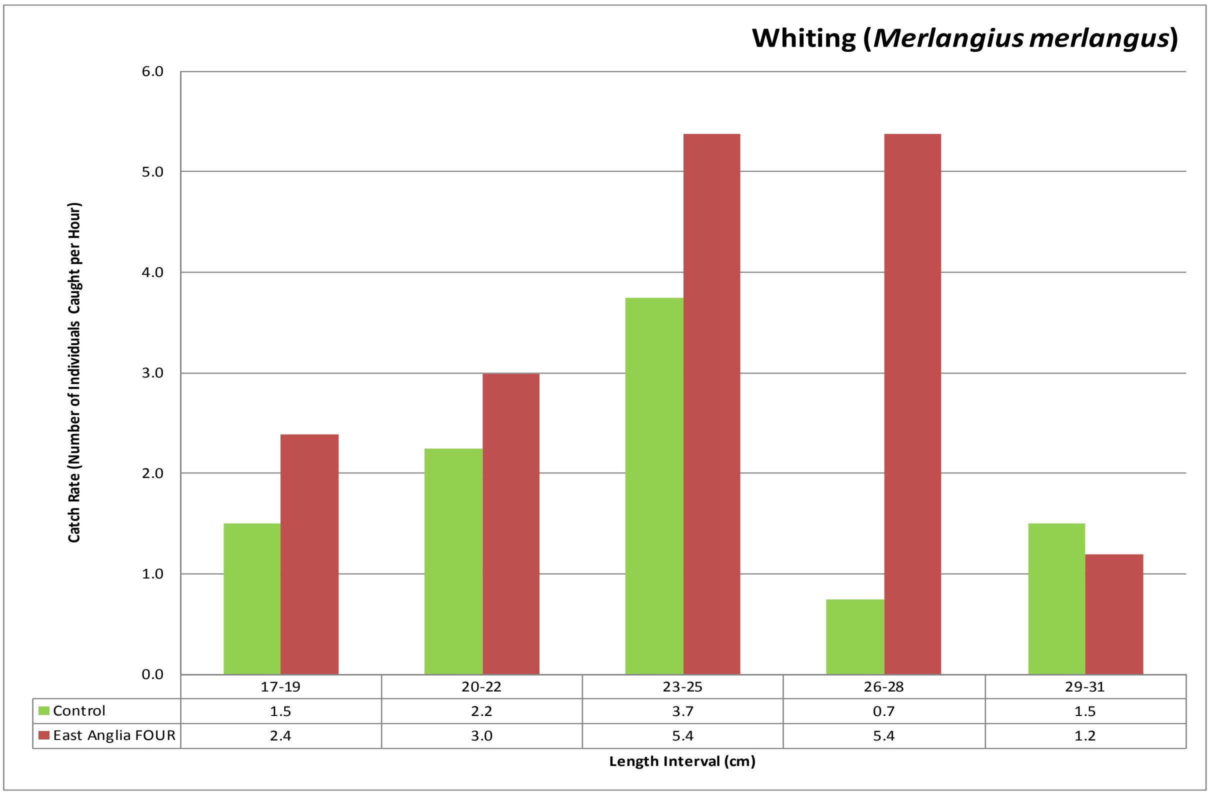


Figure 5.8 Whiting (*M. merlangus*) Length Distribution by Sampling Area

5.3 Minimum Landing Sizes

Minimum landing sizes (MLS) for fish and shellfish species are set by the EC under Regulation No. 850/98 (Annex XII).

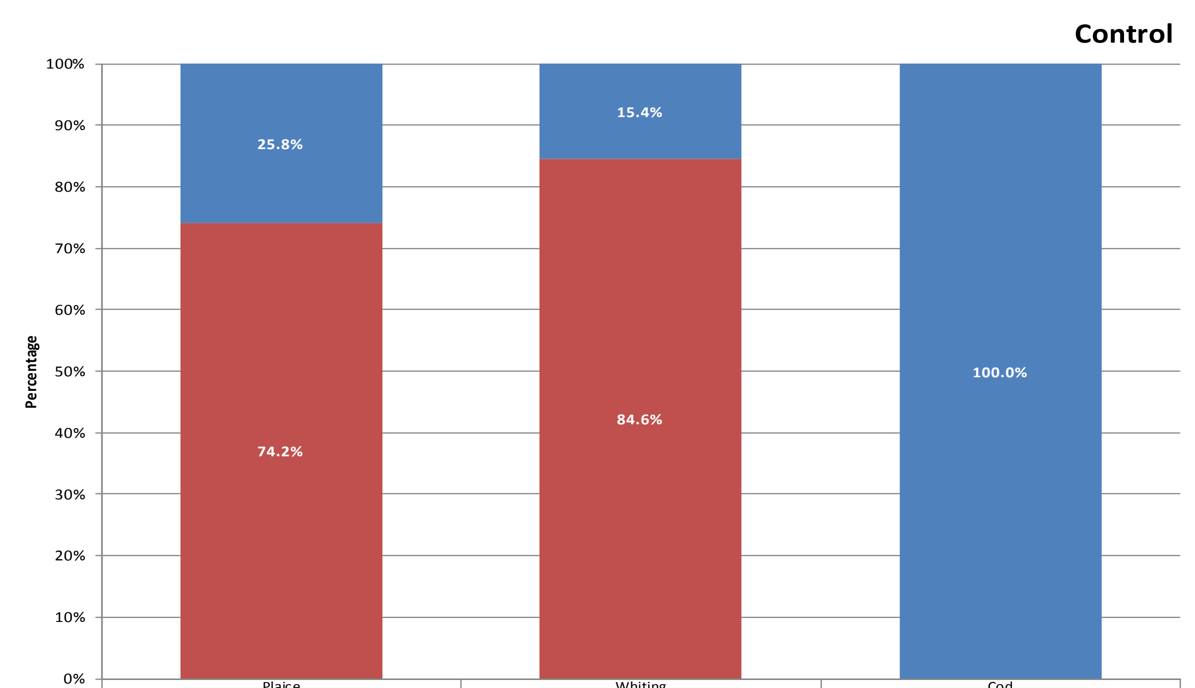
Table 5.2 shows the three fish species caught for which a MLS has been set, and denotes their presence or absence by sampling area (control and East Anglia FOUR).

Table 5.2 MLS Set by EC

Species		EC MLS (cm)	Presence	
Common Name	Scientific Name		Control	East Anglia FOUR
Cod	*Gadus morhua*	35	✓	✓
Plaice	*Pleuronectes platessa*	27	✓	✓
Whiting	*Merlangius merlangus*	27	✓	✓

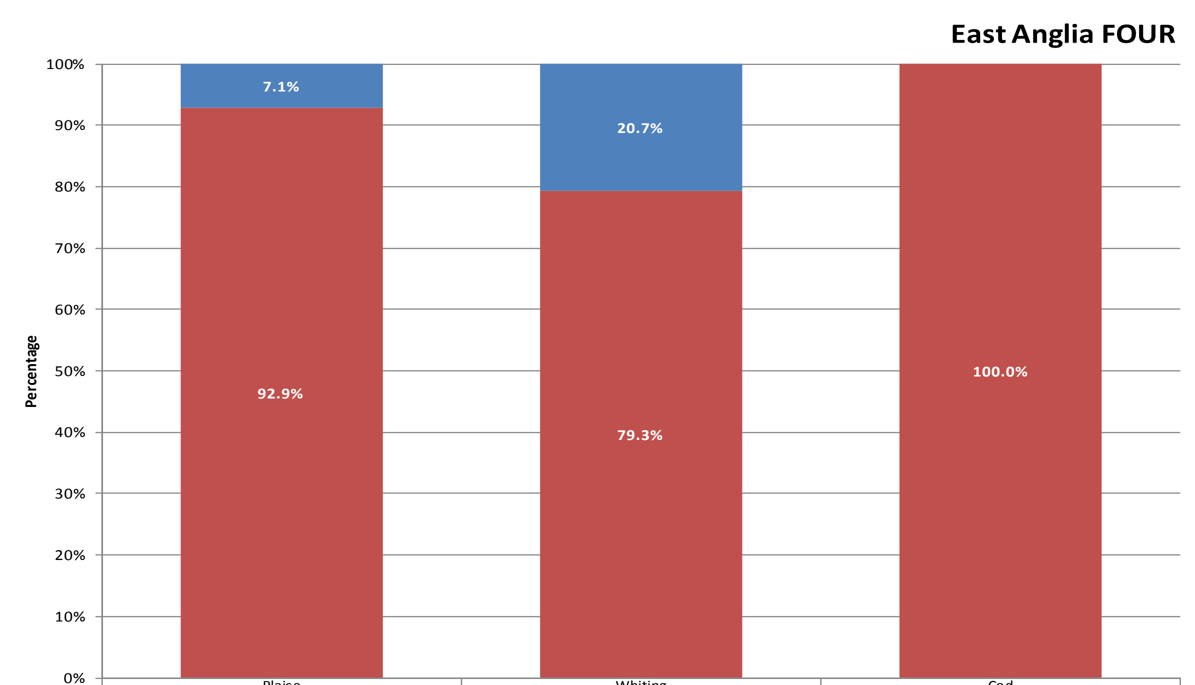
The percentage of individuals caught above and below their set MLS by species is shown in Figure 5.7 and Figure 5.8 for control and East Anglia FOUR stations respectively.

Most of the *P. platessa* (control, 74.2%; East Anglia FOUR, 92.9%) and *M. merlangus* (84.6% and 79.3%) caught at the control stations and within East Anglia FOUR were below the set MLS. One *G. morhua* was caught at the control stations and was above the MLS, and one was found within East Anglia FOUR and was below the MLS.



	Plaice	Whiting	Cod
Above	8	2	1
Below	23	11	0

Figure 5.9 Percentage of the Catch Above and Below the MLS by Species at the Control Stations



	Plaice	Whiting	Cod
Above	4	6	0
Below	52	23	1

Figure 5.10 Percentage of the Catch Above and Below the MLS by Species within East Anglia FOUR

5.4 Sex Ratios

The sex ratios of the three most abundant species caught during the survey are shown in Figure 5.9 and Figure 5.10 for control and East Anglia FOUR stations respectively.

Most of the *L. limanda* (control, 75.0%, East Anglia FOUR, 85.3%) and *P. platessa* (96.8% and 91.1%) caught at the control stations and within East Anglia FOUR were male, whereas the sex ratio for the *M. merlangus* found in both sampling areas was approximately equal.

