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The fish and fisheries of Jones Bank and the wider Celtic Sea

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ABSTRACT

The Celtic Sea is a diverse fishing ground that supports important commercial fisheries for a range of demersal fish, large and small-bodied pelagic fish and a variety of cephalopods and other shellfish. A regional overview of the main commercial fish stocks of the Celtic Sea and of the fish that occur in the vicinity of Jones Bank are provided through analyses of landings data from English and Welsh vessels, and from scientific trawl surveys. Dedicated smaller scale sampling via trawl surveys combined with baited cameras on and around the Jones Bank were also analysed to investigate the importance of sandbank habitats with attention paid to the differences in the species occurring on the top of the bank in comparison to adjacent off-bank habitats. Official landing statistics for UK (English and Welsh) vessels indicated that the predominant commercial demersal species in ICES Divisions VIIg,h (in terms of quantities landed) were anglerfish, megrim, pollack and skates (Rajidae). There were, however, regional differences in the distribution of fish and fisheries, and the area surrounding Jones Bank (ICES Rectangles 28E1 and 28E2) supports fisheries for megrim, anglerfish, skates, hake, ling and turbot, with otter trawl, gillnet and beam trawl the main gears used. Recent survey data collected with GOV (Grande Ouverture Verticale) trawl from the Celtic Sea (ICES Divisions VIIe-h, 2007–2010) were used to highlight the broad scale distribution of the main fish assemblages in the Celtic Sea. Analyses of the fish and cephalopod catches from these surveys indicated that there were four broad assemblages in the area, including (i) a region around the Cornwall (which will also be partly influenced by the necessity to use rockhopper ground gear on these rough grounds), (ii) the shallower regions of the north-western Celtic Sea (including parts of the Bristol Channel), (iii) the deeper parts of the outer shelf and (iv) the central Celtic Sea. These data also provided information on the ichthyofauna of the Jones Bank. Further site-specific data for bank and off-bank habitats were collected during dedicated surveys on the Jones Bank in 2008 using commercial trawlers and baited camera deployments. Twenty-three species were recorded on the top of the bank, where horse mackerel, haddock and boarfish were the most abundant species; 18 species were found along the slope of the bank (with blue whiting, poor cod, hake and horse mackerel predominant) and 18 species observed off the bank (where catches were dominated by blue whiting, poor cod and hake). The differences between camera and trawls were important with cameras only picking up 28% of the species seen in the trawls. However both camera and trawl results suggest that some species are very habitat specific, with species such as haddock only observed on the top of the bank, whilst *Nephrops norvegicus* was abundant on the flat areas off the bank but was infrequent on the top of the bank. These results suggest that future surveys of offshore sandbank habitats should stratify sampling more specifically to deal with smaller scale features that may play an important role in providing a greater range of habitats than just their relative size would suggest.

1. Introduction

The Celtic Sea is a large area that includes ICES Divisions VIIg–h, the western parts of Divisions VIIe–f and the shelf waters in Division VIIj. It is limited to the north by the Irish Sea, to the west by the continental slope of the Porcupine seabight and east by the western English Channel. The shelf waters of the central Celtic Sea are about 100–150 m depth and host a number of shallower banks, including the Labadie Bank, the Jones Bank and the Great Sole Bank. The area has a gravel and sandy bottom in the north but it is muddier towards the south, with patches of rocky ground in some areas (Le Danois, 1948; Pinot, 1974).

The Celtic Sea is a major spawning and fishing site for commercially important pelagic species such as mackerel *Scomber scombrus* and horse mackerel (or scad) *Trachurus trachurus*, demersal fish such as hake *Merluccius merluccius,* haddock

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Melanogrammus aeglefinus, anglerfish *Lophius piscatorius* and megrim *Lepidorhombus whiffiagonis* (Warnes and Jones, 1995) and shellfish, including *Nephrops norvegicus*. Blue whiting *Micromesistius poutassou*, *S. scombrus* and *N. norvegicus* are some of the main prey species found in the stomach contents of predatory fish such as *M. merluccius*, *L. whiffiagonis*, *L. piscatorius*, whiting *Merlangius merlangus* and cod *Gadus morhua* (Pinnegar et al., 2003; Trenkel et al., 2005). Pinnegar et al. (2002) documented a decline in the abundance of large piscivorous species, such as *G. morhua* and *M. merluccius*, in the area and an increase of small, non-commercial pelagic species like boarfish *Capros aper* in French and UK survey catches (ICES, 2008). Increases in *C. aper* have been documented elsewhere in the north-east Atlantic (Fock et al., 2002; Blanchard and Vandermeirsch, 2005), although it should also be noted that Günther (1889) observed that *C. aper* would occur off the Irish coast in large numbers at irregular intervals. Changes in species composition may be part of larger regional species shifts due to climate change, or related to the effects of commercial fishing (Quéro and Cendrero, 1996; Poulard and Blanchard, 2005). Meta-analyses of fish abundance and species distributions in the OSPAR maritime area have shown the important influence of changes in hydrodynamics and sea surface temperature (Tasker, 2008).

The study of offshore demersal habitats have traditionally used invasive sampling, using gears such as trawls, grabs and dredges, with more limited use of visual techniques (e.g. towed video camera and remote operated vehicles) (Kaiser et al., 2004). Traditionally, trawl surveys for fishery resources have been carried out using various kinds of trawl (e.g. beam and otter trawl). Trawling is an extractive technique which can result in detailed species-specific population studies, including length-weight relationships, age-structure and reproductive state. More recently, non-extractive methods, including visual census with video and underwater camera, have become increasingly popular in marine biological studies. The main advantages of the latter methods include a reduced impact on the environment, observation of species *in situ* without the need to remove individuals, and direct images of the species' habitat. Most importantly, cameras can be deployed in habitats difficult to trawl, such as the deep sea (Priede et al., 2010), Marine Protected Areas and other sensitive habitats (Willis et al., 2000) and untrawlable areas (e.g. reefs and oil and gas platforms). However, visual sampling techniques, including baited underwater cameras (BUC) are highly selective and changes in environmental variables such as current speed, tide, light level, time of the day, visibility and bait soak time have been shown to affect the results of BUC studies (Løkkeborg and Johannessen, 1992; Stoner, 2004; Martinez et al., 2011), and they are less effective for small-bodied and cryptic species and non-scavenging species. Nevertheless, the use of different sampling techniques can provide a more holistic picture of the marine habitat(s) of interest and the associated biological communities.

Sandbanks are generally formed by the physical processes of seabed currents in combination with seabed topography (Kaiser et al., 2004). Sandbanks may have distinct faunal assemblages, with subtle differences between the species occurring on the top of the bank in comparison to adjacent off-bank habitats (Kaiser et al., 2004; Ellis et al., 2011, 2013). Previous work in the North Sea carried out by Aberdeen University and Proudman Oceanographic Laboratory (POL) found that piscivorous predators foraged in high numbers in areas with a high sub-surface concentration of chlorophyll and pronounced internal wave activity at the edge of sandbanks (Scott et al., 2010). Such banks also occur in the Celtic Sea, and so could also constitute important topographic features and foraging areas that support higher concentrations of fish and other top-predators (including seabirds and marine mammals). Such sites may also be utilised by commercial fishing vessels and, consequently, may have potential implications in fisheries management.

The Vessel Monitoring System (VMS) recently implemented by Member States of the European Union has showed fishing activity on the continental shelf to be strongly associated with small banks such as the Jones Bank (Sharples et al., 2013). High levels of fishing activity may result in local overfishing and habitat disturbance, and so an improved knowledge of the fauna of sandbanks is required to facilitate the appropriate management of human activities in such habitats. There is need to understand and describe the role that individual sandbanks and sandbank networks play as distinct habitats for the local marine fauna to meet the requirements of Good Environmental Status of the Marine Strategy Framework Directive and to inform on the selection of sites for conservation and marine planning of the EU Habitats Directive. The present study examines the main regional fish assemblages of the wider Celtic Sea and a site-specific description of the ichthyofauna associated with the Jones Bank using official landing data from UK vessels, trawl survey data and observations from baited underwater camera deployments.

2. Methods

2.1. Commercial landings data

Landings data for UK (English and Welsh) vessels were extracted from the Fishing Activity Database (FAD) for the years 2000–2009. The mean annual landings for the main species were examined for ICES Divisions VIIg,h (which covers much of the Celtic Sea) and for ICES statistical rectangles 28E1 and 28E2 (see Fig. 1), over which Jones Bank extends.

2.2. Data from Vessel Monitoring Systems (VMS)

Larger commercial vessels ($\geqslant$15 m overall length) have VMS on board, thus enabling the locations of the vessels (with associated trawl speed) to be reported approximately every 2 h. These data were analysed for the English and Welsh fleets for the years 2005–2008 and over a grid of pixel squares of 3′ by 3′, so providing 200 cells per ICES rectangle (given that each ICES rectangle covers 60′ longitude and 30′ latitude). To identify likely sites of fishing activity, data for otter and beam trawlers were selected by trawl speed, so that steaming (non-fishing) locations were omitted. These data enabled areas of higher effort to be identified. Determining effort for offshore gillnetters is more problematic, as a gillnetter may deploy different nets in terms of mesh size, type of gillnet and number of fleets (i.e. total length of net) over the course of a single trip. Hence, no estimates of effort were provided, and data were simply provided as the proportion of reported vessel locations in each square.

2.3. Scientific trawl surveys

Jones Bank was initially sampled with 2 m beam trawl during a groundfish survey in March 2002 (Ellis et al., 2013), and was then sampled with a Portuguese high headline trawl in March 2003 and 2004. This survey, which is not currently undertaken, was described by Tidd and Warnes (2006). Since 2003, CEFAS have undertaken a fishery-independent trawl survey of the Irish Sea and Celtic Sea in November as part of the internationally-coordinated International Bottom Trawl Survey (IBTS) of the southern and western waters of the North-east Atlantic continental shelf (ICES, 2010a,c).

