The Sizewell C Project

6.3 Volume 2 Main Development Site

Chapter 22 Marine Ecology and Fisheries

Appendix 22D - Sizewell Characterisation Report - Fish

Revision: 1.0

Applicable Regulation: Regulation 5(2)(a)

PINS Reference Number: EN010012

May 2020

Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

TR345 Sizewell Characterisation Report - Fish

Table of contents

List of Tables and Figures

Tables

Figures

Please note that the red line boundary was amended after this document was finalised, therefore figures in this document do not reflect the boundaries in respect of which development consent has been sought in this application. However, amendments to the red line boundary does not have any impact on the findings set out in this document and all other information remains correct.

Executive summary

EDF Energy is planning to construct a new nuclear power station to the north of Sizewell B on the Suffolk coast. As part of the planning process for the new station, Sizewell C, EDF Energy is required to assess the potential impacts of the construction and operation of the station on the local marine ecology. Activities that have the potential to impact on fish communities include, *inter alia*, underwater noise effects during the building of the station, impingement and entrainment effects as a result of water abstraction, and thermal and chemical effects from the discharged cooling water plume.

This report characterises the fish fauna[1] of the Greater Sizewell Bay area based on data collected during impingement sampling from the Sizewell B cooling water system and from a series of coastal fishing surveys and determines which taxa are key components of the system. The datasets used in this report are:

- Impingement sampling at Sizewell B between February 2009 and February 2013 (Some some data on eel and smelt from the extended impingement dataset collected between 2009 and 2017 were also added in February 2020 but no attempt has been made to fully update this characterisation report. For up to date impingement results the reader is referred to BEEMS Technical Report TR406, but the broad patterns described in this report remain valid for characterisation purposes).
- Ten demersal fishing surveys carried out over a 4-year period; quarterly in 2008, once each in June 2009 and June 2010, and quarterly between June 2011 and March 2012[2]. Sampling was conducted using two different fishing gears – a 2 m beam trawl and a commercial otter trawl.
- A coastal pelagic fish survey carried out in March and June 2015.
- Additional information from sources such as sampling undertaken during the operation of the Sizewell A station, characterisation studies for other marine developments in the local area, inshore fishing surveys off the Suffolk coast and international stock assessments.

The use of multiple sampling methods or gears allowed a comprehensive description of the area to be produced, as no one gear or sampling method was able to fully sample the entire community. The report provides an overview of the fish and fisheries ecology of the Greater Sizewell Bay area. It identifies the fish species and taxa that occur in the area and determines which are key on the basis of socio-economic and ecological criteria, and which species of conservation concern are present. The life history stage of fish species occupying the greater Sizewell Bay area, and the highly variable nature of fish abundance, are both highlighted. Many of the fish taxa recorded are present in their juvenile stages in the shallow Sizewell Bay environment, and are part of populations that extend beyond the range of the Sizewell Bay area. For many of these species, abundance is naturally variable seasonally and annually, and examples of this variability are given.

A total of 88 fish taxa were identified in the Greater Sizewell Bay area. Forty species were identified in the 2 m beam trawl catches, 25 in the commercial otter trawl catches and 71 species were identified during impingement sampling. This is a likely reflection of the differences in sampling effort, with more sampling during the impingement programme increasing the likelihood of encountering less abundant taxa.

From the Sizewell B impingement data (the largest dataset) the 5 most abundant fish species at Sizewell B are sprat *Sprattus sprattus*, herring *Clupea harengus*, whiting *Merlangius merlangus*, bass *Dicentrarchus labrax*, and sand goby *Pomatoschistus* sp.. Of the demersal species recorded, Dover sole *Solea solea* and whiting were extremely frequent, occurring in over 90 % and 96 % of the impingement samples, respectively. Gobies, dab *Limanda limanda* and flounder *Platichthys flesus* occurred in over 90 % of the impingement samples. Of the remaining species, 30 of the 71 species impinged were recorded in less than 10 % of the samples, with 6 recorded only once. In the offshore samples, Dover sole was the most commonly occurring demersal species, present in 68 % of beam trawls and all the otter trawl samples. Whiting was found in a third of the beam trawls and 60 % of the otter trawls. Gobies, dab and flounder were also generally common. Thornback rays *Raja clavata*, were common in the otter trawls, though they were rarely captured in the beam

[1] Cephalopods are also included here rather than in the benthic invertebrate characterisation as they are found in open water rather than on the seabed.
[2] Information from the 2014 Sizewell demersal fish survey is used to support the characterisation, though the data were not available at the time of analysis so were not included in the formal data analyses.

trawls. Many of the remaining demersal species were reasonably rare; 26 of the 40 taxa caught in the 2 m beam trawl were present in less than 10 % of tows, with 11 recorded only once, seven of the 25 species in the otter trawls were recorded only once.

The most abundant taxa were also generally the most common. Of the demersal species in the impingement sampling, the four most abundant species were whiting, bass, sand gobies and Dover sole. Both bass and the thin-lipped grey mullet *Liza ramada* were impinged in reasonably large numbers but were not a significant feature of the coastal surveys. In the offshore surveys, Dover sole and gobies dominated. (Gobies were highly abundant in the beam trawls, but were not abundant in the otter trawl surveys, due to the large mesh size of the gear and small body size of the individuals). In the otter trawls, flounder, dab and thornback rays were also highly abundant.

Six pelagic species were recorded within the Bay (Atlantic herring *Clupea harengus,* European sprat *Sprattus sprattus,* anchovy *Engraulis encrasicolus,* mackerel *Scomber scombrus*, horse mackerel (scad) *Trachurus trachurus and* pilchard *Sardina pilchardus*), with sprat being the most abundant. There is some limited evidence that pelagic fish are more abundant in waters further north off Minsmere than around Sizewell itself, although high numbers were found at Sizewell throughout the year.

Cephalopods were not common in either the offshore or onshore samples. Only a single species (the European common squid *Alloteuthis subulata*) was recorded in the coastal surveys. Four species were impinged in Sizewell B, namely the little cuttlefish *Sepiola atlantica*, the European common squid, the cuttlefish *Sepia officinalis* and the common squid *Loligo vulgaris*. Unsurprisingly, given they were not common, cephalopods were not abundant.

Twenty-four taxa are considered to be key members of the community, on the basis of their socio-economic importance, ecological importance or conservation status (Table 1). Each of the 6 socio-economically important species are part of larger populations that, in general, span the southern North Sea or wider North Sea/English Channel - the Greater Sizewell Bay forms only a part of their distribution ranges. Although several species (Dover sole, plaice, dab, whiting, cod *Gadus morhua*, bass, sprat, herring and thornback ray) have spawning and/or nursery areas inshore off the Suffolk coast, they are not limited solely to the Bay.

Of the taxa recorded, six are designated as key on the grounds of socio-economic importance, 16 on the grounds of conservation importance and 13 on the grounds of ecological importance. Several taxa fall under more than one of the three criteria and four under all three (Atlantic herring, cod *Gadus morhua*, European plaice and Dover sole).

Sixteen taxa of conservation importance are known to be present in the area. Two of these (Atlantic salmon *Salmo salar* and sea lamprey *Petromyzon marinus*), were not recorded in any of the BEEMS characterisation surveys described here, while 3 others (sea trout *Salmo trutta*, European eel *Anguilla anguilla* and smelt *Osmerus eperlanus*) were only recorded from the onshore impingement monitoring[3]. With the exception of the European eel and smelt, the conservation species were caught infrequently and in low abundance.

For each key taxon identified their life history and commercial fisheries (if applicable) are presented, together with the information on their distribution, abundance and temporal variability within the Greater Sizewell Bay area.

[3] One sea lamprey has subsequently been recorded during impingement sampling at Sizewell B in 2015

Table 1 Key fishes of Greater Sizewell Bay (those in grey were not found in BEEMS surveys)

Taxon		**Socio-economic**	**Ecological**	**Conservation**
European sprat	*Sprattus sprattus*			
Atlantic herring	*Clupea harengus*			
Whiting	*Merlangius merlangus*			
European sea bass	*Dicentrarchus labrax*			
Sand gobies	*Pomatoschistus* spp.			
Dover sole	*Solea solea*			
Dab	*Limanda limanda*			
Anchovy	Engraulis encrasicolus			
Thin-lipped grey mullet	*Liza ramada*			
European flounder	*Platichthys flesus*			
Atlantic cod	*Gadus morhua*			
European plaice	*Pleuronectes platessa*			
Smelt	*Osmerus eperlanus*			
Thornback ray	*Raja clavata*			
European eel	*Anguilla anguilla*			
Horse mackerel	*Trachurus trachurus*			
Twaite shad	*Alosa fallax*			
River lamprey	*Lampetra fluviatilis*			
Mackerel	*Scomber scombrus*			
Sea trout	*Salmo trutta*			
Allis shad	*Alosa alosa*			
Tope	*Galeorhinus galeus*			
Atlantic salmon	*Salmo salar*			
Sea lamprey	*Petromyzon marinus*			

Changes to the report dated 18 February 2020

The report was reviewed to ensure references were up to date. More recent biological data from the extended 2009-2017 impingement dataset on eels (Section 3.1.15) and smelt (Section 3.1.18) were also added to make the summary more up to date.

1 Context

1.1 Purpose of the report

EDF Energy proposes to construct and operate a new nuclear power station immediately to the north of the existing Sizewell B on the Suffolk coast. Under the Planning Act 2008, this development, as with other nationally-significant infrastructure projects, requires a Development Consent Order (including, in the case of conservation areas, a Habitats Regulations Assessment or HRA) to be granted by the UK Government's Planning Inspectorate. The marine aspects of the development will also require regulatory permits for, amongst other activities, cooling water discharges and activities that disturb the seabed. Decisions on permissions will be taken on the basis of a marine environmental impact assessment (EIA) encompassing the key ecological features of the site and including all marine activities associated with the development.

This report presents the outcomes of the fish characterisation, which aims to describe the ecological breadth and natural variability of the fish species in the Greater Sizewell Bay marine ecosystem. This will be used to identify the key taxa that will be considered in the EIA and as the baseline for the impact assessments. To this end, the fish components of the Sizewell marine system are described.

1.2 Survey coverage

Several datasets have been used in this report, and these are described fully in section 1.4. In summary, the datasets used are:

- Impingement sampling at Sizewell B between February 2009 and February 2013 (some data on eel and smelt from the extended impingement dataset collected between 2009 and 2017 were also added in February 2020 but no attempt has been made to fully update this characterisation report)
- Ten demersal fishing surveys carried out over a 4-year period; quarterly in 2008, once each in June 2009 and June 2010, and quarterly between June 2011 and March 2012. Sampling was conducted using two different fishing gears – a 2 m beam trawl and a commercial otter trawl.
- A coastal pelagic fish survey carried out in March and June 2015.
- Additional information from sources such as sampling undertaken during the operation of the Sizewell A station, characterisation studies for other marine developments in the local area, inshore fishing surveys off the Suffolk coast and international stock assessments.

The fish survey techniques described in this report offer different:

- sampling frequencies and duration;
- spatial coverage;
- sampling from different portion of the water column;
- sampling from different parts of the diurnal cycle; and
- species selectivity.

As such they provide complementary data on the fish communities in Sizewell Bay but also data which are difficult to directly compare. The impingement sampling provides the greatest sampling frequency with at least two 24h samples per month for 4 years. Samples are collected from all tidal states and in all weathers for complete 24h cycles. The Sizewell B intake mainly extracts water from the bottom half of the water column, although at slack water most of the water column is sampled. Only large fish with strong swimming speeds would be able to avoid being impinged if they entered the intake extraction zone. The disadvantages with impingement sampling are that it:

- only provides sampling at one point in the Bay (or, more accurately, it samples along an approximately ±10 km N-S tidal excursion centred on the station intakes);
- may provide a biased sample of the truly benthic community because the intakes are 2-3 m above the seabed; and
- only partially samples the top 1 or 2 m of the water column.

The 2 m beam and commercial otter trawl surveys only effectively sample benthic and coastal demersal species. The techniques offer the advantage of a much wider spatial sampling and sampling of the full benthic community but there have only been 10 sampling periods which have not covered every month of the year. This means that species which are only present in Sizewell Bay seasonally may not have been effectively sampled e.g. bass are present in large numbers from approximately November to the end of February but only 1 coastal fishing survey took place at the beginning of this period. Similarly, acoustic surveys are highly effective at describing aggregations of pelagic species, have limited use for some demersal species but are ineffective for benthic species. Section 2.3 describes how the data from the different sampling techniques has been combined

Geographic coverage of the coastal fishing surveys

The BEEMS programme has been characterising the fish communities of Sizewell since 2008. At the time of planning the initial fishing surveys, the positions of the cooling water intake and outfall infrastructure for the proposed Sizewell C station were as yet undetermined by EDF Energy. Following initial discussions, the survey area was delimited by the widest probable extent of waters influenced by the construction and operation of an NNB with intake/outfall rates substantially higher than at the operating Sizewell B site. This covered an area approximately 3.5 km seawards and 5 km to the north and south of Sizewell B - an area stretching from Dunwich Heath in the north to south of Thorpeness. British Geological Survey sediment maps (Figure 1) indicated the area was homogenous sand and it was initially treated as one geological stratum. The proceeding BEEMS habitat mapping showed this was not the case; while predominantly sand, the area sports a mixed seabed of bedrock, mud and coarse sediments (see BEEMS Technical Report TR087). Thus, once additional information on the likely positions of the intake/outfall structures and the predicted thermo-chemical plume became available in 2010/2011 (see BEEMS Technical Report TR133), the survey area was extended northwards to Dunwich village and southwards to Orford Ness (Figure 2). This area is referred to as the Greater Sizewell Bay.

1.3 Thematic coverage

The characterisation focuses on three principal questions:

1. Which taxa were present around Sizewell over the characterisation period (2008 to 2013)?
2. Which are the key taxa, according to their socio-economic value, ecological role within the ecosystem or conservation interest?
3. What are the spatio-temporal patterns in communities and key taxa (within the limitations of the available data)?

We consider demersal fishes, pelagic fishes and nearshore coastal species where data are available. The reproductive stages (eggs and larvae) of most fishes are planktonic. However, for simplicity, all planktonic data are considered in the zooplankton characterisation (BEEMS Technical Report TR315). Although the report focusses on finfish, we have included cephalopods here rather than in the benthic invertebrates characterisation. Cephalopods such as octopuses, squids and cuttlefish are found in open waters rather than in or on the seabed and, thus, their behaviour and environmental preferences may be considered to match more closely those of fish than the predominantly sessile or locally-distributed benthic invertebrates.

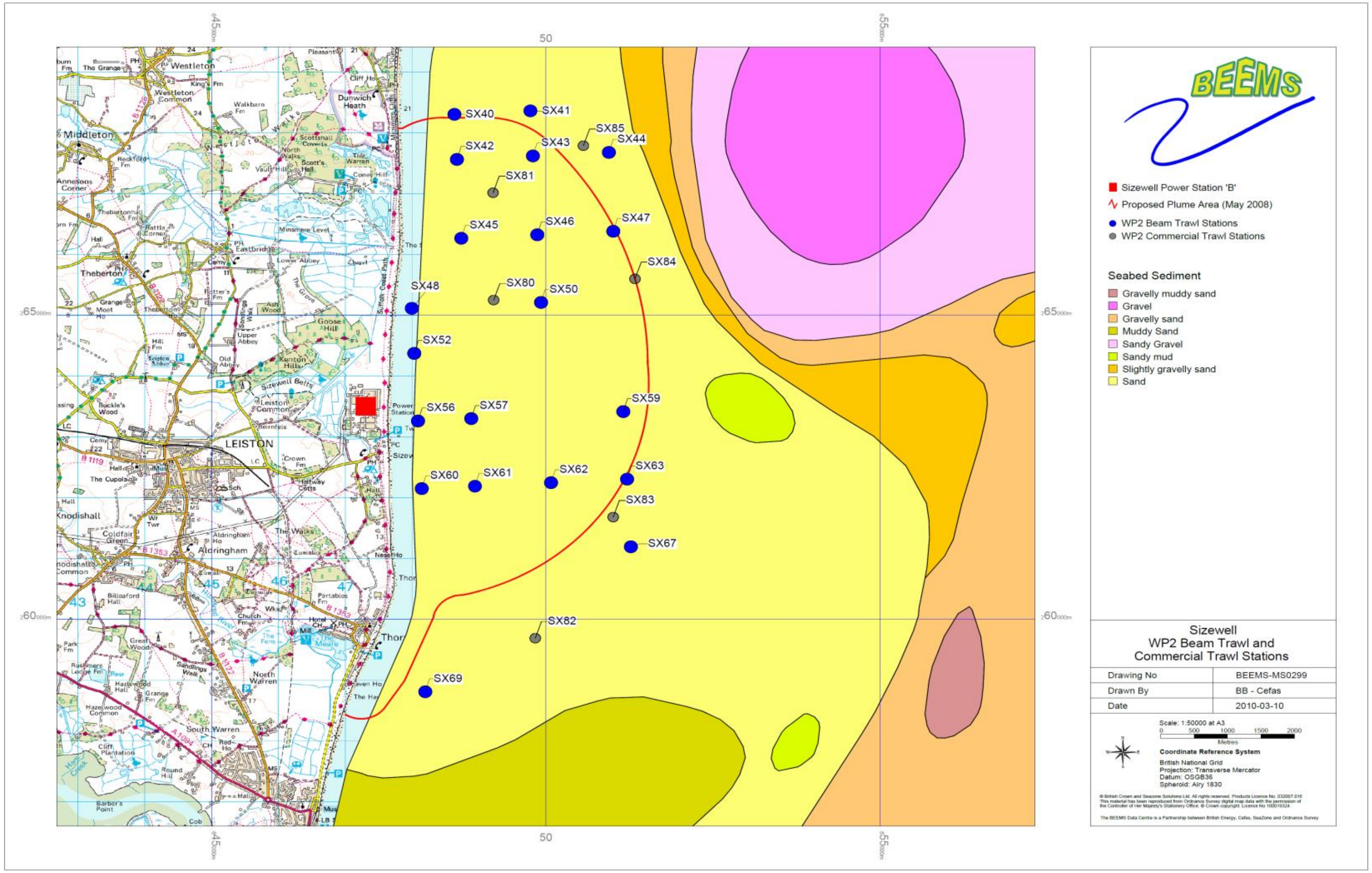


Figure 1. Initial estimation of the likely extent of waters exposed to the Sizewell NNB (red line), overlaid on the coarse-scale British Geological Society seabed map (proceeding acoustic mapping revealed a much more heterogenous seabed (BEEMS Technical Report TR087). Positions of original survey stations for the 2 m beam trawl and commercial otter trawl are shown (see Section 1.4.1.2). From BEEMS Technical Report TR069.

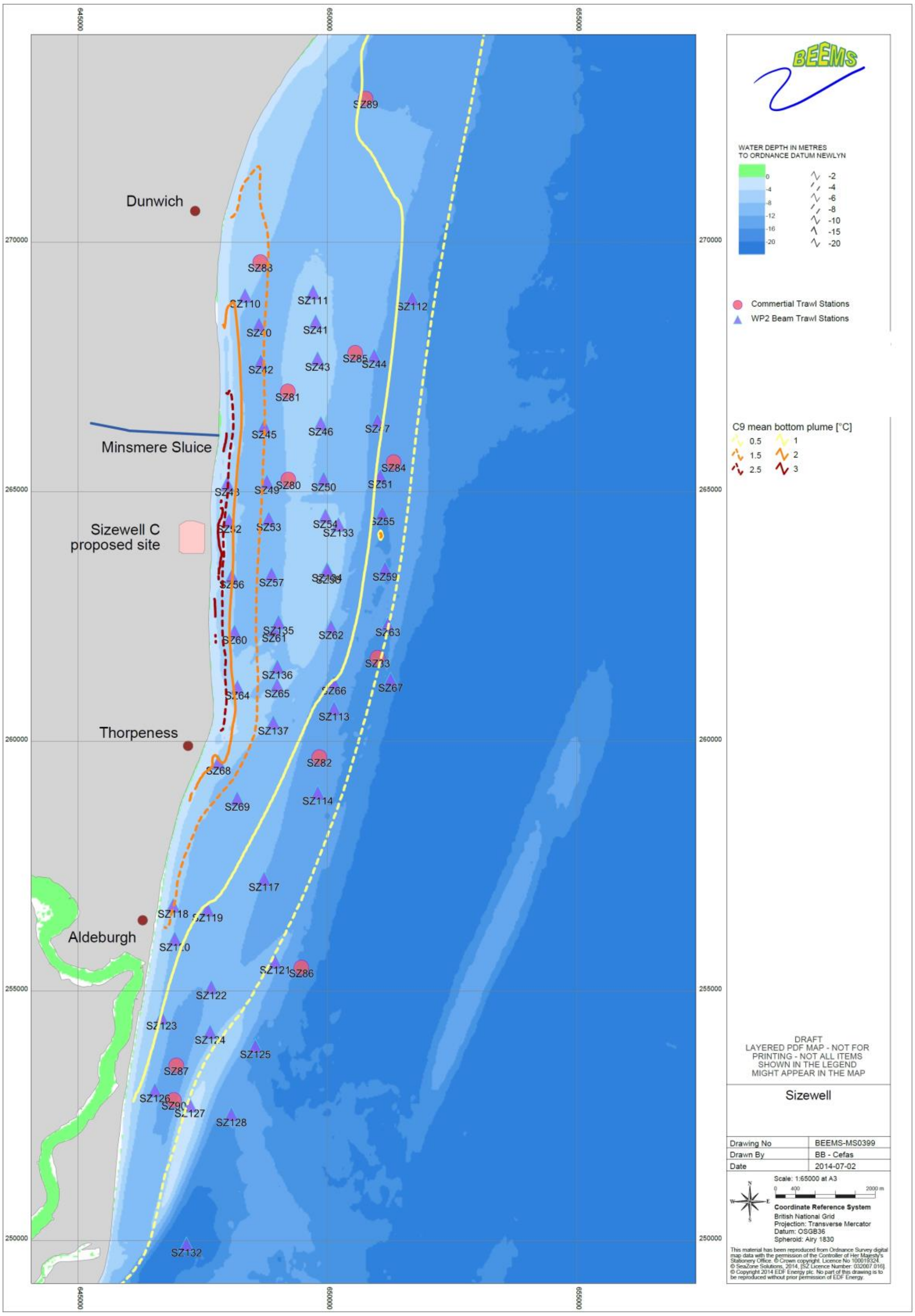


Figure 2. Area surveyed from June 2011 onwards, including positions of the 2 m beam trawl and commercial otter trawl stations in the extended survey grid (see Section 1.4.1.2). Contour lines indicate the thermal uplift (˚C) resulting from the SZC discharge, as modelled in 2010/2011 (BEEMS Technical Report TR133).

1.4 Data and information sources

1.4.1 Sizewell-specific (BEEMS and previous Sizewell power station reports)

1.4.1.1 Coastal pelagic fish surveys

A dedicated acoustic survey was conducted during March and August 2015, with the aim of determining the presence of clupeid species across the bay during the spring and summer periods (BEEMS Technical Report TR359); this survey covered an area from north of Dunwich to south of Aldeburgh. Additional information on speciation was gathered by the deployment of pelagic trawl gear to ground-truth the acoustic signals. Further information on pelagic species is available from the impingement monitoring dataset and, to a lesser degree, the demersal surveys (described in the sections below).

1.4.1.2 Coastal demersal surveys

This report consolidates the outputs of BEEMS technical reports on aspects of the fish communities of the Greater Sizewell Bay area ("feeder reports"). Detailed survey and analysis methods are not provided, except where a new form of output has been created that does not appear in a feeder report. These reports are supplemented with information from the previous environmental assessment work carried out for the Sizewell B development. Beam and commercial otter trawl characterisation surveys were undertaken between 2008 and 2012 (Table 2), beginning in 2008 with quarterly surveys (see Figure 1 for sampling locations). The 2 m beam was towed for 5 minutes and the otter trawl for 30 minutes - full details are provided in BEEMS Technical Reports TR069 and TR201.

The 2008 – 2010 survey series: Commenced in March 2008 with a scoping survey to define sampling positions and test gears. The wooden 2 m beam trawl was successfully deployed at 22 stations in March, with 25 stations visited in May 2008 – giving 29 stations in total. Of the 29, a standard grid of 20 was retained for the remainder of 2008 and for two further surveys, in June 2009 and June 2010 (Figure 1)[4]. The surveys also included a grid of 6 otter trawl stations.

The 2011 – 2012 survey series: New thermal plume model runs produced towards the end of 2010 indicated that the plume area would extend further southwards than originally estimated, and consequently the survey area was expanded. Between June 2011 and March 2012, quarterly surveys were conducted at 40 beam trawl stations (12 from the 2008 – 2010 series, 25 additional stations to the south and 3 to the north) and 10 otter trawl stations (6 from the previous grid, plus 4 additional stations; see Figure 2).[5]

Additional surveys: An additional fish survey was carried out in September 2014. This was a pilot survey with the purpose of testing survey designs for providing targeted baseline information in areas adjacent to the Sizewell C infrastructure. The data from this survey were not available during the period in which the BEEMS fish data were collated and analysed, so were not included in the formal analysis described in the proceeding sections. However, the 2014 survey data have now been processed and, while they are not referred to extensively in this characterisation report, the additional year's worth of data gathered in 2014 provide a similar picture of the Sizewell fishes to that described in Section 0 (see BEEMS Technical Report TR338).

In April and May 2015, a pilot survey with the purpose of targeting juvenile European eels *Anguilla anguilla* (glass eels/elvers). The survey utilised a modified Isaacs-Kidd midwater frame trawl (Methot, 1986) with a small mesh net (2 mm), and which is designed to capture juvenile fish. Although only a single glass eel was captured, several other species were captured, providing additional information on the fish within the Greater Sizewell Bay area (BEEMS Technical Report TR356)

In February 2016, a 5-day survey was carried out that was designed to investigate the distribution of bass in the Greater Sizewell Bay area. The survey used a high headline otter trawl, specifically designed for catching bass aged 0-4 years old. Although bass was the target, several other species were also caught, providing information on their distribution within the survey area (BEEMS Technical Report TR380, in prep.).

---

[4] The full 20 sites were not always successfully sampled, due to occasional gear damage.
[5] The station codes were assigned an SX prefix from 2008 - 2010, but these were revised to an SZ prefix in 2011.

Table 2. Details of the BEEMS coastal 2 m beam and commercial otter trawl survey series used in the characterisation.

Survey	Survey dates	No. of stations		No. of samples	
		Beam	Otter	Beam	Otter
SIZE 1/08	4 - 8 March 2008	22	6	20	6
SIZE 2/08	1 - 6 May 2008	25	6	24	6
SIZE 3/08	9 - 14 September 2008	20	6	18	6
SIZE 4/08	23 - 28 October 2008	20	6	18	6
SIZE 2/09	15 - 22 June 2009	20	6	17	6
SIZE 5/10	17 - 23 June 2010	20	6	18	6
SIZE 5/11	17 - 29 June 2011	40	10	31	10
SIZE 6/11	17 - 25 September 2011	40	10	35	10
SIZE 7/11	18 - 28 November 2011	40	10	36	10
SIZE 1/12	17 - 26 March 2012	40	10	36	10

1.4.1.3 Sizewell B impingement sampling

Fish were sampled from the fine-mesh (10 mm) drum screens in the forebay of the Sizewell B station between February 2009 and February 2013. This sampling was undertaken as part of the Comprehensive Impingement Monitoring Programme, or CIMP[6]. The dataset comprised 125 samples of the estimated number and weight of fish impinged (i.e. captured on the screens) during a 24-hour period with the station pumping at full capacity, with samples taken at approximately two-week intervals. Further details are given in BEEMS Technical Reports TR120, TR196, TR215 and TR270. The dataset provides detailed information on seasonal and annual changes in abundance of pelagic and demersal species (the cooling water system draws water from approximately 3 m off the seabed), as well as cephalopods.

1.4.2 The wider marine environment

Information is available for two local marine developments adjacent to the Greater Sizewell Bay area, and from a characterisation report of the Thames Estuary - the Galloper (Galloper Wind Farm Limited, 2011a, 2011b) and East Anglia ONE (Scottishpower Renewables, 2012) developments and the Marine Aggregate Regional Environmental Assessment for the Outer Thames region[7] (see TEDA, 2010).

In addition, historic information on the inshore fish communities in the East Anglian area is available from Cefas' Young Fish Survey (YFS) data (Cefas, 2011). The YFS ran between 1981 and 2010, and included an area from Flamborough Head in the north to Portland Bill in the south. The surveys used a 2 m beam trawl down to 20 m depth for the duration, plus a push net down to 1 m depth between 1981 and 1999. For the purposes of this characterisation, the data from the 'East' region are the most relevant. These are available for two areas in the vicinity of Sizewell: Winterton to Orford Ness (1981 – 1999 only) and Orford Ness to the mouth of the River Thames (1981 – 2010).

[6] Sampling paused in 2013 at the request of EDF, and was re-instated in 2014.
[7] http://www.marine-aggregate-rea.info/teda

2 Overview of fish communities and selection of key species

From the Sizewell B impingement data the 5 most abundant fish species at Sizewell B are sprat (*Sprattus sprattus*), herring (*Clupea harengus*), whiting (*Merlangius merlangus*), bass (*Dicentrarchus labrax*), and sand goby (*Pomatoschistus* sp.) (BEEMS Technical Report TR406).

2.1 Demersal community

The BEEMS coastal surveys used both beam and otter trawls because each has a different ‘catchability’ - the ability to catch a given species. For example, the 2 m beam trawl predominantly catches small sole, whilst the otter trawl catches larger, faster individuals that can avoid the beam trawl and, with its open mouth, it also catches demersal animals while the 2 m beam trawl catches benthic ones. These two gears, together with the impingement data, provide a composite picture of the demersal fish.

Eighty-eight fish taxa were identified in total from the Greater Sizewell Bay surveys, with forty in the 2 m beam trawls, 25 in the commercial otter trawls and 71 in the impingement sampling (Appendix A). The area was dominated in terms of abundance and frequency of occurrence by a small number of taxa (see below).

2.1.1 Common taxa

The frequency of occurrence data are shown in Table 3 for the impingement data and Table 4 for the beam and otter trawls. Of the demersal species recorded, Dover sole *Solea solea* and whiting were extremely frequent in the impingement dataset, occurring in over 90 % and 96 % of the impingement samples, respectively. Gobies, dab *Limanda limanda* and flounder *Platichthys flesus* were also generally common: all three taxa were recorded in over 90 % of the impingement samples. Other demersal species occurring in more than 80 % of the impingement samples were Nilsson’s pipefish *Sygnathus rostellatus*, lesser weever *Trachinus vipera*, and bass *Dicentrarchus labrax*. Of the remaining species, 30 of the 71 species impinged were recorded in less than 10 % of the samples, with 6 recorded only once.

In the offshore samples, Dover sole was the most commonly occurring species overall, present in 68 % of beam trawls and all the otter trawl samples. Whiting was found in a third of the beam trawls and 60 % of the otter trawls. Gobies, dab and flounder were also generally common: dab were recorded in two thirds of otter trawls and 13 % of beam trawls, gobies in nearly half of the beam trawls and flounder in 75 % of the otter trawls. Thornback rays *Raja clavata*, were common in the otter trawls, being found in 75 %, though they were rarely captured in the beam trawls. Many of the remaining species were reasonably rare; 26 of the 40 taxa caught in the 2 m beam trawl were present in less than 10 % of tows, with 11 recorded only once, seven of the 25 species in the otter trawls were recorded only once.

Cephalopods were not common in either the offshore or onshore samples. Only a single species (the European common squid *Alloteuthis subulata*) was recorded in the coastal surveys; it occurred in only 17 and 7 of the beam and otter trawl samples, respectively. Four species were impinged in Sizewell B, namely the little cuttlefish *Sepiola atlantica*, the European common squid, the cuttlefish *Sepia officinalis* and the common squid *Loligo vulgaris*, but only the little cuttlefish was present in more than 30 % of the samples.

Table 3 Impingement sampling results (ordered by number of individuals caught). Sample count = number of samples in which the species was present, sample % = % of samples in which the species was present, No. = estimated number of each species caught over the 125 sampling occasions, Total = % of total fish caught. Records are ordered by the taxa abundance. **Pelagic fishes**. **Cephalopods**. **The most abundant demersal/coastal fish.** (These data are estimated impingement numbers for the sampling days in the first 4 years of impingement sampling only; the estimated annual impingment numbers for SZB may be found in BEEMS Technical Report TR406)

Common name	Species Latin name	Sample count	Sample %	No.	Total (%)	Cumulative %
Sprat	***Sprattus sprattus***	124	99.2	730,322	48.55%	48.55%
Herring	***Clupea harengus***	114	91.2	234,328	15.58%	64.13%
Whiting	***Merlangius merlangus***	120	96	176,786	11.75%	75.88%
Bass	***Dicentrarchus labrax***	100	80	149,358	9.93%	85.81%
Sand goby	***Pomatoschistus minutus***	117	93.6	66,459	4.42%	90.22%
Dover sole	***Solea solea***	114	91.2	35,698	2.37%	92.60%
Dab	***Limanda limanda***	116	92.8	22,572	1.50%	94.10%
Thin-lipped grey mullet	***Liza ramada***	53	42.4	13,600	0.90%	95.00%
Anchovy	***Engraulis encrasicolus***	48	38.4	12,376	0.82%	95.82%
Little cuttlefish	***Sepiola atlantica***	58	46.4	9,689	0.00%	95.82%
Nilsson's pipefish	*Syngnathus rostellatus*	101	80.8	9,710	0.65%	96.47%
Bib (pout)	*Trisopterus luscus*	104	83.2	8,888	0.59%	97.06%
Lesser weever	*Trachinus vipera*	101	80.8	5,911	0.39%	97.45%
5-bearded rockling	*Ciliata mustela*	109	87.2	4,409	0.29%	97.75%
Flounder	*Platichthys flesus*	119	95.2	4,174	0.28%	98.02%
Pogge (hooknose)	*Agonus cataphractus*	93	74.4	4,161	0.28%	98.30%
Cod	*Gadus morhua*	88	70.4	3,789	0.25%	98.55%
European common squid	***Alloteuthis subulata***	33	26.4	3,449	0.00%	98.55%
Plaice	*Pleuronectes platessa*	106	84.8	3,408	0.23%	98.78%
Transparent goby	*Aphia minuta*	53	42.4	3,368	0.22%	99.00%
Smelt	*Osmerus eperlanus*	94	75.2	3,183	0.21%	99.21%
Common sea snail	*Liparis liparis*	66	52.8	1,397	0.09%	99.31%
Pilchard	***Sardina pilchardus***	28	22.4	1,057	0.07%	99.38%
Dragonet	*Callionymus lyra*	58	46.4	814	0.05%	99.43%
Tub gurnard	*Trigla lucerna*	52	41.6	737	0.05%	99.48%
Lesser spotted dogfish	*Scyliorhinus canicula*	57	45.6	682	0.05%	99.53%
Thornback ray	*Raja clavata*	61	48.8	641	0.04%	99.57%
3-spined stickleback	*Gasterosteus aculeatus*	36	28.8	622	0.04%	99.61%
Greater pipefish	*Syngnathus acus*	39	31.2	528	0.04%	99.64%
Witch	*Glyptocephalus cynoglossus*	31	24.8	445	0.03%	99.67%
Starry smooth-hound	*Mustelus asterias*	44	35.2	399	0.03%	99.70%
Scaldfish	*Arnoglossus laterna*	52	41.6	368	0.024%	99.72%
Common sandeel	*Ammodytes tobianus*	35	28	366	0.024%	99.75%
European eel	*Anguilla anguilla*	65	52	347	0.023%	99.77%
Black goby	*Gobius niger*	26	20.8	337	0.022%	99.79%
Horse mackerel	***Trachurus trachurus***	27	21.6	333	0.022%	99.82%
Greater sandeel	*Hyperoplus lanceolatus*	62	49.6	332	0.022%	99.84%
Snake pipefish	*Entelurus aequoreus*	21	16.8	281	0.019%	99.86%
Twaite shad	*Alosa fallax*	34	27.2	270	0.018%	99.88%
River lamprey	*Lampetra fluviatalis*	40	32	269	0.018%	99.89%
Bullrout	*Myoxocephalus scorpius*	32	25.6	166	0.011%	99.90%
Brill	*Scophthalmus rhombus*	20	16	164	0.011%	99.92%
Rock goby	*Gobius paganellus*	6	4.8	158	0.011%	99.93%
Sand smelt	*Atherina boyeri*	19	15.2	145	0.010%	99.94%
Mackerel	***Scomber scombrus***	9	7.2	120	0.008%	99.94%
Tompot blenny	*Blennius gattorugine*	8	6.4	96	0.006%	99.95%
Painted goby	*Pomatoschistus pictus*	6	4.8	84	0.006%	99.96%
Solenette	*Buglossidium luteum*	20	16	80	0.005%	99.96%
Lemon sole	*Microstomus kitt*	18	14.4	70	0.005%	99.97%
Long-spined sea scorpion	*Taurulus bubalis*	14	11.2	69	0.005%	99.97%
Butterfish	*Pholis gunnellus*	11	8.8	64	0.004%	99.97%
Red mullet	*Mullus surmuletus*	14	11.2	46	0.003%	99.98%
Poor cod	*Trisopterus minutus*	13	10.4	40	0.003%	99.98%
Cuttlefish	***Sepia officinalis***	3	2.4	39	0.000%	99.98%
Viviparous blenny	*Zoarces viviparus*	7	5.6	35	0.002%	99.98%

Common name	Species Latin name	Sample count	Sample %	No.	Total (%)	Cumulative %
Garfish	*Belone belone*	9	7.2	33	0.002%	99.98%
Montagu's sea snail	*Liparis montagui*	6	4.8	33	0.002%	99.99%
Common squid	***Loligo vulgaris***	2	1.6	32	0.000%	99.99%
Grey gurnard	*Eutrigla gurnardus*	9	7.2	29	0.002%	99.99%
Corkwing wrasse	*Crenilabrus melops*	9	7.2	29	0.002%	99.99%
Northern rockling	*Ciliata septentrionalis*	6	4.8	21	0.001%	99.99%
Lumpsucker	*Cyclopterus lumpus*	6	4.8	14	0.001%	99.99%
Tadpolefish	*Raniceps raninus*	2	1.6	13	0.001%	99.99%
John Dory	*Zeus faber*	2	1.6	13	0.001%	99.99%
Saithe	*Pollachius virens*	1	0.8	12	0.001%	100.00%
Ballan wrasse	*Labrus bergylta*	3	2.4	11	0.001%	100.00%
Turbot	*Psetta maxima*	3	2.4	10	0.001%	100.00%
Norway bullhead	*Micrenophrys lilljeborgii*	2	1.6	7	0.000%	100.00%
Thick-lipped grey mullet	*Crenimugil labrosus*	1	0.8	7	0.000%	100.00%
Black sea bream	*Spondyliosoma cantharus*	2	1.6	6	0.000%	100.00%
Cuckoo wrasse	*Labrus mixtus*	1	0.8	5	0.000%	100.00%
Deep-snouted pipefish	*Syngnathus typhle*	1	0.8	5	0.000%	100.00%
4-bearded rockling	*Enchelyopus cimbrius*	3	2.4	4	0.000%	100.00%
Bigeye rockling	*Gaidropsarus macrophthalmus*	2	1.6	3	0.000%	100.00%
Shore rockling	*Gaidropsarus mediterraneus*	2	1.6	2	0.000%	100.00%
Norway pout	*Trisopterus esmarkii*	1	0.8	2	0.000%	100.00%
Sea Trout	*Salmo trutta*	1	0.8	2	0.000%	100.00%
Crystal goby	*Crystallogobius linearis*	1	0.8	1	0.000%	100.00%
Sand sole	*Pegusa lascaris*	1	0.8	1	0.000%	100.00%
Allis shad	*Alosa alosa*	1	0.8	1	0.000%	100.00%
Pollack	*Pollachius pollachius*	1	0.8	1	0.000%	100.00%

2.1.2 Abundant taxa

Abundance data from the the impingement monitoring are given in Table 3 and for the coastal surveys are shown in Figure 3 and given in Appendix B.

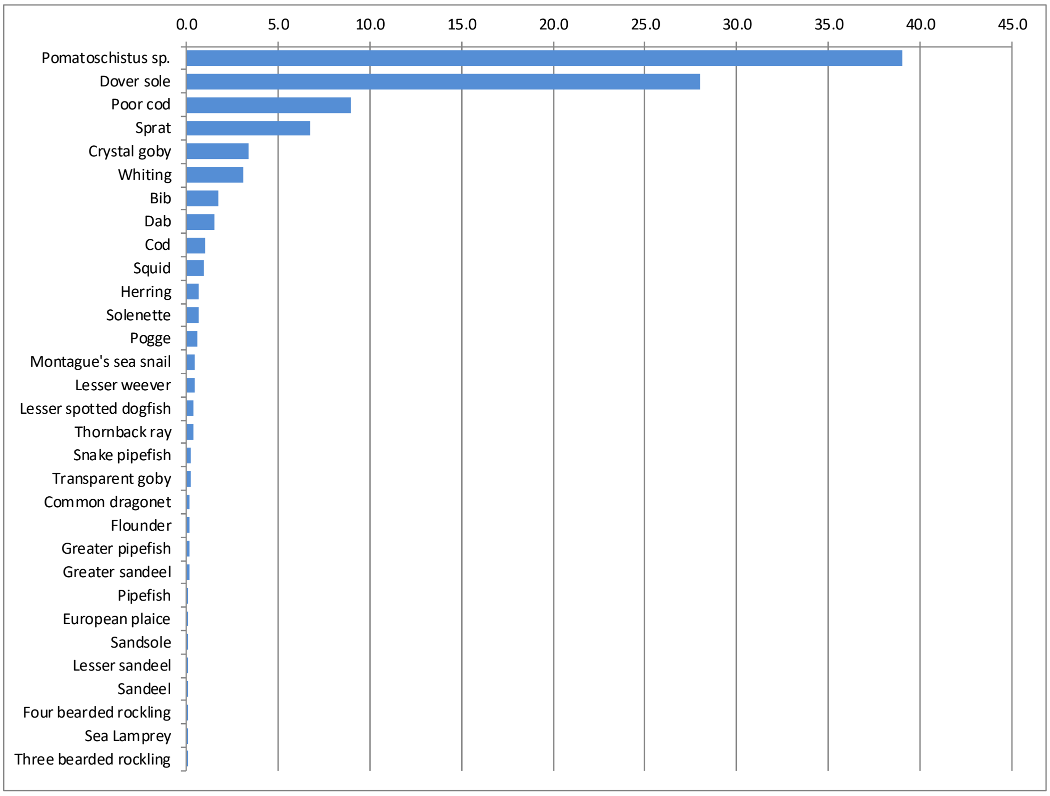
The most abundant taxa were also generally the most common. Of the demersal species in the impingement sampling, the four most abundant species were whiting (11 % by abundance), bass (9 %), sand gobies (4 %) and Dover sole 2 (%). Both bass and the thin-lipped grey mullet *Liza ramada* were impinged in reasonably large numbers but were not a significant feature of the coastal surveys. However, the abundance of bass is seasonal (see section 3.1.4) with the majority of catches in the impingement dataset being made in the winter months. The offshore surveys were conducted quarterly in 2008 and 2011-2012, while the majority of the rest of the surveys were carried out in June to provide consistent annual surveying in that month. Consequently only one of the offshore surveys coincided with the peak times of bass impingement (and therefore abundance).

In the offshore surveys, Dover sole dominated overall; it accounted for 28 % and 39 % of all fish caught in the 2 m beam trawls in the original (2008 – 2010) and expanded (2011 - 2012) survey series and 48 % and 25 % in the otter trawl in the original and expanded series, respectively. Gobies were also highly abundant in the beam trawls (39 % and 22 % by abundance of the original and expanded survey series), but were not abundant in the otter trawl surveys, due to the large mesh size of the gear and small body size of the individuals. Whiting contributed 3 % and 11 % respectively, to the abundance of beam trawl samples in the original and extended survey areas. In the otter trawls, flounder, dab and thornback rays were also highly abundant.

Unsurprisingly, given they were not common, cephalopods were not abundant. Only 30 common squid were recovered from the 2 m beam trawls and 22 from the otter trawls. Around 10,000 little cuttlefish were impinged, which is insignificant compared to the abundance of fish taxa (= 0.3 % of the total number of individuals impinged).

Table 4. Fishes of the Sizewell coastal surveys. N = the number of tows in which the taxon was recorded, % = percentage of stations at which it was present.