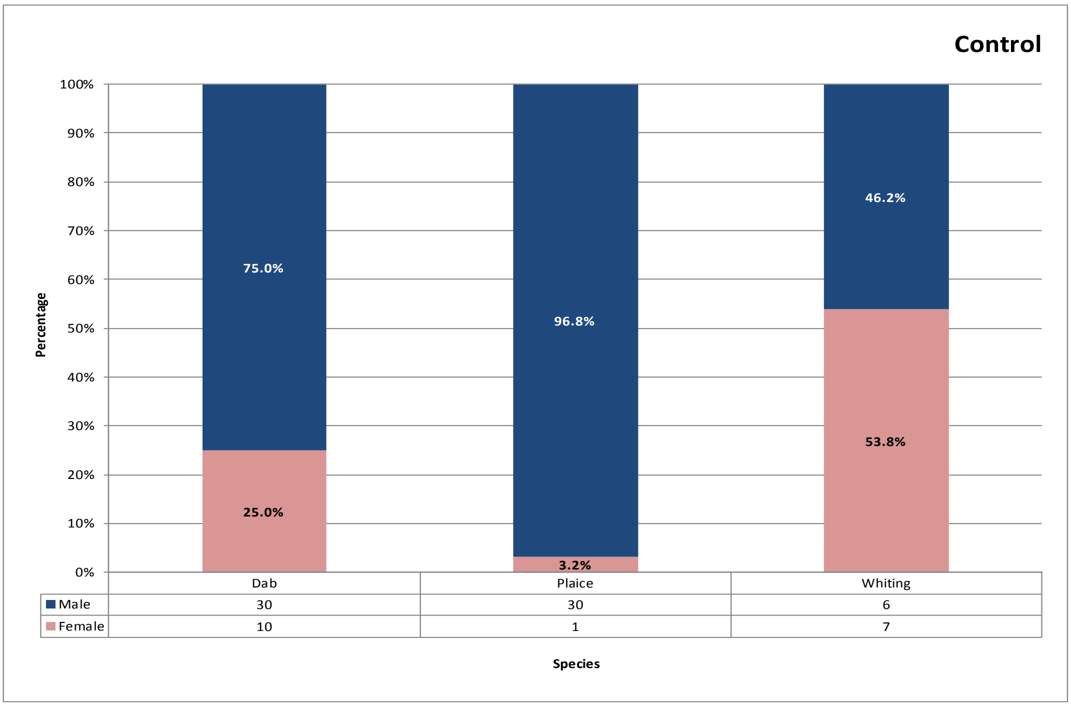


Figure 5.11 Sex Ratio by Species at the Control Stations

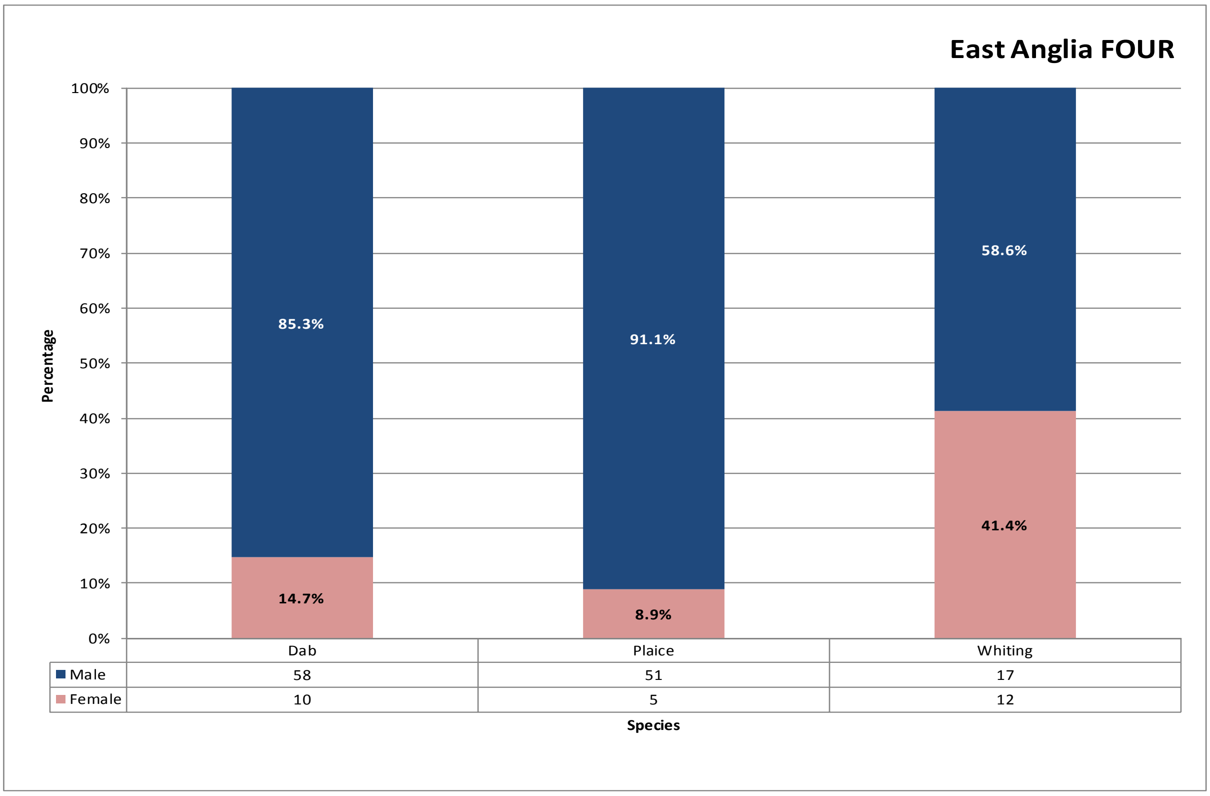


Figure 5.12 Sex Ratio by Species within East Anglia FOUR

5.5 Spawning Condition

The spawning condition, sex and length range (nearest cm below) for the three most abundant species caught during the survey are given below in Table 5.3 to Table 5.4.

The highest proportion of the *L. limanda* caught at the control stations (65.0%) and of the *P. platessa* (control, 74.2%, East Anglia FOUR, 83.9%) and *M. merlangus* (46.2% and 55.2%) caught in both sampling areas were maturing males. The greatest numbers of the *L. limanda* found within East Anglia FOUR were immature (44.1%) and maturing males (36.8%).

Table 5.3 Dab (*L. limanda*) Spawning Condition

Dab							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia FOUR	Total		Min	Max
Female	Immature	6	2	8	7.4%	14	21
	Maturing	4	5	9	8.3%	17	31
	Running	0	3	3	2.8%	19	24
Male	Immature	4	30	34	31.5%	11	21
	Maturing	26	25	51	47.2%	15	28
	Running	0	1	1	0.9%	16	16
	Spent	0	2	2	1.9%	20	20

Table 5.4 Plaice (*P. platessa*) Spawning Condition

Plaice							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia FOUR	Total		Min	Max
Female	Maturing	1	3	4	4.6%	22	29
	Running	0	2	2	2.3%	25	28
Male	Immature	4	1	5	5.7%	11	25
	Maturing	23	47	70	80.5%	17	35
	Running	0	3	3	3.4%	20	25
	Spent	3	0	3	3.4%	26	36

Table 5.5 Whiting (*M. merlangus*) Spawning Condition

Whiting							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia FOUR	Total		Min	Max
Female	Maturing	2	2	4	9.5%	19	27
	Running	2	9	11	26.2%	20	30
	Spent	3	1	4	9.5%	23	26
Male	Immature	0	1	1	2.4%	18	18
	Maturing	6	16	22	52.4%	17	30

6.0 Beam Trawl Results

6.1 Catch Rates and Species Distribution

The total number of individuals caught and the catch rate (number of individuals caught per hour) for fish and shellfish species by sampling area (control and East Anglia FOUR) are given in Table 6.1 below and are illustrated in Figure 6.1. The catch rates by sampling station are shown in Figure 6.2 (red boxes denote stations within East Anglia FOUR).

Spatial distribution plots for *P. platessa* and *L. limanda* are given in Figure 6.3 and Figure 6.4, showing the percentage distribution by catch rate. The circle size corresponds to the catch rate i.e. larger circles indicate greater catch rates.

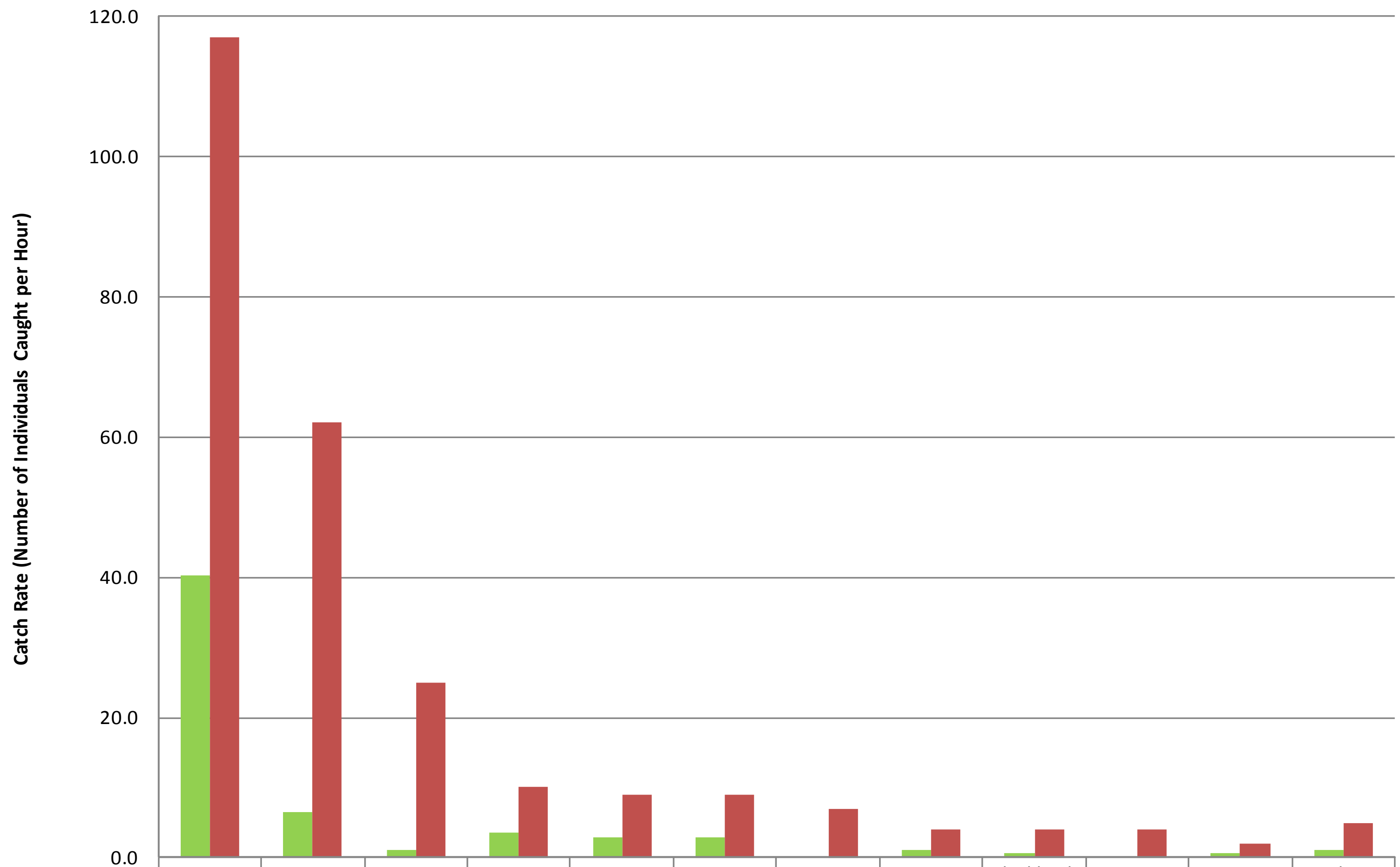
A total of 18 species of fish were caught, 11 of which were found at the control stations and 16 within East Anglia FOUR. Overall, *P. platessa* was the most abundant species caught, followed by *L. limanda*. All other species were caught in relatively low numbers.

