# Report to the
# Department of Trade and Industry

# Fish and fish assemblages of the British Isles

2007

*This document was produced as part of the UK Department of Trade and Industry's offshore energy Strategic Environmental Assessment programme. The SEA programme is funded and managed by the DTI and coordinated on their behalf by Geotek Ltd and Hartley Anderson Ltd.*

# FISH AND FISH ASSEMBLAGES OF THE BRITISH ISLES

CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## EXECUTIVE SUMMARY

In recent years there have been several reports detailing the commercial fish species occurring in the Strategic Environmental Assessment (SEA) areas, and the fisheries operating in these areas. These reports have not examined other 'non-target' species of fish, which may also be sensitive to anthropogenic disturbances associated with the oil and gas industries, as well as other offshore industries.

This report intends to inform the assessment of the potential impact of the offshore oil and gas licensing rounds on non-target fish species, by providing information on the more frequently occurring non-target marine fish occurring around the British Isles, their distribution as indicated from national trawl surveys and their reproductive biology. Those fish species that are more typical of deep-water ecosystems have not been reviewed, as extensive information on these taxa is available in previous SEA reports (Gordon, 2003, 2006). Although many species of fish have been reported from the waters surrounding the British Isles (see Section 2.1), many of these species are occasional vagrants, and such taxa have also been excluded from the present report.

Most of the fish species described in this report have distributions that extend into offshore waters, and may thus be considered potentially vulnerable to human activities in this region. The majority of non-target fish species that are of recognised conservation importance tend to be more coastal, and occur in greatest abundance in relatively shallow coastal water. The allis shad and twaite shad, and the lampreys (*L. fluviatilis and P. marinus*) are diadramous, making spawning migrations into freshwater habitats, and occupying estuarine and inshore waters to feed. The offshore habits of many of these rare, diadramous species are poorly known. Whitefish (Coregonids) are related to the salmon family and are distributed almost exclusively in lakes and rivers of northwest Europe, but may enter brackish and coastal waters in parts of the North Sea. Two species of goby, the giant goby and Couch's goby, are considered rare in the coastal waters of the British Isles, but have not been recorded in more offshore waters.

There are a number of human activities around the British Isles which have the potential to impact fish populations. These include both the direct and indirect effects of commercial fish exploitation, the input of contaminants and nutrients from land, the input of oil and PAHs from land and by the offshore oil and gas industry, and the input of oil, PAHs and antifoulants by shipping. The OSPAR Quality Status Report of the North Sea (OSPAR 2000) identified the extraction and transport of oil and gas by the offshore oil and gas industry as a priority human activity that can impact on the marine environment, and this report focuses on the implications for non-target fish species of continued exploration and production of oil and gas.

The report covers English and Welsh Continental Shelf waters, which includes the mature oil and gas fields of the Southern and Central North Sea, the English Channel and the Irish Sea. It describes the non-target fish resources of the region (i.e. spawning grounds, nursery areas, and the distribution of adult fish), so that regions where these may be adversely affected by oil and gas exploration and production can be identified. The report also summarises the most important consequences of oil and gas exploration for non-target fish populations, such as the use of seismic surveys and the placement of structures on the seabed.

Most of the fish species described in this report spawn in the spring and summer, although some species spawn outside this period. The main spawning periods of the non-target fish species discussed in this report are summarised. Spawning areas and nursery grounds for some fish species are dynamic features of life history and may not be fixed in one location from year to year, especially in the case of some pelagic species. Thus, while some species appear to have similar patterns of distribution from one year to the next, others show greater variability. These variations can be influenced by natural biotic and abiotic factors, such as hydrographic conditions and temperature, or by the distribution of their prey items.

Descriptions of the egg, larval and adult fish distributions discussed in this report were prepared from scientific surveys in UK waters. The combined distribution of spring-spawning fish species shows that the greatest spawning activity occurs in coastal waters, the more southerly stocks in the Channel and southwest beginning their spawning seasons earlier than those in the North Sea.

## 1. INTRODUCTION

It is important to ensure that all users of the sea are managed in an environmentally sustainable way (OSPAR 2000). The offshore oil and gas industry has become a major economic activity in UK waters since the late 1960s and during the 1990s oil production almost doubled. There are now almost 280 oil and gas platforms and installations on the UK continental shelf and 14.373 kilometres of rigid and flexible oil and gas pipelines running between offshore production wells and terminals on land (DTI oil and gas website – *http://og.dti.gov.uk*). There are a number of ways in which offshore oil and gas exploration and production may impact fish populations, including the high energy sound sources used in seismic surveys to locate the geological structures associated with hydrocarbon deposits, the impact on the seabed of drill cuttings at well sites, and the potential impact of hydrocarbon spills. The presence of the hard substrates associated with oil rigs and pipelines can also affect the biological environment, with subsequent colonisation of hard substrata by sessile invertebrates, and various epibenthic invertebrates and fish can be attracted to such structures (e.g. Jorgensen *et al*., 2002; Lokkeborg *et al*., 2002; Soldal *et al*., 2002), whether this be for seeking food and/or shelter.

### *1.1 Seismic surveys*

For fish populations, particularly for species with swim bladders, studies have suggested that the use of air gun arrays used in seismic surveys could affect fish behaviour, including spawning periods, over relatively large areas, and for several days after completion of the survey. It is not considered necessary in this report to complete a review of the effects of underwater acoustic noise on fish, as this subject has been discussed by several authors (e.g. Engas *et al.*, 1993; Turnpenny and Nedwell, 1994; Carter & Hall, 1998; Wardle *et al.*, 1998; Popper *et al.,* 2004). Although the impacts of seismic activity outside the spawning season will be largely transient, resulting only in the temporary redistribution of fish, this effect could be more serious during the spawning season and may lead to the severe disruption of spawning activity. Furthermore, although adult fish may move away from anthropogenic noise disturbance, the impacts of noise on egg and larval stages are poorly known. To minimise these risks, The Fisheries Departments apply licence conditions to prevent seismic surveys during specified periods of the year in certain UK Blocks. These controls have been used effectively for the last decade, and are reviewed regularly, and it is probable that underwater noise produced by the offshore industry now has only a minor impact on fish populations.

During each round of offshore licensing, Government Departments and their Agencies recommend appropriate conditions and restrictions on each Block to minimize the potential environmental impact during drilling and seismic activity on fish, sea birds, marine habitats or interference with other sea users. The Offshore Petroleum Production and Pipelines Regulations (1999) (as amended 2007) require operators to submit an Environmental Statement for all new offshore developments or to obtain a dispensation from this requirement, and the Petroleum Act (1998) requires a consent to discharge chemically treated water used during pipeline commissioning, and this details the permitted volume, the chemical constituents, and rate of discharge.

### *1.2 Cuttings disposal*

The contaminant composition of drilling wastes has changed significantly over the last few decades, in response to technical and regulatory developments. Previous widespread and substantial discharges of oil-based muds, and later synthetic oil muds, have been superseded by alternative disposal methods (either containment and onshore treatment, or reinjection) or by water-based muds (WBM), which can generally be left on site.

In relatively shallow and dispersive waters such as the southern North Sea, it is generally considered that cuttings do not accumulate at the well site but are transported away from the platform and dispersed naturally. WBM released into the water column becomes separated from the cuttings and is diluted, and rock particles in the water column are unlikely to be distinguishable from natural suspended solids. The most common effect of the WBM is an elevation of barium (commonly used as a weighting agent in WBM) concentrations in the sediments, which may extend up to 1,000 m from the drilling location along the predominant tidal axis. Barium is persistent in sediments, in the form of barium sulphate or carbonate, which are essentially insoluble and therefore inert.  In certain circumstances, including where local environmental sensitivities require this (e.g. where scallop beds are present), alternatives such as calcium carbonate may be used.

In deeper, low-energy water, physical changes attributable to drilling discharges can be more long lasting. Effects of WBM cuttings piles on bottom living biological communities are caused mainly by burial and low sediment oxygen concentrations caused by organic enrichment. The toxicity of cuttings piles from drilling with oil based muds (as used to occur in the North Sea) was much greater although those that remain are now generally inert as long as they remain undisturbed.  Recovery of benthic communities from burial and organic enrichment occurs by recruitment of new colonists from planktonic larvae and immigration from adjacent undisturbed sediments. Ecological recovery usually begins shortly after completion of drilling and often is well advanced within a year. Whilst there have been a large number of studies of the site-specific impact of contaminants on benthic fauna, there have been fewer describing the impact of cuttings on fish populations (e.g. Stagg & McIntosh 1996), or the secondary effects on populations through loss of feeding areas (see Hartley *et al.* (2003) for a review of food chain impacts of drill cuttings).

### 1.3 Hydrocarbon spills

The damage caused to the marine environment by an accidental release of oil, condensate or diesel depends on a number of factors, including the size of the spill, the characteristics of the hydrocarbon, the prevailing weather conditions, and the proximity of sensitive populations. Both diesel and condensate are liquids of low viscosity, and when spilt at sea spread rapidly on the sea surface and disperse. The accidental release of oil presents a greater risk, particularly in the event of an oil well blow-out in which the hydrocarbons cannot be contained. There have been no such incidents during drilling activity in UK waters to date (the only significant blowouts on the UKCS to date have been from West Vanguard (1985) and Ocean Odyssey (1988), both involving gas).

Legislation prohibits the discharge of oil to the sea from installations and pipelines, and it is now a requirement for all operators to have an effective response procedure in the form of an oil spill contingency plan. The International Maritime Organisation (IMO), an agency of the United Nations dealing with maritime safety and the prevention of marine pollution, has actively promoted the protection of Special Areas. All hydrocarbon spills have the potential to affect fish populations by tainting, caused by ingestion of hydrocarbon residues in the water column and on the seabed. If large-scale releases of oil were to reach the seabed then there is potential for smothering of features that are used by fish as spawning, feeding or nursery grounds. In the case of hydrocarbon spills, there are potential mitigation measures such as the use of dispersants, although these chemicals can also be toxic to fish (e.g. Koyama & Kakuno, 2004) and dispersants may increase the uptake of polycyclic aromatic hydrocarbons (PAH) by fish in lower salinity, coastal waters (Ramachandran *et al*., 2006).

### 1.4 Layout of the report

The report is divided into four main parts. Section 2 describes the background to the selection of species considered in this report, and discusses other works and reports on species outside the scope of this report. Section 3 describes ichthyofaunal surveys in the North Sea, English Channel, Irish Sea, Bristol Channel and Celtic Sea, with particular emphasis on the distribution of spawning grounds and nursery areas. Section 4 describes briefly the fish assemblages and communities on the UK continental shelf, and Section 5 summarises the distribution and biology of the more common non-target species. The final part of the report, Section 6 summarises the most important consequences of oil and gas exploration for fish populations, focusing on the use of seismic surveys during exploration, and the placement of structures such as well heads and pipelines on the sea bed, and the potential impact these may have on fish populations.

### *1.5 Quality of the data*

The quality of this report depends to a large extent on the accuracy of the data that are used to describe the distribution of fish populations. Routine annual research vessel surveys are undertaken by European Research Laboratories. These are co-ordinated by the International Council for the Exploration of the Sea (ICES), and target major commercial species but also record information on the distribution and abundance of the non-target components of the catch. Much of the information available from these surveys has already been published in the scientific literature and, as a result of the peer review process, conforms to an acknowledged standard. Descriptions of the distribution and seasonal abundance of eggs, larvae, juvenile and adult fish from these sources are generally accurate and reliable. However, despite several decades of monitoring in the marine environment, precise details of the life history of some non-target species is still lacking. For example, because the timing and duration of trawl and plankton surveys are planned to provide the best coverage of the spawning activity of cod, plaice and other commercial species in the Irish and North Seas, species that occur only partially within or outside the survey area or period will not be fully described. It is thus important to realise that survey data gives a snapshot of the distribution of a species in a particular region at a particular time. It should also be recognised that Cefas trawl surveys use a variety of gears, including beam trawls and various configurations of otter trawl (see Sections 3.1 and 3.2), and these will have different catchabilities for the various species and life-history stages. For example, beam trawls are effective for sampling small and medium-sized flatfish and other demersal species, but are not effective for sampling larger gadoids or pelagic fish. Conversely, the otter trawl surveys conducted by Cefas target gadoids, can catch large numbers of pelagic species and are less effective for the smallest demersal fish species.

The maps in this report describe the overall distribution of species as collected over a number of years. While higher resolution data from a single survey would be more accurate, this may not fully describe the distribution of that species in other years. Where possible, the quality of the data used in each section of the report has been assessed and is described in the text.

# 2. BRITISH FISHES

## *2.1 Background*

The fishes of the British Isles have been subject to several major works over the last 170 years, with overviews of the regional fishes given by Yarrell (1836), Couch (1864), Day (1880–1884), Jenkins (1925), Wheeler (1969, 1978, 1992), Whitehead et al (1984–1986) and Lythgoe & Lythgoe (1991). Ichthyologists from neighbouring nations have also provided useful accounts of European marine fishes (e.g. Moreau, 1881–1891; Lozano Rey, 1928–1960; Nobre, 1935; Poll, 1947; Tortonese, 1956–1975; Bauchot & Pras, 1980; Muus *et al.*, 1998; Quero *et al.*, 2003). In addition to these major treatises, there are many scientific articles that expand on the regional ichthyofauna from specific surveys (see Section 4), or provide information on records of rare and unusual fish species (Wheeler *et al.*, 2004).

More than 300 species of fish have been reported from the British Isles, though these include many vagrants, some of which are known from only a few individual specimens, and there are many other species that occur in deeper waters off the continental shelf. The species of marine fish that have been reported from the continental shelf of the British Isles, and some of the more commonly occurring species on the shallower waters along the edge of the continental shelf are listed in Table 2.1.

*Table 2.1: List of fishes from the British Isles. Adapted from Wheeler (1992), Wheeler et al (2004) and Edwards & Davis (1997).*

| Order | Family | Species | Common name | Comments |
|---|---|---|---|---|
| Myxiniformes | Myxinidae | *Myxine glutinosa* | Hagfish | See Section 5.1 |
| Petromyzontiformes | Petromyzontidae | *Lampetra fluviatilis* | River lamprey | See Section 5.2 |
| | | *Petromyzon marinus* | Sea lamprey | See Section 5.2 |
| Chimaeriformes | Chimaeridae | *Chimaera monstrosa* | Rabbit fish | Deep-water: see Gordon (2006) |
| Hexanchiformes | Chlamydoselachidae | *Chlamydoselachus anguineus* | Frilled shark | Deep-water: see Gordon (2006) |
| | Hexanchidae | *Hexanchus griseus* | Six-gilled shark | Deep-water: see Gordon (2006) |
| | | *Heptranchias perlo* | Seven-gilled shark | Deep-water: see Henderson & Williams (2001). |
| Lamniformes | Alopiidae | *Alopias vulpinus* | Thresher shark | Vagrant: See Ellis (2004) |
| | | *Alopias superciliosus* | Big-eyed thresher shark | Vagrant: See Thorpe (1997) |
| | Cetorhinidae | *Cetorhinus maximus* | Basking shark | See Gordon (2003, 2006) |
| | Lamnidae | *Isurus oxyrinchus* | Mako shark | Vagrant |
| | | *Lamna nasus* | Porbeagle shark | Commercial: see Gordon (2003, 2006) |
| Carcharhiniformes | Scyliorhinidae | *Galeus melastomus* | Blackmouthed dogfish | Deep-water: see Gordon (2006) |
| | | *Scyliorhinus canicula* | Lesser-spotted dogfish | see Gordon (2006) See Section 5.3 |
| | | *Scyliorhinus stellaris* | Nurse hound | See Section 5.3 |
| | Pseudotriakidae | *Pseudotriakis microdon* | False catshark | Deep-water |
| | Triakidae | *Galeorhinus galeus* | Tope shark | See Section 5.4 |
| | | *Mustelus asterias* | Starry smooth hound | See Section 5.4 |
| | | *Mustelus mustelus* | Smooth hound | See Section 5.4 |
| | Carcharhinidae | *Prionace glauca* | Blue shark | Pelagic |
| | Sphyrnidae | *Sphyrna zygaena* | Common hammerhead | Vagrant |
| Squaliformes | Squalidae | *Centrophorus squamosus* | Leafscale gulper shark | |
| | | *Centroscymnus coelolepis* | Portuguese dogfish | |
| | | *Centroscymnus crepidater* | Longnose velvet shark | |
| | | *Dalatias licha* | Darkie charlie | |
| | | *Deania calceus* | Shovelnosed shark | Deep-water, some species commercial: see Gordon (2003, 2006) |
| | | *Etmopterus princeps* | Greater lantern shark | |
| | | *Etmopterus spinax* | Velvet belly | |
| | | *Scymnodon ringens* | Knifetooth dogfish | |
| | | *Somniosus microcephalus* | Greenland shark | |
| | | *Squalus acanthias* | Spurdog | Commercial: see Gordon (2003, 2006) |

*Table 2.1 Continued*

| Order | Family | Species | Common name | Comments |
|---|---|---|---|---|
| Squaliformes | Oxynotidae | *Oxynotus centrina* | Angular rough-shark | Deep-water |
| | | *Oxynotus paradoxus* | Sailfin rough-shark | Deep-water |
| | Echinorhinidae | *Echinorhinus brucus* | Bramble shark | Deep-water |
| Squatiniformes | Squatinidae | *Squatina squatina* | Angel shark | See Section 5.5 |
| Torpediniformes | Torpedinidae | *Torpedo nobiliana* | Common electric ray | Vagrant |
| | | *Torpedo marmorata* | Marbled electric ray | Vagrant |
| Rajiformes | Rajidae | *Bathyraja spinicauda* | Spinetail ray | Deep-water |
| | | *Amblyraja hyperborea* | Arctic skate | |
| | | *Amblyraja radiata* | Starry ray | |
| | | *Dipturus batis* | Common skate | |
| | | *Dipturus nidarosiensis* | Black skate | |
| | | *Dipturus oxyrinchus* | Long-nose skate | |
| | | *Leucoraja circularis* | Sandy ray | |
| | | *Leucoraja fullonica* | Shagreen ray | Commerical group: see Gordon (2003, 2006), ICES (2006b,c) |
| | | *Leucoraja naevus* | Cuckoo ray | |
| | | *Raja brachyura* | Blonde ray | |
| | | *Raja clavata* | Thornback ray | |
| | | *Raja microocellata* | Painted ray | |
| | | *Raja montagui* | Spotted ray | |
| | | *Raja undulata* | Undulate ray | |
| | | *Rajella fyllae* | Round skate | |
| | | *Rostroraja alba* | White skate | |
| Myliobatiformes | Myliobatidoidei | *Myliobatis aquila* | Eagle ray | Vagrant |
| | Dasyatidae | *Dasyatis pastinacus* | Sting ray | Vagrant |
| | | *Pteroplatytrygon violacea* | Pelagic stingray | Vagrant: see Ellis (In press) |
| | Mobulidae | *Mobula mobular* | Devil ray | Vagrant |
| Acipenseriformes | Acipenseridae | *Acipenser sturio* | Sturgeon | Rare/vagrant: see ICES (2003) |

*Table 2.1 Continued*

| Order | Family | Species | Common name | Comments |
|---|---|---|---|---|
| Elopiformes | Megalopidae | *Megalops atlanticus* | Tarpon | Vagrant |
| Notacanthiformes | Notacanthidae | *Notacanthus bonapartei* | Spiny eel | Deep-water |
| | | *Notacanthus chemnitzii* | Chemnitz's spiny-eel | Deep-water |
| Anguilliformes | Anguillidae | *Anguilla anguilla* | European eel | See Section 5.6 |
| | Muraenidae | *Muraena helena* | Moray eel | Vagrant |
| | Nemichthyidae | *Avocettina infans* | Snipe eel | Deep-water |
| | | *Nemichthys scolopaceus* | Snipe eel | Deep-water |
| | Congridae | *Conger conger* | European conger eel | See Section 5.6 |
| Clupeiformes | Clupeidae | *Alosa alosa* | Allis shad | See Section 5.7 |
| | | *Alosa fallax* | Twaite shad | See Section 5.7 |
| | | *Clupea harengus* | Herring | Commercial: see Rogers & Stocks (2001) & Gordon (2003, 2006) |
| | | *Sprattus sprattus* | Sprat | Commercial: see Rogers & Stocks (2001) & Gordon (2003, 2006) |
| | | *Sardina pilchardus* | Pilchard | See Section 5.7 |
| | Engraulididae | *Engraulis encrasicolus* | European anchovy | See Section 5.7 |
| Salmoniformes | Argentinidae | *Argentina silus* | Greater silver smelt | Deep-water commercial: see Gordon (2006) |
| | | *Argentina sphyraena* | Lesser silver smelt | See Section 5.8 |
| | Alepocephalidae | *Alepocephalus bairdii* | Baird's smoothhead | Deep-water: see Gordon (2006) |
| | | *Alepocephalus rostratus* | Risso's smoothhead | Deep-water |
| | | *Xenodermichthys copei* | Bluntsnout smoothhead | Deep-water |
| | Osmeridae | *Osmerus eperlanus* | Smelt (sparling) | See Section 5.8 |
| | Salmonidae | *Coregonus lavaretus* | Houting | Rare species: see ICES (2003) |
| | | *Oncorhynchus gorbuscha* | Humpback salmon | Vagrant |
| | | *Oncorhynchus kisutch* | Coho salmon | Non-native species |
| | | *Salmo salar* | Atlantic salmon | Target species |
| | | *Salmo trutta* | Trout | Target species |
| Stomiiformes | Sternoptychidae | *Argyropelecus hemigynus* | Hatchet fish | Deep-water |
| | | *Argyropelecus olfersi* | Hatchet fish | Deep-water |
| | | *Maurolicus muelleri* | Pearlside | Deep-water |
| | | *Sternoptyx diaphana* | Hatchet fish | Deep-water |

*Table 2.1 continued*

| Order | Family | Species | Common name | Comments |
|---|---|---|---|---|
| Aulopiformes | Paralepididae | *Paralepis coregonoides* | Barracudina | Deep-water pelagic vagrant |
| | Alepisauridae | *Alepisaurus ferox* | Longnose lancetfish | Bathypelagic vagrant |
| Gadiformes | Moridae | *Lepidion eques* | - | Deep-water |
| | Gadidae | *Gadiculus argenteus* | Silvery pout | See Section 5.9 |
| | | *Gadus morhua* | Cod | Commercial: see Rogers & Stocks (2001) & Gordon (2003, 2006) |
| | | *Melanogrammus aeglefinus* | Haddock | Commercial: see Rogers & Stocks (2001) & Gordon (2003, 2006) |
| | | *Merlangius merlangus* | Whiting | Commercial: see Rogers & Stocks (2001) & Gordon (2003, 2006) |
| | | *Micromesistius poutassou* | Blue whiting | Commercial: see Gordon (2003, 2006) |
| | | *Pollachius pollachius* | Pollack | See Section 5.9 |
| | | *Pollachius virens* | Saithe | Commercial: see Rogers & Stocks (2001) & Gordon (2003, 2006) |
| | | *Trisopterus esmarki* | Norway pout | Commercial: see Rogers & Stocks (2001) & Gordon (2003, 2006) |
| | | *Trisopterus luscus* | Bib | See Section 5.9 |
| | | *Trisopterus minutus* | Poor cod | See Section 5.9 |
| | | *Antonogadus macropthalmus* | Bigeye rockling | Deep-water |
| | | *Ciliata mustela* | 5-bearded rockling | |
| | | *Ciliata septentrionalis* | Northern rockling | |
| | | *Gaidropsarus mediterraneus* | Shore rockling | See Section 5.10 |
| | | *Gaidropsarus vulgaris* | 3-bearded rockling | |
| | | *Enchelyopus cimbrius* | 4-bearded rockling | |
| | | *Brosme brosme* | Tusk | Commercial: see Gordon (2003, 2006) |
| | | *Molva dypterygia* | Blue ling | Commercial: see Gordon (2003, 2006) |
| | | *Molva macrophthalma* | Spanish ling | Commercial: see Gordon (2003, 2006) |
| | | *Molva molva* | Common ling | Commercial: see Gordon (2003, 2006) |
| | | *Onogadus argentatus* | Arctic rockling | Northern vagrant |
| | | *Phycis blennoides* | Greater forkbeard | Commercial: see Gordon (2006) |
| | | *Raniceps raninus* | Tadpole fish | See Section 5.10 |
| | Merlucciidae | *Merluccius merluccius* | European hake | Commercial: see Gordon (2006) |

*Table 2.1 continued*

| Order | Family | Species | Common name | Comments |
|---|---|---|---|---|
| Gadiformes | Macrouridae | *Coelorinchus coelorhinchus* | Hollow nosed rattail | Deep-water |
| | | *Coryphaenoides rupestris* | Roundhead rat-tail | Deep-water commercial: see Gordon (2006) |
| | | *Malacocephalus laevis* | Softhead rat-tail | Deep-water |
| | | *Macrourus berglax* | Rough rat-tail | Deep-water commercial: see Gordon (2003, 2006) |
| | | *Nematonurus armatus* | Armoured rat-tail | Deep-water |
| | | *Nezumia aequalis* | Smooth rat-tail | Deep-water |
| | | *Trachyrhynchus trachyrhynchus* | Roughsnout rat-tail | Deep-water |
| Ophidiiformes | Ophidiidae | *Ophidion barbatum* | Snake blenny | Deep-water |
| | Carapidae | *Echiodon drummondi* | Pearlfish | Deep-water |
| Lophiiformes | Lophiidae | *Lophius budegassa* | White-anglerfish | Commercial: see Gordon (2003, 2006) |
| | | *Lophius piscatorius* | Anglerfish (monk) | Commercial: see Rogers & Stocks (2001) & Gordon (2003, 2006) |
| | Antennariidae | *Antennarius radiosus* | Big-eye frogfish | Deep-water |
| | Ceratiidae | *Ceratias holboelli* | Deep-sea anglerfish | Deep-water |
| | Himantolophidae | *Himantolophus groenlandicus* | Atlantic football fish | Deep-water |
| Gobiesociformes | Gobiesocidae | *Apletodon dentatus* | Small-headed clingfish | See Section 5.11 (for family) |
| | | *Diplecogaster bimaculata* | Two spotted clingfish | |
| | | *Lepadogaster candollei* | Connemarra clingfish | |
| | | *Lepadogaster lepadogaster* | Shore clingfish | |
| Cyprinodontiformes | Exocoetidae | *Cypselurus heterurus* | Atlantic flying fish | Vagrant |
| | | *Exocoetus volitans* | Two-wing flyingfish | Vagrant |
| | | *Hirundichtyhys speculiger* | Mirrorwing flying fish | Vagrant |
| | Belonidae | *Belone belone* | Garfish | See Section 5.12 |
| | | *Belone svetovidovi* | Short-beaked garfish | Little-known species: see Swaby *et al.* (1992) |
| | Scomberesocidae | *Scomberesox saurus* | Saurey pike | Pelagic vagrant |
| Atheriniformes | Atherinidae | *Atherina boyeri* | Big-scale sandsmelt | Inshore/estuarine |
| | | *Atherina presbyter* | Sand smelt | Inshore/estuarine |
| Lampriformes | Lampridae | *Lampris guttatus* | Opah (moon-fish) | Vagrant |
| | Trachipteridae | *Trachipterus arcticus* | Deal fish | Vagrant |
| | Regalecidae | *Regalecus glesne* | Ribbon fish | Vagrant |

*Table 2.1 continuedv*

| Order | Family | Species | Common name | Comments |
|---|---|---|---|---|
| Beryciformes | Trachichthyidae | *Hoplostethus mediterraneus* | Rough fish | Deep-water commercial: see Gordon (2006) |
| | Diretmidae | *Diretmus argenteus* | | Deep-water |
| | Berycidae | *Beryx decadactylus* | Beryx | Deep-water |
| | | *Beryx splendens* | Lowe's beryx | Deep-water |
| | Holocentridae | *Holocentrus adscensionis* | Squirrel fish | Vagrant |
| Zeiformes | Zeidae | *Cyttopsis roseus* | Red dory | Vagrant |
| | | *Zenopsis conchifer* | Sailfin dory | Vagrant |
| | | *Zeus faber* | John dory | See Section 5.13 |
| | Caproidae | *Capros aper* | Boar fish | See Section 5.13 |
| Gasterosteiformes | Gasterosteidae | *Gasterosteus aculeatus* | 3-spined stickleback | Inshore/estuarine |
| | | *Pungitius pungitius* | 10-spined stickleback | Inshore/estuarine |
| | | *Spinachia spinachia* | Sea stickleback | Inshore/estuarine |
| Syngnathiformes | Macrorhamphosidae | *Macrorhamphosus scolopax* | Snipe-fish | Vagrant |
| | Syngnathidae | *Entelurus aequoreus* | Snake pipefish | |
| | | *Hippocampus hippocampus* | Short snouted sea horse | |
| | | *Hippocampus ramulosus* | Sea horse | |
| | | *Nerophis lumbriciformis* | Worm pipefish | See Section 5.14 (for family) |
| | | *Nerophis ophidion* | Straight-nosed pipefish | |
| | | *Syngnathus acus* | Great pipefish | |
| | | *Syngnathus rostellatus* | Nilsson's pipefish | |
| | | *Syngnathus typhle* | Deep-snouted pipefish | |
| Dactylopteriformes | Dactylopteridae | *Dactylopterus volitans* | Flying gurnard | Vagrant: see Quigley *et al.* (2004) |
| Scorpaeniformes | Scorpaenidae | *Helicolenus dactylopterus* | Blue-mouth redfish | Deep-water |
| | | *Scorpaena porcus* | Small-scaled scorpionfish | Deep-water |
| | | *Scorpaena scrofa* | Red scorpion fish | Deep-water |
| | | *Sebastes norvegicus* | Norway haddock | Deep-water commercial: see Gordon (2003) |
| | | *Sebastes viviparus* | Redfish | Deep-water commercial: see Gordon (2003) |
| | | *Trachyscorpia cristulata* | | Deep-water |

*Table 2.1 continued*

| Order | Family | Species | Common name | Comments |
|---|---|---|---|---|
| Scorpaeniformes | Triglidae | *Aspitrigla cuculus* | Red gurnard | See Section 5.15 |
| | | *Aspitrigla obscura* | Long-finned gurnard | Vagrant, more common further south |
| | | *Eutrigla gurnardus* | Grey gurnard | See Section 5.15 |
| | | *Trigla lucerna* | Tub gurnard | See Section 5.15 |
| | | *Trigla lyra* | Piper | Rare in UK waters |
| | | *Trigloporus lastoviza* | Streaked gurnard | See Section 5.15 |
| | Peristediidae | *Peristedion cataphractum* | Armed gurnard | Vagrant |
| | Cottidae | *Artediellus atlanticus* | Atlantic hook-ear sculpin | Northern vagrant |
| | | *Icelus bicornis* | Two-horn sculpin | Northern vagrant |
| | | *Myoxocephalus scorpius* | Bullrout | |
| | | *Taurulus bubalis* | Sea scorpion | See Section 5.16 |
| | | *Taurulus lilljeborgi* | Norway bullhead | |
| | | *Triglops murrayi* | Sculpin | |
| | Agonidae | *Agonus cataphractus* | Pogge (armed bullhead) | See Section 5.16 |
| | Cyclopteridae | *Cyclopterus lumpus* | Lumpsucker | See Section 5.17 |
| | | *Liparis liparis* | Sea snail | See Section 5.17 |
| | | *Liparis montagui* | Montagu's seasnail | |
| Perciformes | Percichthyidae | *Dicentrarchus labrax* | European seabass | See Section 5.18 |
| | | *Dicentrarchus punctatus* | Spotted sea bass | Vagrant, more common further south |
| | | *Polyprion americanus* | Wreck-fish | See Section 5.18 |
| | Serranidae | *Callanthias ruber* | Parrot sea perch | Southern vagrant |
| | | *Epinephelus guaza* | Dusky perch (grouper) | Southern vagrant |
| | | *Serranus cabrilla* | Comber | Southern vagrant |
| | Apogonidae | *Epigonus telescopus* | Bulls-eye | Deep-water |
| | Pomatomidae | *Pomatomus saltatrix* | Bluefish | Vagrant |
| | Echeneididae | *Phtheirichthys lineatus* | Lousefish | Vagrant |
| | | *Remora remora* | Shark sucker | Vagrant |
| | Coryphaenidae | *Coryphaena hippurus* | Common dolphin fish | Vagrant |

*Table 2.1 continued:*

| Order | Family | Species | Common name | Comments |
|---|---|---|---|---|
| Perciformes | Carangidae | *Campogramma glaycos* | Vadigo | Vagrant |
| | | *Caranx chrysos* | Blue runner | Vagrant |
| | | *Naucrates ductor* | Pilot fish | Vagrant |
| | | *Seriola carpenteri* | Guinean amberjack | Vagrant |
| | | *Seriola dumerili* | Amberjack | Vagrant |
| | | *Seriola rivoliana* | Almaco jack | Vagrant |
| | | *Trachinotus ovatus* | Derbio | Vagrant |
| | | *Trachurus trachurus* | Horse-mackerel (scad) | Commercial: see Gordon (2003, 2006) |
| | Bramidae | *Brama brama* | Rays bream (pomfret) | See Section 5.19 |
| | | *Pterycombus brama* | Silver pomfret | Vagrant |
| | | *Taractes asper* | Rough pomfret | Vagrant |
| | | *Taractichthys longipinnis* | Long-finned bream | Vagrant |
| | Sparidae | *Boops boops* | Bogue | Vagrant |
| | | *Dentex dentex* | Dentex | Vagrant |
| | | *Dentex maroccanus* | Morocco dentex | Vagrant |
| | | *Diplodus cervinus* | Zebra sea-bream | Vagrant |
| | | *Diplodus sargus* | White sea-bream | Vagrant |
| | | *Oblada melanura* | Saddled bream | Vagrant |
| | | *Pagellus acarne* | Auxillary sea-bream | Vagrant |
| | | *Pagellus erythrinus* | Pandora | Vagrant |
| | | *Pagrus pagrus* | Redtail porgy | Vagrant |
| | | *Sarpa salpa* | Saupe | Vagrant |
| | | *Pagellus bogaraveo* | Red sea-bream | |
| | | *Sparus aurata* | Gilt-head sea-bream | See Section 5.19 |
| | | *Spondyliosoma cantharus* | Black sea-bream | |
| | Sciaenidae | *Argyrosomus regius* | Meagre | Vagrant |
| | | *Sciaena umbra* | Brown meagre | Vagrant |
| | | *Umbrina cirrhosa* | Shi drum | Vagrant |
| | Mullidae | *Mullus surmuletus* | Red mullet | See Section 5.20 |
| | Cepolidae | *Cepola rubescens* | Red bandfish | See Section 5.20 |

*Table 2.1 continued*

| Order | Family | Species | Common name | Comments |
|---|---|---|---|---|
| Perciformes | Mugilidae | *Chelon (crenimugil) labrosus* | Thick lipped mullet | See Section 5.21 |
| | | *Liza aurata* | Golden mullet | |
| | | *Liza ramada* | Thin lipped mullet | |
| | | *Mugil cephalus* | Flathead grey mullet | Vagrant |
| | Labridae | *Acantholabrus palloni* | Scale-rayed wrasse | See Section 5.22 |
| | | *Centrolabrus exoletus* | Small-mouthed wrasse | |
| | | *Coris julis* | Rainbow wrasse | |
| | | *Crenilabrus bailloni* | Baillon's wrasse | |
| | | *Crenilabrus melops* | Corkwing | |
| | | *Ctenolabrus rupestris* | Goldsinny | |
| | | *Labrus bergylta* | Ballan wrasse | |
| | | *Labrus mixtus* | Cuckoo wrasse | |
| | Zoarcidae | *Lycenchelys sarsii* | Sar's eelpout | See Section 5.23 |
| | | *Lycodes esmarkii* | Esmarl's eelpout | |
| | | *Lycodes vahlii* | Vahl's eelpout | |
| | | *Zoarces viviparus* | Eelpout/viviparus blenny | |
| | Stichaeidae | *Chirolophis ascanii* | Yarrel's blenny | See Section 5.23 |
| | | *Leptoclinus maculatus* | Spotted snake blenny | |
| | | *Lumpenus lampretaeformis* | Snake blenny | |
| | Pholididae | *Pholis gunnellus* | Butter fish | Most common inshore |
| | Anarhichadidae | *Anarhichas denticulatus* | Jelly cat | See Section 5.24 (for A. lupus) |
| | | *Anarhichas lupus* | Catfish (wolffish) | |
| | | *Anarhichas minor* | Spotted catfish | |
| | Trachinidae | *Echiichthys vipera* | Lesser weever fish | See Section 5.25 |
| | | *Trachinus draco* | Greater weever fish | |
| | Tripterygiidae | *Tripterygion delaisi* | Black-faced blenny | Southerly fish species most common inshore |
| | Blenniidae | *Blennius ocellaris* | Butterfly blenny | See Section 5.26 (for family) |
| | | *Coryphoblennius galerita* | Montagu's blenny | |
| | | *Parablenniusgattorugine* | Tompot blenny | |
| | | *Lipophrys pholis* | Shanny | Littoral species |

*Table 2.1 continued*

| Order | Family | Species | Common name | Comments |
|---|---|---|---|---|
| Perciformes | Ammodytidae | *Ammodytes marinus* | Sandeel | |
| | | *Ammodytes tobianus* | Sandeel | |
| | | *Gymnammodytes semisquamatus* | Smooth sandeel | Commercial group: see Rogers & Stocks (2001) & Gordon (2003, 2006) |
| | | *Hyperoplus immaculatus* | Immaculate sandeel | |
| | | *Hyperoplus lanceeolatus* | Great sandeel | |
| | Callionymidae | *Callionymus lyra* | Common dragonet | |
| | | *Callionymus maculatus* | Spotted dragonet | See Section 5.27 (for family) |
| | | *Callionymus reticulatus* | Reticulate dragonet | |
| | Gobiidae | *Aphia minuta* | Transparent goby | |
| | | *Buenia jeffreysii* | Jeffrey's goby | |
| | | *Crystallogobius linearis* | Crystal goby | |
| | | *Gobius cobitis* | Giant goby | |
| | | *Gobius couchi* | Couch's goby | |
| | | *Gobius cruentatus* | Red-mouthed goby | |
| | | *Gobius gasteveni* | Steven's goby | |
| | | *Gobius niger* | Black goby | |
| | | *Gobius paganellus* | Rock goby | |
| | | *Gobiusculus flavescens* | Two-spot goby | See Section 5.28 (for family) |
| | | *Lebetus guilleti* | Guillet's goby | |
| | | *Lebetus scorpioides* | Diminutive goby | |
| | | *Lesueurigobius friesii* | Fries's goby | |
| | | *Pomatoschistus lozanoi* | Lozano's goby | |
| | | *Pomatoschistus microps* | Common goby | |
| | | *Pomatoschistus minutus* | Sand goby | |
| | | *Pomatoschistus norvegicus* | Norwegian goby | |
| | | *Pomatoschistus pictus* | Painted goby | |
| | | *Thorogobius ephippiatus* | Leopard spotted goby | |

*Table 2.1 continued*

| Order | Family | Species | Common name | Comments |
|---|---|---|---|---|
| Perciformes | Sphyraenidae | *Sphyraena viridensis* | Yellow barracuda | Vagrant |
| | Gempylidae | *Nesiarchus nasutus* | Johnson's scabbardfish | Deep-water |
| | | *Ruvettus pretiosus* | Oilfish | Vagrant |
| | Trichiuridae | *Aphanopus carbo* | Black scabbardfish | Deep-water commercial: see Gordon (2006) |
| | | *Benthodesmus elongatus* | Frostfish | Deep-water |
| | | *Lepidopus caudatus* | Scabbard fish | Deep-water |
| | | *Trichiurus lepturus* | Hair tail | Deep-water |
| | Scombridae | *Auxis rochei* | Frigate mackerel | Vagrant |
| | | *Euthynnus allettaratus* | Little tunny | Vagrant |
| | | *Katsuwonus pelamis* | Skipjack tuna | Vagrant |
| | | *Orcynopsis unicolor* | Plain bonito | Vagrant |
| | | *Sarda sarda* | Bonito | Vagrant |
| | | *Scomber colias* | Atlantic chub mackerel | Vagrant |
| | | *Scomber scombrus* | European mackerel | Commercial: see Rogers & Stocks (2001) & Gordon (2003) |
| | | *Thunnus alalunga* | Albacore | Vagrant |
| | | *Thunnus albacares* | Yellow-fin tuna | Vagrant |
| | | *Thunnus obesus* | Big-eye tuna | Vagrant |
| | | *Thunnus thynnus* | Blue-fin tunny | Pelagic vagrant (though once common in the North Sea) |
| | Xiphiidae | *Xiphias gladius* | Swordfish | Pelagic vagrant |
| | Luvaridae | *Luvarus imperialis* | Luvar | Pelagic vagrant |
| | Istiophoridae | *Istiophorus albicans* | Sailfish | Pelagic vagrant |
| | | *Tetrapturus albidus* | White marlin | Pelagic vagrant |
| | | *Makaira nigricans* | Blue marlin | Pelagic vagrant |
| | Centrolophidae | *Centrolophus niger* | Blackfish | Pelagic vagrant |
| | | *Hyperoglyphe perciformis* | Barrel fish | Pelagic vagrant |
| | | *Schedophilus medusophagus* | Cornish blackfish | Pelagic vagrant |
| | | *Schedophilus ovalis* | Imperial blackfish | Pelagic vagrant |
| | Nomeidae | *Cubiceps gracilis* | Longfin cigar fish | Pelagic vagrant |
| | Tetragonuridae | *Tetragonurus atlanticus* | | Deep-sea/pelagic vagrant |
| | | *Tetragonurus cuvieri* | | Deep-sea/pelagic vagrant |
| | Stromateidae | *Pampus argentus* | Silver pomfret | Rare vagrant: see Davis & Wheeler (1985) |

*Table 2.1 continued*

| Order | Family | Species | Common name | Comments |
|---|---|---|---|---|
| Pleuronectiformes | Psettodidae | *Lepidorhombus boscii* | Four-spot megrim | Deep-water species |
| | | *Lepidorhombus whiffiagonis* | Megrim | Commercial: see Gordon (2003, 2006) |
| | | *Psetta maxima* | Turbot | See Section 5.29 |
| | | *Scophthalmus rhombus* | Brill | |
| | | *Phrynorhombus norvegius* | Norwegian topknot | See Section 5.29 |
| | | *Phrynorhombus regius* | Ekstroms topknot | |
| | | *Zeugopterus punctatus* | Topknot | |
| | Bothidae | *Arnoglossus laterna* | Scald fish | See Section 5.30 |
| | | *Arnoglossus imperialis* | Imperial scaldfish | |
| | | *Arnoglossus thori* | Spotted scaldfish | |
| | Pleuronectidae | *Glyptocephalus cynoglossus* | Witch | See Section 5.31 |
| | | *Hippoglossoides platessoides* | Long-rough dab | See Section 5.31 |
| | | *Hippoglossus hippoglossus* | Halibut | Commercial |
| | | *Limanda limanda* | Dab | See Section 5.31 |
| | | *Microstomus kitt* | Lemon sole | Commercial: see Rogers & Stocks (2001) & Gordon (2003, 2006) |
| | | *Platichthys flesus* | Flounder | See Section 5.31 |
| | | *Pleuronectes platessa* | European plaice | Commercial: see Rogers & Stocks (2001) & Gordon (2003, 2006) |
| | | *Reinhardtius hippoglossoides* | Greenland halibut | Commercial: see Gordon (2003, 2006) |
| | Soleidae | *Bathysolea profundicola* | Deepwater sole | Deep-water |
| | | *Buglossidium luteum* | Solenette | See Section 5.32 |
| | | *Microchirus variegatus* | Thickback sole | |
| | | *Solea lascaris* | Sand sole | |
| | | *Solea solea* | Sole (dover sole) | Commercial: see Rogers & Stocks (2001) |
| Tetraodontiformes | Balistidae | *Balistes ca[riscus* | Trigger fish | See Section 5.33 |
| | | *Canthidermis maculatus* | Rough trigger fish | Vagrant |
| | Tetraodontidae | *Lagocephalus lagocephalus* | Puffer fish | Vagrant |
| | | *Sphoeroides pachygaster* | Smooth pufferfish | Vagrant |
| | Molidae | *Mola mola* | Sunfish | Regular vagrant: see Sims & Southall (2002); Houghton *et al.* (2006) |
| | | *Ranzania laevis* | Truncated sunfish | Vagrant |

### 2.2 Commercial species

Previous SEA reports have provided reports on the commercial fish species for many of the SEA areas. Rogers & Stocks (2001) provided information on 13 commercial fish taxa (cod, haddock, whiting, saithe, Norway pout, herring, sprat, plaice, lemon sole, sole, anglerfish, sand eel and mackerel) in the SEA2 area, and Gordon (2003, 2006) provided overviews of many of the commercially important fish off northern and north-western Scotland (SEA4 and SEA7 respectively). These species have been discussed for many of the SEA areas and are not included in the present report. Certain commercially important fishes (e.g. bass, red mullet, John dory, turbot and brill), which have not been discussed in previous reports, are included in the present report.

### 2.3 Vagrants

Certain fish taxa are only reported occasionally from the British Isles (e.g. some pelagic sharks and rays, flying fish, opah, dealfish, some species of dory, various jacks (Carangidae) and pomfrets (Bramidae), as well as certain tunas (Scombridae) and billfish). Many of these species have wide geographical distributions, and are unlikely to breed or be resident in British waters. These species are not covered in the present report, as their sporadic occurrence and often poorly known biology cannot realistically inform management in the SEA areas.

### 2.4 Rare species

Many species of British fish are considered relatively rare. Although some have been heavily impacted by human activities and are now rare in UK seas (e.g. Angel shark, white skate, Atlantic sturgeon), rarity can also be natural, or simply based on a perception of a species being rare as we do not sample its population effectively. Our current knowledge of some rare species is very poor, and so some rare species are not covered in this report. Those species that are considered rare because of human impacts and for which there is information regarding their biology and areas of local abundance are included in the report.

### 2.5 Deep-water species

For the purposes of this report, we have focused on the non-target fish species occurring on the continental shelf. In addition to examining the commercial species in SEA7, Gordon (2006) also discussed deep-water fish assemblages along the western seaboard of the British Isles, and so our current knowledge of non-target deep-water fish species has already been reviewed.

**Table 2.2:** Marine and estuarine fish listed or that may be nominated for listing under national legislation and international conventions.

| Common Name | Latin Name | Wildlife & Countryside Act | EC Habitats Directive | UK BAP | OSPAR | CITES |
|---|---|---|---|---|---|---|
| River lamprey | *Lampetra fluviatilis* | - | Annex II & V | - | - | - |
| Sea lamprey | *Petromyzon marinus* | - | Annex II | - | Y | - |
| Portuguese dogfish | *Centroscymnus coelolepis* | - | - | - | Y | - |
| Gulper shark | *Centrophorus granulosus* | - | - | - | Y | - |
| Leafscale gulper shark | *Centrophorus squamosus* | - | - | - | Y | - |
| Spurdog | *Squalus acanthias* | - | - | - | Y | May be nominated |
| Basking shark | *Cetorhinus maximus* | Schedule 5 | - | Y | Y | Appendix II |
| Porbeagle | *Lamna nasus* | - | - | - | Y | May be nominated |
| Angel shark | *Squatina squatina* | Schedule 5 | - | - | Y | - |
| Common skate | *Dipturus batis* | Was nominated | - | Y | Y | - |
| Black skate | *Dipturus nidarosiensis* | Was nominated | - | - | - | - |
| Longnose skate | *Dipturus oxyrinchus* | Was nominated | - | - | - | - |
| Thornback ray | *Raja clavata* | - | | | Y (North Sea) | |
| Spotted ray | *Raja montagui* | - | | | Y | |
| White skate | *Rostroraja alba* | Was nominated | - | - | Y | - |

**Table 2.2 (continued):** Marine and estuarine fish listed or that may be nominated for listing under national legislation and international conventions.

| Common Name | Latin Name | Wildlife & Countryside Act | EC Habitats Directive | UK BAP | OSPAR | CITES |
|---|---|---|---|---|---|---|
| Sturgeon | *Acipenser sturio* | Schedule 5 | Annex II & IV | - | Y | Appendix I |
| European eel | *Anguilla anguilla* | - | - | - | Y | - |
| Allis shad | *Alosa alosa* | Schedule 5 | Annex II | Y | Y | - |
| Twaite shad | *Alosa fallax* | Schedule 5 | Annex II | Y | | - |
| Whitefish | *Coregonus lavaretus* | Schedule 5 | Annex IV | - | Y | - |
| Atlantic salmon | *Salmo salar* | - | - | - | Y | - |
| Cod | *Gadus morhua* | - | - | Y (1) | Y | - |
| Orange roughy | *Hoplostethus atlanticus* | - | - | Y (2) | Y | - |
| Seahorses | *Hippocampus* spp. | Schedule 5 | - | - | Y | Appendix II |
| Giant goby | *Gobius cobitis* | Schedule 5 | - | - | - | - |
| Couch's goby | *Gobius couchii* | Schedule 5 | - | - | - | - |
| Bluefin tuna | *Thunnus thynnus* | - | - | - | Y | - |

*(1) As part of the grouped species action plan for commercial marine fish*
*(2) As part of the grouped species action plan for deep-water fish*

### 2.6 Hearing in fishes

The acoustico-lateralis system in fishes is responsible for the detection of sound and vibrations. The inner ear (or labyrinth) is comprised of semicircular canals, which contain ampullary neuromasts. Hair cells in these neuromasts have cilia-like structures (a large kinocilium and shorter stereocilia) protruding into a gelatinous cupula. Sound waves vibrate the otoliths (ear stones), which lie on beds of these sensory hair cells. The lateral-line system of fishes comprises the main lateral line, which is a canal containing hair cells (as described above) as well as free neuromast organs, which tend to be concentrated around the head of fishes. The lateral-line system is sensitive to local hydrodynamic disturbances (Hawkins, 1973) and its role in sound detection is unclear. For general accounts of hearing and the acoustico-lateralis system in fishes, see Bond (1979), Hawkins (1993) and Bone *et al.* (1995).

Many fish possess a gas-filled swimbladder, which serves primarily as a buoyancy organ. It develops in the embryo as a bulge on the foregut, and in some groups (e.g. herrings and salmon), the connection to the gut is retained in the adult fish. In most fish (e.g. cods and spiny-rayed fish), the air duct regresses and the swimbladder becomes isolated. Special areas on its wall in which the blood absorbs or secretes gasses then adjust the pressure. When a fish moves down into greater depth, it quickly becomes subject to greater pressure on its body, and the gas in the swimbladder is compressed. It must, therefore, release more gas into the swimbladder in order to remain buoyant. Many bottom living fish do not need a swimbladder, and in many groups (e.g. flatfish, gobies, sculpins and sandeels), it regresses after the larval stage. Cartilaginous fish, such as dogfish, have no swimbladder, as their large oil filled liver gives them some buoyancy. As well as having buoyancy function, the swimbladder also has a sensory function.

Certain species of fish have connections between the swimbladder and the ear. This may take the form of the Weberian apparatus, where the first few vertebrae and their processes are modified to convey vibrations from the swimbladder to the ear, through the tripus, intercalarium, scaphium and claustrum. Such adaptations are present in certain cyprinids and siluriform fishes, which are typically freshwater species, though there are some tropical marine silurids. Other species, including clupeids, have connections between the swimbladder and the inner ear, whereby the diverticula of the swimbladder extend into the skull, where they form otic bullae and press against the labyrinth wall, helping propagate vibrations from the swimbladder to the ear. Other groups of fishes (e.g. some gadoids) also have a swimbladder that extends into the skull to transduce the sound stimuli from the swimbladder to the ear by particle displacement of bones in the skull.

Fishes with connections between the swimbladder and the ear generally respond to a greater range of sound that those species where the swimbladder does not have a close connection to the ear. Similarly fish without swimbladders tend to be less responsive to sound (Bone *et al.*, 1995; Hawkins, 1973).

In terms of the swimbladder, fishes can broadly be grouped into four categories (Blaxter and Batty, 1990):

(a) Fish without a swimbladder (e.g. most flatfish, wolf-fish)
(b) Physostomous fish, which have an open swimbladder, where a duct connects the swimbladder to the exterior (e.g. clupeids and salmonids)
(c) Physoclistic fish, which have a closed swimbladder that is modified to allow for the secretion or resorption of gas in the absence of ducts (e.g. gadoids)
(d) Species which have a swimbladder filled with lipids (e.g. some bathypelagic fishes)

In recent years there has been increased interested regarding the impacts of anthropogenic noise on marine organisms, and exposure to loud sounds may affect the behaviour and physiology of fishes, as well as leading to a loss of hearing, which may be temporary or permanent, and may affect survivorship (e.g. Popper (2003)). Hence, noise disturbance on breeding, spawning or feeding grounds could have implications on fish populations.

Behavioural responses to sounds may include “freezing”, avoidance behaviour and alarm responses (Hawkins, 1973; Pearson *et al.*, 1992), although in field conditions, depending on the noise and frequency of exposure, fish may become habituated to such disturbances (Hawkins, 1973). Several field studies have examined catch rates of adult fishes before and after disturbance from seismic air guns, with declines in catch rates of gadoids and rockfishes occurring during and immediately after those periods where air guns were used (e.g. Engås *et al.* (1996); Skalski *et al.* (1992). Other field studies, however, have reported that the noise from air guns, other than an initial startle response, have not led to pronounced behavioural changes in reef-associated gadoids (Wardle *et al.*, 2001). In addition to short-term behavioural impacts (ranging from seconds to days), physiological damage can occur. For example, intense sounds can damage the sensory hair cells (Hastings *et al.*, 1996), which will affect the sensory capability of fishes. The impacts of noise disturbance on eggs and larval stages are less clear, though some studies have indicated that noise disturbance can affect the viability of early-life-history stages (Banner and Hyatt, 1973).

Additionally, anthropogenic sounds that do not cause direct physiological damage or affect the behaviour of fish may still “mask” ambient sounds, many of which could be biologically relevant.

Hearing (and sound production) in fishes can, depending on the species, be important for prey detection, predator avoidance, orientation, interspecific behaviour (e.g. territoriality, warning signals) and intraspecific social behaviour (e.g. courtship, mate attraction, shoaling, alarm signals) (Bond, 1979; Hawkins, 1993). More recently, several studies have indicated that some larval reef fish respond to the sounds associated with reefs to locate suitable habitats (Tolimieri *et al.*, 2004; Tolimieri *et al.*, 2000).

# 3. ICHTHYOFAUNAL SURVEYS

## *3.1 North Sea and eastern English Channel*

The North Sea and eastern English Channel region equates with ICES Divisions IVa,b,c and VIId. This ecoregion covers the areas SEA2, 3 and 5, as well as the eastern part of SEA4 and SEA8.

The International Bottom Trawl Survey (IBTS) have internationally coordinated surveys in the first and third quarters. Cefas participate in the third quarter survey each August, and Cefas also participated in the first quarter survey until 1991 and then again from 2001 to 2003. The third quarter survey fishes at 75 fixed stations across most of the North Sea (Figure 3.1.1) with a Grand Ouverture Verticale (GOV) demersal trawl. The GOV trawl is fitted with a cod-end liner of 20 mm stretched mesh and is towed for 30 minutes at a speed of approximately 4 knots. For further details of the survey gear and history of the survey, see Heessen *et al.* (2000) and ICES (1999). Prior to 1992, the survey used a Granton trawl, which was towed for 60 minutes.

The eastern English Channel and southern parts of the North Sea are also sampled each July during an annual beam trawl survey (Figure 3.1.2). The standard gear used in this survey is a 4m-beam trawl with a chain mat, flip up ropes, and a 20 mm codend liner to retain small fish. The gear is towed at 4 knots (over the ground) for 30 minutes, averaging 2 nautical miles per tow. Further details of the gear and survey are given in Kaiser & Spencer (1994) and Kaiser *et al.* (1999), respectively. Surveys in the eastern English Channel and southern North Sea started in 1989, though the survey grid has been sampled most consistently since 1993. An overview of this survey and preliminary data analyses has been provided by Parker-Humphreys (2005).