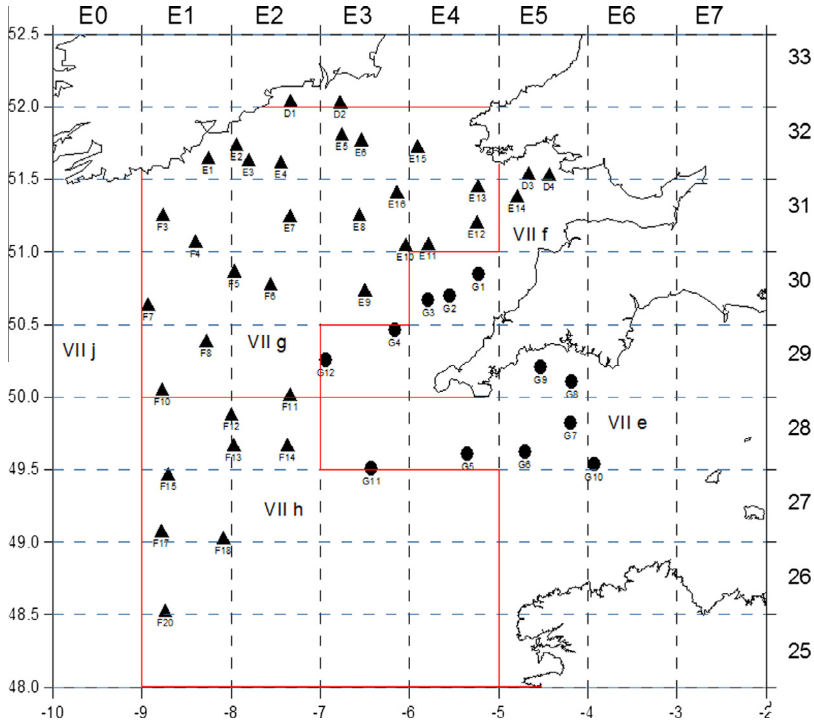

Fig. 1. Celtic Sea showing ICES Divisions and statistical rectangles, and fixed stations fished during an annual groundfish survey. Jones Bank (near trawl station F12) extends over ICES Rectangles 28E1 and 28E2.

The survey operated over a fixed station grid, and the trawl was towed for 30 min at four knots, although towing speed was reduced in areas of strong tide. Fishing was conducted during the day, ranging from 15 min before sunrise to 15 min after sunset, and catch sampling protocols were as given in the IBTS manual.

This survey used two variations of the grande ouverture verticale (GOV) trawl used in the North Sea, a rockhopper GOV on coarse grounds around the Cornish Peninsula (ca. 12 stations), and the standard ground gear GOV for finer grounds elsewhere (ca. 35 stations, see Fig. 1). Differences between the trawl used in this area to that used in the North Sea (see ICES, 2010b for a description) include that the net was made of polyethylene instead of nylon, extra floatation was used instead of the kite, and that the toggle chains were set to 10 cm, instead of 30 cm. To enable coarser ground stations to also be sampled, a modified GOV on rockhopper ground gear, as described by Harley and Ellis (2007), was used in areas where the standard trawl could not be fished successfully. In addition to rockhopper discs on the ground gear, the central sections of the headline and fishing lines on this trawl were only 3 m (instead of 5 m), the sweeps were 20 m long (instead of 50 m), and there was no middle bridle.

2.3.1. Regional analyses of the fish assemblage

Fish catches (kg h^{-1}) from the Celtic Sea part of the survey grid for the years 2007–2010 were fourth-root transformed in PRIMER (Clarke and Gorley, 2006) and multivariate community analyses, including cluster analysis and SIMPER, used to distinguish and characterise the regional fish assemblages. Over this 4-year period, a total of 156 valid tows were made in the region, of which one station (F12) was on the Jones Bank. The GOV trawl, which evolved from a herring trawl, has a high headline height (ca. 4–5 m, depending on water depth), and so pelagic fish were included in data analysis.

2.3.2. Scientific trawl survey data for the Jones Bank

Although no intensive sampling of Jones Bank was undertaken during annual groundfish surveys, site-specific data were available for March 2003, 2004, and from surveys in November (2003–2010, except for 2006 when severe weather hampered field work). Data from these hauls are provided to complement data collected during investigations of the Jones Bank, and provide an insight into the types of fish occurring on and around the bank.

2.4. Commercial trawl survey of Jones Bank

A dedicated ecosystem survey was carried out on the Jones Bank (49°51.21′N, 07°56.87′W) in July 2008 on board of RRS *James Cook* as part of the CMarHab Project (Sharples et al., 2013). Whilst this survey was undertaken, fish samples were collected by the commercial pelagic trawler Fishing Vessel *Imogen* (otter trawl with 16 mm mesh size) and the demersal trawler FV *Crystal Sea* (otter trawl with 100 mm mesh size and cod-end liner of 20 mm mesh size), both chartered through the Cornish Fisherman's Producers Organisation (CFPO). One Marine Resources Assessment Group (MRAG) fisheries observer was onboard each boat to identify species to the lowest taxonomic level and to record length frequency data for the main fish species (by biomass for demersal species, by number for pelagic species). A total of seven successful tows were completed by the FV *Crystal Sea* and five tows were carried out by the FV *Imogen*. Tow duration ranged from 20 to 91 min. No trawling was performed during the night because of potential conflicts with other trawlers in the area. Catches were converted into wet weight per hour.

2.5. Baited camera observations on Jones Bank

During the dedicated survey on Jones Bank on 2008, a Baited Underwater Camera (BUC) system from Marine Scotland Science was deployed in and around the bank. The research area was divided into five sampling sites; the top of the bank (MS1), the slope (MS2) and bottom part of the slope (MS3) across the elongated shape of the bank; and two stations on the flat areas to the south-east (MS4) and north-west (MS5) of the bank (Fig. 2). The sampling station MS5 was adopted later in the cruise after a dye

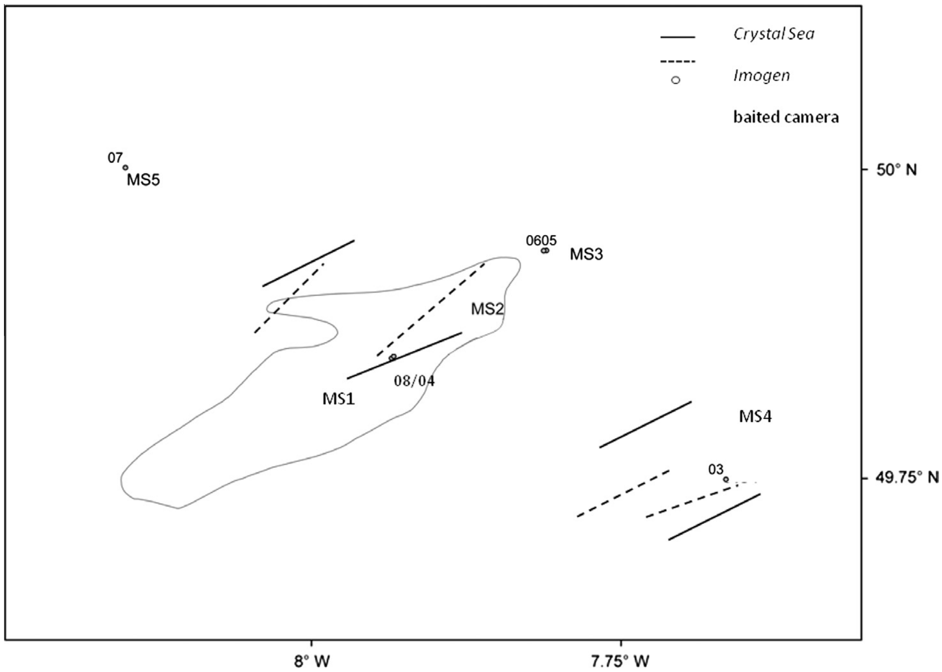

Fig. 2. Jones Bank (contour) showing tracks sampled by the demersal trawler FV *Crystal Sea* and the pelagic trawler FV *Imogen* (July, 2008) and positions of baited underwater camera deployments (03–08) (July, 2008).

dispersion experiment indicated that the surface Ekman flow had a strong southerly component and after the first vertical and horizontal diffusion, the patchy dye drifted SE off the Jones Bank (Inall et al., 2013) indicating that there could be differential properties in the water masses to the west and east of the bank. As a consequence there were no trawl data from MS5, although the BUC was deployed once at this station.

The BUC consisted of an aluminium frame (Jamieson and Bagley, 2005) fitted with a Kongsberg 5 mega pixel underwater camera, flash unit and a 24 V battery pack. The baited camera was deployed on free fall and attached to a flotation package and a tethered line to facilitate recovery. Two ballast acoustic releases where fitted as a back-up recovery system. The BUC was suspended 2 m above the seabed by a flotation package and attached to ballast with a 1 m scale. Fresh mackerel was used as bait to attract species. During the 2008 cruise the BUC was typically left for 2–3 days until recovery. A second bait source (deep frozen mackerel) was wrapped in a plastic mesh bag to increase the duration of the bait supply. The BUC was successfully deployed on six occasions (Fig. 2) and the camera was programmed to take one picture per minute. A total of 4719 pictures were collected over 79 h (for further details see Table 2 and Fig. 2 of Ellis et al., 2013). From each picture, all fish species were identified to the lowest taxonomic level and the maximum number of individuals seen at any one time ($N_{\max}$) calculated.

Table 1
Mean annual reported UK (English and Welsh) landings (in tonnes) from rectangles 28E1 and 29E2 and ICES Divisions VIIg–h.