The station with the greatest total catch rate was BT14 within East Anglia FOUR (510.0/hr) as in the previous survey, with *L. limanda* and *P. platessa* representing 71.8% of the catch.

Table 6.1 Number of Individuals Caught and the Catch Rate for Fish and Shellfish Species by Sampling Area

Species		Number of Individuals Caught			Catch Rate (Number of Individuals Caught per Hour)	
Common Name	Scientific Name	Control	East Anglia FOUR	Total	Control	East Anglia FOUR
Plaice	*Pleuronectes platessa*	67	117	184	40.2	117.0
Dab	*Limanda limanda*	11	62	73	6.6	62.0
Common Dragonet	*Callionymus lyra*	2	25	27	1.2	25.0
Lesser Weever	*Echiichthys vipera*	6	10	16	3.6	10.0
Solenette	*Buglossidium luteum*	5	9	14	3.0	9.0
Whelk	*Buccinum undatum*	5	9	14	3.0	9.0
Bullrout	*Myoxocephalus scorpius*	0	7	7	0.0	7.0
Whiting	*Merlangius merlangus*	2	4	6	1.2	4.0
Thickback Sole	*Microchirus variegatus*	1	4	5	0.6	4.0
Pogge	*Agonus cataphractus*	0	4	4	0.0	4.0
Dover Sole	*Solea solea*	1	2	3	0.6	2.0
Edible Crab	*Cancer pagurus*	1	0	1	0.6	0.0
Grey Gurnard	*Eutrigla gurnardus*	0	1	1	0.0	1.0

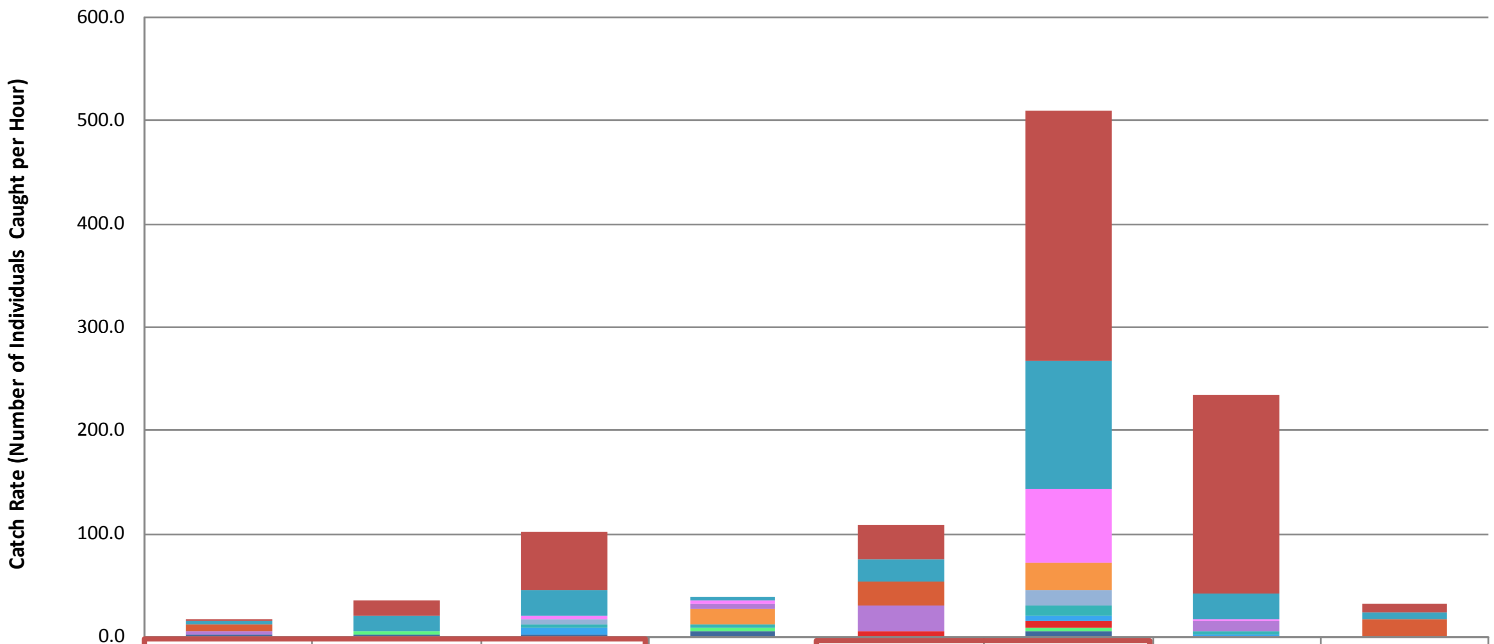
Lemon Sole	*Microstomus kitt*	0	1	1	0.0	1.0
Lesser Spotted Dogfish	*Scyliorhinus canicula*	0	1	1	0.0	1.0
Scaldfish	*Arnoglossus laterna*	0	1	1	0.0	1.0
Squid	*Alloteuthis sp.*	0	1	1	0.0	1.0
Squid	*Loligo sp.*	1	0	1	0.6	0.0
Total No. of Individuals		102	258			
Total No. of Species		11	16			
Catch Rate (No. of Individuals Caught per Hour)		61.2	258.0			



	Plaice	Dab	Common Dragonet	Lesser Weever	Solenette	Whelk	Bullrout	Whiting	Thickback Sole	Pogge	Dover Sole	Other Species
Control	40.2	6.6	1.2	3.6	3.0	3.0	0.0	1.2	0.6	0.0	0.6	1.2
East Anglia FOUR	117.0	62.0	25.0	10.0	9.0	9.0	7.0	4.0	4.0	4.0	2.0	5.0

Species

Figure 6.1 Catch Rates for Fish and Shellfish Species by Sampling Area



	BT09	BT10	BT11	BT12	BT13	BT14	BT15	BT16
Plaice	3.0	15.0	57.0	0.0	33.0	243.0	192.0	9.0
Dab	3.0	15.0	24.0	3.0	21.0	123.0	24.0	6.0
Common Dragonet	0.0	0.0	3.0	3.0	0.0	72.0	3.0	0.0
Lesser Weever	6.0	0.0	0.0	0.0	24.0	0.0	0.0	18.0
Solenette	3.0	0.0	0.0	6.0	24.0	0.0	9.0	0.0
Whelk	0.0	0.0	0.0	15.0	0.0	27.0	0.0	0.0
Bullrout	0.0	0.0	6.0	0.0	0.0	15.0	0.0	0.0
Whiting	0.0	0.0	3.0	3.0	0.0	9.0	3.0	0.0
Thickback Sole	0.0	0.0	6.0	0.0	0.0	6.0	3.0	0.0
Pogge	0.0	0.0	0.0	0.0	6.0	6.0	0.0	0.0
Dover Sole	0.0	3.0	0.0	3.0	0.0	3.0	0.0	0.0
Other Species	3.0	3.0	3.0	6.0	0.0	6.0	0.0	0.0

Station

Figure 6.2 Catch Rates for Fish and Shellfish Species by Station (red box denotes East Anglia FOUR stations)

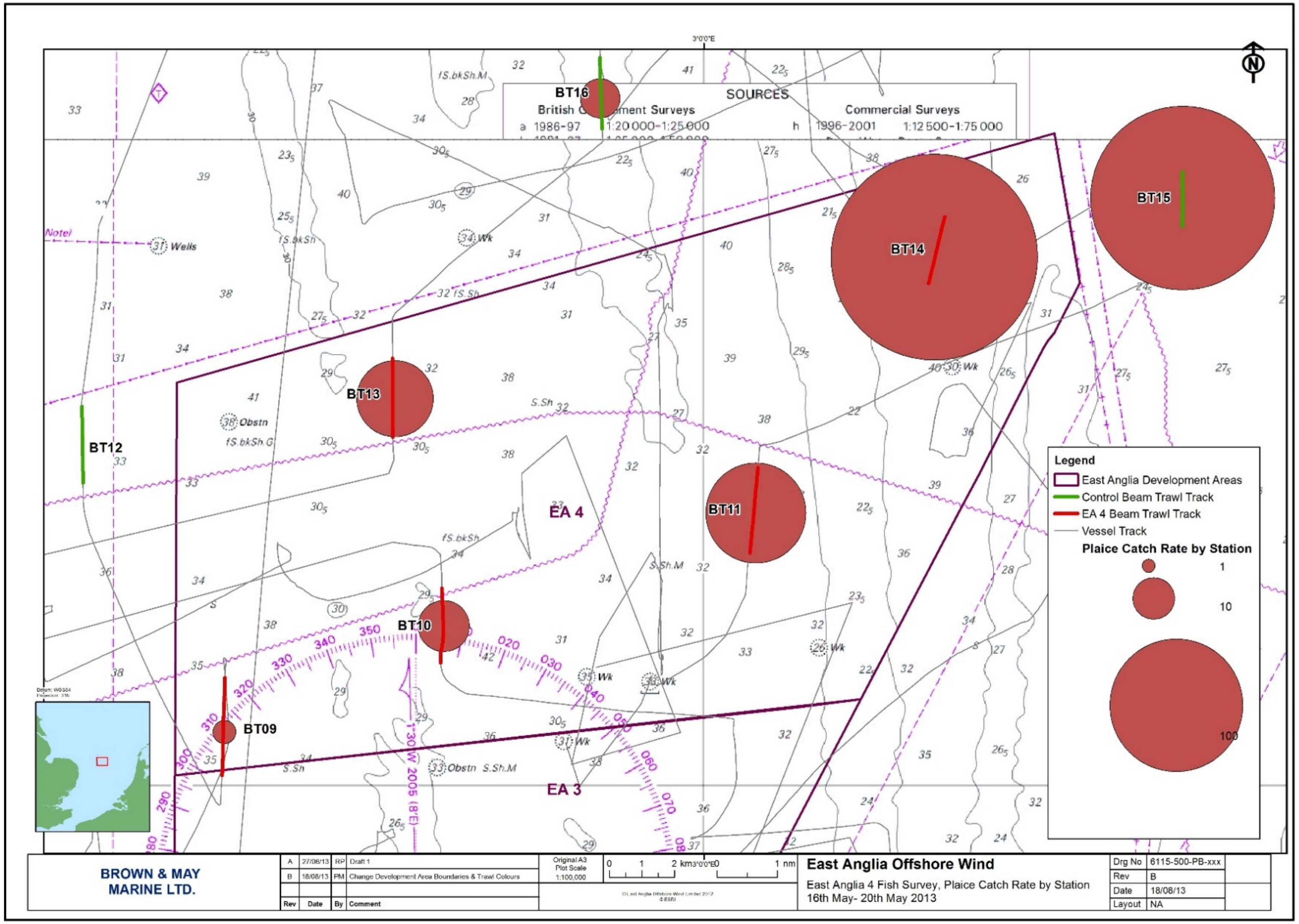


Figure 6.3 Spatial Distribution of Plaice (*P. platessa*) in the Area of East Anglia FOUR