2 m beam trawl	**N**	**%**	**Otter trawl**	**N**	**%**
Dover sole (*Solea solea*)	197	68.2	Dover sole	76	100.0
Gobies (*Pomatoschistus* sp.)	142	49.1	European flounder	57	75.0
Whiting (*Merlangius merlangus*)	89	30.8	Thornback ray	57	75.0
Pogge (*Agonus cataphractus*)	45	15.6	Whiting	46	60.5
Dab (*Limanda limanda*)	38	13.1	Dab	44	57.9
Bib/whiting-pout (*Trisopterus luscus*)	37	12.8	European plaice	33	43.4
European sprat (*Sprattus sprattus*)	32	11.1	Atlantic cod	24	31.6
Crystal goby (*Crystallogobius sp.)*	27	9.3	Bib/whiting-pout	12	15.8
Poor cod (*Trisopterus minutus*)	25	8.7	Atlantic herring	11	14.5
Atlantic herring (*Clupea harengus*)	20	6.9	Tub gurnard	11	14.5
European plaice (*Pleuronectes platessa*)	17	5.9	Starry smooth hound (*Mustelus*	8	10.5
Common European squid (*Alloteuthis subulata*)	17	5.9	Lesser spotted dogfish	7	9.2
Thornback ray (*Raja clavata*)	16	5.5	Common European squid	7	9.2
Atlantic cod (*Gadus morhua*)	13	4.5	European seabass (*Dicentrarchus*	4	5.3
Lesser weever (*Echiithys vipera*)	11	3.8	Brill (*Scophthalmus rhombus*)	3	3.9
Solenette (*Buglossidium luteum*)	9	3.1	Lemon sole (*Microstomus kitt*)	3	3.9
Sea snail (*Liparis liparis*)	7	2.4	Pogge	3	3.9
Unidentified sandeels (*Ammodytes* sp.)	6	2.1	Tope (*Galeorhinus galeus*)	2	2.6
European flounder (*Platichthys flesus*)	6	2.1	Blonde ray (*Raja brachyura*)	1	1.3
Lesser spotted dogfish (*Scyliorhinus canicula*)	6	2.1	Common dragonet	1	1.3
Greater pipe-fish (*Syngnathus acus*)	5	1.7	Grey gurnard (*Eutrigla gurnardus*)	1	1.3
Common dragonet (*Callionymus lyra*)	4	1.4	Red mullet (*Mullus surmuletus*)	1	1.3
Five-bearded rockling (*Ciliata mustela*)	4	1.4	Spotted ray (*Raja montagui*)	1	1.3
Greater sandeel (*Hyperoplus lanceolatus*)	4	1.4	Turbot (*Scophthalmus maximus*)	1	1.3
Montague's sea snail (*Liparis montagui*)	4	1.4	Lesser weever	1	1.3
Nilson's pipefish (*Syngnathus rostellatus*)	4	1.4			
Snake pipefish (*Entelurus aequoreus*)	4	1.4			
Sandeel (*Ammodytes tobianus*)	4	1.4			
Transparent goby (*Aphia minuta)*	3	1.0			
Unidentified pipefish (Syngnathidae)	2	0.7			
Unidentified herring (Clupeidae)	1	0.3			
Four-bearded rockling (*Enchelyopus cimbrius*)	1	0.3			
Corbin's sandeel (*Hyperoplus immaculatus*)	1	0.3			
Unidentified lamprey (Petromyzonidae)	1	0.3			
Lemon sole (*Microstomus kitt*)	1	0.3			
Unidentified sandeels (Ammodytidae)	1	0.3			
Sand sole (*Pegusa lascaris*)	1	0.3			
Three-bearded rockling (*Gaidropsarus vulgaris)*	1	0.3			
European anchovy (*Engraulis ecnrsicolis*)	1	0.3			
Grey mullet (Mugilidae)	1	0.3			
Tub gurnard (*Trigla lucerna*)	1	0.3			



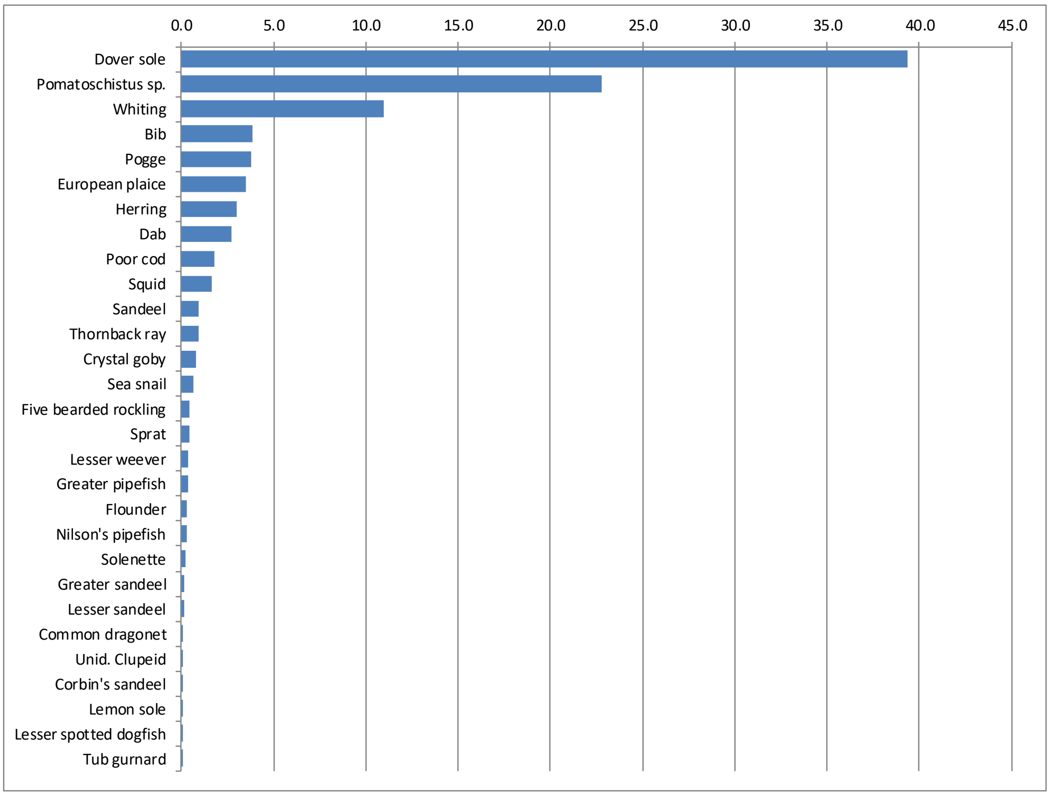
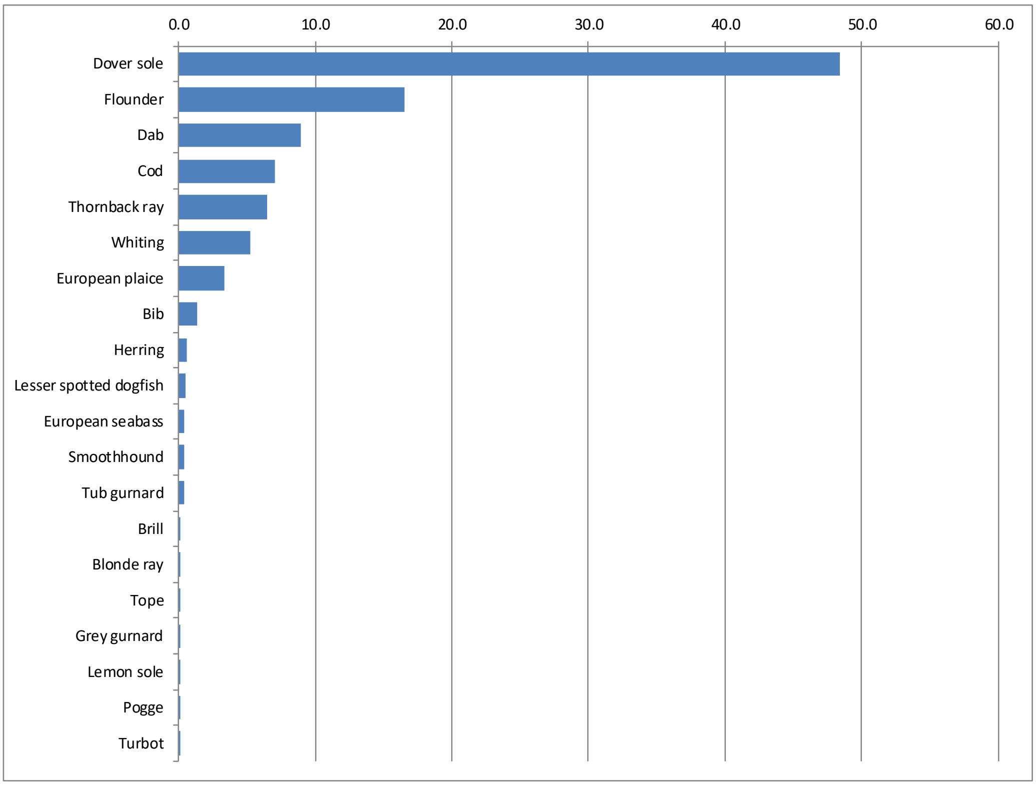


Figure 3. The relative proportions (%) of fish taxa from the 2 m beam trawl (all surveys combined). Top - the 2008 - 2010 surveys; bottom - 2011 - 2012 surveys. Total abundance was calculated as individuals per 1 km^2. Taxa on the lower end of the graph were present in such low proportions as to be indistinguishable on the x-axis.



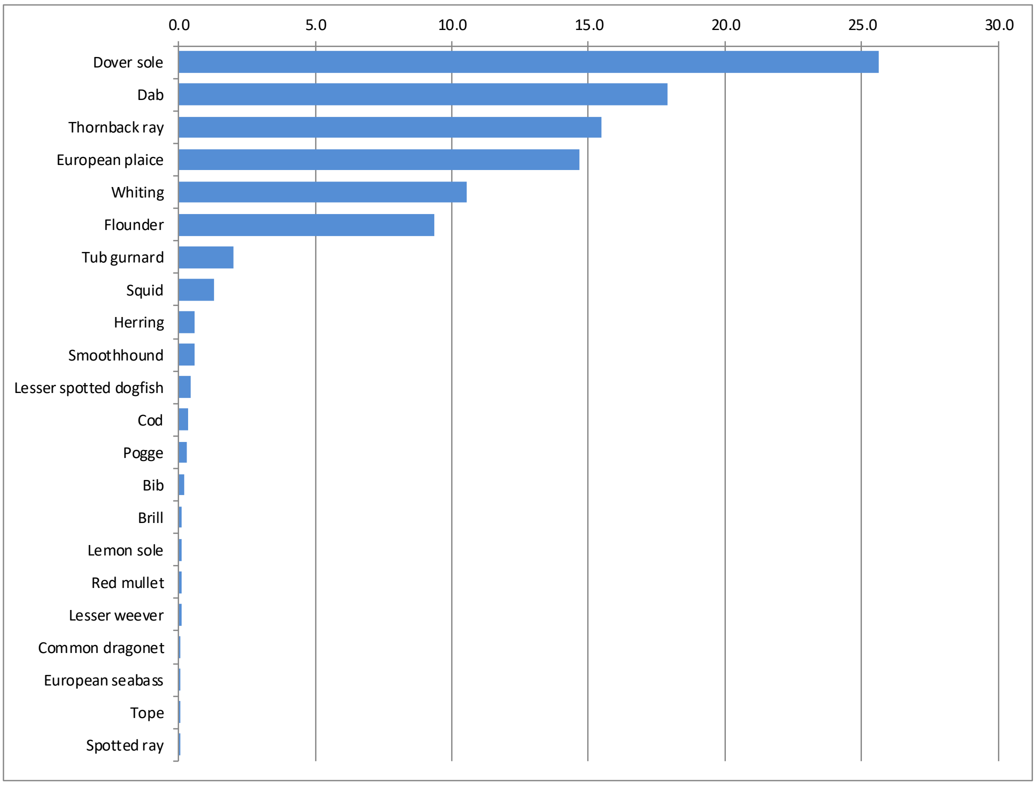


Figure 4. The relative proportions (%) of fish taxa from the commercial otter trawl (all surveys combined). Top - the 2008 - 2010 surveys; bottom - 2011 - 2012 surveys. Total abundance is calculated as individuals/hour. Taxa on the lower end of the graph were present in such low proportions as to be indistinguishable on the x-axis.

2.1.3 Spatial patterns in community structure

Multivariate analytical tools were applied to the coastal survey data to investigate spatio-temporal patterns in the communities. These methods, cluster analysis and ordination, provide slightly different but often complementary information on spatio-temporal patterns. A full description of the analysis is given in Appendix D. To summarise, the analyses provided little evidence of consistent spatial patterns in the fishes from either the 2 m beam or otter trawl samples, suggesting that the fishes of the Greater Sizewell Bay form one large homogenous community; there was little obvious spatial pattern or consistency over time in the cluster to which the samples from each station were assigned, meaning the species mix found at each site changed over time but not in a predictable way (Figure 5 and Figure 6).

2.1.4 Comparison to the wider East Anglian region

A comparable number of taxa were recorded in the Outer Thames Estuary, Galloper and East Anglia ONE areas to those found in the Greater Sizewell Bay: slightly lower numbers in the beam trawls at 28, 33 and 30, respectively, compared to 38 in the Bay, with simillar numbers in the otter trawls at 24 and 30 in the Outer Thames and East Anglia ONE areas compared to 25 in the bay. The apparently lower fish richness in the wider region is probably a function of the order of magnitude lower sampling intensity c.f. the BEEMS surveys (e.g. 289 beam trawls by BEEMS compared to between 20 and 36 for the others); this higher search intensity renders the BEEMS surveys much more likely to encounter rarer species. However, it may also be a function of environmental control, since the Galloper and East Anglia ONE sampling took place further offshore and the Thames survey further south.

A similar picture emerges when considering the dominant taxa. Dover sole, whiting, gobies and dab were particularly prevalent in the Sizewell community, along with reasonably strong representation of flounder, thornback ray, European plaice, European seabass and thin-lipped grey mullet. Gobies were dominant in the beam trawls of all three wider region surveys and sole in the Outer Thames (also Raitt's sandeels in the East Anglia ONE and Galloper areas, bib in the Outer Thames, solenette and lesser weever at East Anglia ONE and dragonets at Galloper), plus whiting, plaice and dab were well represented in the otter trawls at East Anglian ONE. Bib, dominant in both beam and otter trawls from the wider region, were not especially dominant in the inshore waters of the Greater Sizewell Bay, though they were recorded fairly regularly.

The Cefas Young Fish Survey for the Eastern region designated 26 'core species'[8] (Cefas, 2011). That many of these species were common to the Sizewell dominance profile provides further evidence that the Sizewell Bay community is similar to that of the wider region.

Cephalopods were also rarely caught by the Galloper and East Anglian ONE surveys. Twenty unidentified squid were recorded in the Galloper otter trawl catches in April 2009, and 5 little cuttlefish in the 2 m beam trawls of the same survey, though no cephalopods were caught in the October 2008 survey. In the surveys for the East Anglia ONE development, only a single *Loligo* sp. individual was recorded in the beam and otter trawls. However, little cuttlefish, common European squid and common squid were all recorded in trawls targeted at herring, confirming the presence of these species in the wider area.

---

[8] Core species were defined by fitting a cubic spline model through a plot of persistence (number of years present in the survey) and abundance (log CPUE) for all species caught throughout the survey series. Species falling to the right of the break point of the cubic spline curve (i.e. highly persistent and highly abundant) were considered to be 'core'

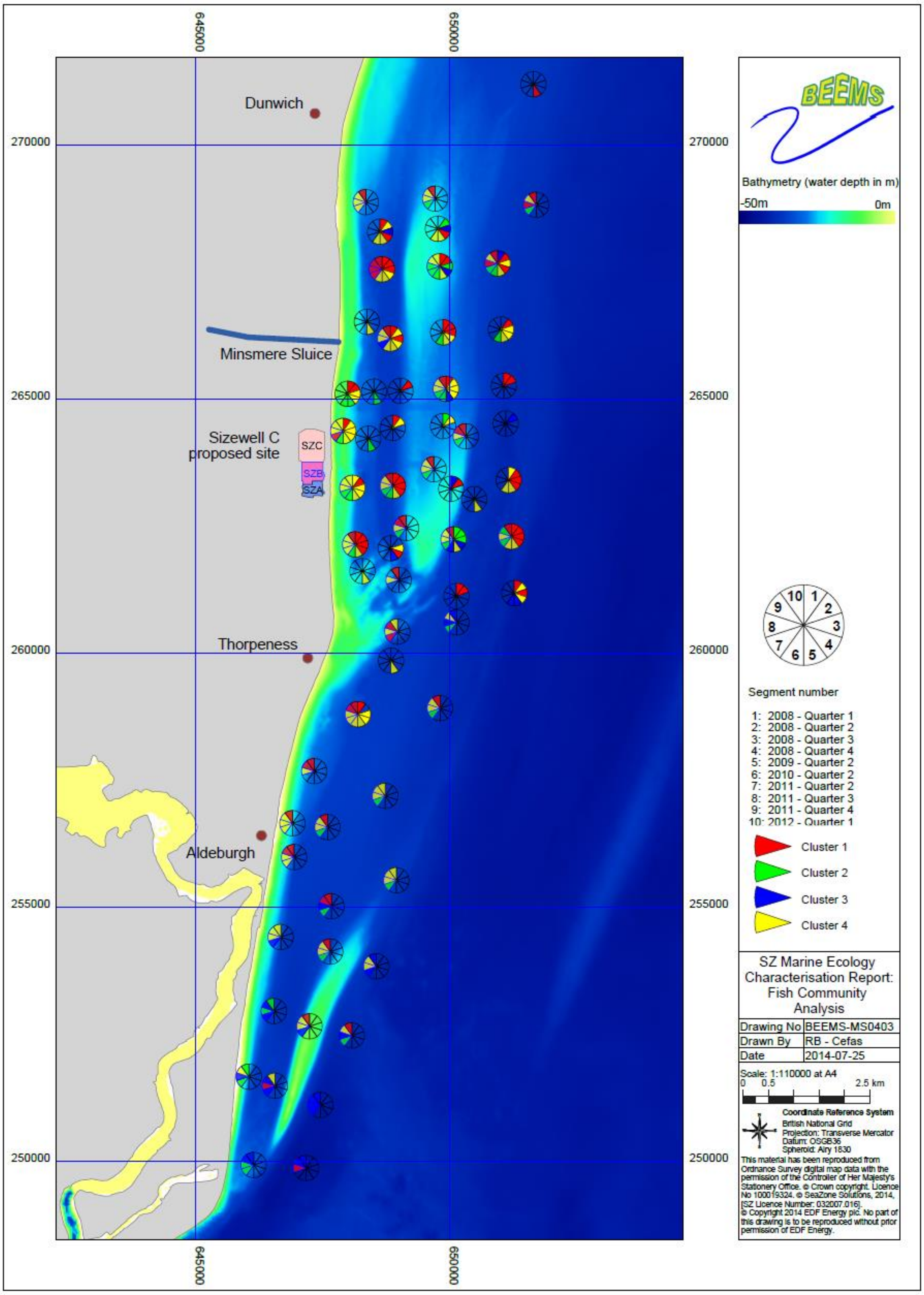


Figure 5. Summary of cluster analysis outputs for the 2 m beam trawl data. Samples were assigned to one of four clusters (indicated by the coloured segments). Segment positions relate to individual surveys and empty segments indicate samples containing no fish.

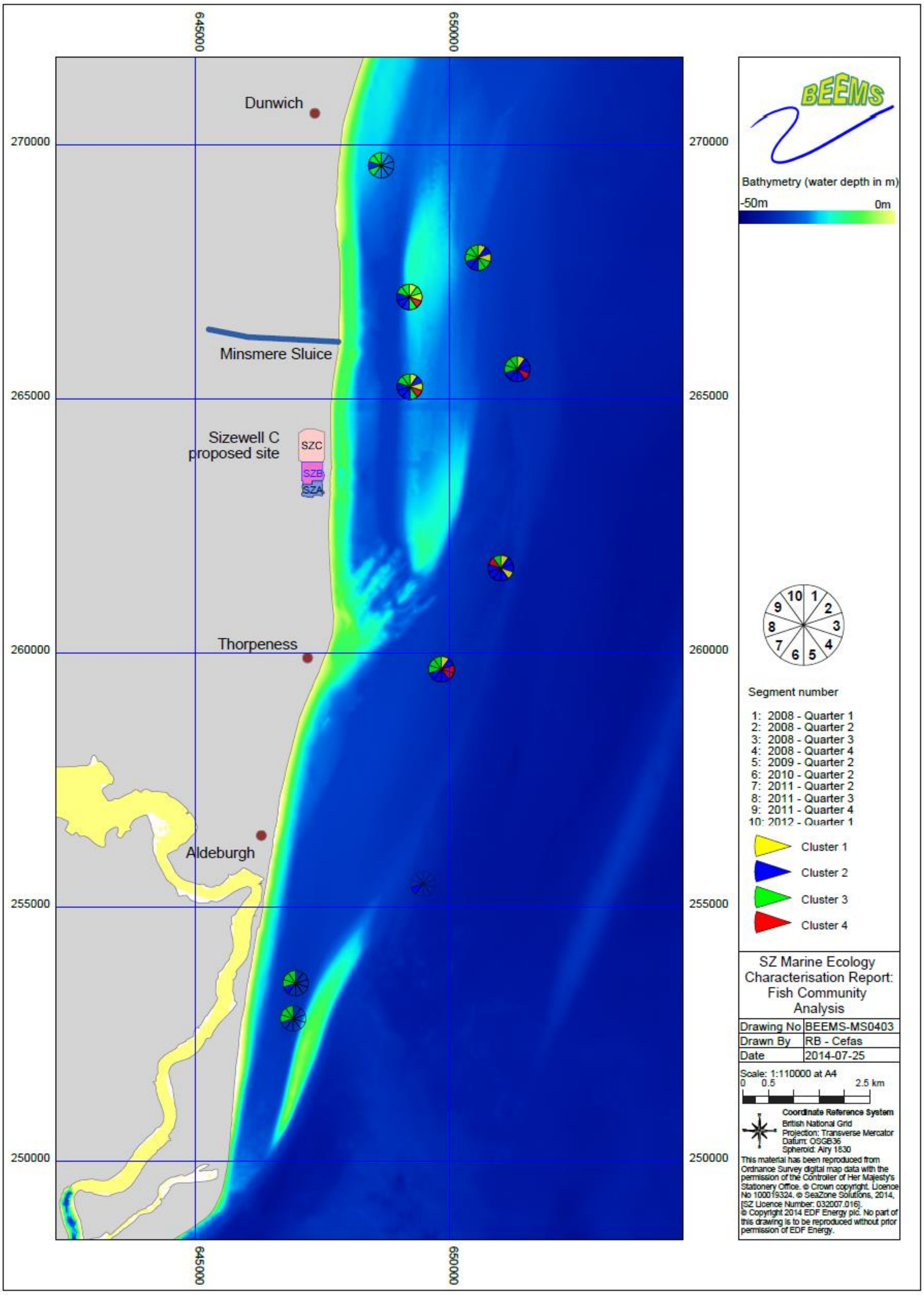


Figure 6. Summary of cluster analysis outputs for the commercial otter trawl data. Samples were assigned to one of four clusters (indicated by the coloured segments). Segment positions relate to individual surveys and empty segments indicate samples containing no fish.

2.2 Overview of the pelagic community

Both gears utilised in the coastal demersal surveys – the 2 m beam trawl and commercial otter trawl - may catch pelagic fish during deployment and retrieval; though neither is specifically designed for this purpose, some information on the species present can be gleaned from them when considered alongside the impingement and acoustic data. The following species were recorded in the coastal demersal and pelagic acoustic surveys:

- Atlantic herring *Clupea harengus* (demersal survey only)
- European sprat *Sprattus sprattus* (demersal and acoustic survey)
- anchovy *Engraulis encrasicolus* (demersal and acoustic survey)
- mackerel *Scomber scombrus* (demersal survey only)
- horse mackerel (scad) *Trachurus trachurus* (demersal survey only)
- pilchard *Sardina pilchardus* (demersal survey only)

Herring, sprat and anchovy were caught in the coastal demersal surveys by the 2 m beam trawl and herring by the otter trawl. Anchovy and small sprat were also captured in the ground-truthing trawls[9] carried out for the June 2015 acoustic survey.

All six species were recorded in the Sizewell B impingement monitoring; collectively, they accounted for approximately 65 % of the total numbers of fish caught, suggesting pelagics are common in the Greater Sizewell Bay area (Table 5). Sprat was the most abundant, at 49 % of the total fish catch, then herring at 16 %.

From the acoustic data, pelagic fish were more abundant in waters further north off Minsmere than around Sizewell itself, although good numbers were found at Sizewell throughout the year (Figure 7). The fish appeared to aggregate in larger schools mainly at the edge of sandbanks during the winter and during the summer were more evenly distributed across the area, although highest densities were consistently found more offshore. Schools were denser and smaller during the summer and although variable between surveys and subareas, more than half of the pelagic fish biomass was found in the near surface waters (2-5 m depth).

The variability of the distribution, behaviour and abundance of pelagics in the acoustic survey suggests it covered only a small component of the mobile pelagic fish community off the East Anglian coast. Information from the East Anglia ONE surveys of winter 2010/2011[10] (Scottishpower Renewables, 2012) suggests that, while the species present in the bay mirror those found in the wider offshore region, there may be differences in relative distribution, at least at certain times of year. Based on the November 2010 data, anchovy was much more dominant in the wider region than in the Sizewell data, comprising 29 % of the total catch (including non-target species) *versus* < 1 % of the Sizewell impingement catch, while at 14 % offshore *versus* 49 % in the Sizewell catch, sprat was much less prevalent (Table 4). Pilchard was also more prevalent in the wider region, at least in November 2010. Only two pelagic species were caught in the February 2011 East Anglia ONE survey - sprat, which dominated the catch (more similarly to the Sizewell data), and anchovy. Unfortunately the survey report does not quote absolute numbers so little more can be said of the January data. On the basis of this evidence, herring and sprat are the most prevalent pelagics around Sizewell.

[9] Using the Lowestoft box trawl
[10] In November 2010 and February 2011. Nine * 20-minute tows using pelagic gear in both cases.

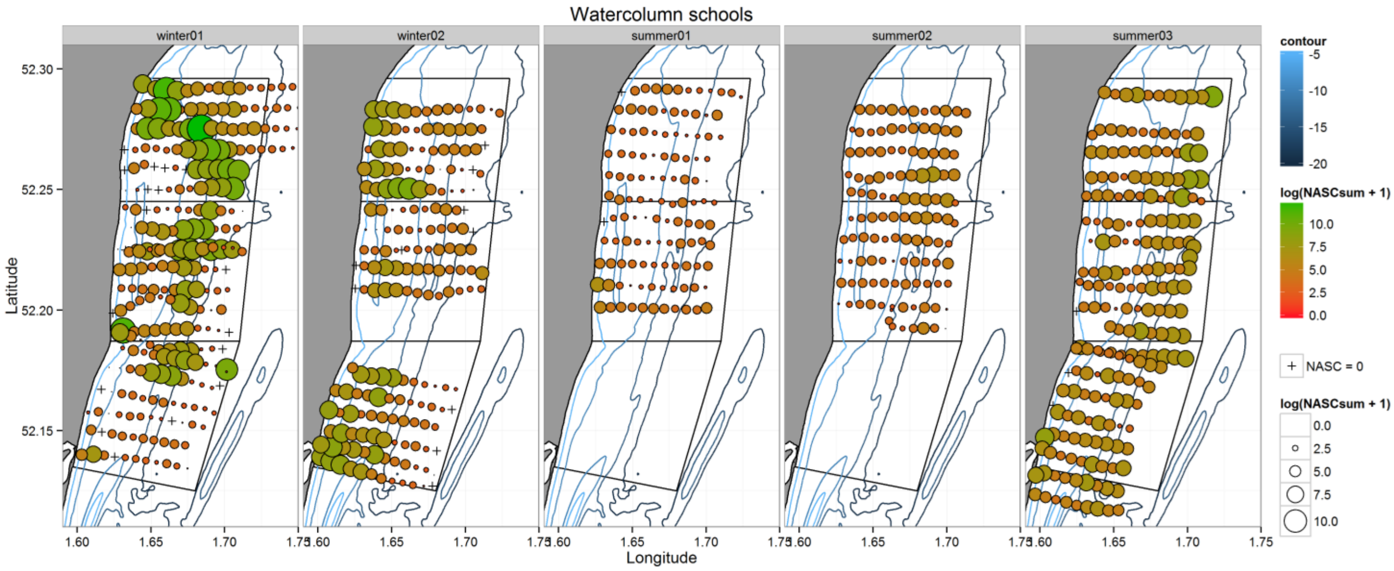


Figure 7: Acoustically derived pelagic fish density distribution (NASC) per 500 m interval from the BEEMS acoustic surveys. Bubble size and colour represent density. The survey was split into strata; Stratum 1 = Minsmere, Stratum 2 = Sizewell, Stratum 3 = Thorpeness. Bathymetry contours (blue) are shown.

Table 5. Pelagic fishes impinged at Sizewell B. No. = estimated total number. T = % of total fish caught (all fish and pelagic species only). Cum. = cumulative % abundance. *n* and S = number and % of samples in which the species was recorded. * species also found in the BEEMS coastal surveys. EAO = relative dominance of the species in the November 2010 East Anglia ONE survey (% of total catch). (These data are estimated impingement numbers for the sampling days in the period 2009 to 2013 only; the estimated annual impingment numbers for SZB may be found in BEEMS Technical Report TR406).

		All fish		Pelagics only			
	No.	**T (%)**	**Cum. (%)**	**T (%)**	***n***	**S (%)**	**EAO (%)**
European sprat*	730 322	48.55	48.55	74.63	124	99.2	14
Atlantic herring*	234 328	15.58	64.13	23.95	114	91.2	11
Anchovy*	12 376	0.82	64.95	1.26	48	38.4	29
Pilchard	1 057	0.07	65.02	0.11	28	22.4	15
Horse mackerel	333	0.02	65.04	0.03	27	21.6	3
Mackerel	120	0.01	65.05	0.01	9	7.2	2

2.3 Temporal changes to marine communities

Changes in the fish community over a longer time period can be approximated by comparing the 2009-2013 Sizewell B impingement data with those generated from impingement sampling at Sizewell A in 1981-1982 (Turnpenny and Utting, 1987; Turnpenny et al., 1983). To compare the 2 datasets it is important to understand that the Sizewell A cooling water system was different from that of Sizewell B in 2 respects (Fleming et al., 1994):

1. Sizewell B has a capped head inlet design that substantially reduces the magnitude of vertical currents at the head. Studies in the USA have shown that such a design can reduce impingement of pelagic fish by up to 90 %.*(*Fleming *et* al 1994);

2. The Sizewell A inlets were 300 m offshore whereas the Sizewelll B inlets are 600 m offshore. The Sizewell B inlets are therefore further from the shallow inshore flatfish nursey areas and would be expected to produce reduced impingment for such species.

A 30 day impingment intercomparison between Sizewell A and B stations during the Sizewell B commissioning trials in 1994 showed the following signiificant differences in impingement:

Species	Reduction in impingment per unit of cooling water flow at Sizewell B compared with Sizewell A
Sole	37%
Dab	54%
Plaice	46%
Sprat	62%
Bass	9%
Average over 63 other species	**51%**

The 1981-1982 Sizewell A dataset comprised 41 x 24-h sampling visits over a 12 month period and resulted in a catch of 73 fish species. In terms of abundance, the top 4 species from the Sizewell A sampling (sprat, whiting, sand goby, and herring), were also in the top 5 from the more recent BEEMS Sizewell B sampling.

As the Sizewell A dataset was only for 1 year for most species it is not possible to state whether the observed changes in abundance over the past 30 years are significant or just the result of natural year to year variation. However, the abundance of 3 species has apparently changed considerably:

Species	Apparent increase in abundance since 1981/2	Rank in SZB impingement data compared with rank in SZA data
Bass	700x	Now the 4th most abundant species at Sizewell, was 28th
Anchovy	150x	Now 7th ,was 37th
Thin lipped mullet	30x	Now 8th, was 24th

Although the most abundant coastal species apparently occur in similar abundances, there is evidence that there has been a change in fish community structure with substantial numbers of juvenile warm water species appearing since the 1980s.

In terms of migratory species the datasets show broadly unchanged abundance of cucumber smelt with a decrease in eel abundance. The data indicate a reduction in tope abundance and an increase in twaite shad numbers but both of these apparent changes may be within natural variation and the changes, if any, are uncertain). Allis shad, lampreys, salmon and sea trout are rare or absent in both datasets.

In terms of potential marine prey for protected birds (red throated diver and terns) the dominant fish species (sprat and herring) remain unchanged with very low numbers of 2 species of sandeels recorded at Sizewell in both datasets (*Ammodytes tobianus* amd *Hyperoplus lanceolatus*).

2.4 Annual variation in key species numbers from the BEEMS impingement data

The abundance of fish in the greater Sizewell Bay area was highly variable over time, as illustrated by the BEEMS impingement data (Figure 8). In 2011, over 4 million sprat were estimated to have been impinged at Sizewell B, compared with just over one million in the other three years of sampling (BEEMS impingement dataset). Herring showed an annual increase in abundance through the 4 year sampling programme, and whiting, bass and sand goby all showed one year where impingement was notable higher (sometimes double) the other three years. This highlights the natural variability of fish populations, which can be as a result of changes to local population levels or environmental factors.

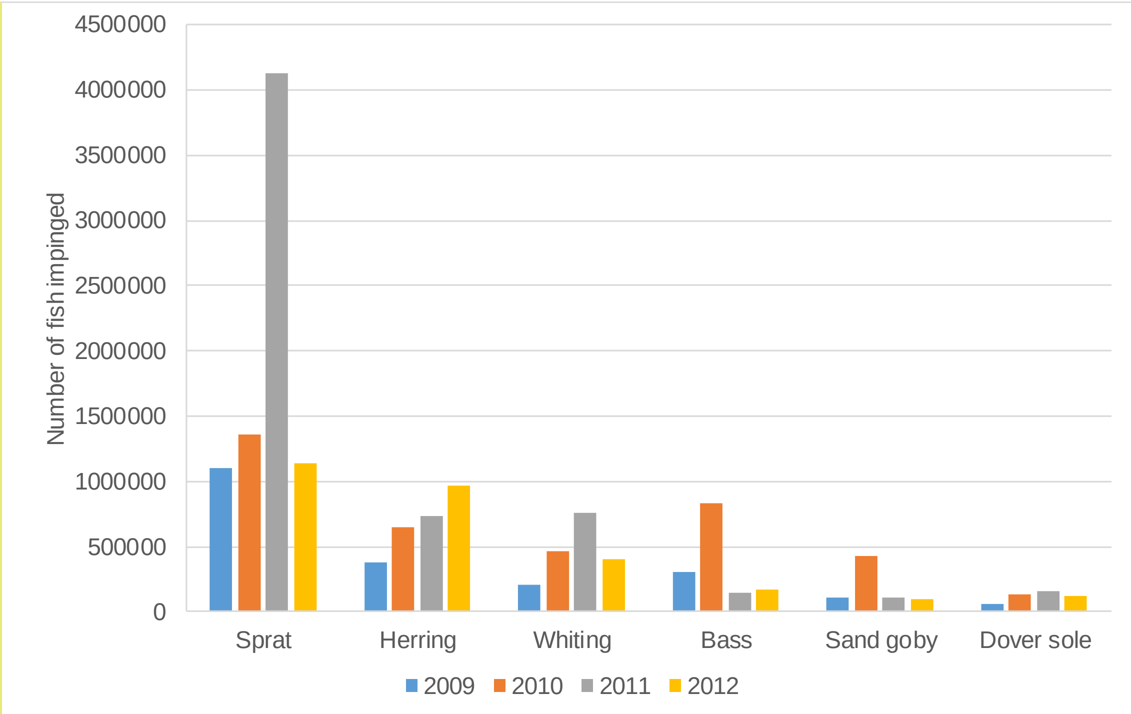


Figure 8. Annual abundance (by number) of the six most abundant fish taxa recorded in the BEEMS impingement samples.

2.5 Seasonal variation in key species numbers from the BEEMS impingement data

The abundance of fish taxa is also highly seasonal, as demonstrated by the BEEMS impingement data. Catches of fish (by number and weight) were notably low over the summer months of June, July and August. During these months, the catches of crustaceans, ctenophores and other invertebrates dominated the impinged fauna (BEEMS Technical Report TR120) (similar patterns were seen in the other years of impingement sampling). During the winter months, large ingresses of fish are seen. The proportion of impingement abundance recorded during each month is given in Table 6. The greatest proportion of sprat were impinged between December and March, while herring were mostly impinged in February to April and bass from October to April. Some species, such as herring (June and July) and bass (May to September), were not impinged for some part of the year, indicating that their abundance offshore in the Greater Sizewell Bay area is also proportionally low. Patterns of impingement catches for individual species throughout the four years of sampling are given in Section 3 (Descriptions of key taxa).

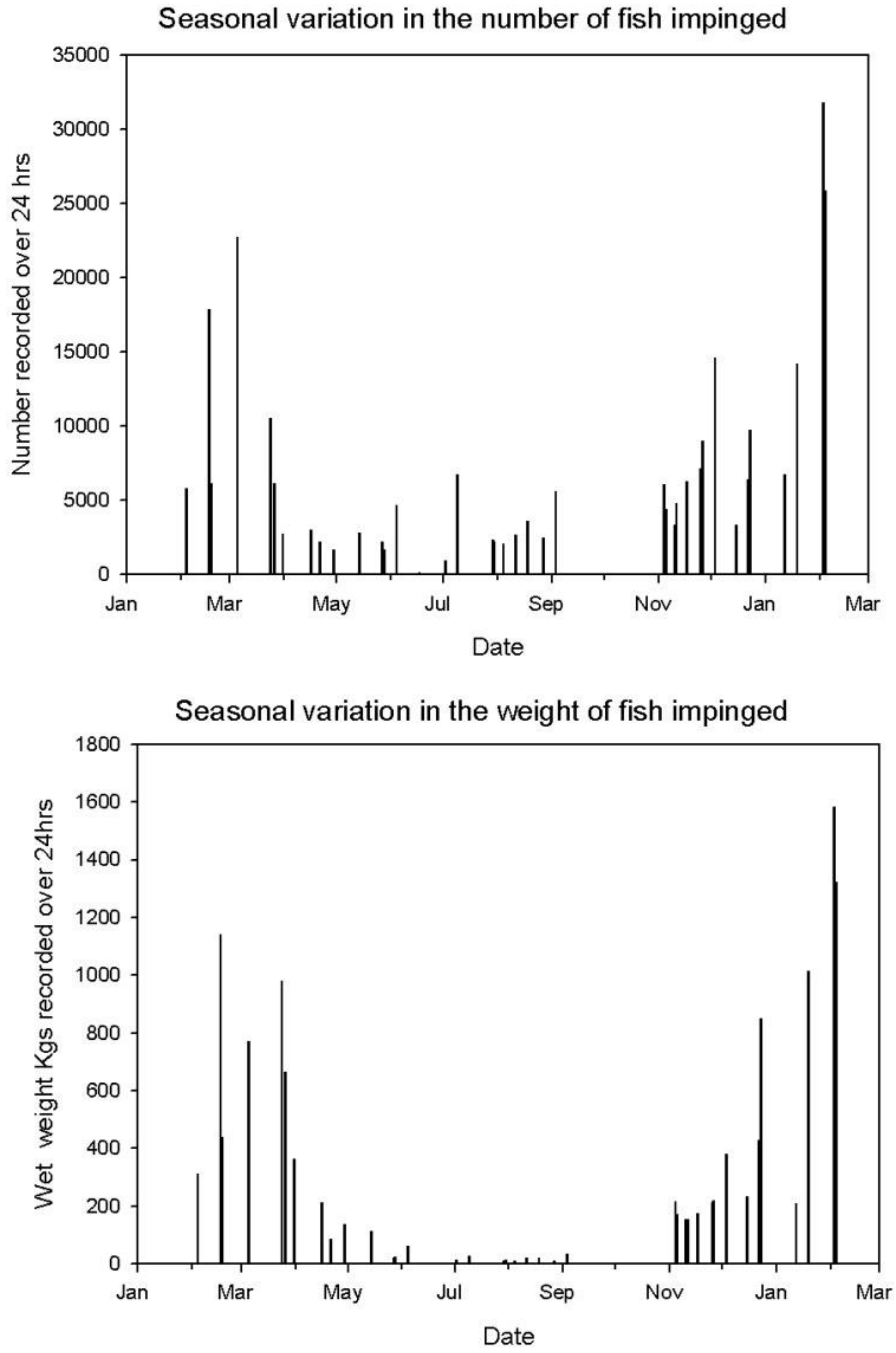


Figure 9. Seasonal variation in (top panel) the number and (bottom panel) the weight of all fish taxa impinged at Sizewell B per 24 hour sample between February 2008 and February 2009 (BEEMS Technical Report TR120).

Table 6 Seasonal variation in key fish species numbers (from impingement data 2009-2013)

Species		SZB annual impingement numbers	% of total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sprat	*Sprattus sprattus*	1,933,302	47.5%	x											
Herring	*Clupea harengus*	682,912	16.8%			x									
Whiting	*Merlangius merlangus*	459,378	11.3%		x										
Bass	*Dicentrarchus labrax*	363,990	8.9%		x										
Sand Goby	*Pomatoschistus minutus*	185,196	4.6%									x			
Dover sole	*Solea solea*	118,392	2.9%				x								
Dab	*Limanda limanda*	66,317	1.6%									x			
Anchovy	*Engraulis encrasicolus*	39,496	1.0%						x						
Mullet, thin lipped	*Liza ramada*	33,674	0.8%		x										
Flounder	*Platichthys flesus*	11,778	0.29%			x									
Plaice	*Pleuronectes platessa*	10,466	0.26%										x		
Cod	*Gadus morhua*	10,297	0.25%	x											
Smelt, cucumber	*Osmerus eperlanus*	9,186	0.23%								x				
Ray, thornback	*Raja clavata*	2,032	0.05%				x								
European eel	*Anguilla anguilla*	1,046	0.03%										x		
Mackerel, horse	*Trachurus trachurus*	979	0.02%									x			
Shad, twaite	*Alosa fallax*	872	0.02%					x							
River lamprey	*Lampetra fluviatilis*	830	0.02%										x		
Mackerel	*Scomber scombrus*	364	0.01%				x								
Sea trout	*Salmo trutta*	8	0.00%					x							
Shad, allis	*Alosa alosa*	3	0.00%					x							

Colour	Abundance: Pecentage of peak month (marked with an x)
	26% - 100%
	6% - 25%
	1% - 5%
	Not present or <1%

2.6 Size distributions of key fish species in the BEEMS impingement data

Overall, the majority of fish sampled by the BEEMS impingement programme were small, ranging up to 25 cm Standard Length, *SL*[11]. This is because many species use the inshore areas such as shallow bays for spawning and nursery areas, and many species show an offshore migration as body size increases. Also, due to their lower swimming speeds, juveniles are more vulnerable to impingement.

Many of the fish impinged, particularly of the species that dominated the impingement catches were small when compared with the maximum size attainable for their species, or were smaller than the size at which the species becomes sexually mature. For example, for herring in the North Sea the length at which 50 % are mature is approximately 25 – 28 cm *TL* (Heessen et al., 2015). The length distribution of herring impinged at Sizewell B shows that approximately 80 % of the herring impinged were below 25 cm *TL*. Similarly, Dover sole females mature at approximately 28 cm and 2-3 years old, and the males at a slightly younger age and smaller size (Heessen et al., 2015). In the BEEMS impingement sampling, approximately 98 % of sole were below the size of maturity.

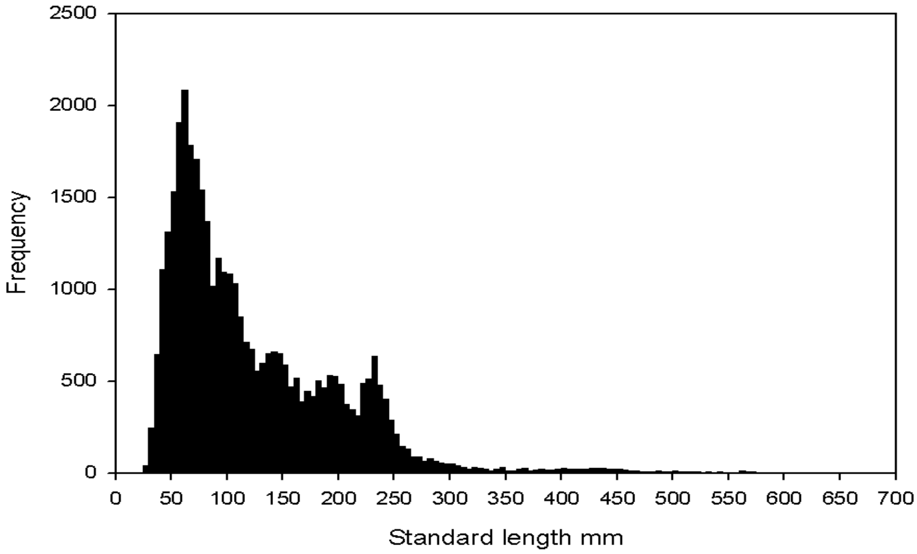


Figure 10. Length distribution (standard length, mm) of all fish impinged at Sizewell B between February 2009 and February 2010 (BEEMS Technical Report TR120).