In addition to these broadscale offshore surveys, Cefas also undertake annual youngfish surveys along the southern and eastern coasts of England, from Poole harbour in the eastern English Channel to Grimsby on the North-east coast. These samples are collected by 2m-beam trawl deployed from commercial fishing vessels. Though these data are not included in the present report, many of the results are available (Rogers *et al.*, 1998a).

## *3.2 Irish Sea, Bristol Channel, western English Channel and Celtic Sea*

A 4m-beam trawl survey is also undertaken in the Irish Sea and Bristol Channel (ICES division VIIa,f) which correspond to SEA6 and part of SEA8 (Figure 3.2.1). The gear and protocols used are the same as in the eastern English Channel survey (see Section 3.1). Surveys in the Irish

Sea/Bristol Channel started in 1988, and a consistent survey grid has been sampled every September since 1993. Equivalent spring surveys were also conducted between 1993 and 1998. For further details of this survey see Ellis *et al.* (2000, 2002a) and Parker-Humphreys (2004a,b). 4m-beam trawl surveys in the western English Channel started in 1982 and are conducted annually in October. It was originally undertaken by the commercial beam trawler *Bogey 1,* from 1988–2001 by the commercial beam trawler *Carhelmar*, *RV Corystes* from 2002–2004, and has been undertaken by *Carhelmar* since 2005.

Cefas now participate in an internationally coordinated groundfish survey in the Irish Sea, western English Channel, Bristol Channel and Celtic Sea as part of the southern and western IBTS survey (Figure 3.2.2). This survey is a two-gear survey using a GOV trawl on fine grounds, and a modified GOV with rockhopper ground gear on hard grounds in St George's Channel and around the Cornish peninsula. Due to changes in the gear used, this survey has been most consistent since 2004. The gear and survey are described in ICES (2004) and ICES (2005, 2006a) respectively.

The Celtic Sea survey operated from 1982–2003, trawling at fixed stations (Figure 3.2.3) each March with a Portuguese High Headline Trawl (PHHT). Between 1982 and 1988, the survey also operated in November-December. A tickler chain was used on fine grounds, but not on coarser grounds. The PHHT is fitted with a cod-end liner of 20 mm stretched mesh and is towed for 30–60 minutes at a speed of approximately 4 knots. For further details of the survey see Warnes & Jones (1995) and Tidd & Warnes (2006).

Although there have been some historical *ad hoc* young fish surveys along the western sea board of England and Wales, there is no consistent approach to sampling the shallow, inshore waters of these areas, and few contemporary data.

### *3.3 Ichthyoplankton surveys*

For more than a decade, ichthyoplankton surveys have been carried out by Cefas to assess the spawning areas of cod and plaice and to investigate the use of the annual egg production method to estimate spawning stock biomass of commercial species. The majority of these surveys have taken place in the Irish Sea, with the exception of an international series in 2004 in the North Sea. Cod and plaice generally spawn from December to May so the surveys were all undertaken during this period. Eggs and larvae from the target species were sorted, identified and enumerated. Where possible, eggs and larvae of the remaining fish species present were also analysed. Selected results for some of these lesser or non-commercial species are presented here. A full account of the methods, plus comprehensive distributions of all the species identified have been described (see Bunn and Fox, 2004; Fox *et al.*, 2005 and Taylor *et al.*, 2007). Details of earlier survey series in the Irish Sea can be found in Nichols *et al.* (1993) and Fox *et al.* (1997).

A Gulf VII high-speed plankton sampler was used as standard on the majority of these surveys (see Nash *et al.*, 1998 for specification). This sampler has a 53 cm diameter unencased body fitted with a conical nosecone of 20 cm diameter aperture, and a net of 270-μm mesh. Ichthyoplankton was collected in a 'cod-end' bag fitted to the end of the main net and constructed from mesh of the same size. Due to practical and logistical constraints, a wider variety of gears were used during the 2004 North Sea survey series. However, all sampler types incorporated meters to record the flow of water into the net, which in turn was used to calculate the volume of water filtered during each deployment.

Gulf design samplers were deployed in an oblique mode, at a speed of 3–4.5 knots, from the surface to within 4 metres of the bottom (or to a maximum depth of 100–150 m at deeper stations) and returned to the surface. To enable a sufficient volume of water to be filtered, the sampler remained in the water for a minimum duration of 15 minutes and single or multiple tows undertaken depending on depth.

On recovery, the net of the sampler was gently washed down from the outside with seawater and the end-bag removed. Non-target plankton was fixed using buffered formaldehyde solution and the samples retained for subsequent sorting and identification ashore. In the laboratory, fish eggs and larvae were picked out of the preserved samples with the aid of low power microscopes. Identification was carried out on the basis of size and appearance according to Russell (1976), and supplemented by various guides and keys produced by the International Council for the Exploration of the Sea (Saville, 1964; Macer, 1967; Nichols, 1971; Demir, 1976; Nichols, 1976). Fish eggs were initially split into groups on the basis of presence or absence of oil globules. Those containing a single or many oil globules could usually be identified to the species level. Eggs with no oil globules are more difficult to separate, particularly in the early stages before embryonic pigmentation develops, and as a result it is not possible to differentiate a significant proportion of these. However, egg diameter was recorded and those measuring from around 0.8 to 1.0 mm are likely to originate from species such as dab (*Limanda limanda*) and to a lesser extent flounder (*Platichthys flesus*). Eggs in the range from about 1.0 to 1.25 mm in diameter cover a larger range of species including whiting (*Merlangius merlangus*), witch (*Glyptocephalus cynoglossus*), *Trisopterus* spp. (Norway pout, poor cod, bib) and others. Eggs of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) also overlap with the upper end of this range. Fish larvae are usually identified to species, although some groups, such as sandeels (Ammodytidae) and rocklings (Gadidae, Lotinae), are only recorded at higher taxonomic levels.

Ichthyoplankton data were expressed as number of organisms per cubic metre of seawater using estimates of the volume of water filtered during deployment. These values were then converted to numbers per metre squared of sea-surface by multiplying by the depth sampled. Numbers $m^{-2}$ of sea surface were plotted as bubble distributions on a square root scale.

Abundances presented here have been selected from two ichthyoplankton survey series; one in the Irish Sea in 2000, and one in the North Sea in 2004. The aim of the surveys undertaken in the Irish Sea was to map the spawning of cod and plaice, both spatially and temporally, over the whole of the central Irish Sea. Eight surveys were carried out at intervals over the period from January to May. Each time the sampling grid remained the same. By contrast, in the 2004 series, because of the size of the area to be covered, the North Sea was divided into sectors that were surveyed at varying intervals by eleven individual cruises. Eight of these cruises were wholly dedicated to the surveying of plaice and cod eggs, whilst additional sampling was undertaken opportunistically on the remaining cruises in order to improve coverage.

It is important to note that because the timing and duration of these surveys were planned to provide the best coverage of the spawning activity of cod and plaice, species that might occur in the Irish and North Seas but spawn only partially within or outside of this period will not be fully described. In addition, depending on the amount of analysis undertaken, not all eggs and particularly larvae were identified from each cruise. Hence, these maps are not intended to represent the total spawning products in either number or total distribution for any given species.

## 4. FISH ASSEMBLAGES AND FISH COMMUNITIES

In recent years, the data collected from annual groundfish surveys have provided data for the descriptions of the fish assemblages in many sea areas (e.g. Rogers *et al.*, 1998b, 1999a, 1999b; Rogers and Ellis 2000). Obviously, these trawl surveys can cover a very broad geographical and bathymetric range, which are appropriate for the descriptions of broadscale fish assemblages. Nevertheless, tows of 30 minutes duration can cover multiple habitat types, and such data cannot be used to describe the species composition of more specific fish communities.

### *4.1 North Sea and eastern English Channel*

There have been many papers describing various elements of the North Sea fish community (Yang, 1982a,b; Bergstad, 1990; Daan *et al.*, 1990, 2005; Knijn *et al.*, 1993; Greenstreet & Hall, 1996; Heessen, 1996; Heessen & Daan, 1996; Rijnsdorp *et al.*, 1996; Fricke, 1999; Greenstreet *et al.*, 1999; Greenstreet & Rogers, 2006), including several papers that document increases in some of the more southerly species (Postuma, 1978; Ehrich & Stransky, 2001; Beare *et al.*, 2004a,b, 2005; Perry *et al.*, 2005;) and pelagic and/or shelf-edge species that may enter the northern North Sea (Heessen *et al.*, 1996; Iversen *et al.*, 2002; Mamie *et al.*, 2007).

In general terms, there are three main fish assemblages in the North Sea (Callaway *et al.*, 2002). The first is associated with the shelf edge and northern North Sea, the second group occurs in the central North Sea, and the third group is found in the southern and eastern North Sea. There is a distinct boundary near the 200 m isobath, which separates the species assemblages of the Northern North Sea and Norwegian Deep and those of the shallower parts of the North Sea.

The fish assemblages of the central and northern North Sea (ICES Divisions IVa-b) are very different to those assemblages further south, and the division in fish assemblages seem to correspond with changes in water depth and temperature. The dominant fish species include demersal species such as whiting and haddock, and pelagic species including mackerel and horse mackerel. In shallower waters (50–100m depth), the fish assemblage is dominated by haddock, whiting, herring, dab and plaice, while at greater depths (100–200m), Norway pout dominate. The northern North Sea also contains a number of boreoarctic species that are rarely found further south (e.g. Vahl's eelpout and Esmark's eelpout).

The southern North Sea (ICES Division IVc) is comparatively shallow and the dominant fish species in this region are those that are more characteristic of inshore waters (<50 m deep). Plaice, sole, dab, whiting, lesser weever, grey gurnard and solenette are all important components of the fish assemblage in this region, though other species such as sandeels and sand gobies, which are poorly sampled by trawls, are also very abundant, and are also important prey species for many species of demersal fish.

### *4.2 Irish Sea*

The marine fishes of the Irish Sea have been well documented over the last 100 years (Herdman and Dawson, 1902; Holt, 1910; Bruce *et al.*, 1963; Nash, 1990; Ellis *et al.*, 2000, 2002a, Parker-Humphreys, 2004a).

Analyses of Cefas beam trawl data (Ellis *et al.*, 2002a) indicate that there are three broad categories of demersal fish assemblage in the Irish Sea (excluding St George's Channel), though several fish species are important components of all assemblages (e.g. lesser-spotted dogfish, whiting, poor cod and grey gurnard). The ichthyofauna of the mud grounds west of the Isle of Man is very distinct from other areas, and is typified by witch and, to a lesser extent, long rough dab, and there is also a smaller patch of mud habitat off the coast of Cumbria. The sandy sediments of the inshore waters of the Irish Sea are dominated by a variety of flatfish, especially plaice, dab, sole and solenette. Finally, there is an offshore assemblage that occurs on the coarser offshore grounds of the central Irish Sea and the fish assemblage in these areas is characterised by various elasmobranch (including greater-spotted dogfish, cuckoo ray and spotted ray), as well as lemon sole, thickback sole and red gurnard. Such a spatial distribution of fish assemblages is also observed in data collected by otter trawls, though in these instances there seem to be a more distinct differentiation between the inshore fish assemblages of the eastern and western Irish Sea, as clupeids, haddock and Norway pout (none of which are sampled effectively by beam trawl) tend to be more abundant in the western Irish Sea (Ellis *et al.*, 2002a).

### *4.3 Bristol Channel, western English Channel and Celtic Sea*

There have been several studies of the fish and fish assemblages in south-western areas, including the Celtic Sea (e.g. Warnes and Jones, 1995; Pinnegar *et al.*, 2002; Trenkel *et al.*, 2004) and Bay of Biscay (e.g. Blanchard, 2001a,b; Blanchard *et al.*, 2002; Souissi *et al.*, 2001; Blanchard & Vandermeirsch, 2005; Poulard & Blanchard, 2005). Preliminary studies using cluster analyses (presence-absence data) of fish catches in the Celtic Sea indicate that there are distinct fish assemblages in the western English Channel (60–90 m deep), Celtic Sea (65–155 m), waters off Brittany (100–200 m), along the edge of the continental shelf (130–285 m) and in deep water (>330 m), and such spatial organization is also in agreement with the observed patterns in epibenthic fauna (Ellis *et al.*, 2002b).

### *4.4 Other fish communities*

Although groundfish surveys provide data that can be used in the description and quantification of fish assemblages over wide spatial areas, they do not cover all elements of the fish community. Most surveys are demersal trawl surveys, and as such do not examine littoral, shallow-sublittoral and estuarine habitats, which can have distinct fish communities, with estuaries and shallow sublittoral areas also acting as important nursery grounds for various marine fish (e.g. flatfish, bass, clupeids). Estuarine and littoral fish communities have been well reviewed by Elliott & Hemingway (2002) and Gibson (1993) respectively.

Additionally, demersal trawl surveys tend to avoid those grounds that may result in gear damage and so areas with rocky outcrops or wrecks are not sampled. Such habitats may have their own fish community, (e.g. reef-associated communities), which can be typified by large predatory fishes, including gadoids and conger eels, as well as wrasse and various cryptic, demersal fish (e.g. Blennidae).

## 5. DISTRIBUTION AND BIOLOGY OF NON-TARGET FISHES

This section briefly summarises the distribution, biology and breeding habits of the most frequently observed non-target fish species occurring in the continental shelf waters. Some commercial species (e.g. bass and turbot) that may be taken in directed fisheries have been included, as they have not been discussed in previous SEA reports. Some of the other species are also of some commercial value and taken in mixed demersal fisheries.

### *5.1 Hagfish (Myxinidae)*

| | |
|---|---|
| *Family:* | Myxinidae |
| *Species:* | Atlantic hagfish *Myxine glutinosa* |
| *Swimbladder:* | Absent |
| *Spawning:* | No definitive spawning season. |

***Distribution***: Within the NE Atlantic, hagfish are distributed from northern Norway to the western Mediterranean, with its distribution determined by temperature, salinity and substrate type (Martini and Flescher 2002). They are bottom dwelling in depths of 20–600 m (Wheeler, 1978), and favour cooler waters (e.g. < 10°C) (Bigelow and Schroeder, 1953). They are found on muddy grounds, where they are often buried with the tip of the head showing. Hagfish are caught routinely in certain parts of the North Sea (Figure 5.1.1), though are uncommon in south-western waters.

***Synopsis***: Hagfish are very slimy, eel-like fishes without eyes, jaws, gill covers, pectoral or pelvic fins. The mouth is a narrow slit with fleshy, broad based barbels, the anterior pair flanking the single nostril in the mid-line (Wheeler, 1978). Hagfish eat bottom-living invertebrates and also scavenge on dead fish (Shelton, 1978). They are relatively sedentary species, though can move in sudden bursts. Sudden changes in temperature and salinity can render them moribund (Martini and Flescher 2002). Maximum size: 60 cm.

***Spawning***: Little is known about the life history of hagfish. Evidence from the Grand Banks suggests that there may up to 3 synchronised spawning events throughout the year (Martini *et al.*, 1997, Grant 2006). They deposit a few (19–30), large (20–25 mm) keratinised eggs (Whitehead *et al.*, 1984).

### 5.2 Lampreys (Petromyzontidae)

| | |
|---|---|
| *Family:* | Petromyzontidae |
| *Main species:* | Lampern *Lampetra fluviatilis*<br>Sea lamprey *Petromyzon marinus* |
| *Swimbladder:* | Absent |
| *Spawning:* | May and June |

***Distribution***: Most lampreys are freshwater species, migrating to the sea to feed and returning to freshwater to breed (Wheeler, 1978). They are found most frequently in estuaries or inshore waters, or in the open sea attached to fish, but also feed on basking sharks and cetaceans. They are considered as a rare fish species in UK waters. Sea lampreys are only caught sporadically in groundfish surveys (Figure 5.2.1) and the behaviour and ecology of the marine stages are poorly known. Lampern, or river lampreys, are primarily a freshwater species, though adults occur in coastal waters.

***Synopsis***: Lampreys are primitive fish, lacking jaws, fin-rays or scales. They are elongate, eel-like fish with small eyes, a distinctive set of gill pouches along their anterior sides, and a sucker-disc mouth (Wheeler, 1978). Adults are parasitic on fishes such as cod, haddock and saithe. The maximum length of the sea lamprey is 90 cm; that of the river lamprey is 50 cm.

***Spawning***: Lampreys breed in swift-running freshwater during May and June, the adults dying shortly after spawning (Wheeler, 1978). The larvae spend the next 5½ years in nearby estuaries buried in mud and feeding on organic matter and detritus; they then metamorphose into young fish 15–20cm long and migrate to the sea.

### *5.3 Catsharks (Scyliorhinidae)*

| | |
|---|---|
| *Family:* | Scyliorhinidae |
| *Main species:* | Lesser-spotted dogfish *Scyliorhinus canicula*<br>Greater-spotted dogfish *Scyliorhinus stellaris* |
| *Swimbladder:* | Absent |
| *Spawning:* | November to July |

***Distribution***: Lesser-spotted dogfish are widely distributed in the North-eastern Atlantic, and occur all around the coast of the United Kingdom (Figures 5.3.1), though their distribution in the North Sea is patchy. They can be found on a variety of substrate types, ranging from mud to rock. They also have a wide bathymetric range, being found from the shallow sublittoral to the edge of the continental shelf at depths of about 300 m (Ellis et al, 2005a). Greater-spotted dogfish have a similar overall biogeographic range, though their distribution is patchier, and they are only locally abundant on areas of coarse ground, especially in parts of the Irish Sea (off Anglesey and the Lleyn Peninsula, and in Cardigan Bay), Bristol Channel and western English Channel (Figure 5.3.2). They are most common in inshore waters, being reported only rarely from waters >100 m deep (Ellis *et al.*, 2005a). Other scyliorhinids reported from UK waters include black-mouth dogfish *Galeus melastomus*, and although this species can be found in the deeper parts of the North Sea and Celtic Sea (Ellis *et al.*, 2005a) and very occasionally in the Irish Sea (Ellis *et al.*, 2002), it is more abundant on the edge of the continental shelf and in deep-water habitats.

***Synopsis***: Scyliorhinid catsharks are relatively small-bodied demersal sharks, and the lesser-spotted dogfish is considered to be the most abundant shark in UK seas. Lesser-spotted dogfish predate on a variety of invertebrates, including various large polychaetes, molluscs, hermit crabs and brachyuran crabs, as well as teleosts. Smaller individuals tend to predate more on small crustaceans and polychaete worms, with larger individuals predating on fish, cephalopods and larger crustaceans and molluscs (Ellis *et al.*, 1996). Greater-spotted dogfish also consume a variety of large crustaceans and demersal fish, though primarily predate on a variety of cephalopods, including octopus (Ellis *et al.*, 1996). As with many elasmobranchs, scyliorhinids often aggregate by sex and size, though it is still unclear as to whether this is geographical (or habitat-related) separation or more behavioural separation. Lesser-spotted dogfish start to mature at lengths of 49 cm (males) and 52 cm (females), with 50% occurring at about 52 and 55 cm in males and females respectively (Ellis & Shackley 1997). Lesser-spotted and greater-spotted dogfish attain lengths of approximately 80 and 130 cm respectively (Ellis *et al.*, 2005b)

***Spawning*****:** Scyliorhinids are egg-layers, with the rectangular egg-cases having long tendrils at each corner. These tendrils are used to attaché the egg-cases to algae (in shallow water) and a variety of sessile, erect invertebrates (e.g. hydroids, sponges, soft corals, bryozoans) in offshore areas (Ellis & Shackley 1997). Large numbers of lesser-spotted dogfish egg-cases can be found in parts of the English Channel and Bristol Channel (Ellis *et al.*, 2005a), and the young hatch at a length of approximately 10 cm, with the egg-cases of greater-spotted dogfish regularly reported from off the Lleyn Peninsula. Lesser-spotted dogfish have a protracted breeding season, depositing pairs of eggs from the winter to the summer, with a peak in egg-laying activity in the summer (June-July) and a decline in egg-laying activity in September.

### 5.4 Houndsharks (Triakidae)

| | |
|---|---|
| *Family:* | Triakidae |
| *Species:* | Tope *Galeorhinus galeus*<br>Starry smooth hound *Mustelus asterias*<br>Smooth hound *Mustelus mustelus* |
| *Swimbladder:* | Absent |
| *Spawning:* | June to August |

***Distribution:*** Tope and smoothhounds are found over a variety of sandy and course grounds and may occur all around the UK coastline, though they are most commonly recorded along southern and western coasts (Figures 5.4.1 and 5.4.2). They tend to be relatively coastal, though can occur further offshore (Ellis *et al.*, 2005a). Juveniles are often found in large bays and in the outer reaches of large estuaries (e.g. Outer Thames Estuary, Solent, Bristol Channel and Cardigan Bay).

***Synopsis:*** Tope is a medium-sized shark that can be found in both demersal and pelagic ecosystems. It is primarily piscivorous, predating on pelagic fish, though it also consumes cephalopods and demersal fish, and smaller individuals consume various crustaceans (Ellis *et al.*, 1996). Tope is aplacentally viviparous, with gestation lasting approximately one year, and may therefore have an annual reproductive cycle, though it is unknown whether tope in the north-eastern Atlantic have resting periods between pregnancies. Studies on the South West Atlantic tope stock indicate that it has a triennial reproductive cycle (Peres & Vooren, 1991), with resting years between pregnancies. Tope is a long-lived species, with longevity of at least 36 years, based on tag returns and age and growth studies (e.g. Moulton *et al.*, 1989; Peres & Vooren, 1991).

The ovarian and uterine fecundity has been estimated as 14–44 and 10–41 respectively for specimens in the Mediterranean Sea (Capapé & Mellinger, 1988), and litter size increases with maternal length. Pups are born after a twelve month gestation period at a size of about 30–40 cm (Compagno, 1984). In the Mediterranean area, males and females mature at lengths of about 125–158 cm and 140+ cm respectively (Capapé & Mellinger, 1988), with first spawning occurring at a length of about 150 cm. Though no age at maturity data are available for the North-eastern Atlantic stock, 50% maturity in males and females in the South West Atlantic occurs at about 11 years (111 cm) and 15 years (123 cm) (Peres & Vooren, 1991)

Although morphologically similar, smoothhounds have a more demersal nature and predate almost exclusively on brachyuran crabs, squat lobsters and other crustaceans (Ellis *et al.*, 1996). Smoothhounds are viviparous, although little is known about their reproductive biology in UK seas. Males mature at about 66–72 cm (Cefas, unpublished data) and females are likely to mature at a larger size. The maximum length of smoothhounds is about 130–150 cm.

***Spawning:*** Parturition occurs during the summer, and although the location of pupping grounds is not accurately known, new-born tope and smoothhounds (including individuals where the umbilical scar is not healed completely, can be found in large bays and in the outer reaches of large estuaries (e.g. Outer Thames Estuary, Solent, Bristol Channel and Cardigan Bay).

### *5.5* Angel shark

| | |
|---|---|
| *Family:* | Squatinidae |
| *Species:* | Angel shark *Squatina squatina* |
| *Swimbladder:* | Absent |
| *Spawning:* | June to July |

***Distribution***: The angel shark occurs in coastal waters around the British Isles, though this is the northern part of its biogeographical range and it is more common further south. It has declined in recent decades (Rogers and Ellis, 2000), and is now most likely to be found off southern and western coasts. They are known from Lyme Bay, Bristol Channel and Cardigan Bay, though there are few recent records.

***Synopsis***: This demersal shark is an inshore and shallow-water species that is an ambush predator that predates on demersal fish, including flatfish (Ellis *et al.*, 1996). Little is known about the biology and ecology of the species, and it is now considered a rare species in UK waters. *S. squatina* has a fecundity of 7–18, and young are born at about 30 cm (Capapé *et al.*, 1990).

***Spawning***: Parturition occurs in the summer.

### 5.6 Anguilliformes (eel and conger)

| | |
|---|---|
| *Family:* | Anguillidae and Congridae |
| *Species:* | European eel *Anguilla anguilla*<br>Conger eel *Conger conger* |
| *Swimbladder:* | Present |
| *Spawning:* | European eel: spring and early summer<br>Conger eel: midsummer |

***Distribution:*** European eels are common in rivers, estuaries and in inshore and shallow seas in northern Europe, and can occur throughout the UK Continental Shelf (Wheeler, 1969). Young male eels migrate to the sea at a length of about 40 cm, females at 54–60 cm, and spend an average of 9–12 years in inshore waters. In contrast, conger eels are exclusively marine fish, occasionally being found inshore, but more usually in deeper waters (Figure 5.6.1). They live on rough ground, and in shallow water can be found in deep shore pools. They are generally most active at night, lying up by day in rock crevices.

***Synopsis:*** European eels are characterised by having a lower jaw that is longer than the upper jaw, a small, rounded pectoral fin, and that the dorsal fin originates well behind the pectoral (Wheeler, 1969). In contrast, the conger eel has an upper jaw that is longer than the lower, the pectoral fin is pointed, and the dorsal fin originates close behind the pectoral fin. Conger eels in shallow water tend to be dull brown on the back with a light gold or white belly; in deeper water they are light brown on the back with grey sides and belly, and with a conspicuous black margin to the dorsal fin. Conger eels predate on bottom-living fishes (e.g. rocklings, dogfish, flatfishes and Pollack), and also consume crabs, lobsters and cephalopods (e.g. O'Sullivan *et al.*, 2004). Conger eels grow to a maximum length of 274 cm.

***Spawning:*** European eels spawn in spring and early summer in the western Atlantic Sargasso Sea area (22–30°N, 48–65°W), with the pelagic eggs carried in midwater by the north-easterly moving Gulf Stream and North Atlantic Current and arriving on European coasts as transparent 'glass-eels' after two and a half to three years (Wheeler, 1969). After metamorphosis in coastal waters, the elvers migrate upstream, and this occurs during February on southern and western coasts, and during March and April in the North Sea. After September the mature eels stop feeding and begin their migration back to the spawning grounds (Whitehead et al, 1986). Conger eels are thought to spawn in mid-summer in deep water (>3,000m) between Gibraltar and the Azores (e.g. O'Sullivan *et al.*, 2003). The larvae drift north-eastwards during the next one or two years before metamorphosing into young adults in shallow coastal waters. Growth rates are thought to be fairly rapid, weighing up to 1.3 kg at age three and 40.5 kg two years later.

### *5.7 Clupeiformes (pilchard, anchovy, shad)*

| | |
|---|---|
| *Family:* | Clupeidae and Engraulidae |
| **Main species:* | Allis shad *Alosa alosa*<br>Twaite shad *Alosa fallax*<br>Pilchard *Sardina pilchardus*<br>European anchovy *Engraulis encrasicolus* |
| *Swimbladder:* | Present |
| *Spawning:* | Allis shad: April and May<br>Twaite shad: May and early June<br>Pilchard: April (Channel), June-Aug (North Sea)<br>Anchovy: April to August |

* Commercially valuable species in this family not included in this report include herring *Clupea harengus* and sprat *Sprattus sprattus.* These species have been reviewed in earlier SEA reports

***Distribution***: The shads are fairly rare in northern UK waters, becoming more common southwards from southwest Ireland (Wheeler, 1969), and are only reported occasionally in groundfish surveys. The twaite shad is more common than the allis shad, especially in the North Sea. Pilchards are uncommon in more northern UK waters, only occasionally penetrating the North Sea in large numbers, particularly during hot summers (Figures 5.7.1). Anchovies are often found in the South-western Approaches, southern North Sea and Irish Sea (Figure 5.7.2), and only reported occasionally from more northern areas.

***Synopsis***: Clupeoids are pelagic fishes that can form very large shoals. They have a relatively high fat content in their flesh. Clupeoids are generally regarded as hearing specialists. Maximum sizes are: allis shad 60cm, twaite shad 50cm, pilchard 25cm, anchovy 20cm. Clupeoids are mainly planktivorous, feeding on copepods, decapods and mollusc larvae, euphausiids, and the eggs and fry of other pelagic fishes.

***Spawning***: Shads spawn in rivers, with the adults returning to the sea after spawning. The eggs sink to the bottom and remain on the gravel of the riverbed until they hatch a few days later. The young fish enter the sea from one to two years later (Wheeler, 1969). Allis shad spawn upstream in fast-flowing water during April-May, while twaite shad spawn further downstream during May-June, in or just above the tidal reaches of many rivers. Anchovies spawn throughout their distribution range, including in low-salinity areas along the Dutch coast in the North Sea, and spawn from April-August. They breed at the end of their first year, and rarely live after their second spawning. Pilchards spawn in the western English Channel from April, and in the North Sea from June to August, the young fish spending their first winter in shoals close inshore in bays or estuaries before moving out to sea the next year. The southern stocks will spawn at age one or more, but the northern stocks mature much later, in their fourth or fifth year.

***Ichthyoplankton surveys:*** Pilchard eggs measure 1.3–1.9 mm in diameter and are recognisable by their segmented yolk, single oil globule and large perivitelline space. The larvae are less easy to identify, as they are difficult to distinguish from other clupeids, such as herring (*Clupea harengus*) and sprat (*Sprattus sprattus*). Spawning is reported to take place from late spring to summer in southern and coastal parts of the North Sea. Little information exists on spawning in the Irish Sea; in the 2000 survey series, a single pilchard egg was identified from a cruise in mid-February, and no larvae were recorded. Relatively dense numbers of pilchard eggs were found in central areas of the North Sea during a survey in April. Lesser abundances were also recorded as early as mid-February in southern waters. Pilchard larvae were positively identified from surveys in March and April, their distribution restricted to central and southern areas (Figure 5.7.3).

### 5.8 Salmoniformes (argentines, smelt)

| | |
|---|---|
| *Family:* | Argentinidae and Osmeridae |
| *Main species:* | Lesser silver smelt *Argentina sphyraena*<br>Greater silver smelt *Argentina silus*<br>Smelt *Osmerus eperlanus* |
| *Swimbladder:* | Present |
| *Spawning:* | February to September |

***Distribution***: Lesser silver smelt are locally abundant on muddy bottoms throughout the continental shelf in depths of 55–200m (Wheeler, 1978). Most Cefas surveys record argentines (Figure 5.8.1); these will be mostly lesser silver smelt. Greater silver smelt are mainly found over muddy bottoms near the edge of the continental shelf in deeper waters (180–550 m), and have been discussed in earlier reports of deep-water fishes (Gordon, 2003, 2006). Smelts are inshore migratory fish widely distributed in shallow waters of the continental shelf, but most common close to river mouths and in estuaries, especially in the southern North Sea. It is taken very occasionally in coastal waters of Cefas groundfish surveys.

***Synopsis***: Argentines and smelt are small families of relatively small, slender-bodied fishes with a pointed head, large eyes and, characteristically of Salmoniformes, they have an adipose second dorsal fin. They predate on bottom-living worms and molluscs, and also forage at night on small mid-water fishes, planktonic and suprabenthic crustaceans and squid. Smelt also feed on planktonic crustaceans and small fishes. Maximum sizes are: lesser silver smelt 27 cm, greater silver smelt 56 cm, and smelt 30 cm.

***Spawning***: Lesser silver smelt spawn from March to July, and have pelagic eggs and larvae. Greater silver smelt spawn from May to September in deeper water. Smelts spawn upstream in freshwater rivers from February to April, the eggs being shed over sand or gravel or amongst submerged plants to which they adhere. After spawning, the adults return to the sea.

***Ichthyoplankton surveys:*** Lesser silver smelt eggs are relatively large (1.7–1.85 mm) with segmented yolk and a single oil globule. Spawning takes place in UK waters during spring and summer. A few eggs and larvae were caught in the Irish Sea in mid- and late-April; mainly southwest of the Isle of Man (Figure 5.8.2). Maximum abundance was 2.7 $m^{-2}$ for the eggs and 0.2 $m^{-2}$ for the larvae. Small numbers of eggs were caught during the North Sea survey, their distribution being confined to the northeast of Scotland in February and March with a maximum abundance of 4.1 $m^{-2}$. No larvae were recorded, although they would be expected to occur throughout most of the year from April onwards.

### 5.9 Gadiformes I

| | |
|---|---|
| *Family:* | Gadidae |
| ** Main species:* | Silvery pout *Gadiculus argenteus*<br>Poor cod *Trisopterus minutus*<br>Bib *Trisopterus luscus*<br>Pollack *Pollachius pollachius* |
| *Swimbladder:* | Present |
| *Spawning:* | Silvery pout: midwinter to spring<br>Poor cod: spring<br>Bib: March to April<br>Pollack: January to April |

* Commercially valuable species in this family not included in this report include cod *Gadus morhua,* haddock *Melanogrammus aeglefinus* and whiting *Merlangius merlangus.* These species have been reviewed in earlier SEA reports

***Distribution:*** Silvery pout are deep-water, open-sea fish, most common over the edge of the Continental shelf in depths of 200–500 m, and are routinely recorded from surveys in the Celtic Sea (Figure 5.9.1). Poor cod are widely distributed in coastal waters of 25–300m from the Norwegian Coast to Portugal (Wheeler, 1978), and are abundant and widespread throughout much of the UK continental shelf (Figure 5.9.2). Bib are most common in southern and western parts of the UK (Figure 5.9.3), are most abundant in rocky areas where large schools aggregate around reefs or wrecks. Larger individuals tend to occur in deeper waters. Pollack are widely distributed in Northern European waters, particularly near rocks in inshore areas and on rough ground down to 200 m. Given their preference for rocky grounds, they are only occasionally taken in groundfish surveys (Figure 5.9.4).

***Synopsis:*** These gadoids are demersal (poor cod and bib) or benthopelagic (silvery pout), and can form large schools. They feed on fish and invertebrates. Silvery pout rarely live for longer than 3 years. The maximum sizes are silvery pout: 15 cm, poor cod: 26 cm, bib: 41 cm, and pollack: 130 cm.

***Spawning*:** Little is known on the life history traits of these species (Wheeler, 1978). The egg and larvae of nearly all gadoids are pelagic or meso-pelagic. Silvery pout breed from mid-winter to spring in deep water, and the eggs and larvae are pelagic. Poor cod spawn in the winter and spring in depths of 50–100 m. Bib spawn in moderately shallow waters in March-April. Pollack spawn in deep water (100–200 m) from January to April, peaking in March (Wheeler, 1978; Ballerstedt, 2006). The eggs and larvae are pelagic and drift shorewards, and the juveniles remain in shallow waters for 1–2 years before migrating into deeper waters.

***Ichthyoplankton surveys:*** Poor cod eggs are similar in appearance to those of whiting *(Merlangius merlangus)* and so are not identified in plankton samples. Similarly the larvae of the two species are difficult to distinguish between and are often grouped together under the nomenclature Gadidae. Poor cod/Norway pout larvae were recorded from April onwards in the Irish Sea across the survey area, peak numbers occurring in April near to the Isle of Man (Figure 5.9.5) and overall number and distribution declining by mid-May.

Bib eggs lack an oil globule, range in diameter from 0.9–1.23 mm and cannot readily be separated from those of a similar size, such as whiting, other *Trisopterus* species or witch. Bib larvae occurred in low numbers at a small proportion of stations in the Irish Sea in the mid-February survey but did not begin to appear in significant numbers until April (Figure 5.9.6). Maximum larval densities reached 5.6 $m^{-2}$. Fewer numbers were present in the eastern Irish Sea and off Anglesey during the final sampling period in late May. In the North Sea a single bib larva (not plotted) was caught off the Scottish coast in February.

Pollack is another species that produces eggs of a similar size range and appearance to many others lacking an oil globule. Their eggs range in diameter from 1.1–1.22 mm and because this overlaps with others such as whiting and bib they were not separately identified. Larvae were caught in low numbers in the Irish Sea from early April, the highest concentrations being recorded close to the North Wales coast (Figure 5.9.7). In the North Sea in 2004, of the samples that were analysed for larvae, pollack were identified from the last survey in April only. They were caught in low numbers mainly in the German Bight. Maximum abundance was 3.0 $m^{-2}$.

Abundances of poor cod/Norway pout larvae between 30 and 145.5 $m^{-2}$ occurred across an extensive area of the northern North Sea in a March survey (Figure 5.9.8), although from larger individuals identified in the samples, the majority of these appeared to be Norway pout (*Trisopterus esmarkii*).

### 5.10 Gadiformes II (Lotinae)

| | |
|---|---|
| *Family:* | Gadidae |
| *Main species:* | Greater forkbeard *Phycis blennoides*<br>Lesser forkbeard *Raniceps raninus*<br>Four-bearded rockling *Enchelyopus cimbrius*<br>Three-bearded rockling *Gaidropsarus vulgaris*<br>Shore rockling *Gaidropsarus mediterraneus*<br>Five-bearded rockling *Ciliata mustela*<br>Northern rockling *Ciliata septentrionalis*<br>Bigeye rockling *Antonogadus macropthalmus* |
| *Swimbladder:* | Present |
| *Spawning:* | Greater forkbeard: late spring and early summer<br>Lesser forkbeard: late summer and early autumn<br>Four-bearded rockling: summer<br>Three-bearded rockling: winter<br>Shore rockling: June and July<br>Five-bearded rockling: winter and spring<br>Northern rockling: March and April<br>Bigeye rockling: no information |

* Commercially valuable species in this family not included in this report include ling *Molva molva.* This species has been reviewed in earlier SEA reports

***Distribution:*** Five-bearded rocklings (Figure 5.10.1) are common in the intertidal and shallow sublittoral zones, though they can be found in deeper waters, on muddy, sandy or gravely bottoms. The related northern rockling is usually found below the tide-mark, mainly in depths of 10–50m, living among rocks and on sandy and muddy bottoms, records of this species are generally infrequent, which may be a result of specimens being misidentified as five-bearded rocklings. Four-bearded rocklings (Figure 5.10.2) live on the central shelf, on muddy or sandy bottoms in 20–250 m of water, and are routinely captured in North Sea surveys. Three-bearded rocklings are also common in continental shelf waters (Figure 5.10.3), occurring at depths of 10–70 m and often on coarse sand, gravel and rocky bottoms. Shore rocklings are common on rocky shores down to 25m, in tide-pools or under algae-covered rocks. Big-eye rocklings live offshore (Wheeler, 1978), and are reported occasionally from the Celtic Sea in relatively deep-water (150–500 m), though they are more abundant further south. Greater forkbeard (Figure 5.10.4) is relatively common in south-western waters, usually on muddy or sandy bottoms in depths of 100–500 m, but can very occasionally be found in shallower waters (Wheeler 1978). Lesser forkbeard, or tadpole fish, is solitary fish that lives in shallow coastal water among algae-covered rocks and are very rarely encountered in trawl surveys, and are uncommon in southern areas (Deniel, 1985; Dauvin, 1987).

***Synopsis:*** The biology of forkbeards in UK waters is little studied, though southern European populations are better studied (e.g. Claridge and Gardner, 1977). Forkbeards and rocklings are demersal fish that predate on a variety of crustaceans, worms, molluscs, and occasionally fish

(Wheeler, 1978; Albert, 1993; Deree, 1999). Rocklings and tadpole fish are cryptic fish that often associate with coarse grounds and are probably sampled ineffectively in trawl surveys. Maximum sizes are greater forkbeard: 75 cm, lesser forkbeard: 30 cm, four-bearded rockling: 41 cm, three-bearded rockling: 53 cm, shore rockling: 35 cm, five-bearded rockling: 25 cm, northern rockling: 18 cm, and bigeye rockling: 25 cm.

***Spawning:*** Forkbeards and rocklings all have pelagic eggs and larvae. The greater forkbeard spawns in spring and early summer, while the lesser forkbeard spawns inshore in late summer and early autumn. Four-bearded rockling breed in deep water (>50 m) from May to August. Three-bearded rockling spawn in January and February, with shore rockling spawning later in the year (June and July). Five-bearded rockling breed offshore in winter and spring, and northern rockling breed in late March and early April (Wheeler, 1978). The biology of the big-eyed rockling in the Celtic Sea is unknown.

***Ichthyoplankton surveys:*** The egg and larval stages of three species of rockling (three-bearded, four-bearded and five-bearded) have been found in both the Irish and North Sea surveys, (Figures 5.10.5–5.10.8). The shore rockling has also been found in the Irish Sea, while the northern rockling has also been recorded in the North Sea. Rockling eggs are small in diameter (0.5–0.99 mm) with a single oil globule, and are not routinely identified to species level. As shore rocklings spawn inshore in the Irish Sea in June and July, they are unlikely to be found in these surveys. Observed egg distributions (Figure 5.10.5) largely reflected the spawning patterns discussed above. In January and February small concentrations occurred mainly in coastal areas, and by April, rockling eggs were caught over most of the study area. Peak numbers were recorded in May in the eastern Irish Sea. Rockling larvae were caught in coastal waters in February, and by April their distribution was widespread across the Irish Sea (Figure 5.10.6) with higher concentrations off the Irish coast and in the central eastern Irish Sea. By mid-May, numbers had declined with the exception of a single station in Liverpool Bay. In the 2004 North Sea surveys, rockling eggs were found to be relatively abundant and were caught over a wide area, both inshore and offshore (Figure 5.10.7). The spawning times of each species, although varied, overlap at least in part with the period sampled and so eggs of any of these species might have been captured. Highest concentrations were recorded during the later surveys that took place from mid-February onwards. Rockling larvae occurred in low numbers and were found in two main areas, in the northern North Sea in March, and in the German Bight in April (Figure 5.10.8).

### 5.11 Clingfish (Gobiesociformes)

| | |
|---|---|
| *Family:* | Gobiesocidae |
| *Species:* | Connemarra clingfish *Lepadogaster candollei*<br>Shore clingfish *Lepadogaster lepadogaster*<br>Two spotted clingfish *Diplecogaster bimaculata*<br>Small-headed clingfish *Apletodon microcephalus* |
| *Swimbladder:* | Present |
| *Spawning:* | April to July |

***Distribution***: Clingfish are widely distributed in the southern and western waters of the UK (Whitehead et al 1986), though due to their small size and preference for coarse ground (Hofrichter *et al.*, 2000; Gonccalves *et al.*, 2002), they are only recorded occasionally in groundfish surveys (Figure 5.11.1). Connemarra clingfish are usually found on rocky shores and in kelp forests at or below the low-water mark. Shore clingfishes are the most common clingfish found in intertidal habitats, being locally abundant at mid-tide level on sheltered boulder shores clinging to the underside of stones or on kelp. Small-headed clingfishes live on the lower shore and in inshore waters down to 25 m. Two-spotted clingfishes are fairly common in western UK waters, living on stony grounds on the lower shore and inshore waters down to 55 m and this species is the most often observed in groundfish surveys.

***Synopsis***: Clingfishes are small, scaleless fishes with a powerful sucking disc on their underside, which they use to cling to the undersides of rocks etc. The two intertidal species, the connemarra and shore clingfishes, grow up to 6–7 cm, while the two deeper-water species, the two-spotted and small-headed clingfishes only attain a maximum length of 4 cm (Whitehead et al, 1986). There is little information on their biology and feeding habits (Wilson, 1981), but it is believed that the adults feed on small crustaceans.

***Spawning***: Little is known about spawning activity, but it is thought that internal fertilization may take place in some species (Whitehead et al, 1986). Spawning takes place during spring and summer (April to July), with the eggs laid in a hollow in the kelp or algae, inside shells or under stones, and then guarded by a parent. The larvae and fry are planktonic for a short period, and in autumn the young fish can be found among the algae (Wheeler, 1978).

### 5.12 Garfish

*Family:* Belonidae

*Main species:* Garfish *Belone belone*

*Swimbladder:* Present

*Spawning:* May and June

***Distribution***: Garfish live in surface waters, mainly offshore, in warm temperate seas. They come into the shallow waters of northern Europe in late spring to spawn, and can be found close inshore throughout summer and autumn (Wheeler, 1978). They are rarely found in the deeper waters of the central and northern North Sea. Given their epipelagic nature they are only occasionally recorded in groundfish surveys (Figure 5.12.1), as the gears used are not appropriate for sampling this species. Related species include the little-known short-beaked garfish (*Belone svetovidovi*) and saurey pike (*Scomberesox saurus*).

***Synopsis***: Garfish is a predatory fish with a long, slender body and elongate jaws (Wheeler, 1978). It has brilliant greeny-blue back and upper sides and silver/yellow belly and lower sides. It grows to a maximum length of 94 cm. Its food comprises of most small surface-living fishes such as young herring, cod and sandeels, small squid and planktonic crustaceans.

***Spawning***: Garfish spawn in coastal waters in May and June, the eggs having long threads that tangle and adhere in algae or flotsam (Wheeler, 1978). The larvae are pelagic (Whitehead, 1986). The young have short jaws, the lower jaw elongating well before the upper.

### 5.13 John dory and boarfish (Zeiformes)

| | |
|---|---|
| *Family:* | Zeidae and Caproidae |
| *Main species:* | John dory *Zeus faber*<br>Boar-fish *Capros aper* |
| *Swimbladder:* | Present |
| *Spawning:* | June to August |

***Distribution***: John dory and boar-fish are widespread in the north-eastern Atlantic. John dory occurs in both shallow and deep water (Figure 5.13.1), with boar-fish are much more common in the deeper waters of the Celtic Sea and other Atlantic sea boards (Figure 5.13.2). John dory occur in small groups, swimming slowly over sandy bottoms and weed-covered rocks (Wheeler, 1978). Boar-fish can occur in very large numbers in deeper waters (100–400 m) and can occur on a variety of grounds, including coral habitats.

***Synopsis***: John dory and boar-fish both have deep compressed bodies with a protrusible mouth. They have heavy spines in their dorsal, anal and pelvic fins. John dory tend to remain motionless vertically stabilised by motion of the dorsal and anal fin, stalking their prey until close enough to be engulfed by a sudden protrusion of the jaw. They feed on a wide range of teleosts fishes, including small gadoids and clupeids (Silva, 1999). John dory are of increased value to commercial fisheries (Dunn, 2001). Boar-fish feed almost entirely on small crustaceans (Lopes *et al.*, 2006). Maximum sizes are John dory: 50 cm, boar-fish: 16 cm.

***Spawning***: John dory spawn in summer in the English Channel, but may not spawn further northwards (Wheeler, 1978). The eggs are large (1.9–2.5 mm) and pelagic. At about 7 mm the young have developed a mouth. In the first year they measure at 9–13 cm, and by the third year have grown to 32–36cms (Wheeler, 1969). Boar-fish migrate inshore to spawn from June to August. The eggs hatch at about 2.1 to 2.5 mm, and post larvae have been discovered in August and September in water at least 37 m deep.

### 5.14 Pipefish and seahorses (Syngnathiformes)

| | |
|---|---|
| *Family:* | Syngnathidae |
| *Species:* | Snake pipefish *Entelurus aequoreus*<br>Worm pipefish *Nerophis lumbriciformis*<br>Straight-nosed pipefish *Nerophis ophidion*<br>Nilsson's pipefish *Syngnathus rostellatus*<br>Great pipefish *Syngnathus acus*<br>Deep-snouted pipefish *Syngnathus typhle*<br>Short snouted sea horse *Hippocampus hippocampus*<br>Sea horse *Hippocampus ramulosus* |
| *Swimbladder:* | Present |
| *Spawning:* | May to August |

***Distribution*:** Pipefish are most common in UK inshore and estuarine waters (Power and Attrill, 2003), generally amongst algae, sea grass and hydroids (Wheeler, 1969). Most species are not captured in groundfish surveys, which do not sample such shallow coastal habitats, although greater pipefish are routinely recorded (Figures 5.14.1). Snake pipefish also lives in drifting algae or kelp in oceanic areas, and so is also recorded in groundfish surveys (Figure 5.14.2). This latter species has increased dramatically in recent years (e.g. Kirby *et al.*, 2006; Kloppmann & Ulleweit, 2007). The precise distribution of seahorses is largely unknown, as they are quite uncommon in northern European waters; those found in the North Sea are probably wanderers carried northwards by ocean currents, although some are resident on southern Channel coasts. Like most of the pipefish they live in shallow inshore water, usually amongst seaweed or eelgrass beds.

***Synopsis*:** Both pipefish and seahorses have slender snouts with small mouths and a complex bony outer skeleton (Wheeler, 1969). They feed by visual location on minute planktonic animals. The maximum lengths of the pipefish are: snake pipefish 61cm, worm pipefish 15cm, straight-nosed pipefish 30cm, Nilsson's pipefish 17cm, great pipefish 46cm, and deep-snouted pipefish 30cm.

***Spawning*:** In both pipefish and seahorses the male carries and incubates the eggs in a ventral brood pouch (Wheeler, 1969). The breeding seasons are: snake pipefish: June–July, worm pipefish: June–August, straight-nosed pipefish: May–August, Nilsson's pipefish: June–August, greater pipefish: May–August, deep-snouted pipefish: June–August, and seahorses: May–August.

### 5.15 Gurnards (Triglidae)

| | |
|---|---|
| *Family:* | Triglidae |
| *Main species:* | Red gurnard *Aspitrigla cuculus*<br>Grey gurnard *Eutrigla gurnardus*<br>Tub gurnard *Trigla lucerna*<br>Piper *Trigla lyra*<br>Streaked gurnard *Trigloporus lastoviza* |
| *Swimbladder:* | Present |
| *Spawning:* | Red gurnard: April to August (Channel), later further north<br>Grey gurnard: January to June<br>Tub gurnard: May to July<br>Piper: no information<br>Streaked gurnard: June to August |

***Distribution:*** Red gurnard are shallow water fish found on the UK Atlantic coasts at depths of 20 to 250m (Figure 5.15.1), and they are less common in more northern European seas. Grey gurnard are usually found offshore in depths of 20–150m on sandy bottoms (Wheeler, 1978), migrating shoreward in the summer where it is found in sandy bays and estuaries and often very shallow water (Wheeler, 1969). Grey gurnard are one of the most abundant and widely distributed gurnards in UK waters (Figure 5.15.2). Tub gurnard are relatively abundant in UK inshore waters at depths of 50 to 150m, often found in estuaries and bays on muddy, gravel and sandy bottoms (Wheeler, 1978). They are most often found in shallow waters, though larger individuals are occasionally captured in deeper waters (Figure 5.15.3). Streaked gurnards live in shallow and moderately deep water (40–100 m) on sand and gravel bottoms (Wheeler 1969); they are routinely caught in the English Channel, but only occasionally individuals occur further north in the North Sea and Irish Sea (Figure 5.15.4). The piper occurs on the continental shelf, and is more common further south. Historically, piper was documented from various parts along the south-western parts of the UK, though there are few contemporary records.

***Synopsis:*** Gurnards are relatively abundant demersal fish. The young tend to be found in shallow bays coastal waters, with larger individuals occurring in deeper water. The lower three rays of the pectoral fins are separate from the fin and modified as sensory organs, with which they can detect prey and they predate on a variety of crustaceans, fish and bottom-living invertebrates (Wheeler, 1978), with larger individuals more piscivorous. Maximum sizes are red gurnard: 40 cm, grey gurnard: 45 cm, tub gurnard: 75 cm, piper: 45 cm and streaked gurnard: 36 cm. A sixth species of gurnard, long-finned gurnard (*Aspitrigla obscura*) is also known from the UK, but is more common further south. The growth and reproduction of south-western populations have been described by Baron (1985a,b)

***Spawning:*** Red gurnard spawn from April to August in the English Channel and later further north. Grey gurnard spawns from April to August in relatively deep northern water, and earlier (January to June) further south. Tub gurnard spawns from May to July, streaked gurnard spawns in midsummer, ripe fish being found from June to August. There is no information about the spawning habits of the piper. The eggs are pelagic.

***Ichthyoplankton surveys:*** Neither the eggs nor the larvae of gurnards are routinely identified to genus or species. Four species occur in both the Irish and North Seas, the most common of which is the grey gurnard. The larvae rarely feature strongly in plankton samples, however they can be caught with larger gear such as the MIK net. It has been suggested the larvae quickly drop out of the water column to feed and so are situated close to the seabed. By April, gurnard eggs were recorded in the eastern Irish Sea, with maximum abundance (112 $m^{-2}$) occurring in May near Liverpool Bay (Figure 5.15.5). Very low numbers of larvae were caught and only in the western Irish Sea.

In the North Sea, grey gurnard are reported to spawn in spring and summer, while the tub gurnard spawns from March to October. Red and streaked gurnards have a more restricted distribution and both spawn in the summer. As a group, gurnard eggs were relatively widespread in the 2004 surveys (Figure 5.15.6). Maximum abundances occurred in January in the southern North Sea, earlier than previously reported. A few eggs were even identified from the surveys in December and January. By contrast, no larvae were reported.

### *5.16 Sea scorpions and pogge (Cottidae and Agonidae)*

| | |
|---|---|
| *Family:* | Cottidae and Agonidae |
| *Main species:* | Bullrout *Myoxocephalus scorpius*<br>Sea scorpion *Taurulus bubalis*<br>Pogge *Agonus cataphractus* |
| *Swimbladder:* | Absent |
| *Spawning:* | Bull rout: December to March<br>Sea scorpion: February to April<br>Pogge: October to January |

***Distribution*:** Bull rout is common in shallow waters (generally from the shore to waters less than 60 m deep) around much of the British Isles (Figure 5.16.1), though is less common along the south coast. Sea scorpions have a similar distribution (Figure 5.16.2) and occur in inshore and littoral zones. Both species favour rough grounds (Wheeler, 1978). Other species of sea scorpion may also occur in the far north of the UK waters (see Table 2.1), with Norway bullhead (*Taurulus lilljeborgi*) also occurring in the Irish Sea. Sea scorpions favour quite coarse grounds, and so are not usually caught in large numbers during groundfish surveys. Pogge is recorded in inshore waters all around Britain and Ireland (Edwards, 2005), and occurs on sandy and coarse grounds, and is frequently caught in groundfish surveys (Figure 5.16.3), and it also occurs in estuarine areas (Power & Attrill, 2002).

***Synopsis:*** Sea scorpions and bullrouts are predatory and target a variety of crustacean and fish prey (Wheeler, 1978; Cardinale, 2000). Pogge have many sensory barbels and predate on benthic invertebrates, including polychaetes, small molluscs and crustaceans. Bull rout is the largest of the sea scorpions, growing to a length of 30 cm, with sea scorpions and Norway bullheads only attaining 18 and 7 cm respectively. The growth of bull rout has been described for Canadian waters (Ennis, 1970), but the age and growth of British populations have not been studied. Pogge rarely attain more than 15 cm.

***Spawning:*** Bullrout spawn from December to March, with small clumps of eggs deposited between rocks or amongst seaweed (Luksenburg *et al.*, 2004). The larvae are pelagic, and can be found in the plankton from March to April. Sea scorpions also spawn in early spring, with small clumps deposited in rock crevices, with the pelagic larvae present in the plankton through the early summer to July. Pogge spawn in shallow waters (< 70 m) and the eggs deposited on kelp holdfasts and similar habitats. The pelagic larvae may be observed from early spring to May, and they settle out in July-August and become bottom dwelling (Wheeler, 1978).

***Ichthyoplankton surveys:*** Bullrouts and other sculpins are a shallow water family that deposit benthic eggs on rocky or weedy substrate, and so eggs are not taken in ichthyoplankton surveys. The younger larval stages are not easily identified to species and are therefore grouped together at the family level (Cottidae). However, based on identification of the larger larvae, two species (bullrout and sea scorpion) were identified in Irish Sea and North Sea surveys, and Norway bullhead was also observed in the Irish Sea survey. For presentation, numbers have been combined with unidentified specimens. In the Irish Sea (Figure 5.16.4), larvae were recorded inshore close to the Irish coast in mid-February and became more widespread during April, though larvae were still confined to inshore waters at abundances of less than 1.8 $m^{-2}$. In the North Sea, cottid larvae were found in low numbers in inshore areas off the north-east coast of Britain, in February and March surveys (Figure 5.16.5).

Pogge also have benthic eggs, though larvae were recorded in both North Sea and Irish Sea surveys. Larvae were found at only a small proportion of stations in the Irish Sea, with the highest densities recorded towards the end of April in the waters around the Isle of Man (Figure 5.16.6). In the North Sea, larvae occurred from February onwards in low abundances and most were distributed in the German Bight (Figure 5.16.7) and the maximum density recorded was 1.7 $m^{-2}$.