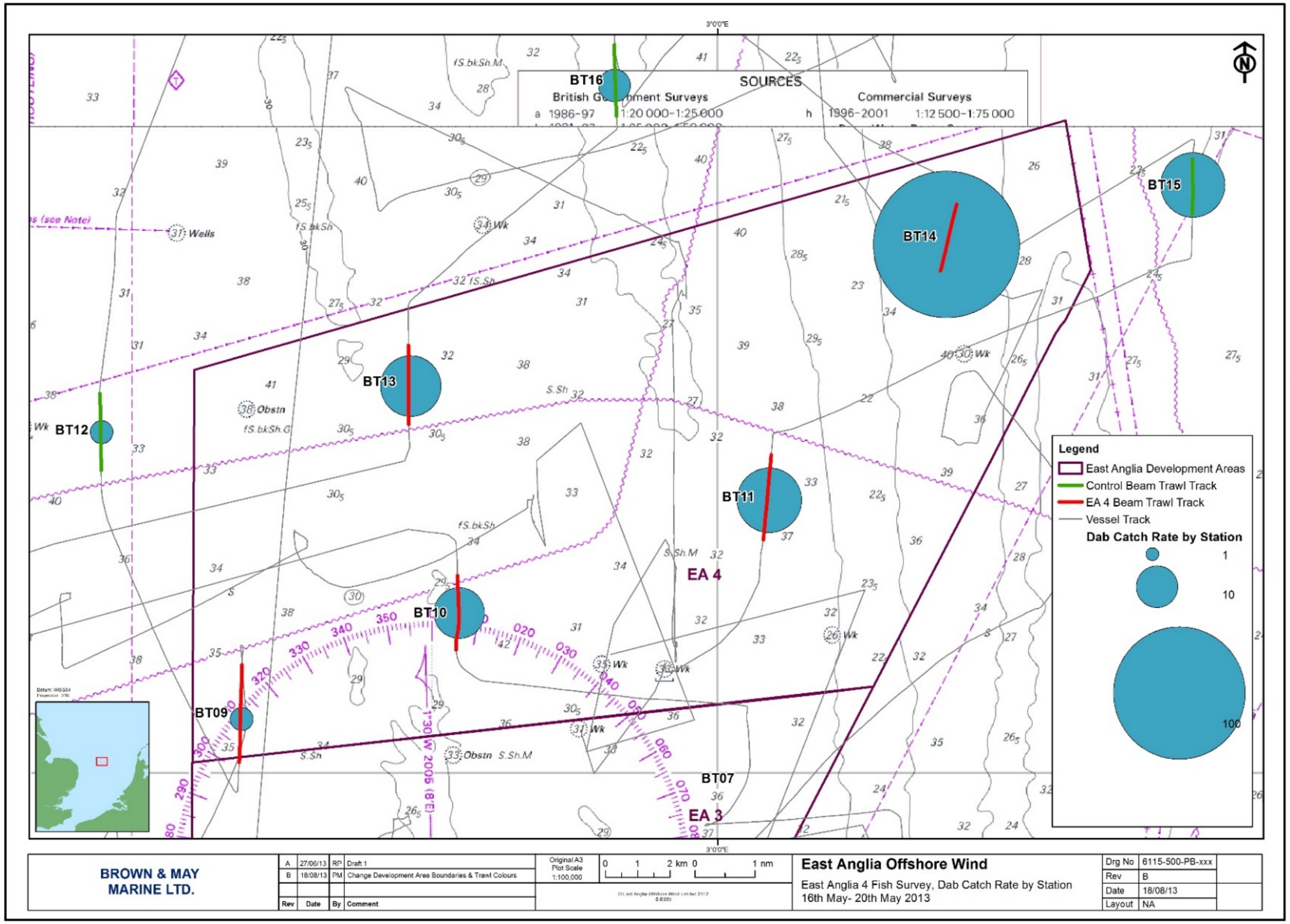
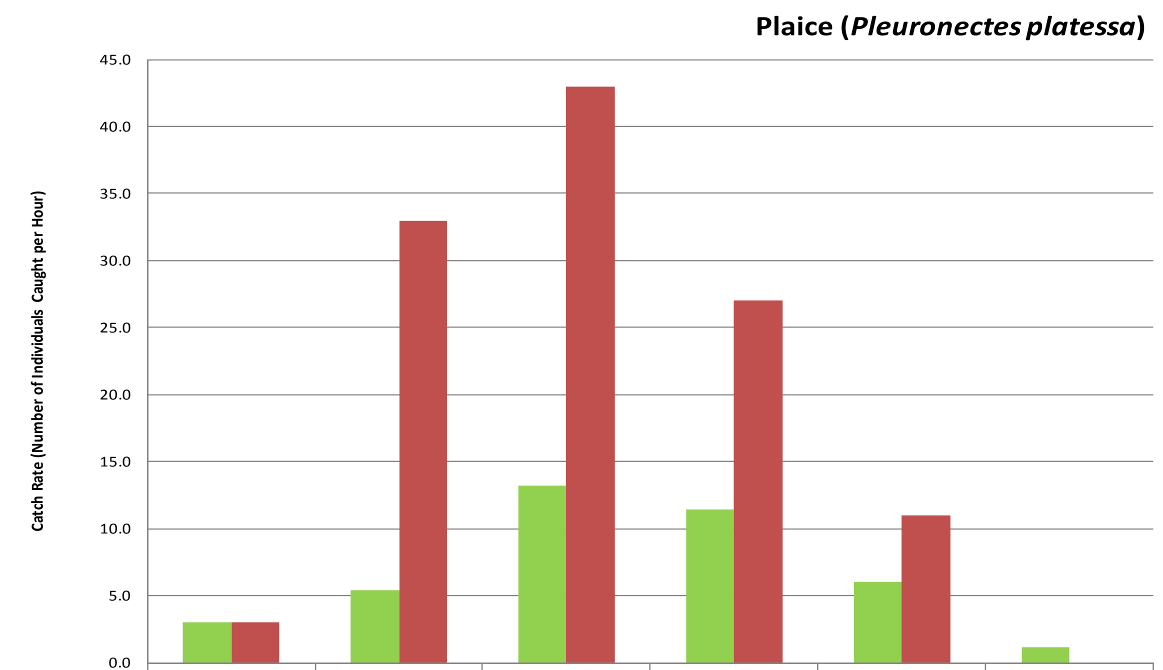


Figure 6.4 Spatial Distribution of Dab (*L. limanda*) in the Area of East Anglia FOUR

6.2 Length Distributions

The length distributions of the two most abundant species caught during the survey, expressed as the catch rate (number of individuals caught per hour) by length (cm) and by sampling area (control and East Anglia FOUR), are shown in Figure 6.5 and Figure 6.6 below.



	10-14	15-19	20-24	25-29	30-34	35-39
Control	3.0	5.4	13.2	11.4	6.0	1.2
East Anglia FOUR	3.0	33.0	43.0	27.0	11.0	0.0

Figure 6.5 Plaice (*P. platessa*) Length Distribution by Sampling Area

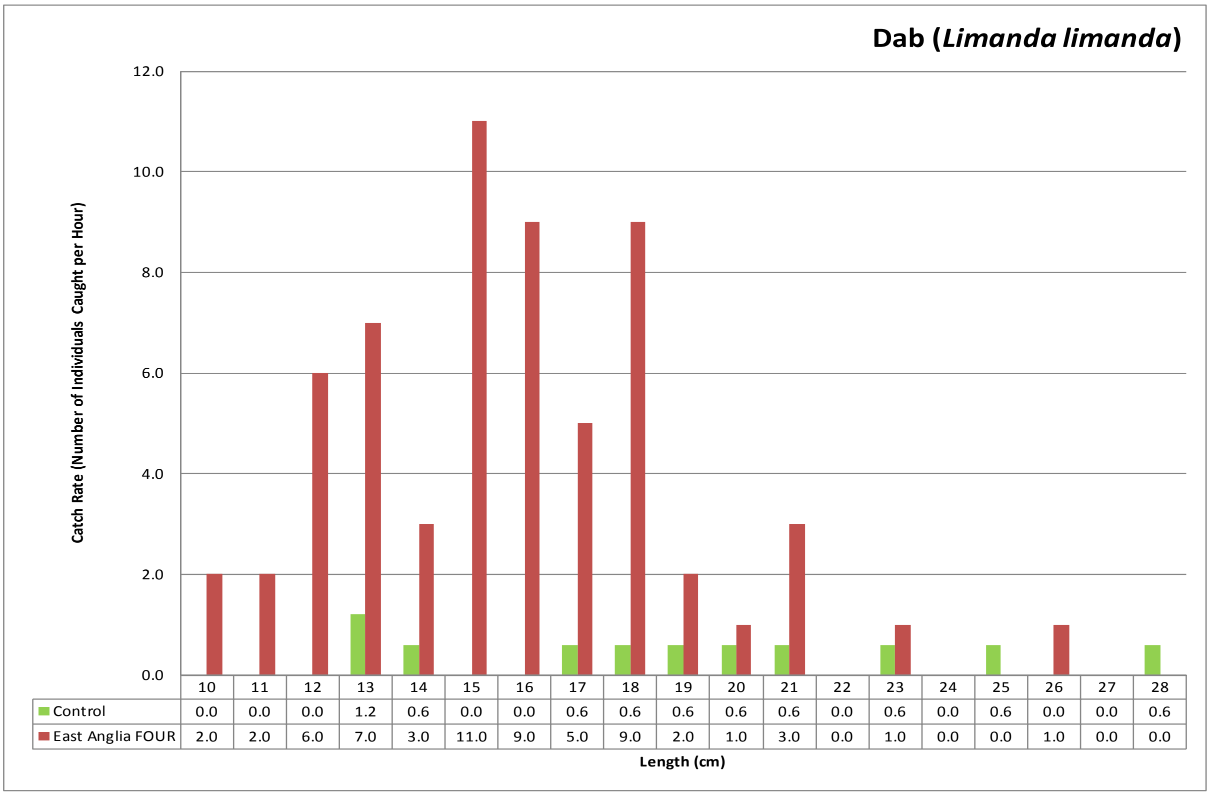


Figure 6.6 Dab (*L. limanda*) Length Distribution by Sampling Area

6.3 Minimum Landing Sizes

Table 6.2 shows the five fish and shellfish species caught for which an EC MLS has been set and denotes their presence or absence by sampling area (control and East Anglia FOUR).