[11] *SL* length refers to the length of a fish measured from the most anterior tip of the body to the posterior end of the vertebral column, and was used to record the lengtsh of fish measured between February 2009 and February 2013. This measurement does not include the length of the tail. For subsequent analysis of length data, *SL* was converted to Total Length, *TL*, as most length-weight conversions are carried out using this measurement, and information on size at maturity or age are usually given for *TL*. *TL* is defined as the length from the most anterior point of the body to the tip of the longer lobe of the caudal fin, usually measured with the lobes compressed along the midline. This is a straight-line measurement and does not measure the curve of the body

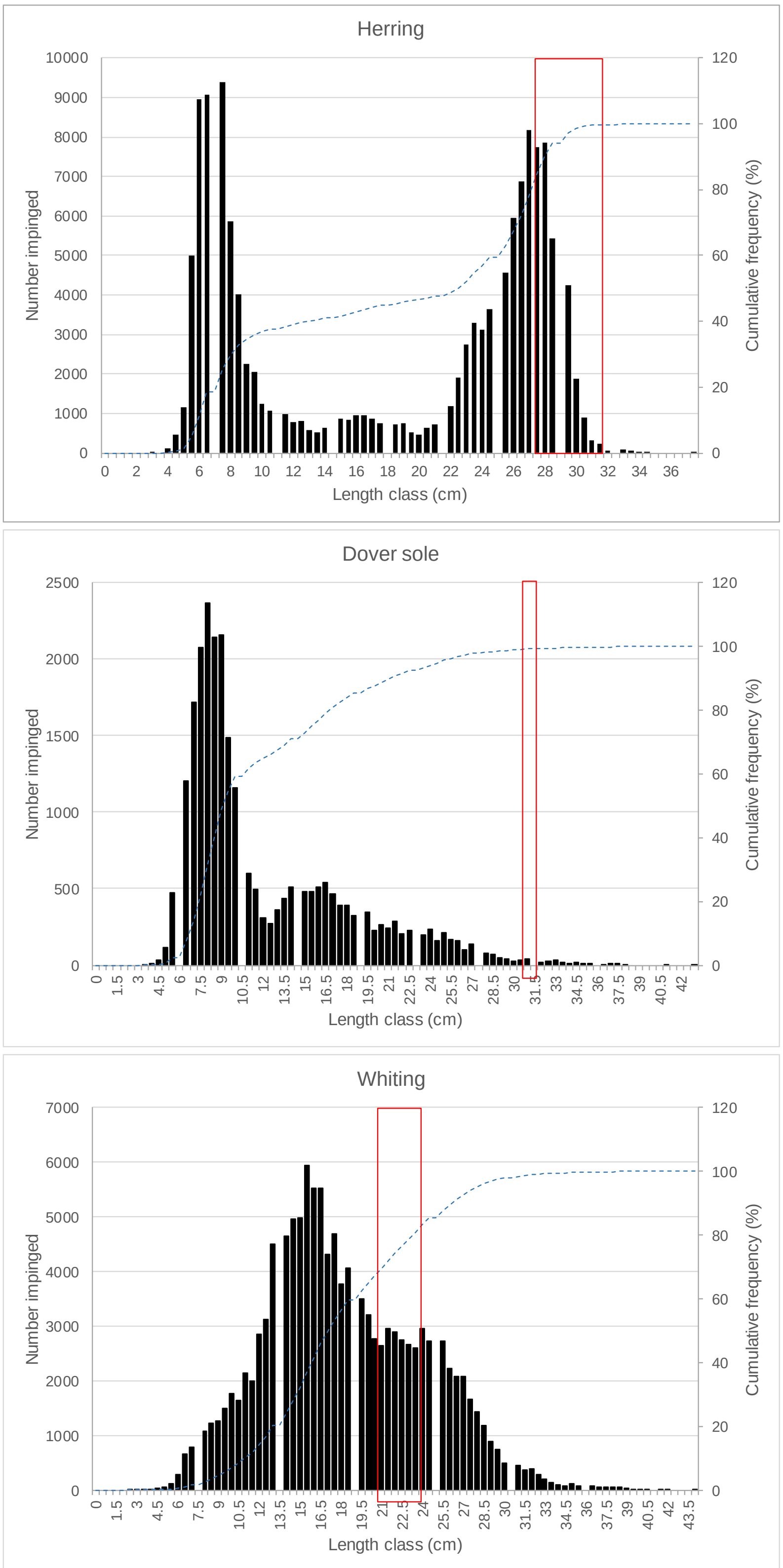


Figure 11. Length distributions (Total Length, cm) of three fish species impinged at Sizewell B between February 2009 and February 2013. The red boxes indicate the estimated size range at which fish are at 50 % maturity (Heessen et al., 2015). The blue dotted line indicates the cumulative total of numbers impinged.

2.7 Spawning and nursery areas of fish species that occur in the Greater Sizewell Bay

Many of the species recorded in the Greater Sizewell Bay area during the BEEMS surveys are part of a larger population that may encompass the southern North Sea, or even the whole of the North Sea. Some, such as bass may undertake migrations as adults between spawning grounds that are outside of the North Sea, but returning to the area to feed (Pawson et al., 2007). Consequently, while the Greater Sizewell Bay area may provide spawning and nursery areas, leading to the capture of eggs and larvae during plankton sampling, and juveniles during impingement or coastal sampling, the whole spawning and nursery areas often extend beyond the area encompassed by the Bay (Table 7). For example, Dover sole spawn throughout the southern North Sea and eastern English Channel, and juveniles tend to be distributed in the Thames estuary, along the east Anglian coast, and also on the continental coast of the southern North Sea (Figure 12). Similarly, sprat spawning and nursery areas are widely distributed throughout the central and southern North Sea (Figure 13).

Table 7. Extent of spawning and nursery areas of commercially-important fish, in comparison with the Greater Sizewell Bay

Species	Spawning/nursery areas	Reference
Dover sole	Spawning grounds are found throughout the southern North Sea and English Channel. Juveniles are distributed along the English, Belgian and Netherlands coasts.	Ellis et al., 2012; Heessen et al., 2015
Plaice	Spawning in the southern North Sea is of greatest intensity along the eastern coasts (off Belgium and the Netherlands). Nursery grounds throughout the North Sea.	Ellis et al., 2012; Heessen et al., 2015
Cod	Spawning grounds are offshore of the Greater Sizewell Bay area. Juveniles may be found in the area, but highest intensities of juveniles are found off the north-east costs of England and Scotland and in the central North Sea.	Ellis et al., 2012; Heessen et al., 2015
Bass	Spawning throughout the western and eastern English Channel. There is no contemporary information on spawning in the North Sea, but evidence indicates that reproductive success and production of the sea bass population there has been much higher in the 1990s and 2000s. 0-group sea bass are found almost exclusively in creeks, estuaries, backwaters and shallow bays that border the southern North Sea.	Colman et al., 2009; Pawson et al., 1987
Herring	Spawning at a low intensity across the survey, greater intensities are seen in the eastern English Channel and off the north-east costs of England and Scotland. High intensity of juveniles seen along the entire east Anglian coast.	Ellis et al., 2012
Thornback ray	Litlle data available on the location of spawning areas, but juveiles are found along the east Anglian coast, particulalrly the Thames area.	Ellis et al., 2012

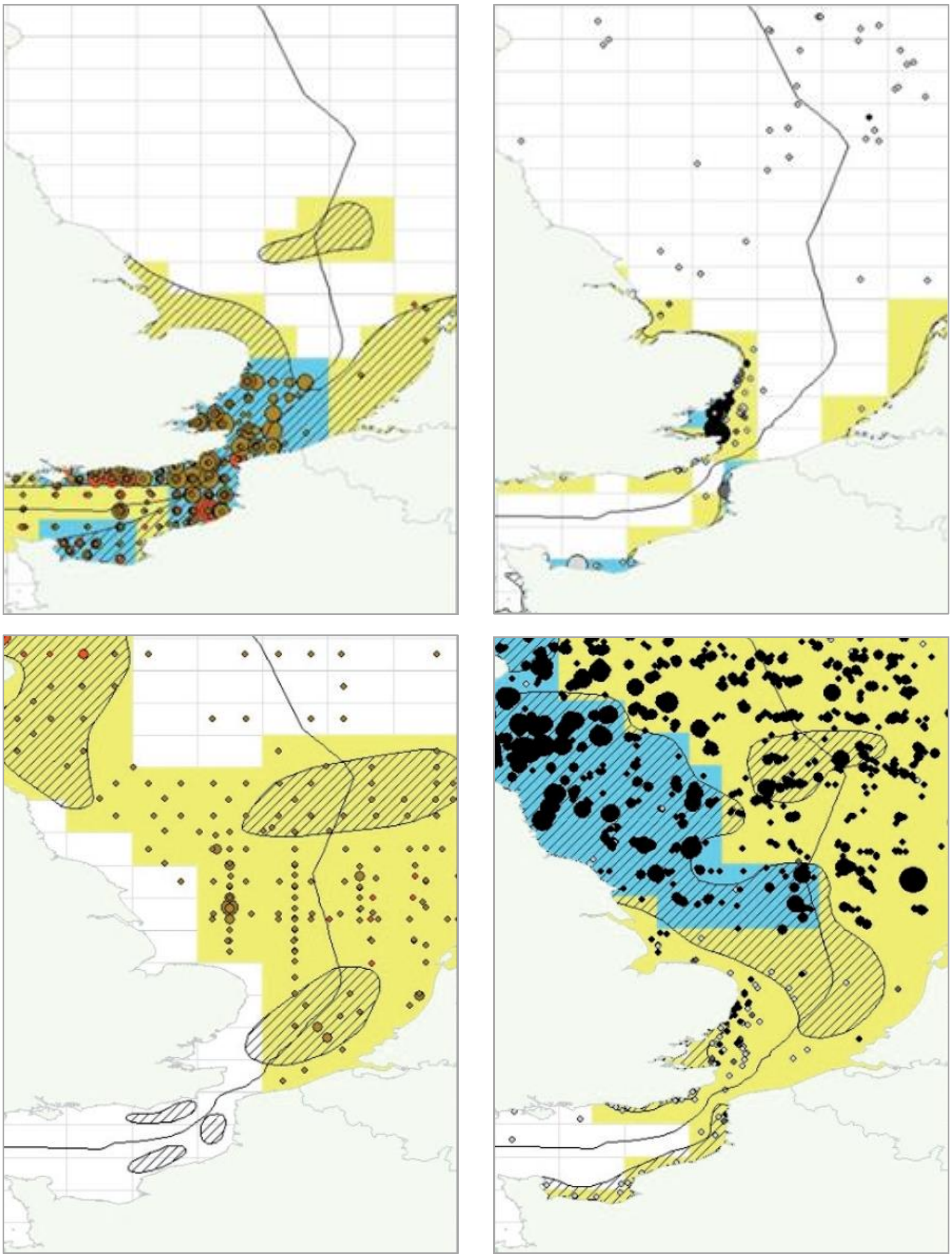


Figure 12. (Left) Spawning areas and (right) nursery grounds of (top) Dover sole and (bottom) whiting in the Central and Southern North Sea (Ellis et al., 2012)

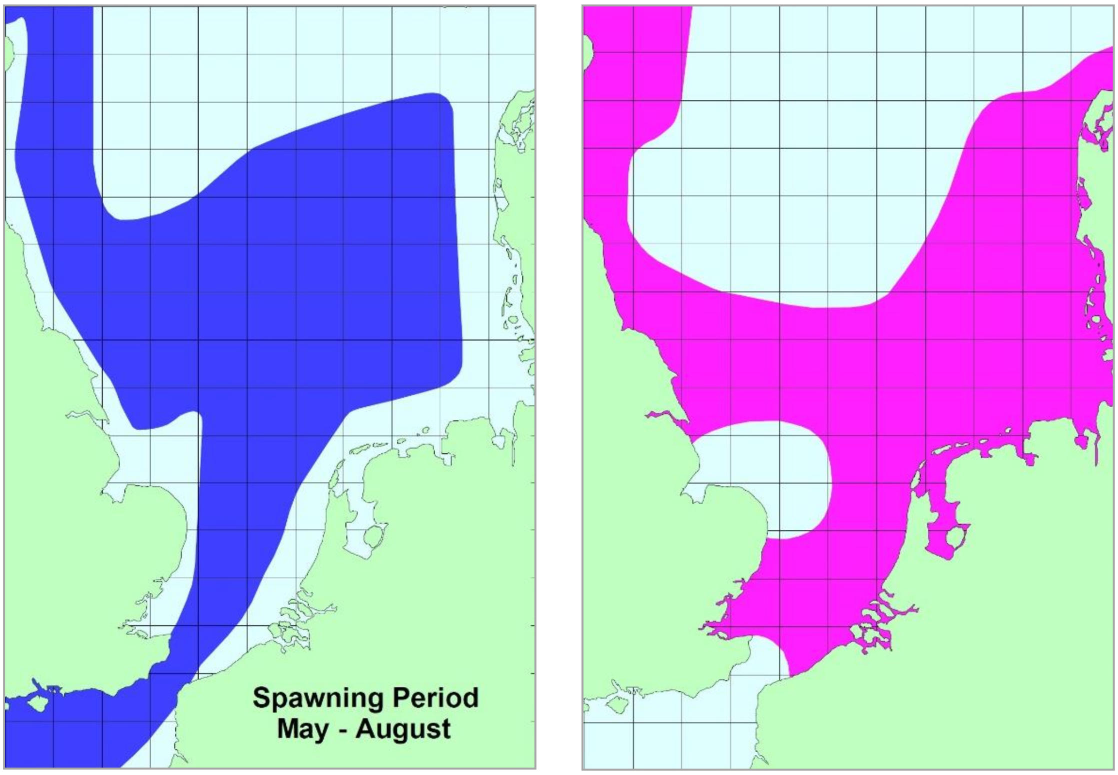


Figure 13. (Left) Spawning areas and (right) nursery grounds of sprat in the Central and Southern North Sea (Coull et al., 1998)

2.8 Selection of key taxa

For the purposes of the Sizewell marine ecology impact assessments, taxa are considered to be key in the ecosystem if they meet at least one of the following criteria:

- Socio-economic value: Species that contribute to the first 95 % of the first sale value of commercially - landed finfish in the area off the east Anglian coast and contributes to the first 95 % of total abundance in at least one of the available datasets (2 m beam trawl, otter trawl, eel surveys, annual impingement). Commercial landings are recorded using statistical rectangles that divide the southern North Sea into areas of 30 minutes latitude by 1 degree longitude and covering approximately 30 nautical miles[2]. For the purposes of describing local commercial fisheries, 6 rectangles have been considered, that extend from north Norfolk to the Thames estuary and eastwards to the middle of the North Sea (BEEMS Technical Report TR123). Socio-economic value was calculated using data supplied by the Marine Management Organisation (MMO) and which was used in (BEEMS Technical Report TR123), but for this report, landings and values were summed for the years 2011-2013. **6 taxa.**

- Conservation importance: The "S41 Priority Species" spreadsheet given by Natural England (http://publications.naturalengland.org.uk/publication/4958719460769792) was used to assess the conservation status of the fishes recorded in the Greater Sizewell Bay. This spreadsheet was built based on the legislation in Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006. It is worth noting that measures in place to provide protection for the named species apply to the adult stock rather than the eggs or larvae, and focus on halting the decline of the spawning stock biomass mainly *via* restriction on exploiting recruited species. The resulting list contains 2 species which are not covered by the sampling described in this report: sea lamprey and Atlantic salmon[12]. **16 taxa.**

- Ecological importance: If a taxon is present in at least 30 % of samples and contributes to the first 95 % of total abundance in at least one of the available datasets (2 m beam trawl, otter trawl, eel surveys, annual impingement), we consider it to be common and/or abundant enough to play a key trophic role within the ecosystem.. **13 taxa.**

There are 24 key taxa in the Greater Sizewell Bay in total. Several taxa fall under more than one criterion and four taxa are important with respect to all three (Dover sole, herring, cod and plaice).

Several fish species (solenette *Buglossidium luteum*, gobies Gobidae, rocklings Lotidae, and lesser weever *Echiichthys vipera*), are included in the ichthyoplankton characterisation (BEEMS Technical Report TR315) either on the basis that they were present in at least 5 % of the samples collected, or that they contributed at least 1 % to the total abundance of ichthyoplankton recorded. However, while they may be present within the Greater Sizewell Bay during planktonic stages, they are not sufficiently abundant to be key components of the fish community in later life stages and are not included here.

The key fish taxa are shown in Table 8 and their spatio-temporal distributions described in the following subsections. Impingement data help elucidate any temporal trends; where impingement data are not referred to in specific sections, the species has not been captured to-date in the impingement monitoring. Summaries of the life histories and fisheries are included where relevant, but full details are not given as these have been provided elsewhere (BEEMS Technical Report TR123 and BEEMS Technical Report TR406).

[12] One sea lamprey was subsequently recorded during impingement sampling at Sizewell B in 2015.

Table 8. Key Sizewell fishes in order of impingment numbers. Colour coding is used to aid visualisation of the ecological criteria (beam trawl samples, otter trawl samples, glass eel surveys and impingement samples).

			Ecological					
Taxon		**Socio-economic**	2 m beam trawl	Otter trawl	Glass eel surveys	CIMP	**Conservation**	**Comments**
European sprat	*Sprattus sprattus*							Important as bird prey
Atlantic herring	*Clupea harengus*	Yes					Yes	Important as bird prey
Whiting	*Merlangius merlangus*						Yes	
European sea bass	*Dicentrarchus labrax*	Yes						
Sand goby	*Pomatoschistus minutus*							
Dover sole	*Solea solea*	Yes					Yes	
Dab	*Limanda limanda*							
Anchovy	*Engraulis encrasicolus*							
Thin-lipped grey mullet	*Liza ramada*							Also important to recreational angling
European flounder	*Platichthys flesus*							
Atlantic cod	*Gadus morhua*	Yes					Yes	
European plaice	*Pleuronectes platessa*	Yes					Yes	
Smelt	*Osmerus eperlanus*						Yes	
Thornback ray	*Raja clavata*	Yes						
European eel	*Anguilla anguilla*						Yes	
Horse mackerel	*Trachurus trachurus*						Yes	
Twaite shad	*Alosa fallax*						Yes	
River lamprey	*Lampetra fluviatilis*						Yes	
Mackerel	*Scomber scombrus*						Yes	
Sea trout	*Salmo trutta*						Yes	
Allis shad	*Alosa alosa*						Yes	
Tope	*Galeorhinus galeus*						Yes	Only found rarely in BEEMS otter trawl surveys
Atlantic salmon	*Salmo salar*						Yes	Not found in any BEEMS survey
Sea lamprey	*Petromyzon marinus*						Yes	One individual observed in 2015 CIMP.

3 Descriptions of key taxa

3.1.1 Dover sole (*Solea solea*)

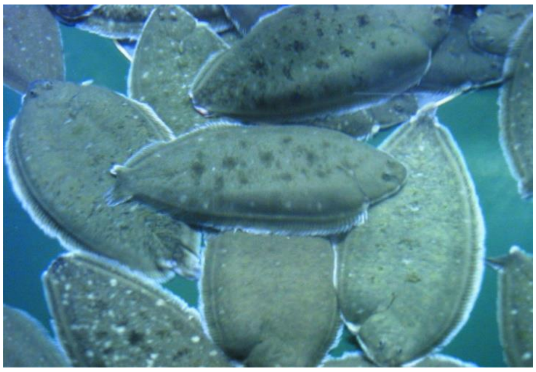


IMAGE: Dover sole. © Crown copyright 2010

The Dover sole is a common UK flatfish species, that is most abundant on fine sand, sandy mud and estuarine mud (UKOOA, 2000; Wheeler, 1969a). Dover sole is mainly taken by beam trawlers in the southern and south-eastern North Sea, in a mixed flatfish fishery with species such as plaice, but it may also be targeted with seines, gill nets, and twin trawls (ICES, 2014a).

Sole were found at all BEEMS 2 m beam and otter trawl sampling sites (Figure 14). Due to gear selectivity, small fish were caught by the 2 m beam trawl (average total length TL = 139 mm, n = 1054 and larger fish by the otter trawl (average TL = 278 mm, n = 942) (Appendix B). The small sole were generally more abundant closest inshore and in the areas around Sizewell B and off Aldeburgh. Variability in abundance over time at individual sites was generally high or very high. In contrast, the abundance of larger sole was more consistent across the survey area, with abundances of 5 - 10 individuals per hour observed.

The abundance of small sole was highly variable from survey to survey – there was a medium to very high coefficient of variation at all but one sites (Figure 14) - with high abundance during the first three surveys, but lower abundance in October 2008 and June 2009 (Figure 15, top). For larger sole, abundance at each sampling site between surveys was less variable (mostly medium variability, see Figure 14), with less variability in abundances between surveys (Figure 15, top). This pattern could also be seen when the abundance data were averaged monthly and standardised to the highest value. High abundances of small sole were seen in May, September and March (Figure 15), whereas highest abundances for larger sole were seen in October and May (Figure 15). In the impingement data, abundance was highest in April and May (Figure 15, middle).

The high annual variability in the abundance of small sole can also be seen in the long-term dataset of the East Anglian area of the Young Fish Survey. Data from 1981 to 2010 show that from year to year, abundance (reported as average catch per unit of effort, or av cpue) ranged between ~5 and ~25 individuals caught per km^2 fished, and that abundance of small sole in 2009 was one of the lowest of the time series (Figure 15, bottom). This is similar to patterns seen in recruitment into the fishery at age 1, where relatively good years of recruitment are seen every 4-5 years (ICES, 2014a). Although sole recruitment can be variable, the spawning stock biomass (SSB - the size of the population that is mature), is regarded by ICES to be above safe limits.

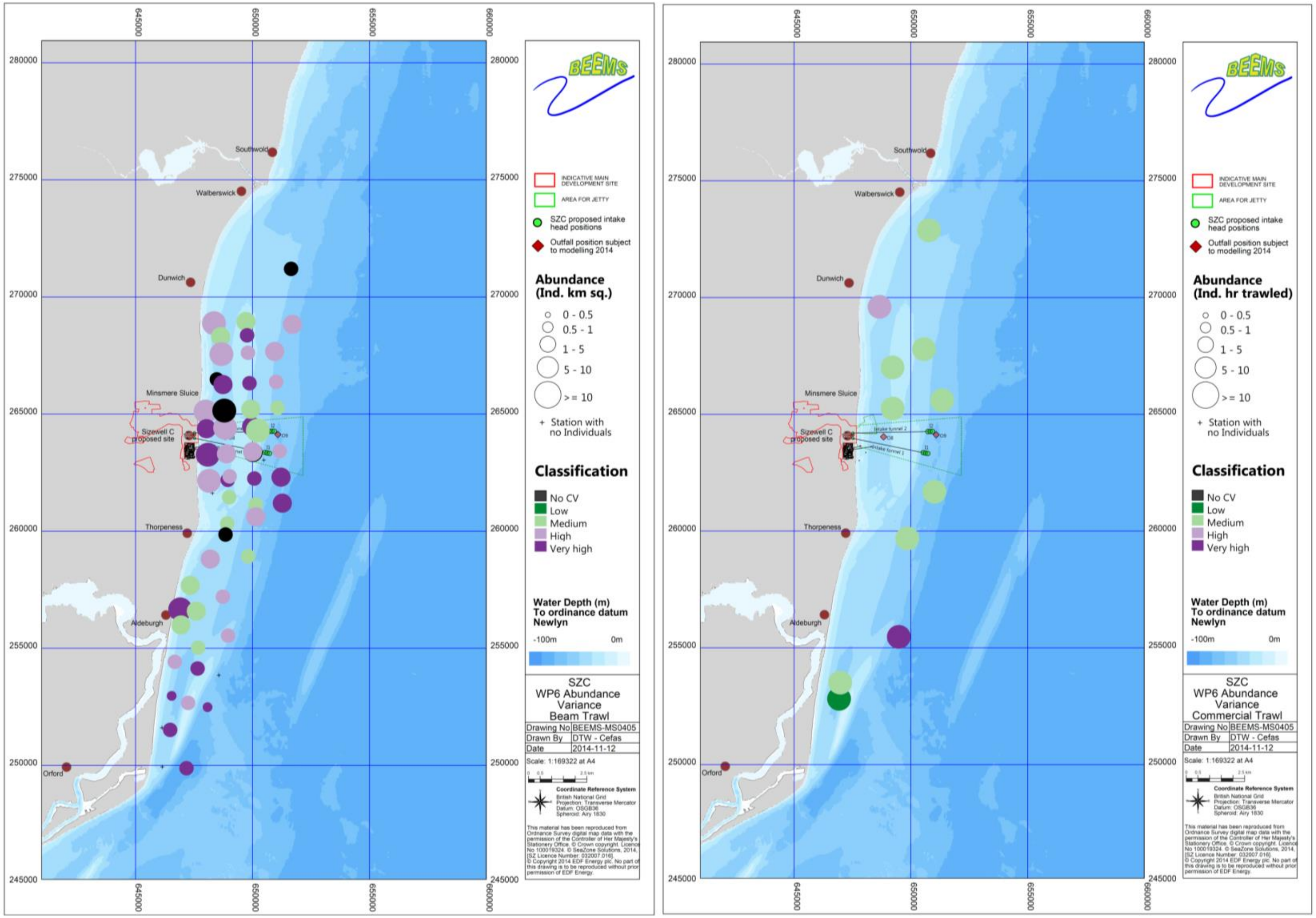


Figure 14. Mean abundance of Dover sole across the study area, together with the coefficient of variation (CV), which represents the degree of variability in mean abundance among surveys. (Left panel: 2 m beam trawl abundance = individuals/km^2; right panel: otter trawl abundance = individuals/hour).

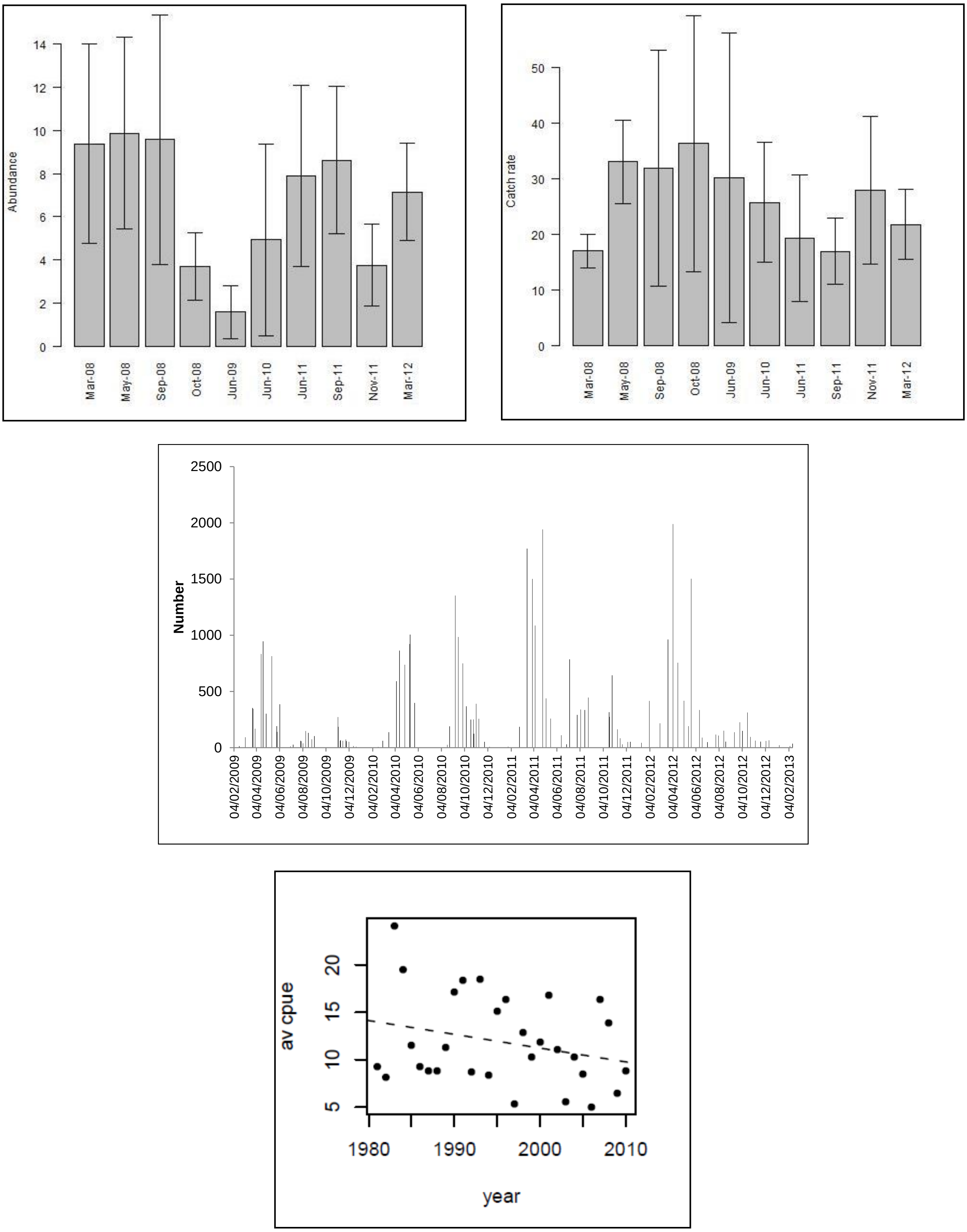


Figure 15. Dover sole patterns: Top: mean abundance (± 95 % C.I.) for each coastal survey (left - 2 m beam trawl abundance as ind/km^2; right - otter trawl catch rate as ind/hour). Middle: impingement monitoring as no./24 hr. Bottom: abundance as average ind./1000 m^2 (av cpue) in the East Anglian region during the Eastern Young Fish Survey (the dashed line shows the general trend; reproduced from Cefas (2011).

3.1.2 European plaice (*Pleuronectes platessa*)

IMAGE: Plaice. © Crown copyright 2010

Plaice are bottom-living and found in a wide range of habitats, but prefer sand or muddy substrata (Maitland and Herdson, 2009; UKOOA, 2000; Wheeler, 1969a). Juveniles are found on beaches characterised by sand or sand and mud and other inshore estuarine areas along the East Anglian coast, although the Wadden Sea and other nursery areas on the eastern side of the North Sea contribute most of the recruitment to the North Sea stock (ICES, 2009a). Plaice is predominantly targeted by beam trawlers in the central part of the North Sea, and is caught in a mixed fishery targeting sole in the southern North Sea. (ICES, 2014b).

Plaice were observed in 5.9 % and 43.4 % of the BEEMS 2 m beam trawl and otter trawl samples, respectively (Table 4), and as with sole, the 2 m beam trawl gear caught individuals on average smaller than those caught by the otter trawl [152 mm *TL* (*n* = 54) *versus* 186 mm *TL* (*n* = 282), see Appendix B]. The distribution of small plaice was patchy across the survey area, with none observed south of Aldeburgh and the majority of observations in the vicinity of the Sizewell B station (Figure 16). Large plaice were observed at all otter trawl sites, although inter-survey abundance was very variable at each sites (Figure 16).

The species remained in low abundance across the survey series, with the exception of September 2011, when relatively high numbers were recorded in both gears - a similarly high abundance was observed in the impingement data at that time (Figure 17, top and middle). It is difficult to determine any trends in plaice abundance through the BEEMS survey series, but long term data on juvenile plaice sampled off the East Coast (in the Young Fish Survey), indicate a decadal-scale decline (Figure 17, bottom). Data on plaice in the North Sea, indicate a slight increase in the abundance of fish age 1 recruiting in to the fishery since 2005 (ICES, 2014b).

3.1.3 Atlantic cod (*Gadus morhua*)

IMAGE: Cod. © John Pinnegar 2010

Cod (*Gadus morhua*) are found in the North-east Atlantic, from the Celtic Sea to Spitsbergen and are distributed widely throughout the North Sea (Wheeler, 1978). Cod are widely distributed throughout the North Sea, but genetic studies show that there are geographically-separated subpopulations and that these subpopulations show long-term differences in productivity (ICES, 2014c).

Cod are caught by towed gears in mixed demersal fisheries, both as a target species and as part of mixed fisheries catching haddock, whiting, *Nephrops*, plaice, and sole (ICES, 2014c). They are also a popular angling target and are caught from both boats and the shore.

Cod were caught by both survey gears, and as with many other species, smaller fish were caught by the beam trawls and larger ones by the otter trawls (2 m beam trawl = 122 mm *TL*, *n* = 17; otter trawl = 362 mm *TL*, *n* = 80) (Appendix B). Small cod were found in only 4.5 % of the beam trawls and they were not widely distributed; their presence was generally restricted to the Sizewell-Minsmere area (Figure 18). Larger individuals were captured in 31.6 % of otter trawl samples. Although these larger fish were present at almost all otter trawl locations, their abundance was highly variable, both at a given site, and between surveys (Figure 18 and Figure 19, respectively). Data from the impingement dataset shows that cod is most abundant in the area in January (Figure 19, middle). In the wider area, long-term trends in the abundance of small cod are difficult to see, although there is some evidence of a slight decline in abundance over recent decades (Figure 19, bottom).

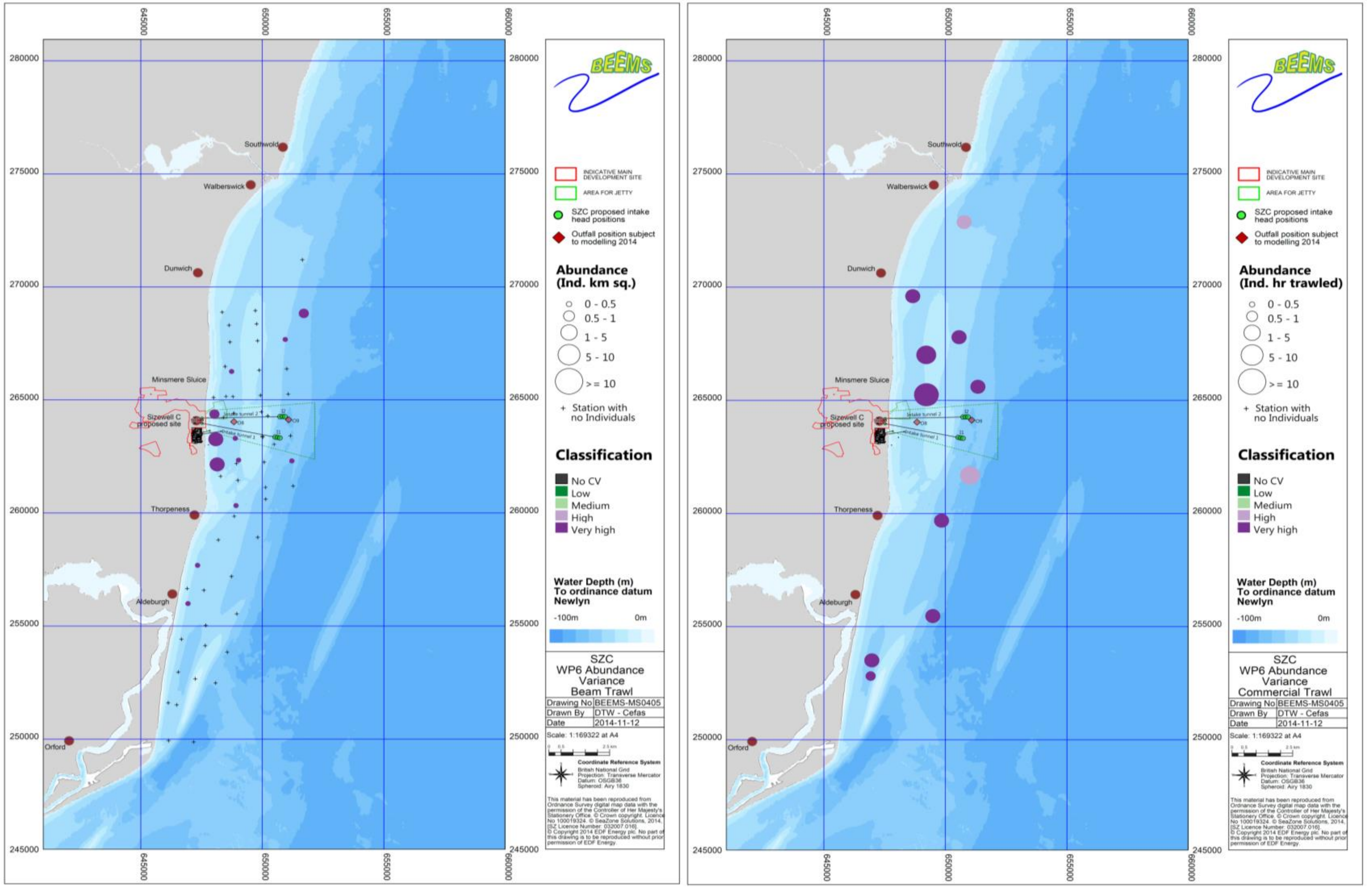


Figure 16. Mean abundance of plaice across the study area, together with the coefficient of variation (CV). (Left panel: 2 m beam trawl abundance = individuals/km^2; right panel: otter trawl abundance = individuals/hour).

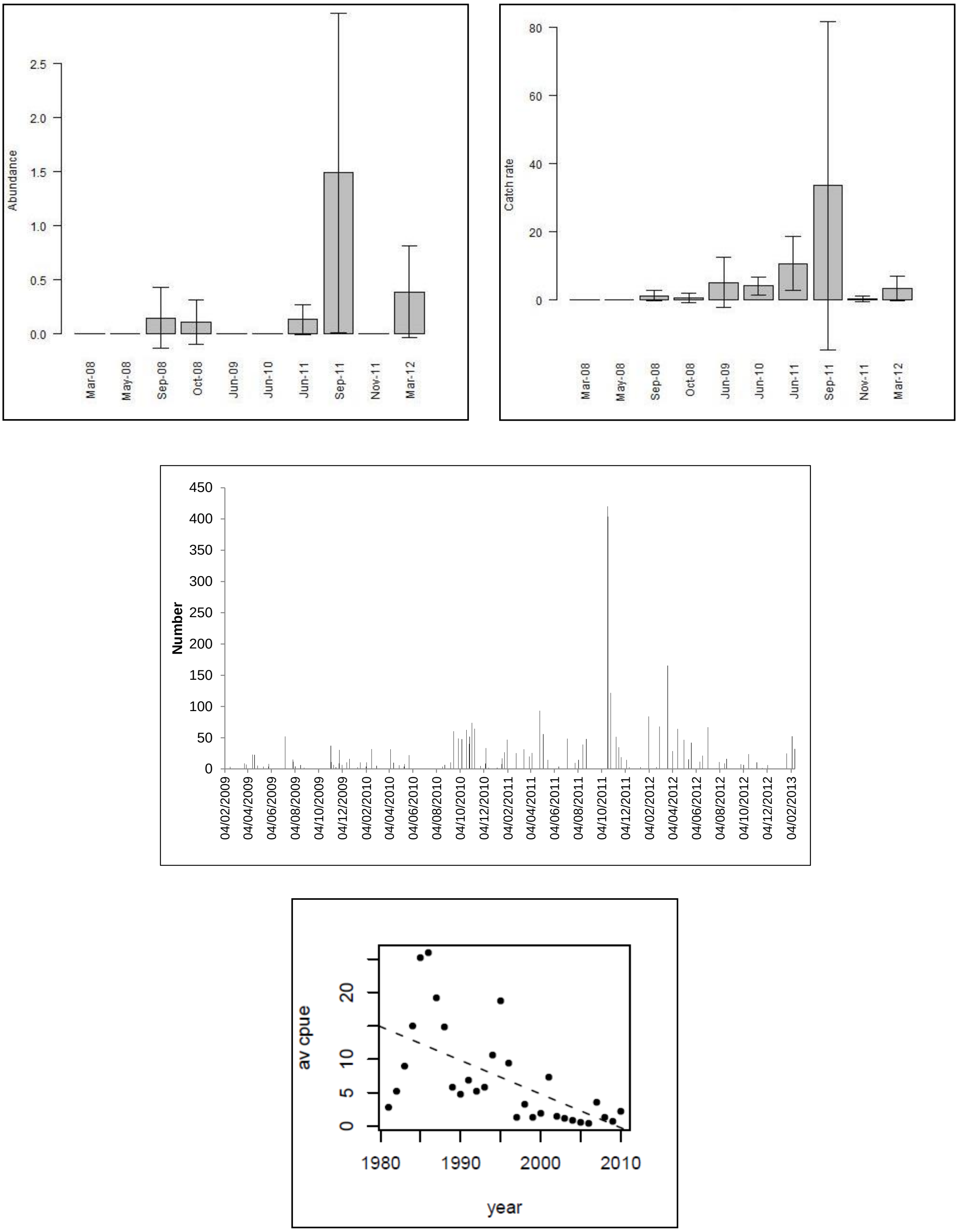


Figure 17. Plaice patterns: Top: mean abundance (± 95 % C.I.) for each coastal survey (left - 2 m beam trawl abundance as ind/km2; right - otter trawl catch rate as ind/hour). Middle: impingement monitoring as no./24 hr. Bottom: abundance as average ind./1000 m2 (av cpue) in the East Anglian region during the Eastern Young Fish Survey (the dashed line shows the general trend; reproduced from Cefas (2011).

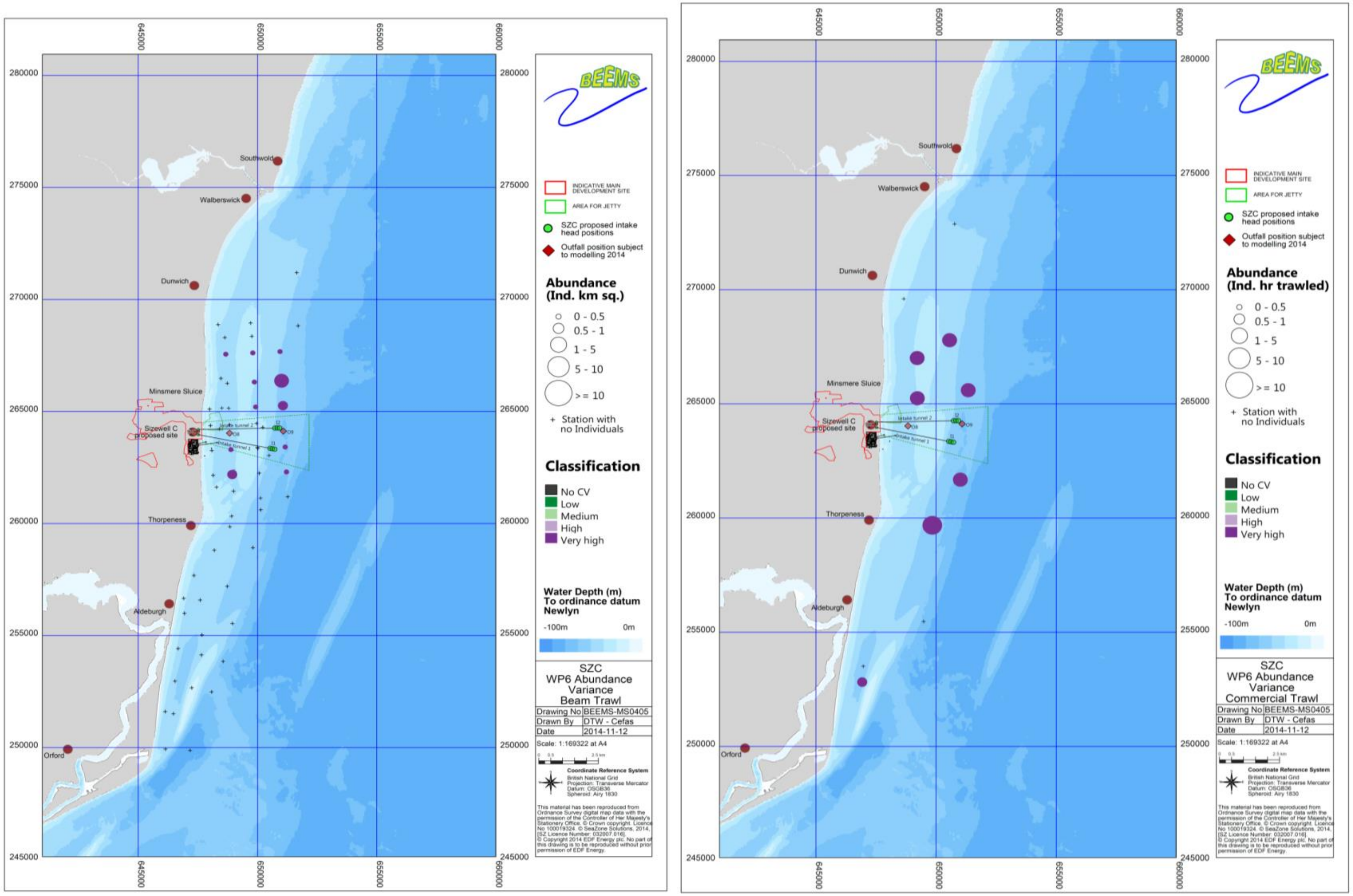


Figure 18. Mean abundance of cod across the study area, together with the coefficient of variation (CV). (Left panel: 2 m beam trawl abundance = individuals/km^2; right panel: otter trawl abundance = individuals/hour).