### 5.17 Lumpsucker and sea snails (Cyclopteridae and Liparidae)

| | |
|---|---|
| *Family:* | Liparidae and Cyclopteridae |
| *Species:* | Sea-snail *Liparis liparis*<br>Montagu's sea-snail *Liparis montagui*<br>Lumpsucker *Cyclopterus lumpus* |
| *Swimbladder:* | Absent |
| *Spawning:* | Lumpsucker: February to May<br>Sea-snail: January to March<br>Montagu's sea-snail: May to June |

***Distribution:*** Lumpsuckers and sea-snails are found around most of the British Isles, though they are most frequent in more northern parts of the area, and rarely found on the south-eastern coasts of England. Lumpsuckers tend to be found on coarse ground, and so are not often recorded in groundfish surveys (Figure 5.17.1). Sea-snail and Montagu's sea-snail are small-bodied benthic species that often occur in inshore areas (e.g. Henderson & Holmes, 1990) are not caught regularly in surveys. They are often confused in surveys or only identified to genus, and so only the distribution of *Liparis* spp. is illustrated (Figure 5.17.2). Both species are reported from St George's Channel (Quero *et al.*, 1980; Cefas unpublished data).

***Synopsis:*** Lumpsuckers tend to inhabit waters from the low-water mark down to about 300 m depth, and they move to shallower waters for spawning. The ventral fins of the lumpsucker are modified to form a suction disc that is used to cling to rocky substrates. The skin has small bony lumps covering the body, with lateral rows of larger bony scutes along the body. Adults grow to between 30–50 cm in length. The colouration of the male changes to blue dorsally and red/orange ventrally during the breeding season. Between February and May, females lay their eggs in shallow coastal waters. Males guard the eggs for 6–7 weeks. The newly hatched fish are 6–7 mm in length and have a 'tadpole like' form. Lumpsuckers feed on small fish, crustaceans and polychaetes. Eggs of the lumpsucker are also commercially harvested as a form of caviar (Reed, 2006). Due to the commercial interest in lumpusuckers in northern European countries, they have been subject to many biological studies (e.g. Davenport, 1985), whereas the non-commercial sea-snails are little studied (e.g. Dunne, 1981). Sea-snails are common in shallow inshore and estuarine waters, and they can be highly variable in abundance. They are small-bodied, rarely attaining lengths >12 cm. These species are an important predator on natantid shrimps.

***Spawning:*** Lumpsucker spawn from February to May and the eggs are laid in shallow waters. The females return to deeper waters after spawning, and the males guard the eggs until hatching occurs after 6 or 7 weeks. In British waters they mostly spawn in the shallow waters along the northern and Scottish coasts. Sea-snail breeds in the spring (January-March), and Montagu's sea-snail breeds in late spring and early summer (May and June). Both species deposit clumps of eggs on the bases of hydroids, bryozoans and algae. (Wheeler, 1978), though the larvae are planktonic.

***Ichthyoplankton surveys:*** Larvae of sea-snails are most common close to the coast. In the Irish Sea (Figure 5.17.3), larvae are generally found from April onwards in coastal and offshore areas, and in the North Sea larvae most commonly occurred in shallower water, particularly in the German Bight area (Figure 5.17.4). Numbers were low (< 1.6 $m^{-2}$) and highest incidence in the series was recorded in February.

### *5.18 Bass (Percichtyidae)*

| | |
|---|---|
| *Family:* | Percichtyidae |
| *Main species:* | European seabass *Dicentrarchus labrax* |
| *Swimbladder:* | Present |
| *Spawning:* | March to June |

***Distribution:*** Bass are common in inshore waters, with juveniles also occurring in river mouths and estuaries, all round the southern and western coasts of the UK. Traditionally they have been considered scarce in the central and northern North Sea (Wheeler, 1969), though targeted fisheries for them have developed off the coast of NE England in recent years. They are often found in rocky, sandy areas, or off sandy shingle beaches, and are also attracted to warm water discharges. Bass migrate inshore in spring (March to June) and offshore in winter (October and November). They can occasionally form large shoals during migrations. Due to their fast swimming nature and the inshore distribution of the juveniles, bass are not sampled very effectively in trawl surveys, though they are caught in those areas where they are most abundant, such as in the English Channel and Bristol Channel (Figure 5.18.1).

***Synopsis:*** Young bass eat mainly crustaceans, amphipods, isopods, small shrimps and young fish (e.g. sand eels, sand smelts and gobies), with adults predating on small shoaling fish, squid, shrimps, prawns and crabs. Bass can attain a length of about 100 cm (Whitehead et al, 1986). The more southerly spotted seabass *Dicentrarchus punctatus* is occasionally recorded in the English Channel. The biology of bass has been well reviewed by Pickett and Pawson (1994).

***Spawning:*** Bass spawn during March to June in UK inshore waters (Wheeler, 1969). The eggs and larvae are pelagic.

### 5.19 Sea-breams (Sparidae)

| | |
|---|---|
| *Family:* | Sparidae |
| *Main species:* | Black sea-bream *Spondyliosoma cantharus*<br>Red sea-bream *Pagellus bogaraveo* |
| *Swimbladder:* | Present |
| *Spawning:* | Black sea-bream: April to May<br>Red sea-bream: September to October |

***Distribution:*** Several species of sea-bream have been recorded from UK waters (Table 2.1), although most are southerly species with distributions that extend to the southern and western coasts of the British Isles. In general terms, sea-breams tend to occur on rocky outcrops, though smaller individuals and smaller species also occur on finer grounds in inshore waters. Hence, this family is not generally sampled effectively in groundfish surveys. Black sea-bream is relatively common in the English Channel and off the western coasts of the British Isles (Figure 5.19.1), and they breed in UK waters. Red (or common) sea-bream was formerly abundant in UK shelf seas (e.g. Wheeler, 1969), and supported fisheries from the western English Channel to Scotland, though the range of this species is now mainly in deeper waters on the edge of the continental shelf. In recent years, small numbers of red sea-bream have appeared in surveys in the South-western Approaches. Other sea-breams are mostly recorded as occasional individuals and they may not breed in UK seas

***Synopsis:*** Sea-breams tend to have deep, compressed bodies. Some species feed on algae, though most sea-breams feed on copepods, amphipods, shrimps, with larger individuals also feeding on decapod crustaceans and small fish. Little is known about the biology of sea-breams in UK seas. Black and red sea-breams grow to lengths of about 50 cm.

***Spawning:*** Red sea-bream spawn in deep water (>100m) around the British Isles in September and October. Black sea-bream spawn during April and May in UK inshore seas (e.g. in the English Channel) and the eggs of this species are laid in a nest (usually a depression on the seabed) where the male protects them.

### 5.20 Red mullet (Mullidae) and red band fish (Cepolidae)

| | |
|---|---|
| *Family:* | Mullidae and Cepolidae |
| *Species:* | Red mullet *Mullus surmuletus*<br>Red bandfish *Cepola rubescens* |
| *Swimbladder:* | Present |
| *Spawning:* | Red mullet: May to June<br>Red bandfish: summer |

***Distribution:*** Red mullet is relatively common in the English Channel and along the southern and western coasts of the British Isles (Figure 5.20.1), and has traditionally been considered a vagrant in more northern waters. It has, however, steadily increased in abundance in the North Sea in recent years (e.g. Beare *et al.*, 2005). It is found on as variety of bottoms, and usually in coastal waters (Wheeler, 1978). Red band fish tend to be restricted to the southern and western coasts of the British Isles (Figure 5.20.2), and its distribution is also dependent on sediment, as it lives in burrows in muddy substrates (Atkinson *et al.*, 1977, 1987; Reeve, 2005). It occurs in waters of 15–200 m depth.

***Synopsis:*** Red mullet are relatively small demersal fish (usually <40 cm) that favour soft bottoms in shallow waters. The lower jaw has two long barbels, and these are used in prey detection. They predate on a variety of benthic invertebrates (N'Da, 1992). Though little studied in UK waters, the biology of populations in the Bay of Biscay and Mediterranean has been well described (e.g. N'Da & Deniel, 2005). Red band fish is a distinctive species, with a thin, elongated body, pointed tail and long dorsal and anal fins stretching almost the entire length of the body. The lateral and dorsal surfaces are red/orange-red in colour, with a orange/yellow belly. They can grow to a length of 70 cm, though are more commonly seen at sizes of 30–35 cm. Some populations of red band fish may be transitory, for example the population of around 14,000 individuals present at Lundy in the mid 1970's has been absent (except for a few individuals) since the 1980's and through to 2005 (Hiscock, 2003). They feed on planktonic crustaceans.

***Spawning:*** Red mullet spawn from May to July; the eggs and larvae are pelagic and are common in August. Red band fish spawn in the summer. The larvae become abundant in August, but also occur from June to September. The summertime spawning of these fish, and their southerly distribution, means that contemporary ichthyoplankton surveys do not sample them effectively. Little is known about the spawning habits of red band fish in UK seas, though their larvae are present from May to October in the Mediterranean (Martin & Sabates, 1991).

### 5.21 Grey mullets (Mugilidae)

| | |
|---|---|
| *Family:* | Mugilidae |
| *Main species:* | Thick lipped mullet *Chelon labrosus*<br>Thin lipped mullet *Liza ramada*<br>Golden grey mullet *Liza auratus* |
| *Swimbladder:* | Present |
| *Spawning:* | July to December |

***Distribution:*** Grey mullets are common fishes in inshore and estuarine waters around the UK; and can also move into freshwater. They often shoal around rocky headlands and tidal pools. They are most abundant along southern and western coasts and less common further north. Given their preference for coastal and estuarine waters, they are rarely encountered in groundfish surveys.

***Synopsis:*** Grey mullets (which are in a different family to the red mullets) have moderately stout-bodies with a relatively small mouth. They feed on the organic layers that are deposited on mud, where they swallow algae, small worms and other material. Some sediment is rejected through the gills, the remaining sediment passing through the alimentary canal. Grey mullets may also graze on algae, and larger individuals may feed on small crustaceans and molluscs. Maximum lengths of thick-lipped mullet: 75 cm, thin-lipped mullet: 60 cm, and golden mullet: 45 cm.

***Spawning:*** There is little information about the spawning habits of grey mullets. Thicklipped grey mullets are thought to spawn in the spring (April/May) in the Bristol Channel (Abbasi & Shackley, 1996), though they spawn in the winter in other parts of their range (Whitehead *et al.,* 1986; Vidy & Franc, 1992). Thinlipped grey mullets spawn from October to January (Whitehead *et al.*, 1986; Abbasi & Shackley, 1996), and golden grey mullets during July to November (Whitehead *et al.*, 1986).

### 5.22 Wrasse (Labridae)

| | |
|---|---|
| *Family:* | Labridae |
| *Species:* | Scale-rayed wrasse *Acantholabrus palloni*<br>Rainbow wrasse *Coris julis*<br>Small-mouthed wrasse/Rock cook *Centrolabrus exoletus*<br>Corkwing *Crenilabrus melops*<br>Goldsinny *Ctenolabrus rupestris*<br>Ballan wrasse *Labrus bergylta*<br>Cuckoo wrasse *Labrus mixtus*<br>Baillions wrasse Symphodus bailloni |
| *Swimbladder:* | Present |
| *Spawning:* | Corkwing: June to September<br>Goldsinny: May to August<br>Ballan wrasse: June to July<br>Cuckoo wrasse: May to July |

***Distribution:*** Wrasses are widespread throughout temperate and tropical seas and a large number of species are known, with eight species known from UK seas, though two species (rainbow wrasse and small-mouthed wrasse) are rare in this area. Goldsinny (Figure 5.22.1), corkwing (Figure 5.22.2), cuckoo (Figure 5.22.3) and ballan wrasse (Figure 5.22.4) are widespread along the southern and western coasts of the British Isles, though they are less frequent in the southern and central North Sea. Baillion's wrasse has traditionally been considered rare in UK seas (e.g. Wheeler, 1978), though it is often recorded in the eastern English Channel (Figure 5.22.5; Dunn & Brown, 2003). Most wrasse occur in inshore waters, where they occur on rocky and weedy bottoms, and as such are only encountered at a few trawl stations.

***Synopsis:*** Wrasse generally have moderately long bodies and are laterally compressed, with strong jaw teeth. Several species of wrasse can have bright colouration, especially males during the breeding season (Gregory, 2003; Skewes, 2003; Ager, 2006). Corkwing, goldsinny and small-mouthed wrasse are generally small, growing to about 15–18 cm in length, with cuckoo and ballan wrasse larger species, attaining lengths of 35 and 60 cm respectively. Baillon's wrasse reaches about 20 cm (Wheeler, 1978). Wrasse have a relatively low economic value, though larger specimens (e.g. ballan wrasse) may be landed. In some species, the male builds an elaborate nest of seaweed in either rock crevices or amongst seaweed or seagrasses. Some species of wrasse change sex from female to male as they increase in size. The nests are a ball or mound with an entrance hole, which the males guard. Wrasse predate on small molluscs and crustaceans. Some species have been used in salmon aquaculture, as they can feed on ectoparasites of farmed salmon (Sayer *et al.*, 1996).

***Spawning:*** Corkwing spawn in mid-summer and post larvae have been found in the plankton from June to September, particularly in July. The goldsinny spawns from May to August, with post larvae most abundant in the plankton in late summer. Larval stages of cuckoo wrasse have been observed in the plankton from May to July, especially in June in the English Channel. Ballan wrasse appear to spawn in June and July. That the eggs are protected in a nest and that the planktonic stages are found in the summer means wrasse are not sampled in contemporary ichthyoplankton surveys.

### 5.23 Eelpouts, snake blennies and butterfish (Zoarcidae, Stichaeidae, Pholidae)

| | |
|---|---|
| *Family:* | Zoarcidae, Stichaeidae, Pholidae |
| *Species:* | Sars's eelpout *Lycenchelys sarsi*<br>Vahl's eelpout *Lycodes vahlii*<br>Esmark's eelpout *Lycodes esmarkii*<br>Viviparous blenny/eelpout *Zoarces viviparus*<br>Yarrell's blenny *Chirolophis ascanii*<br>Snake blenny *Lumpenus lampretaeformis*<br>Spotted snake blenny *Leptoclinus maculatus*<br>Butterfish *Pholis gunnellus* |
| *Swimbladder:* | Present without duct |
| *Spawning:* | July to September and December to February |

***Distribution:*** There are numerous species of eelpout (Zoarcidae) in polar waters, with one species (the eelpout or viviparous blenny) occurring along northern and eastern coasts of the UK. Another three species (Sars's, Vahl's and Esmark's eelpouts) also occur in the deeper waters of the northern North Sea. The viviparous blenny is common in estuaries, rocky shores and on mixed sediments down to depths of 40 m. on muddy & sandy bottoms. Snake blennies (Stichaeidae) and the butterfish are more widely distributed around the UK than the eelpouts, but they are also cold-water species that are more abundant in northern areas. The snake blennies tend to occur offshore, in cooler waters, whereas the butterfish is also commonly found in the shallow sub-littoral and intertidal zones (Koop & Gibson, 1991). The snake blennies and butterfish tend to occur on mixed and coarse grounds. Due to their small size and preference for coarse ground, they are only occasionally captured in trawl surveys (Figure 5.23.1).

***Synopsis:*** Eelpouts, snake blennies and butterfish are all relatively small bodied, elongated benthic fish. The length normally obtained by these species are: viviparous blenny: 30 cm (sometime larger), Yarrell's blenny: 25 cm; snake blenny 49 cm; spotted snake blenny: 20 cm and butterfish: 25 cm. Further north, Sars's, Vahl's and Esmark's eelpouts can reach 18, 52 and 75 cm respectively. Eelpouts, snake blennies and butterfish feed on a variety of small invertebrates, including crustaceans, molluscs, brittlestars, sea urchins and polychaetes (e.g. Wheeler, 1978; Gordon & Duncan, 1979).

***Spawning:*** The viviparous blenny mates in August-September, and the eggs and larvae subsequently develop in the female, before being born as fully formed (4 cm) young in the winter (December to February). Other eelpouts produce a few, relatively large eggs, with Vahl's eelpout producing <100 large eggs and Esmark's eelpout producing up to about 1,200 large (6mm) eggs. The snake blennies and butterfish deposit eggs on the seabed, including rock crevices and on shell debris, with spawning usually occurring from December to March. The late larval stages are planktonic. The postlarvae of Yarrell's blenny have been recorded in the plankton from January to April in the western English Channel (Wheeler, 1978), and the post-larvae of the snake blenny and butterfish also occur in the plankton at this time, with spotted snake blenny post-larvae found in June.

***Ichthyoplankton surveys:*** The larvae of Yarrell's blenny were recorded occasionally in the Irish Sea during April (Figure 5.23.2), and low numbers were observed off the Scottish coast in early March during the North Sea survey. Butterfish spawn from January to March in the Irish Sea (Qasim, 1956), and the larvae can be observed at coastal sites throughout the Irish Sea by early March (Figure 5.23.3). The highest density recorded was 39 $m^{-2}$. By April the distribution of larvae had spread out from the coast, and larvae were still being caught in low numbers throughout the area in May. A single butterfish larvae was identified from the North Sea survey carried out in early March.

### 5.24 Wolf-fish (Anarhicadidae)

| | |
|---|---|
| *Family:* | Anarhichadidae |
| *Main species:* | Atlantic wolf-fish *Anarhichas lupus* |
| *Swimbladder:* | Present |
| *Spawning:* | Late July to November |

***Distribution:*** Atlantic wolf-fish *A. lupus* is distributed from Greenland, Iceland and Spitzbergen in the north, and as far south as New Jersey in the western North Atlantic and the British Isles in the eastern North Atlantic. They typically inhabit depths of 100–300m during the winter and move to shallower waters in the summer. This species is primarily found in the northern North Sea (Figure 5.24.1). Two other species (spotted wolf-fish *A. minor* and northern wolf-fish *A. denticulatus*) have similar distributions, though their southerly limits only extend as far south as the Shetland Islands and northern North Sea and these species are uncommon in British waters.

***Synopsis:*** Wolf-fish are large bodied demersal fishes with elongated bodies, they have well-developed canine and molar teeth and are known to predate on a variety of hard-shelled prey, including molluscs (whelks, scallops, clams, etc.), decapod crustaceans and sea urchins (Nelson and Ross, 1992). Young wolf-fish tend to feed on small crustaceans, including amphipods, euphausids and decapods (Ortova *et al.*, 1990). They inhabit shallow to moderately deep cold waters, extending to depths of 500 m, and tagging studies generally suggest that movements and migrations are limited (Templeman, 1984). Atlantic wolf-fish typically inhabit depths of 100–200 m during the winter and move to shallower waters in the summer (Pavlov and Novikov, 1993). They are generally solitary fish, which aggregate to spawn during July to September, and fish are thought to pair prior to spawning (Falk-Petersen & Hansen, 1991). In the White Sea, *A. lupus* mature at 5–7 years (35 cm length) (Pavlov and Novikov, 1993) and they can live for 22–23 years (Falk-Petersen and Hansen, 1991; Nelson and Ross, 1992). Off the east coast of Canada, *A. lupus* start to mature at 38cm, and 50% maturity is attained at 51–68 cm length, with females maturing at a shorter length further north (Templeman, 1986). Fecundity increases with the size of the female, ranging from 5,000 eggs for a 60 cm female to 40,000 in the largest individuals off Norway (Falk-Petersen and Hansen, 1991). The diameter of maturing oocytes is 1.6–4.2 mm (Templeman, 1986).

***Spawning:*** Little is known about the spawning season of wolf-fish in the North Sea, though they spawn from late July to October in the White Sea (Pavlov and Novikov, 1993; Sokolov and Shevelev, 1994), and from September to November off Iceland (Falk-Petersen and Hansen, 1991). Eggs are laid in depths of 70–300 m (Pavlov and Novikov, 1993), though they will spawn in shallower water (ca. 10 m) in many areas, including off Scotland (Pavlov and Novikov, 1993). Wolf-fish are thought to pair, as reported from SCUBA observations, with eggs laid between boulders (Templeman, 1986b), and males guard the demersal egg masses. Eggs hatch during April and May, suggesting an incubation period of 7–9½ months (Pavlov and Novikov, 1993; Sokolov and Shevelev, 1994). Juvenile wolf-fish are taken primarily in depths of 68–385 m (Ortova *et al.*, 1990).

### 5.25 Weever fish (Trachinidae)

| | |
|---|---|
| *Family:* | Trachinidae |
| *Species:* | Lesser weever fish *Echiichthys vipera*<br>Greater weever fish *Trachinus draco* |
| *Swimbladder:* | Present without duct |
| *Spawning:* | June to August |

***Distribution:*** The lesser weever fish is widely distributed in the coastal waters of the southern North Sea and along the southern and western sea boards of the British Isles (Figure 5.25.1). It is most abundant on sandy sediments in coastal waters less than 50 m deep (Pizzolla, 2002), though it can be found in small numbers in deeper waters. The greater weever is less common and is a more southerly fish species with a patchy distribution around the British Isles, occurring mostly in Cardigan Bay and parts of the English Channel (Figure 5.25.2). Historically, greater weever was regarded as relatively frequent in the North Sea, though populations here may have been reduced due to the severe winter of 1963, and there are few contemporary records of them in the North Sea.

***Synopsis:*** Lesser weevers are small fish, growing to a length of about 15 cm. They have sharp spines on the first dorsal fin and associated with the operculum that are connected to venom glands, and so can give a painful sting. The dorsal fin is black in colouration and this is normally erected as a warning signal to deter predators. Greater weever is of minor commercial importance. Both species are predatory, feeding on crustaceans and small fish (Creutzberg & Witte, 1989; Vasconcelos *et al.,* 2004).

***Spawning:*** Lesser weever spawn from June to August, the eggs are pelagic and are between 1.1–1.37 mm. Greater weevers also spawn from June to August, with the pelagic eggs about 1.1 mm.

### *5.26 Blennies (Blennidae)*

| | |
|---|---|
| *Family:* | Blennidae |
| *Species:* | Butterfly blenny *Blennius ocellaris*<br>Montagu's blenny *Coryphoblennius galerita*<br>Shanny *Lipophrys pholis*<br>Tompot blenny *Parablennius gattorugine* |
| *Swimbladder:* | Absent in adults |
| *Spawning:* | Butterfly blenny and shanny: spring and summer<br>Tompot blenny: mid-March to April<br>Montagu's blenny: July |

***Distribution:*** Four species of blenny occur in UK waters. The butterfly blenny is the only species that is often reported from offshore (Figure 5.26.1), and it occurs on shelly bottoms and other complex habitats in waters of 10–100 m depth off the southern and western seaboards. Both the tompot and Montagu's blenny are also restricted to the western and southwestern UK waters. Adults are common in rocky sub-tidal areas, to depths of about 12 m, where they hide on ledges or between stones, though occasional specimens can be reported from deeper areas. The shanny is an extremely common littoral fish, abundant on rocky coasts or other stony or algae-encrusted areas all around the UK coast. It is most abundant from mid-tide down to the shallow-sublittoral, with occasional specimens occurring to depths of about 30 m. The preference for shallow, rocky habitats means that Montagu's blenny and tompot blenny are only captured occasionally in groundfish surveys, with the shanny not encountered.

***Synopsis:*** Butterfly blennies grow to a maximum length of 20 cm, and feed on small crustaceans, worms and small fish (Kabasakal, 1999). Tompot blennies can grow to 30 cm, though they rarely exceed 20 cm, and they also predate on small crustaceans. The shanny grow to a maximum length of 16cm, and feed on barnacles, small crabs and other crustaceans. Montagu's blenny is one of the smaller blennies, growing to a maximum length of 8.5 cm, and they too feed on barnacles and small crustaceans.

***Spawning:*** Blennies lay their eggs in crevices among algae and rocks, or on shell debris. The eggs are guarded and aerated by the male. The newly-hatched young are planktonic for a short period. The spawning seasons are: butterfly blenny - spring and summer; tompot blenny - mid-March to April; shanny - spring and summer; Montagu's blenny - July. Due to them having benthic eggs and a short planktonic larval stage, these species are not sampled effectively by contemporary plankton surveys.

### 5.27 Dragonets (Callionymidae)

| | |
|---|---|
| *Family:* | Callionymidae |
| *Species:* | Common dragonet *Callionymus lyra*<br>Spotted dragonet *Callionymus maculatus*<br>Reticulate dragonet *Callionymus reticulatus* |
| *Swimbladder:* | Absent |
| *Spawning:* | Common and spotted: April to June |

***Distribution:*** Common dragonet is widespread and abundant in European waters, and is widely distributed and abundant in UK seas (Figure 5.27.1), and it is most abundant in inshore waters (Oakley, 2005). Spotted dragonet is also relatively common, especially in some offshore areas (Oakley 2005), including in the western English Channel and Celtic Sea (Figure 5.27.2). Reticulated dragonet has quite a patchy distribution (Figure 5.27.3), which is due in part to habitat preference and also maybe an artefact of misidentifications.

***Synopsis:*** Dragonets are small-bodied benthic fish, and though common dragonet can reach 20–30 cm in length, spotted and reticulate dragonets are smaller, reaching about 15 and 10 cm respectively. Dragonets tend to favour sandy and gravel bottoms. All species feed on polychaetes, small crustaceans and molluscs (e.g. King *et al.*, 1994).

***Spawning:*** Common dragonet is the most abundant and widely distributed, and spawns in water less than 50 m from early spring through until August (Russell, 1976). Spotted dragonet also spawns from April to August, though the eggs and larvae tend to be found over deeper water than *C. lyra* (Wheeler, 1978). Reticulated dragonet is uncommon in the Irish Sea, and although there is little information on its spawning habits in the Irish and North Seas, it is thought to spawn between April and September in the English Channel (Demir, 1976). The eggs and larvae are pelagic.

***Ichthyoplankton surveys:*** The eggs of dragonets have a sculpted case and are therefore very distinct. Eggs and larvae of the two most common species occurring in the Irish and North Seas have not been separately identified from these surveys. Dragonet eggs were caught throughout the survey period in the Irish Sea (Figure 5.27.4), but were particularly abundant in April in the eastern Irish Sea, reaching densities of 301 $m^{-2}$. Small numbers of larvae occurred in discrete areas as early as January, although subsequent distribution patterns generally reflected those of the eggs . Larvae were abundant across the region in April and May. Numbers reached their maximum (up to 167 $m^{-2}$) during the final survey, especially in areas east of the Isle of Man

(Figure 5.27.5). In the North Sea, dragonet eggs were found in highest abundances during March. Peak numbers (up to 27 $m^{-2}$) occurred off the north east coast of Scotland and near the northern limits of the North Sea (Figure 5.27.6). The larvae were rare, probably because sampling occurred too early in most areas, and low numbers were caught at isolated positions (Figure 5.27.7).

### *5.28 Gobies (Gobidae)*

| | |
|---|---|
| *Family:* | Gobidae |
| *Main species:* | Black goby *Gobius niger*<br>Rock goby *Gobius paganellus*<br>Steven's goby *Gobius gasteveni*<br>Sand gobies *Pomatoschistus* spp.<br>Fries's goby *Lesueurigobius friesii*<br>Jeffrey's goby *Buenia jeffreysii* |
| *Swimbladder:* | Present |
| *Spawning:* | March to August (see below) |

***Distribution:*** Gobies are abundant in inshore waters in temperate waters around the UK coast, and some species are also found in brackish estuarine conditions. Wheeler (1992) listed 19 species as occurring in UK seas. Of these, two species (transparent goby *Aphia minuta* and crystal goby *Crystallogobius linearis*) are small pelagic species, and so are only caught occasionally in trawl surveys. Other species (e.g. giant goby *Gobius cobitis*, red-mouth goby *Gobius cruentatus*, Couch's goby *Gobius couchi* and two-spotted goby *Gobiusculus flavescens*) tend to be restricted to littoral and shallow sub-littoral zones and are therefore not sampled by trawl surveys. Other species are not observed in surveys, possibly due to their small size (e.g. *Lebetus* spp.) or because they favour rocky habitats (e.g. leopard spotted goby *Thorogobius ephippiatus*). Due to the cryptic nature of gobies, the taxonomic problems with the group and the poor catch efficiency for most species, accurate information on their distribution is not available for many species.

Cefas groundfish surveys catch large numbers of *Pomatoschistus*, throughout much of the survey area (Figure 5.28.1). Though these are not identified to species, they will be mostly *Pomatoschistus minutus* in inshore areas and *P. norvegicus* in the offshore areas of the Celtic Sea. Some of the larger gobies (e.g. black and rock gobies) are reported sporadically from surveys off the southern and western sea boards, with Steven's goby recorded from the western English Channel (Figure 5.28.3). Other species observed regularly include Fries's goby (Figure 5.28.3), which is normally encountered on muddy grounds with *Nephrops norvegicus* and Jeffrey's goby, which is one of the more common gobies in the Celtic Sea.

***Synopsis:*** Gobies are typically small, (e.g. most *Gobius* spp. are <17 cm, *Pomatoschistus* spp. <8 cm and *Buenia* <6 cm). The larger species feed on crustaceans, with smaller species feeding on planktonic organisms, polychaetes and algae. The most common goby species found in UK waters are detailed below.

***Spawning:*** Gobies generally spawn on the sea-bed in the summer, laying their eggs in several broods under rocks or in empty shells on the sea-bed, the eggs being guarded by the male. The larvae are generally pelagic. Black gobies spawn May to August; rock gobies spawn from April to June, and it may be presumed that Steven's goby and Fries's goby spawns at similar times of the year. Sand gobies and Jeffrey's gobies both spawn from March to August.

***Ichthyoplankton surveys:*** Up to 11 species of goby are found in the Irish Sea and up to 13 in the North Sea, and the eggs and larvae are not well described, although they are easy to identify as a group because of their prominent swim bladder and characteristic pigmentation. In the Irish Sea, larvae were found on all surveys in 2000, predominantly in coastal or shallow waters, with highest densities recorded in the eastern Irish Sea in mid-May (Figure 5.28.4). In the North Sea, larvae were relatively widespread and reached their highest abundances off the coasts of England and Scotland in February and March (Figure 5.28.5). The maximum concentration was 19.5 $m^{-2}$.

### 5.29 Scophthalmidae

| | |
|---|---|
| *Family:* | Scophthalmidae |
| ** Main species:* | Turbot *Scophthalmus maximus*<br>Brill *Scophthalmus rhombus*<br>Common topknot *Zeugopterus punctatus*<br>Norwegian topknot *Phrynorhombus norvegius*<br>Ekstroms topknot *Phrynorhombus regius* |
| *Swimbladder:* | Absent (present in larval stages) |
| *Spawning:* | Turbot: April to August (North Sea and Irish Sea) and May to September (western English Channel)<br>Norwegian Topknot: March to June<br>Common Topknot: February to May<br>Eckstroms topknot: April to June |

* Other commercially valuable species in this family not included in this report include megrim *Lepidorhombus whiffiagonis.* This species has been reviewed in earlier SEA reports

***Distribution:*** Brill and turbot (Figures 5.29.1 and 5.29.2 respectively) are found around all around the British Isles, but are most common along southern and western coasts. Juveniles tend to occur on inshore nursery grounds, with juvenile turbot most common on exposed beaches. Larger individuals occur in deeper water and tend to occur on sand, gravel and shell gravel substrates. Norwegian topknot (Figure 5.29.3) and common topknot (Figure 5.29.4) are distributed sporadically along the coastal regions of the British Isles, whereas Eckstroms topknot is rarer in British waters, and is occasionally reported from south-western areas. Topknots tend to occur on coarse and rocky grounds, and their preference for hard grounds means that they are not sampled effectively in trawl surveys. There are some populations of Norwegian topknot that also occur on finer grounds in the Bay of Biscay (Chanet *et al.*, 2003).

***Synopsis:*** Turbot and brill are large flatfishes that can attain lengths of 100 and 75 cm respectively (Wheeler, 1978; Tyler-Walters, 2004). Both species have large mouths and are active predators, feeding on a variety of fish, cephalopods and crustaceans. Brill and turbot are both of high commercial value and are an important by-catch in many fisheries in the southern and western waters of the UK. Topknots are little-known flatfishes, that are comparatively small (maximum lengths for the common, Ekstroms and Norwegian topknots are 25, 20 and 12 cm respectively) and all predate on polychaetes, crustaceans and small fishes. The biology of topknots is poorly known, due to their preferred habitats being difficult to sample.

***Spawning:*** Turbot spawn from April to August in the North Sea and Irish Sea, and from May to September in the western English Channel. Spawning occurs over gravely grounds at 10–80 m water depth. The pelagic eggs are about 1 mm in diameter, and hatch within about nine days.

Common topknot spawn from February to May and Norwegian and Eckstroms topknot spawn from about March to June in the western English Channel.

***Ichthyoplankton surveys:*** As Norwegian topknot spawn in late spring and summer, their peak egg production is likely to occur later than the period covered by existing plankton surveys. In the Irish Sea, their eggs were found mainly in April and May (Figure 5.29.5) and were distributed in two areas along the Irish/Northern Irish coast and in the waters between Anglesey and the Isle of Man. Larvae (maximum concentration = 6.8 $m^{-2}$) were caught in the same areas towards the end of April and in May (Figure 5.29.6). Eggs of common topknot were caught mainly in coastal waters of the Irish Sea in April (Figure 5.29.7), with eggs recorded in the western Irish Sea in May. The abundance of larvae was relatively low and patchy, with a few records in the western Irish Sea (Figure 5.29.8). North Sea surveys yielded Norwegian topknot eggs in early spring in central parts of the North Sea (Figure 5.29.9; maximum concentration = 10.8 $m^{-2}$), though no larvae were identified. In the North Sea, a single topknot egg was identified off the north east coast of Scotland in late February.

### 5.30 Scaldfish (Bothidae)

| | |
|---|---|
| *Family:* | Bothidae |
| *Main species:* | Scaldfish *Arnoglossus laterna*<br>Imperial scaldfish *Arnoglossus imperialis* |
| *Swimbladder:* | Absent (present in larval stages) |
| *Spawning:* | April to August |

***Distribution:*** Scaldfish is mostly found on sandy, mixed or muddy bottoms from 10–200 m, and occur on all British and Irish coasts, although it is most abundant on southern and western coasts (Figure 5.30.1). Juvenile scaldfish have also been reported from the eastern Irish Sea (Rogers, 1991). Imperial scaldfish are common in deep waters (>50 m) in the western English Channel and Celtic Sea (Figure 5.30.2), as well as further south in the Bay of Biscay (Wheeler, 1978). A third species, Thor's scaldfish *Arnoglossus thori* may also occur in the south-west, though there are few records of this species.

***Synopsis:*** Scaldfishes are small-bodied and thin flatfish that are not of commercial importance. Scaldfish and imperial scaldfish grow to lengths of about 20 and 25 cm respectively (Wheeler, 1978; Ruiz, 2007). Scaldfishes predate on small fish and invertebrates.

***Spawning:*** Little is known about the spawning habits of scaldfishes, though they tend to spawn in the late spring and summer (Deniel, 1983), and the eggs and larvae are pelagic.

### 5.31 Pleuronectidae

| | |
|---|---|
| *Family:* | Pleuronectidae |
| ** Main species:* | Witch *Glyptocephalus cynoglossus*<br>Long-rough dab *Hippoglossoides platessoides*<br>Dab *Limanda limanda*<br>Flounder *Platichthys flesus* |
| *Swimbladder:* | Absent (present in larval stages) |
| *Spawning:* | February to June |

* Commercially valuable species in this family not included in this report include plaice *Pleuronectes platessa* and lemon sole *Microstomus kitt.* These species have been reviewed in earlier SEA reports

***Distribution:*** This family is widely distributed in the temperate waters of the UK Continental Shelf. They are bottom-living fishes, generally living on muddy or sandy bottoms. Dab is very abundant in shallow water (<50 m), though they also occur in deeper water (Figure 5.31.1). Flounder is widespread in European waters, and most common in inshore and estuarine habitats (Figure 5.31.2), though they also occur offshore (down to about 50 m). Juveniles are abundant close inshore and in the tidal reaches of rivers. Both long-rough dab (Figure 5.31.3) and witch (Figure 5.31.4) are most common in moderately deep water (40–500 m), and are typically found on muddy and sandy-mud substrates.

***Synopsis:*** All these flatfishes are of some commercial importance, though their economic value is far less that other members of the family (e.g. plaice, lemon sole). Further north, the related halibut *Hippoglossus hippoglossus* and Greenland halibut *Reinhardtius hippoglossoides* are also commercially important, and these species are occasionally reported from the waters of England and Wales. Flounder, witch and dab all feed on bottom-living invertebrates, including small crustaceans, molluscs, brittlestars and polychaete worms. Long-rough dab have a larger mouth and will also consume small fish as well as various invertebrates. Maximum lengths are: witch 55 cm, long-rough dab 48 cm, dab 42 cm and flounder 51 cm.

***Spawning:*** Witch first reproduce at 3–4 years of age, spawning in the spring and summer, and the eggs and larvae float near the surface until settling on the sea-bed as young fish 4–5 cm long. The larvae of witch can also delay metamorphosis until they can settle onto suitable muddy sediment. Long-rough dab are sexually mature at 2–3 years, and spawn in the spring. Their eggs and larvae are pelagic, and the post-larvae settle on the seabed at lengths of 35–45 mm. Dab mature at 2–3 years, and spawn in the spring and early summer. Following the plankton egg and larval stages, the postlarvae settle onto the seabed at 13–18 mm. Flounder breed in the spring in shallow water (25–40 m deep), with the juveniles settling out of the plankton at lengths of 15–30 mm.

***Ichthyoplankton surveys:*** Witch eggs can only be positively identified in the late embryonic stages when characteristic pigmentation is visible. Although witch spawn from the spring, surveys in the Irish Sea in 2000 caught late stage eggs as early as January and February in the western Irish Sea. Witch larvae were also found in February, but peak distribution and abundance was recorded in late April when they were found at over a third of the stations (Figure 5.31.5). Maximum abundance was 17.5 $m^{-2}$. Plankton surveys in the North Sea did not yield any late-stage witch eggs, although larvae were found in low densities in isolated patches (maximum abundance = 6.8 $m^{-2}$) in March (Figure 5.31.6).

The eggs of long-rough dab range from 1.38–3.5 mm in diameter (Munk and Nielsen, 2005) and have a characteristic large perivitelline space and no oil globule. Eggs were found over a limited geographical range in the Irish Sea, predominantly in coastal waters in the western Irish Sea, from mid-February to mid-May. Larvae were caught from March to May, but the greatest numbers and distribution were recorded in April, mainly in the western Irish Sea just offshore than the eggs (Figure 5.31.7). Spawning in the North Sea takes place in January-May and, in 2004, the highest abundances eggs were in mid-February in more northern areas. Peak numbers occurred to the northwest of the German Bight and in the waters between the Shetland Isles and Norway (79.6 $m^{-2}$ and 93.9 $m^{-2}$ respectively). In comparison, few larvae were identified in the southern North Sea and English Channel during the study period. The larvae were distributed mainly in the northern North Sea where they occurred in relatively high abundances at numerous stations (Figure 5.31.8).

Dab are another species that produce small eggs with no oil globule, making them indistinguishable from similar sized eggs produced by other fish. In the Irish Sea, the larvae were recorded from mid-February through until the end of May. In late April larvae were caught at all but one station and were particularly dense off the Irish coast and much of the eastern Irish Sea (Figure 5.31.9). Peak abundance was 529.3 $m^{-2}$. Dab larvae remained widespread during the final survey and, although numbers had declined, abundance still reached up to 349.4 $m^{-2}$ off the North Wales coast. Overall dab were the most abundant larvae found during this survey series. In the North Sea, dab larvae were recorded from February, but were found in highest numbers in April in the south-eastern North Sea. The greatest concentrations were 288.2 $m^{-2}$, and patches of dab larvae were also found in the northern North Sea and off the British coast (Figure 5.31.10).

The eggs of flounder also have no oil globule and range in diameter from 0.8–1.13 mm, and so are indistinguishable from eggs of a similar size, such as those of dab. In the Irish Sea the larval distribution was confined mainly to the eastern Irish Sea. The highest concentrations were recorded in April, in a band running from North Wales to the south-eastern coast of the Isle of Man (Figure 5.31.11), but these numbers declined markedly by May. In the North Sea, larval flounder were identified only from an area off the coasts of Germany and the Netherlands. Peak numbers in February were 16.6 $m^{-2}$, rising to 38.9 $m^{-2}$ during the final survey in April.

### 5.32 Soles (Soleidae)

| | |
|---|---|
| *Family:* | Soleidae |
| ** Main species:* | Sand sole *Pegusa lascaris*<br>Solenette *Buglossidium luteum*<br>Thickback sole *Microchirus variegatus* |
| *Swimbladder:* | Absent (present in the larvae of some species) |
| *Spawning:* | March to August |

* Commercially valuable species in this family not included in this report include sole *Solea solea.* This species has been reviewed in earlier SEA reports

***Distribution:*** Solenette is common in European inshore waters, primarily on sandy sediments in inshore waters 5–40 m deep (Amara *et al.*, 2004), though they can be found in deeper waters, and are widely distributed in UK seas (Figure 5.32.1). Sand soles are fairly uncommon in most UK waters, though they can be locally common in some areas, and are mostly restricted to south-western areas (Figure 5.32.2). They are not normally found in the central and northern North Sea, although can be found in small numbers in the southern North Sea. They live in depths of 30–350m, moving to shallower water in summer. Thickback soles tend to live on coarse grounds in offshore areas (> 30 m deep) and are commonly encountered in southern and western areas (Figure 5.32.3).

***Synopsis:*** Soleids are demersal fishes that predate on small benthic invertebrates, including molluscs, small crustaceans and polychaete worms. Nottage & Perkins (1983) reviewed the biology of solenette in the north-eastern Irish Sea. Maximum lengths are: sand sole 35 cm, solenette 13 cm, and thickback sole 33 cm.

***Spawning:*** Sand soles spawn from May to September, solenettes spawn during the spring summer, and thickback soles also spawn in spring and early summer (Deniel, 1984; Amara *et al.*, 1998). Soleids have pelagic eggs and larvae. The eggs of sand sole, solenette and thickback sole are 1.28–1.38, 0.64–0.94 and 1.28–1.42 mm in diameter respectively (Russell, 1976). The young settle out of the plankton at lengths of 12 mm (sand sole), 10 mm (solenette) and 12–18 mm (thickback sole).

***Ichthyoplankton surveys:*** Solenette eggs were found on all Irish Sea surveys where the samples were analysed (Figure 5.32.4). Their distribution was mainly confined to coastal stations in both the western and eastern regions in April and May. Abundance was highest (41.5 $m^{-2}$) in May. Larvae were uncommon until the final survey when up to 18.7 larvae $m^{-2}$ were caught in the eastern Irish Sea (Figure 5.32.5). Almost no larvae were observed off the Irish coast, despite the presence of eggs earlier in the year. Occasional individual eggs were observed in the North Sea survey, although no larvae were recorded.

Thick-back sole eggs were first observed in Irish Sea samples during April, and by May eggs were found in both the eastern and western parts of the Irish Sea, with greatest abundances off the North Wales coast (up to a maximum of 84.2 $m^{-2}$) and in the waters between the Isle of Man and the Cumbrian coast (Figure 5.32.6). Thick-back sole larvae were also caught in the same areas (Figure 5.32.7), and the peak abundance was 15 $m^{-2}$. No eggs or larvae were recorded from the North Sea survey.

### 5.33 Trigger fish and sunfish (Balistidae and Molidae)

| | |
|---|---|
| *Family:* | Balistidae and Molidae |
| *Main species:* | Trigger fish *Balistes carolinensis*<br>Sunfish *Mola mola* |
| *Swimbladder:* | Present |
| *Spawning:* | Unknown |

***Distribution:*** Triggerfish move northwards in the summertime, but occur in southern waters in the winter. They are uncommon in most areas, but can be locally abundant in parts of the Bristol Channel and other south-western waters, where they increased in abundance in the 1990's (e.g. Quigley *et al.,* 1993). Juveniles can be pelagic, although adults tend to inhabit rocky coastal shores and are often observed near wrecks and piers, and so are rarely observed in groundfish surveys. Sunfish are pelagic vagrants and are observed regularly in British waters, but more so along southern and western shores.

***Synopsis:*** Triggerfish have a laterally compressed body, and the first dorsal fin has three prominent spines, of which the first is particularly robust and can be 'locked' to deter predators. They can grow to lengths of about 40 cm and adults predate on crustaceans. Campo *et al.* (2003) discussed the feeding strategies of pelagic stages. Sunfish are large, pelagic species that can attain 4 m in length. They have a small mouth and feed on gelatinous zooplankton (e.g. small jellyfish and salps) and other planktonic organisms.

***Spawning:*** Little is known about the spawning habits of these species. Sunfish are unlikely to spawn in UK seas, though it has been suggested that triggerfish may breed occasionally in the waters of the British Isles.

# 6. SUMMARY

## *6.1 Spawning Seasons Of The Main Non-Target Fish Stocks*

From the information supplied in Section 5, it is apparent that the majority of the non-target and commercial fish species which spawn in UK continental shelf seas show peak spawning activities in the spring and early summer (February to June), although several may spawn over a longer period (e.g. from December until July or August). Given that most non-target fish are not subject to detailed biological studies and that most ichthyoplankton surveys are conducted to overlap with stocks of the main commercial species, usually only generic spawning times are known, and not always the peaks. These spawning periods are summarised in Table 6.1.

It must also be recognised that the spatial distribution of contemporary ichthyoplankton surveys may not be suitable for identifying the sites of peak spawning for some of the species considered, as they may spawn outside the study area. Contemporary data on the eggs and larval stages are only available for parts of the Irish Sea and North Sea, and some species may have important spawning grounds in other waters. Accounts of the ichthyoplankton in other sea areas are available, including the eastern English Channel (Korotenko & Sentchev, 2004a,b; Grioche & Koubbi, 1997; Grioche *et al.*, 1999) and Celtic Sea (Horstman & Fives, 1994; O'Brien & Fives, 1995; Acevedo *et al.*, 2002).

## *6.2 Regulating The Offshore Oil And Gas Industry*

The total input of oil into UK waters from the offshore oil and gas industry decreased significantly after 1985, but stabilised during the 1990s. Approximately two thirds of this input was from discharges of produced water, while oil from cuttings progressively decreased with the decline in use of WBM and cessation of discharge of contaminated oil based cuttings, following a recommendation at the 4th North Sea Conference (OSPAR 2000). A range of potentially toxic materials can be discharged with produced water, including heavy metals, PAHs and production chemicals; the Offshore Chemical Notification Scheme controls the discharge of oil and contaminants in produced water, and current legislation ensures consistent environmental standards throughout the offshore oil and gas industry. The Offshore Petroleum Production and Pipelines Regulations (1999) (as amended 2007) and the Petroleum Act (1998) require environmental assessment of offshore developments and pipeline discharges. Government Departments and their Agencies apply conditions and restrictions to ensure that environmental issues in relation to marine habitats are taken into consideration. Recent legislation ensures that oil and gas production complies with the requirements of the Habitats Directive, and OSPAR has prohibited the dumping of disused offshore installations within the maritime area.

There is some concern within Fisheries Departments that seismic activity could have an adverse impact on the spawning success of fish. Despite a lack of supporting evidence of an adverse effect of population viability, a precautionary approach has been recommended and widely adopted. The current licensing programme imposed by the Fisheries Departments aims to restrict seismic surveys in those areas and months that are most sensitive to spawning fish. These controls have been used effectively for the last decade, and are reviewed regularly, and aim to ensure that the production of underwater noise by the offshore industries has minimal negative impacts on fish populations. The potential impacts of noise on fish are summarised in Section 2.6. The auditory capabilities of most fish species are poorly known, though in general terms those fish species that have a swimbladder are often regarded as being more hearing specialists than those without. The presence or absence of the swimbladder in the fishes included in this report are summarised in Table 6.2.

The other main impact of exploration activity is drilling, which is considered to have only minor localised physical and chemical impacts. In recent years there has been substantial reduction in the quantities of contaminated material discharged from offshore installations during production drilling. The input to the sea of oil from cuttings has progressively decreased owing to the replacement of oil-based drilling muds with water-based and organic-phase drilling fluids, and since 1996 the discharge of oil-based cuttings from platforms has ceased. Analysis of benthic communities affected by contaminated cuttings suggests that persistent effects are relatively localised, but there has been insufficient research to determine the precise scale of impact, and particularly of the cumulative effects of multiple well sites in a field. The impacts of drilling, therefore, may impact on some species of demersal egg-laying fish. Though several species of non-target fish included in this report are demersal egg-layers (e.g. wolf-fish, sea-snails, gobies, some sea-breams and wrasse), there is no evidence of a high specificity for, and fidelity to, particular spawning grounds in these species, as observed in herring for example. The potential food chain impacts of drill cuttings on a variety of fish species were considered as part of the UKOOA drill cuttings initiative (Hartley *et al.* 2003).

OSPAR Decision 98/3, agreed at the Ministerial Meeting of the Contracting Parties at Sintra, Portugal in 1998, requires all redundant North Sea oil and gas installations to be removed for recycling ashore. There are several implications of this decision for the marine environment, including the fate of cuttings piles, the decommissioning and removal of pipelines and other sub-sea structures, and the impact on the marine environment of removing the platforms themselves. The preferred oil and gas industry option for decommissioning is to leave cuttings piles *in situ;* it is possible that these may be rapidly dispersed by trawls, thereby increasing the potential for contamination, and there are concerns about the impact of over-trawling of such cuttings piles.

Table 6.1: Main spawning periods of the main non-target fish species described in the report

| Section | Group | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.1 | Hagfish | No definite spawning season | | | | | | | | | | | |
| 5.2 | Lampreys | | | | | ■ | ■ | | | | | | |
| 5.3 | Catsharks | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | ■ | ■ |
| 5.4 | Houndsharks | | | | | | ■ | ■ | ■ | | | | |
| 5.5 | Angel shark | | | | | | ■ | ■ | | | | | |
| 5.6 | Eel and conger | | | ■ | ■ | ■ | ■ | ■ | | | | | |
| 5.7 | Pilchard, anchovy, shad | | | | ■ | ■ | ■ | ■ | ■ | | | | |
| 5.8 | Argentines, smelt | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| 5.9 | Cod-fishes | ■ | ■ | ■ | ■ | | | | | | | ■ | ■ |
| 5.10 | Cod-fishes – rocklings etc | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | ■ | ■ |
| 5.11 | Clingfish | | | | ■ | ■ | ■ | ■ | | | | | |
| 5.12 | Garfish | | | | | ■ | ■ | | | | | | |
| 5.13 | John dory and boarfish | | | | | | ■ | ■ | ■ | | | | |
| 5.14 | Pipefish and seahorses | | | | | ■ | ■ | ■ | ■ | | | | |
| 5.15 | Gurnards | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| 5.16 | Sea scorpions and pogge | ■ | ■ | ■ | ■ | | | | | | ■ | ■ | ■ |
| 5.17 | Lumpsucker and sea snails | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | ■ |
| 5.18 | Bass | | | ■ | ■ | ■ | ■ | | | | | | |
| 5.19 | Sea breams | | | | ■ | ■ | | | | ■ | ■ | | |
| 5.20 | Red mullet and red band fish | | | | | ■ | ■ | ■ | | | | | |
| 5.21 | Grey mullets | ■ | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 5.22 | Wrasse | | | | | ■ | ■ | ■ | ■ | ■ | | | |
| 5.23 | Eelpouts, snake blennies and butterfish | ■ | ■ | | | | | ■ | ■ | ■ | | | ■ |
| 5.24 | Wolf-fish | | | | | | | ■ | ■ | ■ | ■ | ■ | |
| 5.25 | Weever fish | | | | | | ■ | ■ | ■ | | | | |
| 5.26 | Blennies | | | ■ | ■ | ■ | ■ | ■ | | | | | |
| 5.27 | Dragonets | | | | ■ | ■ | ■ | | | | | | |
| 5.28 | Gobies | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| 5.29 | Left-eyed flatfishes | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| 5.30 | Scaldfish | | | | ■ | ■ | ■ | ■ | ■ | | | | |
| 5.31 | Right-eyed flatfishes | | ■ | ■ | ■ | ■ | ■ | | | | | | |
| 5.32 | Soles | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| 5.33 | Trigger fish and sunfish | Unknown | | | | | | | | | | | |

Table 6.2: Swim bladder presence or absence in the main non-target fish species described in the report

| | | |
|---|---|---|
| Hagfish | Myxinida | No swim bladder |
| Lampreys | Petromyzontidae | No swim bladder |
| Catsharks | Scyliorhinidae | No swim bladder |
| Houndsharks | Triakidae | No swim bladder |
| Angel shark | *Squatina squatina* | No swim bladder |
| Eel and conger | Anguilliformes | Swim bladder present |
| pilchard, anchovy, shad | Clupeiformes | Swim bladder present |
| argentines, smelt, salmonids | Salmoniformes | Swim bladder present |
| Cod-fishes | Gadiformes | Swim bladder present |
| Cod-fishes – rocklings etc | Gadiformes (Lotinae) | Swim bladder present |
| Clingfish | Gobiesociformes | Swim bladder present |
| Garfish | *Belone belone* | Swim bladder present |
| John dory and boarfish | Zeiformes | Swim bladder present |
| Pipefish and seahorses | Syngnathiformes | Swim bladder present |
| Gurnards | Triglidae | Swim bladder present |
| Sea scorpions and pogge | Cottidae and Agonidae | No swim bladder |
| Lumpsucker and sea snails | Cyclopteridae and Liparidae | No swim bladder |
| Bass | Percichtyidae | Swim bladder present |
| Sea-breams | Sparidae | Swim bladder present |
| Red mullet and red band fish | Mullidae and Cepolidae | Swim bladder present |
| Grey mullets | Mugilidae | Swim bladder present |
| Wrasse | Labridae | Swim bladder present |
| Eelpouts, snake blennies and butterfish | Zoarcidae, Stichaeidae, Pholidae | Swim bladder present without duct |
| Wolf-fish | Anarhicadidae | Swim bladder present |
| Weever fish | Trachinidae | Swim bladder present without duct |
| Blennies | Blennidae | Swim bladder absent in adults |
| Dragonets | Callionymidae | No swim bladder |
| Gobies | Gobidae | No swim bladder * |
| Left-eyed flatfishes | Scophthalmidae | No swim bladder * |
| Scaldfish | Bothidae | No swim bladder * |
| Right-eyed flatfishes | Pleuronectidae | No swim bladder * |
| Soles | Soleidae | No swim bladder * |
| Trigger fish and sunfish | Balistidae and Molidae | Swim bladder present |
| * Present in the larvae of some/all of the species | | |

## 7. REFERENCES

Abbasi, A.R. and Shackley, S.E. (1996). Study of population biology of thick-lipped grey mullet, *Chelon labrosus* R. and thin-lipped grey mullet, *Liza ramada* R. *Pakistan Journal of Zoology*, 28: 69–74.

Acevedo, S., Dwane, O. and Fives, J.M. (2002). The community structure of larval fish populations in an area of the Celtic Sea in 1998. *Journal of the Marine Biological Association of the United Kingdom*, 82: 641–648.

Ager, O.E.D. (2006). *Labrus bergylta*. Ballan wrasse. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 05/02/2007].

Albert, O.T. (1993). Distribution, population structure and diet of silvery pout (*Gadiculus argenteus thori* J. Schmidt), poor cod (*Trisopterus minutus minutus* (L.)), four-bearded rockling (*Rhinonemus cimbrius* (L.)), and Vahl's eelpout (*Lycodes vahlii gracilis* Reinhardt) in the Norwegian Deep. *Sarsia*, 78: 141–154.

Amara, R., Mahe, K., LePape, O. and Desroy, N. (2004). Growth, feeding and distribution of the solenette *Buglossidium luteum* with particular reference to its habitat preference. *Journal of Sea Research*, 51: 211–217.

Amara, R., Poulard, J-C., Lagardere, F. and Desaunay, Y. (1998). Comparison between the life cycles of two Soleidae, the common sole, *Solea solea*, and the thickback sole, *Microchirus variegatus*, in the Bay of Biscay (France). *Environmental Biology of Fishes*, 53: 13–209.

Atkinson, R.J.A., Pelster, B., Bridges, C.R., Taylor, A.C. and Morris, S. (1987). Behavioural and physiological adaptations to a burrowing lifestyle in the snake blenny, *Lumpenus lampretaeformis*, and the red band-fish, *Cepola rubescens*. *Journal of Fish Biology*, 31: 639–659.