Table 6.2 MLS Set by EC

Species		EC MLS (cm)	Presence	
Common Name	Scientific Name		Control	East Anglia FOUR
Dover Sole	*Solea solea*	24	✓	✓
Plaice	*Pleuronectes platessa*	27	✓	✓
Whiting	*Merlangius merlangus*	27	✓	✓
Edible Crab	*Cancer pagurus*	13	✓	–
Whelk	*Buccinum undatum*	4.5	✓	✓

The percentage of individuals caught above and below their set MLS by species is shown in Figure 6.7 and Figure 6.8 for control and East Anglia FOUR stations respectively.

The majority of the *P. platessa* caught at the control stations (70.1%) and within East Anglia FOUR (84.6%) were below the MLS. All other species were caught in relatively low numbers.

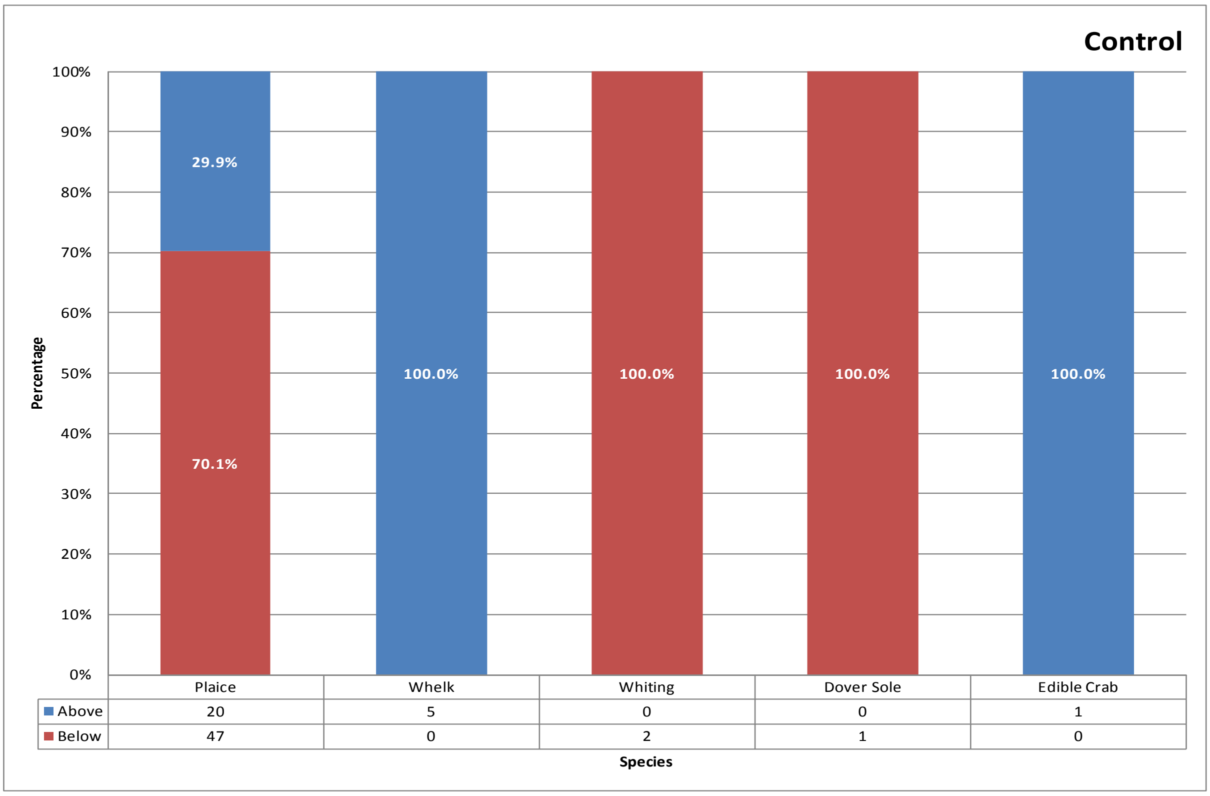


Figure 6.7 Percentage of the Catch Above and Below the MLS by Species at the Control Stations

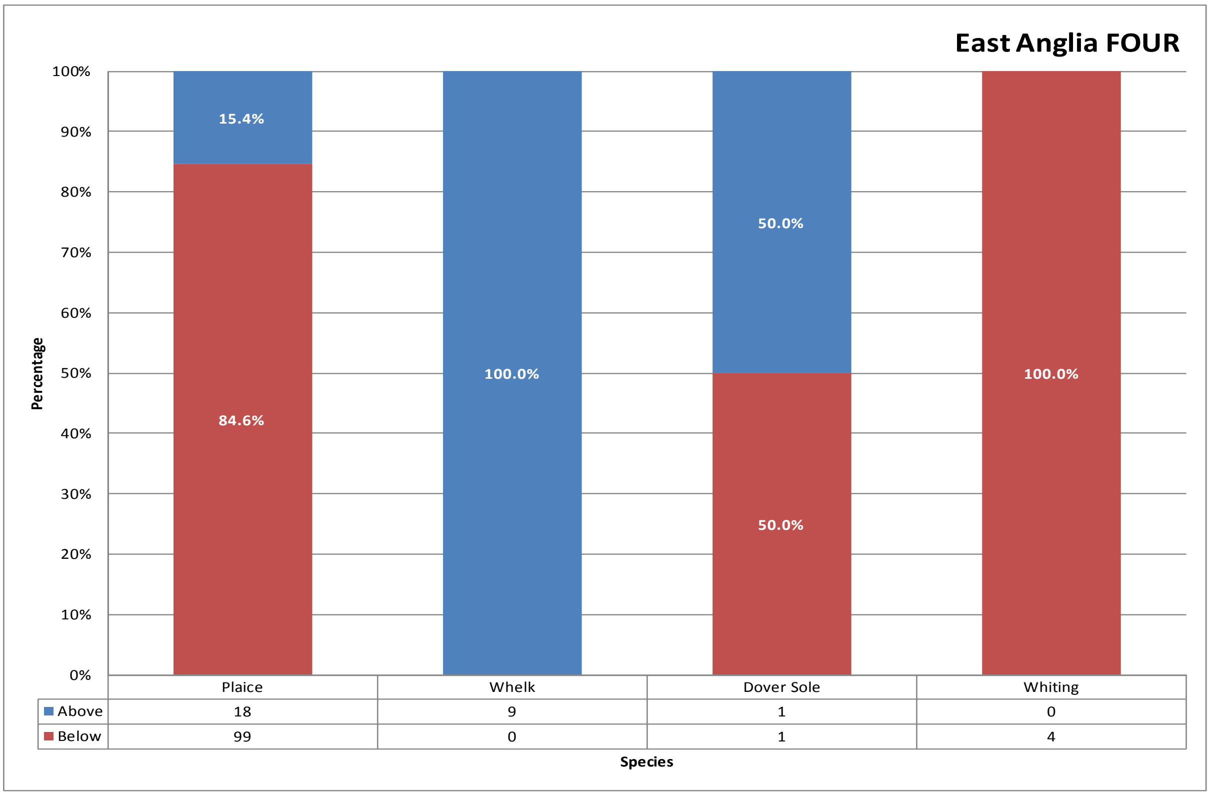


Figure 6.8 Percentage of the Catch Above and Below the MLS by Species within East Anglia FOUR

6.4 Sex Ratios

The sex ratios of the two most abundant species caught during the beam trawl survey are shown in Figure 6.9 and Figure 6.10 for control and East Anglia FOUR stations respectively.

The majority of the *P. platessa* caught at the control stations (97.0%) and within East Anglia FOUR (83.8%) were male. A higher proportion of the *L. limanda* caught at the control stations were female (72.7%), whereas within East Anglia FOUR males were more prevalent (61.3%).