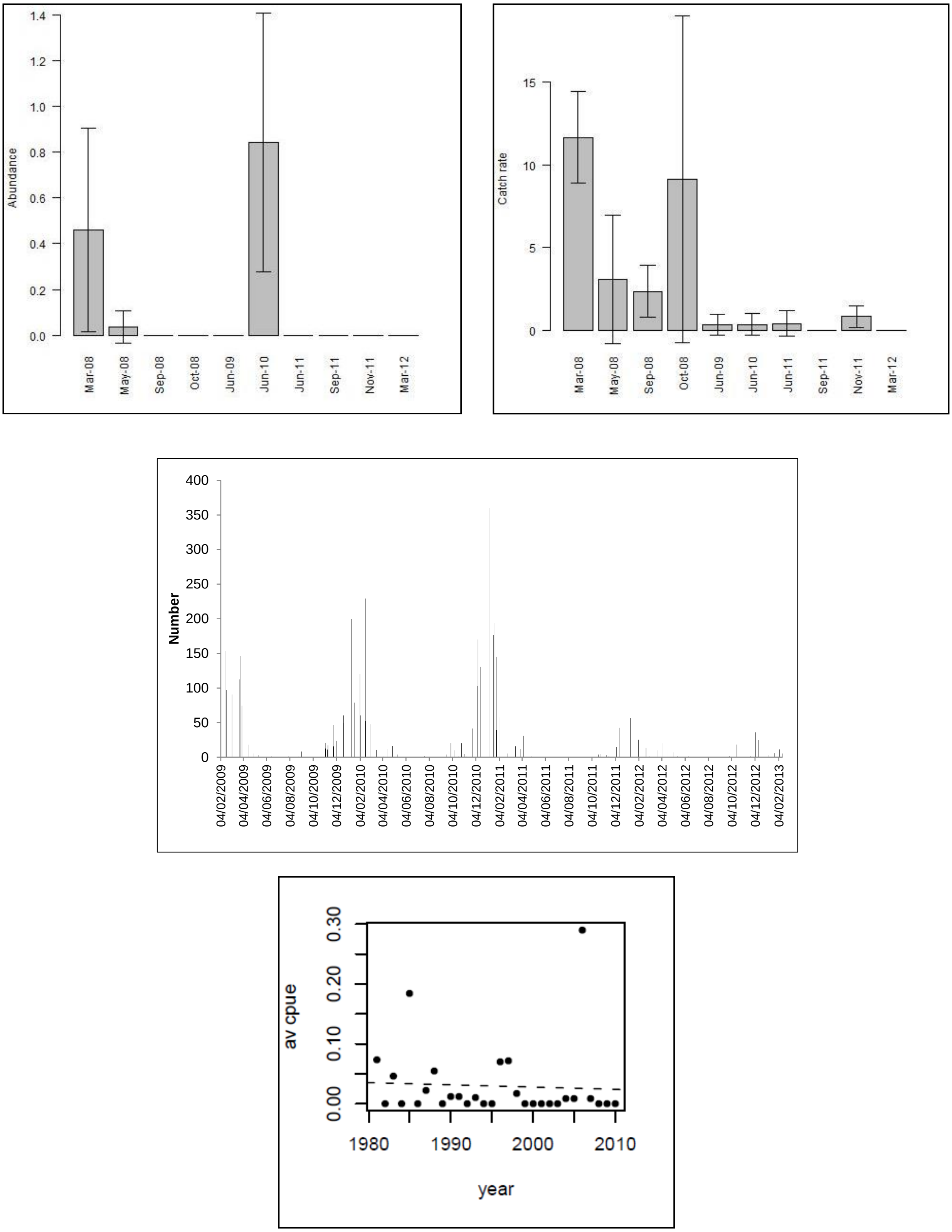


Figure 19. Cod patterns: Top: mean abundance (± 95 % C.I.) for each coastal survey (left - 2 m beam trawl abundance as ind/km2; right - otter trawl catch rate as ind/hour). Middle: impingement monitoring as no./24 hr. Bottom: abundance as average ind./1000 m2 (av cpue) in the East Anglian region during the Eastern Young Fish Survey (the dashed line shows the general trend; reproduced from Cefas (2011).

3.1.4 European sea bass (*Dicentrarchus labrax*)

IMAGE: Sea bass. © Cefas 2002

Sea bass (or bass) are distributed in north-east Atlantic shelf waters from southern Norway through the North Sea, Irish Sea and Bay of Biscay to north-west Africa, and they are found in the Mediterranean and Black Seas (Pickett and Pawson, 1994).

The species grows slowly, and juveniles spend up to three years in nursery areas in estuaries, before undertaking the adult migrations between spawning and feeding rounds. This combination of slow growth, late maturity, spawning aggregation, and strong site fidelity increases their vulnerability to overexploitation and localised depletion (ICES 2013c). Bass of all sizes appear to be attracted to warm-water effluents (Jennings et al., 1993; Maitland and Herdson, 2009; Pawson and Eaton, 1999; Wheeler, 1969a).

Sea bass are targeted by pelagic pair trawlers on offshore spawning grounds in the Western English Channel from December to April, and are taken around the English coast as a seasonal target or bycatch by a large fleet of inshore vessels that use a variety of gears. Bass is also an important marine recreational angling species in the UK, Ireland, France, and the Netherlands (ICES, 2014d).

Bass were caught in 4 of the 76 commercial otter trawl tows in the BEEMS surveys (Figure 20), but not by the 2 m beam trawls. They were not very widespread, but instead were found at only a handful of sites primarily around Sizewell and Minsmere. Bass were commonly recovered from the drum screens of Sizewell B over the winter period (approximately December to April). However, they were also present in particularly high abundances in February (Figure 21), when juveniles are thought to be attracted to the warm water of the outfall (Jennings et al., 1993; Maitland and Herdson, 2009; Pawson and Eaton, 1999; Wheeler, 1969a). In the wider eastern region, a decline in bass abundance has been observed since the early 1980s (Figure 22).

In 2016, a survey was undertaken to investigate the distribution of bass in the Greater Sizewell Bay area. Sampling was undertaken inside and outside of the Sizewell-Dunwich Bank, and close to and distant from the current and proposed intake/outfall locations of Sizewell B and C, respectively. During the 5-day survey, 110 bass were recorded, ranging between 15.5 and 45 cm TL, and aged between 2 and 6 years of age. The majority (105 bass) were recorded inside the Sizewell-Dunwich Bank. Inshore of the bank, although there was a statistically significant difference in the numbers of bass found at the sampling sites furthest from the Sizewell B outfall, there was no significant difference between bass abundance at this site and two sites approximately 1 km north and south of this (BEEMS Technical Report TR380, in prep.).

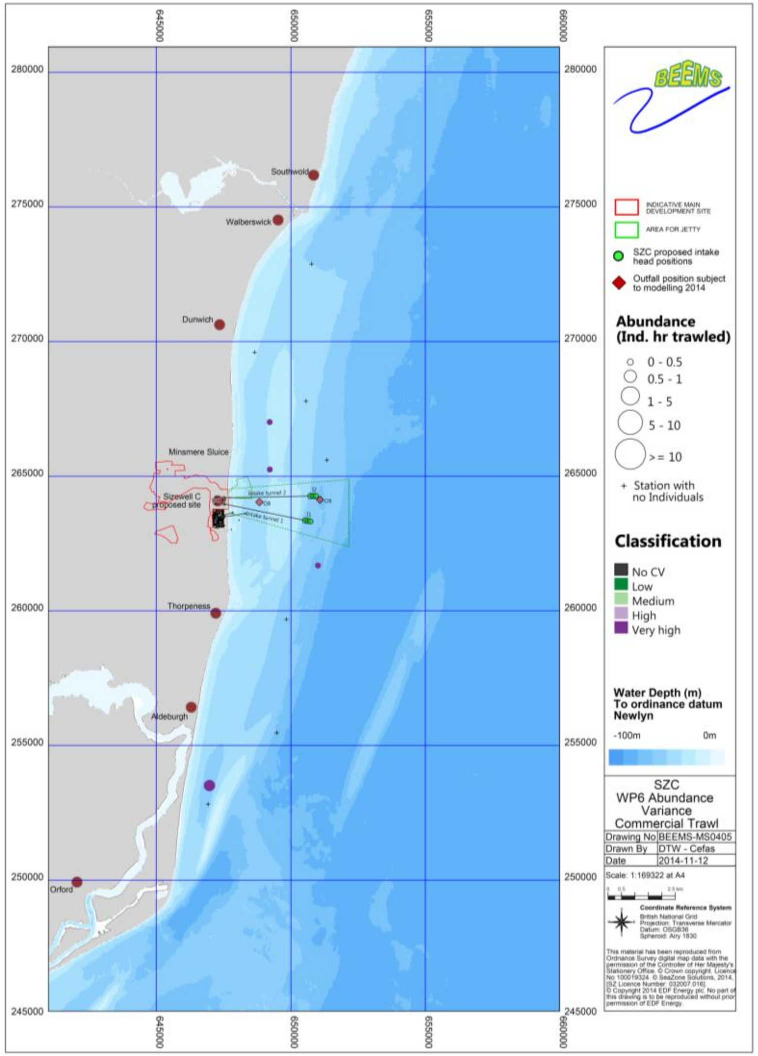


Figure 20. Mean abundance of otter trawl-caught bass across the study area, together with the coefficient of variation (CV). Abundance = individuals/hour.

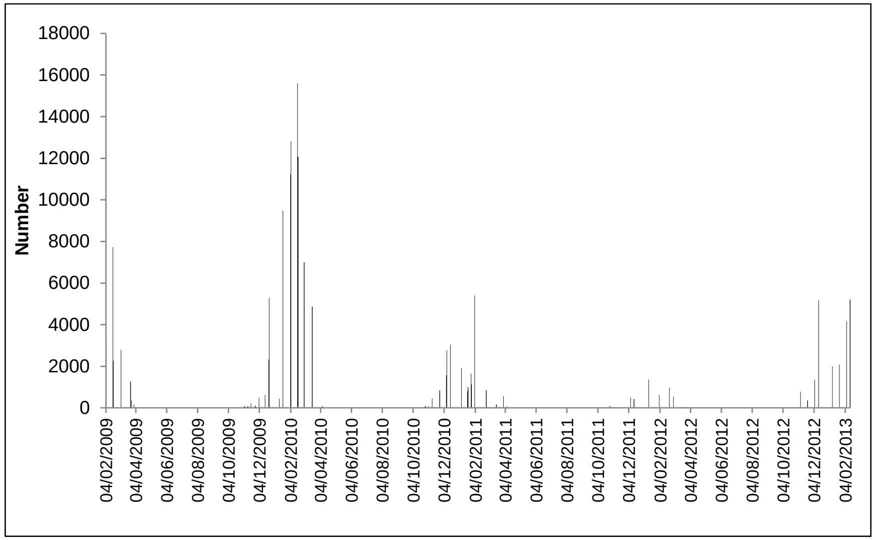


Figure 21. Number of bass (per 24 hours at full station pumping capacity) observed in the BEEMS impingement sampling.

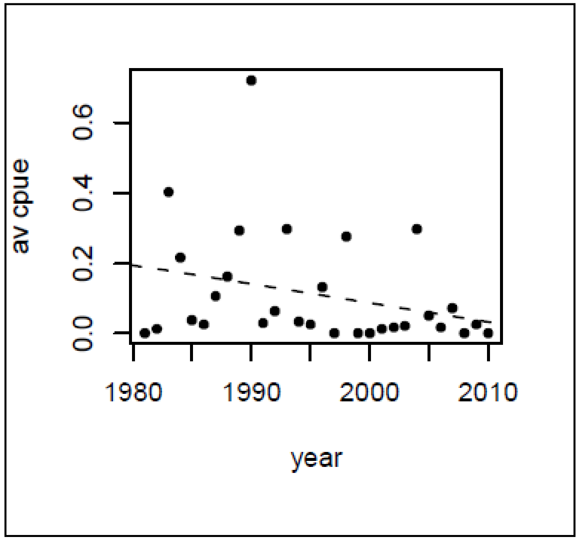


Figure 22. Abundance (mean cpue, average number of ind./1000 m^2 fished) of bass caught in the Eastern Young Fish Survey. The dashed line shows the general trend. Reproduced from Cefas (2011).

3.1.5 Atlantic herring (*Clupea harengus*)

IMAGE: Herring. © Crown copyright 2010

Herring are small pelagic fish that are widely distributed throughout the North-east Atlantic. There are four main spawning components of the North Sea herring population (Postum et al., 1977) though fish from all these components mix throughout the North Sea (Dickey-Collas et al., 2010).

Spawning and nursery areas are vulnerable to anthropogenic influences; gravel extraction or disturbance in the close vicinity of any herring spawning will disturb spawning activity and reduce the available area for successful spawning (ICES, 2013a). Herring abandon and repopulate spawning grounds and an absence of spawning in any particular year does not mean that the spawning ground is not required to maintain a resilient herring population (ICES, 2013b).

Herring abundance and distribution in the North Sea is surveyed annually in the internationally co-ordinated International Bottom Trawl Survey (IBTS), using a Methot Isaacs-Kidd net (MIK) and a GOV trawl net (Grande Ouverture Verticale). Data indicate that juvenile herring are distributed throughout the Eastern English Channel and southern and central North Sea (Figure 23; ICES, 2013a). 0-ringer fish are those in their first year of life (approximately 9 cm *TL*), and 1-ringer fish are those in their second year (approximately 18 cm *TL*).

Atlantic herring were present in 6.9 % of the BEEMS 2 m beam trawl samples, and 14.5 % of otter trawl samples (Table 4). The majority were observed in the samples off or to the north-east of the Sizewell station complex, or in the south, close to Orford Ness (Figure 24). Abundance in the offshore surveys was highly variable and no clear picture emerges of seasonal patterns (Figure 25, top). However, herring were routinely caught during impingement sampling (Figure 25, middle) and abundance can be seen to peak in March each year, when up to 22 800 herring passed through the station in a 24-hour period. Coastal surveying only happened in March in one year, so this peak will not have been detected from the coastal survey series. Taken together, the data suggest a presence of herring around the Sizewell stations that is concentrated in the winter and early spring, with peak abundance in March.

There is little evidence of inter-annual change in numbers within the Greater Sizewell Bay from the BEEMS studies, though this should be set within the context of long term declines in herring abundance from shore surveys in the wider area (Figure 25).

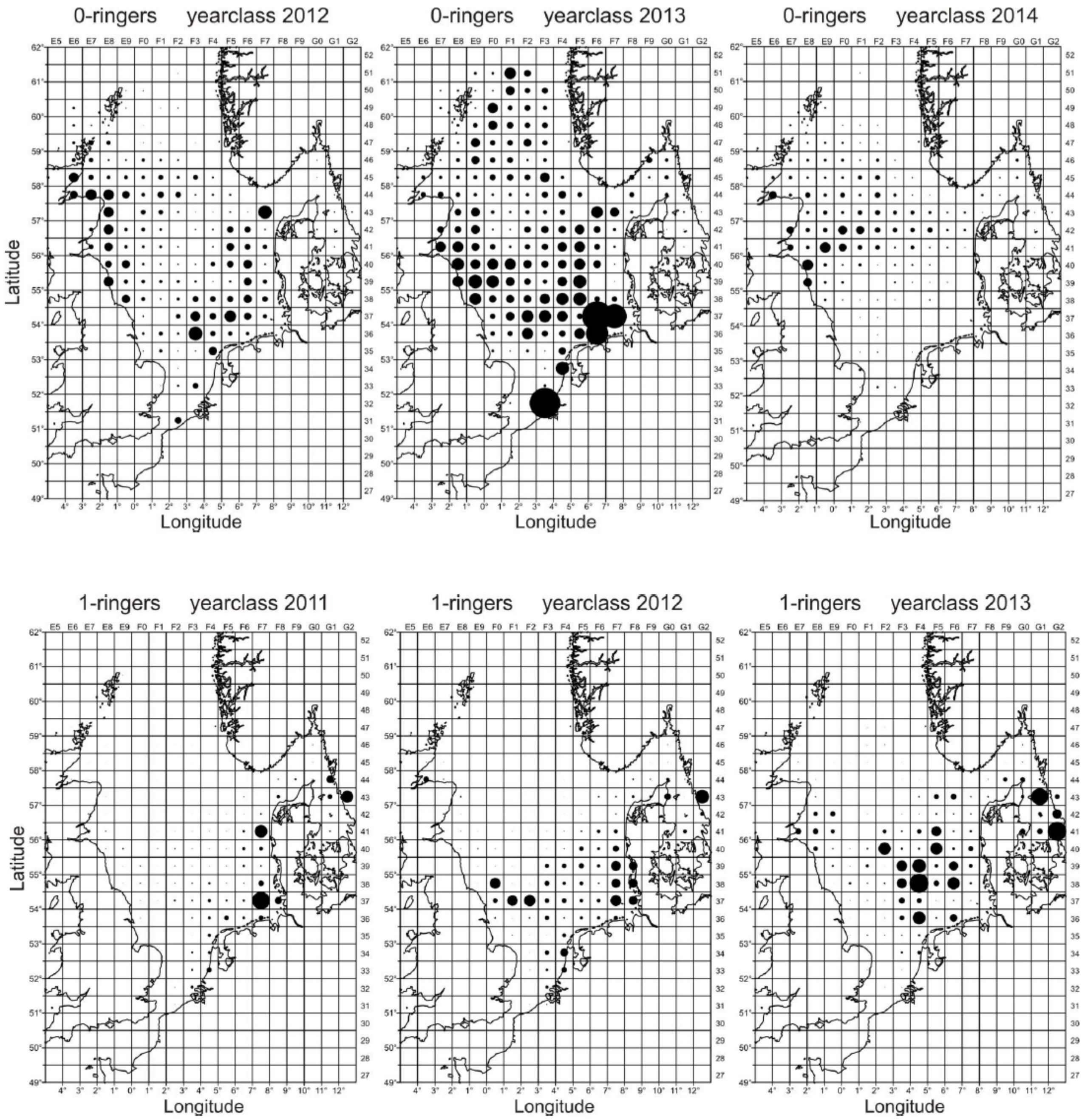


Figure 23. North Sea herring. Top - Distribution of 0-ringer herring, year classes 2012-2014. Density estimates within each statistical rectangle are based on MIK catches in February 2013-2015. Areas of filled circles illustrate densities in no m^{-2}, the area of the largest circle represents a density of $5.67m^{-2}$. All circles are scaled to the same order of magnitude of the square root transformed densities. Bottom - Distribution of 1-ringer herring, year classes 2011-2013. Density estimates within each statistical rectangle are based on GOV catches in February 2013-2015. Areas of filled circles illustrate numbers per hour, scaled proportionally to the square root transformed CPUE data, the area of a circle extending to the border of a rectangle represents 45000 h^{-1} (ICES, 2015).

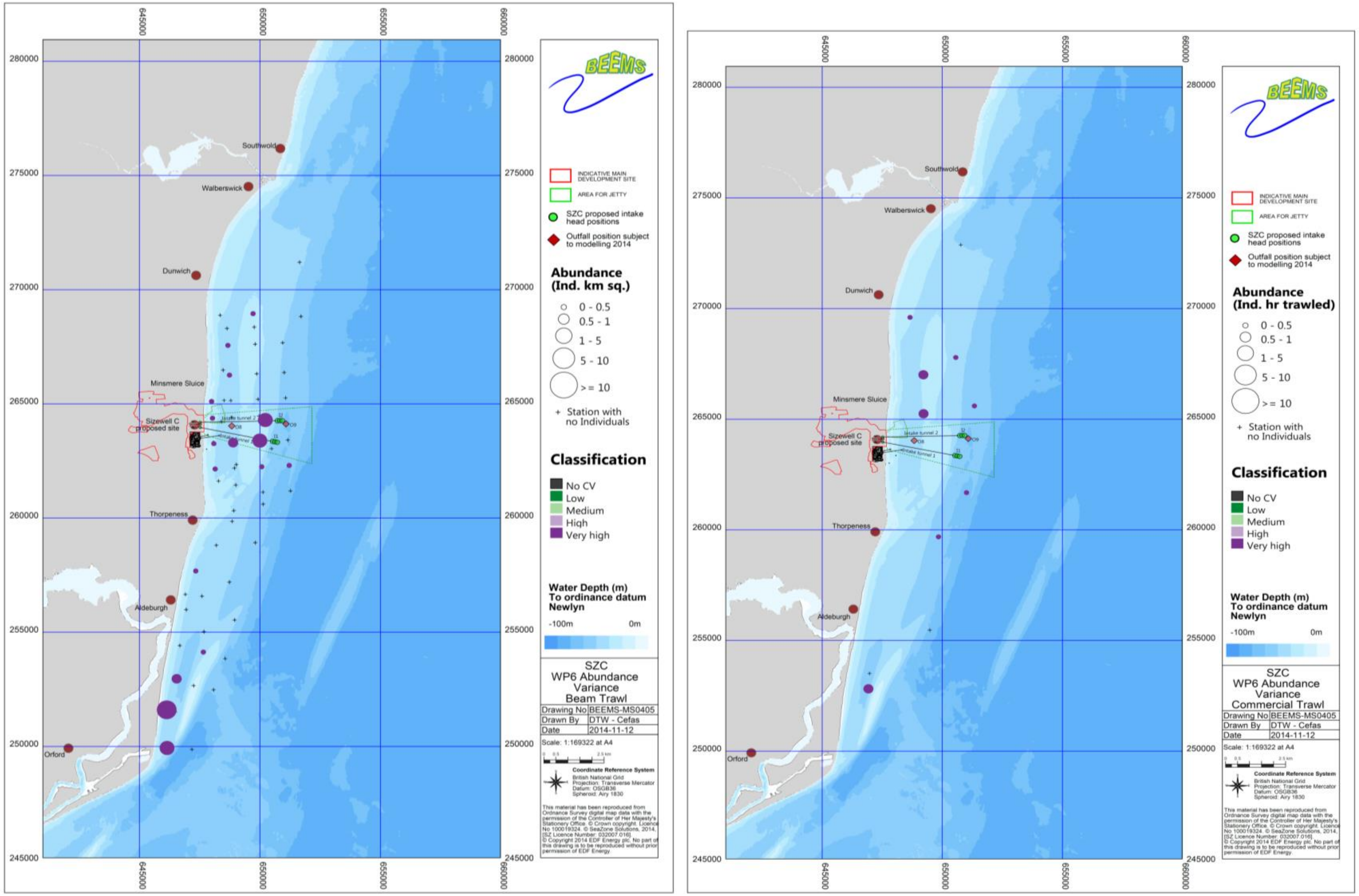


Figure 24. Mean abundance of Atlantic herring across the study area, together with the coefficient of variation (CV). (Left panel: 2 m beam trawl abundance = individuals/km^2; right panel: otter trawl abundance = individuals/hour).

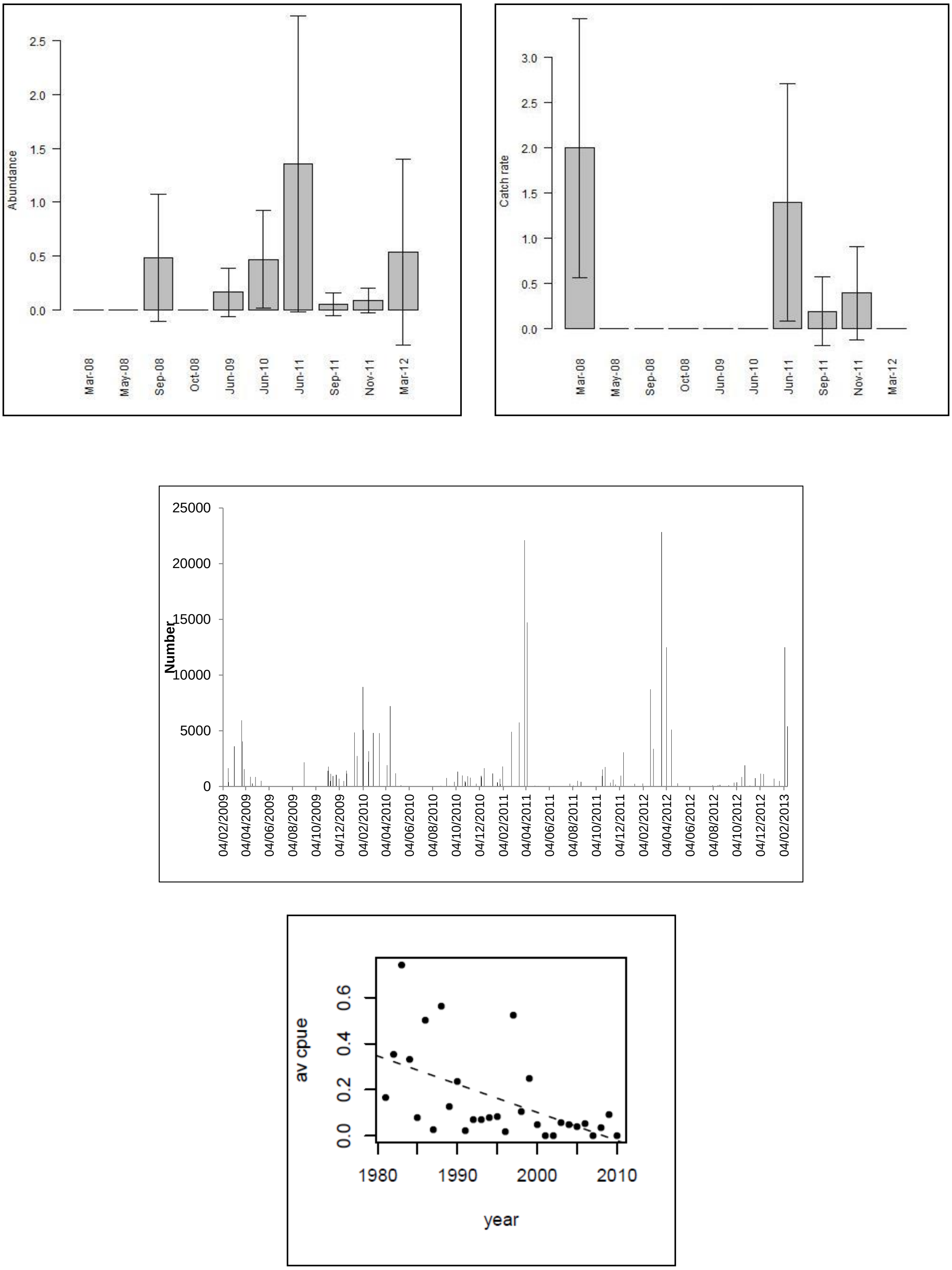


Figure 25. Herring patterns: Top: mean abundance (± 95 % C.I.) for each coastal survey (left - 2 m beam trawl abundance as ind/km2; right - otter trawl catch rate as ind/hour). Middle: impingement monitoring as no./24 hr. Bottom: abundance as average ind./1000 m2 (av cpue) in the East Anglian region during the Eastern Young Fish Survey (the dashed line shows the general trend; reproduced from Cefas (2011).

3.1.6 Thornback ray (*Raja clavata*)

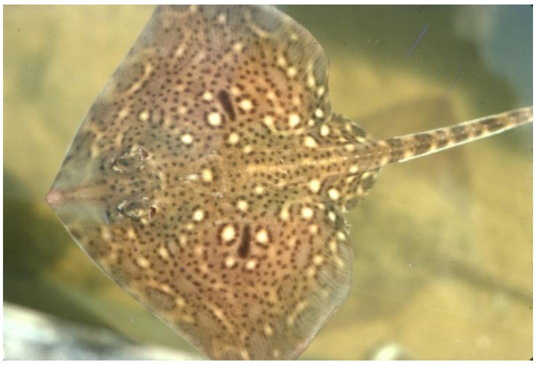


IMAGE: Thornback ray. © Crown copyright 2010

Thornback rays are common in all UK coastal waters, particularly over shallow muddy, sandy or gravelly sea beds. The species is commercially important off the East Coast, where it is caught along the North Norfolk Coast and down the East Coast between Lowestoft and the Thames estuary, out to 15 – 20 nautical miles offshore (ESFJC, 2010). Thornback rays move closer inshore in winter and spring, and spawn inshore in early spring and summer (Maitland and Herdson, 2009; Wheeler, 1969a).

Thornback rays were caught across the survey area (Figure 26). They were largely absent from the beam trawl samples around Thorpeness, though they were recorded offshore of Thorpeness in the otter trawl samples. This may suggest that the 2 m beam trawl gear is not suited to catching thornback rays, rather than a reflection of their inshore distribution. However, the mean, minimum and maximum total length was similar for both gears used (2 m beam trawl - minimum = 110 mm *TL*, maximum = 820 mm *TL*, mean = 340 mm *TL*, *n* = 20; otter trawl - minimum = 120 mm *TL*, maximum = 870 mm *TL*, mean = 383 mm *TL*, *n* = 328), but proportionately more small individuals were caught by the 2 m beam trawl than the otter trawl, suggesting that if small individuals were present off Thorpeness, they would have been caught. Given the small number of individuals recorded in the 2 m beam trawl dataset (only 20 individuals in 253 trawls), it would be difficult to say for certain that there are no thornback rays off Thorpeness. Overall abundance appeared to generally increase through the survey series for both gears, particularly in the otter trawls (Figure 27, top). The highly variable average abundance on each survey (see the large error bars on Figure 27, top) reduces our certainty in whether this temporal pattern is real and consistent.

Thornback ray were uncommon in the impingement sampling (only 641 individuals or 0.04% of the total number), but were relatively frequent (occurring in 48.8 % of samples, Table 3), and appeared to be most abundant during April of each sampling year (Figure 27, middle). However, there was a clear increase in thornback ray abundance in the wider area between 1981 and 2010 (Figure 27, bottom), and it is likely that the pattern of increasing numbers in the wider area is reflected in the Greater Sizewell Bay area.

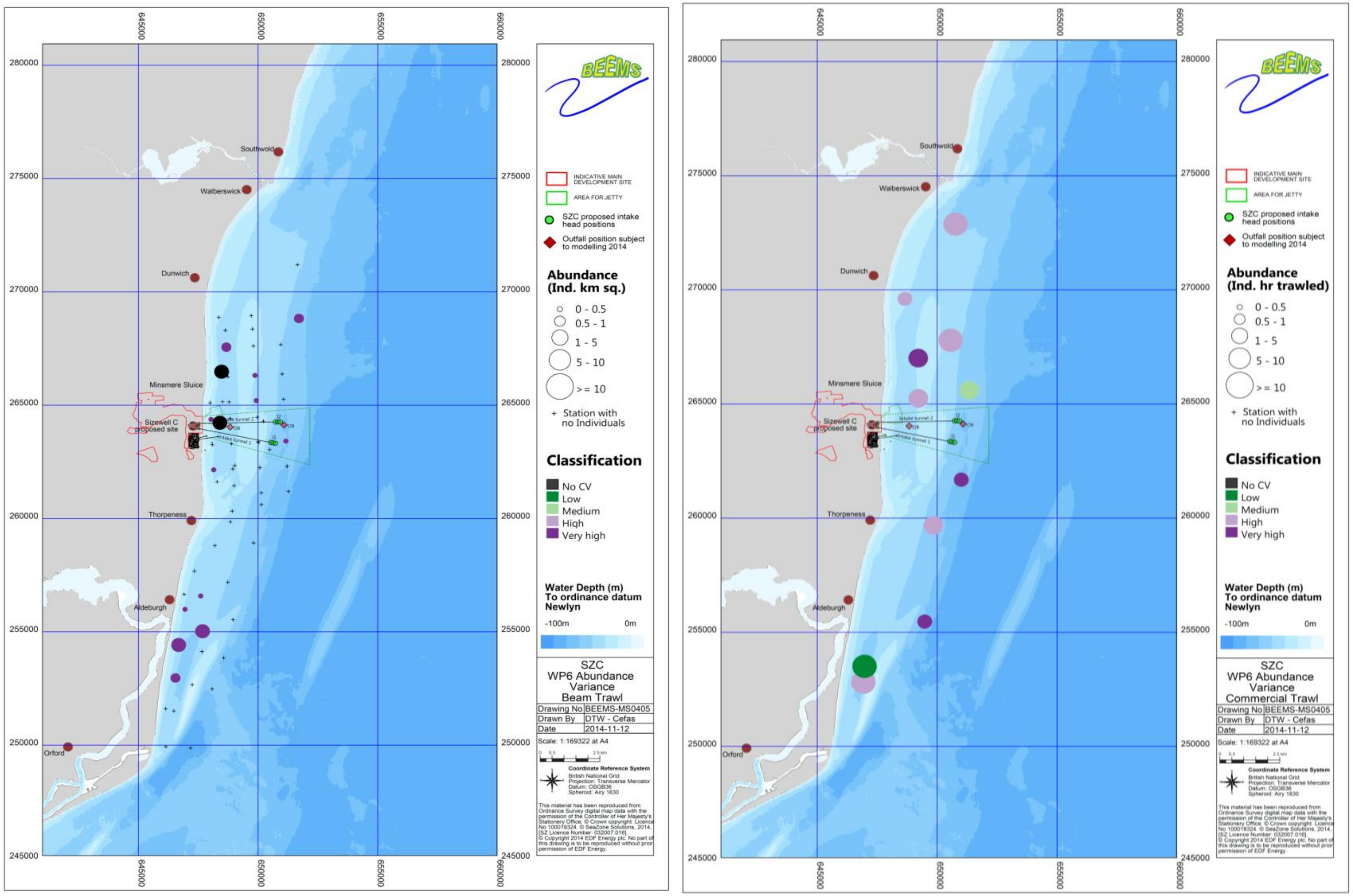


Figure 26. Mean abundance of thornback ray across the study area, together with the coefficient of variation (CV). (Left panel: 2 m beam trawl abundance = individuals/km^2; right panel: otter trawl abundance = individuals/hour).

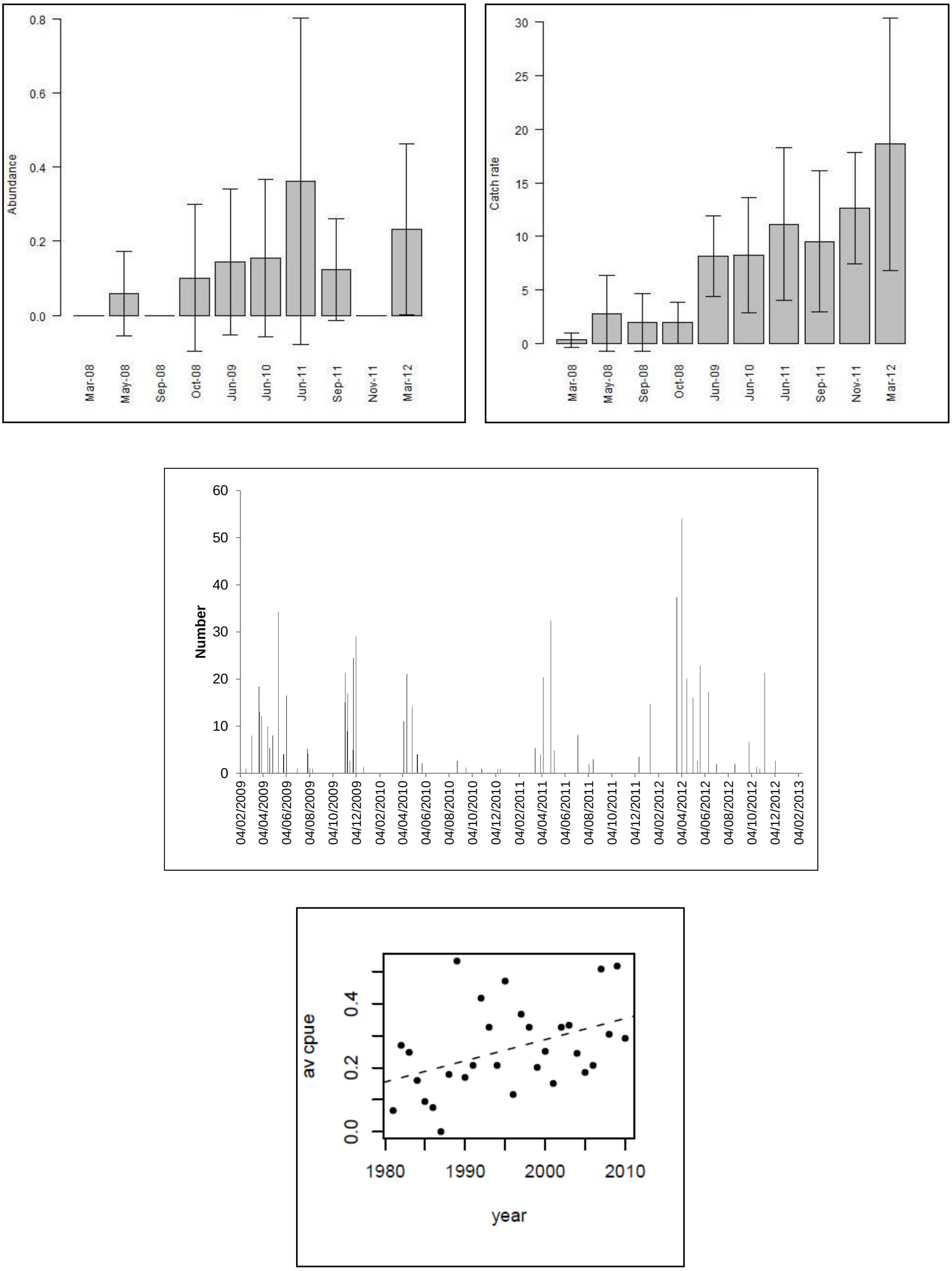


Figure 27. Thornback ray patterns: Top: mean abundance (± 95 % C.I.) for each coastal survey (left - 2 m beam trawl abundance as ind/km2; right - otter trawl catch rate as ind/hour). Middle: impingement monitoring as no./24 hr. Bottom: abundance as average ind./1000 m2 (av cpue) in the East Anglian region during the Eastern Young Fish Survey (the dashed line shows the general trend; reproduced from Cefas (2011).

3.1.7 Thin-lipped grey mullet (*Liza ramada*)

Three species of grey mullet are commonly found in UK waters, namely the thick-lipped grey mullet *Chelon labrosus*, the thin-lipped grey mullet *Liza ramada* and the golden grey mullet *Liza aurata*, although only the first two of these have been recorded in BEEMS survey work at Sizewell. The thick-lipped grey mullet ranges from south-western Norway, around the UK coast to the Canaries, while the thin-lipped grey mullet has a more southerly distribution from Denmark, to the Canaries and the Mediterranean and Black Seas (Wheeler, 1978). All three species are commonly found close inshore and may be seen in compact shoals entering river mouths or in the vicinity of freshwater outlets, although the degree of freshwater tolerance differs between the three species, (Wheeler, 1978).

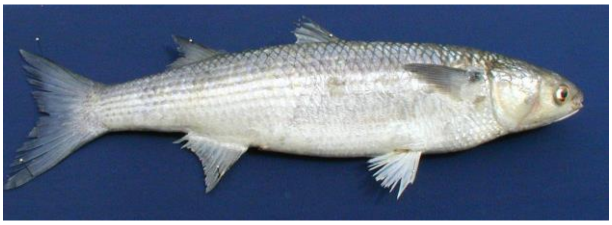


*IMAGE: Thick-lipped grey mullet.
© Crown copyright 2002*

Commercial catches of mullet are generally of low-value bycatch in drift and gill nets targeting sole, rays, bass and cod, and also by pair trawlers targeting bass or black sea bream (Pickett, 2007). However, some targeting of grey mullet does take place, invariably using some form of drift or set nets, or beach seines. On the eastern English coast, directed fishing for grey mullet may be of importance on the estuaries and creeks, particularly around Mersea Island in Essex, where they are caught by drift and gill netters. The last 10-20 years have seen a decline in commercial grey mullet catches because other species, such as bass, have become more lucrative (Pickett, 2007). Grey mullet may also be caught by recreational anglers from the shore and can be caught in harbours, in estuary creeks, around sewage outfall pipes and off jetties and piers.

Thin-lipped grey mullet were not present in the coastal surveys. However, the species occurred in just under half of the impingement samples (53 of the 125 samples), and contributed 0.9 % to the total abundance by number (Table 3). However, the majority of those fish were caught in February 2010 and February 2011 (Figure 28). Similarly, thick-lipped grey mullet were also absent from offshore catches. Only 7 individuals were recorded in the impingement dataset, all in the same sample, taken at the end of March 2009 (a plot for this species is not given).

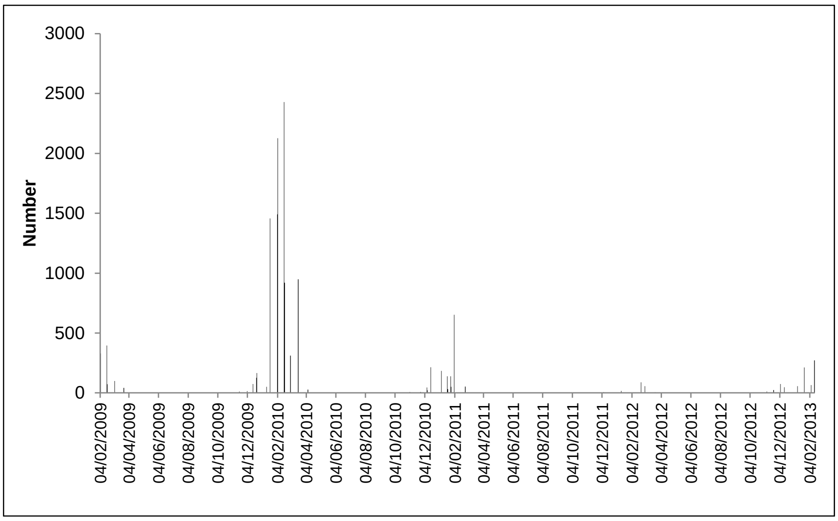


Figure 28. Number of thin-lipped grey mullet (per 24 hours at full station pumping capacity) observed in the BEEMS impingement sampling.

3.1.8 European flounder (*Platichthys flesus*)

Image: Flounder © marlin.ac.uk

A euryhaline flatfish, in which the life cycle includes marine, brackish, and freshwater habitats. Flounder is found along north-east Atlantic coasts from the White Sea to the Mediterranean and Black Seas. Adults migrate inshore/offshore, moving into deeper water to spawn in the winter, and inshore to feed in the summer. Juveniles are usually distributed inshore, and in estuaries. The most important spawning grounds are along the coasts of Belgium, the Netherlands, Germany, and Denmark (ICES, 2014e). In the North Sea flounder is a bycatch in the fishery for commercially important flatfish such as sole and plaice and in mixed demersal fisheries (ICES, 2014e).

Flounder were rare in the BEEMS 2 m beam trawl samples (only 7 individuals, caught over 5 different surveys between March 2008 and September 2011) and were generally small (mean length = 150 mm *TL*, n = 7) (Appendix B). In contrast, flounder was the second most common species in the otter trawl catches, occurring in 75% of tows (Table 4). The few flounder caught in the 2 m beam trawl were found in the central and northern area of the survey grid, whereas larger individuals (mean = 259 mm *TL*, n = 332) caught in the otter trawl, were recorded throughout the survey area (Figure 29). Abundance was highly variable between surveys (Figure 30, top), with very high abundances seen in June 2009 and June 2010.

Flounder was frequent in the impingement samples (in 95.2% of the 125 samples), but contributed only 0.3 % to the total number of fish sampled (Figure 30, middle). The highest abundances were seen in March and February, which may reflect the movement of younger fish inshore (see above).

In the wider area, the abundance of flounder appears to have decreased from the series' high in the early 1980s (Figure 30, bottom). However, the high abundance seen in the 2009 BEEMS otter trawl catches is also seen in the Young Fish Survey dataset.

3.1.9 Dab (*Limanda limanda*)

Dab is a demersal flatfish found on the Northeast Atlantic shelf, through the Bay of Biscay as far as Iceland, Norway, and the Barents and Baltic Seas (ICES, 2014f). The species is common in UK coastal waters, prefering shallow, sandy banks at depths of 20–40 m. Small dab tend to be found in shallower waters than larger fish, but some large dab are caught in shallow bays and estuaries in autumn (Kennedy, 1969).