Species	Mean Annual landings (2000–2009), t			
	28E1, 28E2	%	VIIg–h	%
Megrims	35.4	19.7	679.7	14.8
Anglerfish	35.4	19.7	844.2	18.4
Skates and rays	20.1	11.1	324.6	7.1
Hake	17.4	9.6	176.0	3.8
Ling	8.6	4.8	243.6	5.3
Turbot	6.9	3.8	72.1	1.6
Cod	6.7	3.7	131.6	2.9
Sole	6.0	3.3	122.5	2.7
Conger eel	5.5	3.0	166.0	3.6
Witch	5.4	3.0	31.1	0.7
Pollack	4.9	2.7	496.8	10.8
John dory	3.8	2.1	28.0	0.6
Spurdog	3.4	1.9	108.9	2.4
Haddock	2.8	1.6	99.3	2.2
Lemon sole	2.3	1.3	79.4	1.7
Nephrops	2.3	1.3	11.8	0.3
Plaice	2.1	1.2	52.0	1.1
Squid	1.9	1.1	11.2	0.2
Octopus	1.3	0.7	33.8	0.7
Tope	1.1	0.6	11.7	0.3
Saithe	1.1	0.6	63.7	1.4
Total	180.3		4589.6	

3. Results

3.1. Landings data

The main species landed from ICES rectangles 28E1 and 29E2 by English and Welsh fishing vessels were *L. whiffiagonis*, *L. piscatorius*, skates and rays (Rajidae), *M. merluccius* and ling *Molva molva* (Table 1). Catches of *L. whiffiagonis*, skates, *M. merluccius*, turbot *Psetta maxima*, witch *Glyptocephalus cynoglossus* and John Dory *Zeus faber* were proportionally higher from the rectangles around Jones Bank than observed over the wider region (Fig. 3).

The main fishing gears used in the area were beam trawl, otter trawl and various forms of gillnet, and the total reported landings (2000–2009) by these three categories of gear were 506 t, 718 t and 554 t. Reported catches from longline were only 25 t during this period. Reported landings from beam trawlers were dominated by *L. piscatorius*, *L. whiffiagonis*, sole *Solea solea* and skates and rays, with these four groups accounting for >70% of total reported landings. Otter trawl landings still comprised high proportions of *L. whiffiagonis*, *L. piscatorius* and skates, with *Z. faber* and *M. merluccius* also important components of the catch. Gillnet catches were dominated by *M. merluccius*, *L. piscatorius*, *M. molva*, *P. maxima*, pollack *Pollachius pollachius* and skates (Fig. 4).

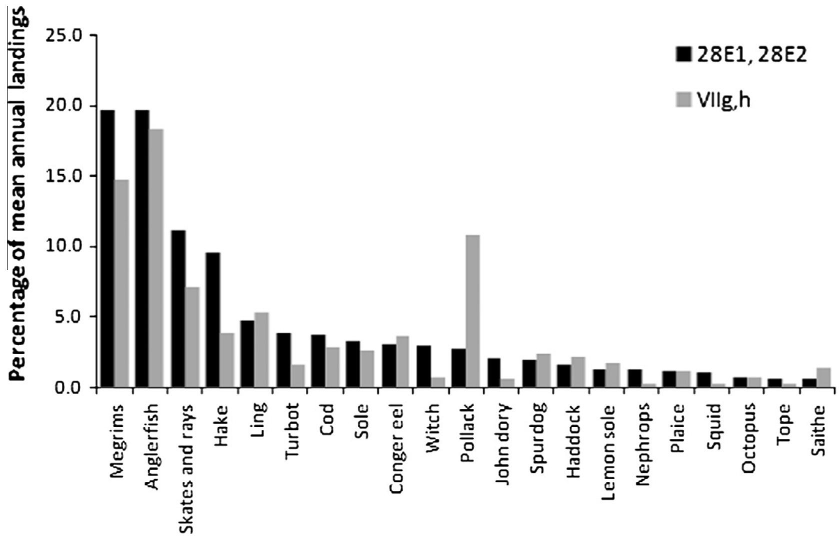

Fig. 3. Proportion of various fish and shellfish species in mean annual landings (2000–2009) from UK (English and Welsh) vessels reported from rectangles 28E1 and 28E2, and from ICES Divisions VIIg,h.

3.2. Distribution of fishing activity

Data from VMS confirmed the presence of gillnetting activity by English-registered fishing vessels in the vicinity of the Jones Bank, and elsewhere in the Celtic Sea (Fig. 5). Comparable data for the beam trawl fleet highlighted that this fleet generally operated further east and closer to shore. The distribution of otter trawler fishing effort was more patchily distributed. It must also be recognised that data for other fleets, including some Anglo-Spanish vessels, were not available.

3.3. Regional analyses of the fish assemblage

During the study period (2007–2010), a total of 99 fish species and 10 cephalopods were recorded from Cefas GOV trawl surveys in the Celtic Sea. The ichthyofauna and shellfish of the Celtic Sea (ICES Divisions VIIe–j), as observed in the recent trawl survey and in earlier surveys (Warnes and Jones, 1995; Tidd and Warnes, 2006) are listed in Appendix A.

Cluster analyses of the GOV trawl survey data indicated that there were four broad assemblages in the regional study area (Fig. 6 and Table 2). Stations fished with rockhopper trawl around the Cornish peninsula were distinct, and this will be a combination of differences in the gear type as well as differences in the fish assemblage associated with the harder grounds in this area that necessitates the use of a more robust trawl with rockhopper discs. Catches in this area were dominated by *T. trachurus*, various gadoids (poor cod *Trisopterus minutus*, *M. aeglefinus* and *M. merlangus*), lesser-spotted dogfish *Scyliorhinus canicula* and squid (*Loligo forbesi* and *Alloteuthis subulata*). The higher biomasses of *L. forbesi* and *T. trachurus* in this area at this time of the year were important in differentiating this group of stations from elsewhere in the survey grid, with catches in this area also comprising a higher biomass of *M. aeglefinus* and *M. merlangus* than recorded in the outer Celtic Sea assemblage.

Those stations off south-eastern Ireland and in the Bristol Channel were also distinct. These stations were generally in shallower water (stations were 28–90 m deep). Although gadoids (e.g. *M. merlangus*), *S. canicula* and *T. trachurus* still formed important components of the catch, there was a greater biomass of flatfish (dab *Limanda limanda* and plaice *Pleuronectes platessa*), clupeids (sprat *Sprattus sprattus* and herring *Clupea harengus*), grey gurnard *Eutrigla gurnardus* and various skates. The high biomasses of many of these species, notably *P. platessa* and *L. limanda*, were important for distinguishing these stations from the two assemblages further offshore, although it is acknowledged that the higher observed biomass of *P. platessa*, *L. limanda* and other demersal fish (e.g. *E. gurnardus* and common dragonet *Callionymus lyra*) in relation to that observed around Cornwall will be influenced by the difference in ground gear.

Those stations slightly further from shore and in waters of 59–116 m deep in the Central Celtic Sea were also dominated by gadoids (*M. merlangus*, *M. aeglefinus*, *T. minutus*, Norway pout *Trisopterus esmarkii* and *M. poutassou*) with *M. merluccius*, *L. whiffiagonis* and long-rough dab *Hippoglossoides platessoides* also important components of the catch. *H. platessoides* and *L. whiffiagonis* were important species for differentiating these grounds from the shallower sites described above. Lemon sole *Microstomus kitt* and *M. merlangus* appeared to be found in greater quantities in this assemblage than in the assemblage observed in the deeper waters to the south and west of the survey grid. The latter assemblage tended to occur in the deeper areas of the survey grid (85–175 m water depth) and *M. merluccius*, *L. whiffiagonis*, *T. minutus* and *M. poutassou* were the predominant catch components, with *C. aper* also a relatively important species. Catches of *M. poutassou* and *M. merluccius* on these grounds helped distinguish this group of stations from the shallower parts of the Celtic Sea.

The majority of stations showed a consistent affinity to one type of assemblage, irrespective of survey year, although the catches at those stations on the borders of the assemblages would sometimes vary between years as to which assemblage type they were most closely allied to.

3.4. Trawl survey data for Jones Bank

Following initial sampling of Jones Bank with 2 m beam trawl during a groundfish survey in 2002 (Ellis et al., 2013), the area was then sampled with a Portuguese high headline trawl in 2003. This catch was dominated (numerically) by *S. scombrus*, with various species of dogfish (notably spurdog *Squalus acanthias*, tope *Galeorhinus galeus* and starry smooth-hound *Mustelus asterias*) taken in appreciable numbers, and these latter species were the predominant part of the biomass caught. *Scomber scombrus* were taken in relatively high numbers the following year.

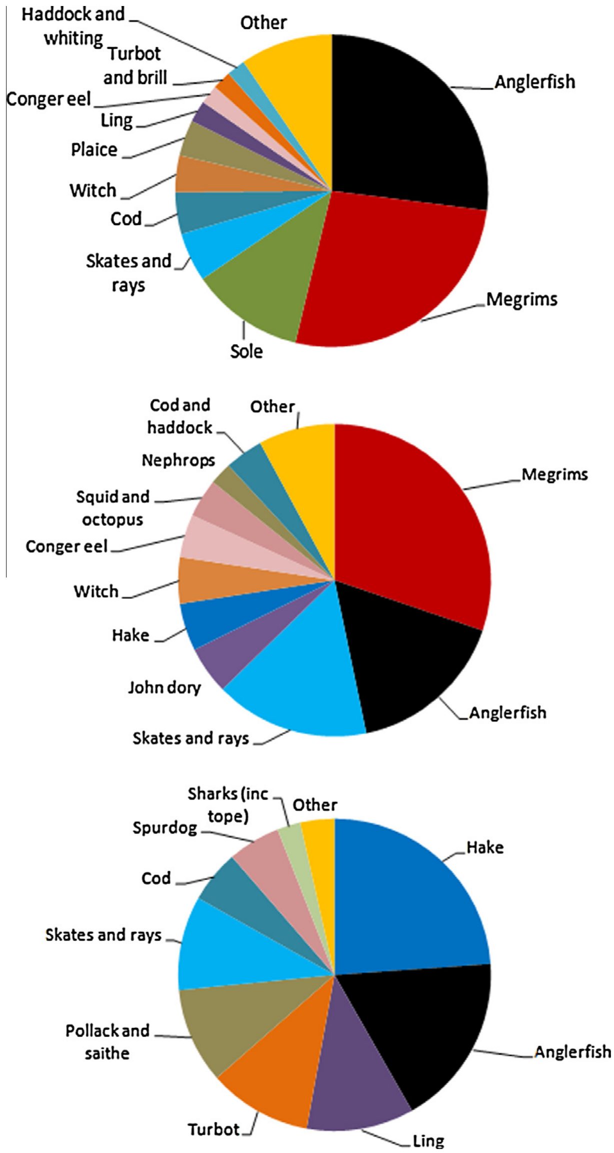

Fig. 4. Proportion of total reported landings (2000–2009) by English and Welsh vessels using beam trawl (top), otter trawl (centre) and gillnet (bottom) from ICES rectangles 28E1 and 28E2.