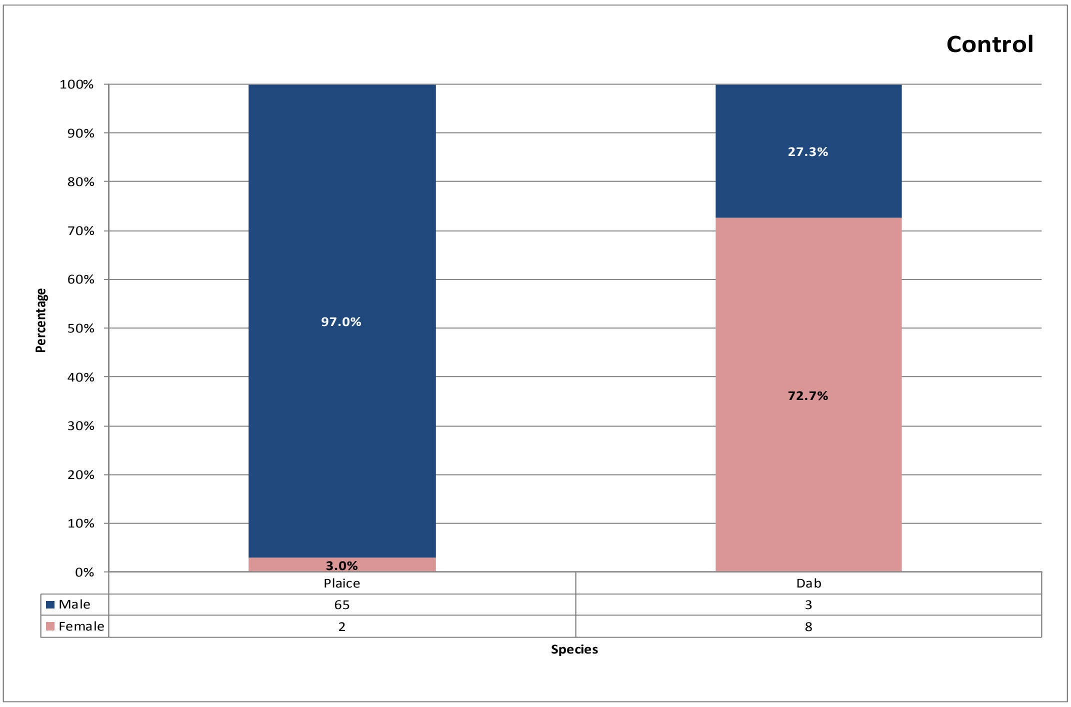


Figure 6.9 Sex Ratio by Species at the Control Stations

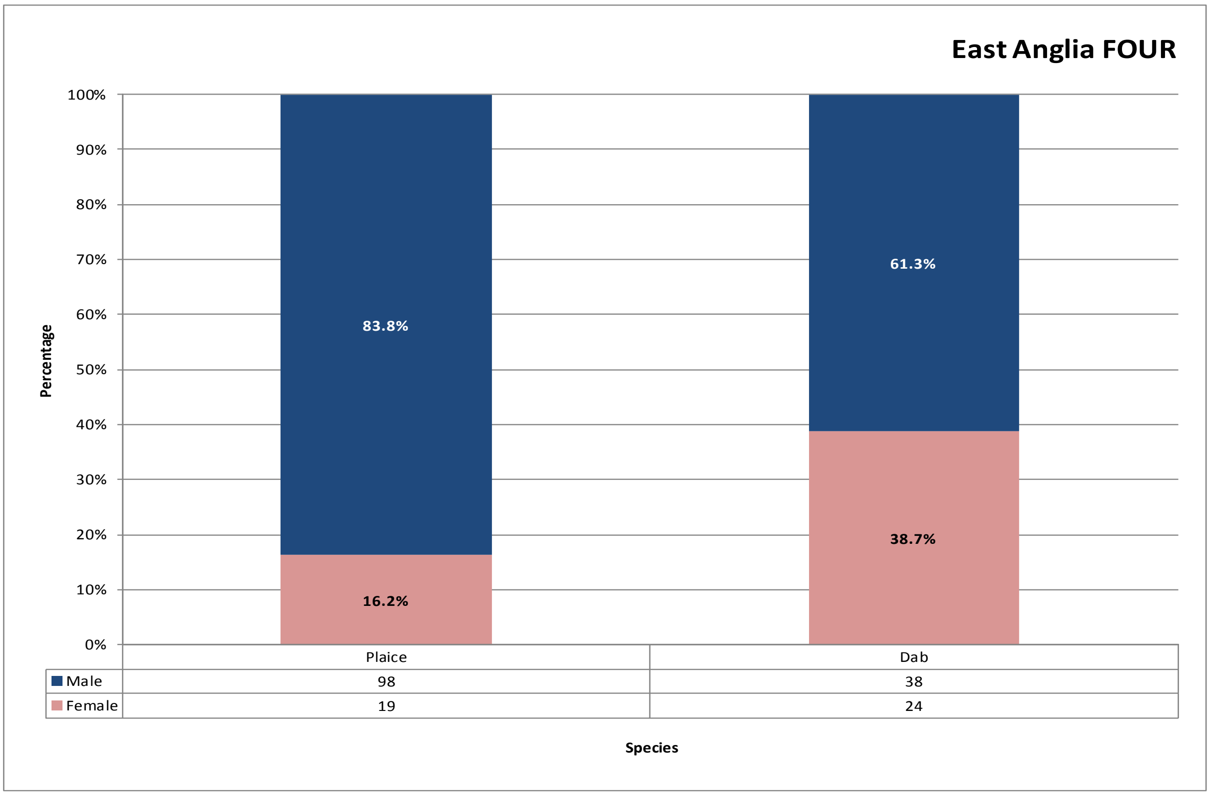


Figure 6.10 Sex Ratio by Species within East Anglia FOUR

6.5 Spawning Condition

The spawning condition, sex and length range (nearest cm below) for the two most abundant species caught during the beam trawl survey are given below in Table 6.3 and Table 6.4.

Most of the *P. platessa* caught at the control stations (80.6%) and within East Anglia FOUR (77.8%) were maturing males. Low numbers of immature, maturing, running and spent *L. limanda* were caught at the control stations, and the majority of those found within East Anglia FOUR were either immature (53.2%) or maturing (45.2%).

Table 6.3 Plaice (*P. platessa*) Spawning Condition

Plaice							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia FOUR	Total		Min	Max
Female	Immature	0	4	4	2.2%	15	25
	Maturing	1	8	9	4.9%	21	26
	Running	0	7	7	3.8%	24	33
	Spent	1	0	1	0.5%	36	36
Male	Immature	3	5	8	4.3%	12	23
	Maturing	54	91	145	78.8%	11	33
	Spent	8	2	10	5.4%	25	35

Table 6.4 Dab (*L. limanda*) Spawning Condition

Dab							
Sex	Maturity	Individuals Caught			% of Total Catch	Length Range (cm)	
		Control	East Anglia FOUR	Total		Min	Max
Female	Immature	2	14	16	21.9%	11	19
	Maturing	3	9	12	16.4%	16	26
	Running	2	1	3	4.1%	16	25
	Spent	1	0	1	1.4%	28	28
Male	Immature	2	19	21	28.8%	10	18
	Maturing	0	19	19	26.0%	15	21
	Spent	1	0	1	1.4%	21	21

7.0 Scientific 2-metre Beam Trawl Results

7.1 Fish Catch Rates and Species Distribution

The total number of individuals caught and the catch rate (number of individuals caught per hour) by fish species and sampling area are given in Table 7.1 and illustrated overleaf in Figure 7.1. The catch rates for fish species by sampling station are given in Figure 7.2.

A total of 16 species of fish were caught in the East Anglia FOUR scientific beam trawl survey. Overall, *B. luteum* were the most abundant species caught followed by *P. minutus*, with all other species found in relatively low numbers. The highest total catch rate was recorded at station T9 (1,741.9/hr), with *B. luteum* accounting for 60.0% of the catch.

Table 7.1 Total Numbers of Individuals Caught and Catch Rate for Fish Species within East Anglia FOUR

Species		Number of Individuals Caught in East Anglia FOUR	Catch Rate (Number of Individuals Caught per Hour) in East Anglia FOUR
Common Name	Scientific Name		
Solenette	*Buglossidium luteum*	294	695.9
Sand Goby	*Pomatoschistus minutus*	73	172.8
Lesser Weever	*Echiichthys vipera*	35	82.8
Scaldfish	*Arnoglossus laterna*	16	37.9
Dab	*Limanda limanda*	12	28.4
Common Dragonet	*Callionymus lyra*	8	18.9
Sprat	*Sprattus sprattus*	6	14.2
Greater Sandeel	*Hyperoplus lanceolatus*	4	9.5
3-bearded Rockling	*Gaidropsarus vulgaris*	3	7.1
Pogge	*Agonus cataphractus*	3	7.1
Reticulated Dragonet	*Callionymus reticulatus*	3	7.1
Spotted Dragonet	*Callionymus maculatus*	3	7.1
Whiting	*Merlangius merlangus*	3	7.1
Bony Fish Larvae	Osteichthyes (larvae)	2	4.7
Great Pipefish	*Syngnathus acus*	1	2.4
Plaice	*Pleuronectes platessa*	1	2.4
Total No. of Individuals		467	
Total No. of Species		16	
Catch Rate (No. of Individuals Caught per Hour)		1,105.3	

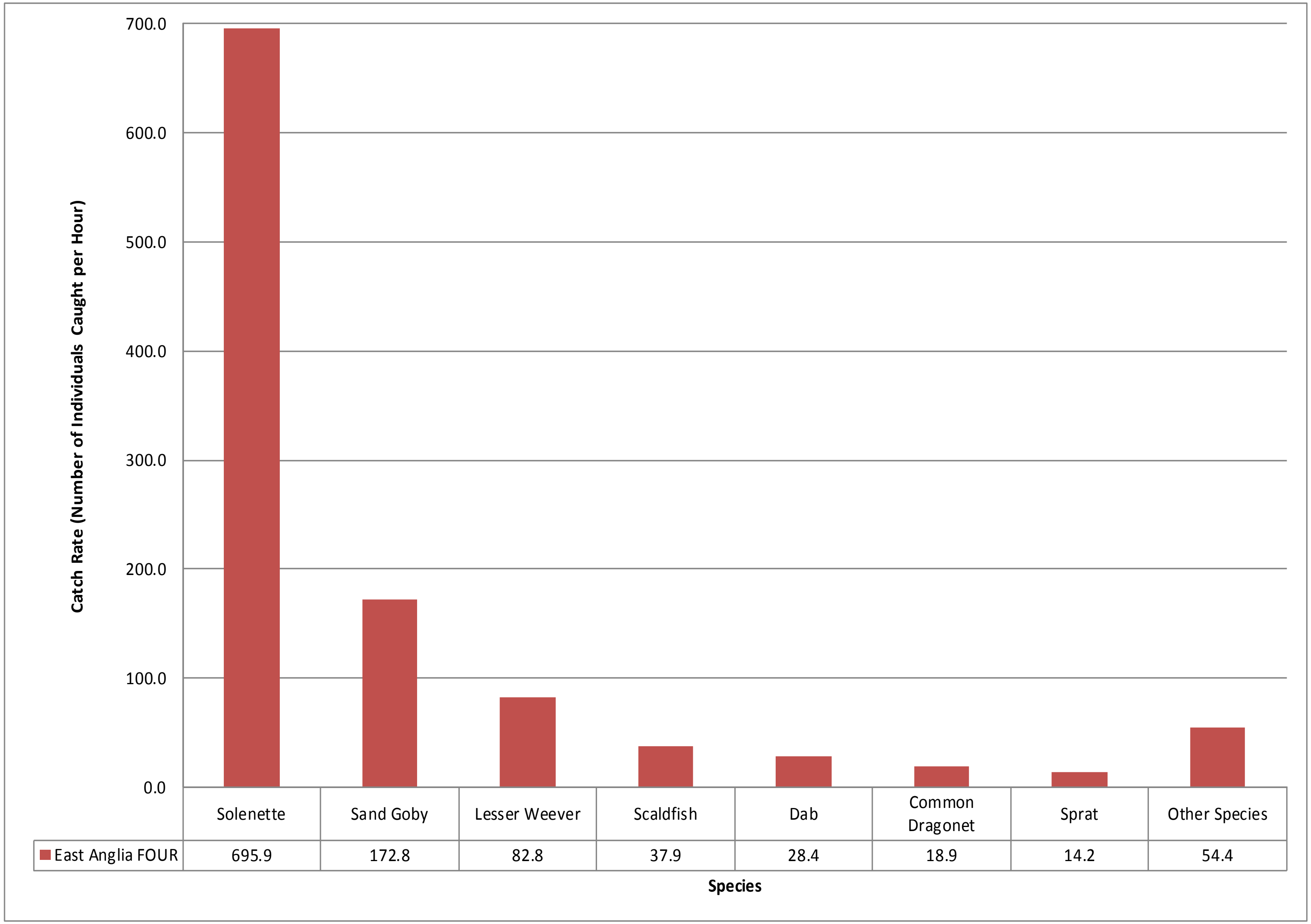
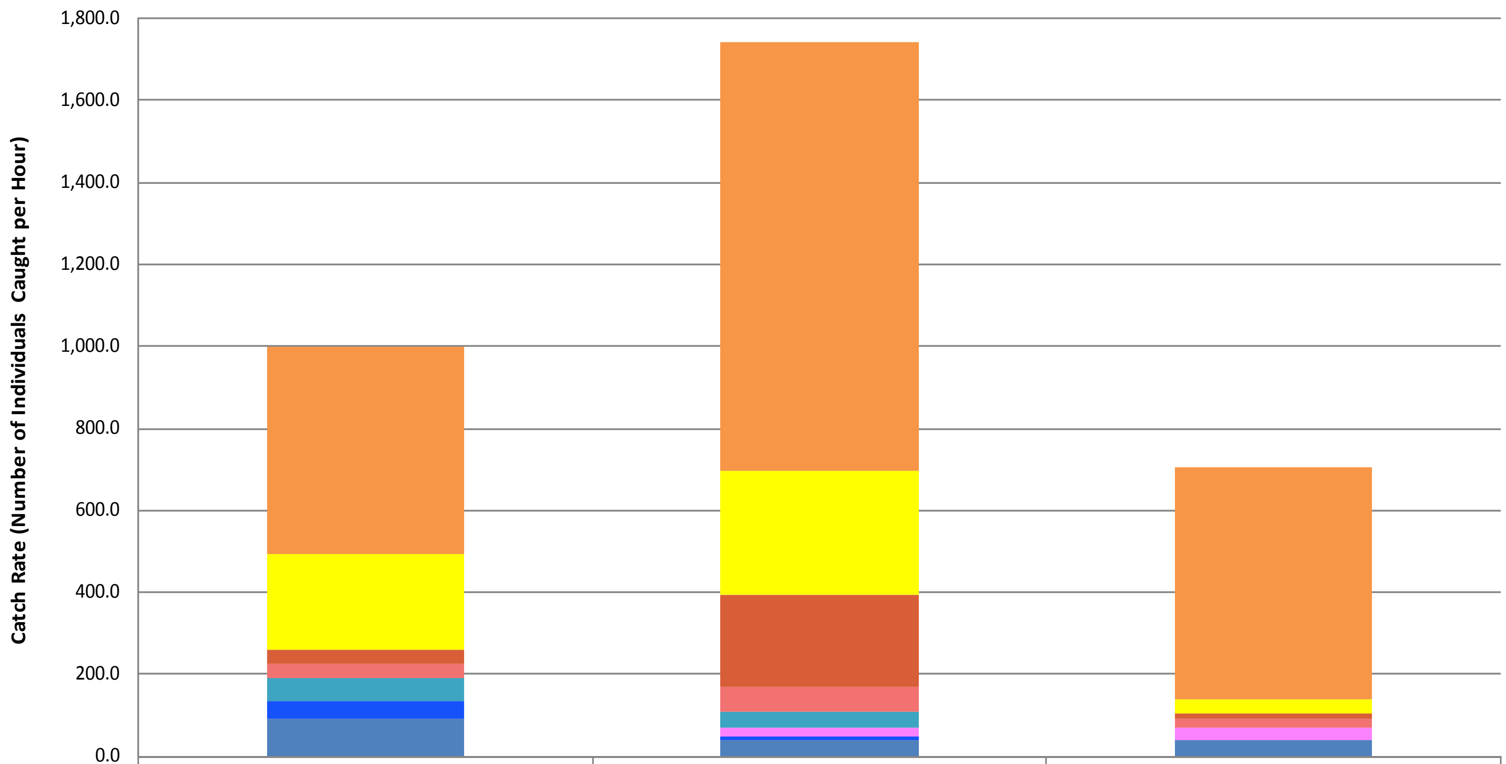