IMAGE: Dab. © Crown copyright 2010

Dab was the fifth most common species in the BEEMS 2 m beam trawl (13.1 %) and otter trawl samples (57.9 %) (Table 4). Small dab caught by the 2 m beam trawl averaged 117 mm *TL* (n = 67), while larger dab caught by the otter trawl averaged 219 mm *TL* (n = 395) (Appendix B). Although not present at all sites, they were widespread across the survey area (Figure 31) and were generally more common in the northern part of the survey area where the substrate is sand or sandy mud.

Abundance was variable at a given site with high or very high variability (Figure 31). Abundance was highest during September surveys, but variance (as shown by the error bars) was very high, indicating overlap between surveys (Figure 32, top). Fluctuations in abundance were also seen in the impingement data, where between September and November 2011, abundance was very high. One 24-hour sample contained an estimated 3 500 fish, seven times more than any other sample (Figure 32, middle). The wider inshore area appears to confirm the natural variability of dab abundance, where the pattern is fluctuating, but decreasing, but may show the high abundance recorded in the impingement dataset in 2010 (Figure 32, bottom).

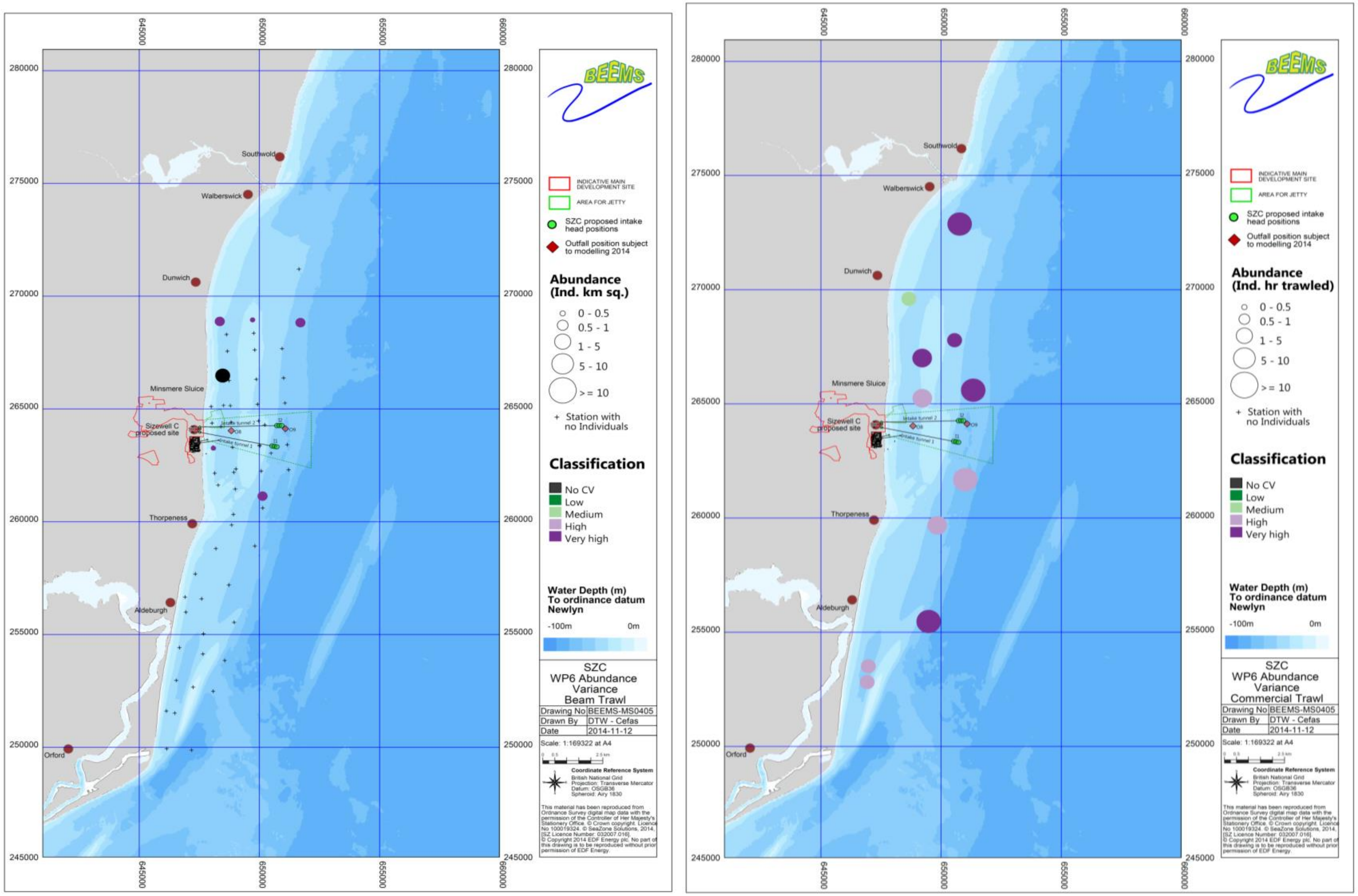


Figure 29. Mean abundance of flounder across the study area, together with the coefficient of variation (CV). (Left panel: 2 m beam trawl abundance = individuals/km^2; right panel: otter trawl abundance = individuals/hour).

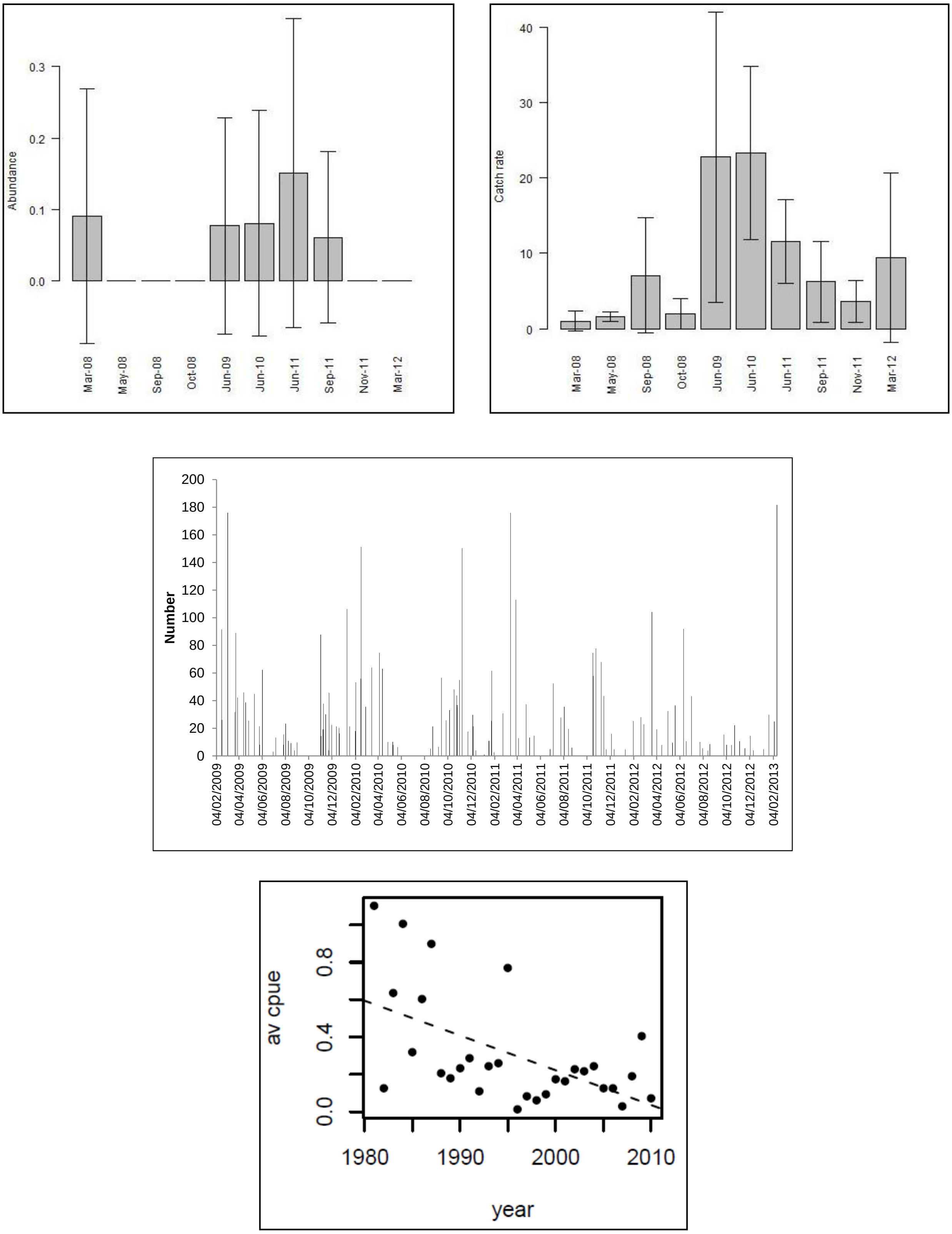


Figure 30. Flounder patterns: Top: mean abundance (± 95 % C.I.) for each coastal survey (left - 2 m beam trawl abundance as ind/km2; right - otter trawl catch rate as ind/hour). Middle: impingement monitoring as no./24 hr. Bottom: abundance as average ind./1000 m2 (av cpue) in the East Anglian region during the Eastern Young Fish Survey (the dashed line shows the general trend; reproduced from Cefas (2011).

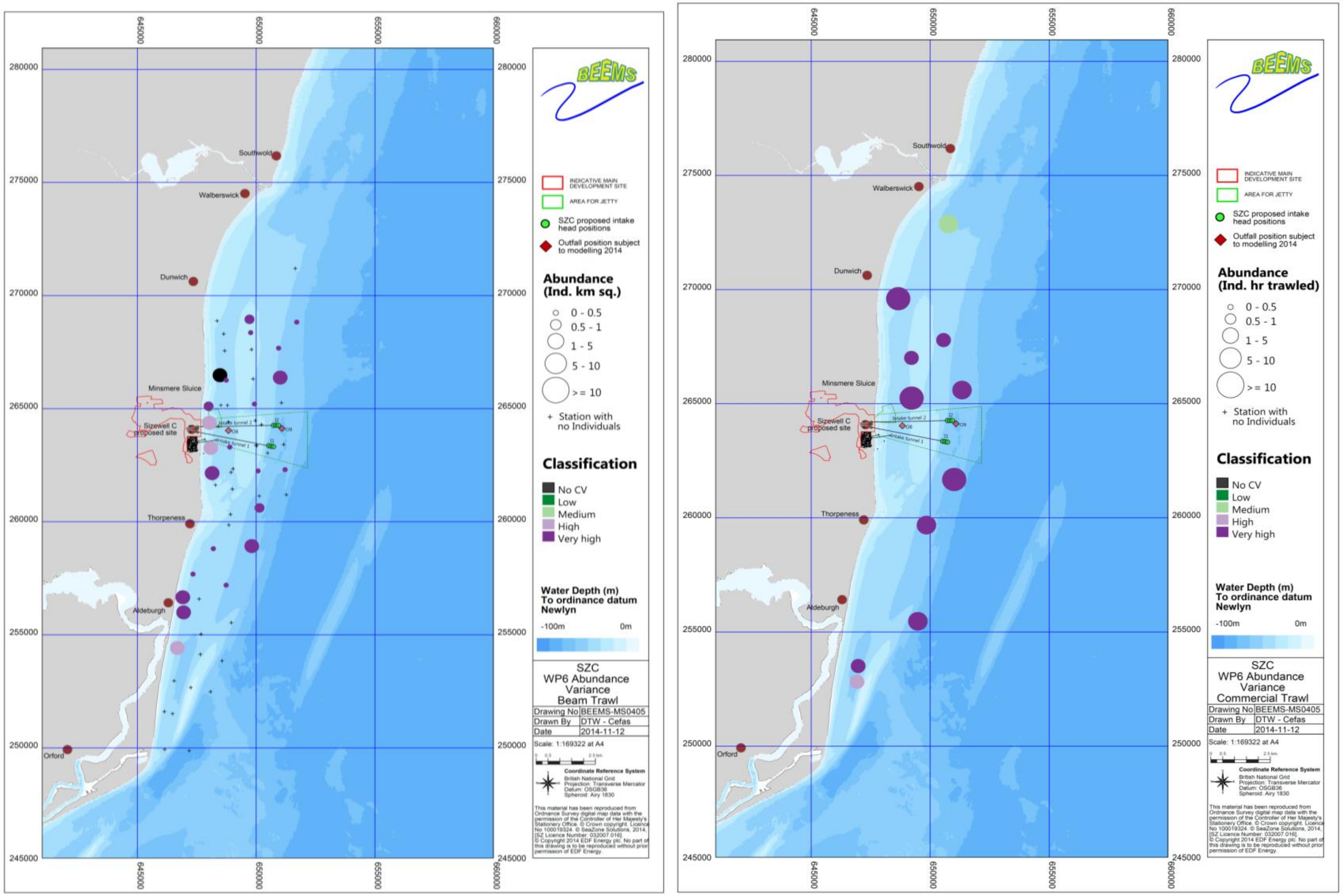


Figure 31. Mean abundance of dab across the study area, together with the coefficient of variation (CV). (Left panel: 2 m beam trawl abundance = individuals/km^2; right panel: otter trawl abundance = individuals/hour).

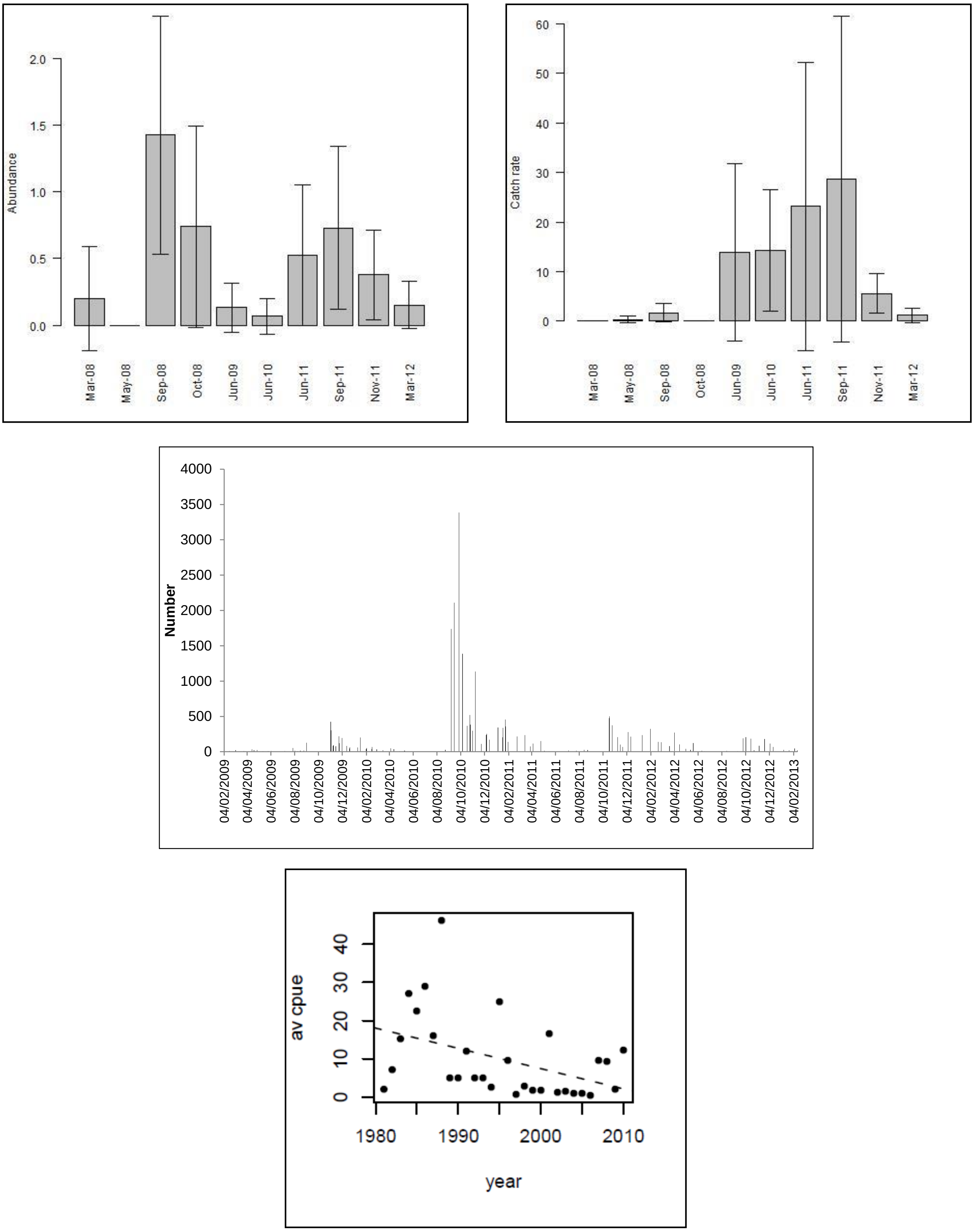


Figure 32. Dab patterns: Top: mean abundance (± 95 % C.I.) for each coastal survey (left - 2 m beam trawl abundance as ind/km2; right - otter trawl catch rate as ind/hour). Middle: impingement monitoring as no./24 hr. Bottom: abundance as average ind./1000 m2 (av cpue) in the East Anglian region during the Eastern Young Fish Survey (the dashed line shows the general trend; reproduced from Cefas (2011).

3.1.10 Whiting (*Merlangius merlangus*)

IMAGE: Whiting. © Crown copyright 2010

The whiting is a common member of the gadoid family and is abundant off the UK's east coast. Whiting are found down to about 100 m depth, and in general young fish are caught in shallow water, whereas the larger fish are caught offshore. Although juveniles are found off the English East Coast (in the vicinity of Sizewell), where they were caught in the BEEMS offshore and onshore surveys, most are distributed through the central and northern North Sea (Ellis et al., 2012). Whiting are caught as bycatch in mixed demersal fisheries, and those targeting flatfish or *Nephrops* (ICES, 2014g). The species is commercially important to the UK fleet, fishing from the ports of north-eastern England, where the majority of the English catch is landed (UKOOA, 2000; Wheeler, 1969a).

Whiting was one of the most commonly-caught species in the BEEMS surveys, present in 30.8 % and 60.5 % of the 2 m beam trawl and otter trawl samples, respectively (Table 4). Whiting caught by the 2 m beam trawl averaged 129 mm *TL* (*n* = 216), while those in the otter trawl gear averaged 253 mm *TL* (*n = 232*) (Appendix B). The species was widespread across the survey area, though abundance was generally highly variable at individual sampling sites (

Figure 33). Abundance varied greatly among the surveys and there was no obvious evidence of seasonal patterns (Figure 34, top), neither was there clear inter-annual change in abundance over the four years of the BEEMS surveys. However, catches in the impingement dataset indicated that the species was most abundant inshore between December and February each year (Figure 34, middle). A two to three decade long decline has been documented for juveniles in the wider area (Figure 34, bottom).

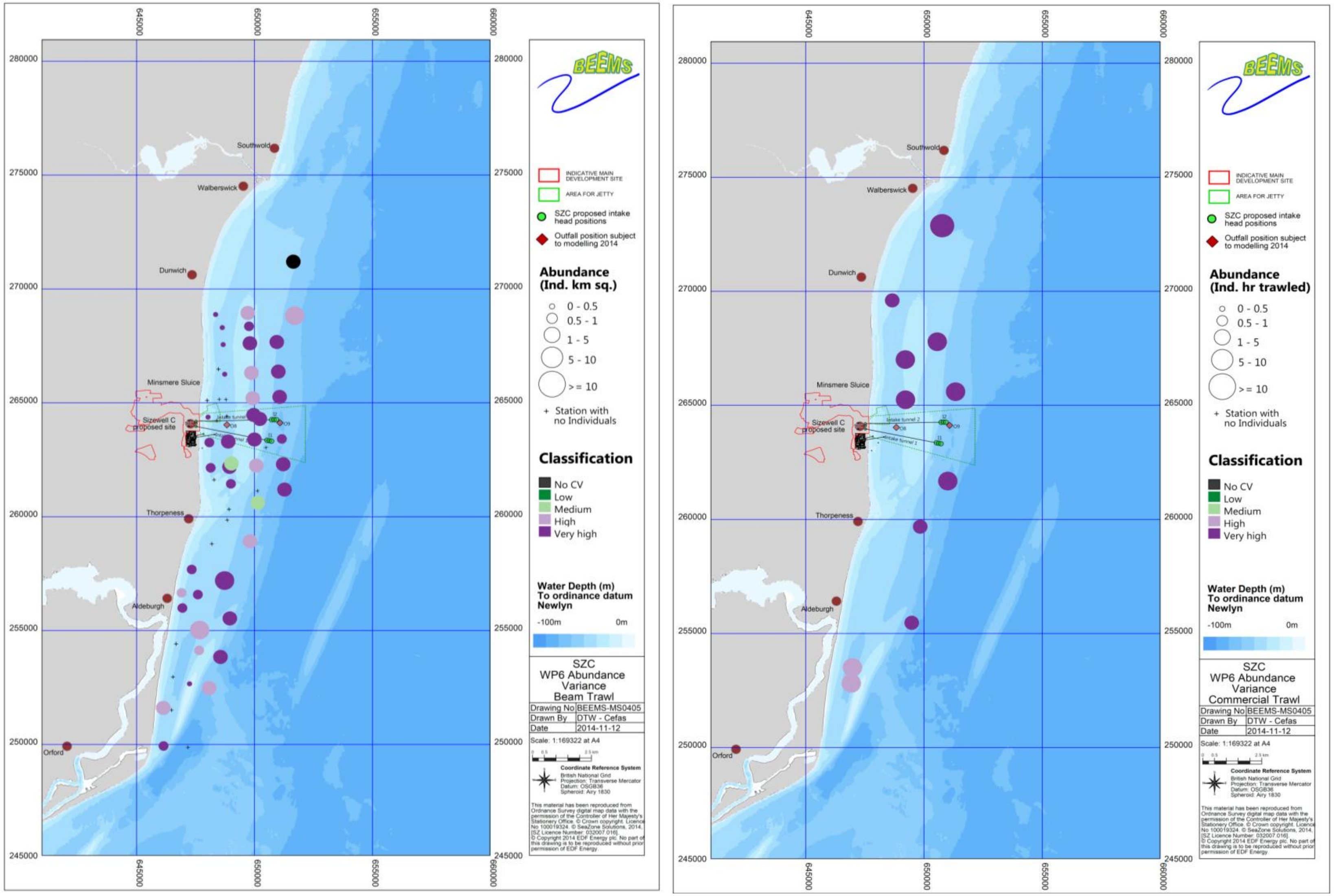


Figure 33. Mean abundance of whiting across the study area, together with the coefficient of variation (CV). (Left panel: 2 m beam trawl abundance = individuals/km^2; right panel: otter trawl abundance = individuals/hour).

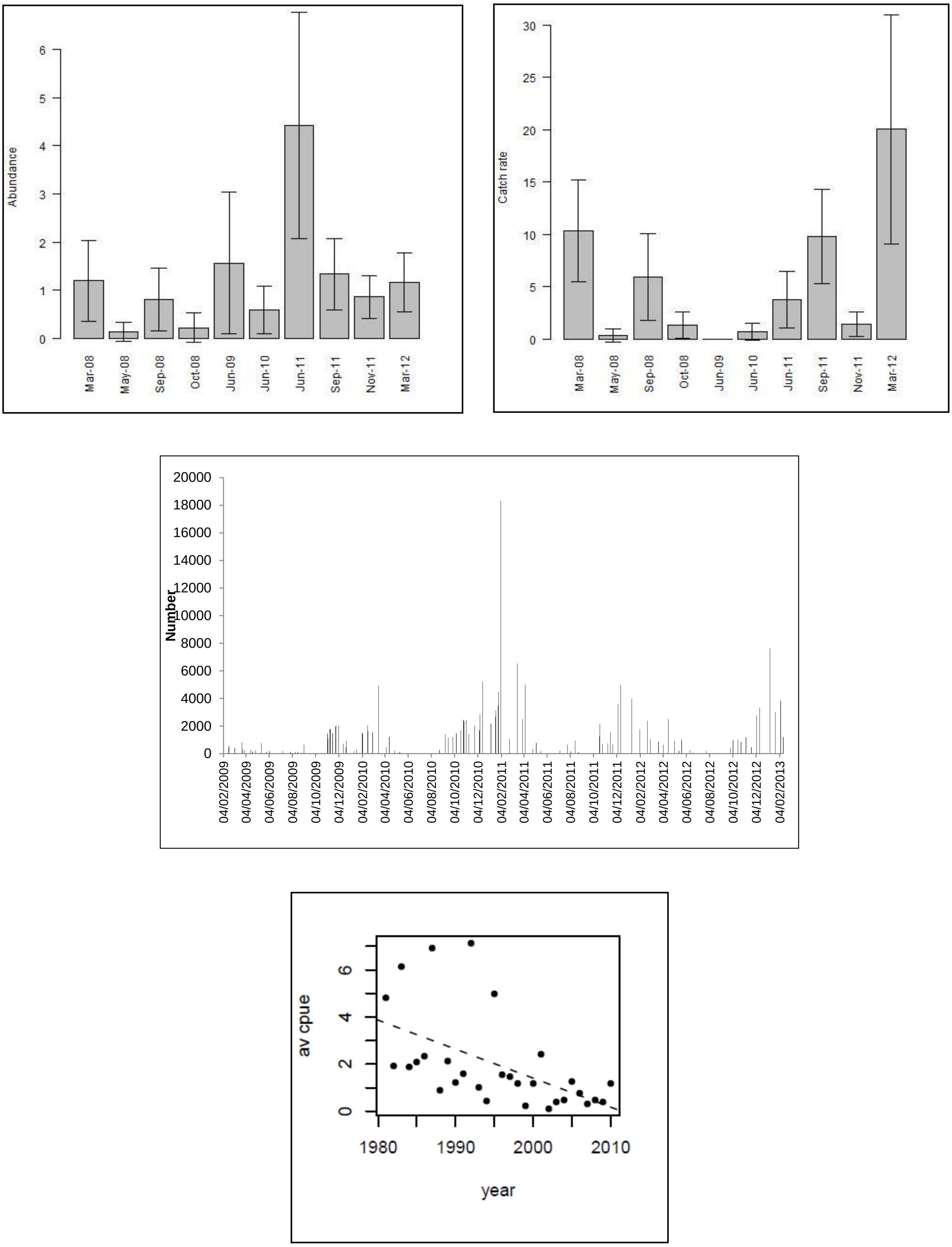


Figure 34. Whiting patterns: Top: mean abundance (± 95 % C.I.) for each coastal survey (left - 2 m beam trawl abundance as ind/km2; right - otter trawl catch rate as ind/hour). Middle: impingement monitoring as no./24 hr. Bottom: abundance as average ind./1000 m2 (av cpue) in the East Anglian region during the Eastern Young Fish Survey (the dashed line shows the general trend; reproduced from Cefas (2011).

3.1.11 European Sprat (*Sprattus sprattus*)

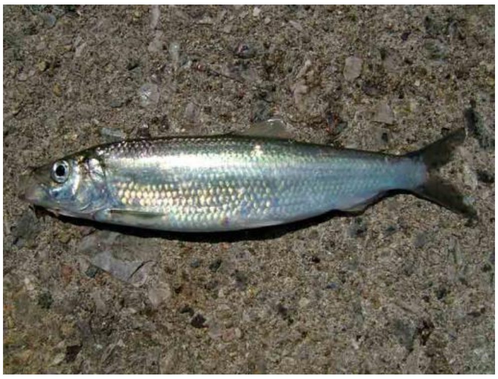


IMAGE: Sprat © Marlin.ac.uk

This small, very abundant pelagic species is common in UK coastal and inshore waters, and is an important prey species in the North Sea ecosystem (ICES, 2014h). Spawning takes place in the North Sea from January to July (Coull et al., 1998). The eggs are pelagic, drifting inshore, where they hatch and develop. It is a migratory species that is generally thought to prefer shallower, warmer water during summer and (actively seek) deeper, cooler (constant temperature) water during winter (Maitland and Herdson, 2009; Wheeler, 1969a). Little is known about the movements of sprat along the Suffolk coast.

Most of the commercial sprat catches are made in the central and southern areas of the North Sea (Figure 35). Catches are made predominantly by vessels of the Danish industrial small-mesh trawl fishery, which target sprat for reduction to meal and oil (ICES, 2014h). The UK fishing fleet lands small quantities of sprat, which are occasionally taken in midwater trawls and in gillnets along the Suffolk coast (ESFJC, 2010). The species is short-lived in the North Sea (up to two, occasionally three years), and the fishery is dependent on each year's incoming year class (ICES, 2014h).

Forty-four sprat were recorded in the BEEMS coastal surveys, in 11.1 % of the 2 m beam trawl samples (they were not caught in the otter trawls; Table 4. Inter-survey variability at a given station was high (

Figure 36), but the majority of sprat were caught in the immediate vicinity of the Sizewell station complex, or to the north and east. The species was largely absent in catches further south, although some were caught off Orford Ness. While average abundance varied a great deal between surveys, the majority of the fish caught were recorded in June 2010 and June 2011 (Figure 37). Sprat is predominantly a winter species in Sizewell Bay; the largest ingresses of sprat to Sizewell B occurred during the winter (Dec – March), with a notably large ingress of sprat during January 2011 (Figure 38). No fish surveys were coincident with this ingress, so it is impossible to determine whether sprat were similarly abundant offshore or concentrated around the intake area.

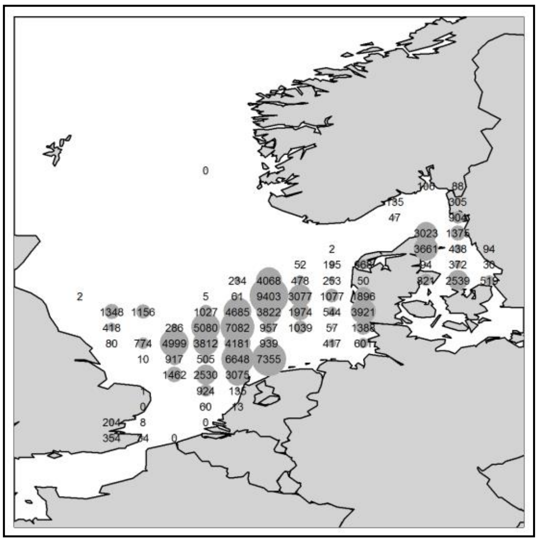


Figure 35. Commercial catches of sprat (in tonnes) in the North Sea and Skagerrak in by ICES statistical rectangle (ICES, 2013a).

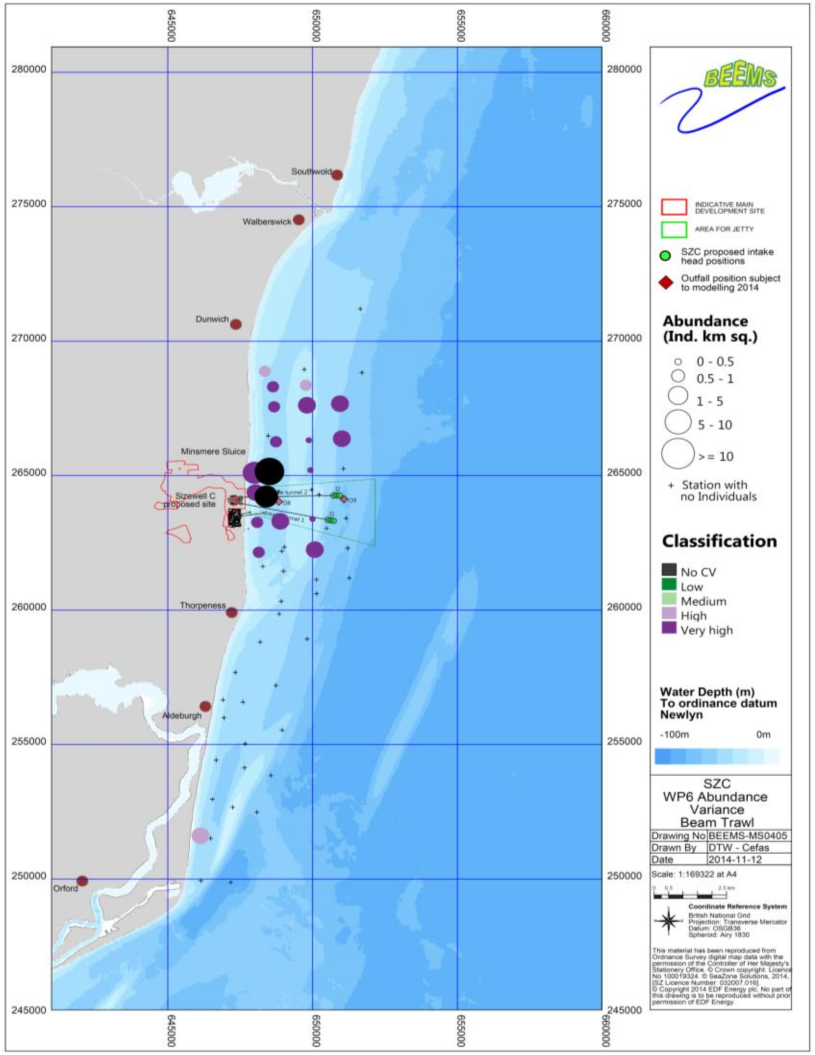


Figure 36. Mean abundance of beam trawl-caught sprat across the study area, together with the coefficient of variation (CV). Abundance = individuals/km².

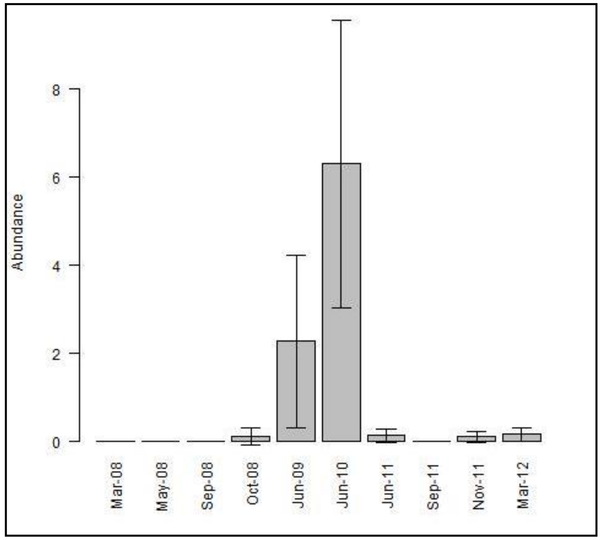


Figure 37. Mean abundance (and 95 % C.I.) of beam trawl-caught sprat for each BEEMS survey. Catch rate = individuals/km².

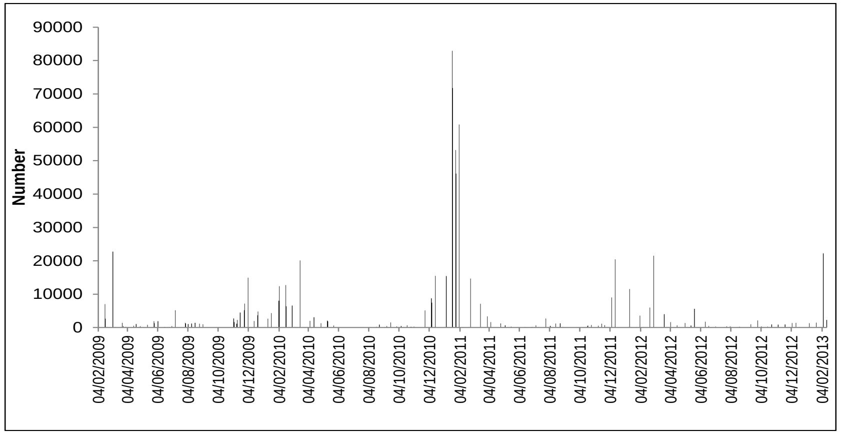


Figure 38. Number of sprat (per 24 hours at full station pumping capacity) observed in the BEEMS impingement sampling, by sample.

3.1.12 Anchovy (*Engraulis encrasicolus*)

IMAGE: Anchovy. © Jeroen van der Kooij 2015

The anchovy is a small (up to 20 cm) clupeid found throughout the North Sea, the Irish Sea and down the European coast into the Mediterranean and Black Seas. The species is more common further south, however, warming waters have seen the incidence of anchovy increase in the north and Baltic Seas over the last two decades (Alheit et al., 2012). Spawning in the North Sea takes place from April to August, peaking from May to July.

Only one anchovy was retained by the 2 m beam trawl, during the baseline pilot survey in 2014. The individual was recorded to the southeast of the Sizewell station complex. Anchovy were frequently impinged, occurring in 48 (38.4 %) of samples collected between 2009 and 2013. However, they comprised only 0.8 % of the total abundance by number. Two extremely large catches (relative to the total number caught during the sampling period) were seen in during the impingement sampling in June 2012 (Figure 39). Should the increased warming of North Sea waters continue, it is likely that the abundance of anchovy, including in the Greater Sizewell Bay area, is likely to increase (Alheit et al., 2012). Anchovy may well be important as a food source for marine-feeding birds; as well as individuals impinged in the Sizewell B station, anchovy larvae were found in the surface waters around the bay (section 2.1.3 of the Sizewell zooplankton characterisation; see BEEMS Technical Report TR315).

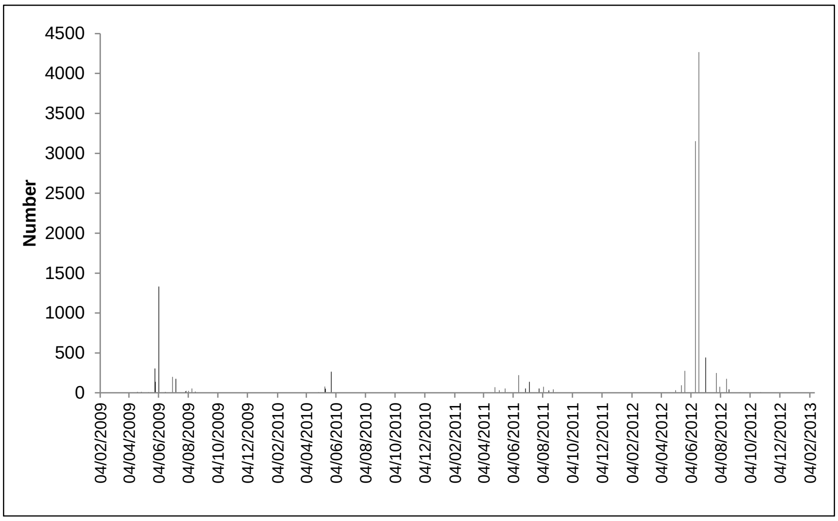


Figure 39. Number of anchovy (per 24 hours at full station pumping capacity) observed in the BEEMS impingement sampling.

3.1.13 Sand gobies (*Pomatoschistus* sp.)

IMAGE: Sand goby © Wikipedia.org

Gobiids are relatively small fish. They are common in inshore UK waters and some species are known to enter the intertidal zone (Maitland and Herdson, 2009; Wheeler, 1969a). There are around 13 species present in the North Sea. Sand gobies are usually abundant on sandy and muddy substrata from mid-tide to approximately 20 m depth (Maitland and Herdson, 2009; Wheeler, 1969a). Spawning is in spring and summer, with the female laying eggs in empty bivalve shells (Wheeler, 1978).

Sand gobies were the second most abundant species in the 2 m beam trawl samples. They were present in 49.1 % (n = 142) of samples and were found across the whole area. Between-site variability at a given sampling site was generally high or very high, particularly in the northerly part of the survey area (Figure 40). Between-survey abundance was also variable (Figure 41, top). No sand gobies were recorded in the commercial trawl samples, probably because the mesh was too large. The species was also frequently caught in the impingement sampling. The species was recorded in 93.6 % (n = 117) of the 125 samples (Figure 41, bottom and was the fifth most abundant species impinged after sprat, herring, whiting and bass (at 4.4 % of the total number of fish sampled). As with the coastal sampling, there were large variations in impingement, with particularly high catches between October and December 2010 (though there were not the large abundances observed in the June 2009 coastal survey).

In the Cefas Young Fish Surveys of the east and south coasts of England, gobies were the dominant species throughout the survey area, with highest densities recorded in the area from Flamborough to Winterton (region 1), followed by the area between Winterton and North Foreland (region 2), and the lowest densities between North Foreland and Portland Bill (region 3) (Rogers and Millner, 1996). For Region 2, estimated densities in September of each year were approximately 41 individuals/1000 m^2 , which is comparable with the abundances observed in the June BEEMS offshore survey (Figure 41, top). Population estimates for sand gobies in the region 2 ranged between 36 – 197 million individuals between 1973 and 1995 (mean = 94.7 million, st dev = 41.3 million individuals).

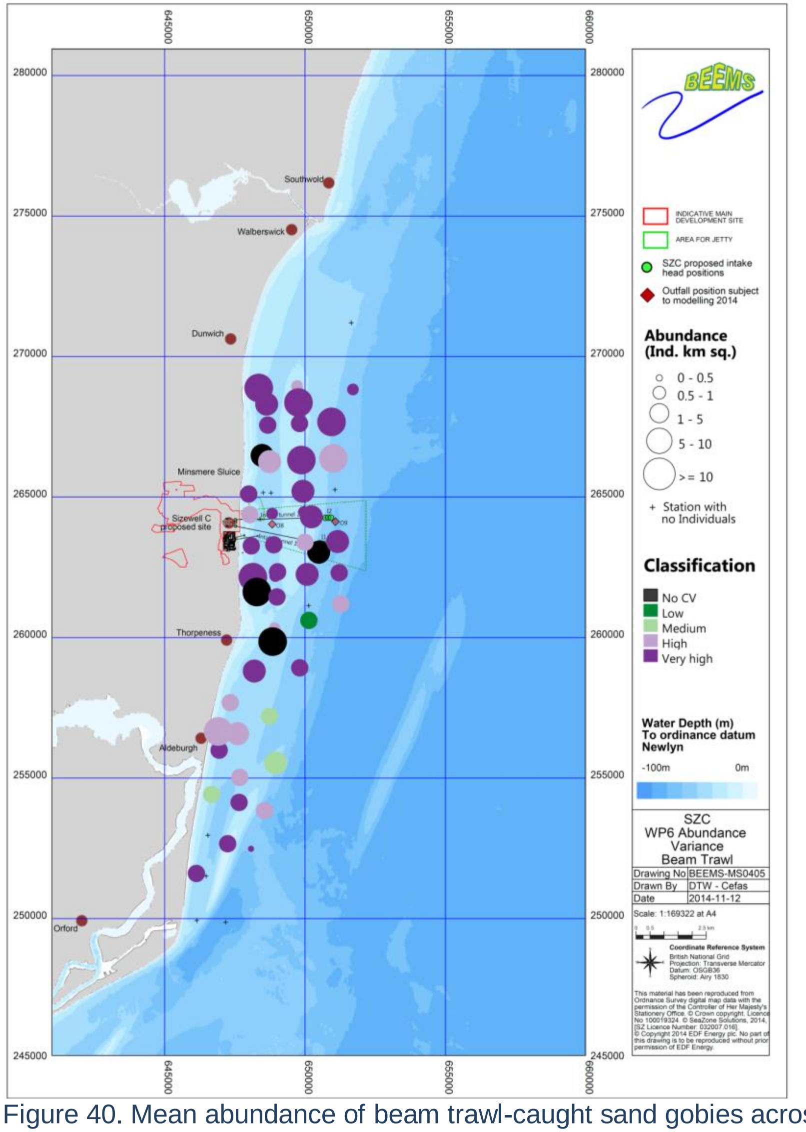


Figure 40. Mean abundance of beam trawl-caught sand gobies across the study area, together with the coefficient of variation (CV). Abundance = individuals/km^2.