Atkinson, R.J.A., Pullin, R.S.V. and Dipper, F.A. (1977). Studies on the red band fish, *Cepola rubescens. Journal of Zoology*, 182: 369–384.

Ballerstedt, S. (2006). *Trisopterus luscus*. Bib or Pouting. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 05/02/2007].

Banner, A., and Hyatt, M. (1973). Effects of noise on eggs and larvae of two estuarine fishes. *Transactions of the American Fisheries Society,* 102: 134–136.

Baron, J. (1985a). Triglid fishes from the Douarnenez Bay. 1. Growth of *Eutrigla gurnardus, Trigla lucerna, Trigloporus lastoviza* and *Aspitrigla cuculus. Cybium*, 9: 127–144.

Baron, J. (1985b). The triglids (Teleostei) of the Bay of Douarnenez. 2. Reproduction of *Eutrigla gurnardus, Trigla lucerna, Trigloporus lastoviza* and *Aspitrigla cuculus. Cybium*, 9: 255–281.

Bauchot, M.L. and Pras, A. (1980). Guide des poissons marins d'Europe. Delachaux & Niestle, 427 pp.

Beare, D. J., Burns, F., Greig, A., Jones, E.G., Peach, K., Kienzle, M., McKenzie, E and Reid, D.G. (2004a). Long-term increases in prevalence of North Sea fishes having southern biogeographic affinities. *Marine Ecology Progress Series*, 284: 269–278.

Beare, D., Burns, F., Jones, E., Peach, K., Portilla, E., Greig, T., Mckenzie, E. and Reid, D. (2004b). An increase in the abundance of anchovies and sardines in the north-western North Sea since 1995. *Global Change Biology*, 10: 1209–1213.

Beare, D., Burns, F., Jones, E., Peach, K. and Reid, D. (2005). Red mullet migration into the northern North Sea during late winter. *Journal of Sea Research*, 53: 205–212.

Bergstad, O.A. (1990). Ecology of the fishes of the Norwegian Deep: Distribution and species assemblages. *Netherlands Journal of Sea Research*, 25(1/2): 237–266.

Bigelow, H.B. and Schroeder W.C. (1953). Fishes of the Gulf of Maine. Fishery Bulletin of the Fish and Wildlife Services.

Blanchard, F (2001a). Dynamics of harvested demersal fish communities: analysis of the species diversity in the Bay of Biscay (Atlantic Ocean) and in the Gulf of Lions (Mediterranean Sea). *Aquatic Living Resources*, 14(1): 29–40.

Blanchard, F. (2001b). The effects of fishing on demersal fish community dynamics: an hypothesis. *ICES Journal of Marine Science*, 58: 711–718.

Blanchard, F. and Vandermeirsch, F. (2005). Warming and exponential abundance increase of the subtropical fish *Capros* aper in the Bay of Biscay (1973–2002). *Comptes rendus Biologies*, 328: 505–509.

Blanchard, F., Bouche, J., and Poulard, J.C., (2002). General trends in the fish community of the Bay of Biscay from 1973 to nowadays: ecosystem effects of fishing or climate? 8th International Symposium on Oceanography of the Bay of Biscay, Gijón (April 2002).

Blaxter, J.H.S., and Batty, R.S. (1990). Swimbladder "behaviour" and target strength. *Rapports et Procès-verbaux des Réunions, Conseil International pour l'Exploration de la Mer,* 189: 233–244.

Bond, C.E. (1979). Biology of Fishes. Philadelphia.

Bone, Q., Marshall, N.B., and Blaxter, J.H.S. (1995). Biology of fishes. Second Edition. London, Chapman & Hall.

Bruce, J.R., Colman, J.S. and Jones, N.S. (1963). Marine fauna of the Isle of Man and its surrounding seas. Liverpool University Press, 307 pp.

Bunn, N. and Fox, C.J. (2004). Spring plankton surveys of the Irish Sea in 2000: hydrography and the distribution of fish eggs and larvae. *Science Series Technical Report*, CEFAS, Lowestoft, No. 124: 131pp.

Callaway, R., Alsvaag, J., de Boois, I., Cotter, J., Ford, A., Hinz, H., Jennings, S., Kroencke, I., Lancaster, J., Piet, G., Prince, P. and Ehrich, S. (2002). Diversity and community structure of epibenthic invertebrates and fish in the North Sea. *ICES Journal of Marine Science*, 59: 1199–1214.

Campo, D., Finoia, M.G., Sinopoli, M. and Vivona, P. (2003). Feeding strategy of grey triggerfish (*Balistes carolinensis* Gmelin, 1789) in the pelagic stage of its life cycle. *Biologia Marina Mediterranea*, 10: 777–780.

Capapé, C. and Mellinger, J. (1988). Nouvelles données sur la biologie de la reproduction du milandre, *Galeorhinus galeus* (Linné, 1778), (Pisces, Triakidae) des côtes tunisiennes. *Cahiers Biologie Marine,* 29: 135–146.

Capapé, C., Quignard, J.P. and Mellinger, J. (1990). Reproduction and development of two angel sharks, *Squatina squatina* and *S. oculata* (Pisces: Squatinidae), off Tunisian coasts: semi-delayed vitellogenesis, lack of egg capsules, and lecithotrophy. *Journal of Fish Biology*, 37(3):347–356.

Cardinale, M. (2000). Ontogenetic diet shifts of bull-rout, *Myoxocephalus scorpius* (L.), in the south-western Baltic Sea. *Journal of Applied Ichthyology*,16: 231–239.

Carter, T.J. & Hall, C.D. (1998). The effects of seismic exploration and underwater explosions on marine life: a bibliography. Marine Laboratory Aberdeen, Report No 3/98.

Chanet, B., Quero, J.C. and Vayne, J.J. (2003). Presence of two populations of Norwegian topknot, *Phrynorhombus norvegicus* (Pleuronectiformes: Scophthalmidae), in western European seas. *Cybium*, 27: 227–232.

Claridge, P.N. and Gardner, D.C. (1977). The biology of the northern rockling, *Ciliata septentrionalis*, in the Severn Estuary and Bristol Channel. *Journal of the Marine Biological Association of the United Kingdom*, 57: 839–848.

Claridge, P.N. and Potter, I.C. (1985). Distribution, abundance and size composition of mullet populations in the Severn Estuary and Bristol Channel. *Journal of the Marine Biological Association of the United Kingdom*, 65: 325–335.

Compagno, L.J.V. (1984). FAO Species Catalogue. Sharks of the World: an annotated and illustrated catalogue of shark species known to date. Part 2: Carcharhiniformes. FAO Fisheries Synopsis No. 125, Vol. 4(2): 251–655.

Couch, J. (1864). A history of the fishes of the British Isles. Volume I-IV. Goombridge & Sons, London.

Creutzberg, F. and Witte, J.I. (1989). An attempt to estimate the predatory pressure exerted by the lesser weever, *Trachinus vipera* Cuvier, in the southern North Sea. *Journal of Fish Biology*, 34: 429–449.

Daan, N., Bromley, P.J., Hislop, J.R.G., and Nielsen, N.A. (1990). Ecology of North Sea fish. *Netherlands Journal of Sea Research,* 26: 343–386.

Daan, N.; Gislason, H.; Pope, J.G. and Rice, J.C. (2005). Changes in the North Sea fish community: evidence of indirect effects of fishing? *ICES Journal of Marine Science,* 62: 177–188.

Dauvin, J-C. (1987). On a uncommon Gadidae species in the waters of Roscoff, *Raniceps ranimus* (Linne, 1758). *Cahiers de Biologie Marine*, 28: 567.

Davenport, J. (1985). Synopsis of biological data on the lumpsucker, *Cyclopterus lumpus* (Linnaeus, 1758). *FAO Fisheries Synopsis*, 147: 36 pp.

Davis, P. and Wheeler, A. (1985). The occurrence of *Pampus argenteus* (Euphrasen, 1788), (Osteichthyes, Perciformes, Stromateoidei, Stromateidae) in the North Sea. *Journal of Fish Biology*, 26(2): 105–109.

Day, F. (1880–1884). The Fishes of Great Britain and Ireland. Volume I-II. Williams and Norgate, London.

Demir, N., 1976. Callionymidae of the northeastern North Atlantic. Fiches d'identification de zooplancton, *148*: 5pp.

Deniel, C. (1983). Reproduction of flatfishes in Douarnenez Bay: Sexual cycles and fecundity of *Arnoglossus thori , A. laterna , A. imperialis*. *Cahiers de Biologie Marine*, 24: 231–252.

Deniel, C. (1984). Reproduction of flat fish (Teleostei: Pleuronectiformes) in Douarnenez Bay. II. Sexual cycles and fecundity of Soleidae: *Solea vulgaris vulgaris, Solea lascaris, Buglossidium luteum*, and *Microchirus variegatus*. Cahiers de Biologie Marine, 25: 257–285.

Deniel, C. (1985). The tadpole-fish *Raniceps raninus* (Linnaeus, 1758) from the north coast of Brittany: Length-growth and length-weight relationships. *Cybium*, 9: 89–92.

Deree, H.L. (1999). Age and growth, dietary habits, and parasitism of the fourbeard rockling, *Enchelyopus cimbrius*, from the Gulf of Maine. *Fishery Bulletin*, 97: 39–52.

Dunn, M.R. (2001). The biology and exploitation of John dory, *Zeus faber* (Linnaeus, 1758) in the waters of England and Wales. *ICES Journal of Marine Science*, 58: 96–105.

Dunn, M.R. & Brown, M.J. (2003). The occurrence of *Symphodus bailloni* on the south coast of England. *Journal of the Marine Biological Association of the United Kingdom*, 83: 875–876.

Dunne, J. (1981). A contribution to the biology of Montagu's sea snail, *Liparis montagui* Donovan, (Pisces). *Irish Naturalists' Journal*, 20: 217–222.

Edwards, A.J. and Davis, P.S. (1997). Pisces. In *The species directory of the marine fauna and flora of the British Isles and surrounding seas* (Howson, C.M. and Picton, B.E., eds.). Ulster Museum and Marine Conservation Society, Belfast and Ross-on-Wye. Ulster Museum Publication 276, 309-324.

Edwards, R.V., (2005). *Agonus cataphractus*. Pogge. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 05/02/2007].

Ehrich, S. and Stransky, C. (2001). Spatial and temporal changes in the southern species component of North Sea fish assemblages. *Senckenbergiana Maritima*, 31: 143–150.

Elliott, M. and Hemingway, K.I. (eds) (2002). Fishes in Estuaries. Blackwell Science Ltd., 352 pp.

Ellis, J.R. (2004). The occurrence of thresher shark off the Suffolk coast. *Transactions of the Suffolk Naturalists' Society,* 40: 73–80.

Ellis, J.R. (In press). Occurrence of pelagic stingray *Pteroplatytrygon violacea* (Bonaparte, 1832) in the North Sea. *Journal of Fish Biology*Ellis, J. R. and Shackley, S.E. (1997). The reproductive biology of *Scyliorhinus canicula* in the Bristol Channel, U.K. *Journal of Fish Biology*, 51:361–372.

Ellis, J. R., Pawson, M.G. and Shackley, S.E. (1996). The comparative feeding ecology of six species of shark and four species of ray (Elasmobranchii) in the North-East Atlantic. *Journal of the Marine Biological Association of the United Kingdom*, 76:89–106.

Ellis, J.R., Rogers, S.I. and Freeman, S.M. (2000). Demersal assemblages in the Irish Sea, St George's Channel and Bristol Channel. Estuarine and Coastal Shelf Science, 51: 299–315.

Ellis, J.R., Armstrong, M.J, Rogers, S.I., and Service, M. (2002a). The distribution, structure and diversity of fish assemblages in the Irish Sea. In *Marine biodiversity in Ireland and adjacent waters* (J.D.Nunn, ed.). Ulster Museum, Belfast, 93–114.

Ellis, J.R., Lancaster, J.E., Cadman, P.S. and Rogers, S.I. (2002b). The marine fauna of the Celtic Sea. In Marine biodiversity in Ireland and adjacent waters (J.D.Nunn, ed.). Ulster Museum, Belfast, 45–65.

Ellis, J.R., Cruz-Martinez, A., Rackham, B.D. and Rogers, S.I. (2005a). The distribution of chondrichthyan fishes around the British Isles and implications for conservation. *Journal of Northwest Atlantic Fishery Science,* 35: 195–213.

Ellis, J.R., Dulvy, N.K., Jennings, S., Parker-Humphreys, M. and Rogers, S.I. (2005b). Assessing the status of demersal elasmobranchs in UK waters: A review. *Journal of the Marine Biological Association of the United Kingdom*, 85: 1025–1047.

Engås, A., Løkkeborg, S., Ona, E & Soldal, A.V. (1993). Effects of seismic shooting on catch and catch-availability on cod and haddock. *Fisken og Havet*. No. 9. 117 pp.

Engås, A., Løkkeborg, S., Ona, E., and Soldal, A., V. (1996). Effects of seismic shooting on local abundance and catch rates of cod (Gadus morhua) and haddock (Melanogrammus aeglefinus). *Canadian Journal of Fisheries and Aquatic Sciences,* 53: 2238–2249.

Ennis, G.P. (1970). Age, growth, and sexual maturity of the shorthorn sculpin, *Myoxocephalus scorpius*, in Newfoundland waters. *Journal of the Fisheries Research Board of Canada*, 27: 2155–2158.

Falk-Petersen, I.-B., and Hansen, T. K. (1991). Reproductive biology of wolffish *Anarhichas lupus* from North-Norwegian waters. ICES-CM-1991/G:14, 17 pp.

Fox, C.J., Dickey-Collas, M. and Winpenny, A.J., (1997). Spring plankton surveys of the Irish Sea in 1995: The distribution of fish eggs and larvae. *Science Series Technical Report*, CEFAS, Lowestoft, No. 104: 106pp.

Fox, C.J., Taylor, M., Dickey-Collas, M., Van Damme, C.J.G., Bolle, L., Dann, N., Rohlf, N., Kraus, G., Munk, P., Fossum, P. and Bailey, N., (2005). Initial results from the 2004 ichthyoplankton survey of the North Sea. ICES CM 2005/AA:04 (mimeo).

Fricke, R. (1999). Annotated checklist of the marine and estuarine fishes of Germany, with remarks on their taxonomic identity. *Stuttgarter Beiträge zur Naturkunde*, (A) 587: 1–67.

Gibson, R.N. (1993). Intertidal teleosts – life in a fluctuating environment. In *Behaviour of Teleost Fishes* (Pitcher, T.J., ed.). Chapman & Hall, London, 513–536.

Gonccalves, E.J., Barbosa, M., Cabral, H.N. and Henriques, M. (2002). Ontogenetic shifts in patterns of microhabitat utilization in the small-headed clingfish, *Apletodon dentatus* (Gobiesocidae). *Environmental Biology of Fishes*, 63: 333–339.

Gordon, J.D.M. (2003). Fish & Fisheries in the SEA4 Area. Report to the Department of Trade and Industry, 97 pp.

Gordon, J.D.M. (2006). Fish & Fisheries in the SEA7 Area. Report to the Department of Trade and Industry, 122 pp.

Gordon,J.D.M. and Duncan,J.A.R. (1979). Some notes on the biology of the snake blenny, *Lumpenus lampretaeformis* on the west coast of Scotland. *Journal of the Marine Biological Association of the United Kingdom*, 59: 413–419.

Grant, S.M (2006). An exploratory fishing survey and biological resource assessment of Atlantic hagfish occurring on the SW slope of Newfoundland Grand Bank. *Journal of North-western Atlantic Fishery Science,* 36: 91–110

Gray, J.S., Clarke, K.R., Warwick, R.M. & Hobbs, R.M. (1990). Detection of the initial effects of pollution on marine benthos: an example from the Ekofisk and Eldfisk oil fields, North Sea. *Marine Ecology Progress Series,* 46: 151–165.

Greenstreet, S.P.R. and Hall S.J. (1996). Fishing and the ground-fish assemblage structure in the north-western North Sea: an analysis of long-term and spatial trends. *Journal of Animal Ecology*, 65:577–598.

Greenstreet, S.P.R. and Rogers, S.I. (2006). Indicators of the health of the North Sea fish community: identifying reference levels for an ecosystem approach to management. *ICES Journal of Marine Science*, 63: 573–593.

Greenstreet, S.P.R., Spence, F.E. and McMillan, J.A. (1999). Fishing effects in northeast Atlantic shelf seas: patterns in fishing effort, diversity and community structure. V. Changes in structure of the North Sea groundfish species assemblage between 1925 and 1996. *Fisheries Research*, 40:153–183.

Gregory, P., (2003). *Labrus mixtus*. Cuckoo wrasse. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 05/02/2007].

Grioche, A. and Koubbi, P. (1997). A preliminary study of the influence of a coastal frontal structure on ichthyoplankton assemblages in the English Channel. *ICES Journal of Marine Science*, 54(1): 93–104.

Grioche, A., Koubbi, P. and Harlay, X. (1999). Spatial patterns of ichthyoplankton assemblages along the eastern English Channel French coast during Spring 1995. *Estuarine, Coastal and Shelf Science*, 49(1): 141–152.

Hartley, J., Trueman, R., Anderson, S., Neff, J., Fucik, K. and Dando, P. (2003). Drill Cuttings Initiative: Food Chain Effects Literature Review. United Kingdom Offshore Operators Association, Aberdeen, Scotland. 118 pp + Appendices.

Hastings, M. C., Popper, A. N., Finneran, J. J., and Lanford, P. J. (1996). Effects of low-frequency underwater sound on hair cells of the inner ear and lateral line of the teleost fish Astronotus ocellatus. *Journal of the Acoustical Society of America,* 99: 1759–1766.

Hawkins, A. D. (1973). The sensitivity of fish to sounds. *Oceanography and Marine Biology Annual Review*, 11: 291–340.

Hawkins, A. D. (1993). Underwater sound and fish behaviour. In *Behaviour of Teleost Fishes* (T. J. Pitcher, ed.), pp. 129–169. Chapman & Hall, London.

Heessen, H.J.L. (1996). Time-series data for a selection of forty fish species caught during the International Bottom Trawl Survey. *ICES Journal of Marine Science*, 53: 1079–1084.

Heessen, H.J.L. and Daan, N. (1996). Long-term trends in ten non-target North Sea fish species*. ICES Journal of Marine Science*, 53:1063–1078.

Heessen, H.J.L. Hislop, J.R.G. and Boon T.W. (1996). An invasion of the North Sea by blue-mouth, *Helicolenus dactylopterus* (Pisces, Scorpaenidae). *ICES Journal of Marine Science*, 53: 874–877.

Heessen, H.J.L., Dalskov, J. and Cook, R.M. (2000). The International Bottom Trawl Survey in the North Sea, Skagerrak and Kattegat; a history of one of the "ancestors" of MEDITS. Proceedings of the Symposium on Assessment of demersal resources by direct methods in the Mediterranean and the adjacent seas, Pisa (Italy), 18–21 March 1998. Actes de colloques, Institut Francais de Recherche pour l'Exploitation de la Mer, 26: 13–36.

Henderson, A.C., and Williams, R.S. (2001). A new record of the sharpnose seven-gill shark *Heptranchias perlo*, from the North-east Atlantic. *Journal of the Marine Biological Association of the United Kingdom*, 81: 707–708.

Henderson, P.A. and Holmes, R.H.A. (1990). Population stability over a ten-year period in the short-lived fish *Liparis liparis* (L.). *Journal of Fish Biology*, 37: 605–615.

Herdman, W.A. and Dawson, R.A. (1902). Fishes and fisheries of the Irish Sea. *Lancashire Sea-Fisheries Memoir*, no. 11, 98 pp.

Hiscock, K. Elliott, M., Laffoley, D., and Rogers, S. (2003). Data use and information creation: Challenges for marine scientists and for managers. *Marine Pollution Bulletin,* 46: 534–541.

Hofrichter, R., Breining, T. and Patzner, R.A. (2000). Habitat selection and feeding ecology of two Atlantic clingfish species, *Apletodon dentatus* and *Diplecogaster bimaculata* in Brittany, France. *Zeitschrift fur Fischkunde*, 5: 71–81.

Holt, E.W.L. (1910). Report of a survey of trawling grounds on the coasts of Counties Down, Louth, Meath and Dublin. Part I: Record of fishing operations. *Report on the Sea and Inland Fisheries of Ireland for 1909, Scientific Investigations* I, 1–538.

Horstman, K.R. and Fives, J.M. (1994). Ichthyoplankton distribution and abundance in the Celtic Sea*. ICES Journal of Marine Science*, 51(4): 447–460.

Houghton, J.D.R; Doyle, T.K., Davenport, J. and Hays, G.C. (2006). The ocean sunfish *Mola mola*: insights into distribution, abundance and behaviour in the Irish and Celtic Seas. *Journal of the Marine Biological Association of the United Kingdom*, 86(5): 1237–1243.

ICES (1999). Manual for the International Bottom Trawl Surveys. Revision VI. ICES CM 1999/D:2 (Addendum II, Ref G), 49pp.

ICES (2003). Report of the Working Group on Fish Ecology (WGFE). ICES CM 2003/G:04, 110pp.

ICES (2004). Report of the Study Group on Survey Trawl Gear for the IBTS Western and Southern Areas. 11–13 February 2004 Santander, Spain. ICES CM 2004/B:01, 26 pp.

ICES (2005). Report of the International Bottom Trawl Survey Working Group (IBTSWG). ICES CM 2005/D:05, 131 pp.

ICES (2006a). Report of the International Bottom Trawl Survey Working Group (IBTSWG). ICES CM 2006/RMC:03, 298 pp.

ICES (2006b). Report of the Working Group on Elasmobranch Fishes (WGEF). 14–21 June 2005, Lisbon. ICES CM 2006/ACFM:03, 232 pp.

ICES (2006c). Report of the Working Group on Elasmobranch Fishes (WGEF). 14–21 June 2006, ICES Headquarters. ICES CM 2006/ACFM:31, 299 pp.

Iversen, S.A., Skogen, M.D. and Svendsen, E. (2002). Availability of horse mackerel (*Trachurus trachurus*) in the north-eastern North Sea, predicted by the transport of Atlantic water. *Fisheries Oceanography*, 11:245–250.

Jenkins, J.T. (1925). The fishes of British Isles. Frederik Warne & Co. Ltd., London, 408 pp.

Jorgensen, T., Lokkeborg, S. and Soldal, A.V. (2002). Residence of fish in the vicinity of a decommissioned oil platform in the North Sea. *ICES Journal of Marine Science*, 59 (Supplement), 288–293.

Kabasakal, H. (1999). Description of the feeding morphology and the food habits of the butterfly blenny, *Blennius ocellaris* Linnaeus, 1758, from north-eastern Aegean Sea (Turkey). *Netherlands Journal of Zoology*, 49: 177–187.

Kaiser, M.J. and Spencer, B.E. (1994). Fish scavenging behaviour in recently trawled areas. *Marine Ecology Progress Series*, 112: 41–49.

Kaiser, M.J., Rogers, S.I. and Ellis, J.R. (1999). Importance of benthic habitat complexity for demersal fish assemblages. *American Fisheries Society Symposium,* 22: 212–223.

King, P.A., Fives, J.M. and McGrath, D. (1994). Reproduction, growth and feeding of the dragonet, *Callionymus lyra* (Teleostei: Callionymidae), in Galway Bay, Ireland. *Journal of the Marine Biological Association of the United Kingdom*, 74: 513–526.

Kirby, R.R, Johns, D.G and Lindley, J.A. (2006). Fathers in hot water: rising sea temperatures and a Northeastern Atlantic pipefish baby boom. *Biology Letters*, 2: 597–600.

Kloppmann, M.H.F. and Ulleweit, J. (2007). Off-shelf distribution of pelagic snake pipefish, *Entelurus aequoreus* (Linnaeus, 1758), west of the British Isles. *Marine Biology*, 151: 271–275

Knijn, R.J., Boon, T.W., Heessen, H.J.L. and Hislop, J.R.G. (1993). Atlas of North Sea Fishes. *ICES Cooperative Research Report*, 194:368pp.

Koop, J.H. and Gibson, R.N. (1991). Distribution and movements of intertidal butterfish *Pholis gunnellus. Journal of the Marine Biological Association of the United Kingdom*, 71: 127–136.

Korotenko, K.A. and Sentchev, A.V. (2004a). On the formation of anomalies in the ichthyoplankton concentration field along the French coast in the eastern English Channel. *Russian Academy of Sciences, Oceanology*, 44 (5): 644–653.

Korotenko, K.A. and Sentchev, A.V. (2004b). On the formation of ichthyoplankton assemblages along the Eastern English Channel French Coast: numerical approach. *Okeanologiya,* 44(5): 686–696.

Koyama, J. and Kakuno, A. (2004). Toxicity of heavy fuel oil, dispersant, and oil-dispersant mixtures to a marine fish, *Pagrus major. Fisheries Science*, 70: 587–594.

Lokkeborg, S., Humborstad, O.-B., Jorgensen, T. and Soldal, A.V. (2002). Spatio-temporal variations in gillnet catch rates in the vicinity of North Sea oil platforms. *ICES Journal of Marine Science*, 59 (Supplement), 294–299.

Lopes, M., Murta, A.G. and Cabral, H.N. (2006). The ecological significance of the zooplanktivores, snipefish *Macroramphosus* spp. and boarfish *Capros aper*, in the food web of the south-east North Atlantic. *Journal of Fish Biology*, 69: 363–378.

Lozano Rey, L. (1928). Fauna Ibérica: Peces. Museo Nacional de Ciencias naturals, Madrid, 692 pp.

Lozano Rey, L. (1947). Peces Ganoideos y Fisóstomos. Memorias de la Real Academia de Ciencias, Madrid, 839 pp.

Lozano Rey, L. (1952a). Peces Fisoclistos, Subserie Toracicos, Primera Parte (Ordenes Bericiformes, Zeiformes, Perciformes, Escorpeniformes y Balistiformes). Memorias de la Real Academia de Ciencias, Madrid, 378 pp.

Lozano Rey, L. (1952b). Peces Fisoclistos, Subserie Toracicos, Segunda Parte (Ordenes Labriformes y Escombriformes). Memorias de la Real Academia de Ciencias, Madrid, 703 pp.

Lozano Rey, L. (1960). Peces Fisoclistos, Subserie Toracicos (Ordenes Equeniformes y Gobiformes, Pediculados y Asimetricos. Ictiologia Iberica, Madrid, 613 pp.

Luksenburg, J.A., Pedersen, T. and Falk-Petersen, I.B. (2004). Reproduction of the shorthorn sculpin *Myoxocephalus scorpius* in northern Norway. *Journal of Sea Research*, 51: 157–166.

Lythgoe, J. and Lythgoe, G. (1991). Fishes of the sea. The North Atlantic and Mediterranean. Blandford Press, London, 256 pp.

Macer, C.T. (1967). Ammodytidae. Fiches d'identification des oeufs et larves de poissons. No. 2: 6pp.

Mamie, J.C.J., Beare, D.J., Jones, E.G., Kienzle, M., Dobby, H., Heath, M.R. and Reid, D.G. (2007). Aspects of the distribution and growth of bluemouth (*Helicolenus dactylopterus*, Delaroche 1809) since its invasion of the northern North Sea in 1991. *Fisheries Oceanography*, 16: 85–94.

Martin, P. and Sabates, A. (1991). Spatio-temporal distribution pattern of the red band-fish *Cepola rubescens* Linnaeus at different stages of its life cycle in the northwestern Mediterranean. *Journal of Fish Biology*, 39: 549–557.

Martini, F. H. and Flescher, D. (2002). Hagfishes, Order Myxiniformes. In *Bigelow and Schroeder's Fishes of the Gulf of Maine* (B.B. Collette and G. Klein-MacPhee, eds.). 3rd Edition. Washington and London: Smithsonian Institution Press, 9–16.

Martini, F., J.B. Heiser, and Lesser, M.P. (1997). A population profile for Atlantic hagfish, *Myxine glutinosa (L.)*, in the Gulf of Maine: morphometrics and reproductive state. *Fishery Bulletin,* 95(2): 311–320.

Moreau, E. (1881–1891). Histoire naturelle des Poissons de la France. Paris, Volumes I-II, and Supplement.

Moulton, P.L., Saddlier, S.R. & Knuckey, I.A. (1989). New time-at-liberty record set by tagged school shark *Galeorhinus galeus* caught off southern Australia. *North American Journal of Fisheries Management*, 9: 254–255.

Munk, P. and Nielsen, J.G. (2005). Eggs and larvae of North Sea fishes. Biofolia, Frederiksberg, 215 pp.

Muus, B.J., Nielsen, J.G., Dahlstrom, P.D. and Nystrom, B.O. (1998). Peces de mar de Atlantico y del Mediterraneo. Omega, Barcelona, 337 pp.

Nash, R.D.M. (1990). Fish assemblages in the Irish Sea. In Irish Sea Study Group Report Part 1: Nature Conservation. Liverpool University Press, 325–333.

Nash, R.D.M., Dickey-Collas, M. and Milligan, S.P. (1998). Descriptions of the Gulf VII/PRO-NET and MAFF/Guildline unencased high-speed plankton samplers. *Journal of Plankton Research*, 20: 1915–1926.

N'Da, K. (1992). Diet of the red mullet *Mullus surmuletus* (Mullidae) in the northern area of the Bay of Biscay. *Cybium*, 16: 159–167.

N'Da, K. and Deniel, C. (2005). Growth of juveniles of striped red mullet (*Mullus surmuletus*) in the northern area of the Bay of Biscay. *Cybium*, 29: 175–178.

Nelson, G. A., and Ross, M. R. (1992). Distribution, growth and food habits of the Atlantic wolffish (*Anarhichas lupus*) from the Gulf of Maine-Georges Bank region. *Journal of Northwest Atlantic Fishery Science*, 13: 53–61.

Nichols, J.H. (1971). Pleuronectidae. Fiches d'identification des oeufs et larves de poissons, *Nos. 4–6*: 18pp.

Nichols, J.H. (1976). Soleidae of the eastern North Atlantic. Fiches d'identification de zooplancton., *150/151*.

Nichols, J.H., Haynes, G.M., Fox, C.J., Milligan, S.P., Brander, K.M. and Chapman, R.J. (1993). Spring plankton surveys of the Irish Sea in 1982, 1985, 1987, 1988 and 1989: hydrography and the distribution of fish eggs and larvae. *Fisheries Research Technical Report*. *No. 95*: 111 pp.

Nobre, A. (1935). Vertebrados (mammiferos, reptis e peixes). Fauna marinha de Portugal 1, 574 pp.

Nottage, A.S. and Perkins, E.J. (1983). The biology of solenette, *Buglossidium luteum* (Risso), in the Solway Firth. *Journal of Fish Biology*, 22: 21–27.

Oakley, J.A. (2005). *Callionymus lyra*. Common dragonet. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 05/02/2007].

O'Brien, B. and Fives, J.M. (1995). Ichthyoplankton distribution and abundance off the west coast of Ireland. *ICES Journal of Marine Science*, 52: 233–245.

Ortova, E. L., Berestovskiy, E. S., Karamushko, O. V., and Norvillo, G. V. (1990). On feeding and distribution of young wolffishes, *Anarhichas lupus* and *A. minor*, in the Barents and Norwegian Seas. *Journal of Ichthyology*, 30: 126–131.

OSPAR (2000). Quality Status Report. Region II. Greater North Sea. OSPAR Commission, London.

O'Sullivan, S., Moriarty, C., FitzGerald, R.D., Davenport, J. and Mulcahy, M.F. (2003). Age, growth and reproductive status of the European conger eel, *Conger conger* (L.) in Irish coastal waters. *Fisheries Research*, 64: 55–69.

O'Sullivan, S., Moriarty, C. and Davenport, J. (2004). Analysis of the stomach contents of the European conger eel *Conger conger* in Irish waters. *Journal of the Marine Biological Association of the United Kingdom*, 84: 823–826.

Parker-Humphreys, M. (2004a). Distribution and relative abundance of demersal fishes from beam trawl surveys in the Irish Sea (ICES Division VIIa) 1993–2001. *Science Series Technical Report,* CEFAS, Lowestoft, 120, 68 pp.

Parker-Humphreys, M. (2004b). Distribution and relative abundance of demersal fishes from beam trawl surveys in the Bristol Channel (ICES Division VIIf) 1993–2001. *Science Series Technical Report,* CEFAS, Lowestoft, 123, 69 pp.

Parker-Humphreys, M. (2005). Distribution and relative abundance of demersal fishes from beam trawl surveys in the EASTERN English Channel (ICES division VIId) and the southern North Sea (ICES Division IVc) 1993–2001. *Science Series Technical Report,* CEFAS, Lowestoft, 124, 92 pp.

Pavlov, D. A., and Novikov, G. G. (1993). Life history and peculiarities of common wolffish (*Anarhichas lupus*) in the White Sea. *ICES Journal of Marine Science*, 50: 271–277.

Pearson, W. H., Skalski, J. R., and Malme, C. I. (1992). Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* spp.). *Canadian Journal of Fisheries and Aquatic Sciences*, 49: 1343–1356.

Peres, M. B. & Vooren, C. M. (1991). Sexual development, reproductive cycle, and fecundity of the school shark *Galeorhinus galeus* off southern Brazil. *Fishery Bulletin,* 89: 655–667.

Perry, A.L., Low, P.J., Ellis, J.R. and Reynolds, J.D. (2005). Climate Change and Distribution Shifts in Marine Fishes. *Science,* 308: 1912–1915.

Pickett, G.D. and Pawson, M.G. (1994). Sea bass. Biology, exploitation and conservation. *Chapman & Hall*, 364 pp.

Pinnegar, J. K., Jennings, S., O'Brien, C. M., and Polunin, N. V. C. (2002). Long-term changes in trophic level of the Celtic Sea fish community and fish market price distribution. *Journal of Applied Ecology*, 39: 377–390.

Pizzolla, P.F. (2002). *Echiichthys vipera*. Lesser weever fish. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 05/02/2007].

Poll, M. (1947). Poissons marins. Faune de Belgique, 452pp.

Popper, A. N. (2003). Effects of anthropogenic sounds on fishes. *Fisheries*, 28: 24–31.

Popper, A.N., Fewtrell, J., Smith, M.E. and McCauley, R.D. (2004). Anthropogenic sound: effects on the behavior and physiology of fishes. *Marine Technology Society Journal*, 37: 35–40.

Postuma K.H. (1978). Immigration of southern fish into the North Sea. *Rapports et Procès-verbaux des Réunions, Conseil International pour l'Exploration de la Mer*, 172: 225–229.

Poulard, J.C. and Blanchard, F. (2005). The impact of climate change on the fish community structure of the eastern continental shelf of the Bay of Biscay. *ICES Journal of Marine Science*, 62: 1436–1443.

Power, M. and Attrill, M.J. (2003). Long-term trends in the estuarine abundance of Nilsson's pipefish (*Syngnathus rostellatus* Nilsson). *Estuarine, Coastal and Shelf Science*, 57: 325–333.

Power, M. and Attrill, M.J. (2002). Factors affecting long-term trends in the estuarine abundance of pogge (*Agonus cataphractus*). *Estuarine, Coastal and Shelf Science*, 54: 941–949.

Qasim, S.Z., (1956). Time and duration of the spawning season in some marine teleosts in relation to their distribution. *Journal du Conseil internationale pour l'Exploration de la Mer*, *21*: 144–155

Quero, J-C., Dunne, J. and Labastie, J. (1980). *Liparis liparis* (Linne, 1766) (Pisces, Scorpaeniforme, Liparidae) in Saint-Georges Channel and Bristol Channel. Distribution, abundance and biological data. *Revue des Travaux de l'Institut des Peches Maritimes* Nantes, 44: 235–243.

Quero, J.C., Porche, P. and Vayne, J.J. (2003). Guide les poisons de l'Atlantique europeen. Delachaux & Niestle, Paris, 465 pp.

Quigley, D.T.G., Flannery, K. and O'Shea, J. (1993). Trigger fish *Balistes capriscus* Gmelin. *Irish Naturalists' Journal*, 24: 223–228.

Quigley, DTG; Flannery, K; O'Shea, J; Blake, G; Smith, T (2004). First records of flying gurnard *Dactylopterus volitans* (L.) from Irish Waters and a review of north-western European records. *Irish Naturalists' Journal*, 27(12): 458–460.

Ramachandran, S.D., Sweezey, M.J., Hodson, P.V., Boudreau, M., Courtenay, S.C., Lee, K., King, T. and Dixon, J.A. (2006). Influence of salinity and fish species on PAH uptake from dispersed crude oil. *Marine Pollution Bulletin*, 52: 1182–1189.

Reed, K.A. (2006). *Cyclopterus lumpus*. Lumpsucker. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 05/02/2007].

Reeve, A. (2005). *Cepola rubescens*. Red bandfish. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 05/02/2007].

Rijnsdorp, A.D., Leeuwen, P.I., Van Daan, N. and Heessen, H.J.L. (1996). Changes in abundance of demersal fish species in the North Sea between 1906–1909 and 1990–1995. *ICES Journal of Marine Science*, 53: 1054–1062.

Rogers, S.I. (1991). The occurrence of young scaldfish *Arnoglossus laterna* (Walbaum, 1792) in the eastern Irish Sea. *Journal of Fish Biology*, 39: 889–891.

Rogers, S.I. and Ellis, J.R. (2000). Changes in the demersal fish assemblages of British coastal waters during the 20th century. *ICES Journal of Marine Science*, 57:866–881.

Rogers, S.I. and Stocks, R. (2001). North Sea fish and fisheries. Strategic Environmental Assessment - SEA2. Technical Report 003 - Fish & Fisheries, 72 pp.

Rogers, S.I., Millner, R.S. and Mead, T.A. (1998a) The distribution and abundance of young fish on the east and south coast of England (1981 to 1997). *Science Series Technical Report*, CEFAS, Lowestoft, 108: 130 pp.

Rogers, S.I., Rijnsdorp, A.D., Damm, U. and Vanhee, W. (1998b). Demersal fish populations in the coastal waters of the UK and continental NW Europe from beam trawl survey data collected from 1990 to 1995. *Journal of Sea Research* 39:79–102.

Rogers, S.I., Clark, K.R. and Reynolds, J.D. (1999a). The taxonomic distinctness of coastal bottom-dwelling fish communities of the Northeast Atlantic. *Journal of Animal Ecology*, 68: 769–782.

Rogers, S.I., Maxwell, D. Rijnsdorp, A.D., Damm, U. and Vanhee, W. (1999b). Fishing effects in Northeast Atlantic shelf seas: patterns in fishing effort, diversity and community structure IV. Can comparisons of species diversity be used to assess human impacts on coastal demersal fish faunas? *Fisheries Research*, 40: 135–152.

Ruiz, A. (2007). *Arnoglossus laterna*. Scaldfish. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 21/02/2007].

Russell, F.S. (1976). The eggs and planktonic stages of British marine fishes. Academic Press, London, 524 pp.

Saville, A. (1964). Clupeoidae. Fiches d'identification des oeufs et larves de poissons, *No. 1*: 5 pp.

Sayer, M.D.J., Treasurer, J.W. and Costello, B.M.J. (Eds.) (1996). Wrasse: Biology and Use in Aquaculture. Fishing News Books Ltd, 256 pp.

Shelton, R.G.J. (1978). On the feeding of the hagfish *Myxine glutinosa* in the North Sea. *Journal of the Marine Biological Association of the United Kingdom*, 58: 81–86.

Silva, A. (1999). Feeding habits of John Dory, *Zeus faber*, off the Portuguese continental coast. *Journal of the Marine Biological Association of the United Kingdom*, 79: 333–340.

Sims, D.W. and Southall, E.J. (2002). Occurrence of ocean sunfish, *Mola mola* near fronts in the western English Channel. Journal of the Marine Biological Association of the United Kingdom, 82(5): 927–928.

Skalski, J.R., Pearson, W.H., and Malme, C.I. (1992). Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp.). *Canadian Journal of Fisheries and Aquatic Sciences,* 49: 1357–1365.

Skewes, M. (2003). *Crenilabrus melops*. Corkwing wrasse. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 05/02/2007].

Sokolov, K. M., and Shevelev, M. S. (1994). New findings of egg clutches of wolffish *Anarhichas* in the Barents Sea. ICES-CM-1994/O:10.

Soldal, A.V., Svellingen, I., Jorgensen, T. and Lokkeborg, S. (2002). Rigs-to-reefs in the North Sea: Hydroacoustic quantification of fish in the vicinity of a "semi-cold" platform. *ICES Journal of Marine Science*, 59 (Supplement), 281–287.

Sorbe,J.C. (1977). The diet of *Phycis blennoides* (Brunnich 1768) in the southern Bay of Biscay. *Revue des Travaux de l'Institute des Peches Maritimes, Nantes*, 41: 271–281.

Souissi, S., Ibanez, F., Ben Hamadou, R., Boucher, J., Cathelineau, A.C., Blanchard, F., and Poulard, J.C. (2001). A new multivariate mapping method for studying species assemblages and their habitats: example using bottom trawl surveys in the Bay of Biscay (France). *Sarsia*, 86: 527–542.

Stagg, R.M. and McIntosh, A. (1996). Hydrocarbon concentrations in the northern North Sea and effects on fish larvae. *Science of the Total Environment*, 186: 189–201.

Swaby, S.E., Potts, G.W. and Wheeler, A. (1992). The first record of the short-beaked garfish *Belone svetovidovi* (Belonidae) in British waters. *Journal of the Marine Biological Association of the United Kingdom*, 72: 507–508.

Taylor, N., Fox, C.J., Bolle, L., Dickey-Collas, M., Fossum, P., Kraus, G., Munk, P., Rolf, N., Van Damme, C. and Vorbach, M. (2007). Spring plankton surveys of the North Sea in 2004: the distribution of fish eggs and larvae. I*CES Cooperative Research Report* No. 285, *in press*.

Templeman, W. (1984). Migrations of wolffishes, *Anarhichas* sp., from tagging in the Newfoundland area. *Journal of Northwest Atlantic Fisheries Science,* 5: 93–97.

Templeman, W. (1986). Some biological aspects of Atlantic wolffish (*Anarhichas lupus*) in the Northwest Atlantic. *Journal of Northwest Atlantic Fishery Science*, 7: 57–65.

Thorpe, T. (1997). First occurrence and new length record for the bigeye thresher shark in the Northeast Atlantic. *Journal of Fish Biology,* 50: 222–224.

Tidd, A. and Warnes, S. (2006). Species distributions from English Celtic Sea groundfish surveys 1992–2003. *Science Series Technical Report,* CEFAS, Lowestoft, 137, 54 pp.

Tolimieri, N., Jeffs, A., and Montgomery, J. C. (2000). Ambient sound as a cue for navigation by the pelagic larvae of reef fishes. *Marine Ecology Progress Series* 207, 219–224.

Tolimieri, N., Haine, O., Jeffs, A., McCauley, R., and Montgomery, J. (2004). Directional orientation of pomacentrid larvae to ambient reef sound. *Coral Reefs,* 23: 184–191.

Tortonese, E. (1956). Leptocardia, Cyclostoma, Selachii. Fauna d'Italia 2. Calderini, Bologna, 334 pp.

Tortonese, E. (1970). Osteichthyes. Pesci ossei (parte 1). Fauna d'Italia 10. Calderini, Bologna, 565 pp.

Tortonese, E. (1975). Osteichthyes. Pesci ossei (parte 2). Fauna d'Italia 11. Calderini, Bologna, 636 pp.

Trenkel, V. M., Pinnegar, J. K., Rochet, M.-J., and Rackham, B. D. (2004). Different surveys provide similar pictures of trends in a marine fish community but not of individual fish populations. *ICES Journal of Marine Science*, 61: 351–362.

Turnpenny, A.W.H. and Nedwell, J.R. (1994). The effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys. Consultancy Report FCR 089/94. Fawley Aquatic Research Laboratories Ltd.

Tyler-Walters, H. (2004). *Psetta maxima*. Turbot. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 05/02/2007].

Vasconcelos, R., Prista, N., Cabral, H. and Costa, M.J. (2004). Feeding ecology of the lesser weever, *Echiichthys vipera* (Cuvier, 1829), on the western coast of Portugal. *Journal of Applied Ichthyology*, 20: 211–216.

Vidy, G. and Franc, J. (1992). Seasonal occurrence of grey mullet fry in Tunisian coastal areas. *Cybium*, 16: 53–71.

Wardle, C.S., Carter, T.J., Urquhart, G.G., Johnstone, A.D.F., Ziolkowski, A.M., Hampson, G and Mackie, D. (1998). The sound of a triple 'G' seismic airgun and its effects on the behaviour of marine fish. *Fisheries Research Services* report. No. 10/98.

Wardle, C.S., Carter, T.J., Urquhart, G.G., Johnstone, A.D.F., Ziolkowski, A.M., Hampson, G. and Mackie, D. (2001). Effects of seismic air guns on marine fish. *Continental Shelf Research*, 21: 1005–1027.

Warnes, S. and Jones, B.W. (1995). Species distributions from English Celtic Sea groundfish surveys, 1984 to 1991. *Fisheries Research Technical Report, MAFF Directorate of Fisheries Research, Lowestoft,* 98: 42pp.

Wheeler, A. (1969). The fishes of the British Isles and North-west Europe. Michigan State University Press, 613 pp.

Wheeler, A. (1978). Key to the Fishes of Northern Europe. Warne, London, 380 pp.

Wheeler, A. (1992). A list of the common and scientific names of fishes of the British Isles. Journal of Fish Biology, 41(Supplement A): 1–37

Wheeler, A.C., Merrett, N.R., and Quigley, D.T.G. (2004). Additional records and notes for Wheeler's (1992) list of the common and scientific names of fishes of the British Isles. *Journal of Fish Biology* 65 (supplement B) iii, 40pp.

Whitehead, P.J.P., Bauchot, M.-L., Hureau J.-C., Nielsen J., and Tortonese E. (eds) (1984-1986). Fishes of the North-Eastern Atlantic and the Mediterranean. 3 Vols, UNESCO, Paris 1473 pp.

Wilson, J.P.F. (1981). A note on the biology of the Cornish Clingfish *Lepadogaster lepadogaster* (Bonnaterre). *Irish Naturalists' Journal*, 20: 209–210.

Yang, J. (1982a). An Estimate of the Fish Biomass in the North Sea. *Journal du Conseil International pour l'Exploration de la Mer*, 40:161–172.

Yang, J. (1982b). The dominant fish fauna in the North Sea and its determination. Journal of Fish Biology, 20:635–643.

Yarrell, W. (1836). A history of British fishes. John Van Voorst, London, 472 pp.

# FISH AND FISH ASSEMBLAGES OF THE BRITISH ISLES

# FIGURES

Figure 3.1.1: North Sea IBTS survey stations (GOV trawl)

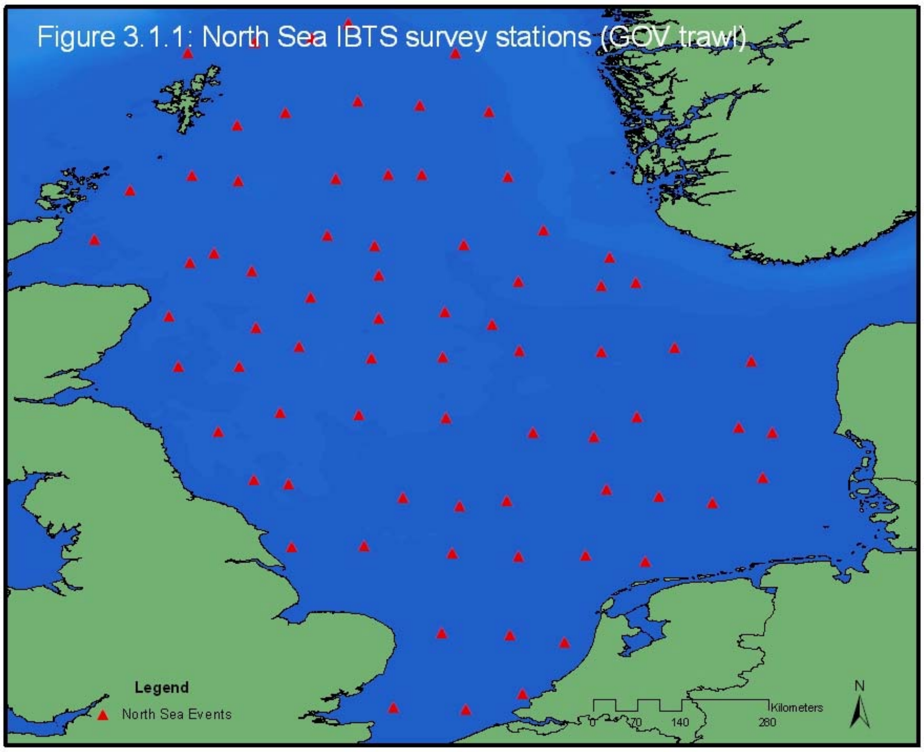


Figure 3.1.2: Eastern English Channel survey stations (4m beam trawl)

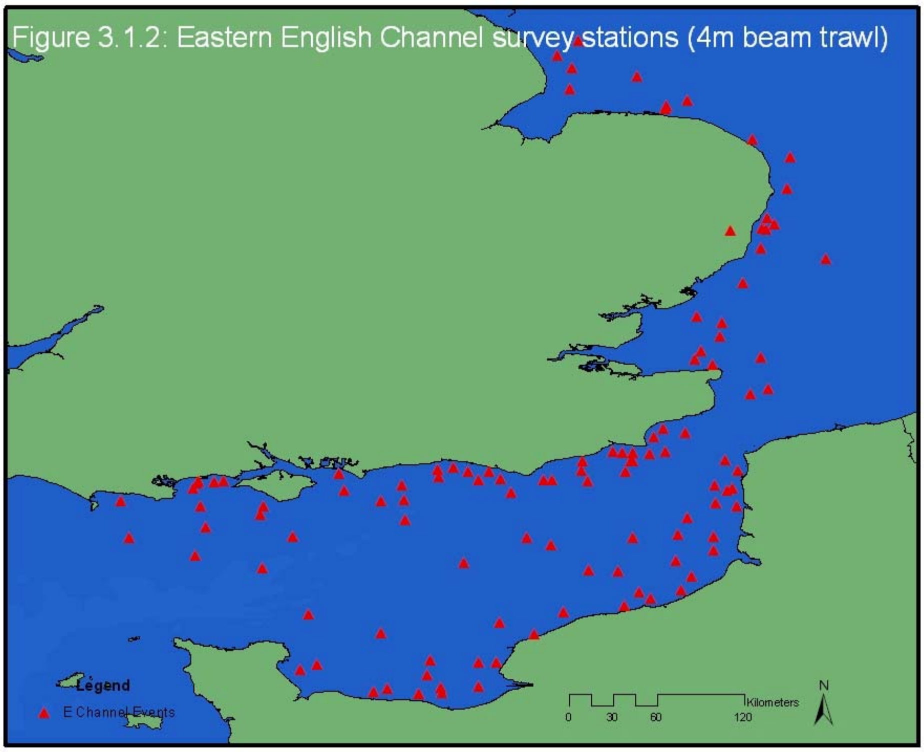

Figure 3.2.1: Irish Sea, Bristol Channel and western English Channel survey stations (4m beam trawl)

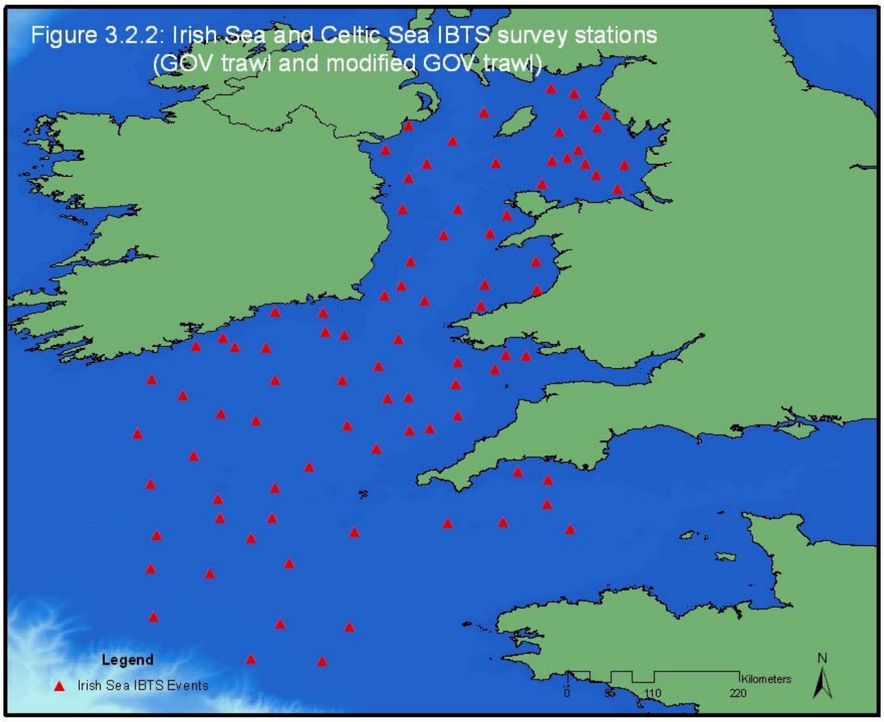


Figure 3.2.2: Irish Sea and Celtic Sea IBTS survey stations (GOV trawl and modified GOV trawl)

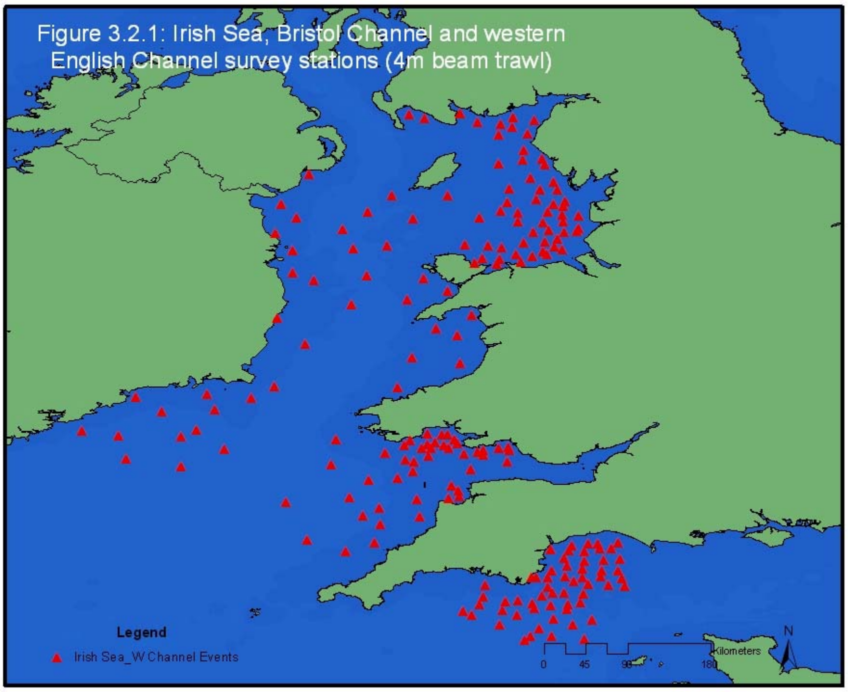

Figure 3.2.3: Celtic Sea survey grid (Portuguese High Headline Trawl)