Figure 7.1 Catch Rates for Fish Species for Stations within East Anglia FOUR



	T8	T9	T10
Solenette	508.3	1,045.2	565.4
Sand Goby	233.3	301.9	34.6
Lesser Weever	33.3	224.5	11.5
Scaldfish	33.3	61.9	23.1
Dab	58.3	38.7	0.0
Common Dragonet	0.0	23.2	28.8
Sprat	41.7	7.7	0.0
Other Species	91.7	38.7	40.4

Station

Figure 7.2 Catch Rates for Fish Species by Station within East Anglia FOUR

7.2 Fish Length Distributions

The length distributions of *B. luteum* and *P. minutus*, expressed as the catch rate (number of individuals caught per hour) by length (mm), are shown in Figure 7.3 and Figure 7.4. It should be noted that the poisonous *E. vipera* is not measured as a safety precaution and is therefore excluded from this section.

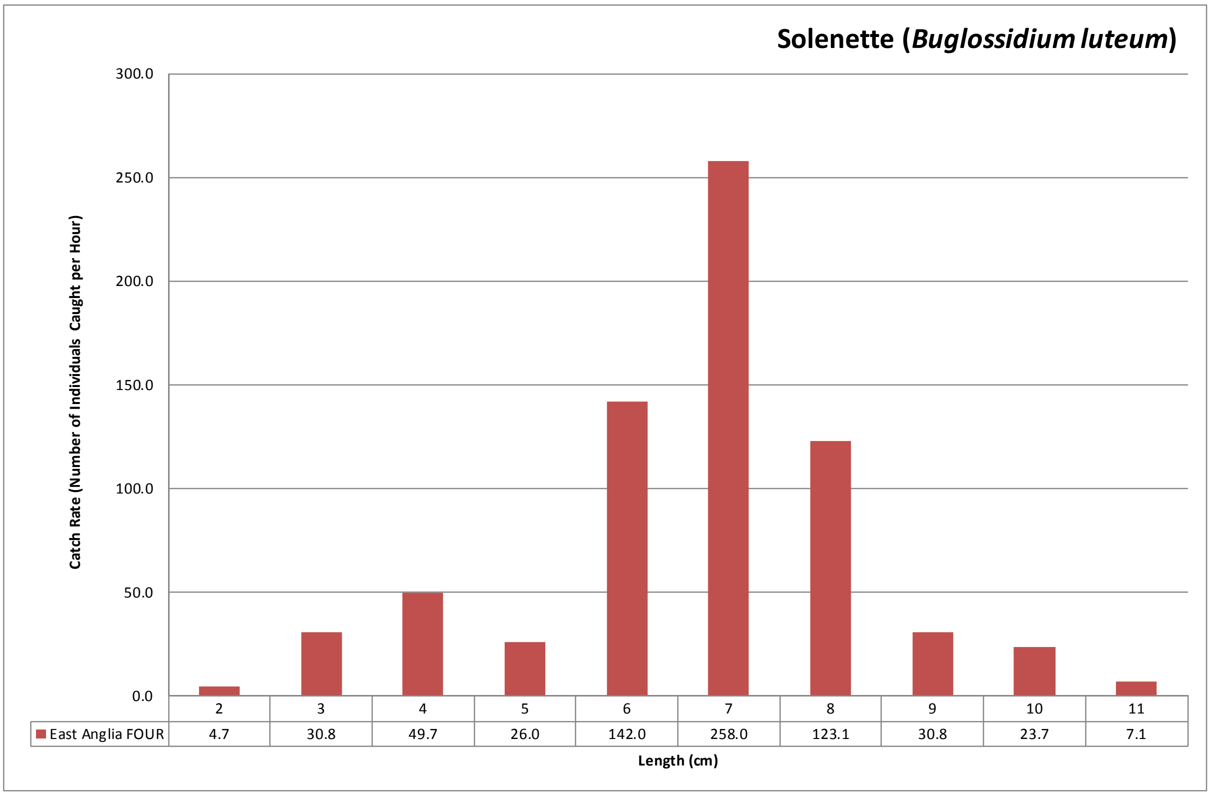


Figure 7.3 Solenette (*B. luteum*) Length Distribution for Stations within East Anglia FOUR

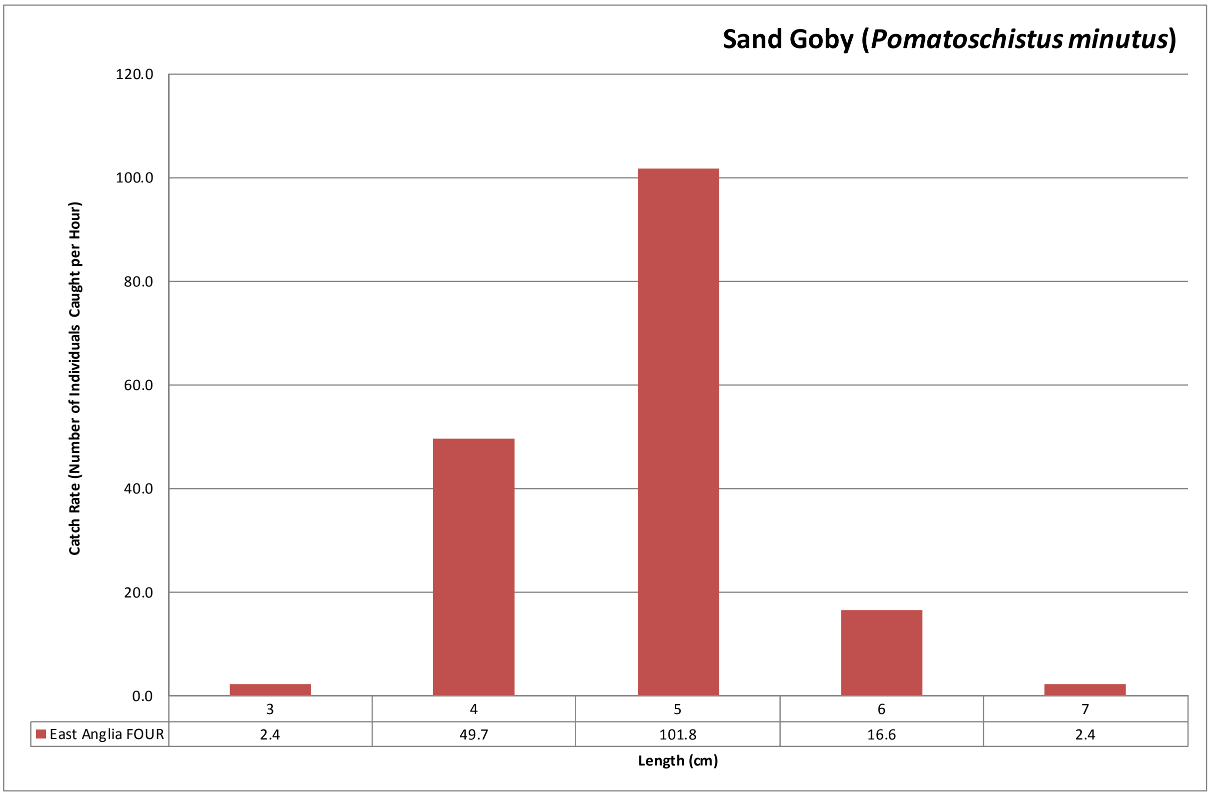


Figure 7.4 Sand Goby (*P. minutus*) Length Distribution for Stations within East Anglia FOUR

8.0 Appendix (of Annex 5)

8.1 Appendix 1 – Health and Safety

8.1.1 Personnel

Brown and May Marine (BMM) staff protocol followed the standard health and safety protocol outlined in the BMM "Offshore Operational Procedures for Surveys using Commercial Fishing Vessels".

All BMM staff have completed a Sea Survival course approved by the Maritime and Coastguard Agency, meeting the requirements laid down in: **STCW 95 Regulation VI/1 para 2.1.1 and STCW Code section A- VI/1** before boarding any vessel conducting works for the company. Employees are also required to have valid medical certificates (ENG1 or ML5), Seafish Safety Awareness, Seafish Basic First Aid and Seafish Basic Fire Fighting and Fire Prevention certificates before participating in offshore works.