During November surveys with GOV trawl (with single tows undertaken in 2003–2005 and 2007–2010), a total of 40 fish species were recorded (Table 3, Fig. 7), with the species observed most consistently including *M. merluccius*, *T. minutus*, various flatfish (*H. platessoides, L. whiffiagonis*), *C. aper*, dogfish (*S. acanthias* and *S. canicula*) and some non-commercial demersal species (e.g. *E. gurnardus*, spotted dragonet *Callionymus maculatus* and *C. lyra*). Numerically, the most abundant species in catches included species such as *M. poutassou, T. minutus, T. esmarkii, H. platessoides, C. aper* (especially in November 2007 and 2008) and pearlside *Maurolicus muelleri* (in November 2007 only).

In contrast to the hauls sampled in March surveys, only occasional *S. scombrus* were caught on the bank during November surveys, and four species (*G. galeus, P. maxima,* pilchard *Sardina pilchardus* and tub gurnard *Trigla lucerna*) recorded during these March surveys have not as yet been observed in the November surveys on the Jones Bank.

Overall, 46 species of fish were reported from these trawl surveys on the Jones Bank, including data from 2 m beam trawl catches that confirmed the presence of silvery pout *Gadiculus argenteus* and two species of goby (Jeffreys' goby *Buenia jeffreysi* and Norwegian goby *Pomatoschistus norvegicus*).

3.5. Commercial trawl survey data for Jones Bank

During the commercial trawl survey of the Jones Bank, a total of 25 fish species caught and identified during trawling undertaken by FV *Crystal Sea*, three of which (*C. aper*, *T. trachurus* and *S. scombrus*) were also present in the pelagic catches of FV *Imogen*. The dominant species caught by demersal trawl were *T. trachurus*, *M. poutassou*, *T. minutus*, *M. aeglefinus*, *M. merluccius* and the crustacean *N. norvegicus*. *C. aper* was the most abundant species taken by the pelagic trawl.

Of the 25 species recorded in this survey, 23 species were caught at the top of the bank (MS1), which showed the greatest species richness. The dominant species (mean catch >10 kg h^{-1}) were *T. trachurus*, *M. aeglefinus* and *C. aper* (Table 4) with just over 0.8 kg h^{-1} of *N. norvegicus* caught at the top of the bank. A total of 18 species were caught on the slope (MS2), and the most abundant fish species, in decreasing order of biomass, were *M. poutassou*, *T. minutus*, *M. merluccius* and *T. trachurus* (Table 4). The biomass of *N. norvegicus* at this site (13.7 kg h^{-1}) was higher that on the top of the bank. On the flat area southeast off the bank (MS4), 18 fish species were caught, of which *M. poutassou*, *T. minutus* and *M. merluccius* were abundant. Catches of *N. norvegicus* at this site (52 kg h^{-1}; Table 4) were the highest during the survey. *M. aeglefinus* was an abundant species on the top of the bank but was not observed at off-bank sites.

Although 25 species were recorded during this survey, only in a few cases there were sufficient samples at all three sites to warrant comparisons in the size frequency, including *C. aper* (catches from FV *Imogen*), and *T. trachurus* and *M. poutassou* (catches from FV *Crystal Sea*, Fig. 8). Results from two-sample Kolmogorov–Smirnov tests comparing the shapes of the length distribution curves for each fish species at each of the three sites showed that the length-frequency distribution of *C. aper* off the bank (MS4), differed significantly from that on the top and the slope (MS1 and MS2-3) (K–S test, $D = 0.3417$, $P = 0.002$; $D = 0.4345$, $P < 0.0001$) with a higher frequency of larger individuals associated with stations at the bank and slope (Fig. 8). The length-frequency distributions of *T. trachurus* and *M. poutassou* were not significantly different between sites.

3.6. Baited camera observations of fish species from Jones Bank

The presence of fish attracted to the baited camera during the 2008 sampling cruise was remarkably low, comprising 18 observations of six fish species in six successful deployments. The bait remained untouched for several hours before any fish were attracted. Arrival times ranged from 4 to 659 min and 78% of fish arrivals to the bait were recorded after the first 120 min. Maximum numbers of fish observed at any one time (N_{max}) was also low (1 or 2). No relationship between N_{max} and current direction or speed was found, given the paucity of data (Table 5).

The six fish species recorded by the baited camera were *M. aeglefinus*, *E. gurnardus*, *M. merlangus*, conger eel *Conger conger*, *S. canicula*, and *T. minutus*, and *N. norvegicus* was also recorded (Fig. 9). The mean maximum number of fish per sampling site was very low (0.5–1.5 fish per deployment, 0.5–2 if including *N. norvegicus*). Four species (*M. aeglefinus*, *M. merlangus*, *T. minutus* and *E. gurnardus*) were observed at the top of the bank (MS1); four species (*M. merlangus*, *C. conger*, *T. minutus* and *E. gurnardus*) and *N. norvegicus* were recorded at the end of the slope (MS3), and four species (*M. Merlangus, C. conger, S. canicula* and *E. gurnardus*) and *N. norvegicus* were seen in the two deployments off the bank (MS4-5; Table 5). *C. conger* and *N. norvegicus* were both absent from the top of the bank

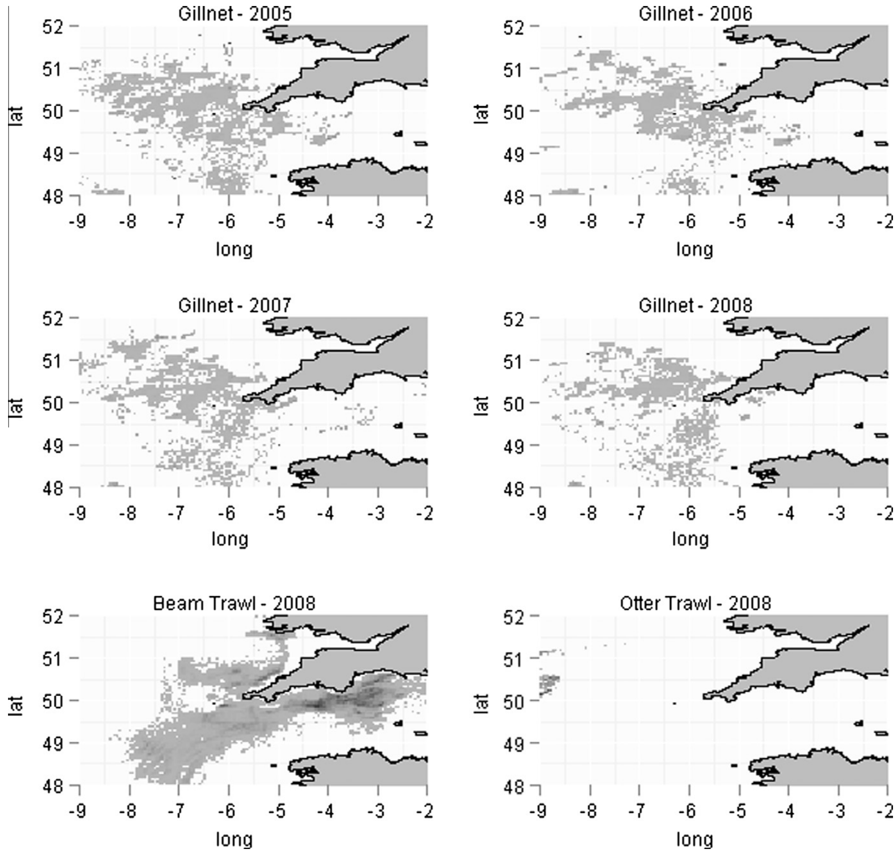

Fig. 5. Estimated spatial distribution of fishing activity by gillnetters (2005–2008) in the Celtic Sea. For comparative purposes, the spatial distribution of fishing effort for otter and beam trawlers (2008 only) is also given. Data from UK (English and Welsh) fishing vessels ⩾15 m length.

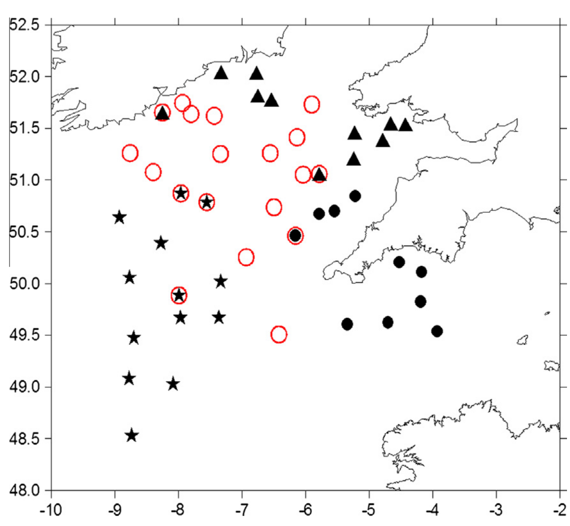

Fig. 6. Distribution of fish assemblages in the Celtic Sea (2007–2010) as inferred from analyses of GOV trawl survey data. The assemblages include those occurring around the Cornish Peninsula (●), the shallower waters of the Celtic Sea (▲), central Celtic Sea (○) and deeper parts of the Celtic Sea (★). The reader should refer to Fig. 1 to see which type of ground gear was used. Stations with multiple symbols indicate sites where catches were related to different assemblages in different years.

site, whereas *M. aeglefinus* was only observed at the bank area. *M. merlangus* was the only species recorded on every deployment but no diel pattern was observed in terms of the day/night deployments, arrival times or current. *C. conger* was only recorded during night time hours. Although no relationship was found between N_{max} and current direction or speed, three of the four records where N_{max} was 2 occurred when the mean current speed was minimal (Table 5). No flatfish were recorded by the BUC during this survey.