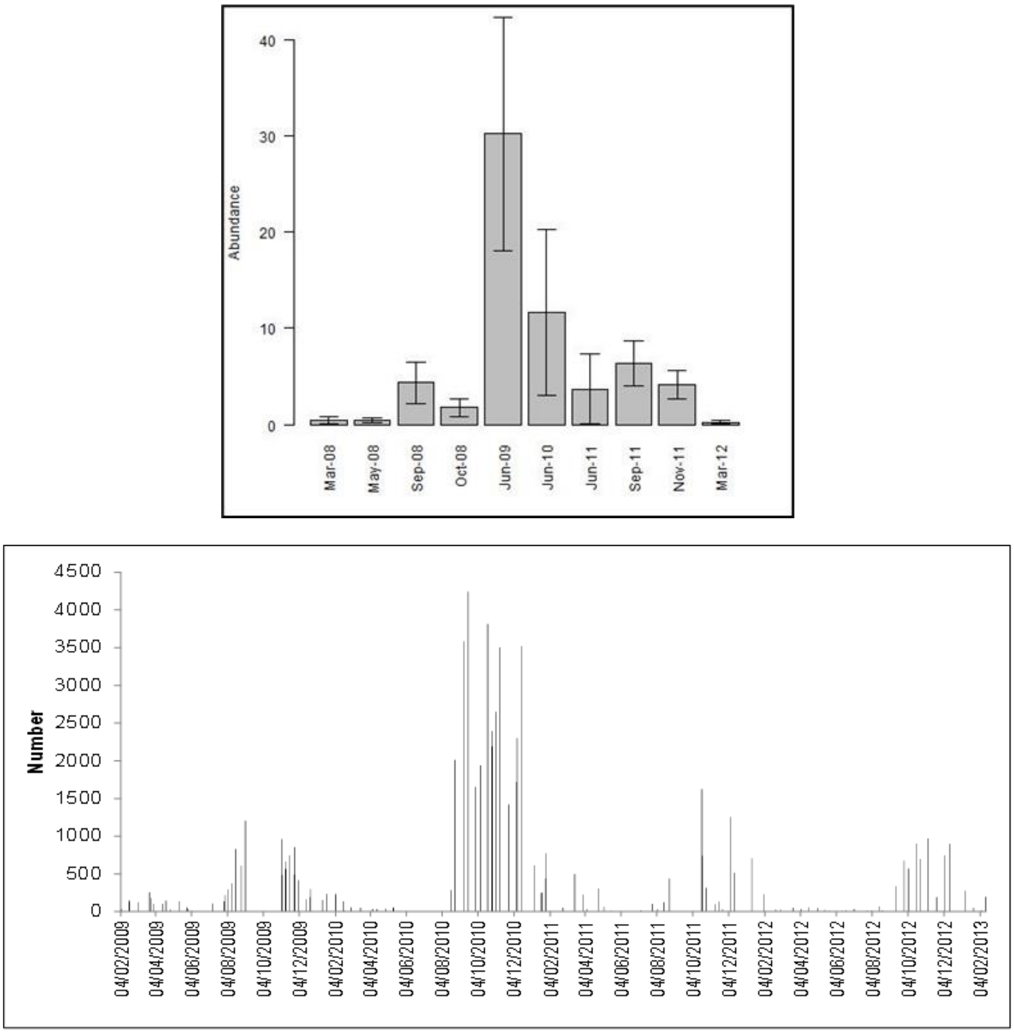


Figure 41. Sand goby patterns: Top - mean abundance (and 95 % C.I.) for each BEEMS survey (2 m beam trawl abundance = individuals/km2). Bottom - BEEMS impingement sampling, number per 24 hours at full station pumping capacity.

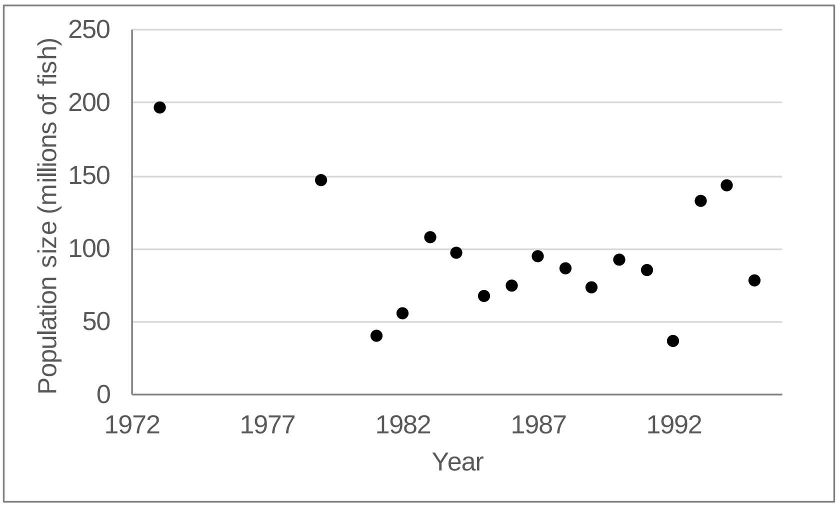


Figure 42. Estimated population size (millions of individuals) of sand gobies in Region 2 of the Young Fish Survey, 1973 – 1995 (Rogers and Millner, 1996).

3.1.14 Twaite shad (*Alosa fallax*) and Allis shad (*A. alosa*)

IMAGE: Twaite shad. © Crown copyright 2005

Twaite shad occurs along most of the west coast of Europe, from southern Norway to the eastern Mediterranean Sea. It is normally found in the sea, or in the lower reaches of large unpolluted rivers where there is easy access to spawning grounds (Maitland and Hatton-Ellis, 2003). Twaite shad males mature at 3 – 4 years and females approximately one year later (Aprahamian et al., 2003, 1998). Spawning takes place within or just above the tidal reaches of rivers, although the fish do not travel far upstream (Wheeler, 1969a). Adults gather in the estuaries of suitable rivers in early summer (April to June), moving upstream to spawn from mid-May to mid-July (temperature dependant) (Aprahamian et al., 1998; Maitland and Hatton-Ellis, 2003). After spawning the adults migrate seaward; the 0+fish remain in estuaries and freshwater during the summer and migrate to the sea in autumn (Aprahamian et al., 1998). The following spring a portion of these re-enter the estuary, migrating to the sea once more in late summer/early autumn (Aprahamian et al., 1998). Spawning populations of twaite shad have been recorded in 37 UK rivers, four of which still support spawning - the Severn, Usk, Tywi and Wye. Populations in these four rivers appear to be reasonably stable (Aprahamian et al., 1998). Twaite shad are iteroparous, with up to six spawning migrations (Aprahamian et al., 1998).

Allis shad *Alosa alosa* occurs along the eastern Atlantic coast from Norway to North Africa and also in the western Mediterranean. It has declined significantly throughout its range and is now extinct in several former areas. The most important spawning rivers for *A. alosa* are now French west coast and Portuguese rivers draining into the Atlantic (Maitland and Hatton-Ellis, 2003). Some recolonisation has occurred in rivers in north-western France. *Alosa alosa* was once abundant in the River Severn and supported a commercial fishery (Day, 1890 cited by Henderson, 2003). It was recorded as breeding in the River Wye in 1935 and is considered to have spawned in the River Severn and some other British rivers, but in recent years has been caught only rarely in UK waters, and no spawning has been recorded. There are, therefore, currently no known spawning sites for this species in the UK, and only two locations in the UK where individuals in breeding condition have been recorded: the river Tamar in SW England and the Solway Firth on the border between England and Scotland (Jolly et al., 2012). Immature adults are occasionally found in the Bristol Channel, the English Channel and the east coast. It is possible that British-caught specimens are part of the Loire–Gironde population (Henderson, 2003).

Allis shad mature at between 3 and 8 years old, with most females maturing at 5 - 6 years and males at 4 - 5 years (Maitland and Lyle, 2005). Mature fish that have spent most of their lives in the marine environment cease feeding and move up the estuaries of large rivers at the end of February, migrating into freshwater during late spring (April–June). Males migrate upstream first, followed by females 1 or 2 weeks later. Spawning occurs in freshwater at night over substrata ranging from mud to sandy gravel at depths of 0.15 – 9.5 m. Eggs develop optimally at temperatures of 15 – 25°C. Spent *A. alosa* (fish that have spawned) migrate back to the sea, though most die after reproduction (i.e. they are semelparous).

Incubation takes 72 – 120 h depending on temperature and the larvae measure 4.25 – 9.2 mm at hatching. After hatching, the young remain in the slow-flowing reaches of the lower parts of rivers, but migrate seawards in the surface layers of the water column during autumn and winter to reach the marine environment by December of their first year (Aprahamian et al., 2003). The larvae grow rapidly to between 80 and 140 mm at age 1. Most juveniles remain at sea until they mature. Studies on population genetic structure for both *A. alosa* and *A. fallax* have demonstrated strong fidelity to breeding grounds, compatible with homing to natal spawning sites (Jolly et al., 2012).

Shad populations have declined across Europe, and various anthropogenic factors, such as over fishing, pollution, habitat degradation and the building of dams and weirs which obstruct migration, have been implicated in this decline (Aprahamian et al., 2003). Consequently, both species have been placed on Appendix III of the Bern Convention and Annexes II and V of the EU Habitats Directive. Allis shad is also included on the list of Threatened and/or Declining Species produced by OSPAR, on Schedule 5 of the Wildlife and Countryside Act (1981) and as a Priority Species in the UK Biodiversity Action Plan.

No shad were caught in the BEEMS coastal surveys. Both species were recorded on the Sizewell B impingement screens, although Allis shad was only recorded once, a 59 cm TL individuals captured in May 2009, which would probably have been mature. The majority of twaite shad were caught between April and August (Figure 43). Of the 154 twaite shad caught between February 2009 and February 2012, approximately 86 % were mature ≥30 cm TL. Males mature at around 27 – 31 cm and females between 27 and 38 cm depending on the locality (Aprahamian et al., 2003), so many of those impinged will have been maturing or mature fish.

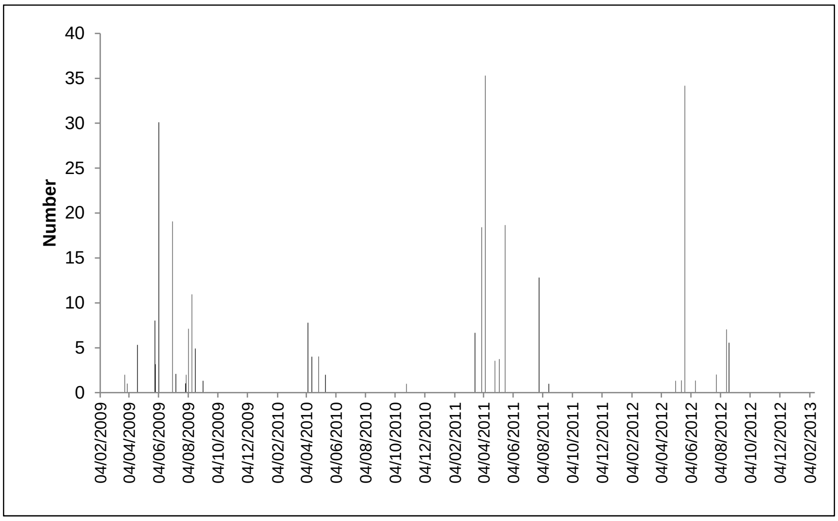


Figure 43. Numbers of Allis and Twaite shad impinged during 125 x 24-h sampling occasions at Sizewell B nuclear power station between February 2009 and February 2013.

3.1.15 European eel (*Anguilla anguilla*)

IMAGE: European eels. © Crown copyright 2003

The European eel *Anguilla anguilla* is present in rivers and estuaries throughout northern Europe (Wheeler, 1969a). The species is catadromous, breeding in a specific region of the North Atlantic (thought to be the Sargasso Sea) (Feunteun, 2002; McCleave and Arnold, 1999; van Ginneken and Maes, 2005; Wheeler, 1969a). After hatching the young larvae (known as leptocephali) are transported back to European coasts by ocean currents (Feunteun, 2002; van Ginneken and Maes, 2005; Wheeler, 1969a). As they approach the continental shelf, the leptocephali become glass eels, or elvers. In the North Sea, elvers ascend rivers in March and April after metamorphosis, although some may remain in estuaries or coastal waters (Tzeng et al., 1997).

Little is known about the residence times of glass eels in the southern North Sea. Reports suggest that glass eels are transported at between 7- 8 km per day north to south, based on the time between eels passing the 1000 m depth contour, and reaching the coasts of Holland, Belgium and Germany (4 -5 months) (Tesch, 2003). The eels then seek a salinity cue to transition from oceanic waters to coastal ones, so the time spent in the open North Sea is dependent on when they sense this cue. During the transition period, Tesch (2003) suggested that there would be a 14-day rhythm of activity towards freshwater environments, as the glass eels are influenced by tidal currents and daylight, alternatively hiding in the substrate or moving in the water column to move inshore, as a result of the combination of these two factors.

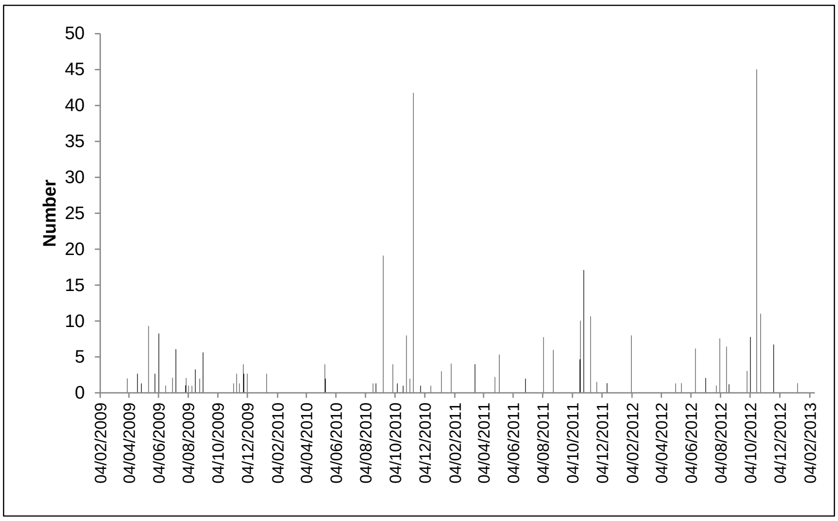
Once in freshwater, the eels (now termed yellow eels) spend many years growing and feeding (7-12+ for males and 9-19+ years for females; (van Ginneken and Maes, 2005; Wheeler, 1969a). On reaching an average length of approximately 41 cm (males) and 54-60 cm (females), they begin migrating out to sea, where they become silver eels (Feunteun, 2002; van Ginneken and Maes, 2005; Wheeler, 1969a). Silver eels are believed to complete their return migration in deep water (~2000 m) using Gulf Stream counter-currents that help them move in a generally westward direction. Their passage is aided by anatomical changes such as modifications to their retina, which are similar to those of abyssal fish, and changes to the wall of the swimbladder that allow the eels to swim at such depths.

A significant decrease in the recruitment of European glass eels was observed between 1979 and 2009, to approximately 5 % of the 1960-1979 levels (ICES, 2014i). Consequently, the species was listed as critically endangered in the IUCN Red List in 2008 and in 2014 (Freyhof and Kottelat, 2010; ICES, 2014i), is listed as a UKBAP Priority species and has been included on the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2010). Although recent assessments suggest that recruitment over the last three years has increased to approximately 12 % of the 1960-1979 levels, the most recent ICES advice on the European eel is that the stock was still critical in 2014 (ICES, 2014i). Historically, strong fisheries for adult eels existed in East Anglian rivers, but, due to the reduced number of eels, fishing is largely a subsistence activity, although a fyke net fishery still operates in the River Thames (Potts et al., 1993). A commercial glass eel fishery has also operated in the East Anglian region (Defra, 2010), showing that European eels are present in the waters adjacent to the study area. In the River Stour glass eel recruitment monitoring has been carried out to improve information on stock status (Defra, 2010), and in 2014 glass eels recruited into the river between March and August.

The scientific literature suggests that glass eels generally arrive in the North Sea in January to February. However, this is dependent on met-ocean conditions over Northern Europe and the relative strength of the Gulf Stream and associated currents around the British Isles. Observations suggest that eels enter the North Sea from both the English Channel and from the north, following currents that flow around Scotland and southwards into the southern North Sea. However, it is possible to catch glass eels in the southern North Sea from January to mid-May depending on the prevailing met-ocean conditions. Environment Agency eel recruitment data from fish weirs and traps on the Rivers Stour and Blackwater indicate that glass eels migrate upstream in rivers from April through the year and can be found as late in the year as September. However, numbers recorded in these local rivers in recent years appear to be peak in May/June. Sampling for glass eels on tributaries of the River Thames is carried out annually between April and September also suggesting that glass eels would be present in the East Anglia marine environment prior to entering freshwater, in or around April and May (BEEMS Technical Report TR356).

No eels were found in the BEEMS 2 m beam trawl and otter trawl surveys of the Greater Sizewell Bay between 2008 and 2012. In April and May 2015, an additional survey was undertaken targeted towards glass eels in the area of the current SZC and proposed SZC intakes, using similar techniques that had previously been applied at Hinkley Point (BEEMS Technical Report TR356). Only one glass eel was captured from the 105 valid hauls, and given that this gear had been successfully utilised at Hinkley Point, it was concluded that this lack of glass eels at Sizewell was indicative of the extremely low local abundance and high level of dispersal of this particular life stage in this open coastal area of the North Sea.

SZB impingement monitoring during the CIMP programme (with 10 mm mesh filtration) detected 2 glass eels (both 67.5 mm long) and a number of yellow eels ranging in length from 228 mm to 893 mm . No silver eels were caught. The species was not abundant, but was present in 65 % of the samples (Table 3). Eels were impinged throughout the year, but with larger numbers being impinged in the autumn (November and December) (Figure 44, top). Ninety percent of the yellow eels were greater than 280 mm in length with a median length of approximately 400 mm (BEEMS Technical Report TR406)., and it is likely that they were either moving between different river systems along the East Anglian coast or living in coastal waters locally. The general decline in eel populations across Europe is reflected in the inshore Young Fish Surveys (see Figure 44, bottom); but there has been no discernible trend in catches on the Sizewell B screens in the period 2009-2017 of impingement monitoring.



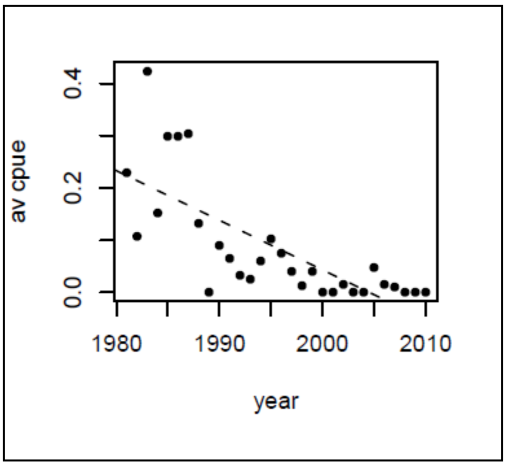


Figure 44. European eel patterns: Top - BEEMS impingement sampling, number per 24 hours at full station pumping capacity. Bottom - abundance (mean cpue, average number of individuals per 1000 m^2 fished) caught in the East Anglian region during the Eastern Young Fish Survey [the dashed line shows the general trend; reproduced from Cefas (2011)].

3.1.16 Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta*)

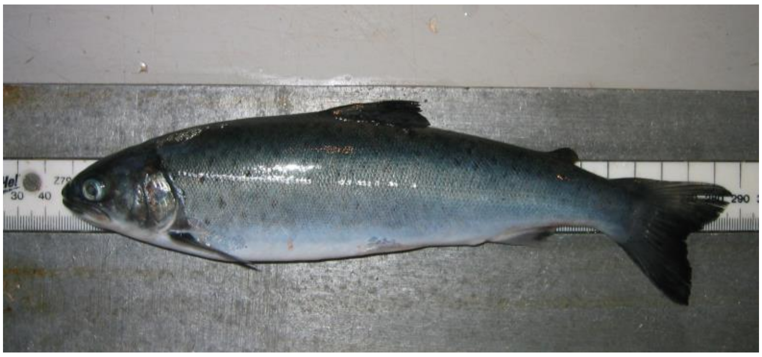


IMAGE: Salmon. © Crown copyright 2004

Atlantic salmon is an anadromous species that originates in rivers around the North Atlantic, from Spain to Russia, in Iceland, and on the eastern coast of North America (Wheeler, 1969a). Salmon spawn in freshwater in the autumn and winter (usually November and December) (Wheeler, 1969a), after which any surviving adults return to the sea (most salmon die after spawning). The eggs hatch in spring and juvenile fish spend one to three years in freshwater before migrating to sea in springtime. After one to three years at sea, the salmon return to their home rivers as mature adults. Little is known about their movements in the North Sea, but it is thought that they may move into the Norwegian Sea in the summer and autumn of their first sea year, and that some could migrate as far as western Greenland during the following summer (Environment Agency and Cefas, 2012).

A fishery for Atlantic salmon and sea trout operates on the East Anglian coast, but the catch is predominantly of sea trout and fewer than 5 salmon are taken per year. There are no 'salmon rivers' (other than the Thames) between the Humber estuary and the Solent. The salmon ‘stock’ in the Thames is very small; it was originally restored by stocking, but fish release stopped in 1994 and the population subsequently declined, reaching a low in 2005 with no returning salmon recorded. Adult salmon are still found in the Thames but genetic studies have confirmed that these are all strays from other south coast rivers or from northern France and there is no evidence of any reproduction taking place in the Thames (Griffiths et al., 2011).

A national assessment of the status of the salmon resource in England and Wales is undertaken annually (Potter et al., 2004). These assessments show there are no main salmon rivers in East Anglia (Environment Agency and Cefas, 2012). Little is known about their movements in the sea and even less about the local area, however, there have been efforts to reintroduce salmon into the River Thames. Initial results in the 1980s and 1990s were optimistic, with approximately 300 fish returning each year. Since then it is estimated that only approximately 20 fish return each year, probably as a consequence of unfavourable flow and water quality conditions (Environment Agency and Cefas, 2012).

Sea trout co-exist with salmon and have similar life-cycles. Some trout are fully resident in their natal stream or river (predominantly males, termed brown trout), while others undertake a smolt transformation and migrate to sea to grow (predominantly females, termed sea trout). Migrants return to spawn in their natal areas when they are sexually mature. Trout breed in winter from October to January, in gravel beds known as ‘redds’. The female covers the eggs with sand and fine gravel. After hatching the larvae remain in the gravel until they are approximately 25 mm long, after which they emerge and begin feeding (Wheeler, 1969a). Post smolts migrate down the East Anglian coast around late May to early June, with adults migrating through the summer.

In the North Sea sea trout occur in 5 genetically distinct groupings – Moray Forth, North East UK, East UK (Humber to North Norfolk), East North Sea (Rhine – Denmark) and Western Norway. Fish caught by anglers in East Anglia are predominantly from the NE coast of the UK with small numbers from Denmark, the Rhine and a few from Norfolk and SW England (Living North Sea project: Fish migration from sea to source). Results from UK tagging studies have shown that most post-smolts migrate up to 100 - 150 km from their natal river. However post-smolts from rivers between the Tweed and the Yorkshire Esk travel throughout the southern and central North Sea (migrations of up to 750 km). Tag returns from 1950s work shows that their route is down to East Anglia, across to the Frisian Islands/Waddensee and, if they are returning after just one winter at sea, back to the Tweed. If spending two winters at sea, tag returns show that they can go as far as the tip of Denmark. On average, these 1950s smolts took 60 days from tagging in the Tweed estuary to get to Great Yarmouth (where most recaptures were made), a distance of 445 km (Solomon, 1984). More recent acoustic tracking studies have shown that north east coast post-smolts generally migrate within 2-3 m of the surface but have been observed to dive to depths of 80 m.

Although sea trout are present in the rivers of Suffolk, these are not major trout rivers (Environment Agency, 2013). Little is known about local stocks (Environment Agency, 2013). On the basis of the data gathered from BEEMS surveys, neither species is present to any appreciable degree, or is considered likely to be seen, in the Greater Sizewell Bay. Neither was recorded at any point in the coastal survey series, and there has been only one record from the Sizewell B impingement screens during the four years of monitoring (one sea trout, captured in May 2010).

3.1.17 River lamprey (*Lampetra fluviatilis*) and sea lamprey (*Petromyzon marinus*)

IMAGE: Lamprey. © Crown copyright 2010

Lampreys (Petromyzonidae) live in temperate zones and are mostly freshwater or anadromous (Maitland 2003a). They are not true fish, having no lower jaw but a suction disc mouth. Three species occur in the British Isles, but only two (river lamprey *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus*) are estuarine/coastal. Both are parasitic and the adults feed by attaching to other fish using the suction disc and using the rasp-like tongue to remove body fluid and tissue (Pickering, 1978).

River lamprey are widespread in catchments throughout the UK, except in northwest Scotland and in industrial areas where water quality is poor or where obstacles prevent the upstream migration of adults prior to spawning. River lampreys reach a size of 30-50 cm. River lamprey migrate from their coastal feeding grounds into freshwater rivers and streams in the spring. Spawning is usually in March and April when the water temperature reaches 10 – 11 ˚C (Maitland 2003a). Adult river lampreys spawn in shallow nests in gravel and stony areas, after which the adults die (Maitland, 2003a; Pickering, 1978). The larvae (ammocoetes) bury themselves in soft mud downstream of the nesting sites, where they filter-feed on micro-organisms and detritus for up to five years. They then metamorphose to the adult form in July to September and migrate as young adults out to sea in winter at a length of 9−12 cm. They then spend one or two years feeding at sea before maturing at ~30 cm. At the onset of maturity, the adults stop feeding and returning to suitable freshwater habitat to spawn (Pickering, 1978).

The sea lamprey is the largest of the 3 lamprey species found in the UK, reaching a size of approximately one metre in length. The species is uncommon in the UK and although found around the coast, the main population centres are concentrated on the Bristol Channel. Sea lamprey demonstrate a similar life history to the river lampreys, however the larval and adult stages are slightly longer (0.5- 1 year longer). In contrast to river lampreys, after metamorphosis juvenile sea lamprey migrate directly to the sea (Wheeler, 1969a). Genetic studies on sea lamprey have demonstrated that they do not home to their natal river and instead exhibit regional panmixia (i.e they can breed with any individuals in the population without genetic or behavioural constraints) using a ‘suitable river’ strategy to complete their life cycle. River suitability appears to be based upon the detection by adults of bile acid-based pheromones released by larvae (Waldman et al., 2008). Gaudron and Lucas (2006) have reported that river lamprey also respond to bile acid pheromones and the species is therefore considered likely to adopt a similar life cycle strategy to the sea lamprey.

Fisheries for river lamprey exist in Sweden and Finland (Maitland, 2003a), and the River Ouse has a fishery for lamprey, as there are spawning populations of both species present in the River Derwent. River lamprey numbers have declined in the UK over the last 100 years and the species has disappeared from many rivers. As a result, the species has been given conservation protection (Maitland, 2003a). Sea lamprey are absent from many northern British rivers and are extinct in some southern ones (Maitland, 2003a). Because of its decline across Europe, sea lamprey are listed as a conservation species.

River lamprey were present in 32 % of the impingement samples, but the species was not abundant (only 269 individuals out of the approximately 1.5 million fish impinged during the 125 sampling operations) (Table 3). Apart from March 2010, when more than 30 river lampreys were caught in a single 24-hour sample, the majority of river lampreys were recorded between October and December, possibly reflecting the downward migration into the estuarine/coastal environment. No sea lampreys were impinged. Lampreys were similarly rare in impingement sampling conducted at Sizewell A power station in May 1981 – April 1982 (Turnpenny et al., 1983). Forty-one 24h samples were collected and only three sea lampreys were observed, and no river lampreys. The sea lampreys were caught on three separate occasions (two visits in June 2981, one visit in April 2982), and all were small ≤ 23 g. A single (unidentified) lamprey was captured in June 2010 in the 2 m beam trawl, between Sizewell and Thorpeness. Considering the regular impingement of river lampreys in 2009-2012, but no recordings of sea lampreys, this specimen was likely a river lamprey, though information on their distribution in the estuarine/coastal environment is sparse (Maitland, 2003a).

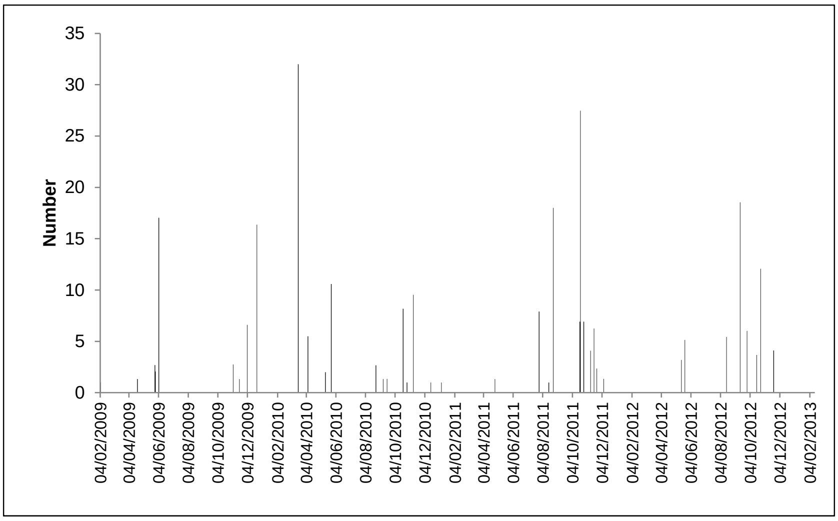


Figure 45. Numbers of river lamprey impinged during 125 x 24-h sampling occasions at Sizewell B nuclear power station between February 2009 and February 2013.

3.1.18 Smelt (*Osmerus eperlanus*)

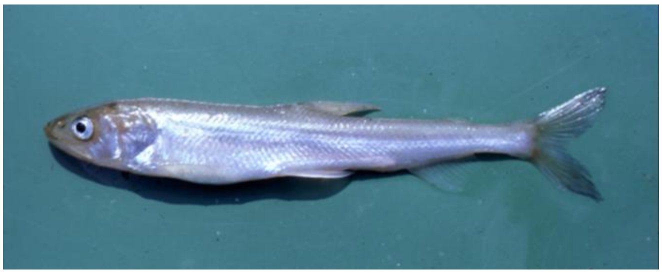


IMAGE: Smelt. © Crown copyright 1981

Smelt are found in coastal waters and estuaries around the western coast of Europe, from southern Norway to north-west Spain (Maitland, 2003b). Although there are several non-migratory populations in large freshwater lakes in Scandinavia, the species has usually been found in coastal waters and migrates into large clean rivers to spawn (Wheeler, 1969b). Adults live in the marine environment, but migrate to estuarine or slightly brackish rivers in early spring (February to April) to spawn, after which the adults return to sea (Maitland, 2003b). Smelt shed their adhesive eggs onto the river bed in the brackish reaches of tidal rivers during March and April, where they hatch in about 3−4 weeks. Spawning appears to be determined by temperature and tides. In the River Thames, spawning takes place in the Wandsworth area of the estuary and 0+ fish first appear at 18mm at Greenwich in mid-May (Colclough et al., 2002).

The smelt was once common in Great Britain and supported commercial fisheries in the estuaries of most large rivers from the Clyde and Tay south. Maitland (2003b) reports that fisheries for smelt existed in the tidal reaches of all the Broads rivers in Norfolk until at least 2002; commercial fisheries ‘yielding 3 to 6 t’ per annum were still active in the River Waveney in 1991; smelt are occasionally taken in herring nets in the Orwell Estuary; and commercial fishermen were taking large catches – 190−250 kg per day in the Medway and the River Thames by 2002. Today, smelt occur in at least 36 water courses in England and Wales, with large populations in the rivers Thames, Humber and Dee, the Wash and Great Ouse, as well as in water courses of the Norfolk Broads. Smaller populations exist in the rivers Alde/Ore, Ribble and Conwy, and recovery of supposed extinct populations seems to be underway in the rivers Tyne and Mersey (Colclough and Coates, 2013).

There are commercial fisheries for smelt in the Rivers Waveney, Bure and Yare, predominantly for angling baits, although smelt are now sold to restaurants (A. Moore, Cefas, pers. comm.) and since 2011 there has been a requirement for commercial smelt fisheries to be authorised by the Environment Agency and to make annual catch returns. The annual catch of smelt in 2014 was 11,006 kg from 4 licence holders (Environment Agency, 2015). However, the report does not state the rivers that the licence holders exploited, but it is known that they are based in the Ouse (Yorkshire and Cambridge), Waveney/Yare and Thames (A. Moore, Cefas, pers. comm.).

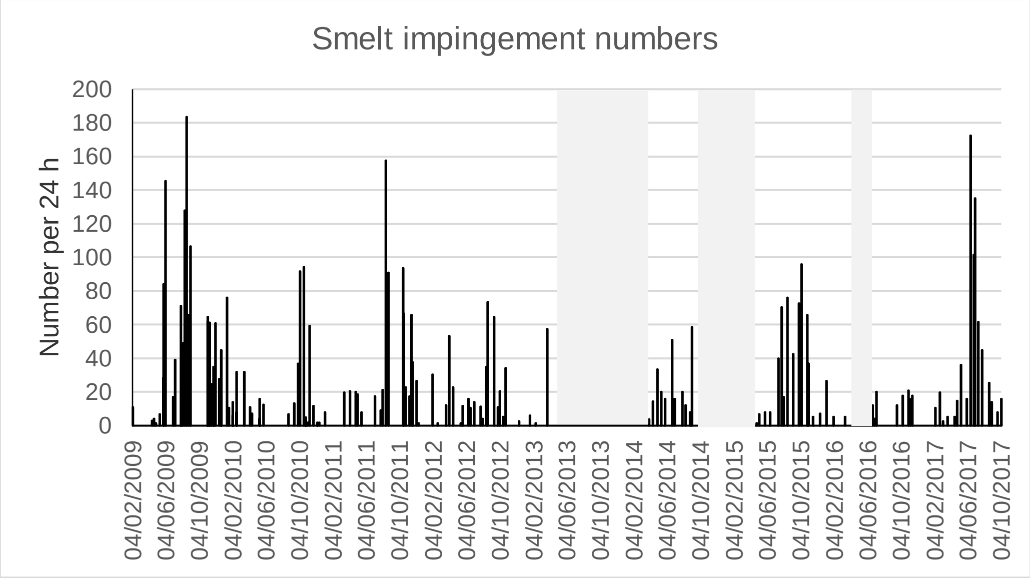
In the marine environment, smelt are found all along the Anglian coast, in the southern North Sea and on the European coast from at least the river Scheldt in the Netherlands to the River Elbe in Germany but there is no targeted fishery at sea. The nearest estuary to Sizewell with a known smelt population is the Alde/Ore, approximately 25 km to the south of Sizewell. Other than that, the nearest estuary to Sizewell is the Blyth at approximately 12 km to the north of Sizewell. Adult smelt have been sampled in the Blyth but there is no evidence of a breeding population. Surveying using fyke nets and kick sampling methods was carried out in the tidal and estuarine areas of the Blyth in April and May 2016 and found no evidence of suitable spawning habitat, a barrier to upstream migration, no eggs nor any smelt in spawning condition at the time that other Anglian rivers contained spawning aggregations (BEEMS Technical Report TR382). This work concluded that it was highly unlikely that there was a spawning population in the Blyth nor the habitat to support one.

Cefas has recently undertaken a two-year study on the migratory behaviour of smelt in four rivers in Suffolk and Norfolk. Smelt tagged in the River Yare during the spawning migration either continued to move upstream to spawn or migrated into the Rivers Bure, Waveney and Wensum again, presumably to spawn . Fish were detected in Oulton Broad, the centre of Norwich and Beccles. A significant number of the smelt were again detected migrating out to sea at Great Yarmouth and a single fish subsequently moved into Lake Lothing at Lowestoft. There was very little residency in the estuary at Breydon Water and the results of the work suggest that smelt are more coastal/marine than estuarine/brackish in habit (Moore et al., 2015).

No smelt were found in the BEEMS coastal surveys. However, they were common, though not abundant, in impingement samples [found in 73% of samples collected between 2009 to 2013 but accounted for only 0.2% of fish sampled (Table 3)]. Peak numbers of smelt were impinged in June and August, with low numbers from January to May. Impingement modelling showed 74% of smelt were impinged between June and November. The numbers of smelt impinged in the period 2009-2017 is shown in Figure 46 and shows no trend. The impinged smelt length distribution at Sizewell B is shown in Figure 47 with the numbers at age in Figure 48. The majority of smelt impinged at Sizewell were 1 group (49%) and 2 group (39%) with a further 12% in the 3+ group. Only 0.03% (7 out of were approximately 24,000 fish were apparently large 0 group fish (but these were not aged and could easily have been slightly below average length 1 group fish). From the impingement data, smelt are predominantly present off Sizewell in the summer as either juvenile (1-year olds with 50% maturity) or as adults (fully mature fish) which is indicative of the fish using waters off Sizewell as part of their extensive summer feeding grounds. 0 group fish (i.e. born in a 12-month period from May in each year) were not present).

Information on smelt stocks is limited. Colclough and Coates (2013) concluded that the smelt found in the Wash are probably from a common stock which may access some or all of the tributaries that flow into the Wash, and Maitland (2003a) reported that it is likely that stocks in Suffolk belonged to a population associated with the Norfolk Broads and the estuarine and brackish waters around Great Yarmouth and Lowestoft. More recent genetic analysis of 215 smelt collected from the SZB CIMP programme and from the Thames, Waveney, Great Ouse and Tamar estuaries showed that East Anglian smelt are genetically homogeneous with no genetic structuring seen within the region. Smelt from the Tamar was clearly distinct from the East Anglian collections (BEEMS Technical Report TR423).

Given the genetic information on the smelt at Sizewell, it is probable that the smelt impinged are from multiple locations on the east coast of the UK and, based on the relative distances from Sizewell, from European estuaries of at least the Scheldt (Belgium) and the Elbe in Germany. Considering only UK populations and given the limited number of licences issued for commercial exploitation, the size of fishery landings will be a substantial underestimate of the stock size.



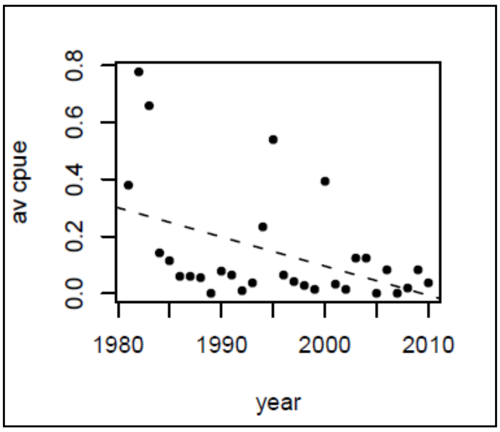


Figure 46. Smelt patterns: Top – SZB impingement sampling, number of fish impinged per 24 hours. Bottom - abundance (mean cpue, average number of individuals per 1000 m^2 fished) caught in the East Anglian region during the Eastern Young Fish Survey [the dashed line shows a fitted trend line that has not been subject to statistical evaluation; reproduced from Cefas (2011)].

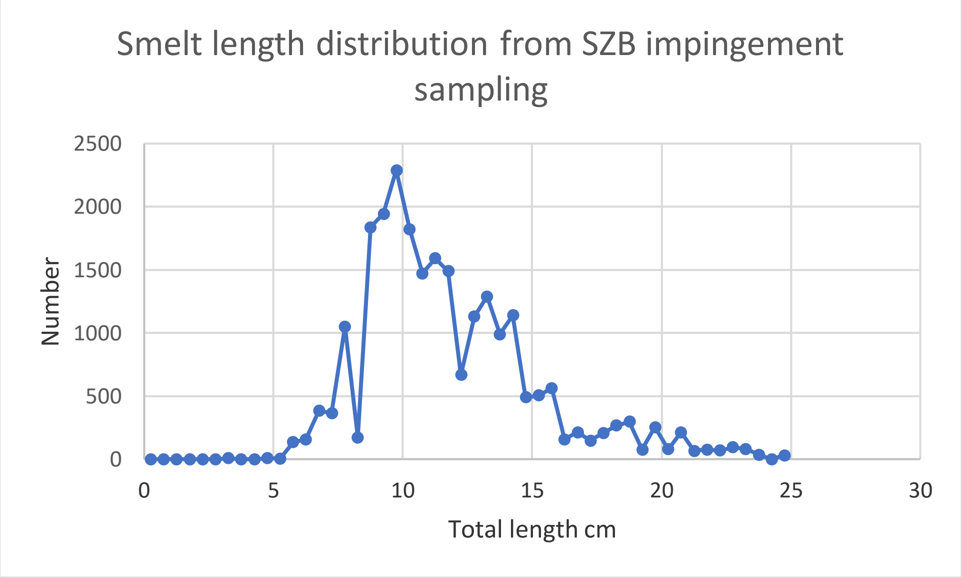


Figure 47 Measured smelt length distribution in the period 2009-2017 from SZB impingment sampling

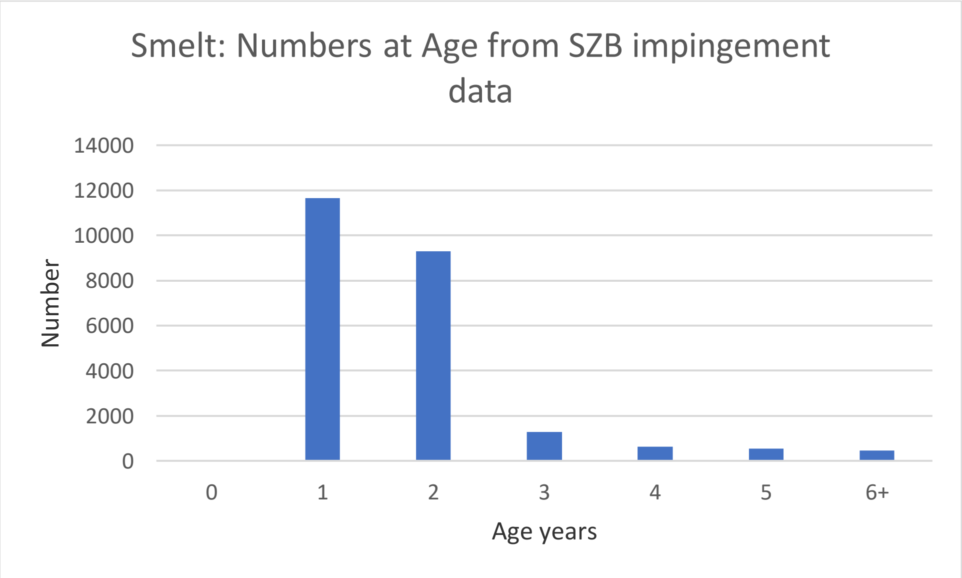


Figure 48 Measured smelt numbers at age in the period 2009-2017 from SZB impingment sampling

3.1.19 Tope (*Galeorhinus galeus*)

The tope is a shallow-water shark species found from Scotland and southern Norway, southwards to the coast of north-western Africa and the Mediterranean Sea (ICES, 2009b). Tope is generally found over gravel or sand down to depths of approximately 55 m (Wheeler, 1969a), although tagging studies have shown that it may be found deeper than this (ICES, 2009b). As with many shark species, it is long-lived and late maturing (approximately 36 and 11 years, respectively).

IMAGE: Tope. © Crown copyright 2003

ICES regards tope in the North-east Atlantic as a single stock (ICES, 2014j). There are currently no targeted commercial fisheries in the Greater Sizewell Bay area, but individuals may be taken as bycatch in trawl, gillnet and longline fisheries, and also by demersal and pelagic set gears. In the North Sea, longline fishing of tope is forbidden by EU regulation No°57/2011. In 2008, Defra introduced a Statutory Instrument (SI Number 2008/691) that prohibits fishing for tope other than by rod and line, and establishes a tope bycatch limit of 45 kg per day for commercial fisheries targeting other species. Tope is an important target species in recreational sea angling (ICES, 2014j).Two individuals were recorded in the BEEMS otter trawl samples: a 91 cm individual in September 2008 and a 59 cm individual in June 2011. Both were caught at the sites furthest offshore to the south-east and north-east of the Sizewell station complex respectively (Figure 49).