8.1.2 Vessel Induction

Before boarding, the survey team were shown how to safely board and disembark the vessel. Prior to departure the skipper briefed the BMM staff on the whereabouts of the safety equipment, including the life raft, emergency flares and fire extinguishers, and also the location of the emergency muster point. The safe deck areas, man-overboard procedures and emergency alarms were also discussed. The survey team were warned about the possible hazards, such as slippery decks and obstructions whilst aboard. The BMM staff were briefed about trawling operations and the need to keep clear of all winch's when operational and a safety drill was conducted. All hazards were assessed prior to the survey in the BMM health and safety risk assessment.

8.1.3 Daily Safety Checks

The condition of the life jackets, EPIRB's, and life raft were inspected daily. Also checked were the survey team working areas, including the fish room and the wheelhouse to ensure these areas were clear of hazards such as clutter and obstructions.

8.1.4 Post Trip Survey review

Upon completion of the survey a "Post Trip Survey Review" was filed, see Table 7.1 overleaf.

Table 8.1 Post Trip Survey Review

Project: East Anglia 3	**Vessel:** Jubilee Spirit
Surveyors: Lucy Shuff, Alex Winrow-Giffin, Jake Laws	**Skipper:** Ross Crookes
Survey Area: Southern North Sea	**Total Time at Sea:** 13 Days
Dates at Sea: 15/05/2013 – 27/05/2013	

	Comments	Actions
Did vessel comply with pre-trip safety audits?	Yes Passed audit by LOC on 14/02/2013	N/A
Skipper and crew attitude to safety?	Good	N/A
Vessel machinery failures?	Fuel pipe blockage on 17/05/2013 AIS malfunction on 20/05/2013	Repaired by crew at sea Repaired by engineer on 21/05/2013
Safety equipment failures?	None	N/A
Accidents?	None	N/A
Injuries?	None	N/A

11.0 Annex 6: Subacoustech Method Statement relating to underwater noise propagation modelling parameters

Project title	
Project number	E603
Author(s)	T Mason
Company	Subacoustech Environmental Ltd.
Report number	E603IR0101
Date of issue	19th January 2017

Method Statement relating to underwater noise propagation modelling parameters

Underwater noise propagation modelling is proposed as part of the Environmental Impact Assessment (EIA) for Norfolk Vanguard. As part of this, a decision must be made as to certain modelling parameters in the Evidence Plan Process. This Method Statement examines the methodology used in the East Anglia Three Offshore Wind Farm (OWF) EIA as the most recent EIA to go through examination and updates it based on best available current research and guidelines.

Modelling

The underwater noise modelling will utilise a combined parabolic equation (as per RAM/RAMSGeo) and ray-tracing (for high frequency elements) solver within the dBSea package. This incorporates bathymetry and seabed and sediment data to ensure realism to the environment. During modelling, the results will be precautionary, using the worst case for:

- Hammer energies
- Ramp-up profiles
- Cumulative noise exposure
- Position of the receptor in the water column

The impact criteria to be applied are also designed to be conservative.

Thresholds and criteria

Underwater noise impacts on marine life are under investigation around the world and new research is published frequently. Two key and current papers concerning underwater noise impacts have been published: NMFS (2016)[12] and the American National Standards Institute (ANSI)-approved Popper *et al.* (2014)[13], for marine mammals and fish, respectively. These update the recommended criteria for use in impact assessments.

[12] National Marine Fisheries Service. 2016. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.

[13] Popper A N, Hawkins A D, Fay R R, Mann D A, Bartol S, Carlson T J, Coombs S, Ellison W T, Gentry R L, Halvorsen M B, Løkkeborg S, Rogers P H, Southall B L, Zeddies D G, Tavolga W N., ASA S3/SC1.4 TR-2014 Sound

Marine Mammals

Since it was published in 2007, Southall *et al*[14] has been the source of the most widely used criteria to assess the effects of noise on marine mammals. The Norfolk Vanguard Scoping Opinion advises that NMFS (2016) impact criteria are reviewed. NMFS (2016) was co-authored by many of the same authors from Southall *et al.* and effectively updates it. Most criteria become more restrictive.

Table 5.1 shows the criteria used in the underwater noise impact assessment for East Anglia THREE and the most up to date criteria provided by NMFS (2016). The criteria are divided into species 'hearing groups' which represent the sound frequencies over which the group of species are sensitive. The thresholds to be used in the Norfolk Vanguard EIA will be discussed and agreed with stakeholders through the Evidence Plan Process.

PTS (Permanent Threshold Shift)	**East Anglia Three**		**NMFS (2016)**	
	SPL_{peak} Unweighted (dB re 1 µPa)	SEL_{cum} Weighted (dB re 1 µPa²s)	SPL_{peak} Unweighted (dB re 1 µPa)	SEL_{cum} Weighted (dB re 1 µPa²s)
High Frequency (HF) Cetaceans (e.g. Harbour porpoise)	200	179 (single strike)	202	155
Mid Frequency (MF) Cetaceans (e.g. Bottlenose dolphin)	230	198	230	185
Low Frequency (LF) Cetaceans (e.g. Baleen whales)	230	198	219	183
Phocid Pinnipeds (e.g. harbour seal)	218	186	218	185

Table 5.1 Criteria for assessment of injury to marine mammals

East Anglia THREE used an assumption that a fleeing response or avoidance of an area occurred concurrently with the noise exposure believed to cause a temporary reduction in hearing sensitivity (Temporary Threshold Shift or "TTS"). *Table 5.2* represents the criteria for this effect, and therefore the concurrent fleeing response.

TTS (Temporary Threshold	**East Anglia THREE**		**NMFS (2016)**	
	SPL_{peak}	SEL_{cum}	SPL_{peak}	SEL_{cum}

Exposure Guidelines for Fishes and Sea Turtles, Springer Briefs in Oceanography, DOI 10.1007/978-3-319-06659-2

[14] Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene Jr., C. R., Kastak, David, Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A., and Tyack, P. L. (2007) Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations, Aquatic Mammals, 33 (4), pp. 411-509

Shift)	Unweighted (dB re 1 µPa)	Weighted (dB re 1 µPa^{2}s)	Unweighted (dB re 1 µPa)	Weighted (dB re 1 µPa^{2}s)
High Frequency (HF) Cetaceans (e.g. Harbour porpoise)	194	164	196	140
Mid Frequency (MF) Cetaceans (e.g. Bottlenose dolphin)	224	183	224	170
Low Frequency (LF) Cetaceans (e.g. Baleen whales)	224	183	213	168
Phocid Pinnipeds (e.g. harbour seal)	212	171	212	170

Table 5.2 Criteria for assessment of TTS to marine mammals

While, strictly speaking, the criteria are designed for TTS rather than fleeing, this follows the methodology agreed for use in East Anglia THREE's criteria, as there is little broadly accepted evidence currently available for setting behavioural avoidance criteria. However, the following alternative criteria applied for East Anglia THREE could be used, which are identified in the table below, derived from Southall *et al.*, 2007.

Potential avoidance of area	East Anglia THREE	
	SPL_{peak} Unweighted (dB re 1 µPa)	SEL_{cum} Weighted (dB re 1 µPa^{2}s)
High Frequency (HF) Cetaceans (e.g. Harbour porpoise)	168	145
Mid Frequency (MF) Cetaceans (e.g. Bottlenose dolphin)	None	160-170
Low Frequency (LF) Cetaceans (e.g. Baleen whales)	None	142-152
Phocid Pinnipeds (e.g. harbour seal)	As TTS	As TTS

Table 5.3 Criteria for assessment of potential avoidance of an area by marine mammals

Fish

The vast variety and variation in fish species leads to a greater challenge in production of a generic noise criterion, or range of criteria, for the assessment of noise impacts. Whereas previously broad criteria were applied based on limited studies, the publication of Popper *et al.* (2014) provides an authoritative summary of the latest sound exposure guidelines. The following table provides a summary of the most conservative of these, in respect of offshore pile driving, alongside the criteria recommended for East Anglia THREE.

Effect on fish	**East Anglia Three**		**Popper *et al.* (2014)**	
	SPL_{peak} Unweighted (dB re 1 µPa)	SEL_{cum} Unweighted (dB re 1 µPa^{2}s)	SPL_{peak} Unweighted (dB re 1 µPa)	SEL_{cum} Unweighted (dB re 1 µPa^{2}s)
Fish injury	206	211	207	203
TTS	None	None	None	186
Startle response / C-turn reaction	200	None	Qualitative	Qualitative
General behavioural response	168 – 173	None	Qualitative	Qualitative

Table 5.4 Criteria for assessment of effects on fish

The Popper *et al.* guidelines do not recommend quantitative criteria for behavioural effects on fish as the best research available is limited to very specific studies on species under artificial conditions. Therefore, it is recommended that behavioural effects for fish are considered qualitatively only.

It should be noted that two follow-ups to the Popper *et al.* (2014) report (Hawkins *et al.* 2015[15], Hawkins and Popper 2016[16]) elaborate further on the challenge of setting criteria for the large variety of sensitivities of the many species of fish and invertebrates. The reports detail the data gaps, especially in relation to many species sensitive to the particle motion rather than pressure component of sound in the water and to the potential for impacts from seabed vibration. Although clearly identifying that many species will not be sensitive to the sound pressure for which the criteria are based, there are neither recognised criteria or thresholds in terms of particle motion currently available, nor appropriate data to apply the criteria to.

The papers make a strong recommendation to undertake research to fill these data gaps. Until such research exists, however, it is recommended to continue to use the existing criteria as defined in Popper *et al.* 2014 as best practice.

Piling locations

Concurrent piling at two locations within NV East and two in NV West will be modelled for locations at the furthest extent of the boundaries, in order to provide the maximum combined sound propagation. Consideration will also be given to seabed bathymetry when selecting the worst-case scenario concurrent piling locations.

The underwater noise modelling will also assess the worst-case scenario for a single piling location within NV East and NV West which may be represented by one of the locations identified for concurrent piling or may be a new location, subject to the bathymetry data.

[15] Hawkins, A. D., Pembroke, A., and Popper, A. 2015. Information gaps in understanding the effects of noise on fishes and invertebrates. Reviews in Fish Biology and Fisheries, 25: 39–64

[16] Hawkins, A. D., and Popper, A. N. 2016. A sound approach to assessing the impact of underwater noise on marine fishes and invertebrates. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsw205

In addition, the maximum noise impact contour for harbour porpoise will be modelled at one location with NV East and NV West which provides the maximum overlap with the Southern North Sea proposed Special Area of Conservation. This may be represented by one of the locations identified above or may be a new location.

A geophysical survey at Norfolk Vanguard was undertaken in 2016 and the bathymetry data from this will be assessed to identify the worst-case scenario location, when available.