4. Discussion

The distribution of fish is known to be influenced by a variety of factors, including depth, sediment type, temperature and salinity (e.g. Ellis et al., 2000, 2002a; Van der Kooij et al., 2011). The wider Celtic Sea contains a variety of sediment types (Pinot, 1974), ranging from the muddy *N. norvegicus* grounds to rocky outcrops (e.g. around the Scilly Isles and Cornwall), and many of the main trawling grounds are quite heterogeneous, with individual bottom trawl catches potentially yielding mud-associated fauna (e.g. *N. norvegicus*) as well as fauna that is more typically associated with coarse grounds. In terms of bathymetry, the current survey data used only extend to waters of 175 m, and it should be recognised there are extensive areas of ICES Divisions VIIh–j that extend to depths of more than 200 m, and many fish species that typically associate with the (upper) slope can be encountered in these areas. In terms of biogeographical boundaries, many Lusitanian fish species range as far north as the Celtic Sea and western English Channel, and some northern fish species, including some gadoids, have their southern limits in the Celtic Sea. There appeared to be some biogeographical differentiation between the faunal assemblages to the north and south of ca. 49°N (ICES, 2005; Ellis et al., 2013).

These factors all contribute to the Celtic Sea having a diverse ichthyofauna in comparison to, for example, the North Sea. Furthermore, a diverse range of fish are exploited commercially in this region, with English fleets landing a variety of small pelagic fish

Table 2
Dominant fish and cephalopods encountered in GOV trawl surveys of the Celtic Sea.

Shallow Celtic Sea Average similarity: 54.97			Central Celtic Sea Average similarity: 57.22		
Species	Average abundance	Cum.%	Species	Average abundance	Cum.%
Merlangius merlangus	2.99	11.17	*M. merlangus*	2.32	8.53
Scyliorhinus canicula	2.96	21.78	*M. aeglefinus*	2.35	16.22
Limanda limanda	1.86	27.78	*T. minutus*	1.9	23.53
Eutrigla gurnardus	1.64	33.66	*Trisopterus esmarkii*	2.11	30.83
Clupea harengus	1.99	39.23	*Merluccius merluccius*	1.58	37.05
Sprattus sprattus	1.64	44.28	*S. canicula*	1.8	42.39
Pleuronectes platessa	1.69	49.21	*Lepidorhomus whiffiagonis*	1.15	46.42
Trachurus trachurus	1.22	53.17	*Hippoglossoides platessoides*	1.18	50.43
Melanogrammus aeglefinus	1.79	56.9	*Micromesistius poutassou*	1.21	54.06
Trisopterus minutus	1.17	60.55	*Microstomus kitt*	0.92	57.08
Raja clavata	1.32	63.9	*E. gurnardus*	1.09	60.05
Callionymus lyra	1.03	67.13	*Gadus morhua*	1.18	62.82
Raja montagui	0.96	69.52	*Zeus faber*	0.94	65.54
Raja microocellata	1.06	71.49	*Loligo forbesi*	0.82	68.16
			C. lyra	0.87	70.77
Outer Celtic Sea Average similarity: 55.12			Cornwall Average similarity: 49.01		
M. merluccius	1.72	8.91	*T. trachurus*	3.27	20.34
L. whiffiagonis	1.36	16.60	*L. forbesi*	1.71	32.24
T. minutus	1.51	23.64	*T. minutus*	1.72	42.74
M. poutassou	1.47	30.13	*M. aeglefinus*	2.32	52.15
S. canicula	1.32	35.97	*M. merlangus*	1.66	60.87
M. aeglefinus	1.41	41.79	*S. canicula*	1.27	66.86
H. platessoides	1.15	47.43	*Alloteuthis subulata*	0.77	71.64
Capros aper	1.54	52.64			
Sepiola atlantica	0.65	56.02			
Eledone cirrhosa	0.82	59.37			
T. esmarkii	0.97	62.47			
Argentina spp.	0.63	65.26			
T. trachurus	0.77	67.87			
Microchirus variegatus	0.62	70.40			

(e.g. *T. trachurus* and *S. scombrus*), gadiforms (*P. pollachius, M. molva, M. merluccius, G. morhua, M. aeglefinus* and *P. virens*), pleuronectiforms (*L. whiffiagonis*, *S. solea*, *M. kitt, P. maxima, P. platessa* and *G. cynoglossus*), elasmobranchs (various skates and dogfish) and other demersal fish (including *Lophius* spp., *C. conger* and *Z. faber*).

In terms of regional fish assemblages, multivariate analyses of trawl survey provided a useful method for identifying the broad spatial patterns and structure of fish assemblages, although it should also be acknowledged that the assemblages described refer to that part of the fish community sampled by that gear at that time of the year. The inferences of such analyses can also be influenced by the extent of survey coverage, and if the survey included more stations in deep water to the west of the existing survey grid and/or sites further south, then this could result in the current stations being considered relatively more similar to each other. Nevertheless, there was a clear bathymetric/latitudinal cline in the fish assemblages in the study area, with coastal species (e.g. *L. limanda* and *P. platessa*) more abundant in the north-eastern part of the survey grid, and species such as *L. whiffiagonis*, *M. merluccius* and *M. poutassou* becoming increasingly abundant further offshore. These patterns broadly correspond with the epibenthic assemblages described in the area (Ellis et al., 2002b, 2013).

There has been increased interest in sandbanks as habitat features in recent years (see Kaiser et al., 2004; Ellis et al., 2011), partly due to the EC Habitats Directive. In many of the studies conducted on inshore sandbanks, which are active, the richness of the fish and larger epifauna communities on the crests of sandbanks is generally lower than alongside the banks, possibly due to the dynamic nature of this environment. Offshore sandbanks are an important feature of the Celtic Sea, and some of these banks are sometimes considered 'moribund'. Hence, it is unclear as whether the fauna on the crests of the banks is species-poor in relation to the slopes and adjacent off-bank habitats. Although 2 m beam trawling indicated a lower species diversity on the banks themselves (Ellis et al., 2013), it is difficult to demonstrate this for fish with the current data, as larger trawls are towed for a longer duration and so typically sample both the sides and crest of the bank.

A total of 46 fish species were observed on and around Jones Bank, although this was based on a relatively low survey effort. Individual hauls on Jones Bank typically yielded 15–29 fish species, and further survey effort at other times of the year and with additional sampling gears would be required to fully ascertain the number of fish species utilising this topographic feature. Individual trawl catches from Jones Bank often included a high biomass of aggregating species, and this has been observed for *S. scombrus*, dogfish (including *G. galeus* and *S. acanthias*), *C. aper* and *M. poutassou*, suggesting a variety of different species may aggregate near the bank at certain times.

The Jones Bank (Fig. 1 of Sharples et al., 2013) was identified as an area of enhanced sub-surface mixing and high productivity by Sharples and Moore (2009) based on *RRS Charles Darwin* cruise CD173, July/August 2005. Indeed, during the 2008 survey, episodes of internal waves increasing mixing through the thermocline were observed using Turbulence Microstructure Profiling and a Simrad EK60 echosounder (Palmer et al., 2013). These events seem to be driven by physical processes and this may have important consequences in the distribution of fish species around the bank, for example the large fish aggregations that can be encountered. Although not directly comparable, both underwater camera and trawl data from the 2008 dedicated survey at Jones Bank showed some degree of fish habitat preference between the Jones bank and flatter sites adjacent to the bank (although only 15 km

Table 3
Occurrence of fish and commercial shellfish (and number caught per hour) at the Jones Bank (2003–2010).

Group	Species	March-03 PHHT	March-04 PHHT	November-03 GOV	November-04 GOV	November-05 GOV	November-07 GOV	November-08 GOV	November-09 GOV	November-10 GOV	%Occur.
Decapoda	*Cancer pagurus*						2				11.1
	Nephrops norvegicus				52.5	294	164	292	42	6	66.7
Cephalopoda	*Alloteuthis subulata*	9.1	18.9		1.5				2		44.4
	Illex spp.							2		8	22.2
	Loligo forbesi				25.5	6	4	8	12		55.6
	Todarodes eblanae	1.1						4		4	33.3
	Sepia elegans									2	11.1
	Sepia officinalis				1.5				2		22.2
Elasmobranchii	*Squalus acanthias*	77.0	9.5	12	3	2		6	22	6	88.9
	Scyliorhinus canicula	6.8	6.3		1.5	2	46	12	6	8	88.9
	Galeorhinus galeus	83.8									11.1
	Mustelus asterias	53.2							2	2	33.3
	Dipturus batis				1.5		2			4	33.3
	Leucoraja naevus						2		4	4	33.3
Gadiformes	*Enchelyopus cimbrius*							2			11.1
	Gadus morhua				1.5	4	10	2		6	55.6
	M. aeglefinus	5.7			1.5	2		12	14	64	66.7
	Merlangius merlangus	1.1							4	24	33.3
	Merluccius merluccius	2.3	3.2		63	46	40	58	16	30	88.9
	M. poutassou	29.4	63.2	14		42	96		30	8756.6	77.8
	Molva molva								2		11.1
	Phycis blennioides						4	2			22.2
	Pollachius pollachius					2					11.1
	Trisopterus esmarkii	1.1		6	51	96	58		114	4006.7	77.8
	Trisopterus minutus	4.5	18.9	52	279	214	56	78	293.1	368	100.0
Pleuronectiformes	*Arnoglossus imperialis*	1.1		2			6		2	2	55.6
	Arnoglossus laterna							2			11.1
	G. cynoglossus						2			2	22.2
	H. platessoides	2.3	3.2	4	156	144	264.2	94	46	218	100.0
	L. whiffiagonis	1.1	12.6	8	4.5	16	16	26	16	24	100.0
	Limanda limanda			2	1.5	2	2			10	55.6
	Microchirus variegatus				13.5	6	34	4	22	24	66.7
	Microstomus kitt		3.2	2	1.5		2		6	2	66.7
	Pleuronectes platessa				1.5			2		8	33.3
	Psetta maxima	1.1									11.1
Boarfish and dories	*Zeus faber*	1.1					2			2	33.3
	Capros aper		12.6	2	10.5	10	1528.6	71879.2	114	313.7	88.9
Miscellaneous pelagic and benthopelagic fish	*Argentina* spp.	2.3			1.5		6		2		44.4
	Belone belone			2							11.1
	Maurolicus muelleri		3.2		3	2	99.4				44.4
	Sardina pilchardus		3.2								11.1
	Scomber scombrus	7214.4	3294.9					2			33.3
	Trachurus trachurus	7.9	6.3	4	1.5			2	12	18	77.8
Miscellaneous demersal fish	*Conger conger*			2		2				4	33.3
	Lophius budegassa						2		4		22.2
	Lophius piscatorius					2			2	6	33.3
	Aspitrigla cuculus		3.2							2	22.2
	Eutrigla gurnardus	24.9	6.3		16.5	74	26	10	198	38	88.9
	Trigla lucerna	1.1									11.1
	Callionymus lyra	3.4	6.3	2	3	6	28		10	16	88.9
	C. maculatus	2.3		2	3	2	6	28	76	38	88.9
	Gobiidae indet.				4.5						11.1