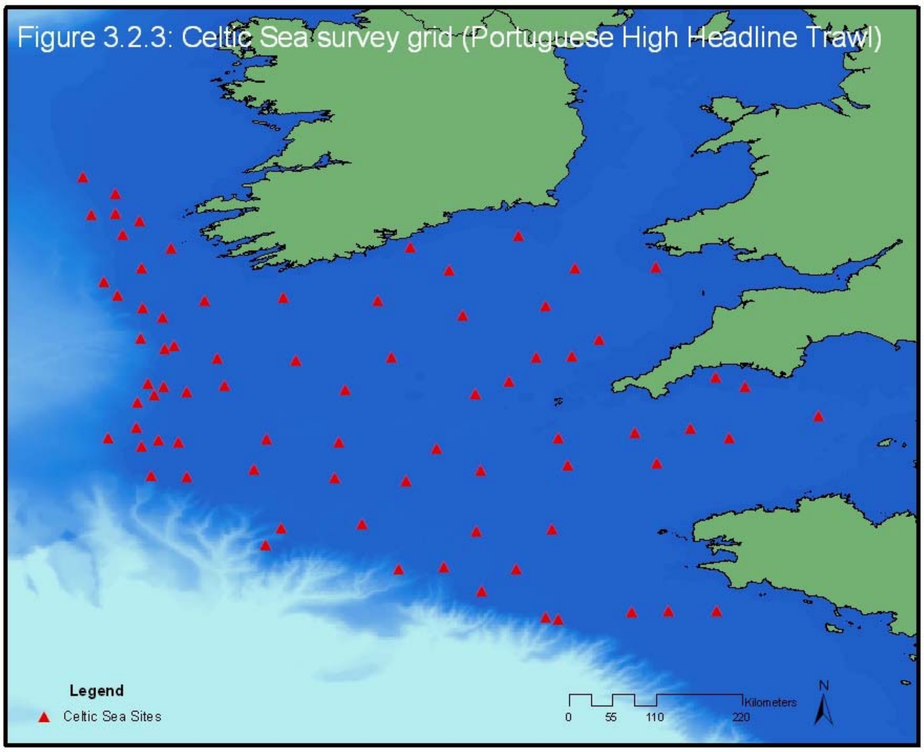

Figure 5.1.1: Occurrence of hagfish in Cefas trawl survey

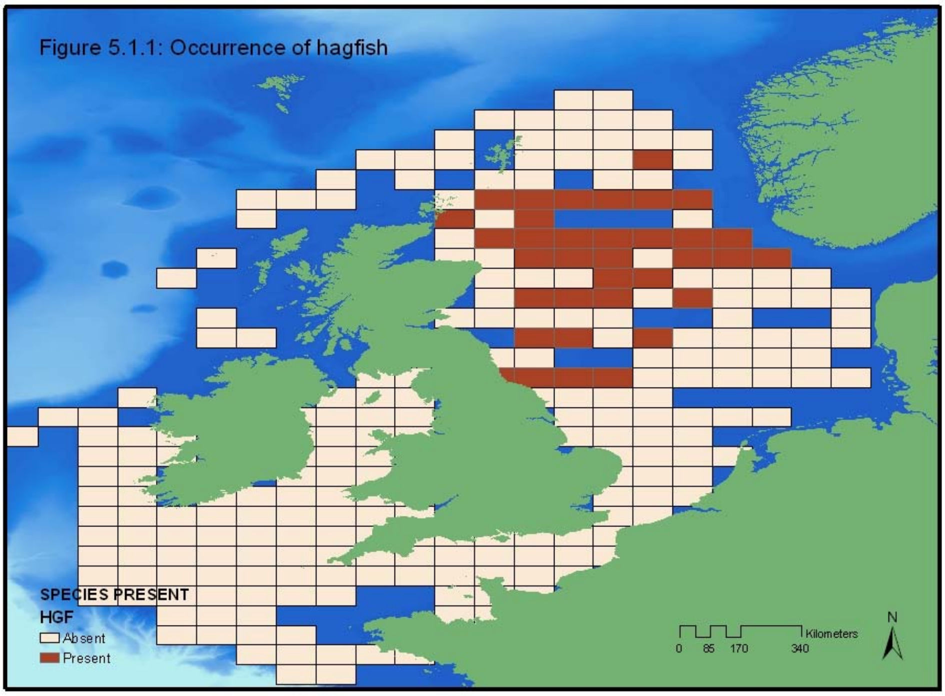


Figure 5.2.1: Occurrence of sea lamprey in Cefas trawl surveys

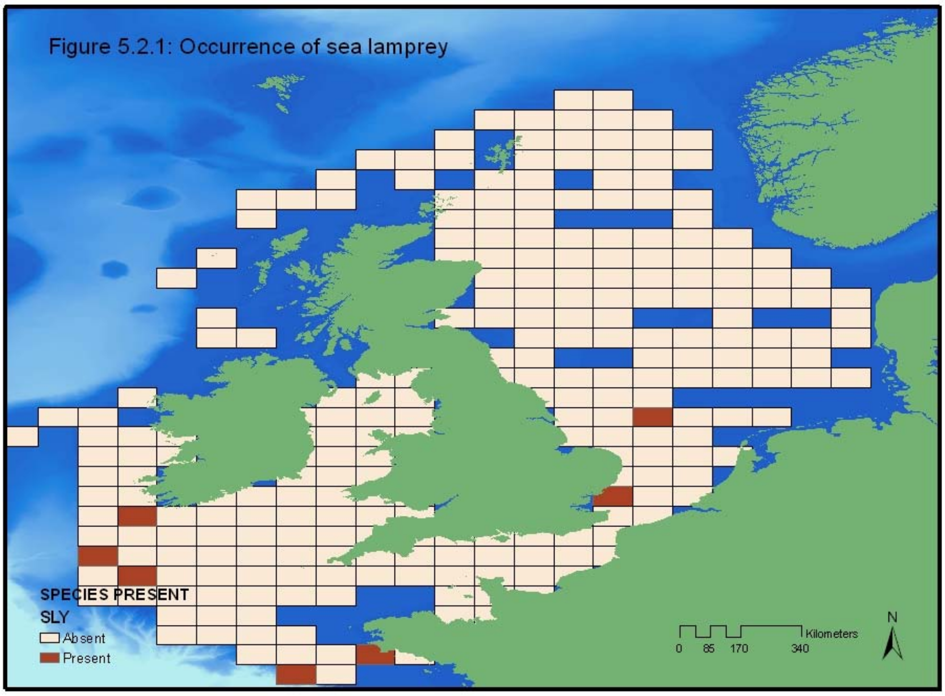

Figure 5.3.1: Occurrence of lesser-spotted dogfish in Cefas trawl surveys

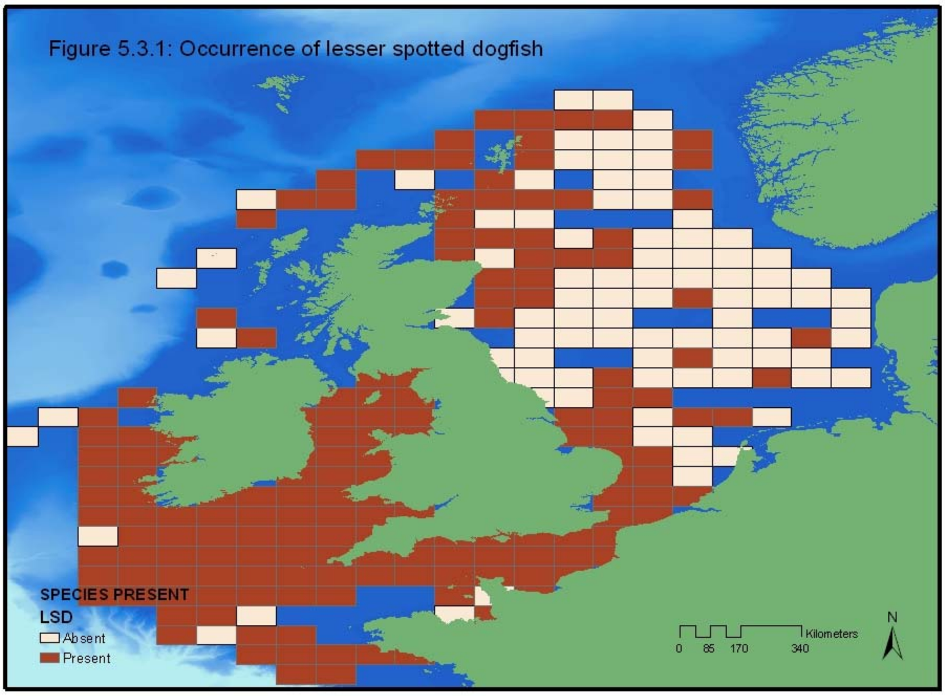


Figure 5.3.2: Occurrence of greater-spotted dogfish in Cefas trawl surveys

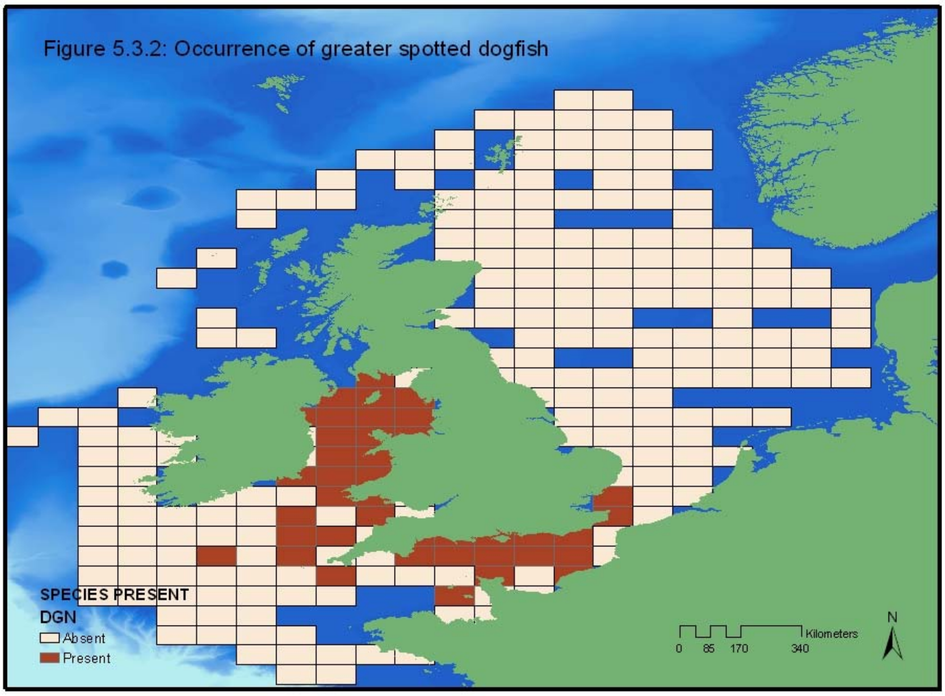

Figure 5.4.1: Occurrence of tope in Cefas trawl surveys

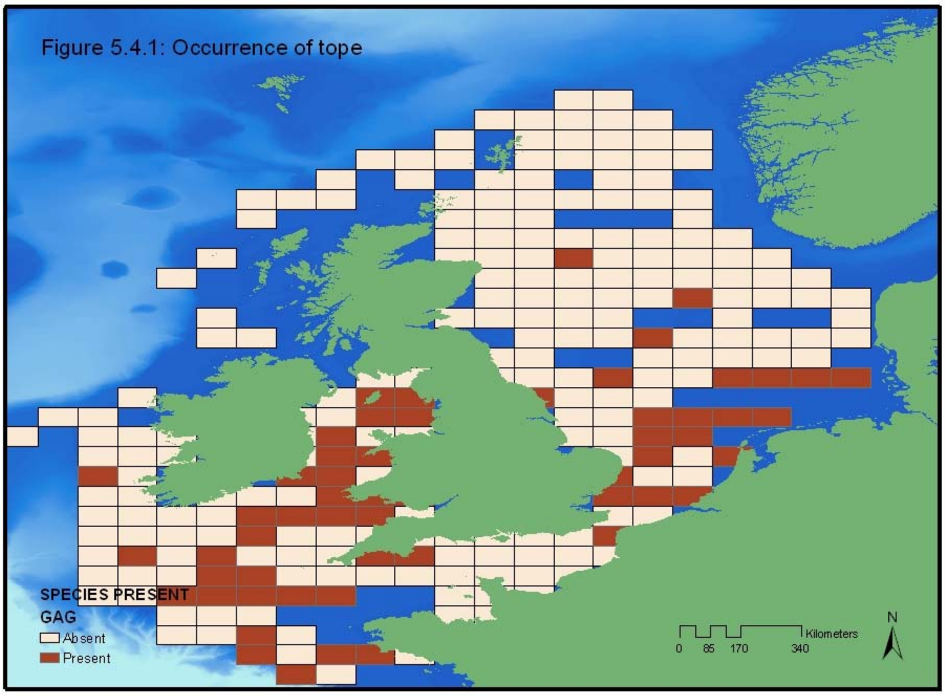


Figure 5.4.2: Occurrence of smoothhound and starry smoothhound in Cefas trawl surveys

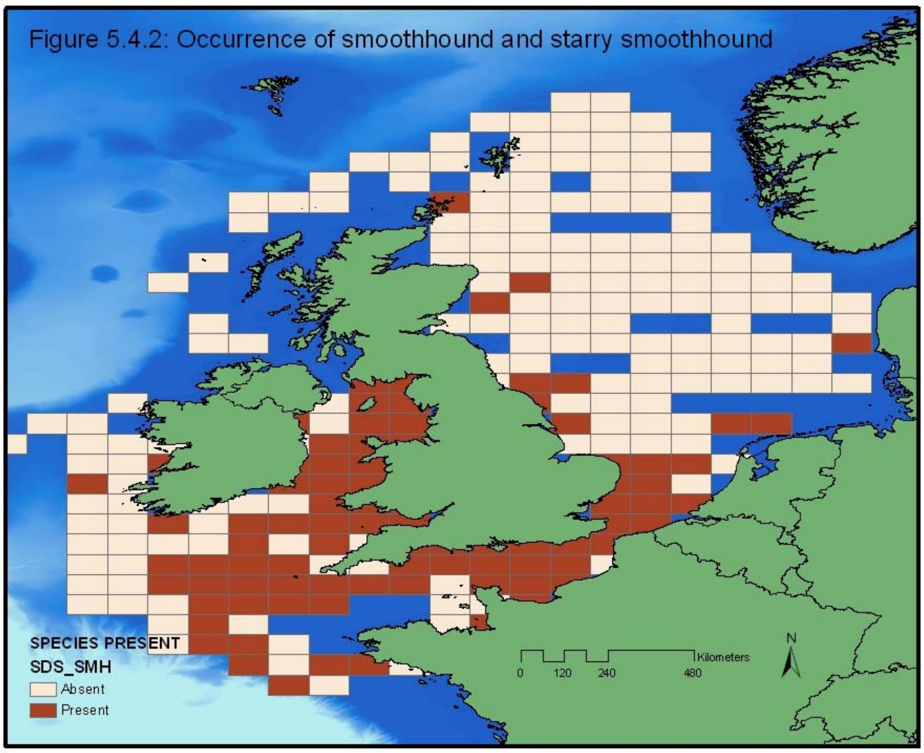

Figure 5.6.1: Occurrence of conger eel in Cefas trawl surveys

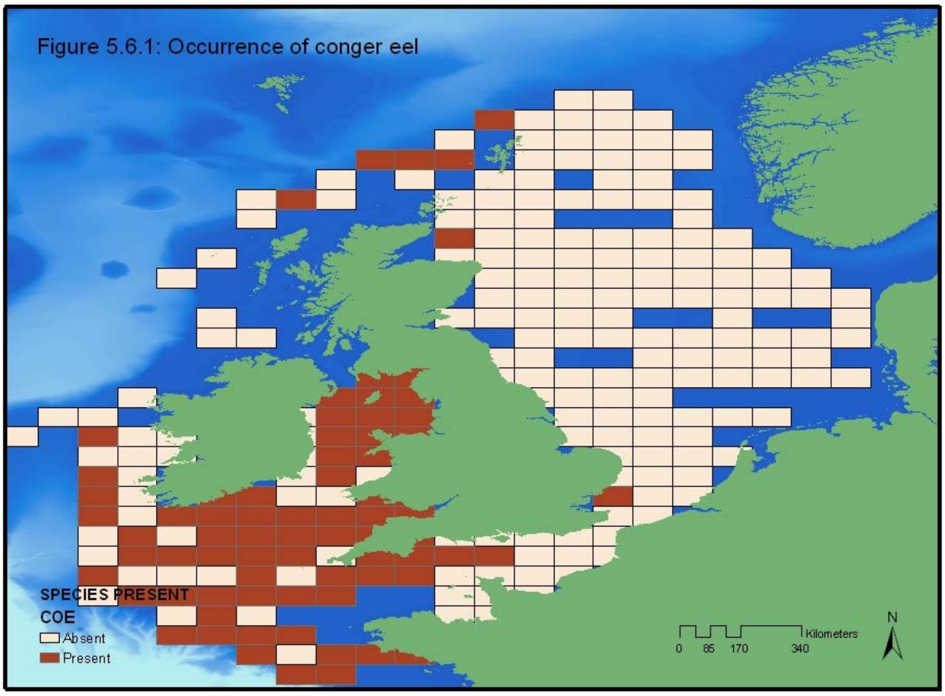


Figure 5.7.1: Occurrence of pilchard in Cefas trawl surveys

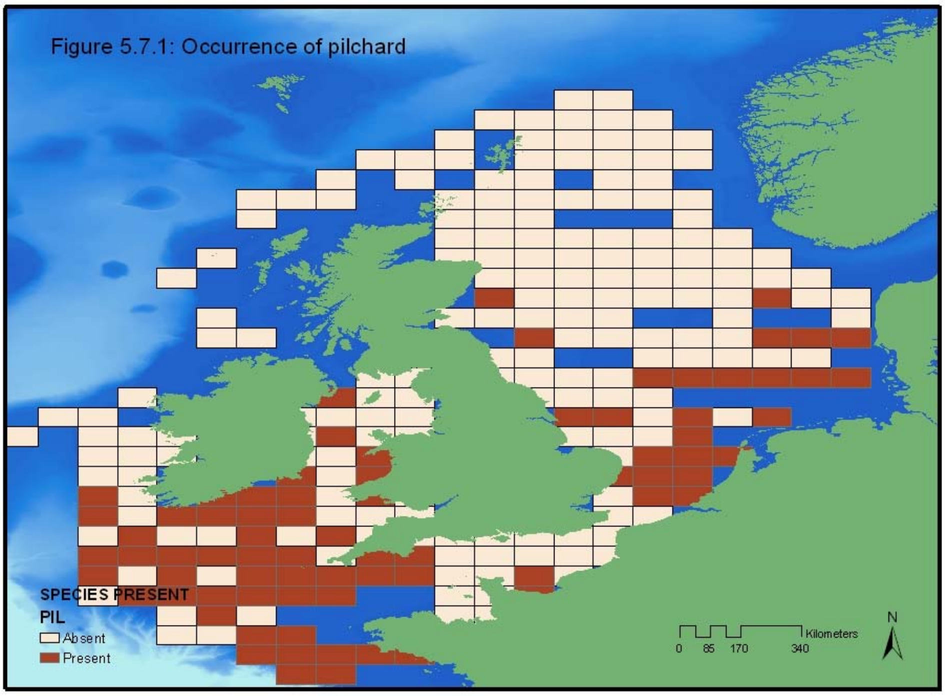

Figure 5.7.2: Occurrence of anchovy in Cefas trawl surveys

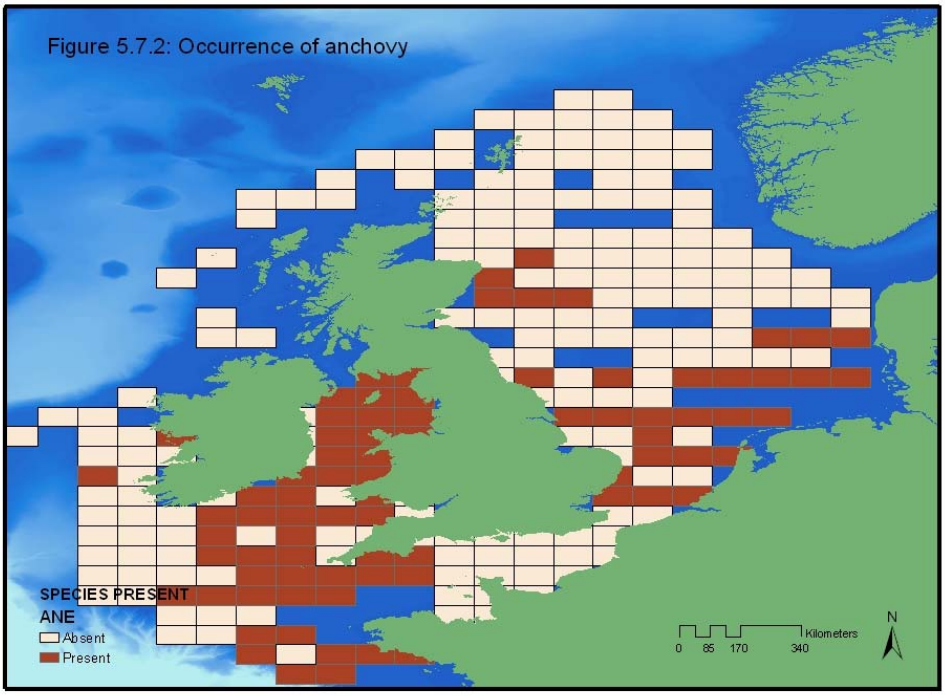

*Figure 5.7.3: Distribution of pilchard eggs in the North Sea*

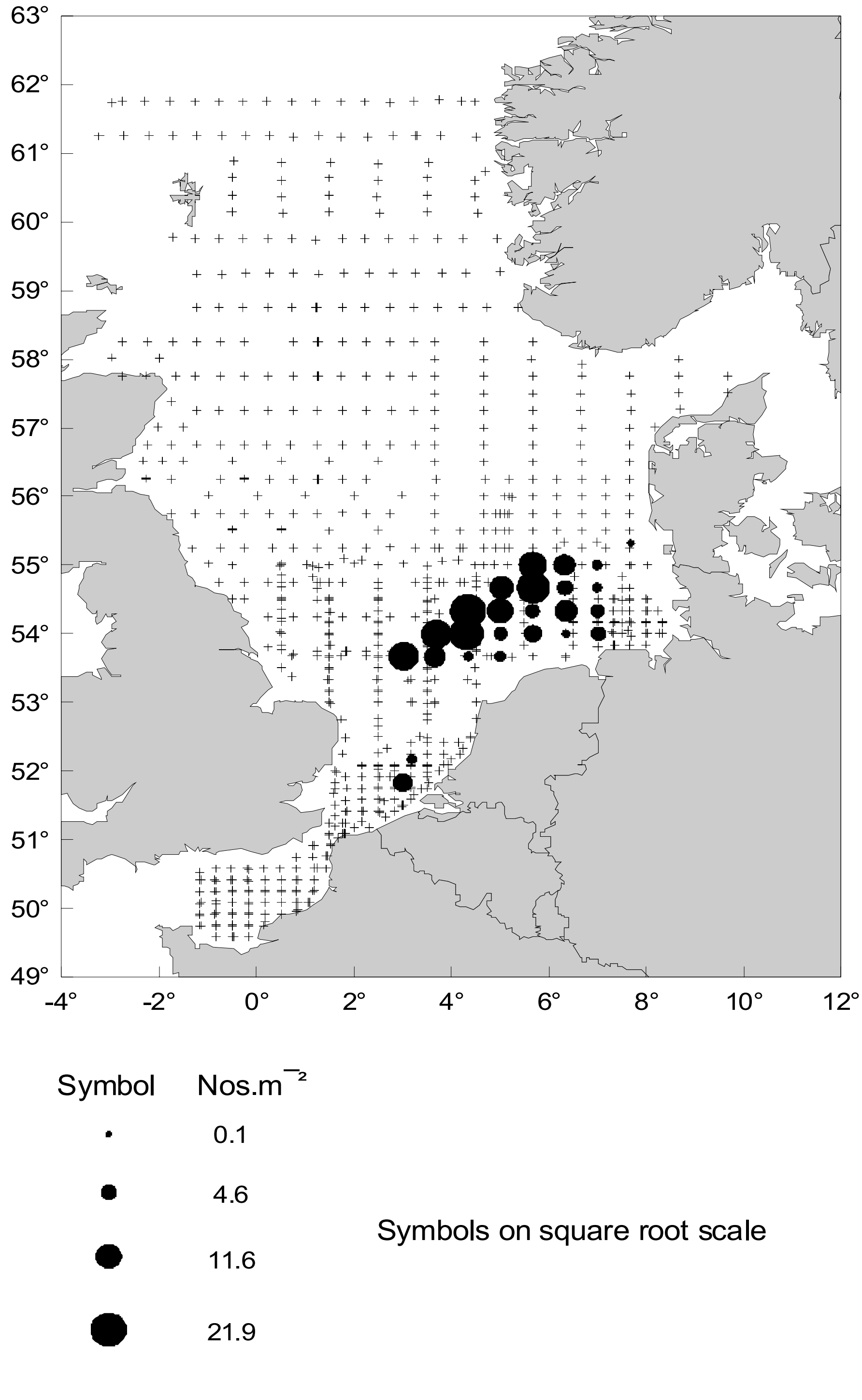


*Figure 5.7.3. Composite map of pilchard egg distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

Figure 5.8.1: Occurrence of argentines in Cefas trawl surveys

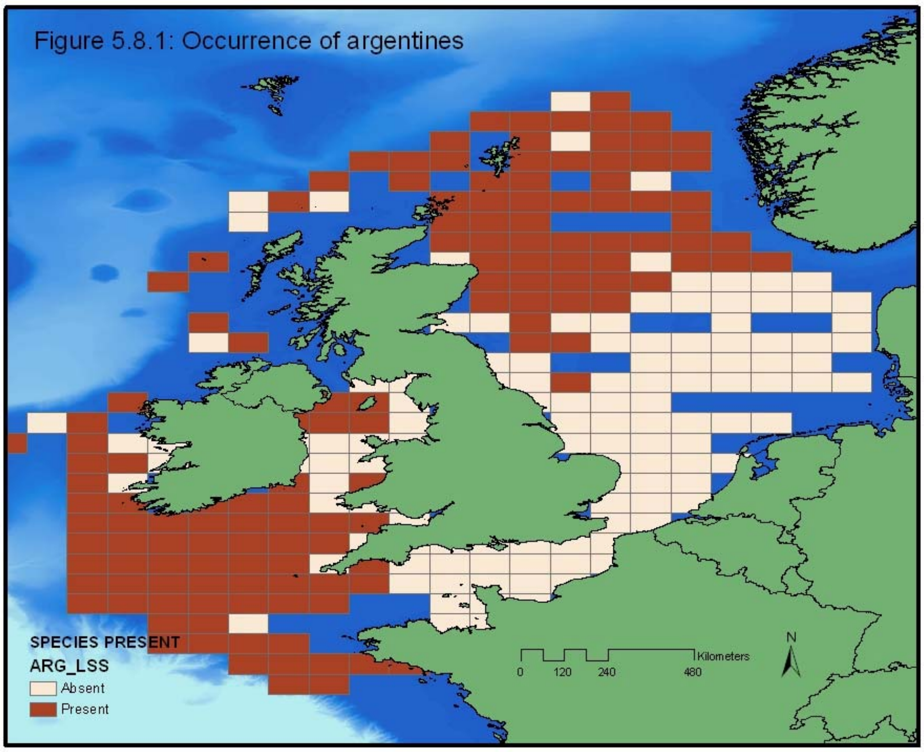

*Figure 5.8.2: Distribution of lesser argentine eggs in the Irish Sea*

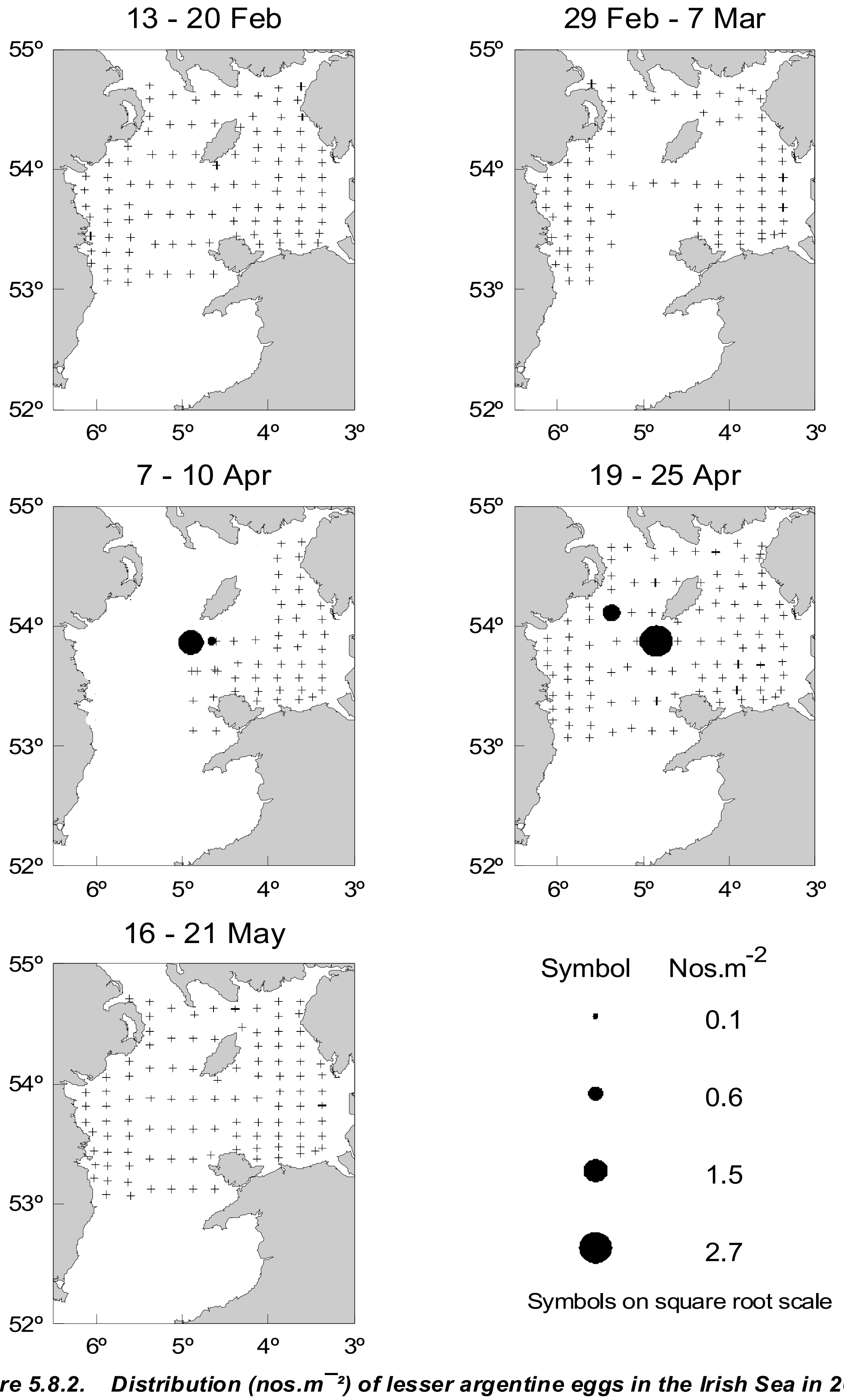


***Figure 5.8.2. Distribution (nos.m⁻²) of lesser argentine eggs in the Irish Sea in 2000. From Bunn & Fox, 2004.***

Figure 5.9.1: Occurrence of silvery pout in Cefas trawl surveys

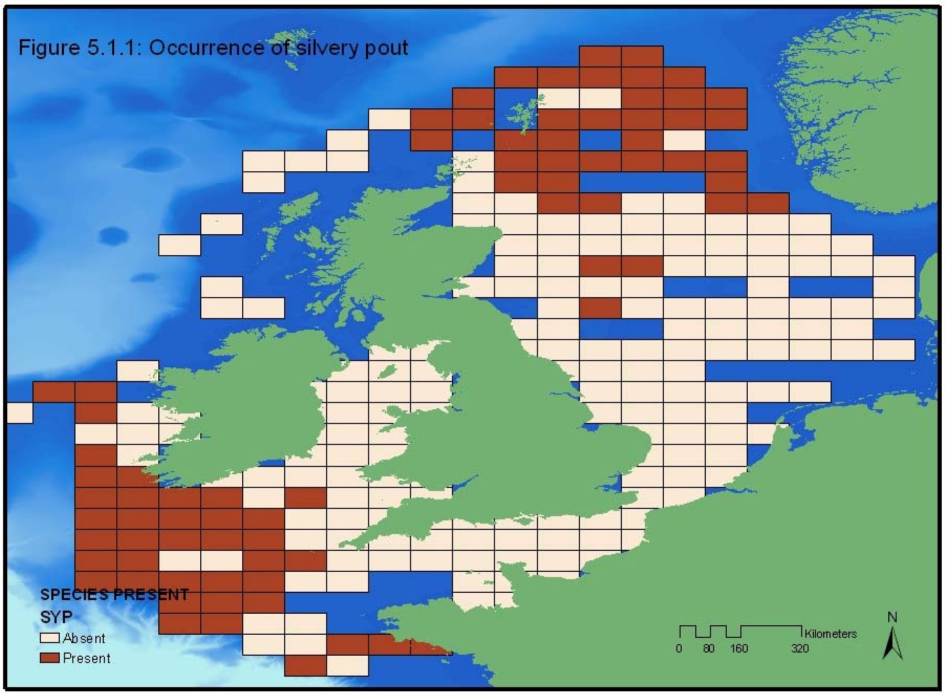


Figure 5.9.2: Occurrence of poor cod in Cefas trawl surveys

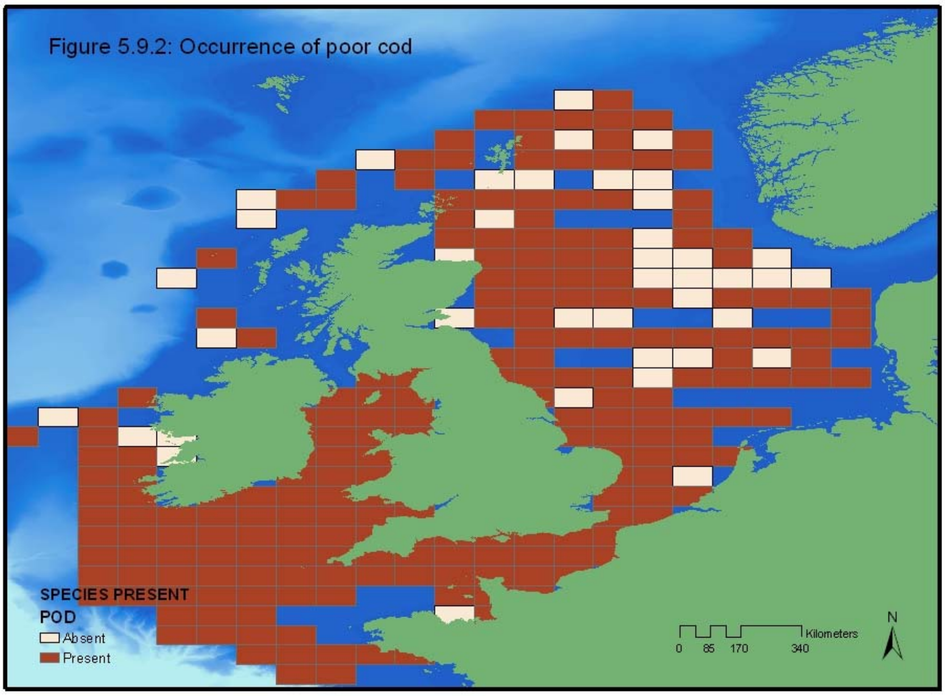

Figure 5.9.3: Occurrence of bib in Cefas trawl surveys

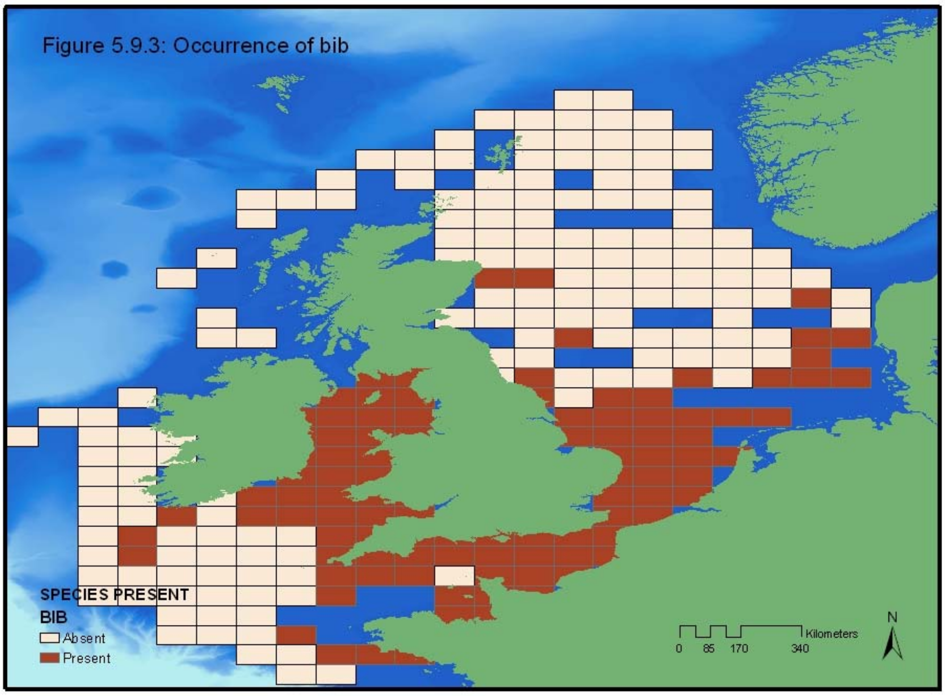


Figure 5.9.4: Occurrence of pollack in Cefas trawl surveys

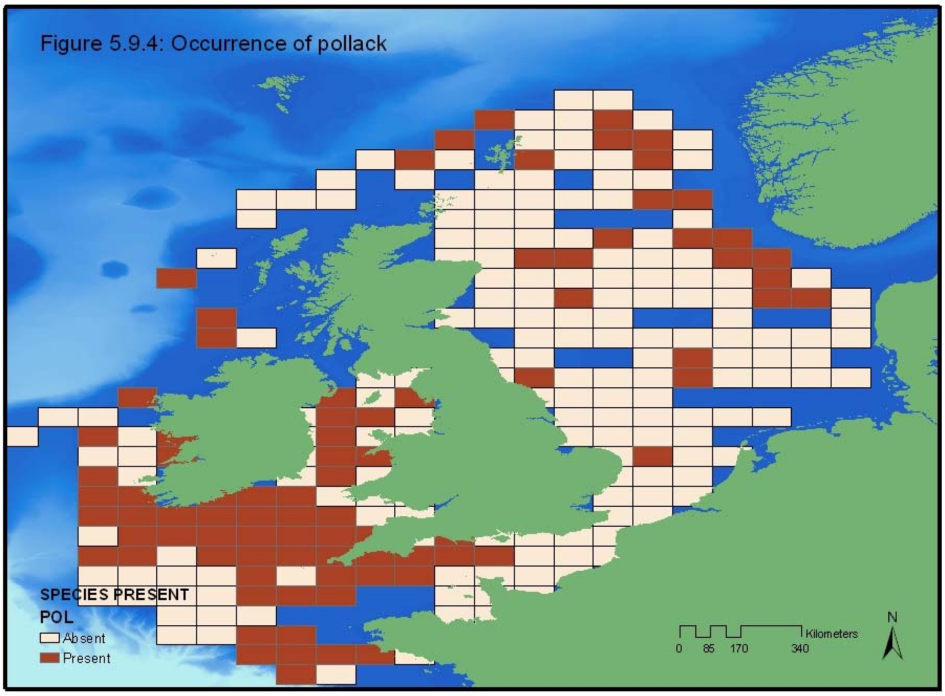

*Figure 5.9.5: Distribution of Norway pout/poor cod larvae in the Irish Sea*

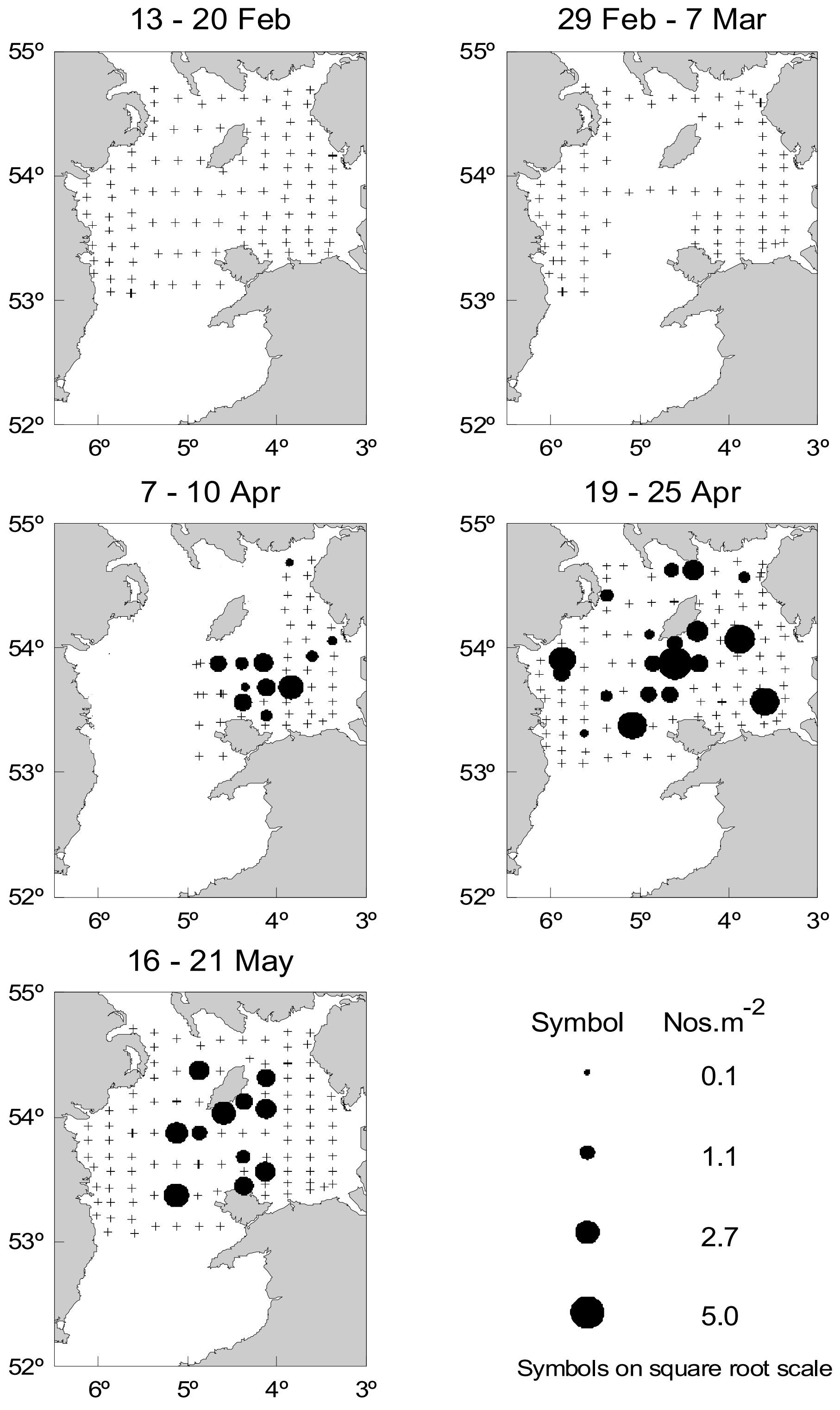


***Figure 5.9.5. Distribution (nos.m$^{-2}$) of Norway pout and poor cod (Gadidae) larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.9.6: Distribution of bib larvae in the Irish Sea*

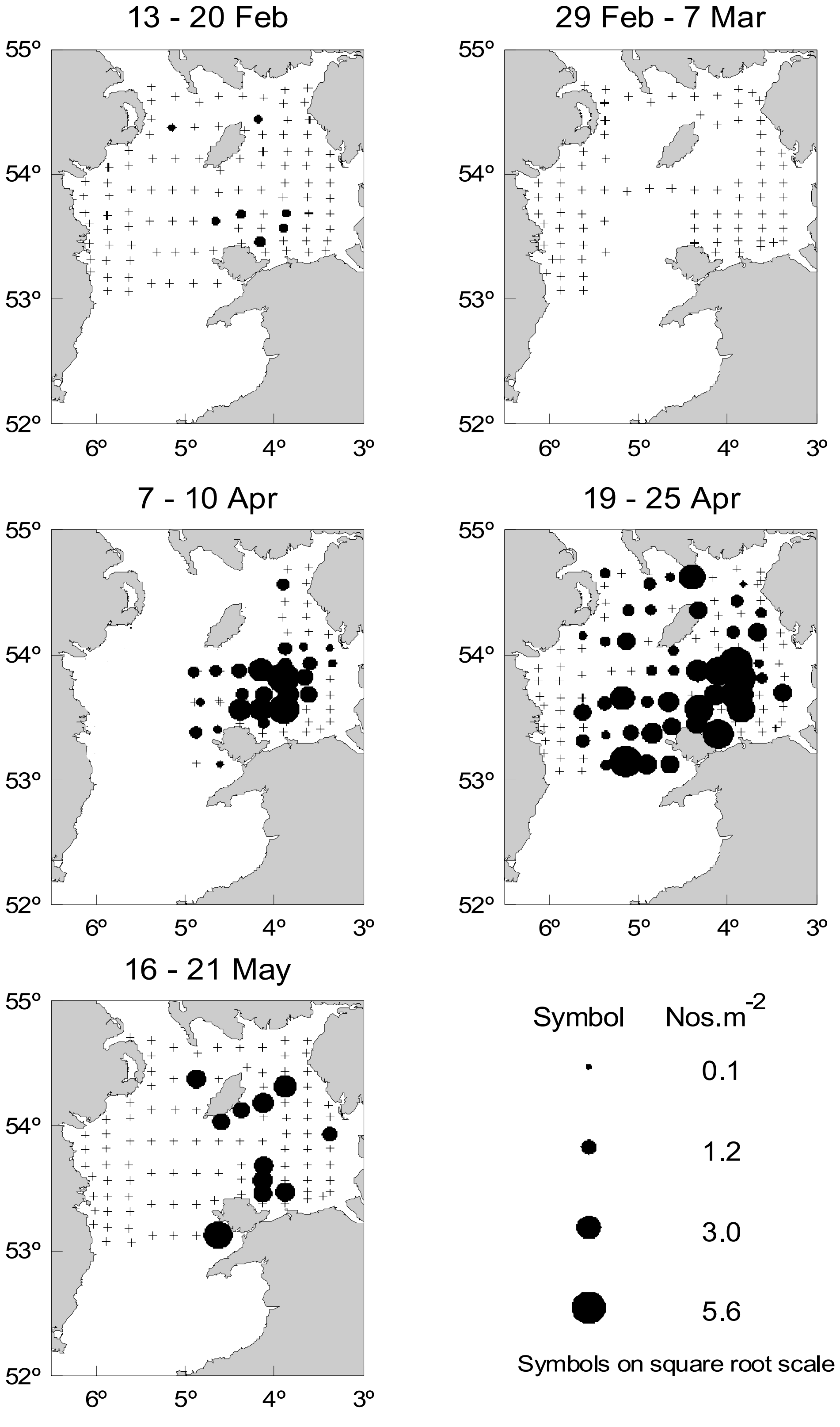


***Figure 5.9.6. Distribution (nos.m⁻²) of bib larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.9.7: Distribution of pollack larvae in the Irish Sea*

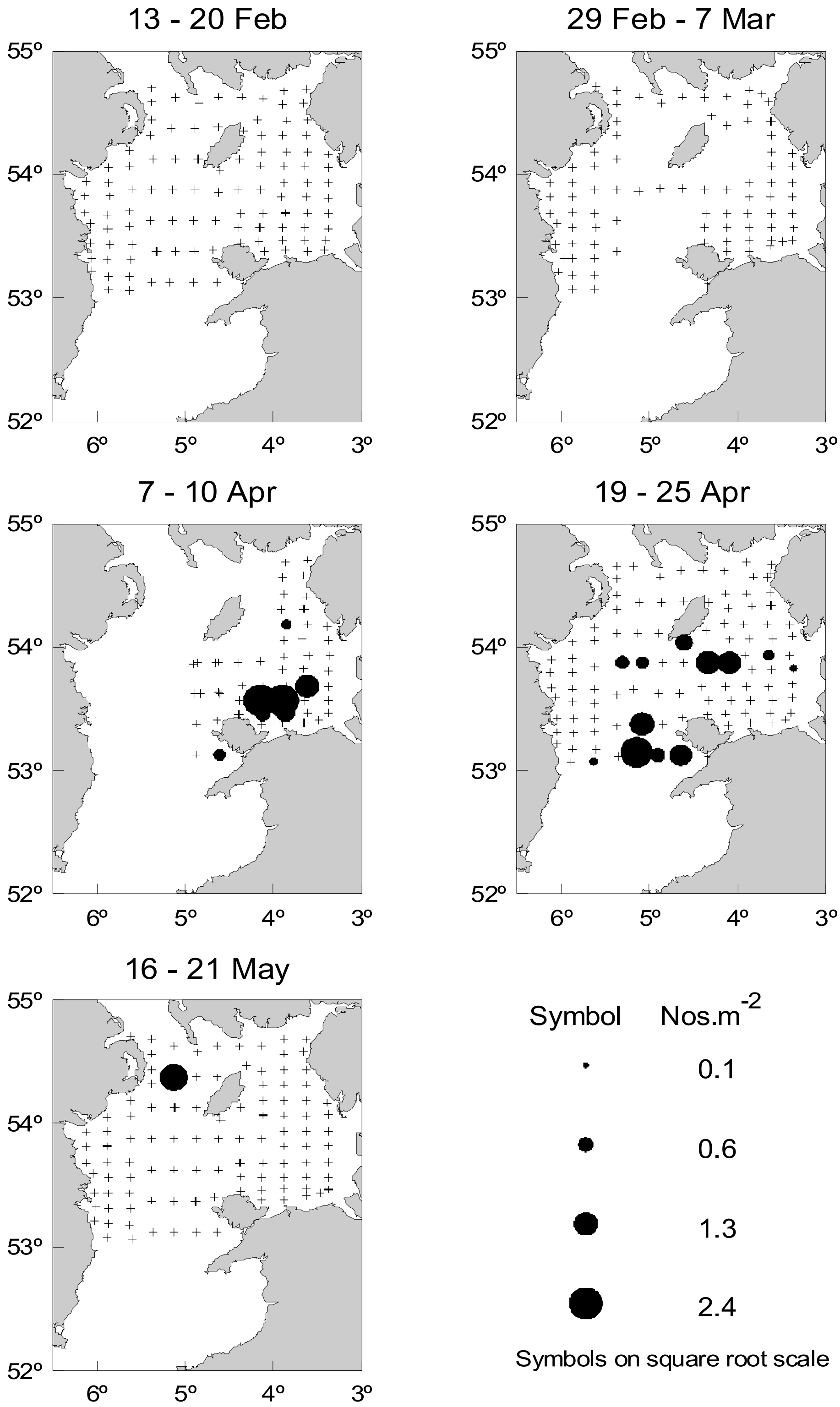


***Figure 5.9.7. Distribution (nos.m$^{-2}$) of pollack larvae in the Irish Sea in 2000. From Bunn & Fox, 2004***

*Figure 5.9.8: Distribution of Norway pout/poor cod larvae in the North Sea*

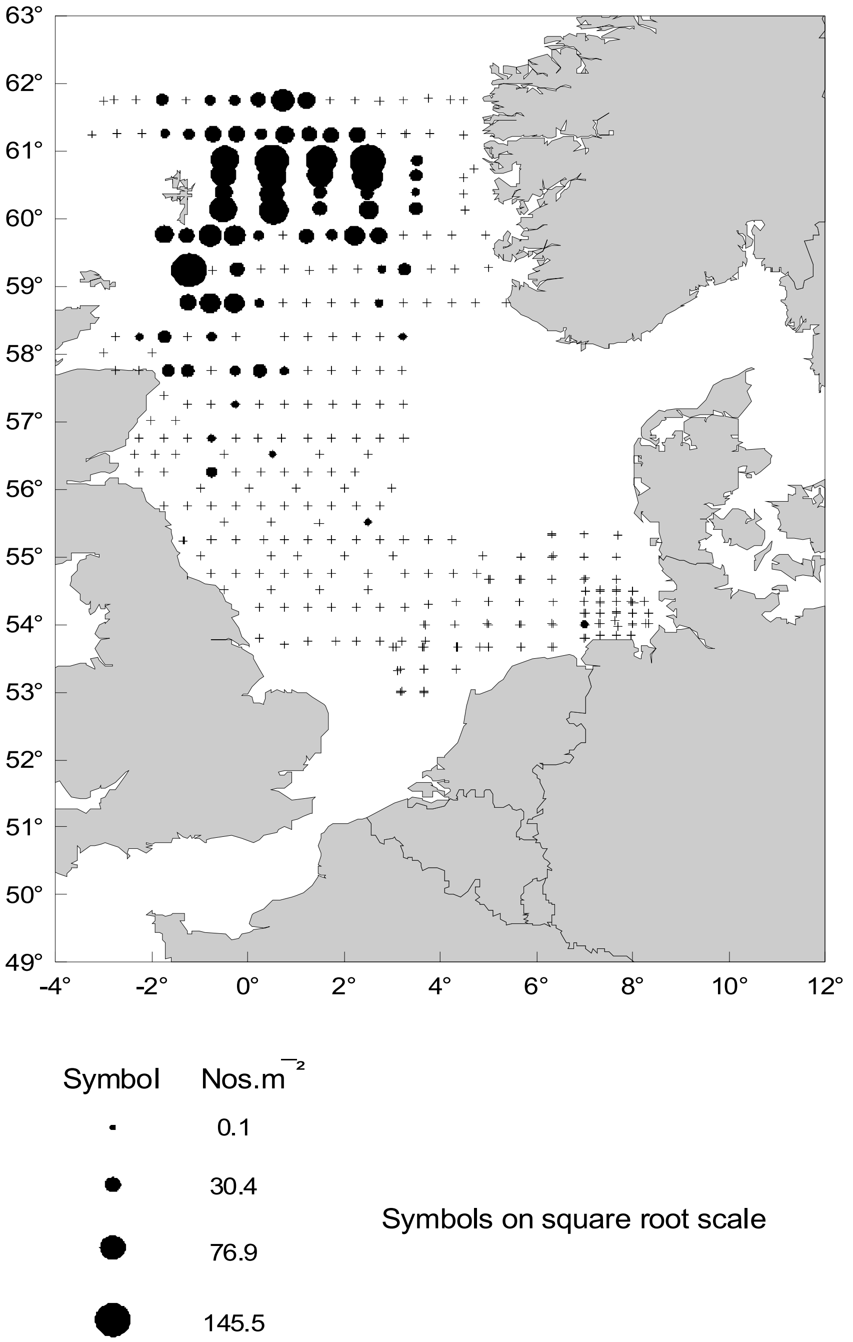


*Figure 5.9.8. Composite map of Norway pout and poor cod (Gadidae) larval distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