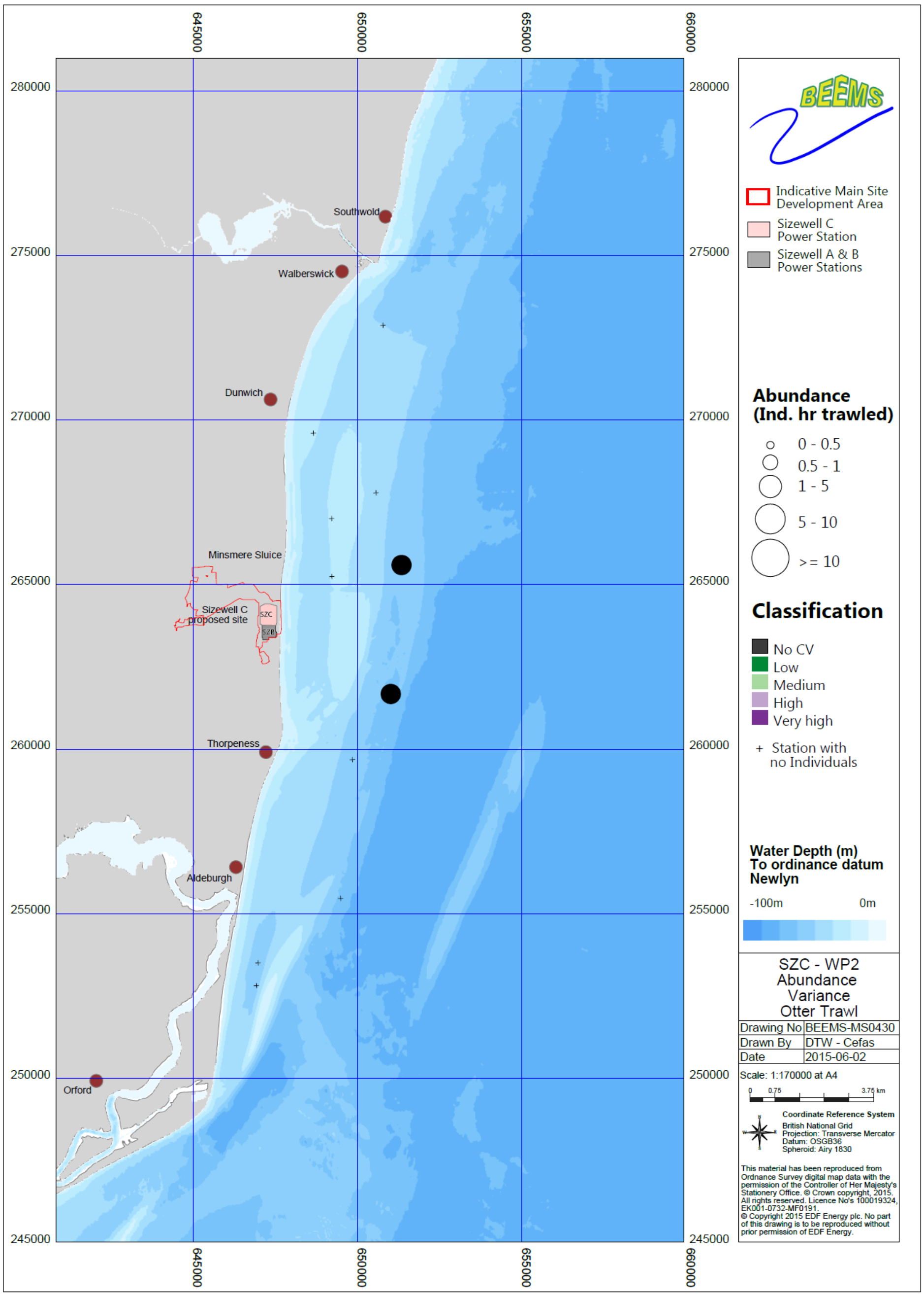


Figure 49 Abundance of otter trawl-caught tope across the study area. Abundance = individuals/hour

3.1.20 Mackerel (*Scomber scombrus*)

IMAGE: Mackerel. © Crown copyright 2004

Mackerel is a common pelagic fish found from the Bay of Biscay northwards through the English Channel, Irish and North Seas, to the west of Scotland and Iceland. Commercial fisheries for mackerel exist around the UK, with the majority of fisheries occurring in the northern North Sea, around Shetland, and the west coasts of Scotland and Ireland. In recent years, substantial fisheries have existed around Iceland and the Faroes (ICES, 2014k).

No mackerel were caught in the BEEMS coastal sampling, and the species was both uncommon (present in only 7 % of samples), and present in low abundances (only 119 fish recorded; Table 3) in impingement samples (all were recorded in either April or October(Figure 50).

3.1.21 Horse mackerel (*Trachurus trachurus*)

IMAGE: Horse mackerel. © Crown copyright 2004

Horse mackerel, or scad, is a bony pelagic species distributed from northern Norway to the Bay of Biscay (Wheeler, 1969a). It forms large shoals that can be found near coastal areas in the summer and in deeper water during colder months. It is rarely found deeper than approximately 55 m (Wheeler, 1969a). In the southern North Sea, the main spawning grounds are along the coasts of Belgium, the Netherlands, Germany and Denmark (ICES, 2014k).

No horse mackerel were caught in the coastal sampling at Sizewell, and the species was uncommon (present in 21 %) of samples, and present in low abundances (only 332 fish recorded; Appendix C) in impingment samples (all recorded in October - December 2010; Figure 51). It is therefore difficult to draw conclusions on the distribution through the Greater Sizewell Bay area, or on recent changes in abundance.

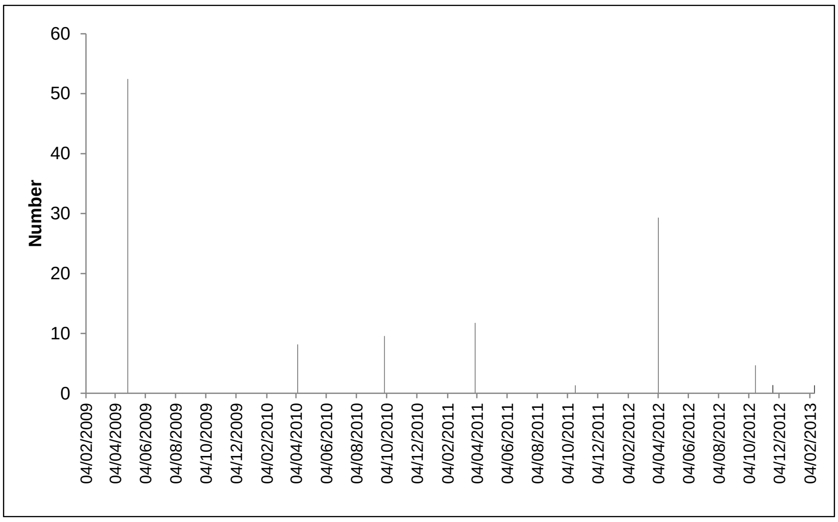


Figure 50. Numbers of mackerel impinged during 125 x 24-h sampling occasions at Sizewell B nuclear power station between February 2009 and February 2013.

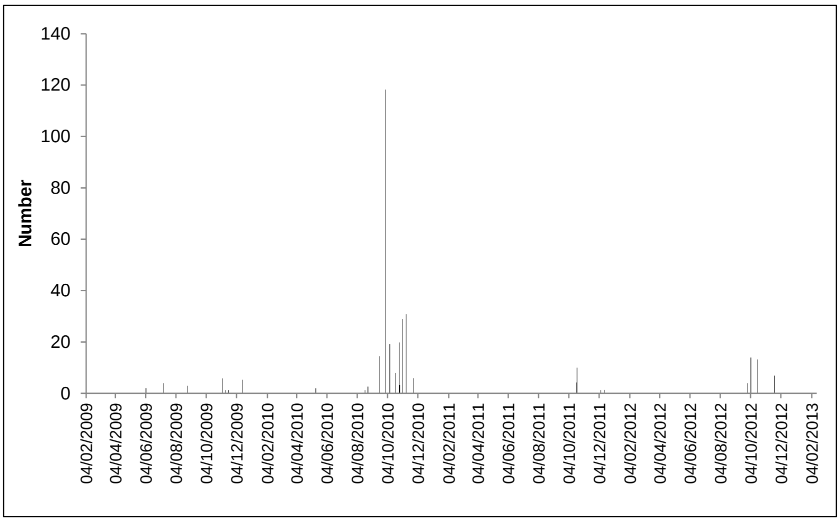


Figure 51. Numbers of horse mackerel impinged during 125 x 24-h sampling occasions at Sizewell B nuclear power station between February 2009 and February 2013.

4 Summary

Between March 2008 and March 2012, extensive sampling was undertaken to characterise the fish fauna of the Greater Sizewell Bay. The purpose of the sampling was to provide information to support the preparation of the EIA for the proposed Sizewell C station. Sampling consisted of coastal surveys, using 2 m beam trawl, otter trawl and acoustic gear, and onshore sampling of organisms impinged in the cooling water systems of Sizewell B. In total, the dataset comprised 253 beam trawl samples, 76 otter trawl samples, 2 Lowestoft box trawl samples and 125 impingement samples. Sampling covered the area from Dunwich in the north to Orford Ness in the south, and offshore to approximately 3.5 km, registering eighty-eight demersal and pelagic fish taxa.

The community was dominated by relatively few species, such as sprat, herring, whiting, bass, sand gobies and Dover sole. Even with extensive sampling, many of the other taxa were found in only low abundance or infrequently, including those considered to be of conservation importance.

Fish distributions and abundances in the bay mirrored those of the wider East Anglian region, with a similar set of species dominating catches at the Galloper and East Anglia ONE windfarm sites and in the outer Thames Estuary, as well as in the long-term fishery surveys of the Anglian coast. This suggests the fish fauna of the Greater Sizewell Bay are representative of, and thus indistinct from, the milieu of the wider region.

Of the taxa recorded, six are designated as key on the grounds of socio-economic importance, 16 on the grounds of conservation importance and five on the grounds of ecological importance. Several taxa fall under more than one of the three criteria and four under all three (Dover sole, cod, European plaice and Atlantic herring). Most of the commercially important species are widely distributed throughout the North Sea, and for stock assessment purposes they are assessed at very large scales - the whole of the North Sea, or the North Sea and the English Channel combined. For species whose spawning or nursery areas intersect with the likely SZC area of influence, the Greater Sizewell Bay tends to represent only a small proportion of the total spawning/nursery area Table 7.

The conservation species were largely absent from the coastal surveys and tended to be present in the impingement sampling only. Only smelt, European eels and lampreys could be considered as common or frequently caught; with smelt and the European eel the most abundant. This was also the case historically, as both species were in the top 20 in terms of abundance on the Sizewell A drum screens and were present in more than 80 % of the 41 samples taken (Turnpenny et al., 1983). Allis shad declined between the historical and contemporary impingement sampling (9 % of samples historically *versus* 0.8 % of samples in 2009 - 2013), whereas Twaite shad were slightly more frequent (25 % of samples in 2009-2013 *versus* 22 % of samples historically). Sea lamprey were only recorded during the earlier sampling at Sizewell A, whilst river lamprey were only recorded during the later sampling at Sizewell B.

The majority of the key ecological taxa were distributed across the bay. Most were commonly found, but not abundant. Abundance was generally highly variable, both from survey to survey and seasonally.

References

Alheit, J., Pohlmann, T., Casini, M., Greve, W., Hinrichs, R., Mathis, M., O'Driscoll, K., Vorberg, R., Wagner, C., 2012. Climate variability drives anchovies and sardines into the North and Baltic Seas. Prog. Oceanogr. 96, 128–139.

Aprahamian, M.W., Aprahamian, C.D., Bagliniere, J.L., Sabatie, R., Alexandrino, P., 2003. *Alosa alosa* and *Alosa Fallax* spp. Literature Review and Bibliography, Environment Agency R&D Report No. W1-014/TR.

Aprahamian, M.W., Lester, S.M., Aprahamian, C.D., 1998. Shad conservation in England and Wales, Environment Agency Technical Report W110.

BEEMS Technical Report TR069. Sizewell Nearshore Communities: Results of the 2 m Beam Trawl and Plankton Surveys 2008–2010, Edition 3.

BEEMS Technical Report TR087. Interpretation of BEEMS Swath Bathymetry and Backscatter Data. Cefas.

BEEMS Technical Report TR120. SZ Comprehensive Impingement Monitoring Programme 2009/10: Final Report.

BEEMS Technical Report TR123. Review of commercial and recreational fisheries activity in the vicinity of Sizewell Power Station.

BEEMS Technical Report TR133. SZ Thermal plume modelling: Delft 3D Stage II modelling results including geomorphology.

BEEMS Technical Report TR196. SZ Comprehensive Impingement Monitoring Programme Year II; Final Report.

BEEMS Technical Report TR201. Sizewell Nearshore Communities: Results of the 2 m Beam Trawl and Day Grab Surveys 2011−2012. Edition 2. Cefas.

BEEMS Technical Report TR215. Comprehensive Impingement Monitoring Programme, Year III – Final Report.

BEEMS Technical Report TR270. Comprehensive Impingement Monitoring Programme 2012-2013 at Sizewell B: Annual report.

BEEMS Technical Report TR315. Sizewell zooplankton synthesis. 2008-2012.

BEEMS Technical Report TR338. Sizewell Nearshore Communities: Results of the 2 m Beam Trawl and Day Grab Surveys 2014.

BEEMS Technical Report TR356. Sizewell Glass Eel Surveys.

BEEMS Technical Report TR359. Acoustic surveying of pelagic fish off Sizewell (2015).

BEEMS Technical Report TR380. Sizewell juvenile fish survey 2016.

BEEMS Technical Report TR382. Smelt populations in the vicinity of Sizewell.

BEEMS Technical Report TR406. Sizewell C - Impingement predictions based upon specific cooling water deisgn

Cefas, 2011. Trends in the inshore marine community of the east and south UK coast: 1970s to present.

Colclough, S., Coates, S., 2013. A review of the status of smelt *Osmerus eperlanus* (L.) in England and Wales – 2013. Report EA/001 to the Environment Agency, York, UK, by SC2, Chatham, Kent.

Colclough, S.R., Gray, G., Bark, A., Knights, B., 2002. Fish and Fisheries of the Tidal Thames: management of the modern resource, research aims and future pressures. J. Fish Biol. 61 (Supple, 64–73.

Colman, J.E., Pawson, M.G., Holmen, J., Haugen, T.O., 2009. European sea bass in the North Sea; past, present and future status, use and management challenges. In: Global Challenges in Recreational Fisheries, in: Aas, Ø. (Ed.), . Wiley-Blackwell, Oxford, pp. 111–129.

Coull, K.A., Johnstone, R., Rogers, S.I., 1998. Fisheries Sensitivity Maps in British Waters.

Defra, 2010. Eel Management plans for the United Kingdom: Anglian River Basin District.

Dickey-Collas, M., Nash, R.D.M., Brunel, T., van Damme, C.J.G., Marshall, C.T., Payne, M.R., Corten, A., Geffen, A.J., Peck, M.A., Hatfield, E.M.C., Hintzen, N.T., Enberg, K., Kell, L.T., Simmonds, E.J., 2010. Lessons learned from stock collapse and recovery of North Sea herring: a review. ICES J. Mar. Sci. 67, 1875–1886.

Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N., Brown, M.J., 2012. Spawning and nursery areas of selected fish species in UK waters.

Environment Agency, 2015. Salmonid and freahswater Fisheries Statistics for England and Wales, 2014.

Environment Agency, 2013. Salmonid & Freshwater Fisheries Statistics for England & Wales, 2012.

Environment Agency, Cefas, 2012. Annual Assessment of Salmon Stocks and Fisheries in England and Wales 2012.

ESFJC, 2010. Fisheries Mapping Project [WWW Document]. URL http://www.eastern-ifca.gov.uk/index.php?option=com_content&view=article&id=130&Itemid=199

Feunteun, E., 2002. Management and restoration of European eel population (*Anguilla anguilla*): An impossible bargain. Ecol. Eng. 18, 575–591.

Fleming, J.M., Seaby, R.M.H., Turnpenny, A.W.H., Fleming, 1994. A comparison of fish impingement rates at Sizewell A & B power stations , Journal Unknown. Fawley.

Freyhof, J., Kottelat, M., 2010. *Anguilla anguilla* [WWW Document]. IUCN Red List Threat. Species. URL www.iucnredlist.org

Galloper Wind Farm Limited, 2011a. Galloper Wind Farm Environmental Statement. Chapter 13: Natural Fish and Shellfish resources.

Galloper Wind Farm Limited, 2011b. Galloper Wind Farm Environmental Statement. Chapter 15: Commercial Fisheries.

Gaudron, S.M., Lucas, M.C., 2006. First evidence of attraction of adult river lamprey in the migratory phase to larval odour. J. Fish Biol. 68, 640–644.

Griffiths, A.M., Ellis, J.S., Clifton-Dey, D., Machado-Schiaffino, G., Bright, D., Garc ia-Vazquez, E., Svenes, J.R., 2011. Restoration versus recolonization: The origins of Atlantic salmon (*Salmo salar*) currently in the River Thames. Biol. Conserv. Conserv 144, 2733–2738.

Heessen, H.J.L., Daan, N., Ellis, J.R. (Eds.), 2015. Fish atlas of the Celtic Sea, North Sea, and Baltic Sea based on international research-vessel surveys. KNNV Publishing.

Henderson, P.A., 2003. Background information on species of shad and lamprey. Countryside Commission for Wales, Bangor.

ICES, 2015. Report of the Herring Assessment Working Group for the Area South of 62N (HAWG). 10-19 March 2015, ICES HQ, Copenhagen, Denmark. ICES CM 2015/ACOM:06.

ICES, 2014a. Advice on sole in Subarea IV (North Sea). ICES Advice November 2014, Book 6.

ICES, 2014b. Advice on plaice in Subarea IV (North Sea). ICES Advice November 2014, Book 6.

ICES, 2014c. Advice on cod in Subarea IV (North Sea), Division VIId (Eastern Channel) and Division IIIa West (Skaggerak). ICES Advice June 2014, Book 6.

ICES, 2014d. Advice on European sea bass in Divisions IVbc, VIIa, and VIId–h (Irish Sea, Celtic Sea, English Channel, and southern North Sea). ICES Advice June 2014, Book 5.

ICES, 2014e. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). 30 April – 7 May 2014. ICES CM 2014/ACOM:13.

ICES, 2014f. Advice on dab in Subarea IV (North Sea) and Division IIIa (Skaggerak - Kattegat). ICES Advice June 2014, Book 6.

ICES, 2014g. Advice on whiting in Subarea IV (North Sea) and Division VIId (Eastern Channel) . ICES Advice November 2014, Book 6.

ICES, 2014h. Advice on sprat in Subarea IV (North Sea). ICES Advice June 2014, Book 6.

ICES, 2014i. Report of the Joint EIFAAC/ICES/GCCM Working Group on Eel. 3-7 November, Rome, Italy. ICES CM 2014/ACOM:18.

ICES, 2014j. Report of the Working Group on Elasmobranch Fishes (WGEF). 17 – 26 June 2014. ICES CM 2-14/ACOM:19. (Draft).

ICES, 2014k. Report of the Working Group on Widely Distributed Stocks (WGWIDE). 26 August – 1 September 2014. ICES CM 2014/ACOM:15.

ICES, 2013a. Report of the Herring Assessment Working Group for the Area South of 62N (HAWG). ICES CM 2013/ACOM:06.

ICES, 2013b. Advice on Herring in Subarea IV (North Sea). ICES Advice May 2013, Book 6.

ICES, 2009a. Advice on Plaice in Subarea IV. ICES Advice 2009, Book 6: 61−73.

ICES, 2009b. Report of the Joint Meeting between ICES Working Group on Elasmobranch Fishes (WGEF) and ICCAT Shark Subgroup, 22–29 June 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:16. 424 pp.

Jennings, S., Lancaster, J.E., Ryland, J.S., Shackley, S.E., 1993. The age structure and growth dynamics of young-of-the-year bass *Dicentrarchus labrax*, populations. J. Mar. Biol. Ass. U.K. 71, 799–810.

Jolly, M.T., Aprahamian, M.W., Hawkins, S.J., Henderson, P.A., Hillman, R., O Maoileidigh, N., Maitland, P.S., Piper, R., M.J., G., 2012. Population genetic structure of protected Allis shad (*Alosa alosa*) and twaite shad (*Alosa fallax*). Mar. Biol. 159, 675–687.

Kennedy, M., 1969. The Sea Angler's Fishes. Stanley Paul, London.

Maitland, P.S., 2003a. Ecology of the River, Brook and Sea Lamprey, Conserving Natura 2000 Rivers Ecology Series No. 5.

Maitland, P.S., 2003b. The status of smelt *Osmerus eperlanus* in England, English Nature Research Reports.

Maitland, P.S., Hatton-Ellis, T.W., 2003. Ecology of the Allis and Twaite Shad, Conserving Natura 2000 Rivers Ecology Series No. 3. English Nature, Peterborough.

Maitland, P.S., Herdson, D., 2009. Key to the Marine and Freshwater Fishes of Britain and Ireland. Environment Agency, Bristol.

Maitland, P.S., Lyle, A.A., 2005. Ecology of Allis shad *Alosa alosa* and twaite shad *Alosa fallax* in the Solway Firth, Scotland. Hydrobiologia 534, 205–221.

McCleave, J.D., Arnold, G.P., 1999. Movements of yellow-and silver-phase European eels (*Anguilla anguilla L.*) tracked in the western North Sea. ICES J. Mar. Sci. J. du Cons. 56, 510–536.

Methot, R.D., 1986. Frame trawl for sampling pelagic juvenile fish. California Cooperative Oceanic Fisheries Investigations (CalCOFI). Report Number XXVII, 267-278.

Moore, A., Ives, M., Davison, P., Privitera, L., 2015. A preliminary study on the movements of smelt, Osmerus eperlanus, in two East Anglian rivers. doi: 10.1111/fme.12150. Fish. Manag. Ecol. doi:doi: 10.1111/fme.12150

OSPAR, 2010. Background document for European eel *Anguilla anguilla*.

Pawson, M.G., Eaton, D.R., 1999. The influence of a power station on the survival of juvenile sea-bass (*Dicentrarchus labrax* L.) in an estuarine nursery area. J. Fish Biol. 54, 1143–1160.

Pawson, M.G., Kelley, D.F., Pickett, G.D., 1987. The distribution and migrations of bass Dicentrarchus labrax L. in waters around England and Wales as shown by tagging. J. Mar. Biol. Assoc. U.K. 67, 183–217.

Pawson, M.G., Pickett, G.D., Leballeur, J., Brown, M., Fritsch, M., 2007. Migrations, fishery interactions, and management units of sea bass (*Dicentrarchus labrax*) in Northwest Europe. ICES J. Mar. Sci. 64, 332–345.

Pickering, A.D., 1978. Physiological aspects of the life cycle of the river lamprey, *Lampetra fluviatilis* L, Forty-sixth annual report for the year ended 31st March 1978, Annual Report.

Pickett, G.D., 2007. A Review of the status of grey mullet in commercial fisheries in England - June/July 2007. Report to Defra.

Pickett, G.D., Pawson, M.G., 1994. Sea bass. Biology, exploitation and conservation, Fish and Fisheries 12. Chapman & Hall, London.

Postum, K.H., Saville, A., Wood, R.J., 1977. Herring spawning grounds in the North Sea. ICES Co-op. Res. Rep. 61, 1–15.

Potter, E.C.E., Crozier, W.W., Schön, P.-J., Nicholson, M.D., Maxwell, D.L., Prévost, E., Erkinaro, J., Gudbergsson, G., Karlsson, L., Hansen, L.P., MacLean, J.C., Maoiléidigh, N.Ó., Prusov, S., 2004.

Estimating and forecasting pre-fishery abundance of Atlantic salmon (*Salmo salar* L.) in the Northeast Atlantic for the management of mixed-stock fisheries. ICES J. Mar. Sci. 61, 1359–1369.

Potts, G.W., Swaby, S.E., English Nature, P., 1993. Review of the status or estuarine fishes (ENRR034), No. 34 English Nature Research Reports.

Rogers, S.I., Millner, R.S., 1996. Factors affecting the annual abundance and regional distribution of English inshore demersal fish populations: 1973 to 1995. ICES J. Mar. Sci. 53, 1094–1112.

Scottishpower Renewables, 2012. East Anglia ONE Offshore Windfarm Environmental Statement. Volume 2 Offshore. Chapter 10 - Fish Ecology. 2012.

Solomon, D.J., 1984. Sea Trout Investigation – Phase 1. Final Report for NRA. R&D Note 318.

Tesch, F.W., 2003. The Eel, 5th ed. John Wiley & Sons.

Turnpenny, A.W.H., Utting, N.J., 1987. The seasonal incidence of fish species at the cooling water intake of Sizewell Power Station. CEGB.

Turnpenny, A.W.H., Utting, N.J., Millner, R.S., Riley, J.D., 1983. The effect of fish impingement at Sizewell “A” Power Station, Suffolk on the North Sea fish stocks. CEGB/MAFF.

Tzeng, W.-N., Severin, K.P., Wickstrom, H., 1997. Use of otolith microchemistry to investigate the environmental history of European eel *Anguilla anguilla*. Mar. Ecol. Prog. Ser. 149, 73–81.

UKOOA, 2000. Industry Issues, Environment, Fisheries Maps [WWW Document]. URL http://www.ukooa.co.uk/issues/fisheries

van Ginneken, V.J., Maes, G.E., 2005. The European eel (*Anguilla anguilla*, Linnaeus), its lifecycle, evolution and reproduction: a literature review. Rev. Fish Biol. Fish. 15, 367–398.

Waldman, J., Grunwald, C., Wirgin, I., 2008. Sea lamprey *Petromyzon marinus*: an exception to the rule of homing in anadromous fishes. Biol. Lett. 46, 659–662.

Wheeler, A., 1978. Key to the Fishes of Northern Europe. Frederick Warne, London.

Wheeler, A., 1969a. The fishes of the British Isles and North West Europe. Macmillan and Co Ltd, London.

Wheeler, A., 1969b. Fish-life and pollution in the lower Thames: a review and preliminary report. Biol. Conserv. 2, 25–30.

Appendix A: Fish species in Greater Sizewell Bay

Taxa recorded during BEEMS coastal surveys (2 m beam trawl, commercial otter trawl, Lowestoft box trawl) and Cefas Comprehensive Impingement Monitoring Programme (CIMP). The taxa found in the Cefas Entrainment Monitoring Programme (CEMP) are listed for information, but were not included in the characterisation (see Section 1.3).

	CEMP			CIMP	Beam trawl	Otter trawl	Lowestoft box trawl
	Egg	Larva	Juvenile				
Anchovy (*Engraulis encrasicolus*)	•						
European seabass (*Dicentrarchus labrax*)	•						
Bib/whiting-pout (*Trisopterus luscus*)							
Tompot blenny (*Blennius gattorugine*)							
Viviparous blenny (eelpout) (*Zoarces viviparus*)							
Brill (*Scophthalmus rhombus*)							
Bullrout (*Myoxocephalus scorpius*)							
Butterfish (*Pholis gunnellus*)			•				
Atlantic cod (*Gadus morhua*)							
Dab (*Limanda limanda*)			•				
Long rough dab (*Hippoglossoides platessoides*)	•						
Lesser spotted dogfish (*Scyliorhinus canicula*)							
Common dragonet (*Callionymus lyra*)	•	•					
European eel (*Anguilla anguilla*)							
European flounder (*Platichthys flesus*)		•					
Garfish (*Belone belone*)	•						
Black goby (Gobius niger)							
Crystal goby (*Crystallogobius sp.)*							
Painted goby (*Pomatoschistus pictus*)							
Rock goby (*Gobius paganellus*)							
Sand goby (*Pomatoschistus minutus*)							
Sand gobies (*Pomatoschistus* sp.)							
Transparent goby (*Aphia minuta)*							
Unidentified gobies (Gobiidae)		•	•				
Grey gurnard (*Eutrigla gurnardus*)							
Tub gurnard (*Trigla lucerna*)							
Unidentified gurnards (*Trigla* sp.)	•						
Atlantic herring (*Clupea harengus*)		•	•				
Unidentified herring (Clupeidae)		•					
Pogge (*Agonus cataphractus*)							
John Dory (*Zeus faber*)							
River lamprey (*Lampetra fluviatalis*)							
Unidentified lamprey (Petromyzonidae)							
Lumpsucker (*Cyclopterus lumpus*)							
Mackerel (*Scomber scombrus*)							
Horse mackerel (*Trachurus trachurus*)							
Red mullet (*Mullus surmuletus*)							
Grey mullet							
Thick-lipped grey mullet (*Crenimugil labrosus*)							
Thin-lipped grey mullet (*Liza ramada*)							
Norway bullhead (*Micrenophrys lilljeborgii*)							
Pilchard (*Sardina pilchardus*)	•	•					
Deep-snouted pipefish (*Syngnathus typhle*)							
Greater pipe-fish (*Syngnathus acus*)							
Nilson's pipefish (*Syngnathus rostellatus*)							
Snake pipefish (*Entelurus aequoreus*)							
Unidentified pipefish (Syngnathidae)		•	•				
European plaice (*Pleuronectes platessa*)							
Right-eyed flatfishes (Pleuronectidae)		•					
Pollack (*Pollachius pollachius*)							
Poor cod (*Trisopterus minutus*)							
Norway pout (*Trisopterus esmarkii*)							
Blonde ray (*Raja Brachyura*)							

	CEMP			CIMP	Beam trawl	Otter trawl	Lowestoft box trawl
	Egg	Larva	Juvenile				
Spotted ray (*Raja montagui*)							
Thornback ray (*Raja clavata*)							
Three-bearded rockling (*Gaidropsarus vulgaris*)							
Four-bearded rockling (*Enchelyopus cimbrius*)							
Five-bearded rockling (*Ciliata mustela*)							
Bigeye rockling (*Gaidropsarus macrophthalmus*)							
Northern Rockling (*Ciliata septentrionalis*)							
Shore rockling (*Gaidropsarus mediterraneus*)							
Unidentified rocklings (*Gaidropsarus* spp. / *Onos* spp.)	•						
Saithe (*Pollachius virens*)							
Sand sole (*Pegusa lascaris*)							
Lesser sandeel (*Ammodytes tobianus*)							
Greater sandeel (*Hyperoplus lanceolatus*)							
Corbin's sandeel (*Hyperoplus immaculatus*)							
Unidentified sandeels (Ammodytidae)	•	•	•				
Unidentified sandeels (*Ammodytes* sp.)							
Scaldfish (*Arnoglossus laterna*)							
Black sea bream (*Spondyliosoma cantharus*)							
Long-spined sea scorpion (*Taurulus bubalis*)							
Sea snail (*Liparis liparis*)		•					
Montague's sea snail (*Liparis montagui*)							
Sea Trout (*Salmo trutta*)							
Allis shad (*Alosa alosa*)							
Twaite shad (*Alosa fallax*)							
Smelt (Osmerus eperlanus)							
Sand smelt (*Atherina boyeri*)							
Dover sole (*Solea solea*)	•	•					
Unidentified soles (Solea sp.)		•					
Lemon sole (*Microstomus kitt*)							
Solenette (*Buglossidium luteum*)		•					
European sprat (*Sprattus sprattus*)	•	•	•				
Starry smoothhound (*Mustelus asterias*)							
3-spined stickleback (Gasterosteus aculeatus)							
Tadpolefish (*Raniceps raninus*)							
Tope (*Galeorhinus galeus*)							
Turbot (*Scophthalmus maximus*)							
Lesser weever (*Echiithys vipera*)	•						
Whiting (*Merlangius merlangus*)							
Witch (*Glyptocephalus cynoglossus*)		•					
Ballan wrasse (*Labrus bergylta*)							
Corkwing wrasse (*Crenilabrus melops*)							
Cuckoo wrasse (*Labrus mixtus*)							
Little cuttlefish (*Sepiola atlantica*)							
European common squid (*Alloteuthis subulata*)							
Cuttlefish (*Sepia officinalis*)							
Common squid (*Loligo vulgaris*)							

Appendix B: Abundance - coastal surveys

2 m beam trawls: mean abundance (standardised to 1 km^2 swept area) from the coastal surveys. n = number of samples collected during each survey. The September 2014 data were not included in the calculation of means, as they were not used in the formal data analyses. (see Section 1.4.1.2)

	Original Grid						Extended Grid				Original		Extended		Length range					
	Size 1/08 Mar (*n* = 20)	Size 2/08 May (*n* = 24)	Size 3/08 Sep (*n* = 18)	Size 4/08 Oct (*n* = 18)	Size 2/09 Jun (*n* = 17)	Size 5/10 Jun (*n* = 18)	Size 5/11 Jun (*n* = 31)	Size 6/11 Sep (*n* = 35)	Size 7/11 Nov (*n* = 36)	Size 1/12 Mar (*n* = 36)	Mean abundance	s.d	Mean abundance	s.d	No. of fish	Min (mm)	Max (mm)	Average	s.d	Size 1/14 Sep (*n* = 22)
Atlantic cod	0.42	0.04	-	-	-	0.76	-	-	-	-	0.20	0.32	-	-	17	40	260	115	86.8	-
Atlantic herring	-	-	0.44	-	0.19	0.47	1.14	0.05	0.08	0.48	0.18	0.22	0.44	0.51	58	30	300	99	99.3	0.10
Bib/whiting-pout	-	-	1.26	0.13	-	1.10	2.36	0.15	0.03	-	0.41	0.60	0.64	1.15	96	20	205	83	39.8	0.54
Dab	0.18	-	1.28	0.67	0.07	0.07	0.44	0.64	0.35	0.14	0.38	0.51	0.39	0.21	73	35	295	113	69.6	0.40
Dover sole	8.52	9.47	8.63	3.32	1.53	4.84	6.61	7.55	3.46	6.43	6.05	3.28	6.01	1.77	1329	15	385	137	73.7	13.70
European anchovy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	45	45	45		0.04
European flounder	0.08	-	-	-	-	0.08	0.13	0.05	-	-	0.03	0.04	0.05	0.06	6	110	230	158	48.9	-
European plaice	-	-	0.13	0.09	-	-	0.11	1.30	-	0.35	0.04	0.06	0.44	0.59	58	55	250	148	37.5	0.24
European sprat	-	-	-	0.09	1.31	6.29	0.10	-	0.08	0.13	1.28	2.51	0.08	0.05	105	25	125	51	23.2	-
Grey gurnard	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	30	35	33	3.5	0.11
Grey mullet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	15	15	15		0.05
Lemon sole	-	-	-	-	-	-	0.04	-	-	-	-	-	0.01	0.02	1	115	115	115		-
Sandeels	0.10	0.12	-	-	0.1.	0.14	0.68	0.13	-	0.10	0.08	0.06	0.23	0.31	26	35	145	60	27.5	-
Thornback ray	-	0.06	-	0.09	-	0.15	0.300	0.11	-	0.21	0.05	0.06	0.15	0.13	21	110	820	338	244	0.15
Whiting	1.09	0.13	0.72	0.20	1.72	0.42	3.71	1.17	0.80	1.05	0.71	0.61	1.68	1.36	302	45	325	135	64.6	4.37
Common dragonet	-	0.03	0.11	-	0.07	-	-	-	-	0.05	0.04	0.05	0.01	0.02	6	55	175	93	46.6	0.11
Gobies	0.37	0.42	3.91	1.57	31.7	14.70	3.52	5.57	3.79	0.19	8.78	12.50	3.27	2.24	1304	10	70	35	14.5	13.6
Lamprey	-	-	-	-	-	0.05	-	-	-	-	0.01	0.02	-	-	1	225	225	225		-
Lesser spotted dogfish	-	0.04	-	-	0.08	0.21	-	-	-	0.05	0.06	0.08	0.01	0.03	10	110	200	153	28.9	0.24
Lesser weever	-	0.19	-	-	0.07	0.27	0.12	0.05	0.05	0.05	0.09	0.12	0.07	0.03	16	70	135	108	17.3	0.20
Unidentified Clupeid	-	-	-	-	-	-	-	0.05	-	-	-	-	0.01	0.03	1	45	45	45		-
Pipefishes	0.18	0.24	-	-	-	0.13	0.22	-	0.09	0.06	0.09	0.11	0.09	0.09	18	75	320	156	78.3	-
Pogge	-	0.06	-	-	0.15	0.37	0.78	0.73	0.69	0.05	0.10	0.15	0.56	0.34	81	20	130	58	26.5	0.87
Poor cod	-	-	0.08	-	10.20	0.06	1.00	-	-	-	1.72	4.14	0.25	0.50	156	15	85	43	14.8	-
Rocklings	-	0.06	-	-	0.12	-	-	0.35	-	-	0.03	0.05	0.09	0.18	10	30	150	100	41.2	0.05
Sand sole	-	0.12	-	-	-	-	-	-	-	-	0.02	0.05	-	-	2	60	65	63	3.5	- 0
Sea snails	-	-	-	-	-	0.61	0.30	0.03	0.14	0.05	0.10	0.25	0.13	0.12	17	25	75	46	13.0	-
Solenette	-	0.06	0.70	0.13	-	0.10	-	-	-	0.13	0.17	0.27	0.03	0.06	16	70	105	90	9.1	0.11
Starry smoothound	-	-	-	-	-	-	-	-	-	-	-	-	- 0	-	1	325	325	325		0.05
Tub gurnard	-	-	-	-	-	-	0.04	-	-	-	-	-	0.01	0.02	1	155	155	155		-

	Size 1/08 Mar (*n* = 20)	Size 2/08 May (*n* = 24)	Size 3/08 Sep (*n* = 18)	Size 4/08 Oct (*n* = 18)	Size 2/09 Jun (*n* = 17)	Size 5/10 Jun (*n* = 18)	Size 5/11 Jun (*n* = 31)	Size 6/11 Sep (*n* = 35)	Size 7/11 Nov (*n* = 36)	Size 1/12 Mar (*n* = 36)	Mean abundance	s.d	Mean abundance	s.d	Length range: No. of fish	Min (mm)	Max (mm)	Average	s.d	Size 1/14 Sep (*n* = 22)
	Original Grid						Extended Grid				Original		Extended							
European common squid	-	-	-	-	0.23	0.14	1.01	-	-	-	0.06	0.10	0.25	0.50	30	20	90	55	15.5	-

Commercial otter trawls: mean catch rate (number per hour) from the coastal surveys. n = number of samples collected during each survey.

Species	Size 1/08 Mar (*n* = 6)	Size 2/08 May (*n* = 6)	Size 3/08 Sep (*n* = 6)	Size 4/08 Oct (*n* = 6)	Size 2/09 Jun (*n* = 6)	Size 5/10 Jun (*n* = 6)	Size 5/11 Jun (*n* = 10)	Size 6/11 Sep (*n* = 10)	Size 7/11 Nov (*n* = 10)	Size 1/12 Mar (*n* = 10)	Average abundance	s.d	Average abundance	s.d	Length range: Number of fish.	Min (mm)	Max (mm)	Average	s.d	Size 1/14 Sep (*n* = 7)
	Original grid						Extended grid				Original		Extended							
Atlantic cod	11.7	2.44	2.33	9.15	0.32	0.33	0.39	-	0.81	-	4.37	4.83	0.30	0.38	95	200	660	366	104	4.17
Atlantic herring	2.00	-	-	-	-	-	1.39	0.19	0.39	-	0.33	0.82	0.50	0.62	16	35	310	159	119	-
Bib/whiting-pout	1.67	- 0	2.00	0.82	0.33	-	0.39	0.19	-	-	0.80	0.86	0.15	0.19	29	90	265	162	40.3	3.39
Brill	-	-	-	-	-	0.33	-	0.19	-	0.20	0.06	0.14	0.10	0.11	3	205	265	238	30.6	-
Dab	-	0.34	1.67	-	13.90	14.30	23.20	28.70	5.59	1.16	5.04	7.06	14.70	13.30	397	55	320	222	41.5	0.55
Dover sole	17.00	31.80	31.90	36.30	30.20	25.80	19.30	17.00	28.00	21.80	28.90	6.72	21.50	4.73	1019	70	430	277	40.3	21.90
European flounder	1.00	1.56	7.07	2.00	22.70	23.30	11.50	6.23	3.64	9.38	9.61	10.6	7.70	3.47	361	60	380	258	55.2	8.33
European plaice	-	-	1.33	0.67	5.19	4.18	10.70	33.60	0.40	3.38	1.90	2.24	12.00	15.00	304	105	320	191	39.3	6.32
European seabass	0.33	0.63	-	-	-	0.32	0.20	-	-	-	0.21	0.26	0.05	0.10	5	320	360	344	15.2	-
Grey gurnard	-	-	0.40	-	-	-	-	-	-	-	0.07	0.16	-	-	1	130	130	130		-
Lemon sole	-	-	0.33	-	-	-	-	-	0.20	0.20	0.06	0.14	0.10	0.12	3	215	280	245	32.8	-
Red Mullet	-	-	-	-	-	-	0.39	-	-	-	-	-	0.10	0.19	2	130	165	148	24.7	-
Thornback ray	0.33	1.56	2.00	1.95	8.15	8.23	11.10	9.54	12.60	18.60	3.70	3.53	13.00	3.95	407	120	870	402	181.0	22.50
Turbot	-	0.31	-	-	-	-	-	-	-	-	0.05	0.13	-	-	38	305	305	305		-
Whiting	10.3	0.31	5.93	1.32	-	0.67	3.75	9.81	1.40	20.10	3.09	4.17	8.75	8.32	405	70	365	244	48.1	49.10

Species	Original grid						Extended grid				Original		Extended		Length range					
	Size 1/08	**Size 2/08**	**Size 3/08**	**Size 4/08**	**Size 2/09**	**Size 5/10**	**Size 5/11**	**Size 6/11**	**Size 7/11**	**Size 1/12**	**Average abundance**	**s.d**	**Average abundance**	**s.d**	**Number of fish.**	**Min (mm)**	**Max (mm)**	**Average**	**s.d**	**Size 1/14**
	Mar	**May**	**Sep**	**Oct**	**Jun**	**Jun**	**Jun**	**Sep**	**Nov**	**Mar**										**Sep**
	***(n* = 6)**	***(n* = 6)**	***(n* = 6)**	***(n* = 6)**	***(n* = 6)**	***(n* = 6)**	***(n* = 10)**	***(n* = 10)**	***(n* = 10)**	***(n* = 10)**										***(n* = 7)**
Blonde ray	-	-	-	-	-	0.33	-	-	-	-	0.06	0.14	-	-	1	395	395	395		-
Common dragonet	-	-	-	-	-	-	0.19	-	-	-	-	-	0.05	0.10	1	150	150	150		-
Lesser spotted dogfish	-	-	-	-	0.97	0.66	0.99	0.20	-	0.19	0.27	0.43	0.35	0.44	17	205	620	523	102.0	1.41
Lesser weever	-	-	-	-	-	-	-	0.39	-	-	-	-	0.10	0.19	2	135	145	140	7.1	-
Pogge	-	-	-	-	-	0.32	0.99	-	-	-	0.05	0.13	0.25	0.50	10	90	145	119	23.0	1.10
Spotted ray	-	-	-	-	-	-	0.20	-	-	-	-	-	0.05	0.10	1	170	170	170		-
Starry smooth hound	-	-	0.33	-	-	1.00	0.79	1.16	-	-	0.22	0.40	0.49	0.58	18	275	985	438	183.0	1.12
Tope	-	-	0.33	-	-	-	0.19	-	-	-	0.06	0.14	0.05	0.10	2	590	910	750	226.0	-
Tub gurnard	-	-	-	-	0.32	1.00	6.31	0.20	-	0.20	0.22	0.40	1.68	3.09		125	340	170	39.0	-
European common squid	-	-	-	-	-	-	4.12	0.19	-	-	-	-	1.08	2.03	22	40	110	78	19.2	-

Appendix C: Predicted Sizewell B Annual Impingement from 2009-2013 data

Fish impinged in Sizewell B from BEEMS CIMP sampling 2009-2013. Numbers of fish are the scaled up impingement catch during the sampling periods raised to the full annual cooling water flow at Sizewell B.