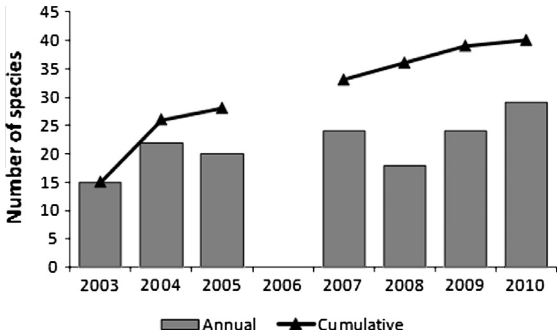

Fig. 7. Number of fish species taken in GOV trawl during annual groundfish surveys on Jones Bank (2003–2010).

apart). Small-scale changes in fauna might be induced by geographically forced changes in water masses, tidal flow and nutrients, but may also be related to differences in substrate, food availability, competition or predator-prey interactions.

Banks could have attracting characteristics *per se*, as several pelagic species showed the highest catches per tow at the bank and at least one of the abundant pelagic species, *C. aper*, was observed to segregate by size, with larger individuals associated with the bank. They may provide a visual reference point that favour navigation, encounters and schooling behaviour similarly to some fish aggregating devices (FADs) (Freon and Dagorn, 2000). Both survey methods (baited camera and trawl) indicated a near-absence of *N. norvegicus* on the bank crest, whereas *M. aeglefinus* and *M. merlangus* were found almost exclusively in this area. The burrowing behaviour of *N. norvegicus* requires muddier sediments and therefore this species was systematically found on off-bank sites (Ellis et al., 2013). *M. aeglefinus*, which was only recorded on the bank, is a more exclusive benthic feeder in comparison to other gadoids such as *M. merlangus* and *G. morhua* (Hislop et al., 1991; ICES, 1997), and the latter species were more evenly distributed in the study area. Therefore differences in feeding preferences may explain the contrasting distribution patterns of gadoids surrounding the bank.

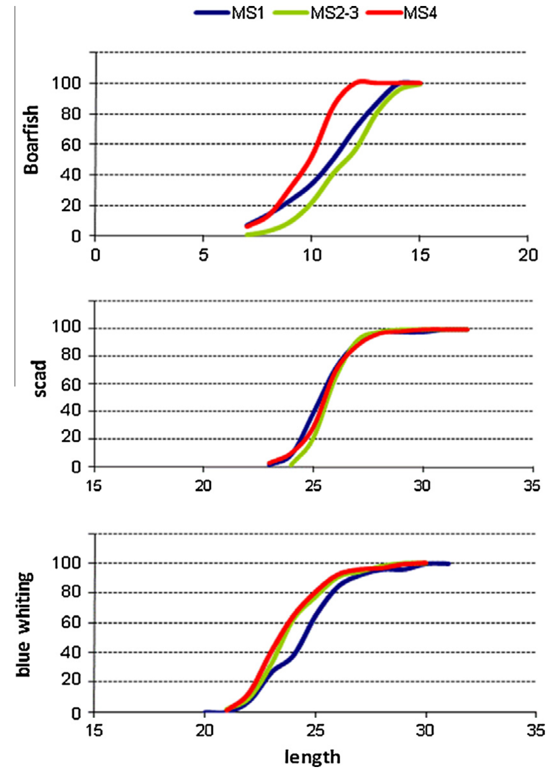

Fig. 8. Cumulative length-frequency distributions of boarfish *Capros aper*, scad *Trachurus trachurus* and blue whiting *Micromesistius poutassou*, observed in catches from the commercial fishing vessels *FV Crystal Sea* and FV *Imogen* at the top of Jones bank (MS1), on the slope (MS2) and off the bank (MS4).

Some flatfish, including *L. whiffiagonis* (the highest flatfish catch), *G. cynoglossus* and *S. solea*, did not show any clear distribution patterns and were caught in all three sampled sites. However *P. platessa*, a more coastal flatfish, was only caught on the top of the bank, possibly indicating bathymetry as an

Table 4
CPUE (kg h^{-1}) of fish and shellfish on the top of Jones Bank (MS1), on the slope (MS2) and off the bank (MS4-5) as observed on the demersal trawler *FV Crystal Sea* (cs) and the pelagic trawler *FV Imogen* (i) at Jones Bank during the 2008 survey.

Station	MS1	MS2	MS2	MS1	MS4	MS4	MS4	MS3	MS2	MS1	MS2	MS4	MS4	MS4	MS4
Species | vessel	cs1	cs2	cs3	cs4	cs5	cs6	cs7	i1	i2	i3	i4	i5	i6	i7	i8
Trachurus trachurus	198.8	18.9	25.1	83.5	17.1	9.0	3.3	4	2						
Capros aper	25.9	1.4	2.6	3.4	0.4	0.6	0.6	120	50	12	180		30		
Melanogrammus aeglefinus	101.2	5.0		69.6											
Merluccius merluccius	1.5	38.6	29.1	17.0	47.8	13.0	43.5								
Aspitrigla cuculus	2.7		0.3	1.7											
Eutrigla gurnardus	6.2	2.9	0.8	1.7	1.6	2.5	1.5								
Merlangius merlangus	8.0														
Loligo spp.	2.4	1.4	1.6	1.6	3.6	2.4	7.5								
Micromesistius poutassou	1.2	114.2	145.7	11.3	82.9	213.1	101.1								
Conger conger	12.2			0.5	12.9										
Argentina spp.	0.4		0.7	0.6		1.1									
Callionymus spp.	4.1														
Scomber scombrus	5.6	1.6	0.3	0.7				0.6							
Scyliorhinus canicula	1.9	9.2	12.9	12.9	46.4										
Lepidorhombus whiffiagonis	1.5	12.0	4.2	6.8	7.9	6.6	1.8								
Glyptocephalus cynoglossus	2.1		6.1	1.5	11.7	5.4	3.9								
Solea solea	1.5	1.7	0.5	1.4	0.8	0.1	3.3								
Pleuronectes platessa	5.5														
Zeus faber				2.9		1.0									
Lophius piscatorius		4.6	4.4	6.4	7.2										
Nephrops norvegicus		13.5	13.8	1.7	125.7	27.0	3.3								
Gadus morhua				2.2	21.7										
Trisopterus minutus		42.1	53.7	13.0	39.8	46.3	26.1								
Molva molva		2.6													
Rajidae (indet.)					1.6	1.9									

Table 5
Observations of fish species during BUC deployments, giving deployment date, sampling station (MS), species, maximum number of fish (N_{max}), the time elapsed from deployment ($T_{elap.}$, in minutes), time at N_{max} (GMT), day/night deployment (D/N), tidal state (neap (np) or spring (spr) tide) and speed in m s^{-1} (S) and direction (dir) of the current at the bottom at the time of N_{max}.

Deployment	Date	MS	Species	N_{max}	$T_{elap.}$	GMT	Light	Tide	S	dir
bc_03	12–13	MS4	*M. merlangus*	2	271	06:02	D	Np	0.18	325
			C. conger	1	144	03:35	N	Np	0.26	262
bc_04	14–15	MS1	*M. aeglefinus*	2	10	07:24	D	Np	0.10	312
			M. merlangus	1	48	08:02	D	Np	0.10	1
			E. gurnardus	1	277	11:51	D	Np	0.31	64
bc_05	15–16	MS3	*M. merlangus*	2	138	15:54	D	Np	0.18	85
			T. minutus	1	173	16:29	D	Np	0.15	120
			C. conger	1	576	23:10	N	Np	0.12	215
bc_06	17	MS3	*M. merlangus*	1	35	03:03	N	Np	0.28	46
			T. minutus	1	659	13:27	D	Np	0.32	23
			C. conger	1	266	06:54	D	Np	0.33	196
			E. gurnardus	1	407	09:15	D	Np	0.39	239
bc_07	18–19	MS5	*M. merlangus*	1	259	19:36	D	np/spr	0.23	202
			E. gurnardus	1	343	21:00	D	np/spr	0.37	236
			S. canicula	1	422	22:19	N	np/spr	0.36	237
bc_08	19	MS1	*M. aeglefinus*	1	112	18:31	D	spr	0.47	131
			M. merlangus	1	127	18:36	D	spr	0.46	132
			T. minutus	2	153	19:02	D	spr	0.46	142