Figure 5.10.1: Occurrence of 5-bearded rockling in Cefas trawl surveys

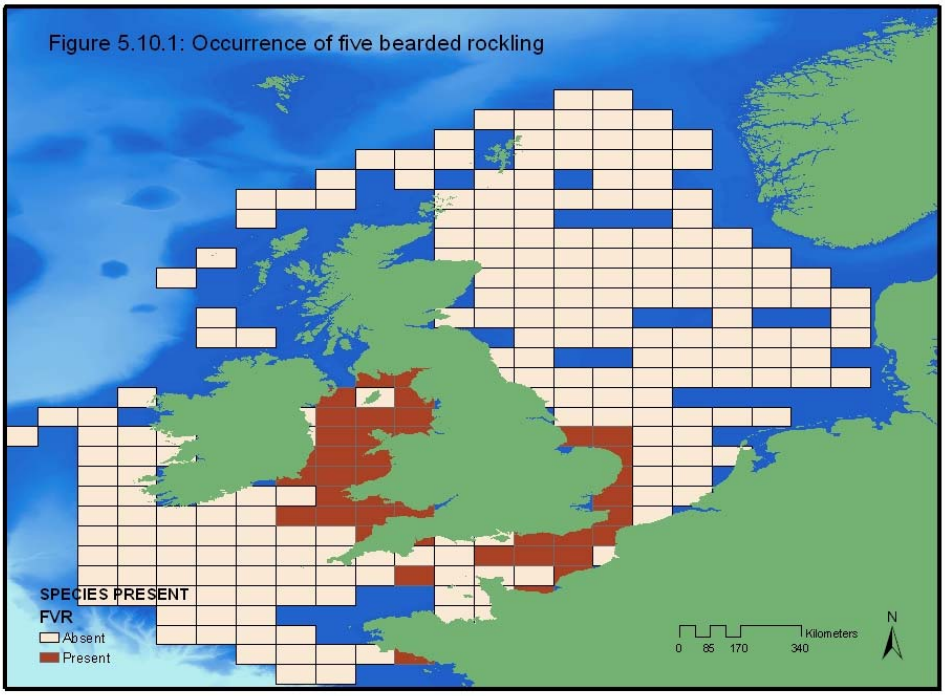


Figure 5.10.2: Occurrence of 4-bearded rockling in Cefas trawl surveys

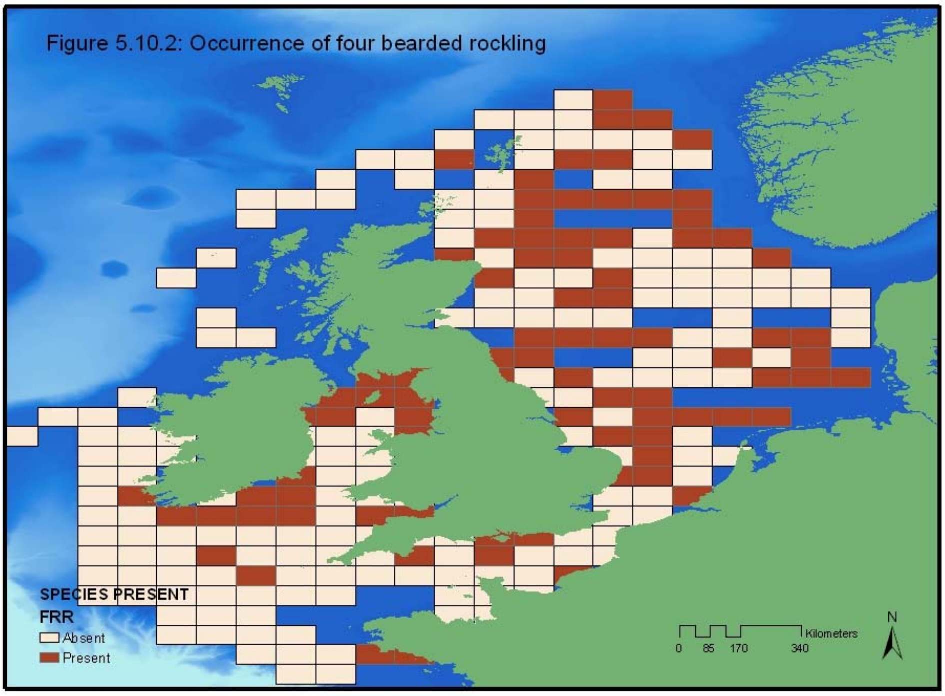

Figure 5.10.3: Occurrence of 3-bearded rockling in Cefas trawl surveys

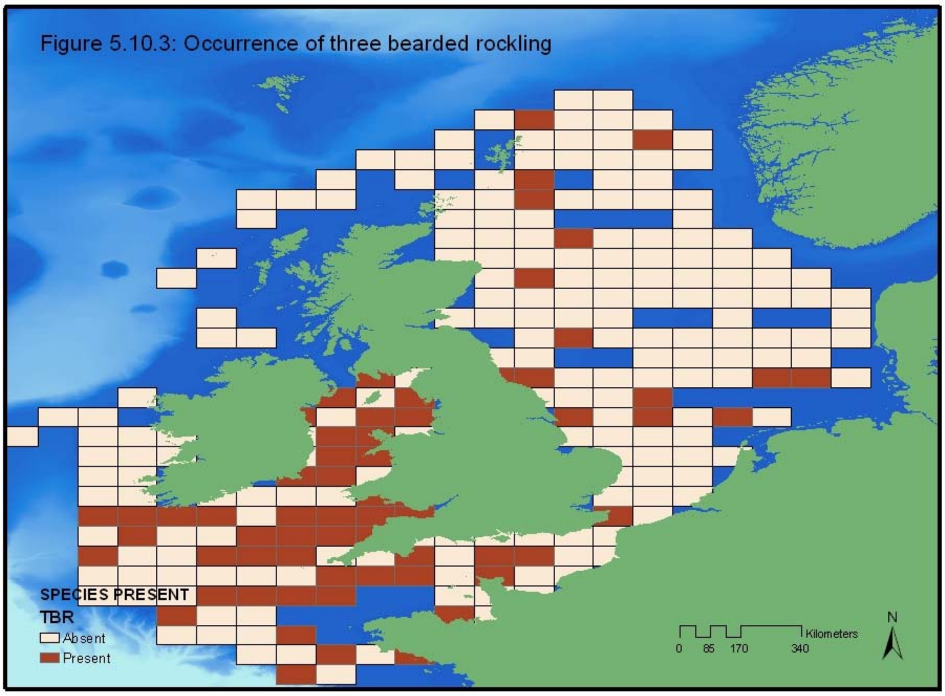


Figure 5.10.4: Occurrence of forkbeard in Cefas trawl surveys

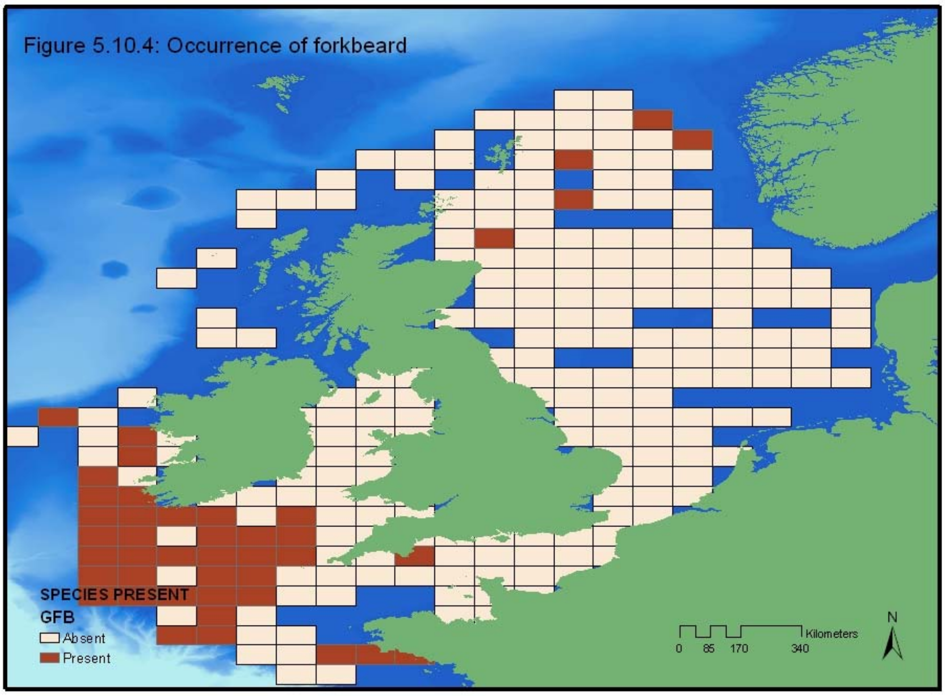

*Figure 5.10.5: Distribution of rockling eggs in the Irish Sea*

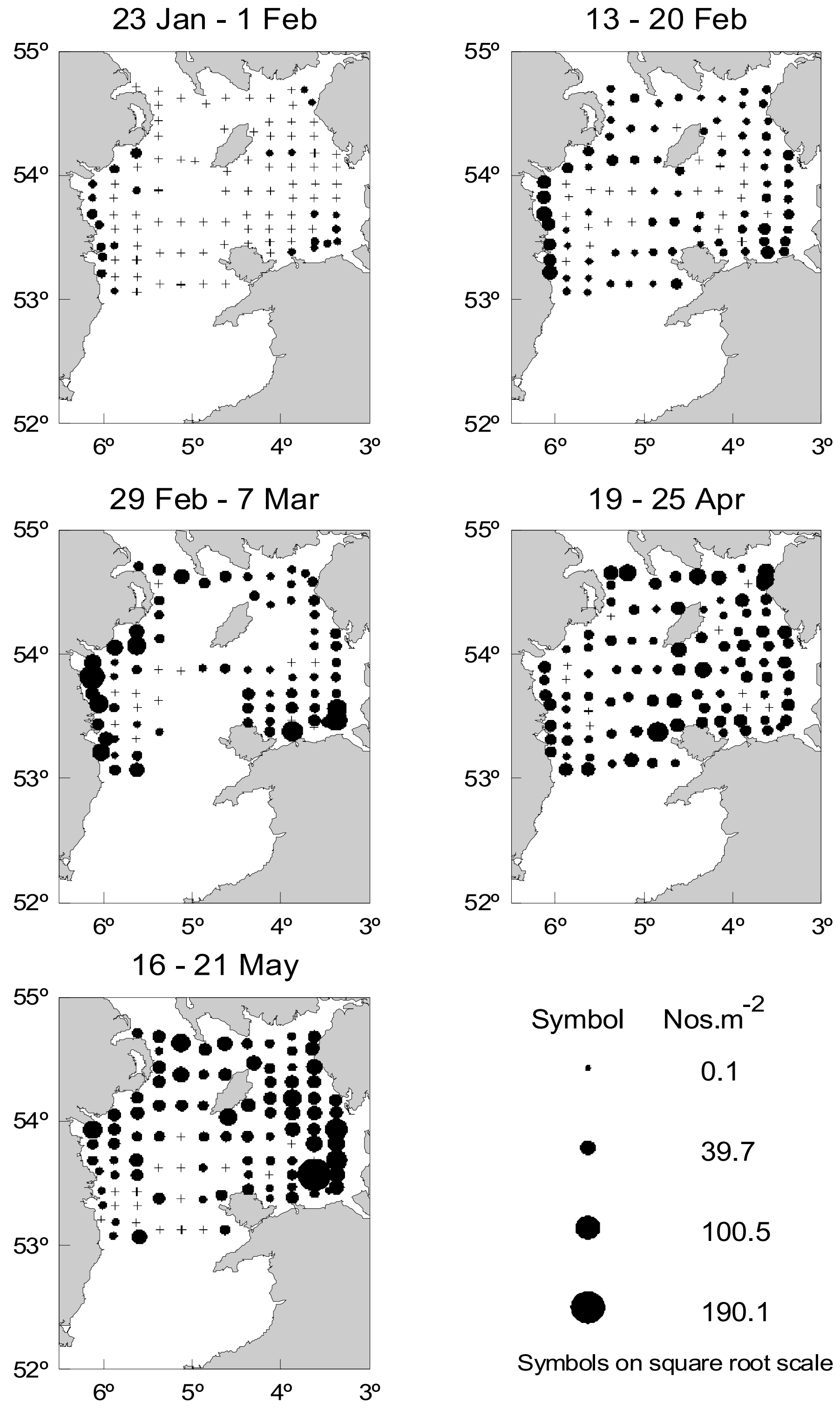


***Figure 5.10.5. Distribution (nos.m⁻²) of rockling eggs in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.10.6: Distribution of rockling larvae in the Irish Sea*

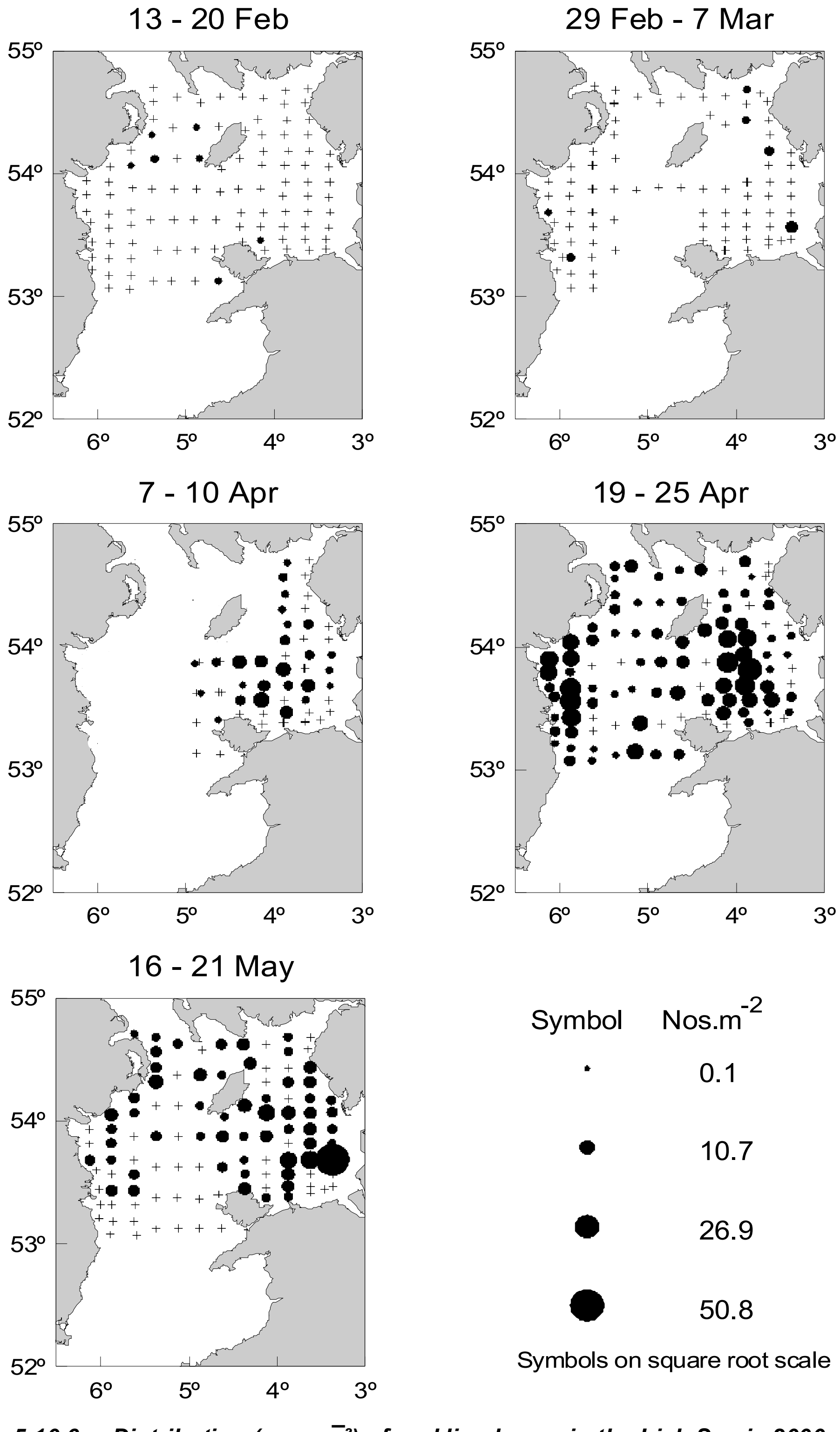


***Figure 5.10.6. Distribution (nos.m$^{-2}$) of rockling larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.10.7: Distribution of rockling eggs in the North Sea*

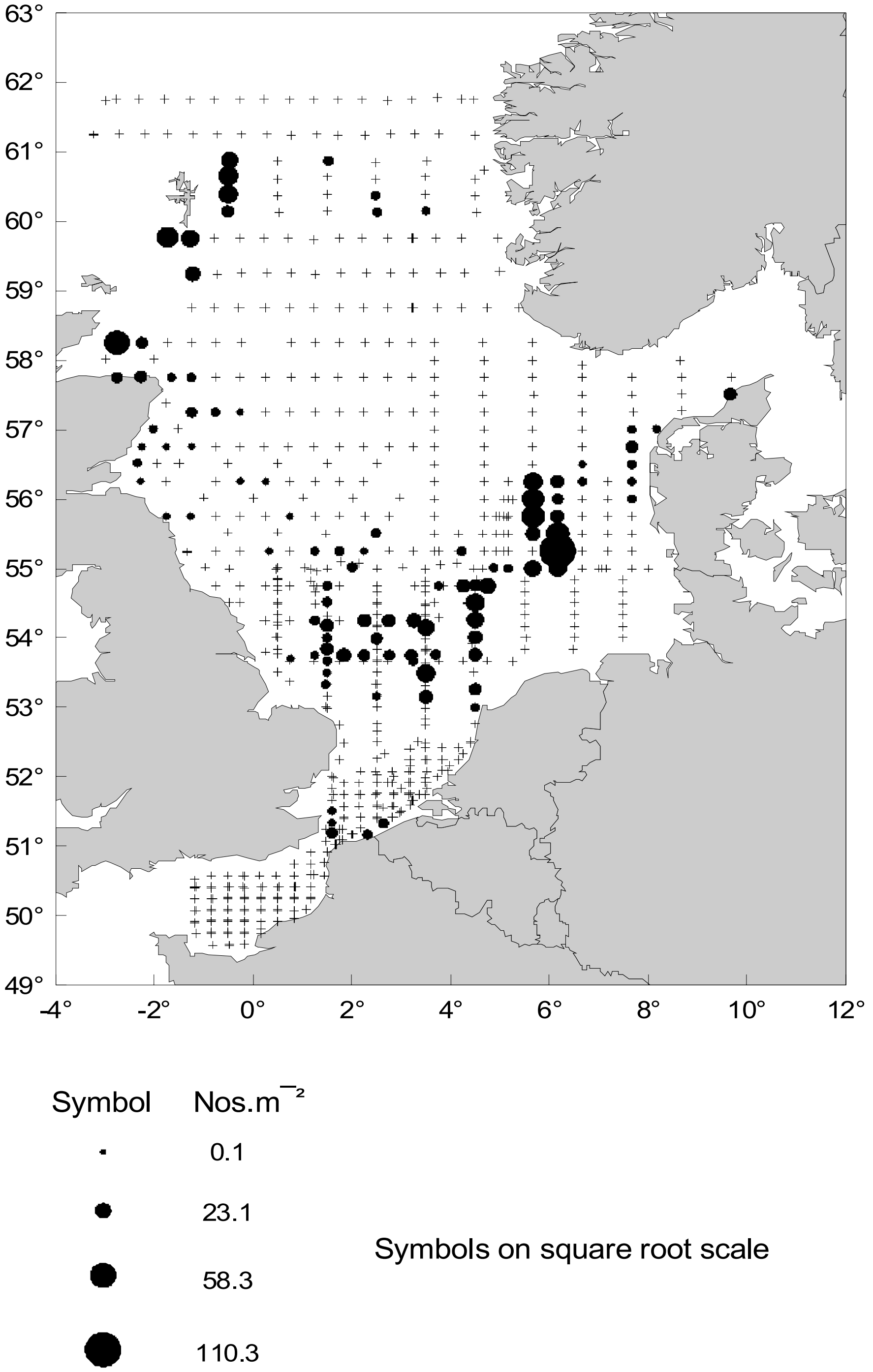


*Figure 5.10.7. Composite map of rockling egg distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

*Figure 5.10.8: Distribution of rockling larvae in the North Sea*

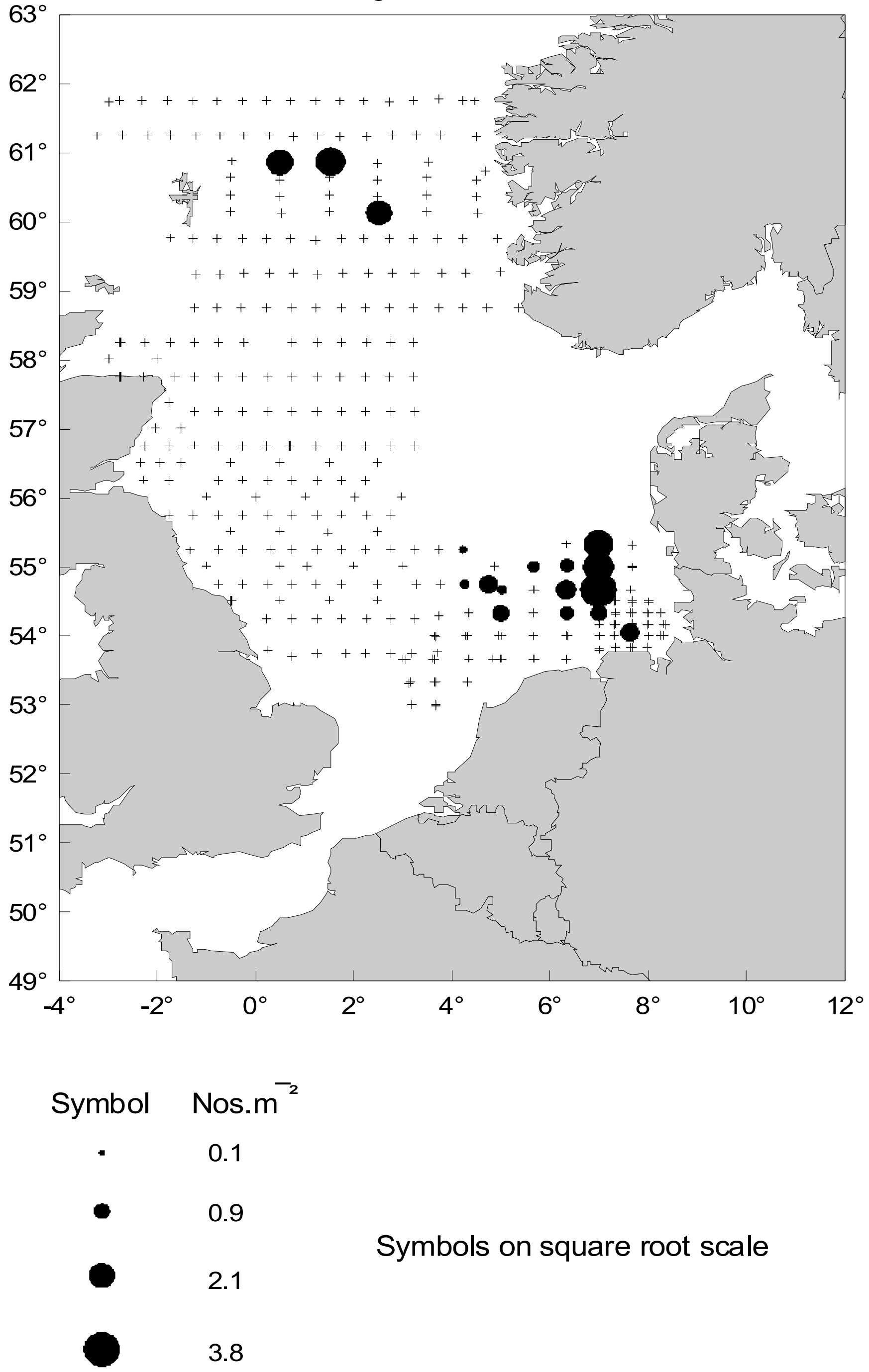


*Figure 5.10.8. Composite map of rockling larval distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

Figure 5.11.1: Occurrence of clingfish (Gobiesociformes) in Cefas trawl surveys

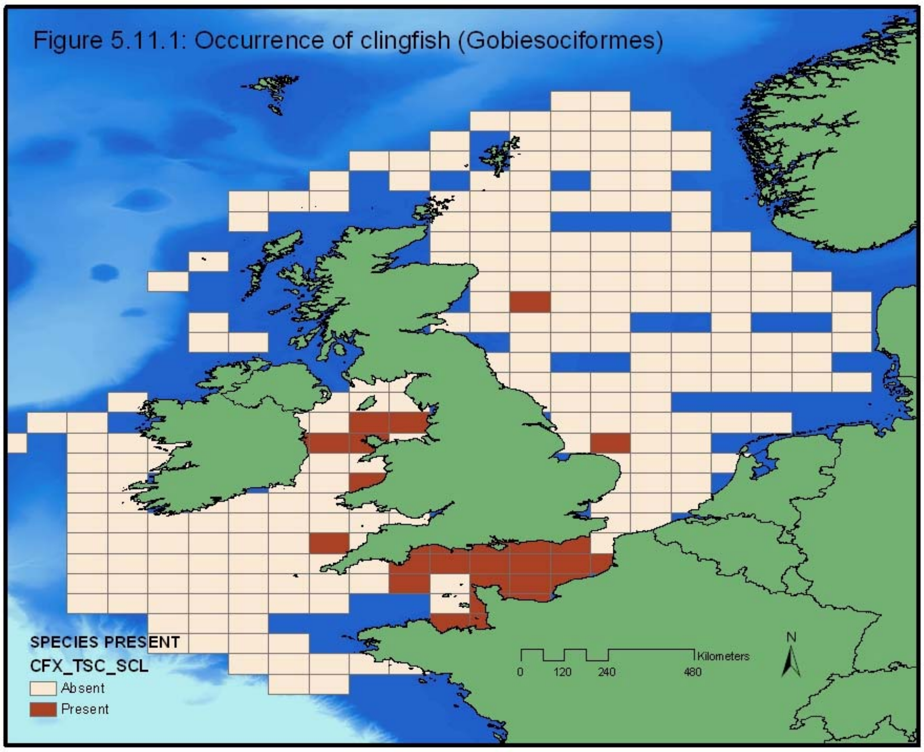


Figure 5.12.1: Occurrence of garfish in Cefas trawl surveys

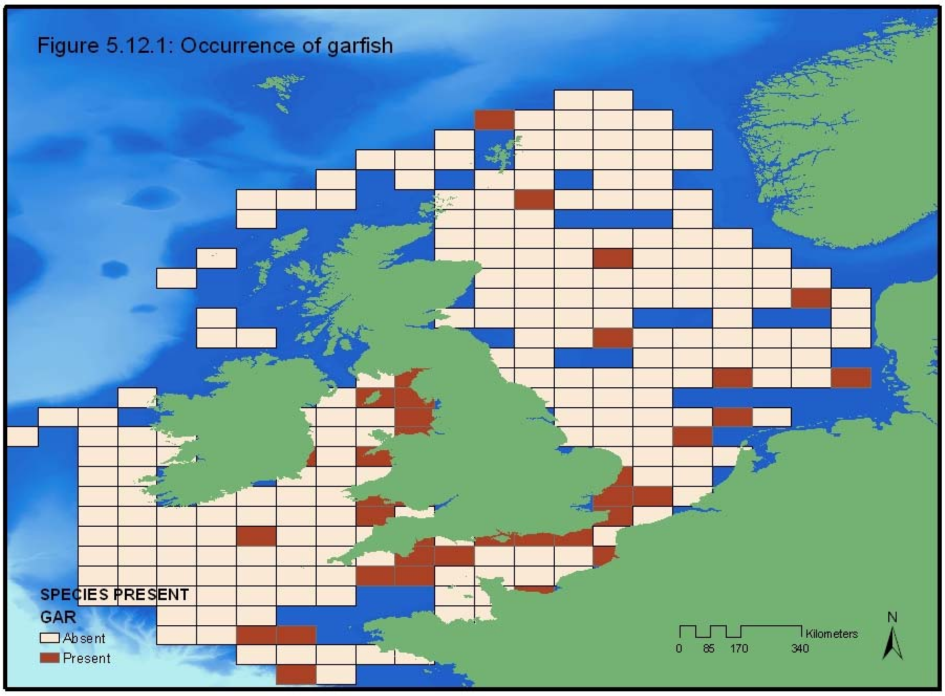

Figure 5.13.1: Occurrence of John dory in Cefas trawl surveys

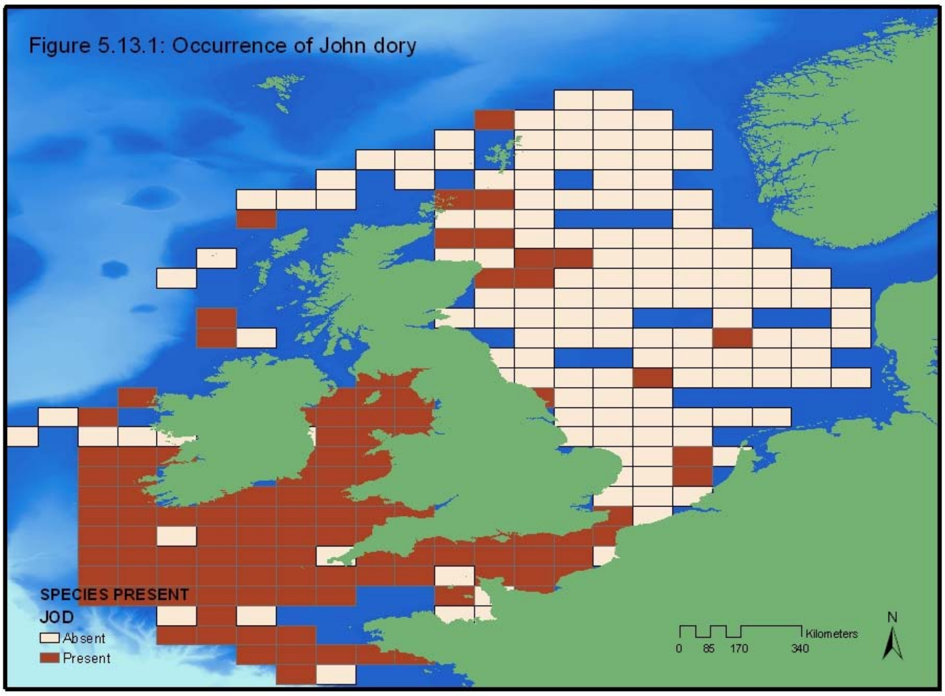


Figure 5.13.2: Occurrence of boarfish in Cefas trawl surveys

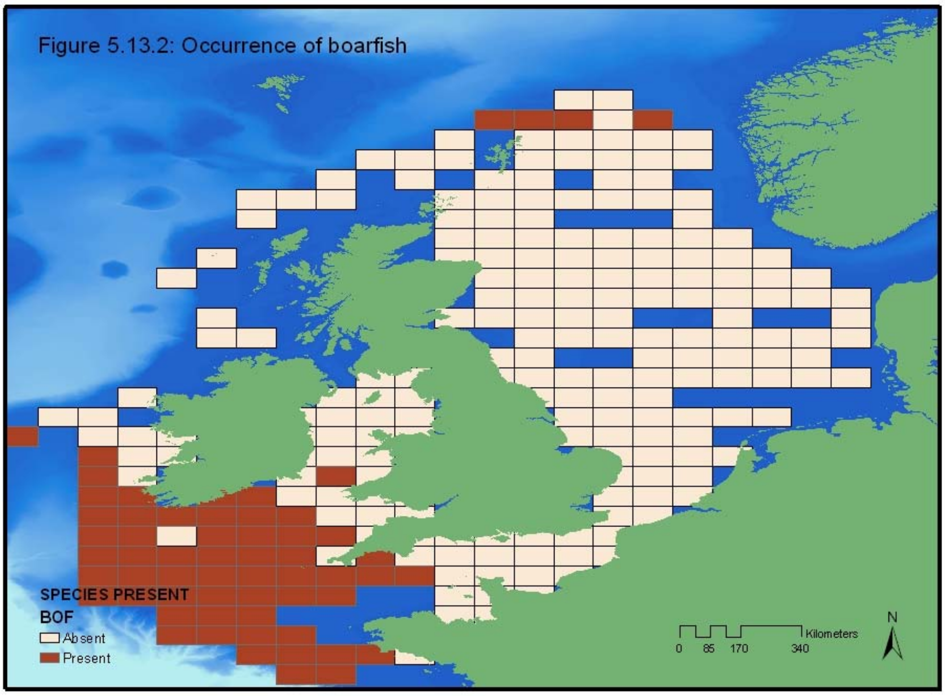

Figure 5.14.1: Occurrence of greater pipefish in Cefas trawl surveys

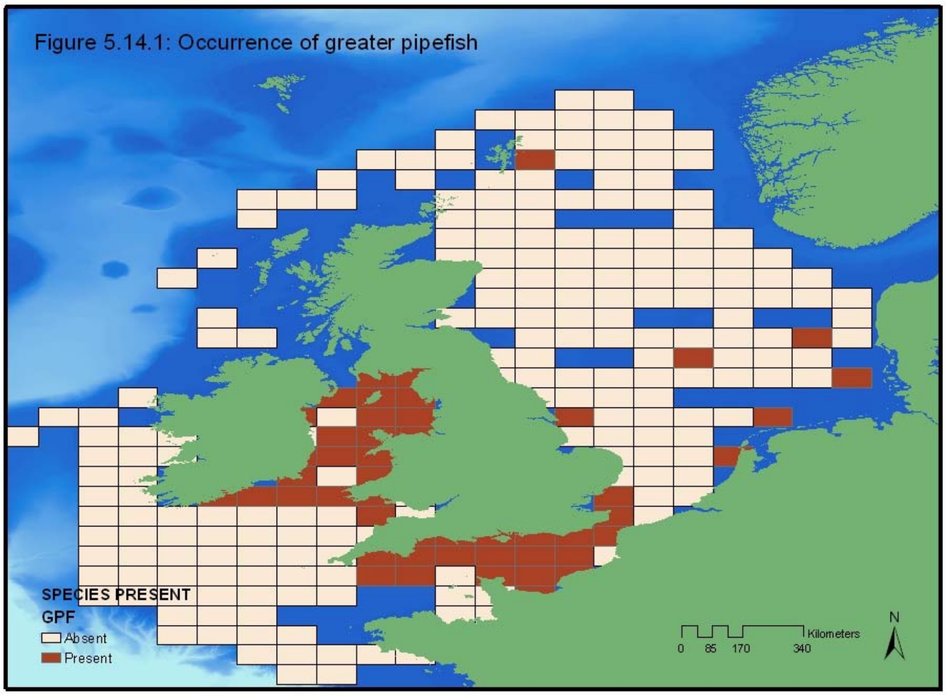


Figure 5.14.2: Occurrence of snake pipefish in Cefas trawl surveys

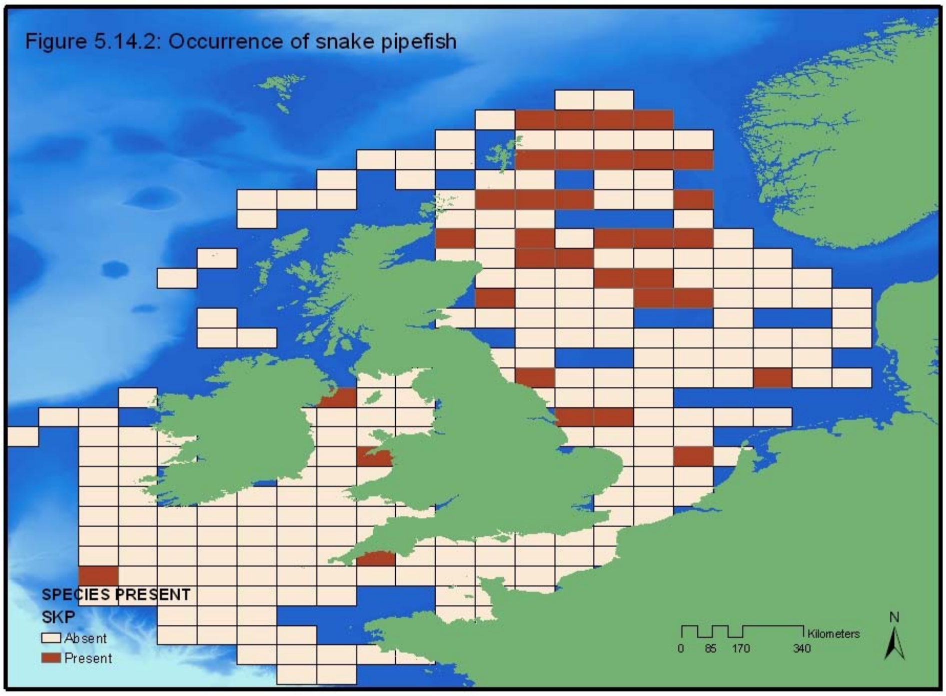

Figure 5.15.1: Occurrence of red gurnard in Cefas trawl surveys

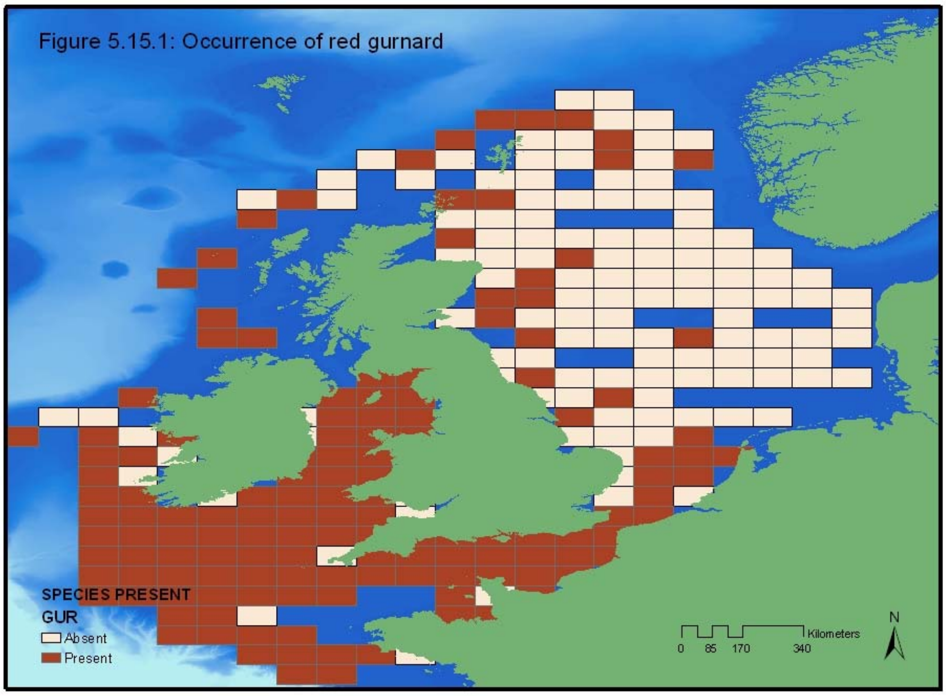


Figure 5.15.2: Occurrence of grey gurnard in Cefas trawl surveys

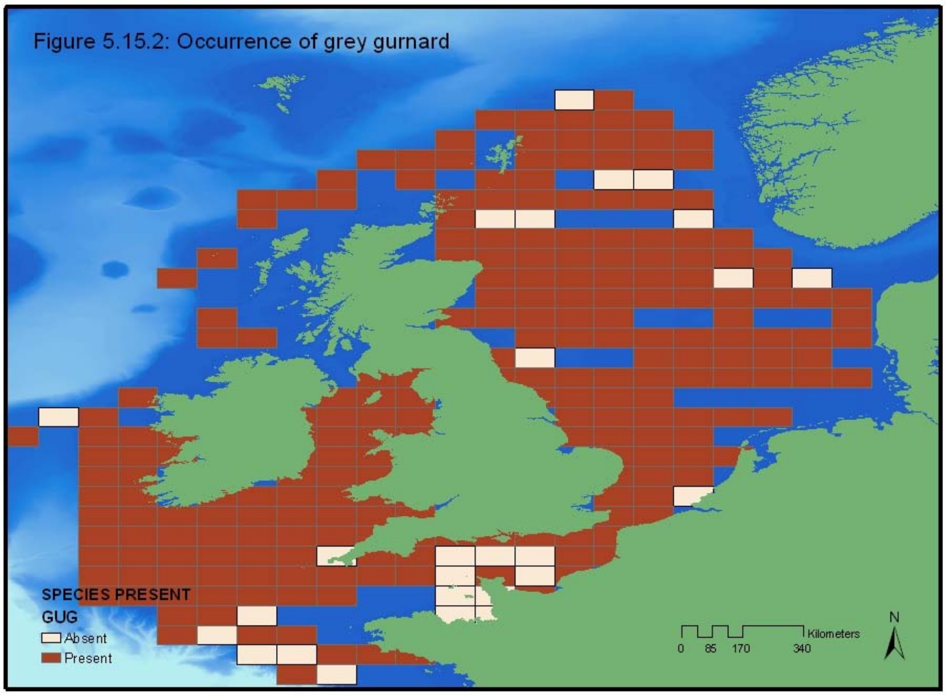

Figure 5.15.3: Occurrence of tub gurnard in Cefas trawl surveys

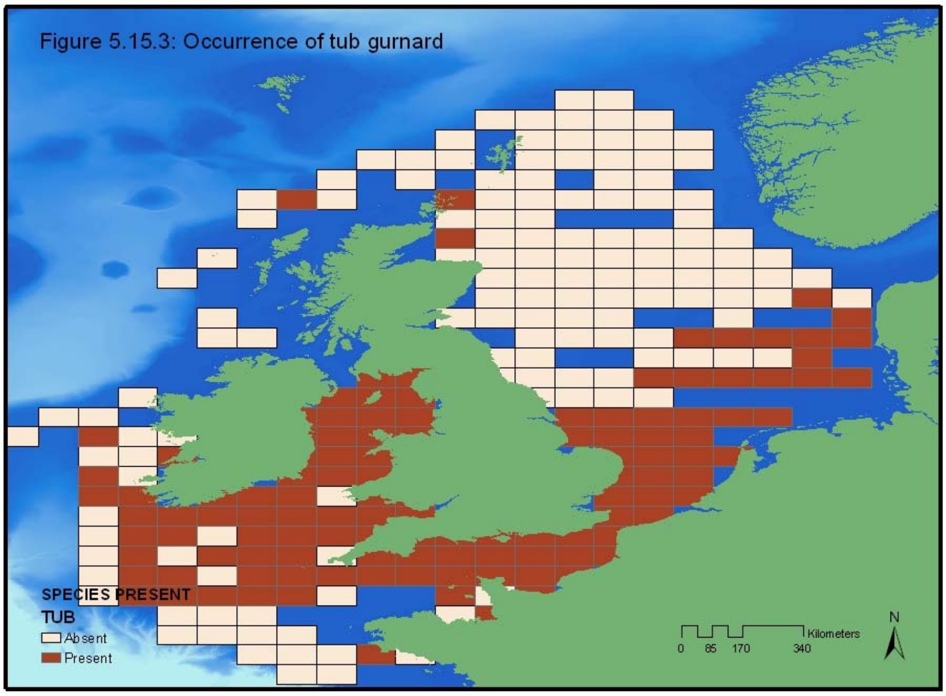


Figure 5.15.4: Occurrence of streaked gurnard in Cefas trawl surveys

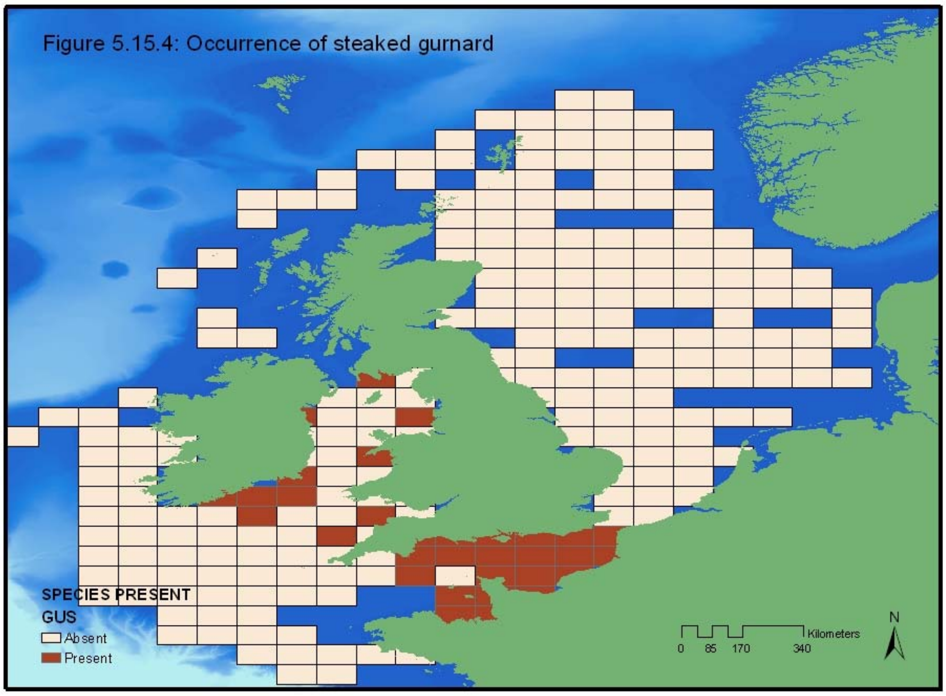

*Figure 5.15.5: Distribution of gurnard eggs in the Irish Sea*

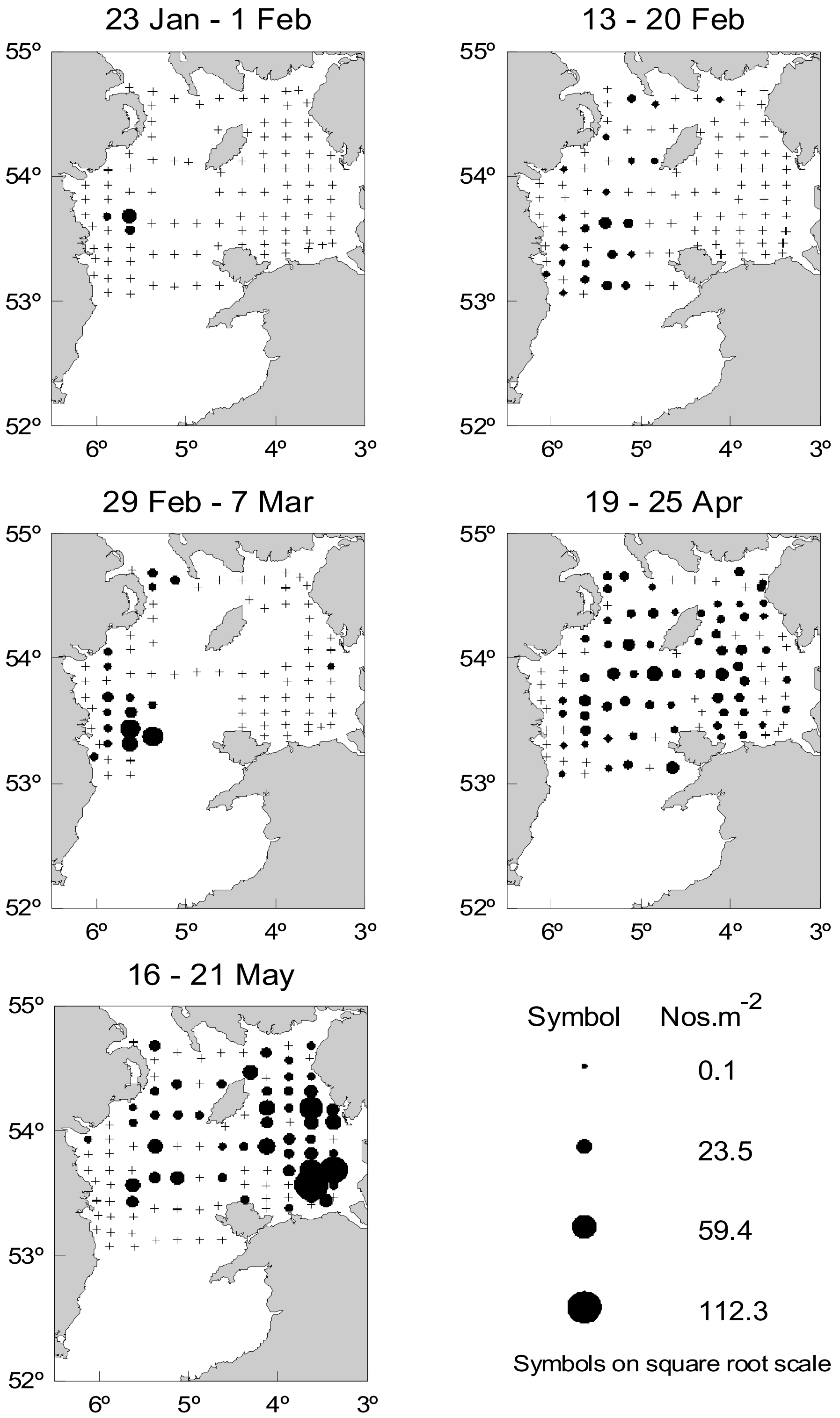


***Figure 5.15.5. Distribution (nos.m$^{-2}$) of gurnard eggs in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.15.6: Distribution of gurnard eggs in the North Sea*

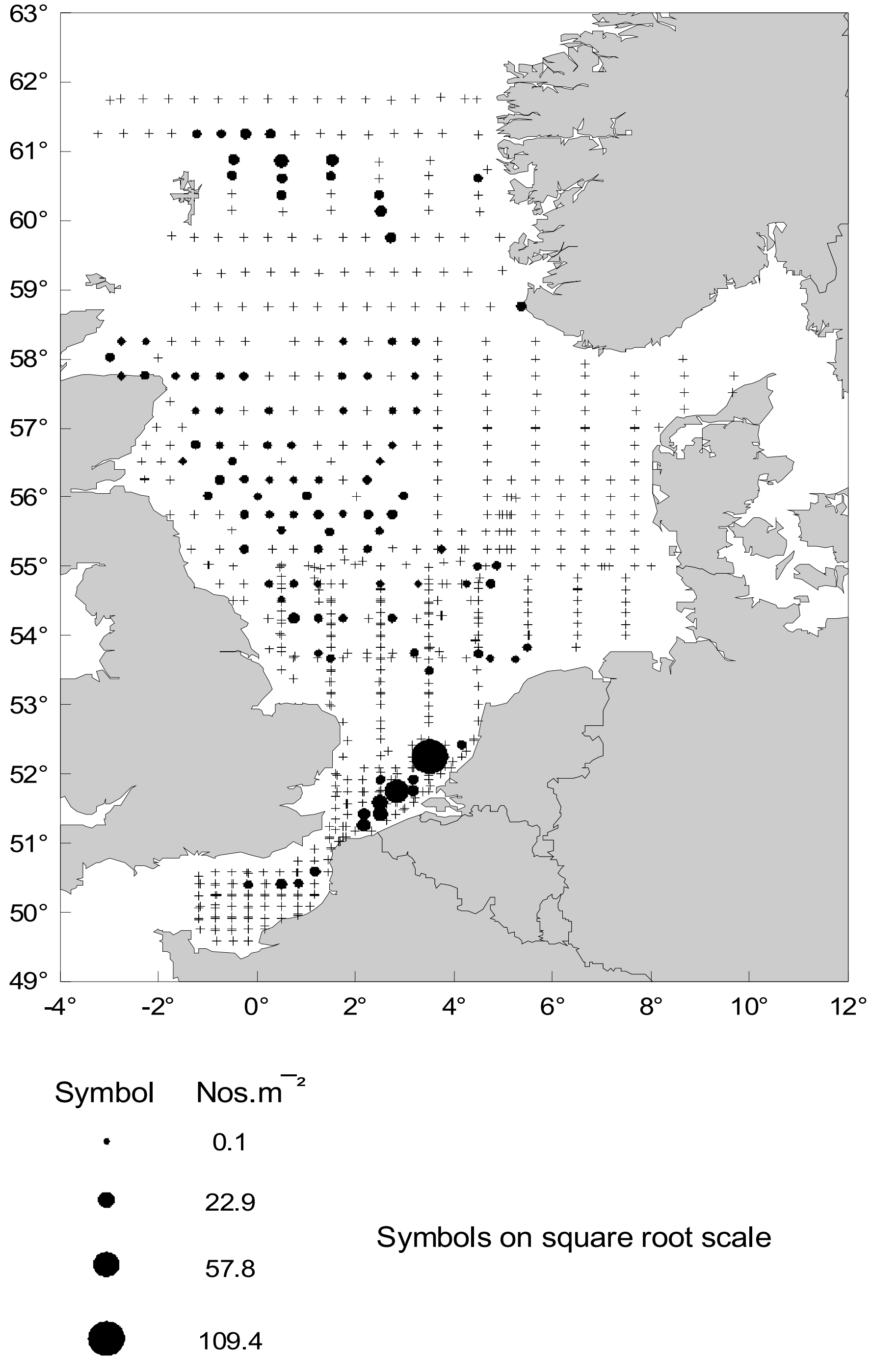


*Figure 5.15.6. Composite map of gurnard egg distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