Common name	Latin name	Mean	% of total	cumulative %
Sprat	*Sprattus sprattus*	4132631	51.8%	51.8%
Herring	*Clupea harengus*	968431	12.1%	63.9%
Whiting	*Merlangius merlangus*	759928	9.5%	73.4%
Bass	*Dicentrarchus labrax*	831330	10.4%	83.8%
Goby, Sand	*Pomatoschistus minutus*	429478	5.4%	89.2%
Sole, Dover	*Solea solea*	152588	1.9%	91.1%
Dab	*Limanda limanda*	152887	1.9%	93.0%
Anchovy	*Engraulis encrasicolus*	114981	1.4%	94.5%
Mullet, Thin-lipped grey	*Liza ramada*	101370	1.3%	95.8%
Pipefish, Nilsson's	*Syngnathus rostellatus*	47202	0.6%	96.4%
Pout	*Trisopterus luscus*	61610	0.8%	97.1%
Weever, lesser	*Trachinus vipera*	39332	0.5%	97.6%
Rockling, 5-bearded	*Ciliata mustela*	16766	0.2%	97.8%
Hooknose	*Agonus cataphractus*	16881	0.2%	98.0%
Flounder	*Platichthys flesus*	14451	0.2%	98.2%
Goby, Transparent	*Aphia minuta*	19967	0.3%	98.5%
Plaice	*Pleuronectes platessa*	19954	0.2%	98.7%
Cod	*Gadus morhua*	13865	0.2%	98.9%
Smelt, Cucumber	*Osmerus eperlanus*	14033	0.2%	99.1%
Sea snail, Common	*Liparis liparis*	4843	0.1%	99.1%
Pilchard	*Sardina pilchardus*	7925	0.1%	99.2%
Dragonet	*Callionymus lyra*	5302	0.1%	99.3%
Dogfish, Lesser spotted	*Scyliorhinus canicula*	3266	0.0%	99.3%
Gurnard, Tub	*Trigla lucerna*	3382	0.0%	99.4%
Ray, Thornback	*Raja clavata*	3154	0.0%	99.4%
Pipefish, Greater	*Syngnathus acus*	3902	0.0%	99.5%
Stickleback, 3-spined	*Gasterosteus aculeatus*	4448	0.1%	99.5%
Starry smooth-hound	*Mustelus asterias*	2683	0.0%	99.6%
Witch	*Glyptocephalus cynoglossus*	4287	0.1%	99.6%
Sandeel, Common	*Ammodytes tobianus*	3714	0.0%	99.7%
Scaldfish	*Arnoglossus laterna*	1740	0.0%	99.7%
Goby, Black	*Gobius niger*	2184	0.0%	99.7%
Eel	*Anguilla anguilla*	1469	0.0%	99.7%
Sandeel, Greater	*Hyperoplus lanceolatus*	1256	0.0%	99.7%
Scad	*Trachurus trachurus*	3013	0.0%	99.8%
Shad, Twaite	*Alosa fallax*	1435	0.0%	99.8%
Lamprey, River	*Lampetra fluviatalis*	1162	0.0%	99.8%
Pipefish, Snake	*Entelurus aequoreus*	2618	0.0%	99.8%
Bullrout	*Myoxocephalus scorpius*	1085	0.0%	99.9%
Brill	*Scophthalmus rhombus*	1267	0.0%	99.9%
Goby, Rock	*Gobius paganellus*	2019	0.0%	99.9%
Smelt, Sand	*Atherina boyeri*	705	0.0%	99.9%
Mackerel	*Scomber scombrus*	530	0.0%	99.9%

Common name	Latin name	Mean	% of total	cumulative %
Solenette	*Buglossidium luteum*	600	0.0%	99.9%
Blenny, Tompot	*Blennius gattorugine*	1012	0.0%	99.9%
Sole, Lemon	*Microstomus kitt*	576	0.0%	99.9%
Sea scorpion, long-spined	*Taurulus bubalis*	395	0.0%	99.9%
Goby, Painted	*Pomatoschistus pictus*	815	0.0%	100.0%
Butterfish	*Pholis gunnellus*	194	0.0%	100.0%
Mullet, Red	*Mullus surmuletus*	333	0.0%	100.0%
Viviparous blenny	*Zoarces viviparus*	397	0.0%	100.0%
Poor cod	*Trisopterus minutus*	342	0.0%	100.0%
Garfish	*Belone belone*	269	0.0%	100.0%
Gurnard, Grey	*Eutrigla gurnardus*	251	0.0%	100.0%
Wrasse, Corkwing	*Crenilabrus melops*	234	0.0%	100.0%
Sea snail, Montagu's	*Liparis montagui*	282	0.0%	100.0%
Rockling, Northern	*Ciliata septentrionalis*	156	0.0%	100.0%
Tadpolefish	*Raniceps raninus*	156	0.0%	100.0%
Saithe	*Pollachius virens*	156	0.0%	100.0%
John Dory	*Zeus faber*	78	0.0%	100.0%
Turbot	*Psetta maxima*	109	0.0%	100.0%
Wrasse, Ballan	*Labrus bergylta*	118	0.0%	100.0%
Lumpsucker	*Cyclopterus lumpus*	97	0.0%	100.0%
Mullet, Thick-lipped grey	*Crenimugil labrosus*	91	0.0%	100.0%
Sea bream, Black	*Spondyliosoma cantharus*	74	0.0%	100.0%
Norway bullhead	*Micrenophrys lilljeborgii*	53	0.0%	100.0%
Wrasse, Cuckoo	*Labrus mixtus*	67	0.0%	100.0%
Rockling, 4-bearded	*Enchelyopus cimbrius*	39	0.0%	100.0%
Pipefish, Deep-snouted	*Syngnathus typhle*	41	0.0%	100.0%
Rockling, Bigeye	*Gaidropsarus macrophthalmus*	23	0.0%	100.0%
Sea Trout	*Salmo trutta*	30	0.0%	100.0%
Rockling, Shore	*Gaidropsarus mediterraneus*	28	0.0%	100.0%
Pout, Norway	*Trisopterus esmarkii*	26	0.0%	100.0%
Goby, Crystal	*Crystallogobius linearis*	14	0.0%	100.0%
Sand sole	*Pegusa lascaris*	13	0.0%	100.0%
Pollack	*Pollachius pollachius*	13	0.0%	100.0%
Shad, Allis	*Alosa alosa*	11	0.0%	100.0%

Appendix D: Multivariate analysis of fish communities

Two types of analysis were used: cluster analysis and ordination. These methods provide slightly different but often complementary information on spatio-temporal patterns in biological communities. For clarity, species are referred to by their Cefas 3-letter codes in the proceeding figures. These codes are given in Table 9. The beam and otter trawl data were analysed separately because it is difficult to combine the two data types.

D.1 Cluster analysis

Cluster analysis forms groups of samples based on similarities in the distribution of component taxa. Hierarchical cluster analysis, used here, places samples into clusters and these clusters into larger clusters, based on how similar their taxon compositions are. Samples that are the most similar cluster together first, followed by those less similar, until all samples are joined. The final output is a tree diagram or dendrogram in which the x-axis represents a sample and the y-axis the level of similarity at which the samples and clusters have been joined. Cluster analysis was performed on a Bray-Curtis similarity matrix constructed from the sample data. Ward's method was used to determine the clusters; this uses the average distance between samples to form clusters.

D.2 Ordination

Ordination is used to investigate patterns in species' distributions among samples, with samples that are more similar to each other closer together on the resulting ordination plot. Ordination is a useful alternative to cluster analysis if data do not easily conform to clear groupings (i.e. it allows the identification of gradients of change, rather than forcing the data into discrete groupings).

Here, a constrained method, which combines the biological and environmental data in one analysis, was used. Canonical correspondence analysis (CCA) is a semi-quantitative analysis that determines gradients (in this case gradients in taxon abundance) in the explanatory parameters, for example the effect of sampling year and/or sampling location on the composition of the catch. The data are represented as points (one for each sample) on pairs of axes, each of which is the position of the sample at the measured variable. The first pair of axes usually plot the two parameters that explain the most variability in the data.

The biological data were log transformed (*log(abundance +1)*)[13], to prevent dominant taxa from overly influencing the ordination. The dataset was also truncated: the rarest taxa (those more likely to be poorly sampled due to probability of capture by the sampling gear) were excluded by keeping only the 25 most abundant. Bray-Curtis similarities were used to determine the similarity matrix.

D.3 Multivariate patterns

Clusters are identified from the dendrogram by drawing a cut-off at a suitable level of sample similarity (the 'height' axis on Figure 52). This is a largely subjective process and a trade-off between the level of similarity at which samples can justifiably be grouped and the production of clusters that are analytically informative – the lower the cut-off, the more similar are the samples in each cluster but the more clusters identified. Here, the number of samples and the differences between them did not warrant division into a large number of clusters for either the 2 m beam trawl or otter trawl data. Thus, the dendrograms were cut at a height of approximately 10 for the beam trawls and 1.5 for the otter trawls (Figure 52), giving four clusters each.

For the 2 m beam trawl, cluster 3 was predominantly made up of samples containing no fish (Figure 52).The three remaining clusters shared many of the same taxa, and were distinguished mostly by differences in relative abundances (Figure 53). Cluster 1 largely comprised adult and juvenile sole and whiting. Clusters 2 and 4 displayed greater diversity than cluster 1, being made up of sole (both clusters), whiting and bib (cluster 2) and sand gobies, pogge and dab (cluster 4). For the otter trawl, clusters 1 and 4 were the most similar (Figure 52); both contained cod and sole, with whiting present in cluster 1 but practically absent from

[13] A value of 1 was added to the abundance of each species prior to the log transformation to take account of zeroes in the dataset (one cannot take a log of 0).

cluster 4 (Figure 54). Sole were also present within clusters 2 and 3, but also greater abundance of flatfish species and whiting. The large number of shared species between clusters 2 and 3 and clusters 1 and 4 of the otter trawl data and between clusters 1, 2 and 4 of the beam trawl data suggest that there are no distinct communities in the area, either over space or time.

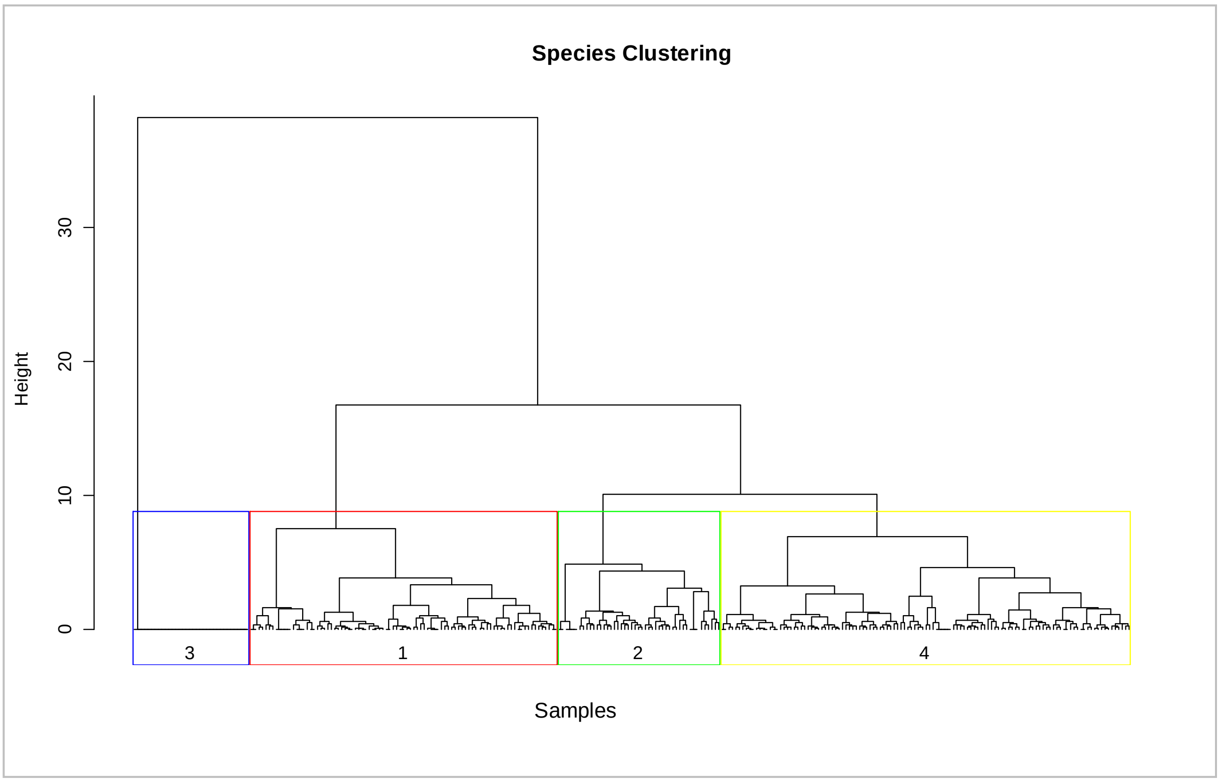
Table 9. Cefas 3-letter species codes used in the multivariate analysis

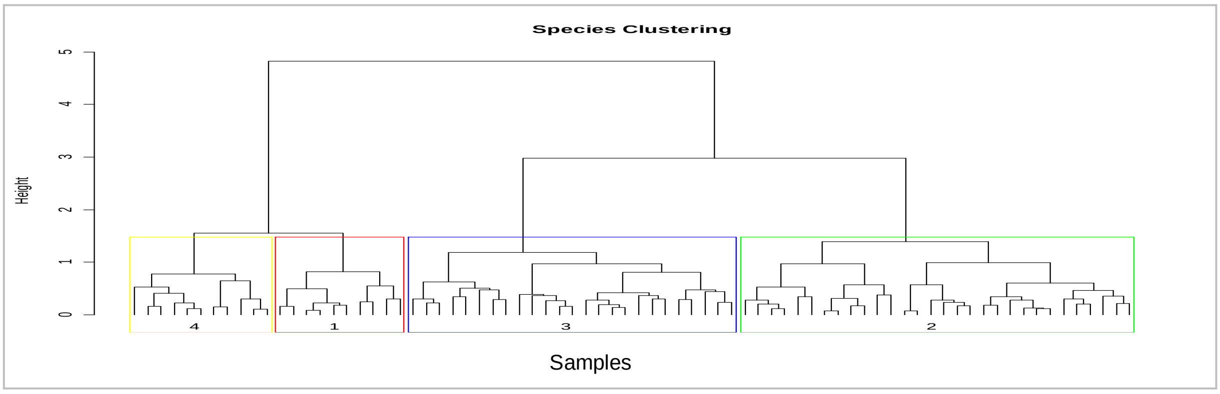
Code	Species	Code	Species
ATS	Squid (*Alloteuthis subulata*)	MLP	Velvet swimming crab (*Necora puber*)
BIB	Bib/whiting-pout (*Trisopterus*	MSS	Montague's sea snail (*Liparis montagui*)
BLL	Brill (*Scophthalmus rhombus*)	MUR	Red mullet (*Mullus surmuletus*)
BLR	Blonde ray (*Raja Brachyura*)	NPF	Nilson's pipefish (*Syngnathus rostellatus*)
CDT	Common dragonet (*Callionymus*	POD	Poor cod (*Trisopterus minutus*)
CLG	Crystal goby (*Crystallogobius sp.)*	POG	Pogge (*Agonus cataphractus*)
COD	Atlantic cod (*Gadus morhua*)	POM	Sand goby (*Pomatoschistus minutus*)
DAB	Dab (*Limanda limanda*)	SAN	Unidentified sandeels (*Ammodytes* sp.)
PLE	European plaice (*Pleuronectes*	SDR	Spotted ray (*Raja montagui*)
ESB	European seabass (*Dicentrarchus*	SDS	Starry smoothhound (*Mustelus asterias*)
FLE	European flounder (*Platichthys*	SOL	Dover sole (*Solea solea*) – adult
FVR	Five-bearded rockling (*Ciliata*	SOLJ	Dover sole (*Solea solea*) - juvenile
GAG	Tope (*Galeorhinus galeus*)	SOT	Solenette (*Buglossidium luteum*)
GPF	Greater pipe-fish (*Syngnathus acus*)	SPR	European sprat (*Sprattus sprattus*)
GUG	Grey gurnard (*Eutrigla gurnardus*)	THR	Thornback ray (*Raja clavata*)
HER	Atlantic herring (*Clupea harengus*)	TUB	Tub gurnard (*Trigla lucerna*)
LEM	Lemon sole (*Microstomus kitt*)	WEL	Lesser weever (*Echiithys vipera*)
LSD	Lesser spotted dogfish (*Scyliorhinus*	WHG	Whiting (*Merlangius merlangus*)

A similar picture emerged from the CCA: There was some spatial separation in the average position of the samples belonging to different clusters for both gears but, in general, samples were close together and the clusters overlapped - samples from any one cluster were always in closer proximity to one sample of a different cluster than the maximum distance to other samples of their own cluster (Figure 55). For the otter trawls, there appeared to be a distinction between the left half of the plot in which the samples were characterised by the presence of cod (clusters 1 and 4) and the right half of the plot in which plaice, dab (cluster 3 only), flounder and, to some extent, thornback rays played a more important role (clusters 2 and 3) - the ‘cod’ samples were found only around Sizewell, whereas the ‘flatfish’ samples were found throughout the area (Figure 52). However, particular stations were not always assigned to the same cluster over time, indicating a lack of clear spatial or habitat-related patterns in fish distribution (Figure 52).

Some small temporal effects could be discerned in the 2 m beam trawl samples, where 2009 and also 2010 were separated from the other years (though this does not correspond to the clustering of samples; see the variability of samples in cluster 4 on Figure 55), though the apparent higher fish diversity in quarter 2 (spring; Figure 56) is likely to be simply a function of increased sample size (more surveys in spring equate to more samples and a consequently greater chance of recording additional species). Otherwise, there was little in the way of temporal pattern in the 2 m beam trawl data (Figure 57).

Temporally, the otter trawl CCA produced little evidence of strong patterns. When it was run with sampling year as a covariate, clusters 1 and 4 were associated with samples predominantly collected in 2008; samples collected in 2009, 2010 and 2011 were mostly attributed to cluster 3 and samples from 2012 most frequently to cluster 2 (Figure 55). However, on closer examination, grouping the data by year or, indeed, by quarter yielded little in the way of obvious temporal pattern (Figure 58 and Figure 59, respectively).





Overall, there is little evidence of consistent spatial or temporal pattern in the fishes when viewed together, indicating that the fishes of the Greater Sizewell Bay form one large homogenous community.

Figure 52: Clustering dendrogram of the fish species caught by the 2 m beam trawl (top) and otter trawl (bottom). Coloured boxes indicate the 4 clusters described in the text.

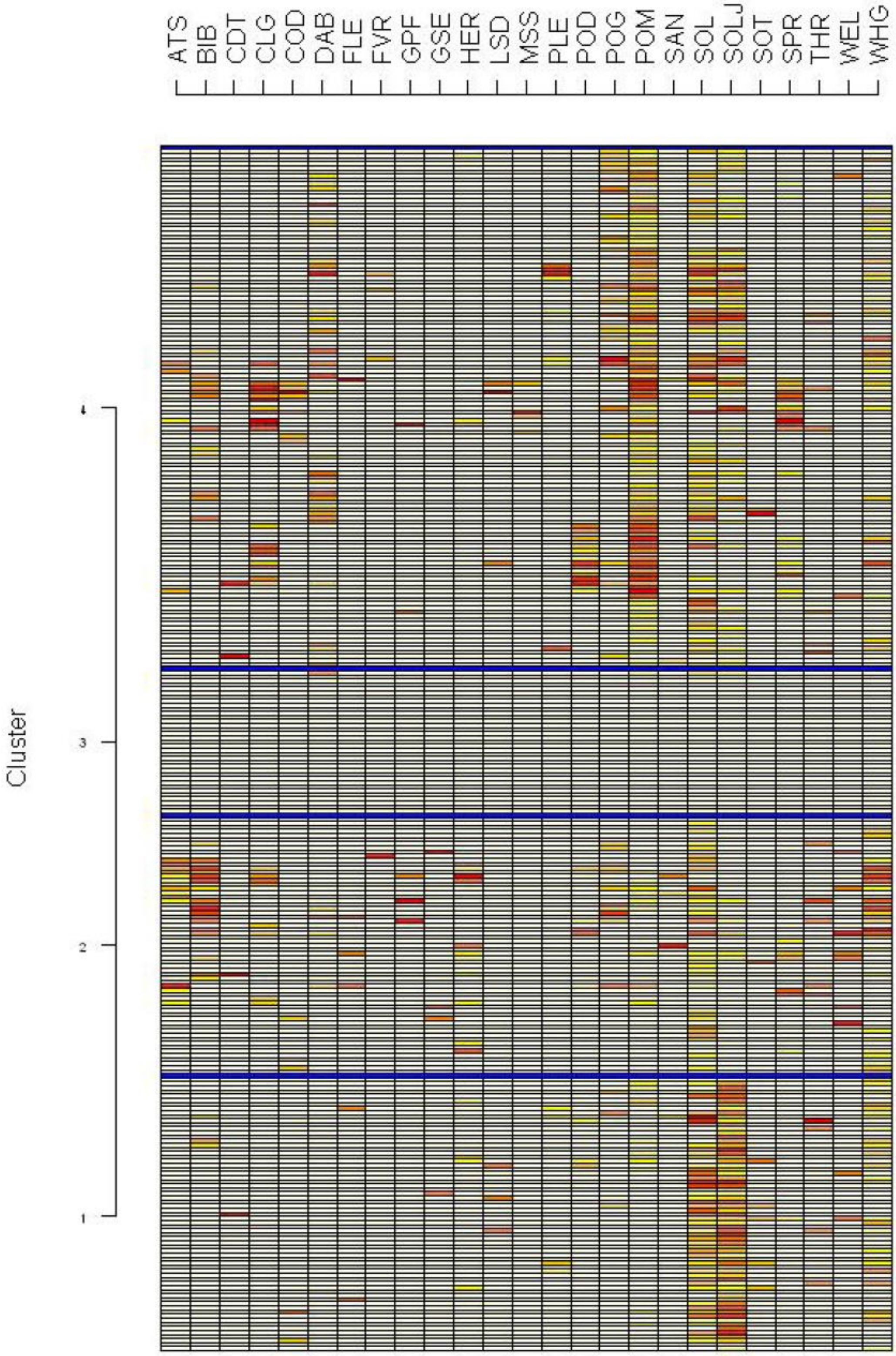


Figure 53: The 2 m beam trawl samples, grouped by their designated cluster. Each row represents a sample (i.e. trawl) and blue lines separate the clusters. Each taxon's abundance is standardised across the heatmap to the maximum abundance observed (red = highest, yellow = lowest).

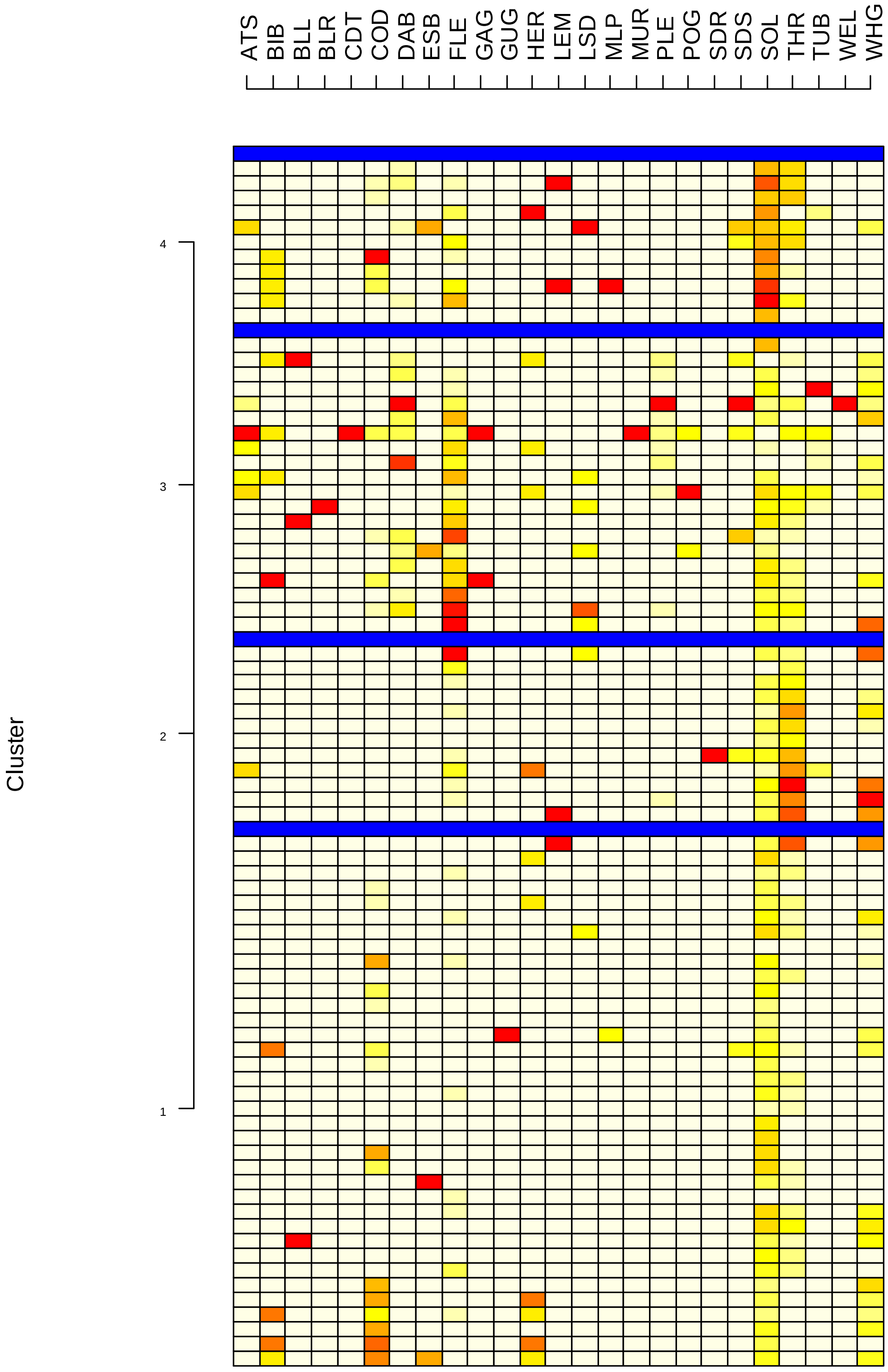


Figure 54: The otter trawl samples, grouped by their designated cluster. Each row represents a sample (i.e. trawl) and blue lines separate the clusters. Each taxon’s abundance is standardised across the heatmap to the maximum abundance observed (red = highest, yellow = lowest).

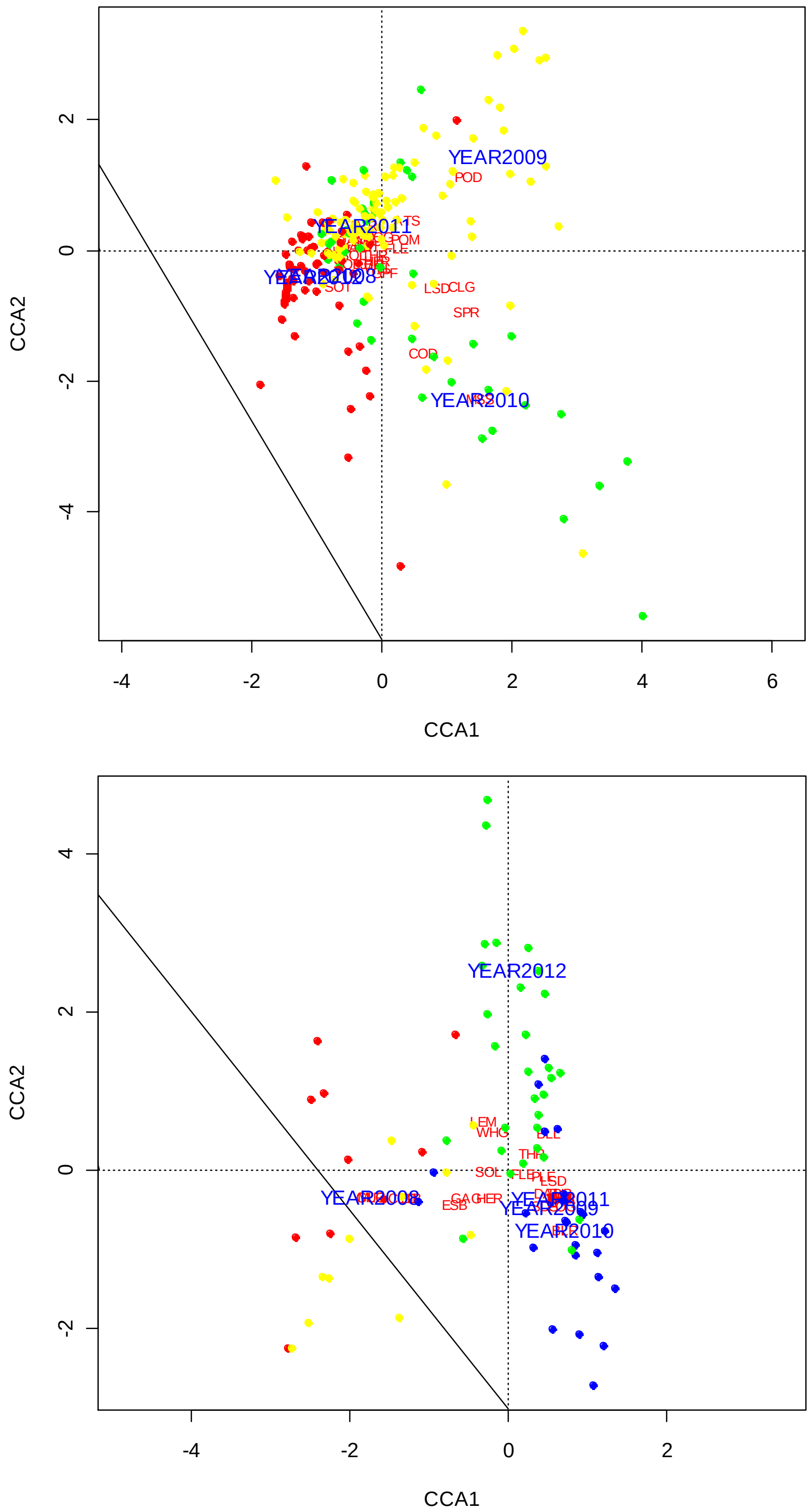


Figure 55. Canonical correspondence analysis ordination plot of the 2 m beam trawl (top) and otter trawl (bottom). Samples are coloured according to the results of the cluster analysis. Scores for taxa and years are also plotted for reference. Cluster 1 = red, cluster 2 = green, cluster 3 = blue, cluster 4 = yellow.

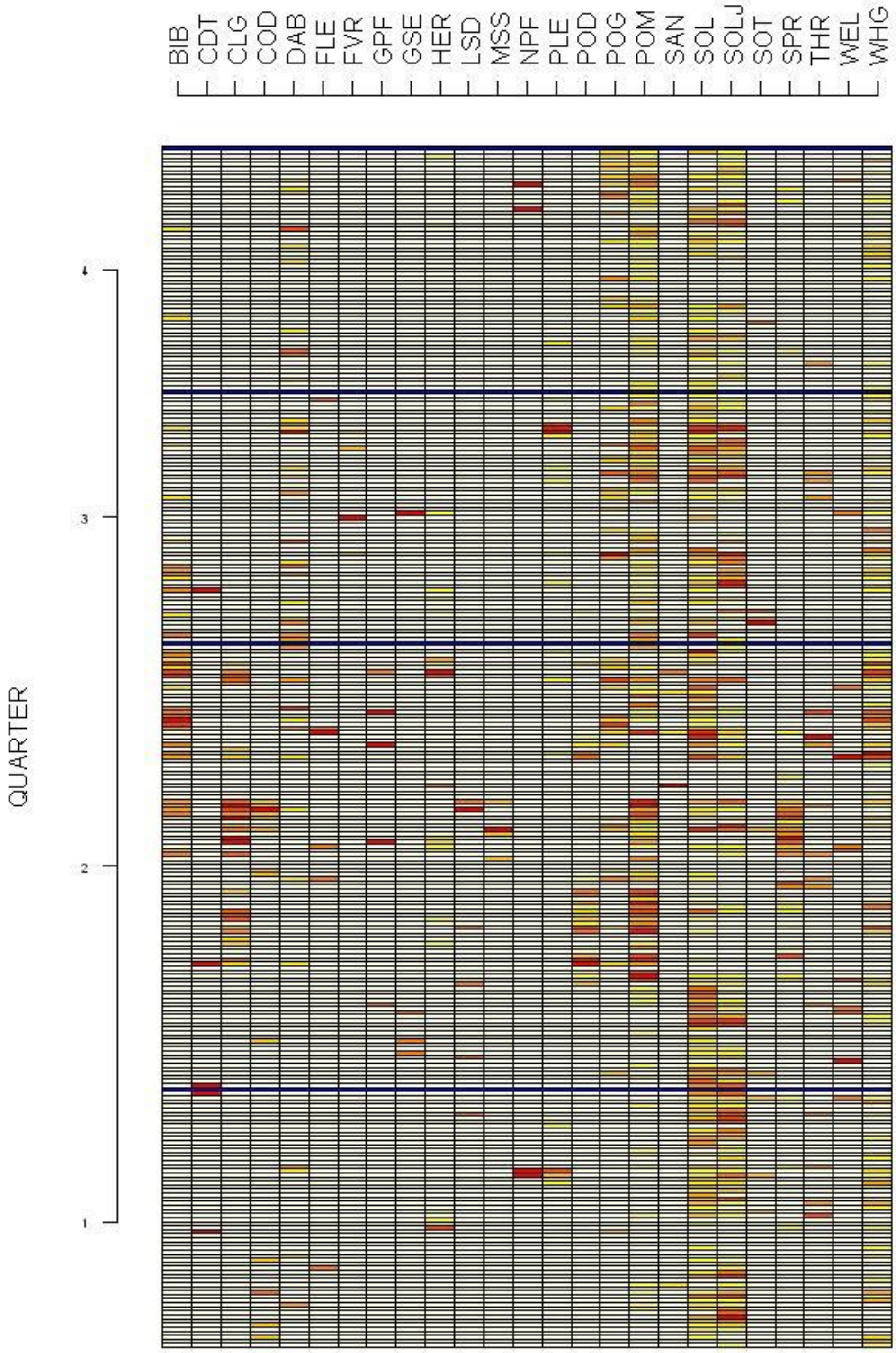


Figure 56. The 2 m beam trawl samples, grouped by quarter. Each row represents a sample (i.e. trawl) and blue lines separate the quarters. Each taxon’s abundance is standardised across the heatmap to the maximum abundance observed (red = highest, yellow = lowest).

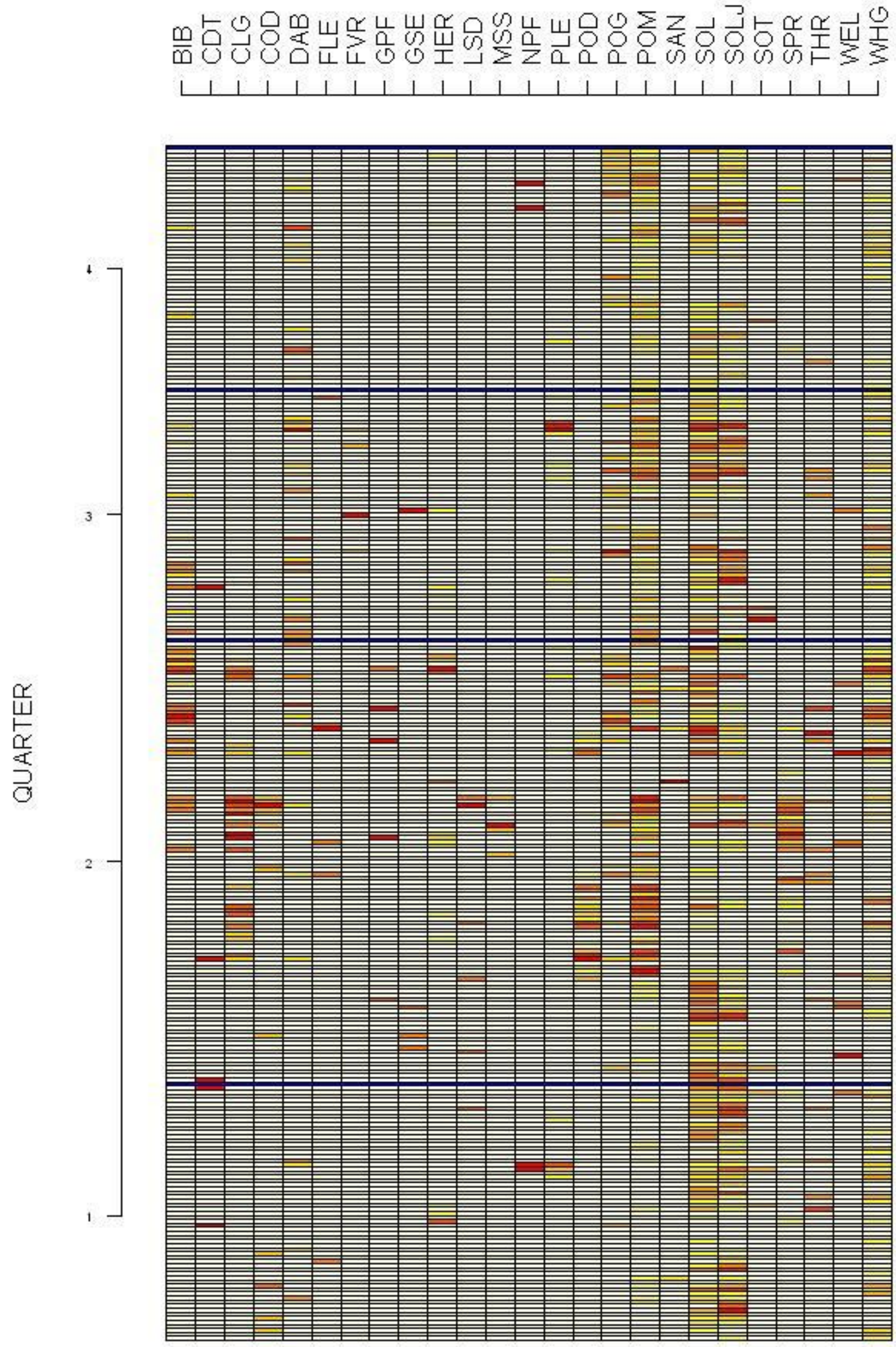


Figure 57. The 2 m beam trawl samples, grouped by year. Each row represents a sample (i.e. trawl) and blue lines separate the years. Each taxon's abundance is standardised across the heatmap to the maximum abundance observed (red = highest, yellow = lowest).

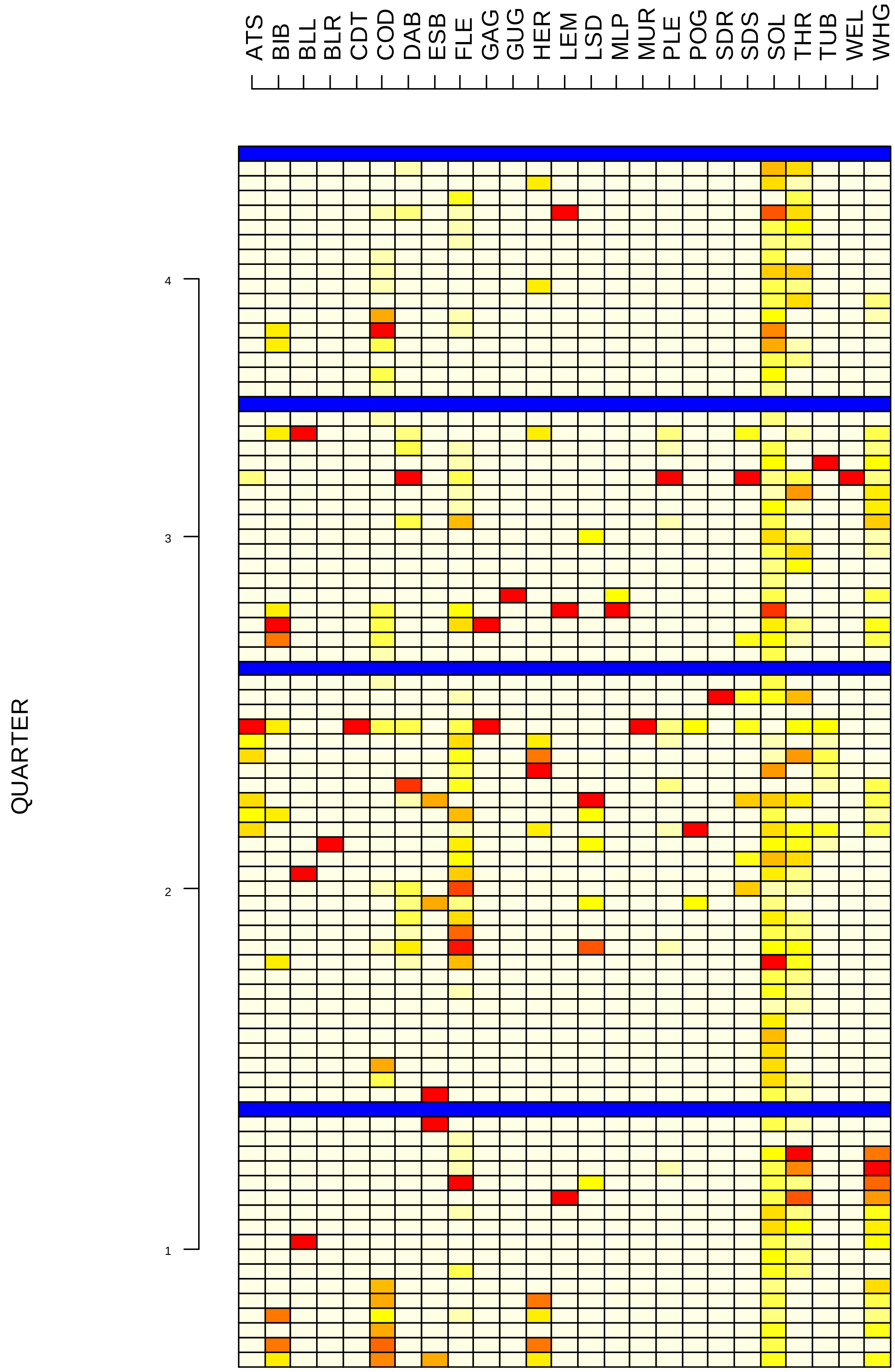


Figure 58. The otter trawl samples, grouped by quarter. Each row represents a sample (i.e. trawl) and blue lines separate the quarters. Each taxon's abundance is standardised across the heatmap to the maximum abundance observed (red = highest, yellow = lowest).

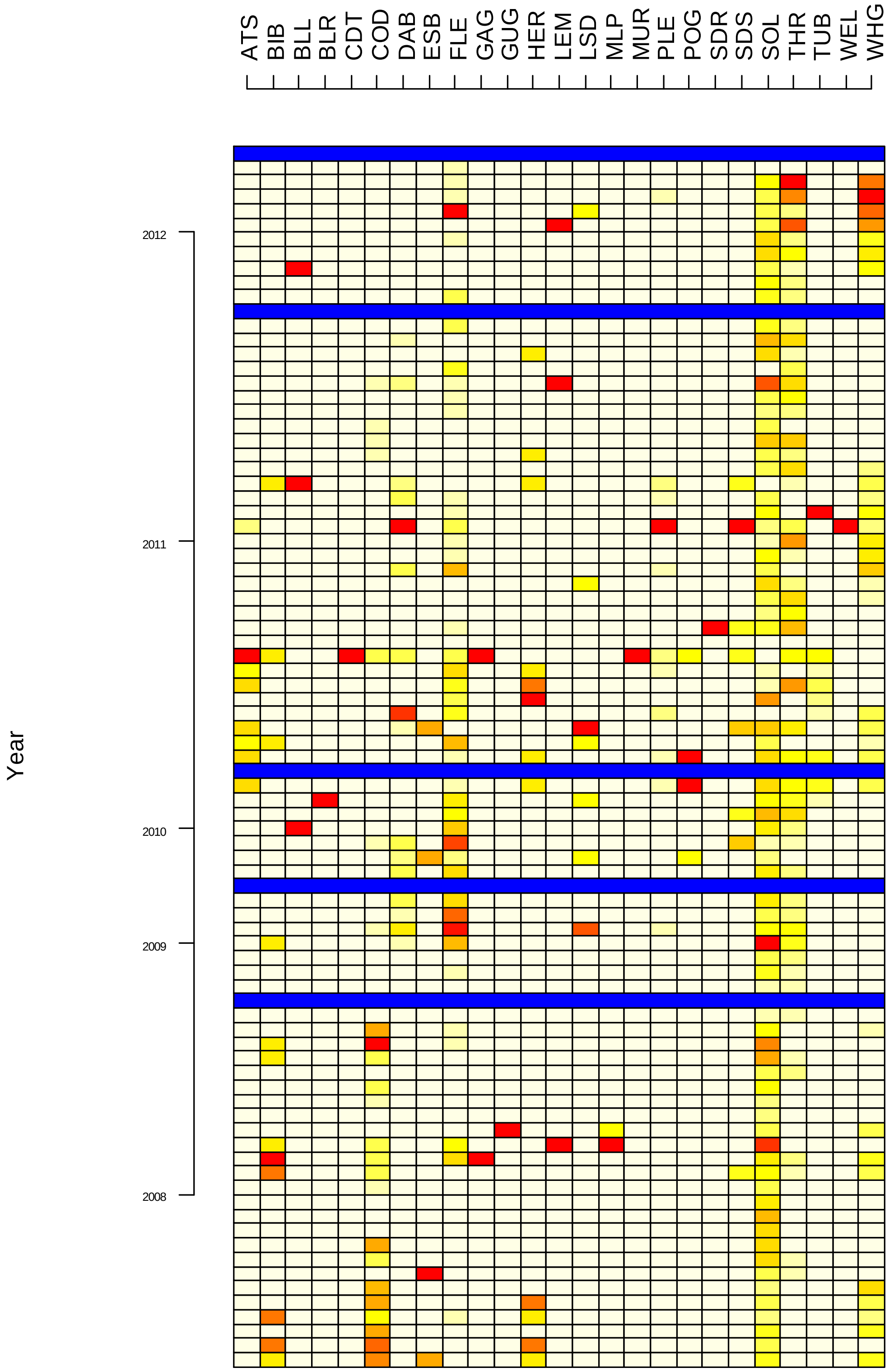


Figure 59. The otter trawl samples, grouped by year. Each row represents a sample (i.e. trawl) and blue lines separate years. Each taxon's abundance is standardised across the heatmap to the maximum abundance observed (red = highest, yellow = lowest).