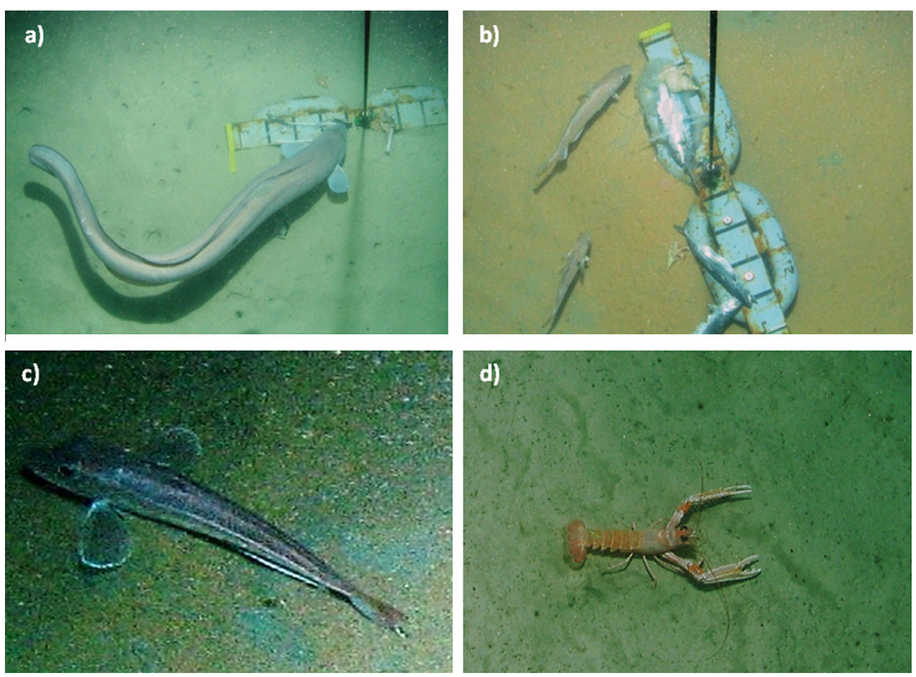

Fig. 9. Examples of fish and shellfish observed on Jones Bank during baited camera deployments, including (a) conger eel *Conger conger*; (b) whiting *Merlangius merlangus* and haddock *Melanogramus aeglefinus*; (c) grey gurnard *Eutrigla gurnardus*; (d) *Nephrops norvegicus*. The camera system ballast, scale (1 m) and bait (mackerel) are also seen shown (a and b).

important factor influencing their distribution (as was also indicated by the analyses of fish assemblages).

The abundance and activity of fish around the baited camera during the 2008 cruise were low compared with comparable work undertaken in the northern North Sea (Martinez et al., 2011) and only 18 fish observations (six species) were recorded at the Jones Bank. Short arrival times are expected in well populated areas or areas of fish concentration, such as reefs and sea mounts (Cappo et al., 2004). The relatively long arrival times observed in the present study (>2 h) were more comparable to those of deep sea fish (King, 2006) rather than shallow water species (Willis et al., 2000; Stoner et al., 2008). Earlier studies in deep water (>2000 m) showed that N_{max} can be low when fish were most abundant and with many other feeding opportunities (Priede et al., 1990). This however would not explain the long delay before the first fish arrived at the bait. The six fish species and *N. norvegicus* recorded accounted for 28% of the total of 25 species caught in the 2008 commercial trawl survey, and was slightly higher than the 20% reported by Priede et al. (2010) in deep water west of Ireland. Intra-specific competition and trophic guild may both induce baited visual methods to under-represent smaller individuals and non-scavenging species.

There are several hypotheses that may account for the low abundance of fish in the camera footage. Video and still footage showed fish approaching baits from downward current (following olfactory cues), but this behaviour could be modified by the

Table A1
Taxonomic list of fish and shellfish observed in the Celtic Sea during Cefas groundfish surveys (1982–2011) in quarter 1, quarter 4 or at both times of the year (B). It should be noted that some shellfish were not recorded consistently during the time series.

Family	Scientific name	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
		B	1	B	B	B	B	B	1	1	1	1	1	1	1	1	1	1	1	1	1	1	B	4	4	4	4	4	4	4	4
Petromyzonidae	*Lampetra fluviatilis*																														
	Petromyzon marinus																														
Hexanchidae	*Hexanchus griseus*					*																									
Lamnidae	*Lamna nasus*																											*			*
Scyliorhinidae	*Galeus melastomus*										*											*					*		*		
	Scyliorhinus canicula	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Scyliorhinus stellaris	*		*	*	*	*	*			*													*	*	*		*	*	*	*
Triakidae	*Galeorhinus galeus*	*	*	*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*	*		*	*	*	*	*
	Mustelus spp.				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Squalidae	*Squalus acanthias*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Dalatias licha																		*												
	Etmopterus spinax																*	*	*	*											
Torpedinidae	*Torpedo nobiliana*				*		*		*				*							*						*	*			*	
Rajidae	*Dipturus batis*			*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*			*	*	*	*	*
	Dipturus nidarosiensis				*											*															
	Dipturus oxyrinchus									*																					
	Leucoraja circularis		*								*																				
	Leucoraja fullonica	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*					*	*			*
	Leucoraja naevus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*
	Raja brachyura		*	*	*			*	*						*	*	*		*			*		*	*	*	*	*	*	*	*
	Raja clavata	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*
	Raja microocellata		*	*	*								*	*		*	*	*		*		*	*	*	*	*	*	*	*	*	*
	Raja montagui	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*
	Raja undulata								*																						
Dasyatidae	*Dasyatis pastinaca*												*											*							
Chimaeridae	*Chimaera monstrosa*																*	*	*												
Anguillidae	*Anguilla anguilla*	*	*					*																					*		
Congridae	*Conger conger*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Clupeidae	*Alosa alosa*	*													*	*	*	*		*					*						
	Alosa fallax			*										*	*													*			*
	Clupea harengus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Sprattus sprattus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Sardina pilchardus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Engraulis encrasicolus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Salmonidae	*Salmo salar*																*														
Argentinidae	*Argentina silus*	*	*																												
	Argentina sphyraena	*	*	*	*	*	*	*			*	*																			
	Argentina spp.				*				*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sternoptychidae	*Maurolicus muelleri*		*		*		*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Myctophidae	Myctophidae (indet.)																	*													
Macrouridae	*Malacocephalus laevis*																	*													
Gadidae	*Gadiculus argenteus*		*	*	*						*		*		*		*	*	*	*		*	*	*	*	*	*	*	*	*	*
	Gadus morhua	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Melanogrammus aeglefinus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Merlangius merlangus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Micromesistius poutassou	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Pollachius pollachius	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Pollachius virens	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*				*				
	Trisopterus esmarkii	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Trisopterus luscus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Trisopterus minutus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Raniceps raninus														*			*	*										*	*	
	Gadidae																			*											

Phycidae	*Phycis blennoides*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*
Lotidae	*Ciliata mustela*		*																							*	*			*		
	Ciliata septentrionalis				*																			*			*	*	*		
	Enchelyopus cimbrius				*							*		*	*	*	*	*			*	*		*	*		*	*	*	*	*
	Gaidropsarus vulgaris	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*				*	*	*	*	*	
	Gaidropsarus mediterraneus			*											*						*										
	Gaidropsarus macropthalmus														*																*
	Gaidropsarus spp.			*									*																		
	Molva molva	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Molva dypterygia	*																													
	Molva macrophthlma																											*			
Merluccidae	*Merluccius merluccius*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Carapidae	*Echiodon drummondi*						*									*		*													
Lophiidae	*Lophius piscatorius*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Lophius budegassa		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Lophius spp.	*																													
Belonidae	*Belone belone*		*	*			*									*			*					*						*	*
Scombersocidae	*Scomberesox saurus*																											*			
Bercyidae	*Beryx decadactylus*																		*												
	Beryx splendens																*	*	*	*											
Zeidae	*Zeus faber*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Caproidae	*Capros aper*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Macroramphosidae	*Macroramphosus scolopax*	*					*	*				*																			
Syngnthidae	*Entelurus aequoreus*																										*	*	*	*	
	Syngnathus acus						*	*													*				*	*	*	*	*	*	*
	Syngnathus rostellatus																													*	
	Syngnathidae (indet.)			*									*																		
Scorpaenidae	*Helicolenus dactylopterus*	*			*	*	*	*	*	*							*	*	*	*				*							
Triglidae	*Aspitrigla cuculus*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Eutrigla gurnardus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Trigla lucerna	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Trigloporus lastoviza												*	*	*	*	*	*		*		*	*							*	
Cottidae	*Taurulus bubalis*										*																				
Agonidae	*Agonus cataphractus*				*	*				*	*			*	*			*			*			*	*	*	*		*	*	*
Cyclopteridae	*Cyclopterus lumpus*																							*							
Liparidae	*Liparis liparis*																										*		*		
Moronidae	*Dicentrarchus labrax*	*	*	*		*	*	*			*		*	*	*	*			*		*	*	*	*	*	*	*	*	*	*	*
Carangidae	*Trachurus trachurus*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sparidae	*Pagellus bogaraveo*	*			*		*																	*							
	Boops boops																										*				
	Spondyliosoma cantharus	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*						*
Mullidae	*Mullus surmuletus*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cepolidae	*Cepola rubescens*											*	*		*		*	*						*	*	*	*	*	*	*	*
Mugilidae	Mugilidae (indet.)							*																							
Labridae	*Crenilabrus melops*																									*					
	Ctenolabrus rupestris					*							*		*	*	*			*		*			*	*	*	*	*	*	*
	Labrus bergylta				*																										
	Labrus mixtus	*				*											*										*	*	*		
Stichaidae	*Chirolophis ascanii*																							*			*				
Pholidae	*Pholis gunnellus*																								*						
Trachinidae	*Echiichthys vipera*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*
	Trachinus draco		*												*	*	*				*		*								
Blenniidae	*Blennius ocellaris*									*																*				*	
Ammodytidae	*Ammodytes tobianus*																								*			*			
	Ammodytes spp.	*							*									*	*	*											
Ammodytidae	*Gymnammodytes semisquamatus*																							*							
	Hyperoplus immaculatus																							*	*	*	*	*	*	*	*
	Hyperoplus lanceolatus														*											*	*	*	*	*	*
	Ammodytidae (inder)	*	*	*	*	*	*	*	*	*		*	*		*	*	*	*		*			*					*	*	*	*