Figure 5.16.1: Occurrence of bullrout in Cefas trawl surveys

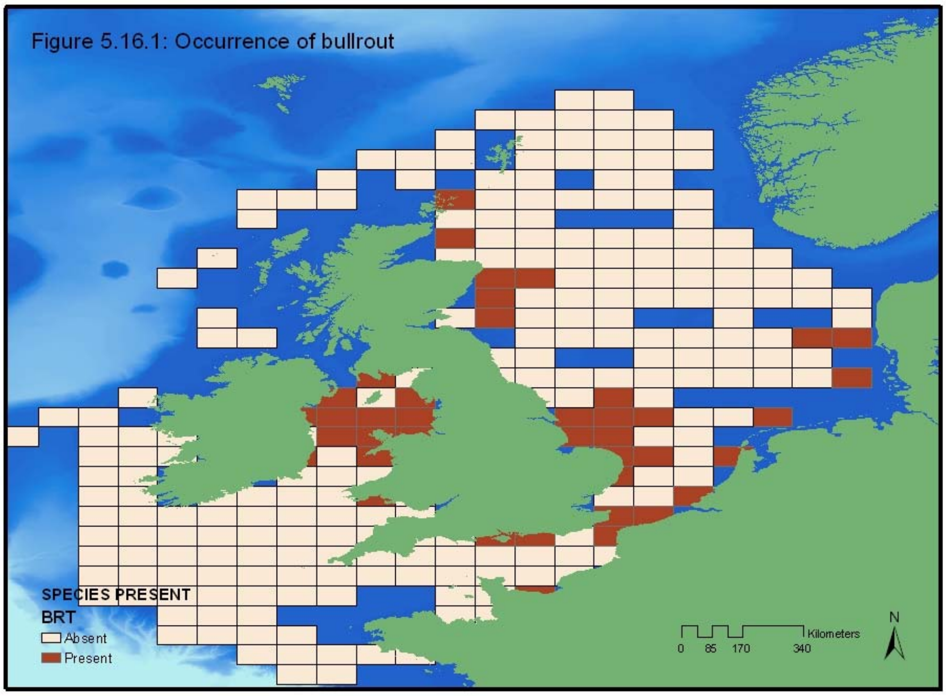


Figure 5.16.2: Occurrence of sea-scorpion in Cefas trawl surveys

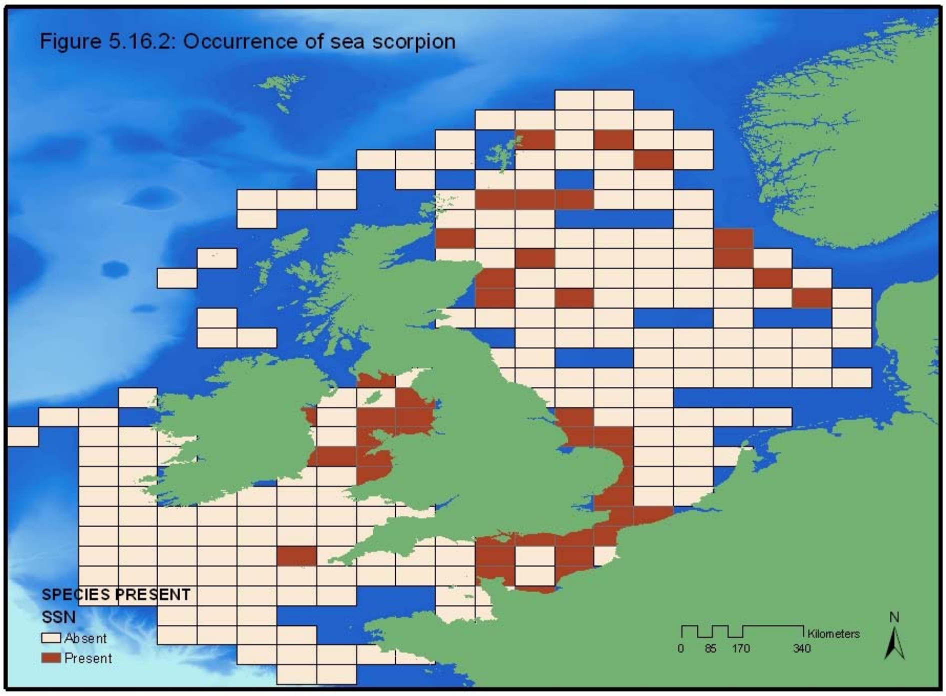

Figure 5.16.3: Occurrence of pogge in Cefas trawl surveys

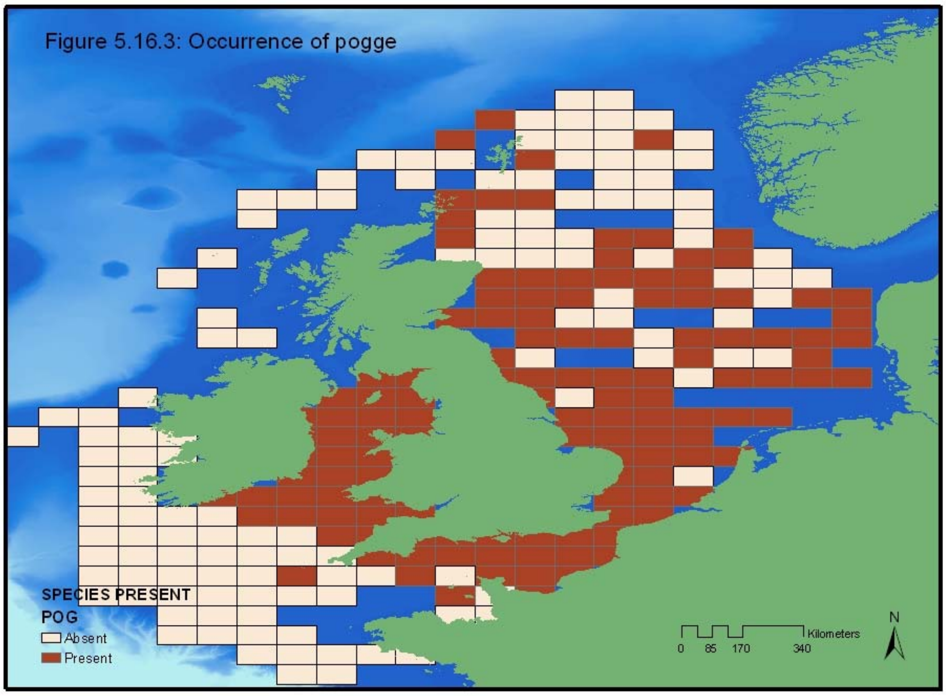

*Figure 5.16.4: Distribution of cottid larvae in the Irish Sea*

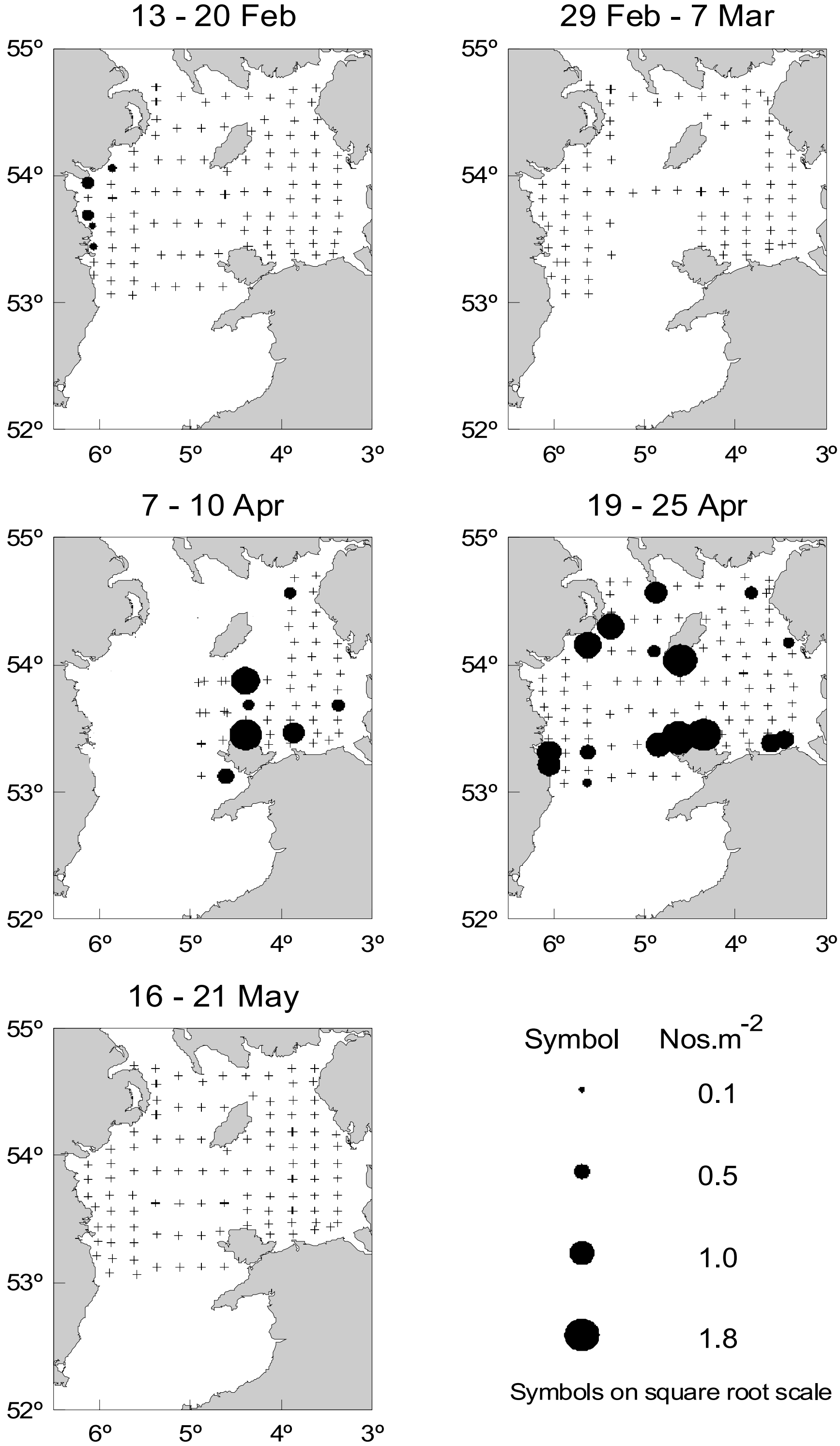


***Figure 5.16.4. Distribution (nos.m⁻²) of Cottidae larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.16.5: Distribution of cottid larvae in the North Sea*

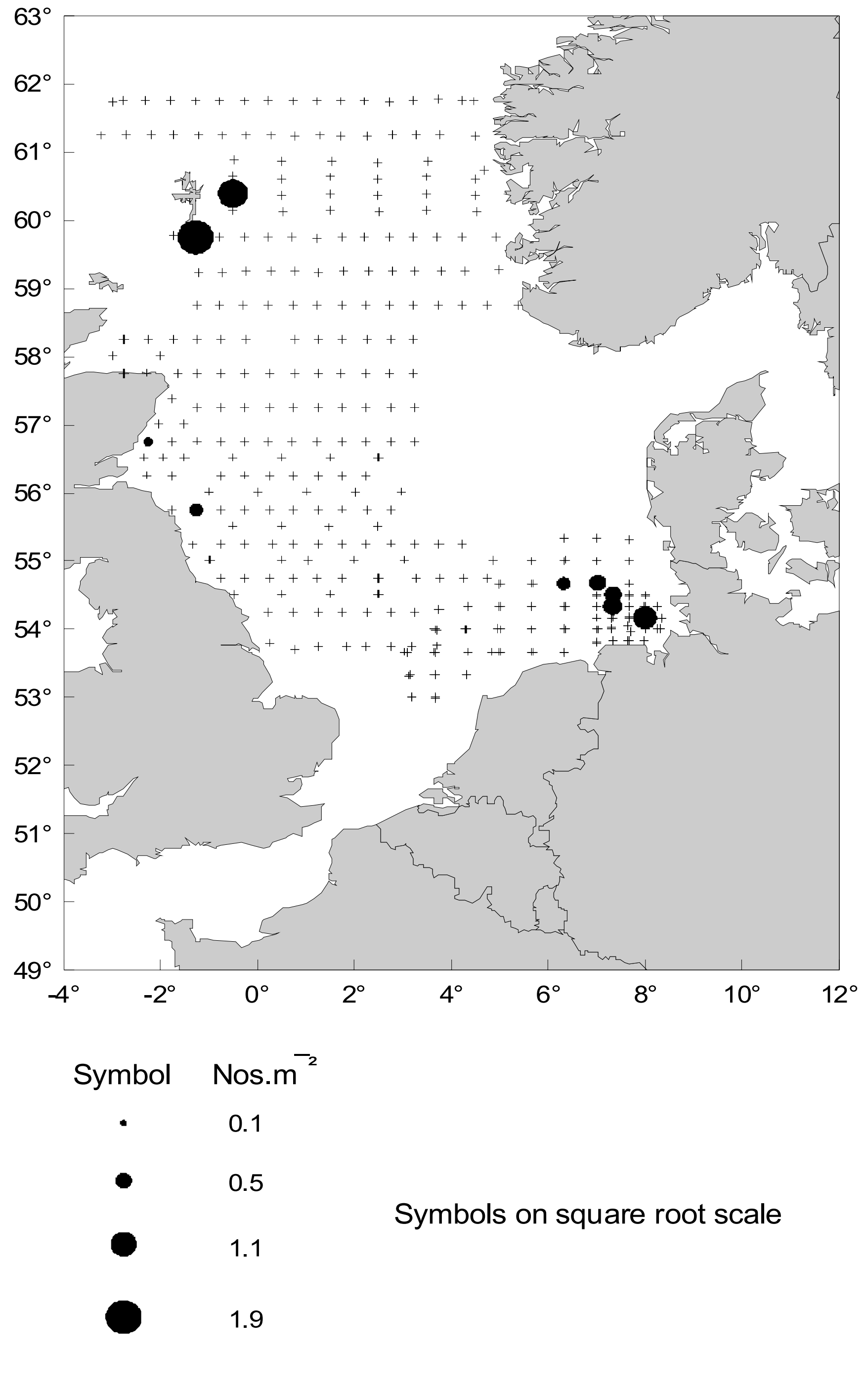


*Figure 5.16.5. Composite map of Cottidae larval distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

*Figure 5.16.6: Distribution of pogge larvae in the Irish Sea*

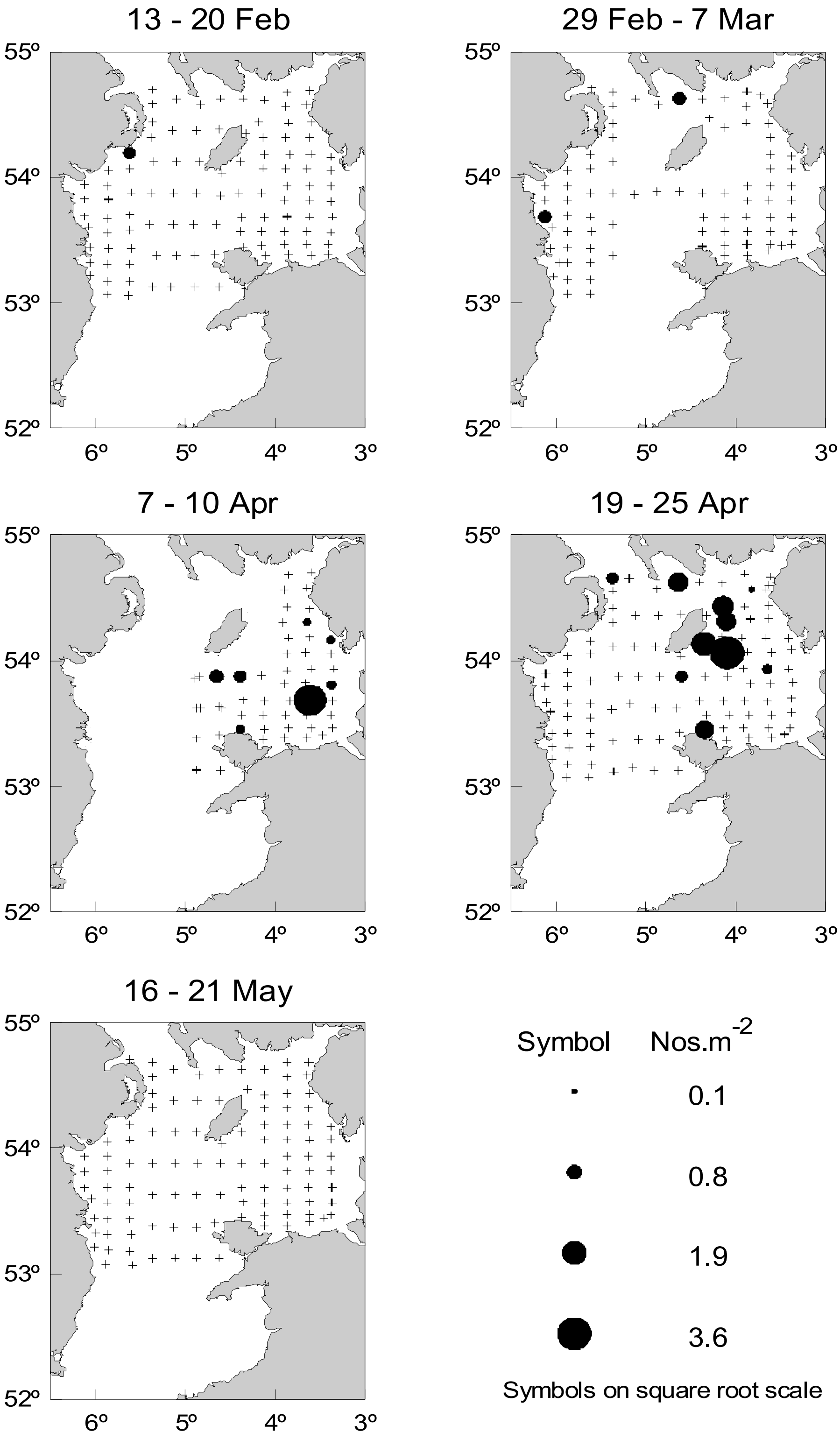


***Figure 5.16.6. Distribution (nos.m⁻²) of pogge larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.16.7: Distribution of pogge larvae in the North Sea*

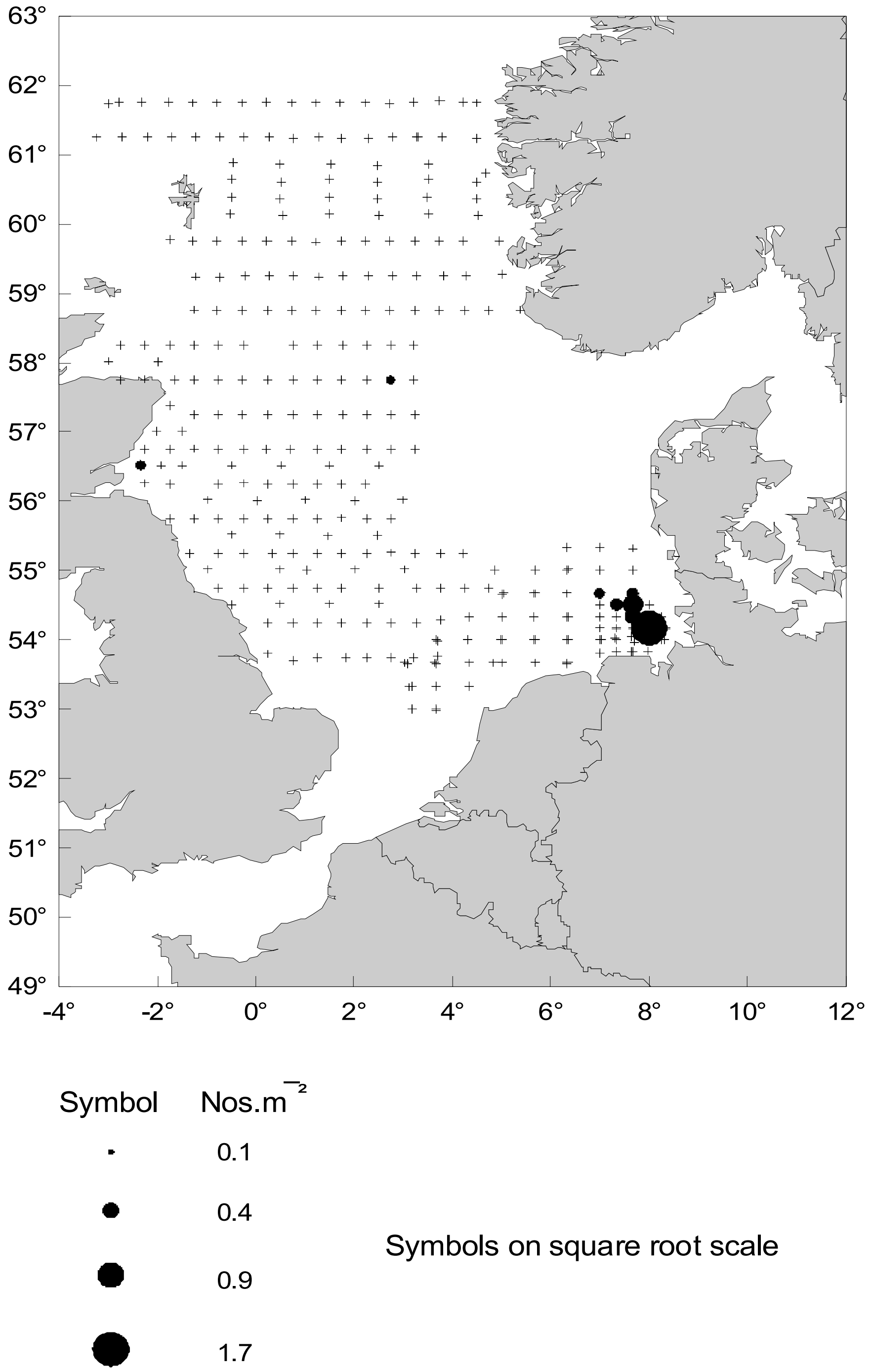


*Figure 5.16.7. Composite map of pogge larval distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

Figure 5.17.1: Occurrence of lumpsucker in Cefas trawl surveys

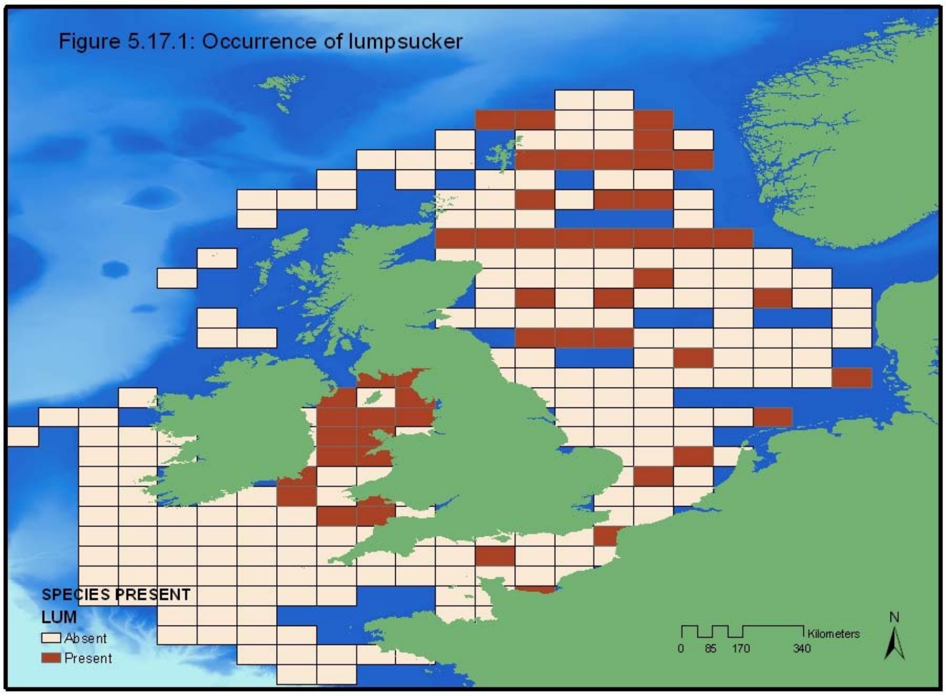


Figure 5.17.2: Occurrence of sea snails (Liparis sp.) in Cefas trawl surveys

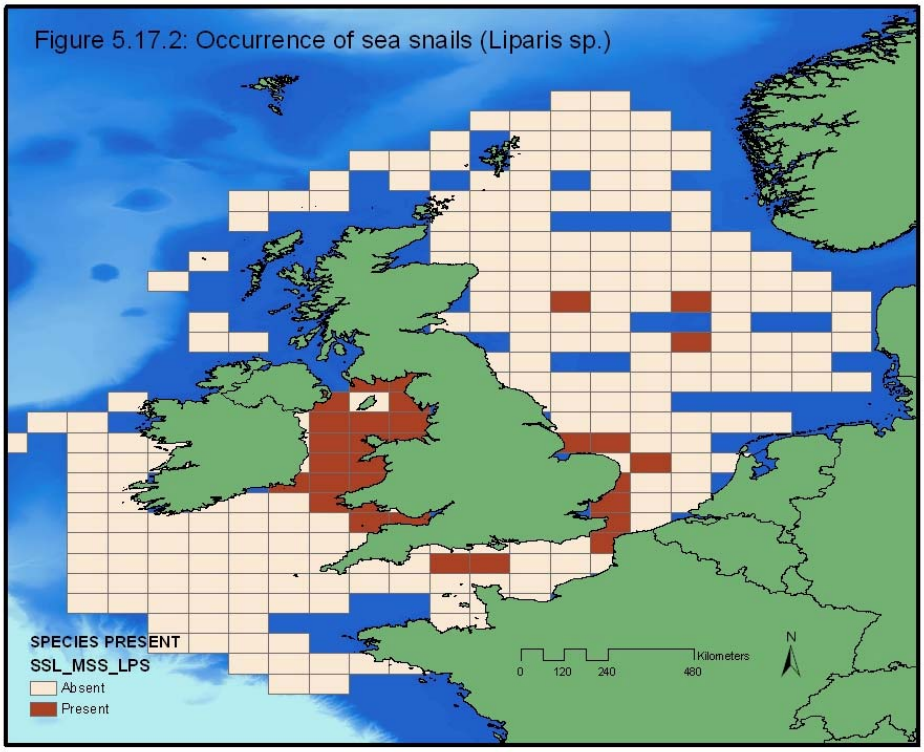

*Figure 5.17.3: Distribution of liparid larvae in the Irish Sea/North sea*

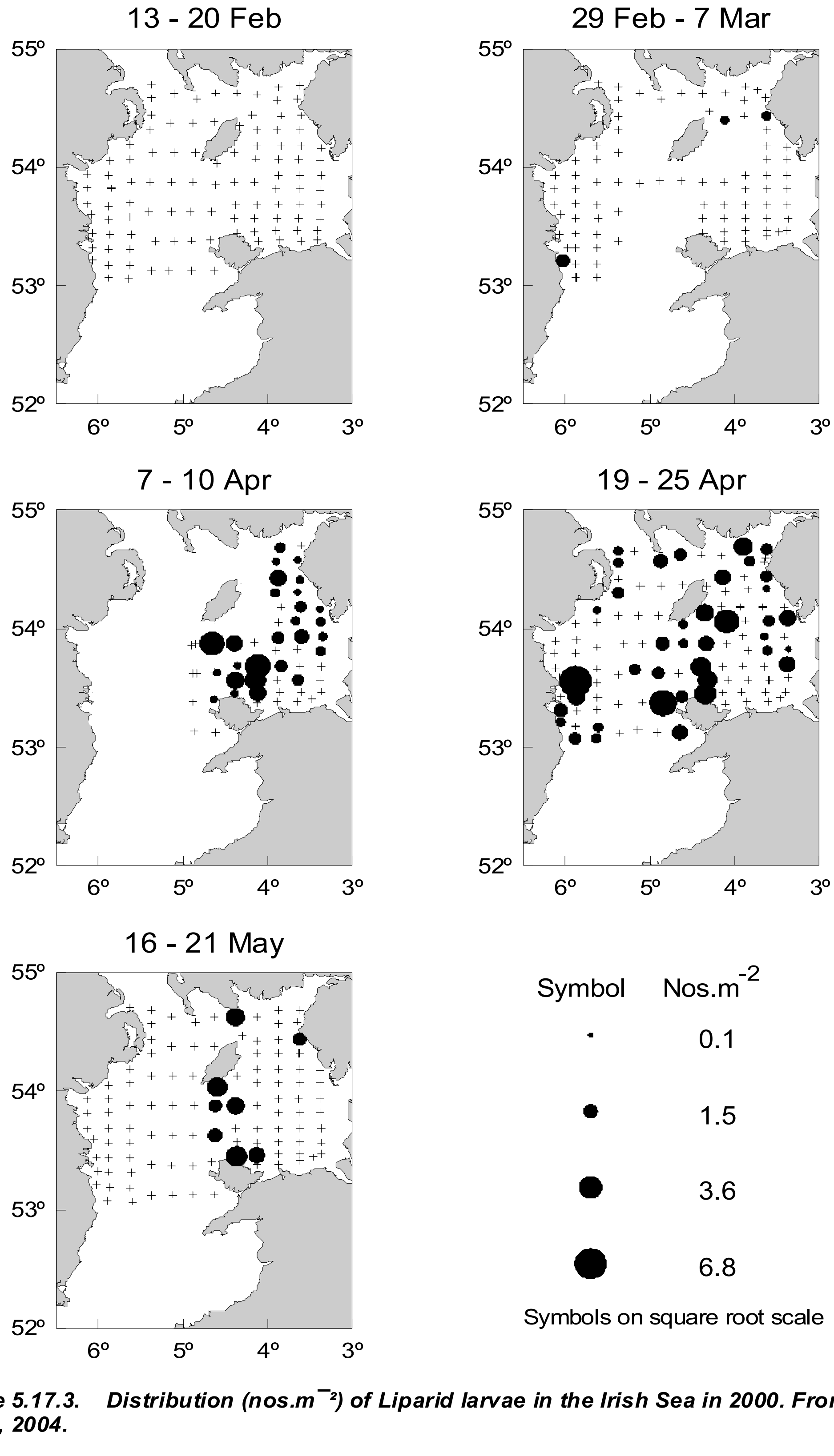


***Figure 5.17.3. Distribution (nos.m⁻²) of Liparid larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.17.4: Distribution of liparid larvae in the North Sea*

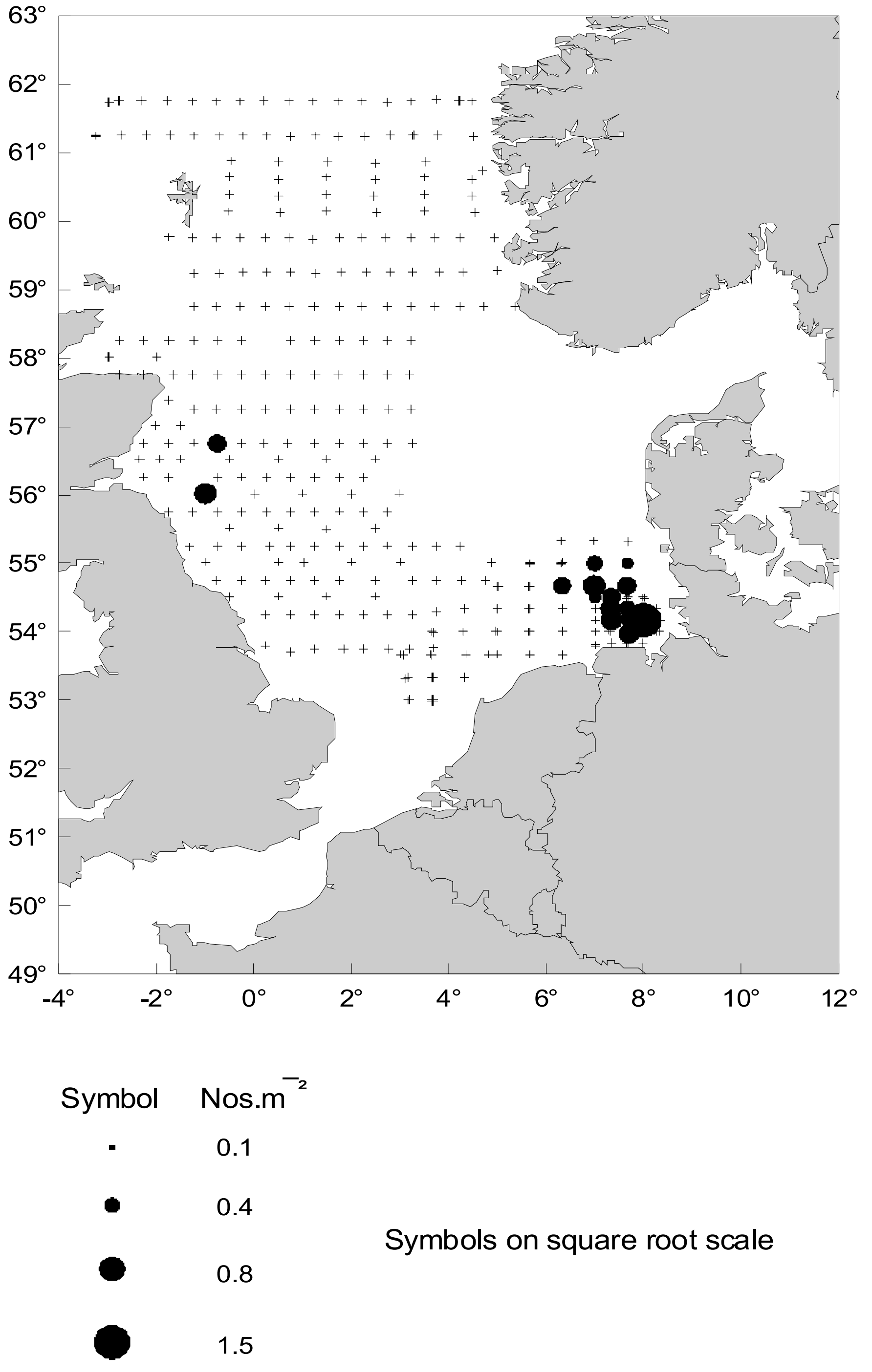


*Figure 5.17.4. Composite map of Liparid larval distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

Figure 5.18.1: Occurrence of bass in Cefas trawl surveys

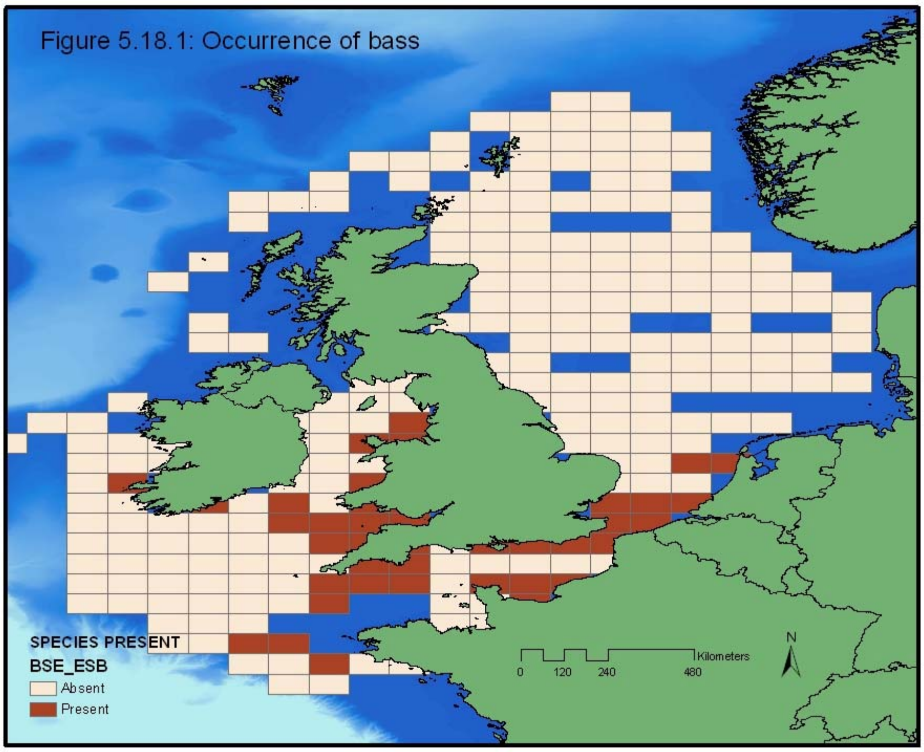


Figure 5.19.1: Occurrence of black sea bream in Cefas trawl surveys

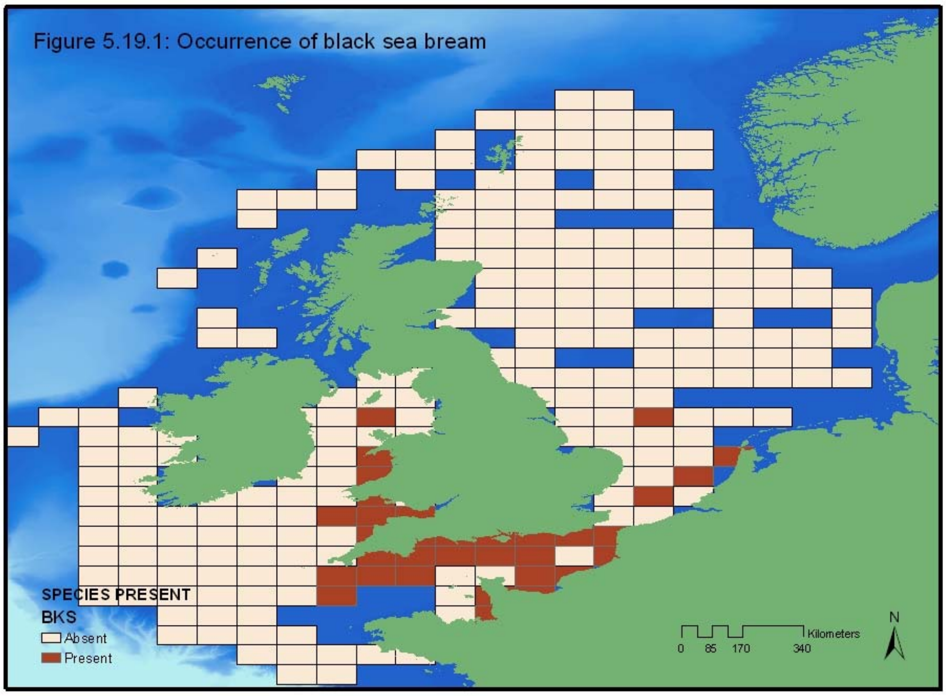

Figure 5.20.1: Occurrence of red mullet in Cefas trawl surveys

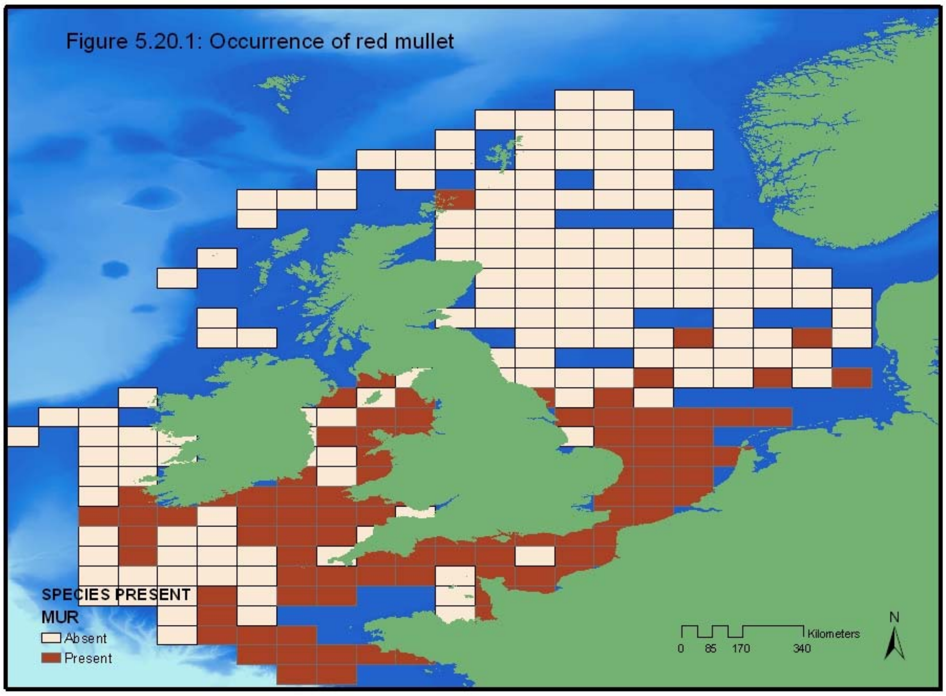


Figure 5.20.2: Occurrence of red band fish in Cefas trawl surveys

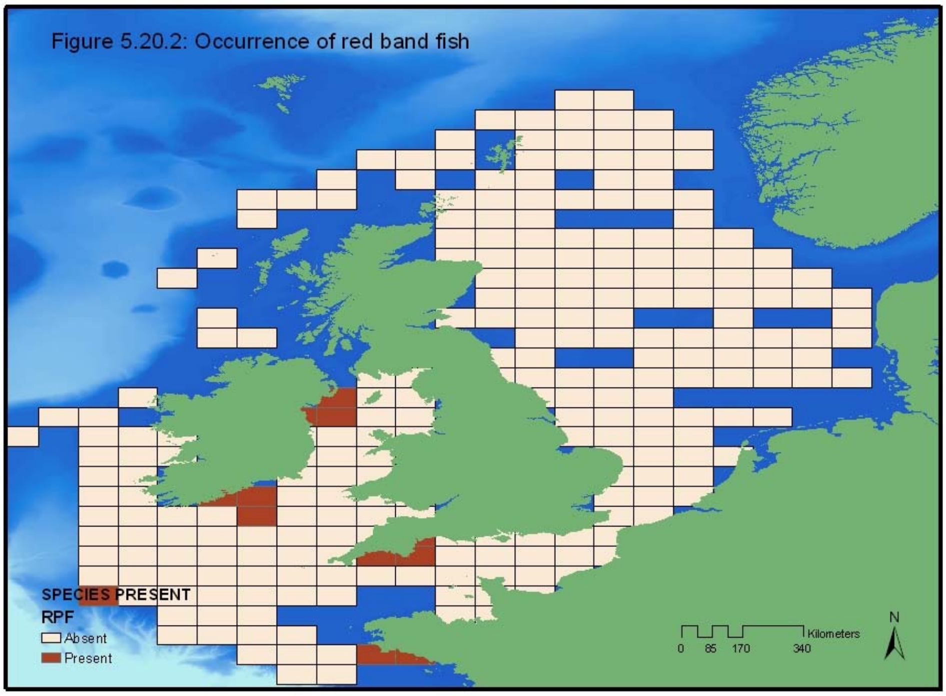

Figure 5.22.1: Occurrence of goldsinny wrasse in Cefas trawl surveys

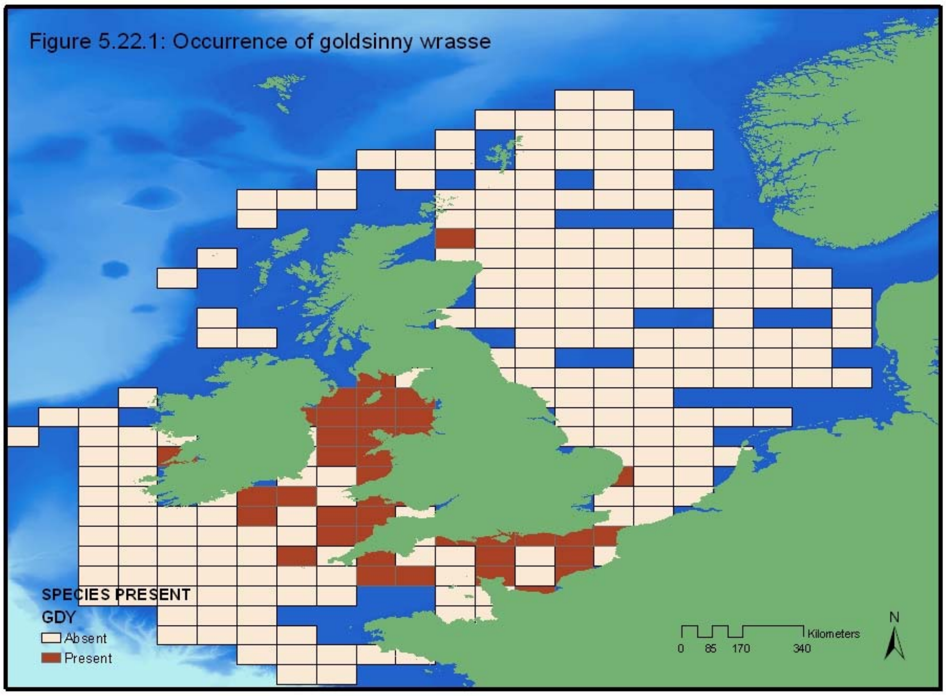


Figure 5.22.2: Occurrence of corkwing wrasse in Cefas trawl surveys

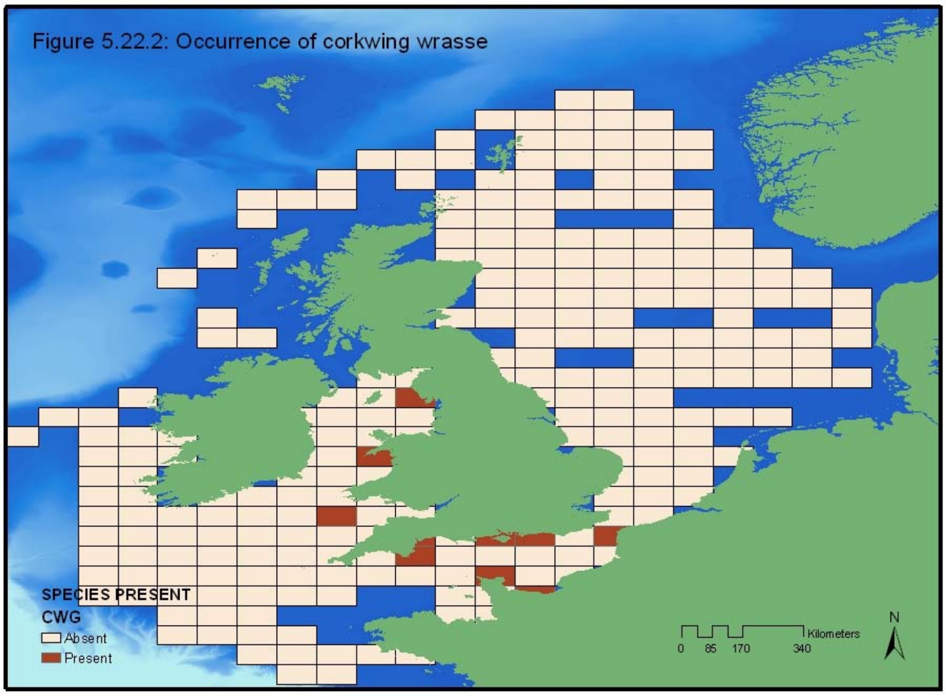

Figure 5.22.3: Occurrence of cuckoo wrasse in Cefas trawl surveys

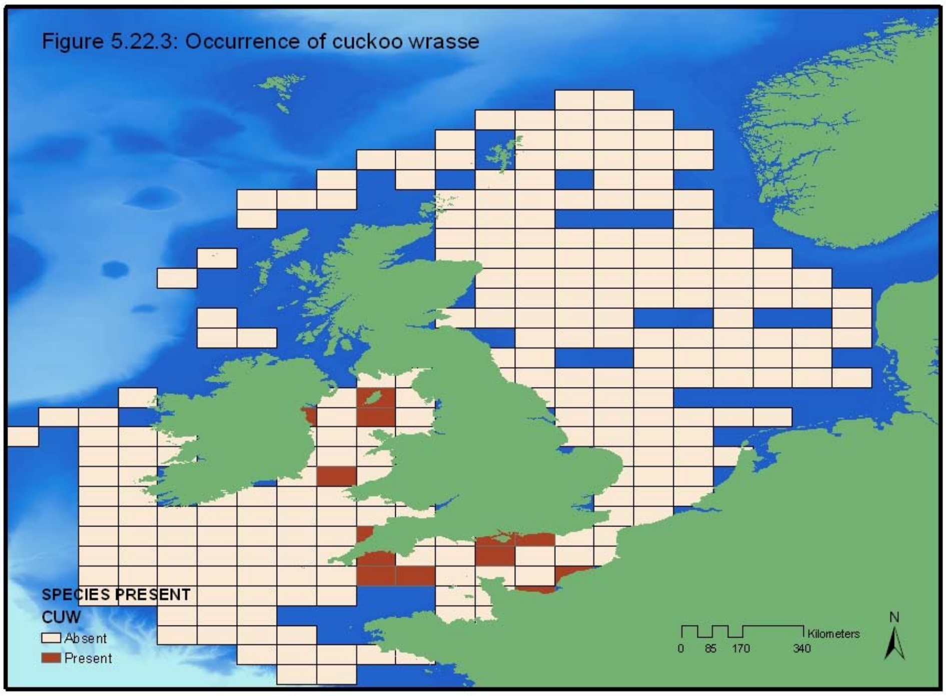


Figure 5.22.4: Occurrence of ballans wrasse in Cefas trawl surveys

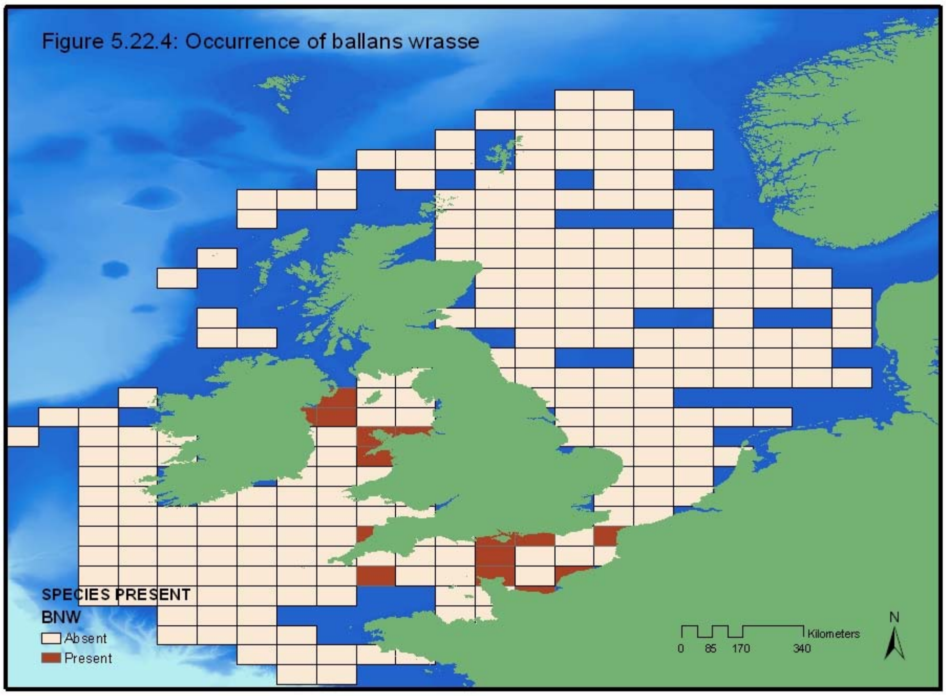

Figure 5.22.5: Occurrence of Baillion's wrasse in Cefas trawl surveys

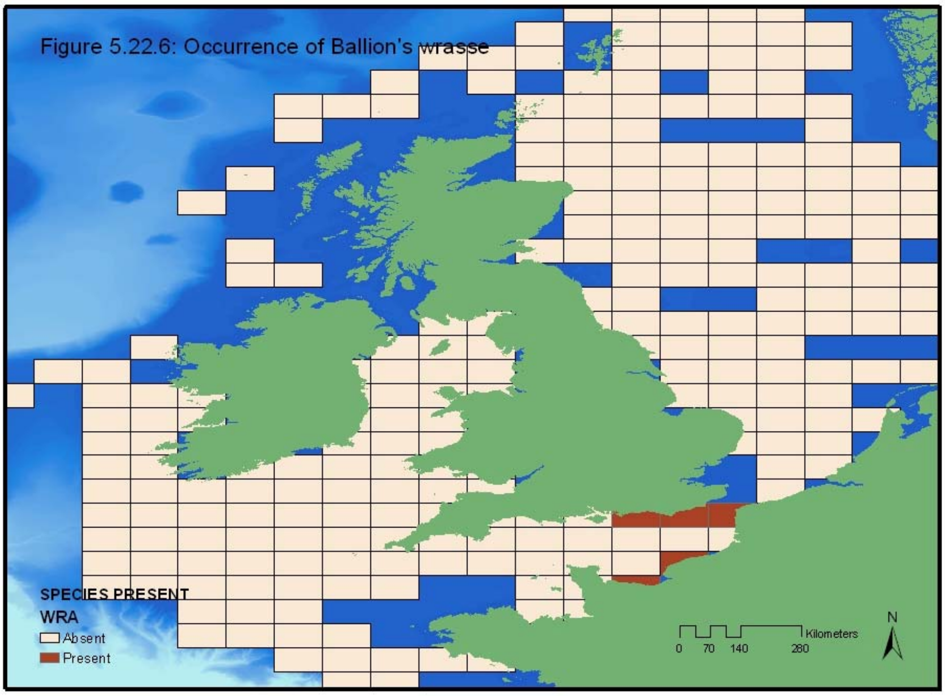


Figure 5.23.1: Occurrence of Eelpouts, snake blennies and butterfish

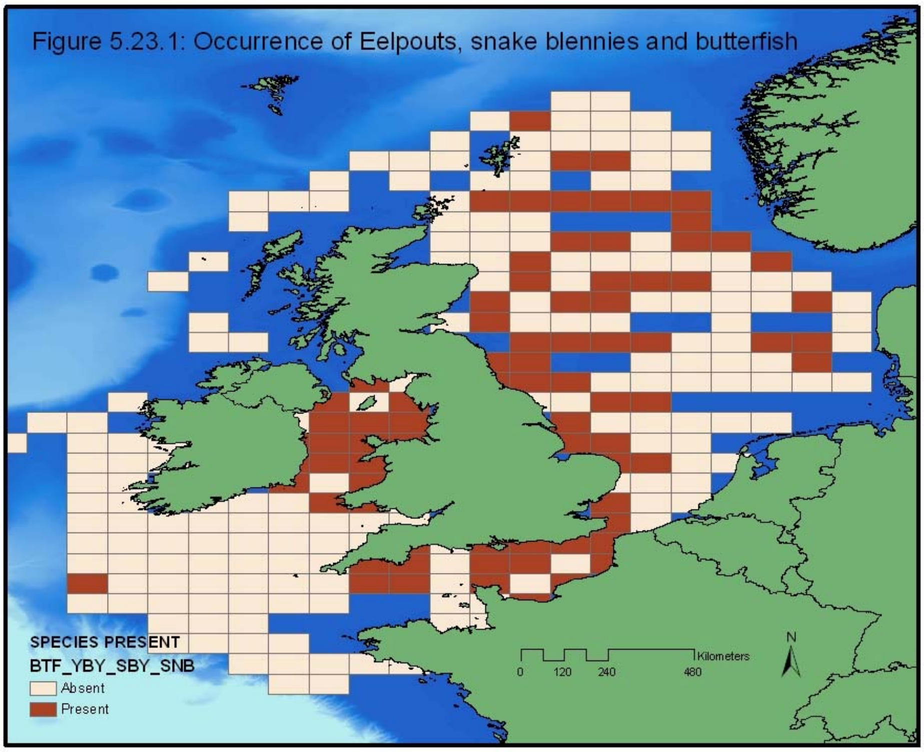

*Figure 5.23.2: Distribution of Yarrell's blenny larvae in the Irish Sea*

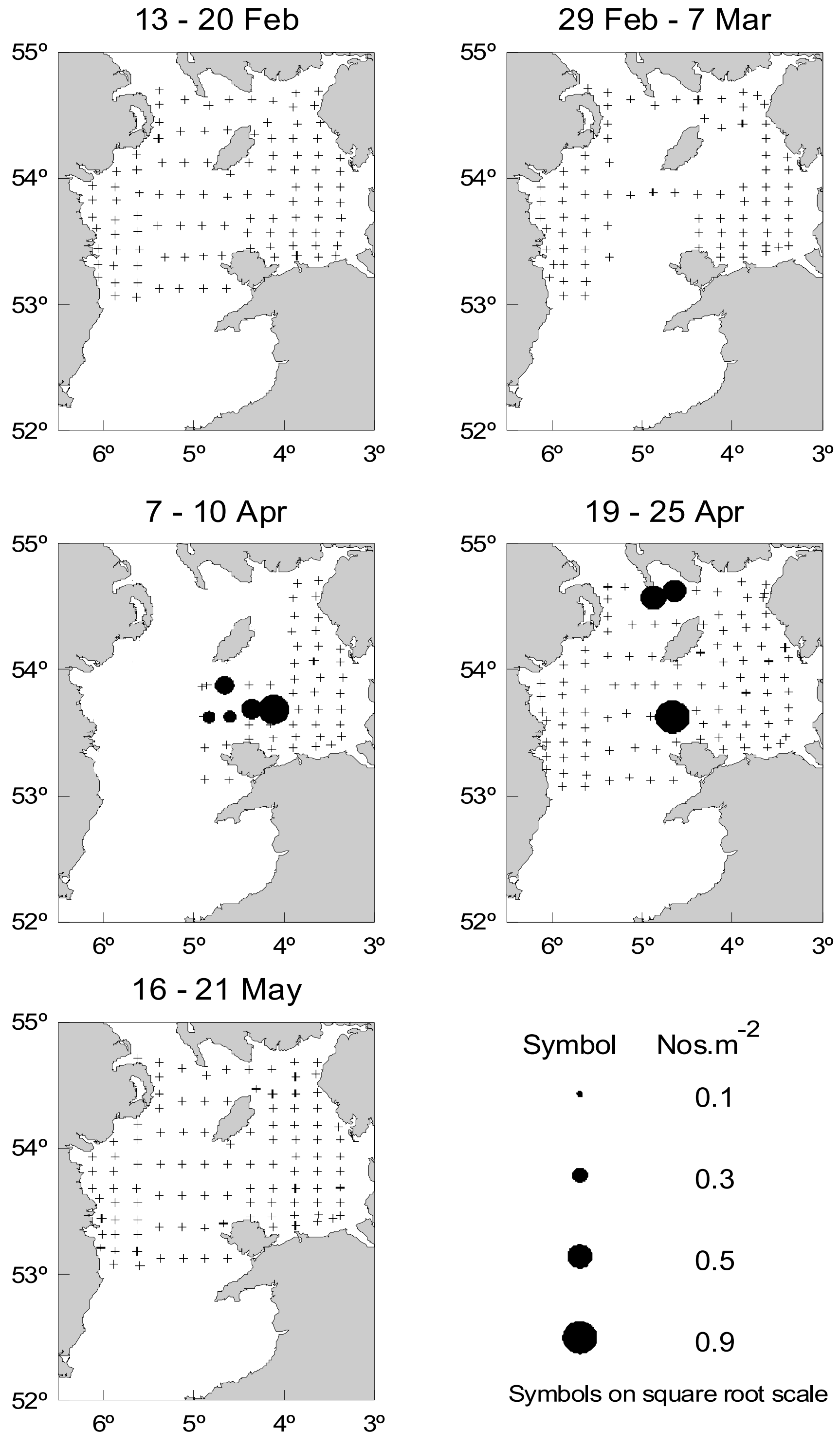


***Figure 5.23.2. Distribution (nos.m$^{-2}$) of Yarrell's blenny larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.23.3: Distribution of butterfish larvae in the Irish Sea*