(*continued on next page*)

Table A1 (*continued*)

Family	Scientific name	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
		B	1	B	B	B	B	B	1	1	1	1	1	1	1	1	1	1	1	1	1	1	B	4	4	4	4	4	4	4	4
Callionymidae	*Callionymus lyra*	*		*	*	*	*	*											*	*	*	*	*	*	*	*	*	*	*	*	*
	Callionymus maculatus			*		*	*														*	*	*	*	*	*	*	*	*	*	*
	Callionymus reticulatus				*			*																*			*		*		*
	Callionymidae (indet.)	*	*	*	*	*			*	*	*	*	*	*	*	*	*	*	*	*											
Gobiidae	*Aphia minuta*																										*				
	Buenia jeffreysii																					*					*	*	*	*	*
	Crystallogobius linearis																				*	*					*	*		*	
	Gobius gasteveni																					*				*					*
	Gobius spp.									*																					
	Lesueurigobius friesii																											*		*	
	Pomatoschistus norvegicus																					*									
	Pomatoschsitus spp.																								*	*	*	*	*	*	*
	Gobiidae (indet.)	*	*	*	*	*				*	*	*	*	*	*	*	*	*	*	*	*			*							
Scombridae	*Scomber scombrus*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Scophthalmidae	*Lepidorhombus boscii*						*		*	*	*	*			*		*	*	*	*								*			
	Lepidorhombus whiffiagonis		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Lepidorhombus spp.	*																													
	Psetta maxima		*	*	*			*			*			*	*								*	*	*	*	*	*	*	*	*
	Scophthalmus rhombus		*		*	*	*	*	*	*	*				*	*	*		*					*	*		*	*	*	*	*
	Phrynorhombus norvegius			*	*	*																*	*			*	*		*	*	*
	Phrynorhombus regius		*			*									*														*		
	Zeugopterus punctatus																												*		
Bothidae	*Arnoglossus imperialis*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Arnoglossus laterna	*	*	*	*	*	*			*			*		*	*						*		*	*	*	*	*	*	*	*
Pleuronectidae	*Glyptocephalus cynoglossus*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Hippoglossoides platessoides	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Limanda limanda	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Microstomus kitt	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Platichthys flesus				*							*	*			*		*		*		*	*					*	*	*	
	Pleuronectes platessa	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Soleidae	*Buglossidium luteum*				*	*									*						*	*	*	*	*	*	*	*	*	*	*
	Microchirus variegatus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Pegusa lascaris					*																	*	*	*	*	*	*	*	*	
	Solea solea	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Balistidae	*Balistes capriscus*																							*						*	
Bivalvia	*Pecten maximus*																					*		*						*	
Cephalopoda	*Sepia elegans*																							*		*		*	*	*	*
	Sepia officinalis																							*		*		*	*	*	*
	Sepia orbignyana																							*	*					*	
	Alloteuthis subulata				*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Loligo forbesi				*		*	*						*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Loligo vulgaris				*									*			*					*	*		*						
	Loligo spp.				*		*	*																							
	Loliginidae (indet.)				*	*	*	*	*	*	*	*	*			*															
	Illex illecebrosus						*	*							*		*	*	*			*		*	*	*	*	*	*	*	*
	Todarodes saggittatus							*									*	*			*			*							
	Todaropsis eblanae													*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Ommastrephidae (indet.)				*	*	*	*	*	*	*	*	*			*															
Crustacea	*Palinurus elephas*				*																										*
	Homarus gammarus				*												*		*			*		*		*	*		*	*	
	Nephrops norvegicus			*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Lithodes maia																												*		
	Maja brachydactyla																							*	*	*	*	*	*	*	*
	Cancer pagurus										*	*	*	*	*		*	*	*		*	*	*	*	*	*	*	*	*	*	*

presence of predators or, in case of juveniles, by adults of the same species (Martínez et al., unpublished data). The presence of large predatory fish, including *C. conger*, is thought to affect the behaviour of smaller fish species (Nickell and Sayer, 1998). *C. conger* are usually associated with rocky grounds and wrecks, and the large individuals (>1.5 m, Fig. 9) recorded in the Jones Bank area may have a large feeding territory. The presence of other predators, such as marine mammals, may have also influenced the occurrence of smaller fish species around the BUC. Although the influence of marine mammals in the presence of fish species around baited cameras has not been specifically studied during the 2008 cruise, JNCC (Joint Natural Conservation Committee) bird and marine mammals observers on the upper bridge of the vessel detected a few groups of common dolphin *Delphinus delphis* and an unidentified seal associated with trawlers in the Jones Bank area (A. Webb, JNCC, pers. comm.).

Another explanation for the low levels of fish activity detected with the BUC was the strength of the current. Previous studies have shown that current can be an important factor affecting fish feeding behaviour in the presence of a bait (Stoner, 2004; Onsrud et al., 2005; Heagney et al., 2007). The mean current speed at the bottom recorded during the study at the Jones Bank during the first 2 h of deployment (when the bait is most attractive) ranged from 0.15 to 0.34 cm s^{-1}, but only during one deployment was the mean current speed below 0.26 cm s^{-1}. As a result, the camera could have been deployed on a range of currents above an Effective Current Threshold where the search for food was not energetically efficient for fish under a certain body size. Finally, the Jones Bank area is regularly fished, and so the noise and disturbance of fishing activities may affect fish behaviour, or fishing activities (sea floor disturbance and exposure of benthic food and/or discarding) may provide concurrent opportunities for scavenging (Olaso et al., 2002), so reducing opportunistic feeding on a single bait source. Although noise levels associated with modern research vessels built under guidelines to diminish noise emissions (i.e. ICES, 2009) may be negligible in fish avoidance (Fernandes et al., 2000), it may still be important when fishing activity concentrates around a site such as the Jones Bank. Intense fishing activity can also modify flatfish availability to baited cameras. The flatfish species remain close to the seafloor during trawl herding and favour survival over feeding, so lowering activity rates (Ryer, 2008) that reduce the food search. In addition, some species like *L. Limanda* have been described to aggregate and actively feed on areas disturbed by demersal trawls (Kaiser and Ramsay, 1997) and consequently may be less available for the baited camera.

Analyses of VMS data have provided improved estimates of the distribution of fishing effort (Lee et al., 2010; Jennings and Lee, 2012). Recent VMS data for English-registered fishing vessels (>15 m in length) confirmed that gillnetters operated in the vicinity of the Jones Bank, although beam trawlers tended to operate further east. Data for other nations were unavailable, and improved coordination to collate international effort is required. In terms of gillnets, the degree of effort is more problematic to gauge from VMS data, as the numbers, types and soak times of gillnets deployed may be variable within a trip. More accurate information (e.g. with improved observer coverage, remote electronic monitoring (REM) and/or on-board cameras) would be required to better estimate the degree of fishing effort for fisheries that may target small-scale topographic features, such as sandbanks.

In this paper we described the fisheries and regional fish assemblages on the continental shelf of the Celtic Sea, and provided site-specific information on the ichthyofauna of the Jones Bank based on multiple sampling techniques. Although this description of the local species is only a snap-shot and does not take seasonality into account, the different selectivities of the sampling techniques allow a more holistic description of the local assemblages plus *in situ* observations of the marine fauna with the cameras. Results showed that the Jones Bank has an influence on the distribution of the local fish and invertebrate fauna (Ellis et al., 2013), which may relate to both the hydrodynamics associated with the bank and also the physical structure and topography of the bank and surrounding area.

However these processes can be masked by larger regional dynamics, like species shifting due to environmental changes (e.g. climate change). Although there is evidence of increase in water temperature at a global scale (IPCC, 2007) and in the European oceans (Holliday et al., 2008), the direct and indirect relationships between this increase and changes in the abundance and distribution of fish species may be difficult to disentangle from other natural and anthropogenic effects, including fisheries and habitat disturbance. Tasker, (2008) described the overall effect of climate change through variations in sea surface temperature may have over the abundance and distribution of marine species from zooplankton to seabirds in OSPAR areas II and III (North Sea and the Celtic Sea, respectively). Although climate change may not be directly accountable for such changes it is likely that has a large influence over some Lusitanian species, such as boarfish *C. aper*, which is an abundant, aggregating planktivore (Lopes et al., 2006). In this paper it has been shown that *C. aper* is influenced by the presence of the Jones Bank at a very local level. This species has increased its presence in the northern boundaries of its distribution, although such episodes may have periodically occurred before (Günther, 1889), and given their relative large abundance may have an important trophic role in the ecosystem (Lopes et al., 2006).

5. Conclusions

Multidimensional community analysis on the Celtic Sea fish community from scientific trawl surveys (2007–2010) showed four different assemblages. Around the Jones Bank, 46 fish species were recorded using data from diverse trawls surveys (2003–2010). The most abundant species included *S. scombrus* (in the spring), dogfish (including tope and spurdog), *C. aper*, *M. poutassou* and *T. esmarkii*. A dedicated survey of the Jones Bank in 2008 with commercial trawlers complemented with baited camera deployments recorded 25 species with *T. trachurus*, *M. poutassou*, *T. minutus*, *M. aeglefinus* and *M. merluccius* the most abundant species recorded in demersal trawl catches. *C. aper* was the main species sampled by pelagic trawl. More species were found on the top of the bank (23 species) in comparison to the slope and off-bank areas (18 species each). Offshore sandbanks can play an important role in structuring local fish assemblage and may allow for the dispersion of some more inshore species. Physical, oceanographic and biological factors can contribute to this small-scale distribution of the fish assemblages around the banks and multi-gear sampling can contribute to assess these factors. Further dedicated surveys on and around offshore banks are needed to establish differences in fish diversity between the single banks and adjacent areas with a survey design adequate to assess seasonal patterns in fish assemblages.

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Appendix A.

See Table A1.

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