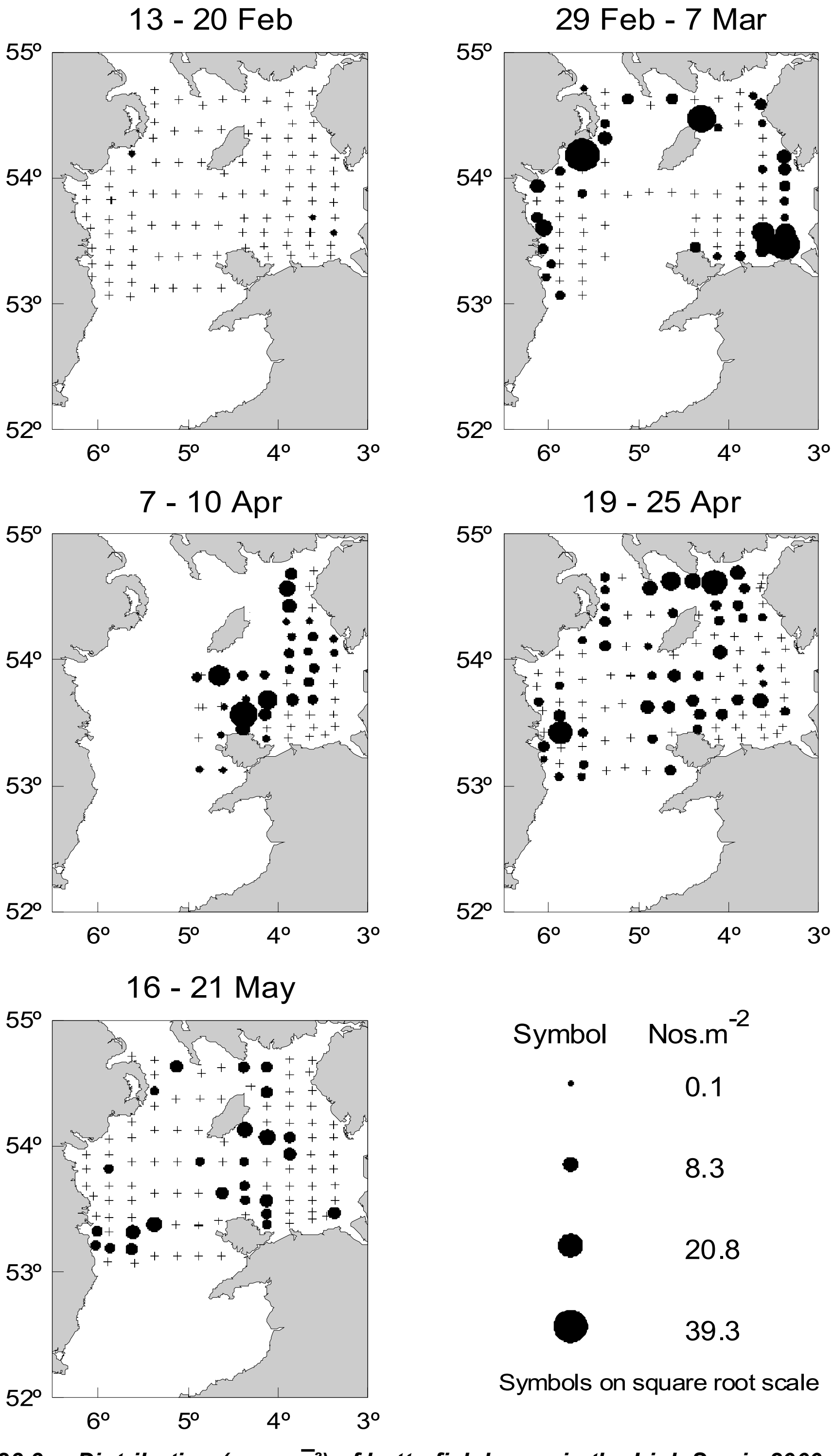


***Figure 5.23.3. Distribution (nos.m$^{-2}$) of butterfish larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

Figure 5.24.1: Occurrence of wolf-fish in Cefas trawl surveys

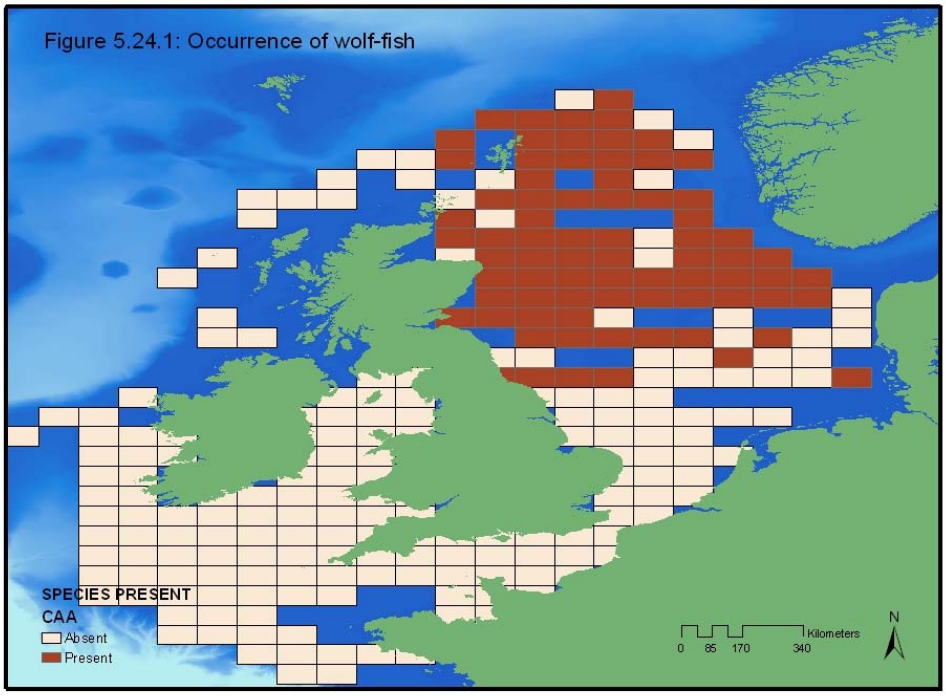


Figure 5.25.1: Occurrence of lesser weever in Cefas trawl surveys

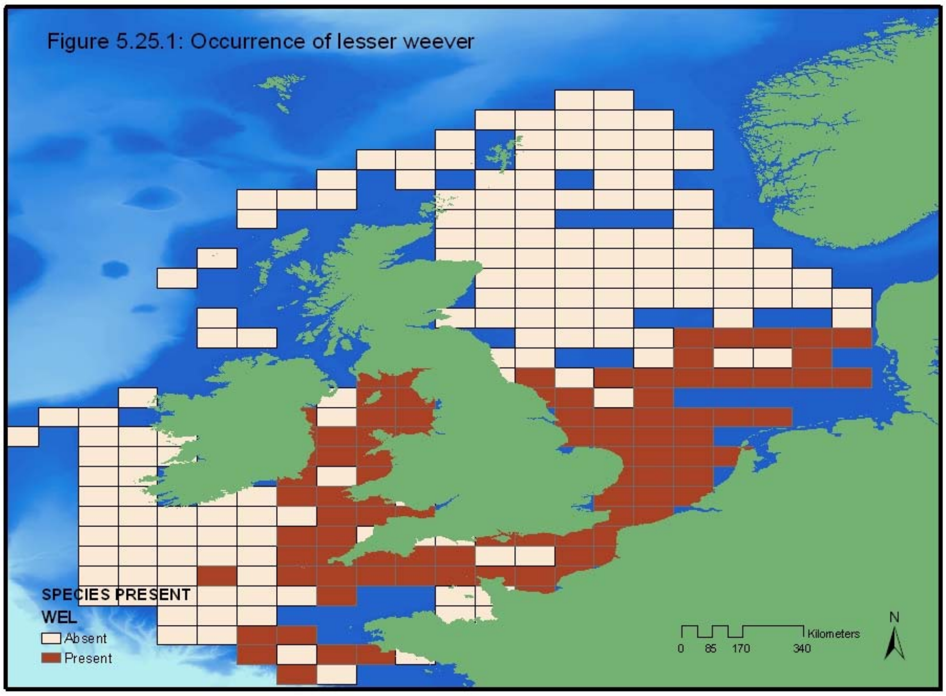

Figure 5.25.2: Occurrence of greater weever in Cefas trawl surveys

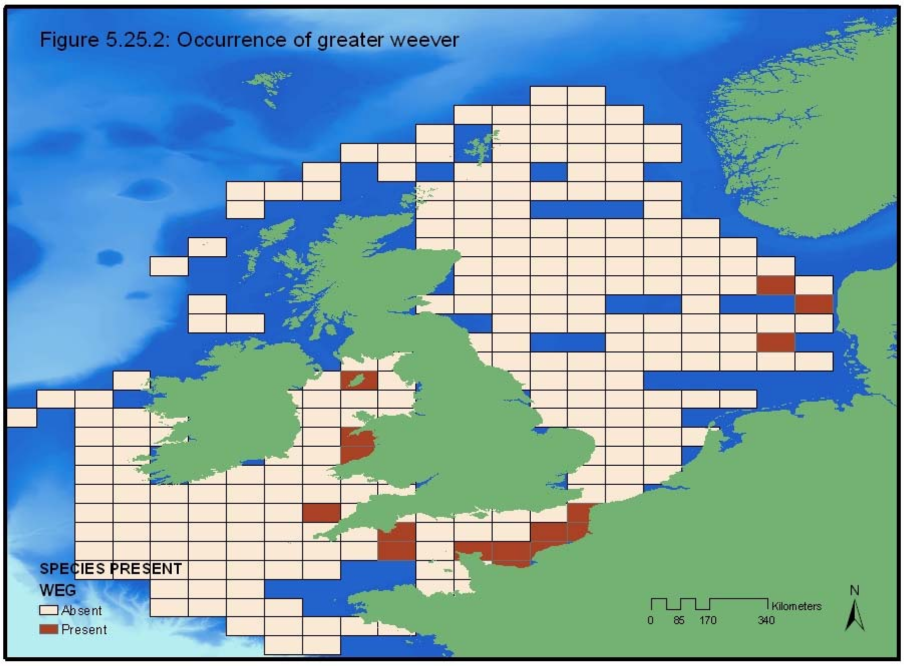


Figure 5.26.1: Occurrence of butterfly blenny in Cefas trawl surveys

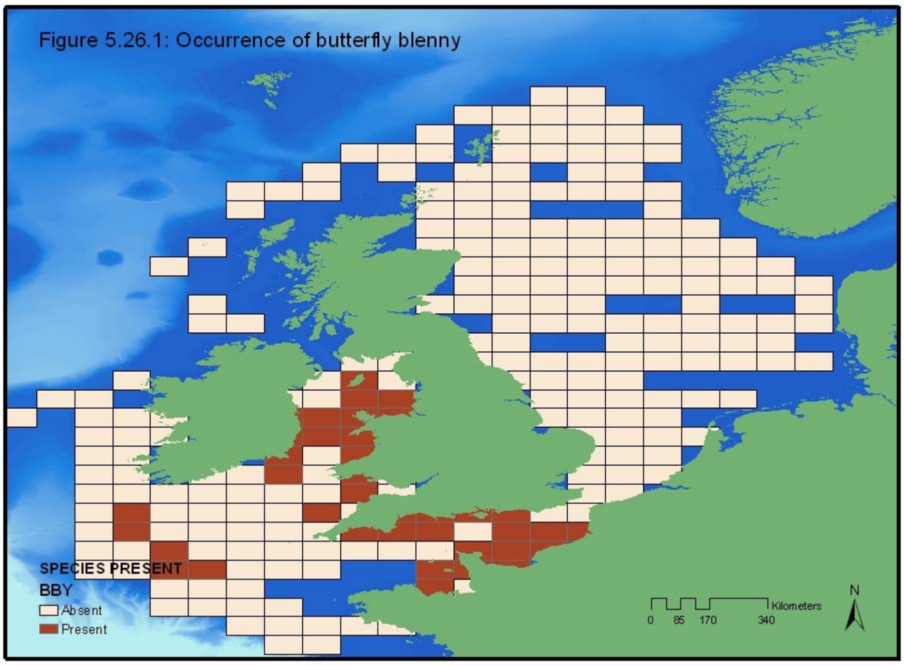

Figure 5.27.1: Occurrence of common dragonet in Cefas trawl surveys

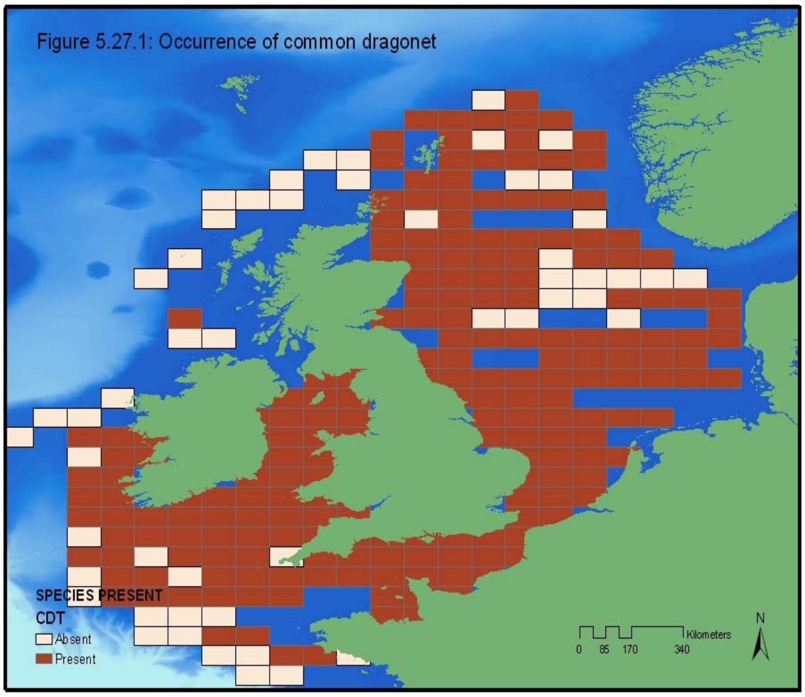


Figure 5.27.2: Occurrence of spotted dragonet in Cefas trawl surveys

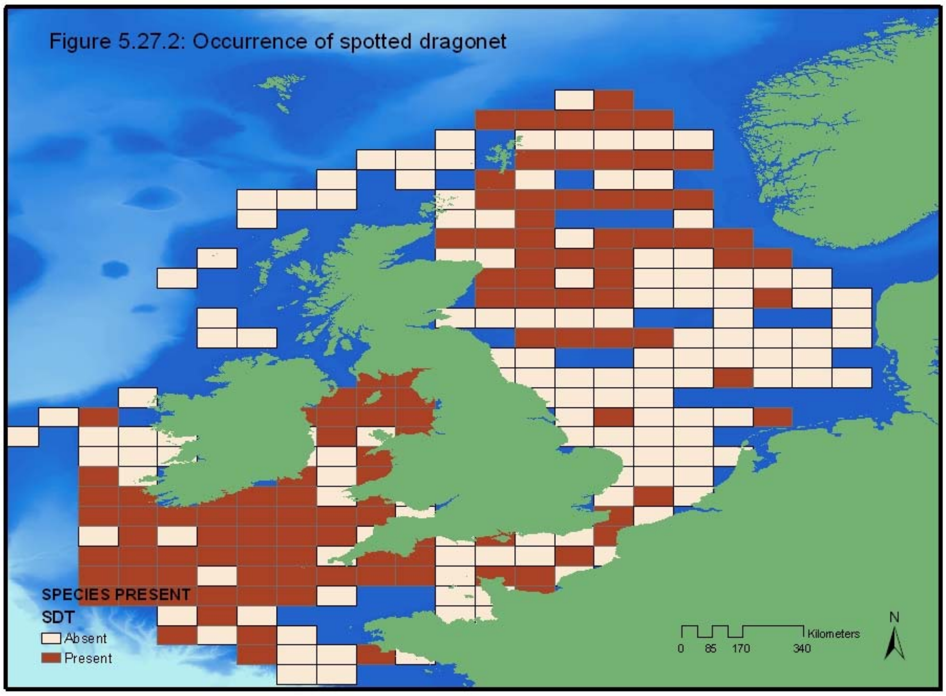

Figure 5.27.3: Occurrence of reticulated dragonet in Cefas trawl surveys

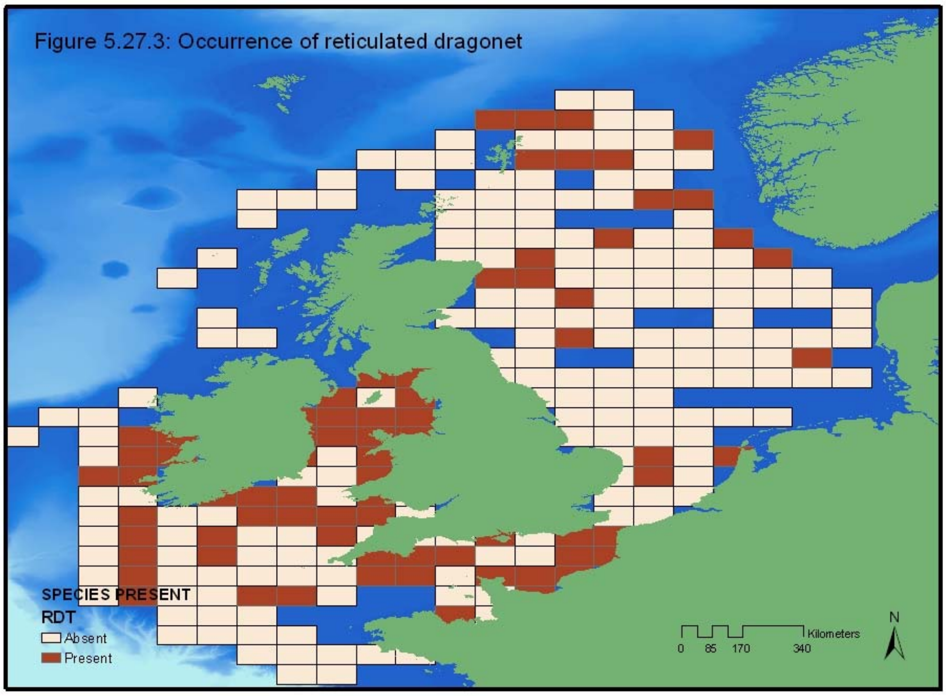

*Figure 5.27.4: Distribution of dragonet eggs in the Irish Sea*

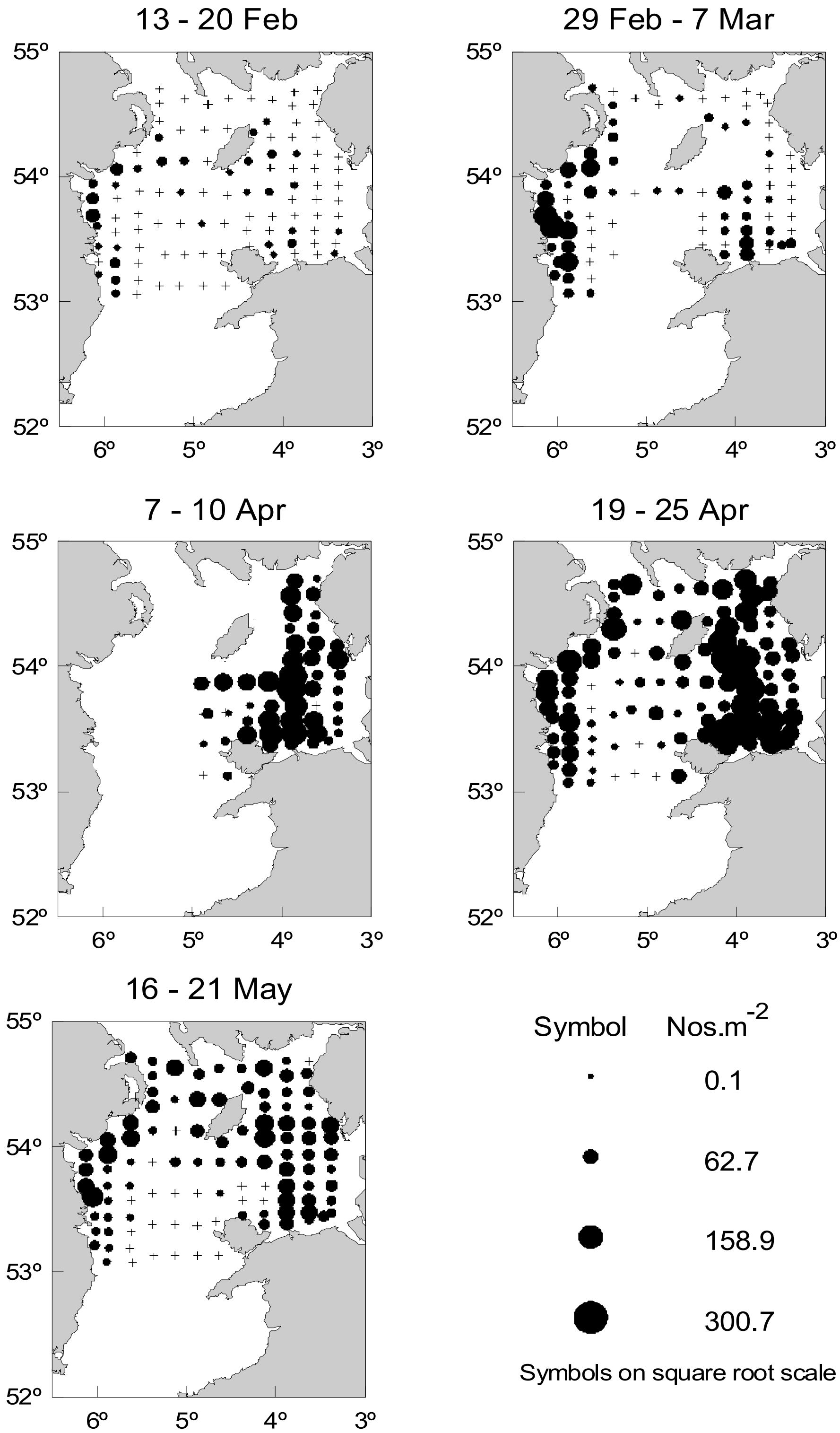


***Figure 5.27.4. Distribution (nos.m$^{-2}$) of dragonet eggs in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.27.5: Distribution of dragonet larvae in the Irish Sea*

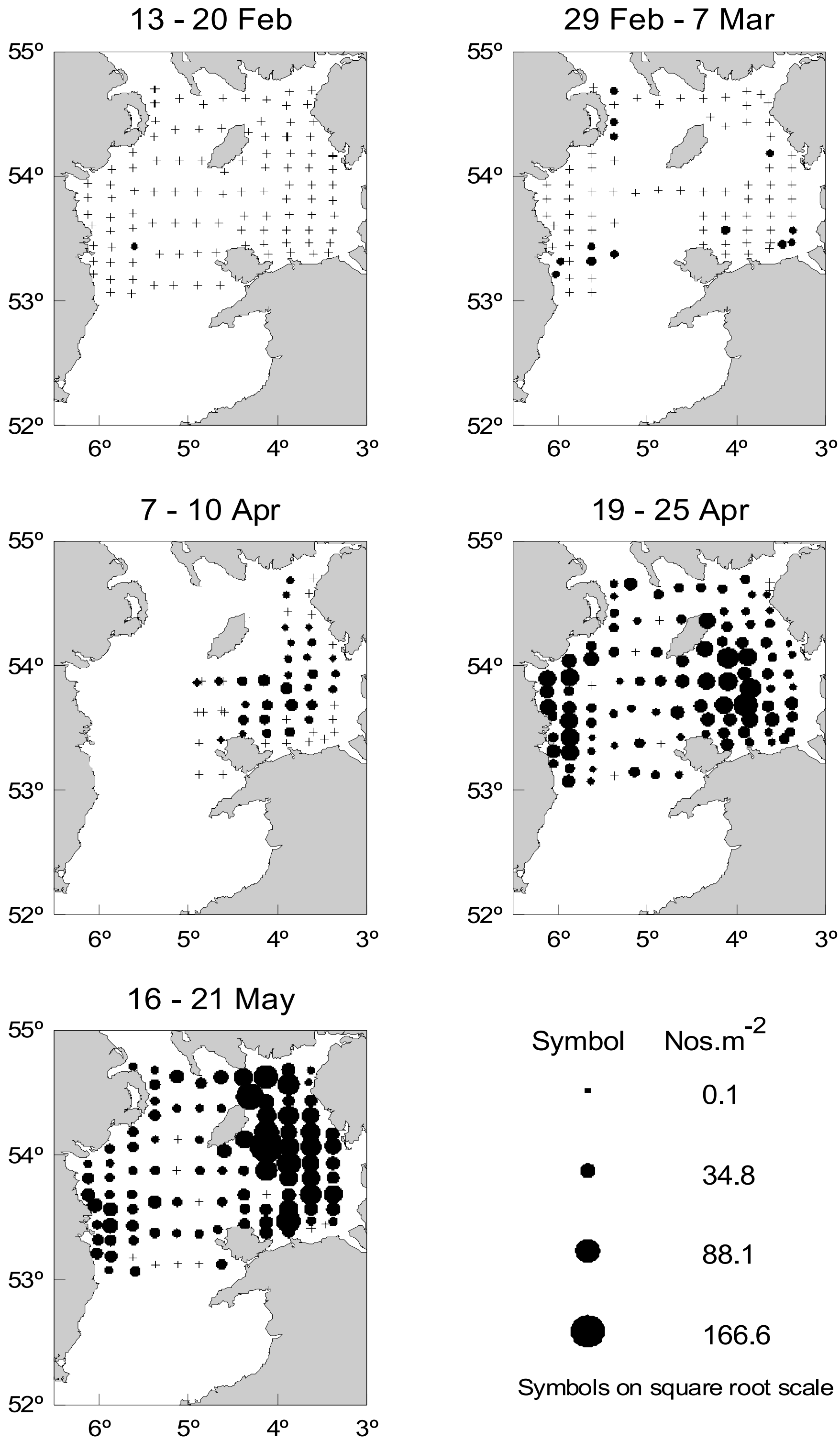


***Figure 5.27.5. Distribution (nos.m⁻²) of dragonet larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.27.6: Distribution of dragonet eggs in the North Sea*

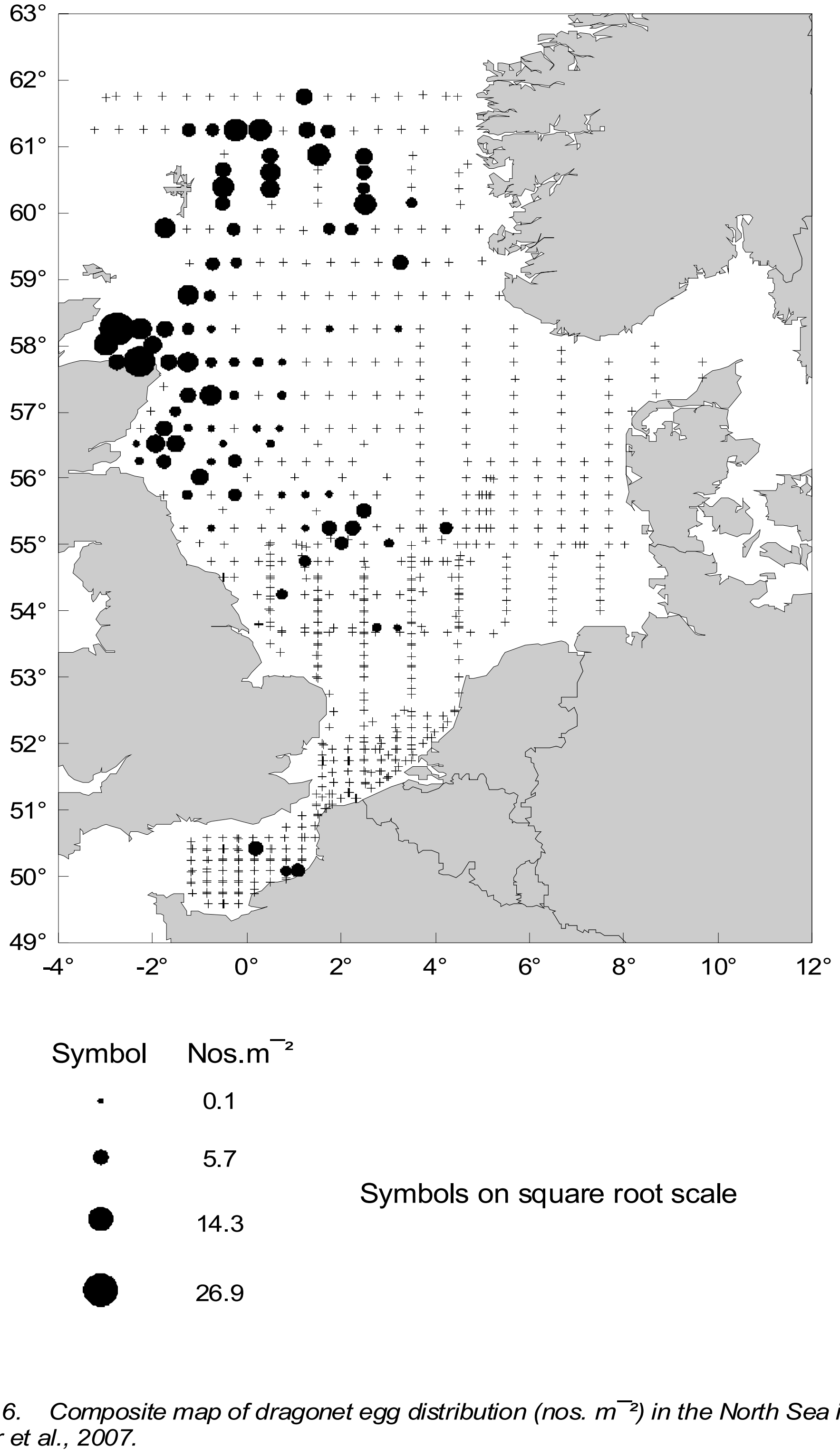


*Figure 5.27.6. Composite map of dragonet egg distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

*Figure 5.27.7: Distribution of dragonet larvae in the North Sea*

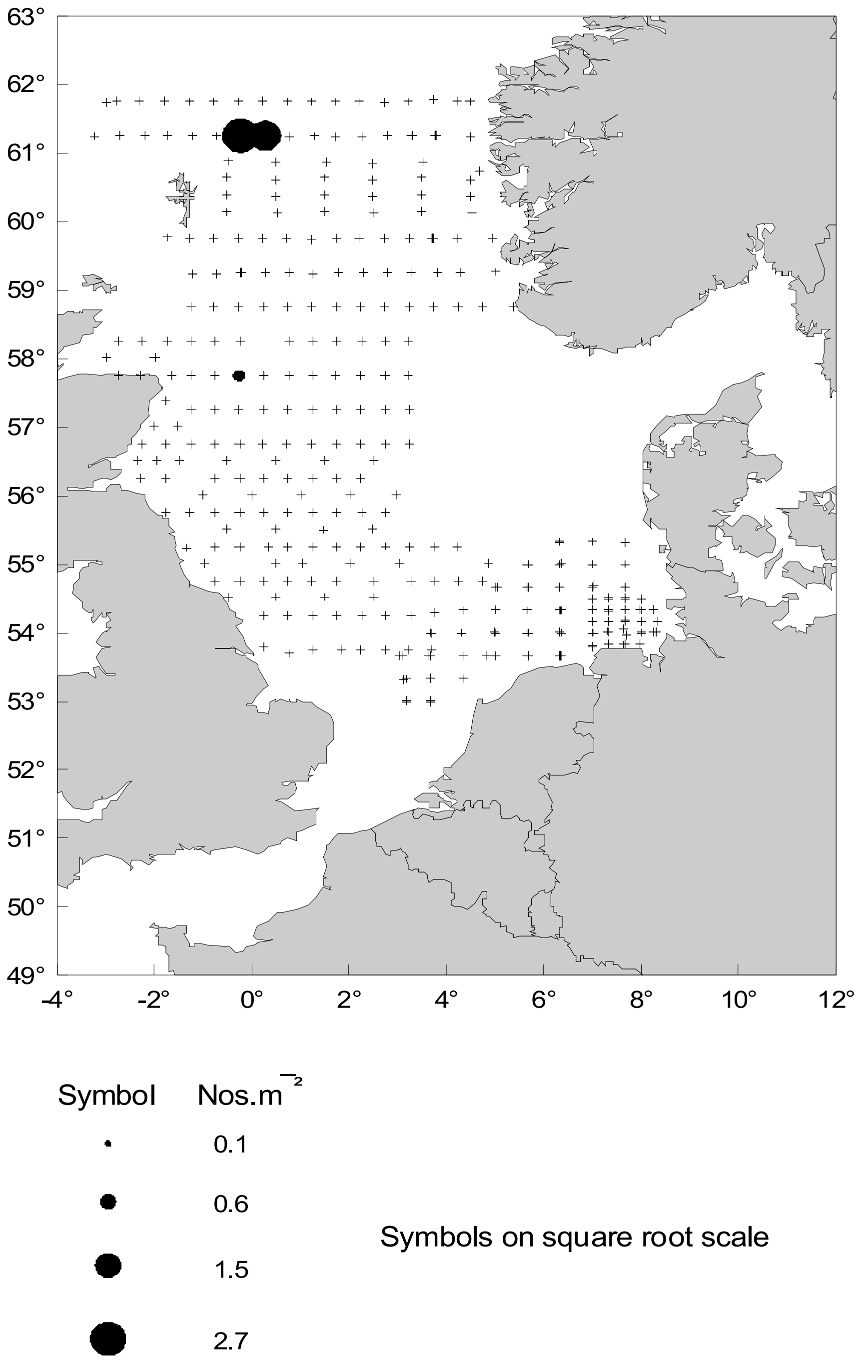


*Figure 5.27.7. Composite map of dragonet larval distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

Figure 5.28.1: Occurrence of sand gobies in Cefas trawl surveys

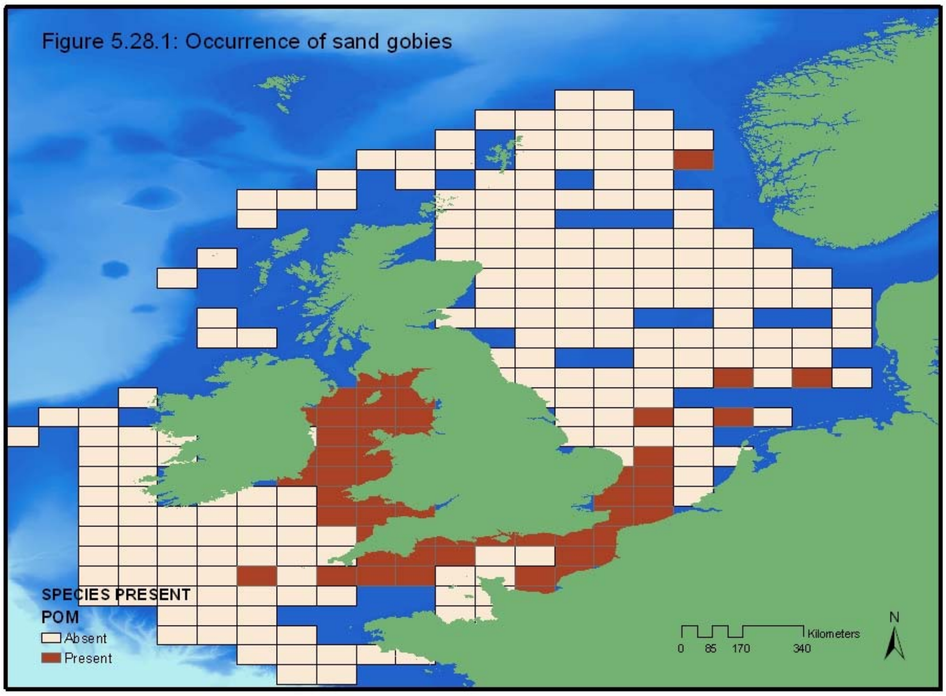


Figure 5.28.2: Occurrence of Gobius spp. in Cefas trawl surveys

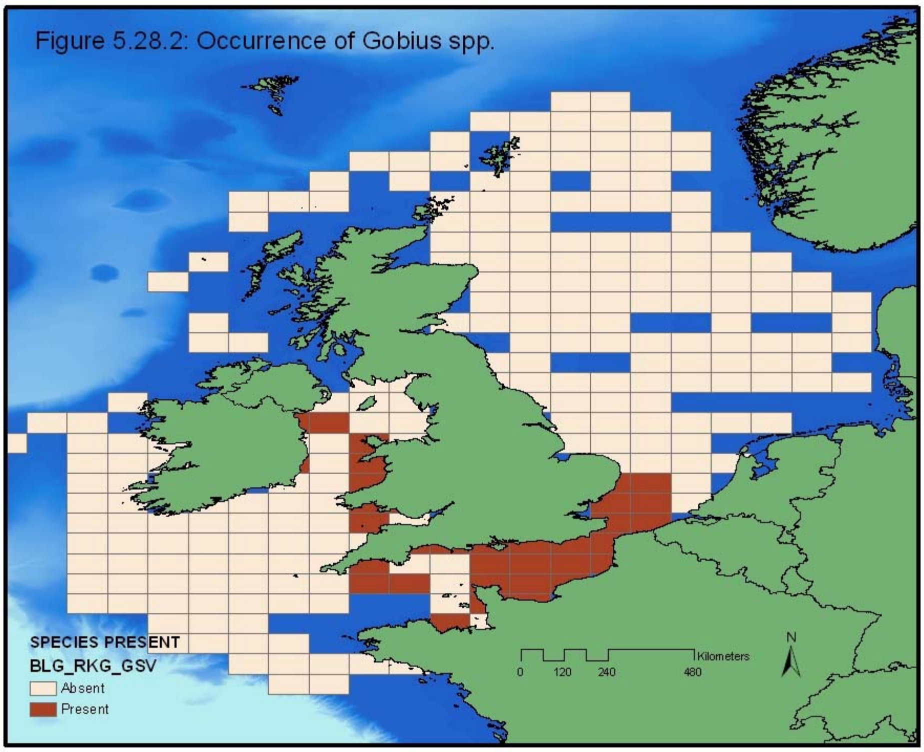

Figure 5.28.3: Occurrence of Fries's goby in Cefas trawl surveys

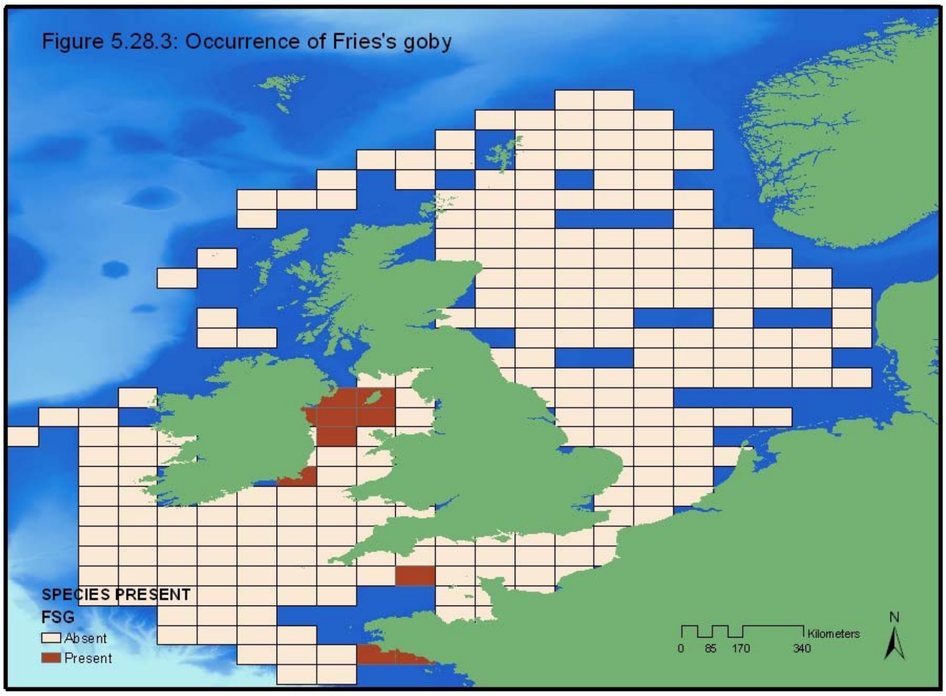

*Figure 5.28.4: Distribution of goby larvae in the Irish Sea*

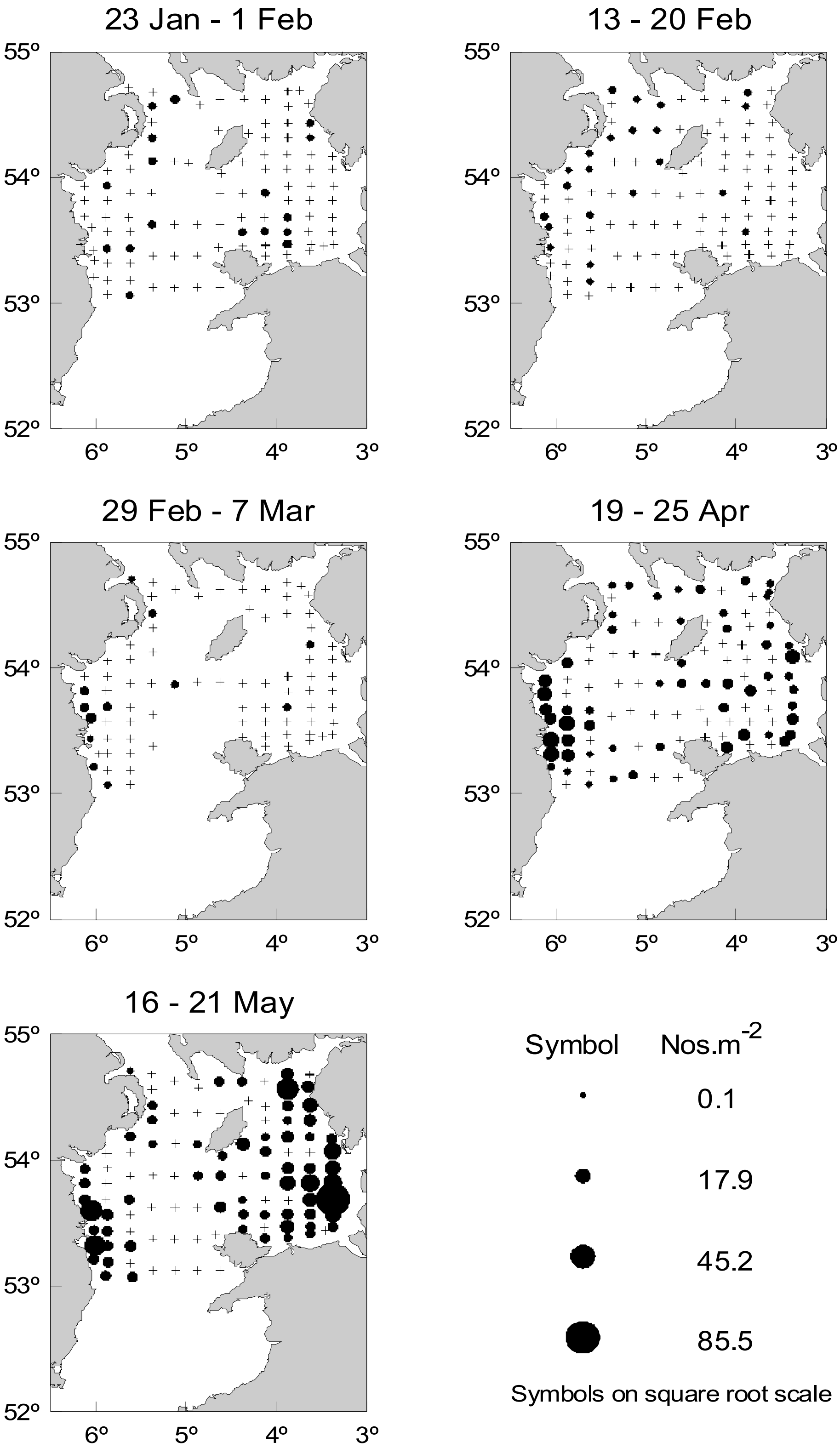


***Figure 5.28.4. Distribution (nos.m⁻²) of goby larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.28.5: Distribution of goby larvae in the North Sea*

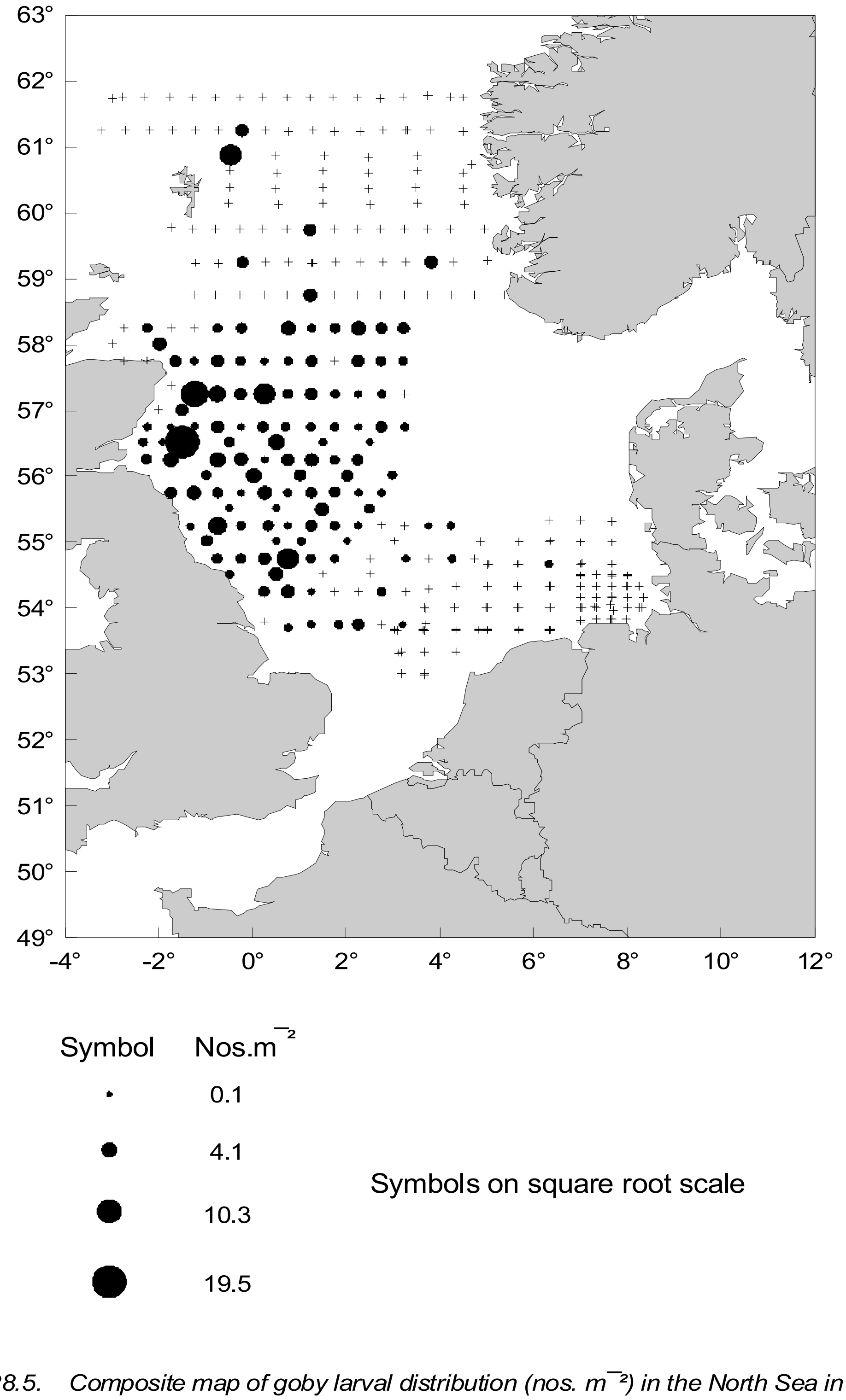


*Figure 5.28.5. Composite map of goby larval distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

Figure 5.29.1: Occurrence of brill in Cefas trawl surveys

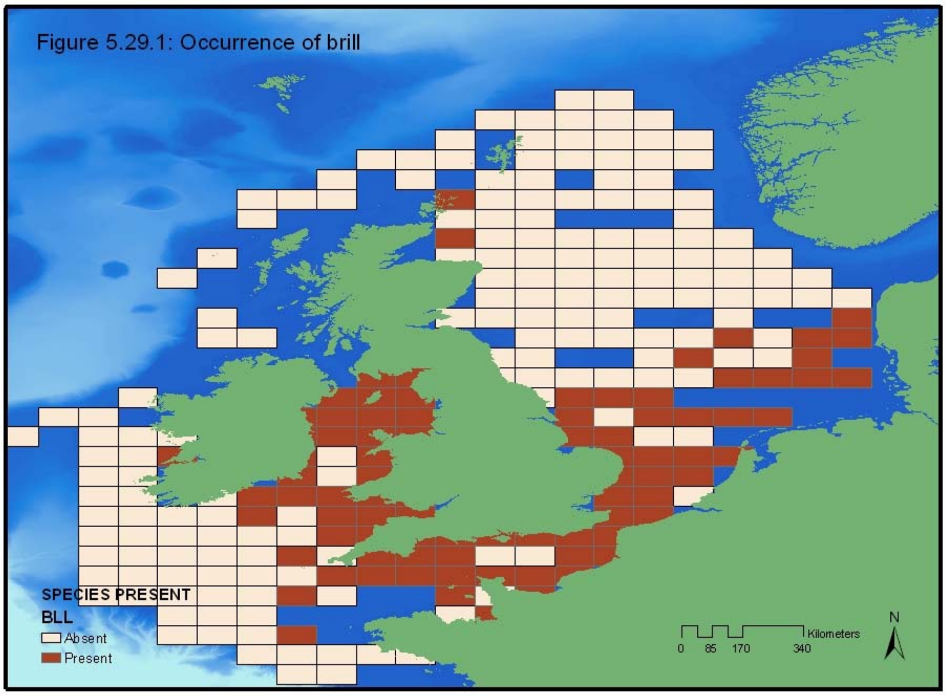


Figure 5.29.2: Occurrence of turbot in Cefas trawl surveys

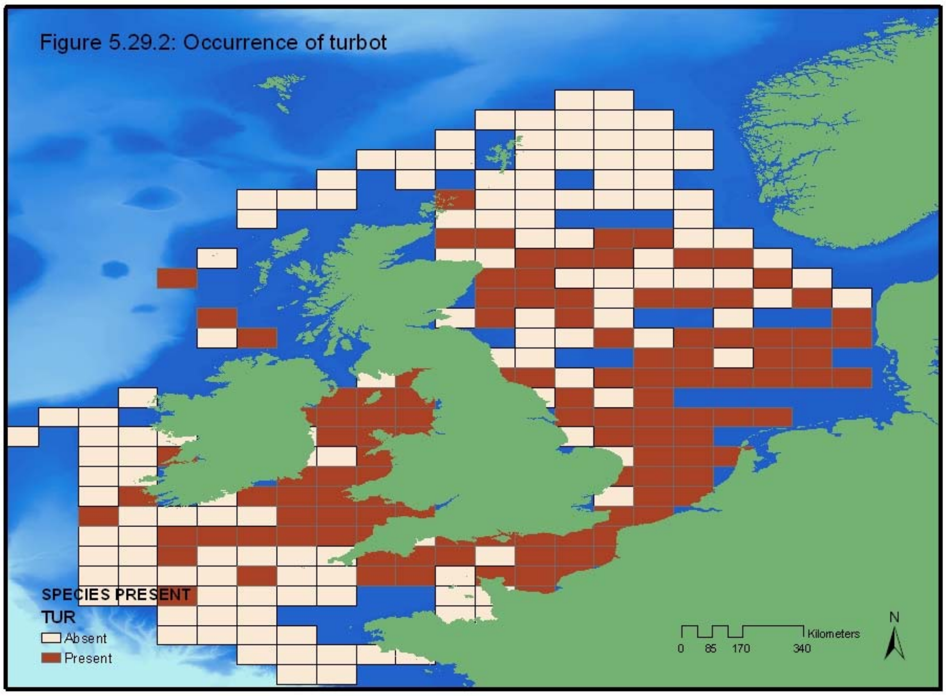

Figure 5.29.3: Occurrence of Norwegian topknot in Cefas trawl surveys

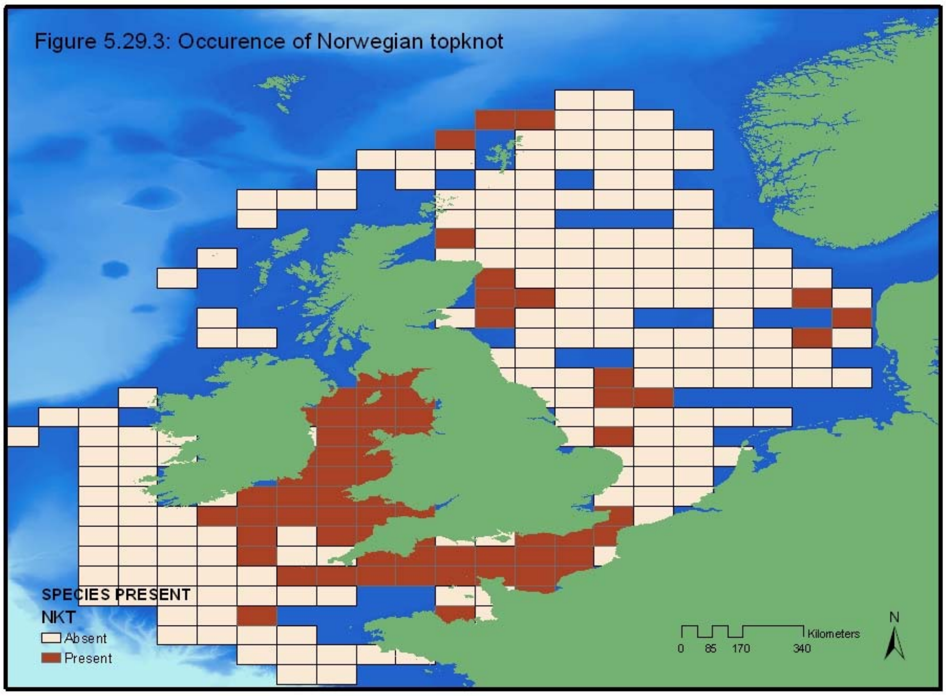


Figure 5.29.4: Occurrence of common topknot in Cefas trawl surveys

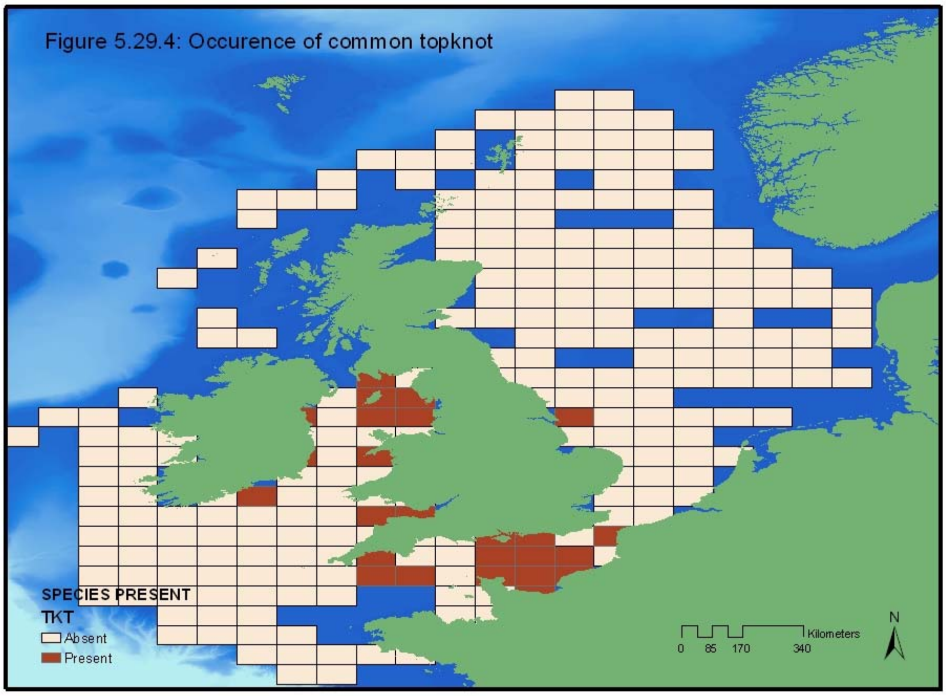

*Figure 5.29.5: Distribution of Norwegian topknot eggs in the Irish Sea*

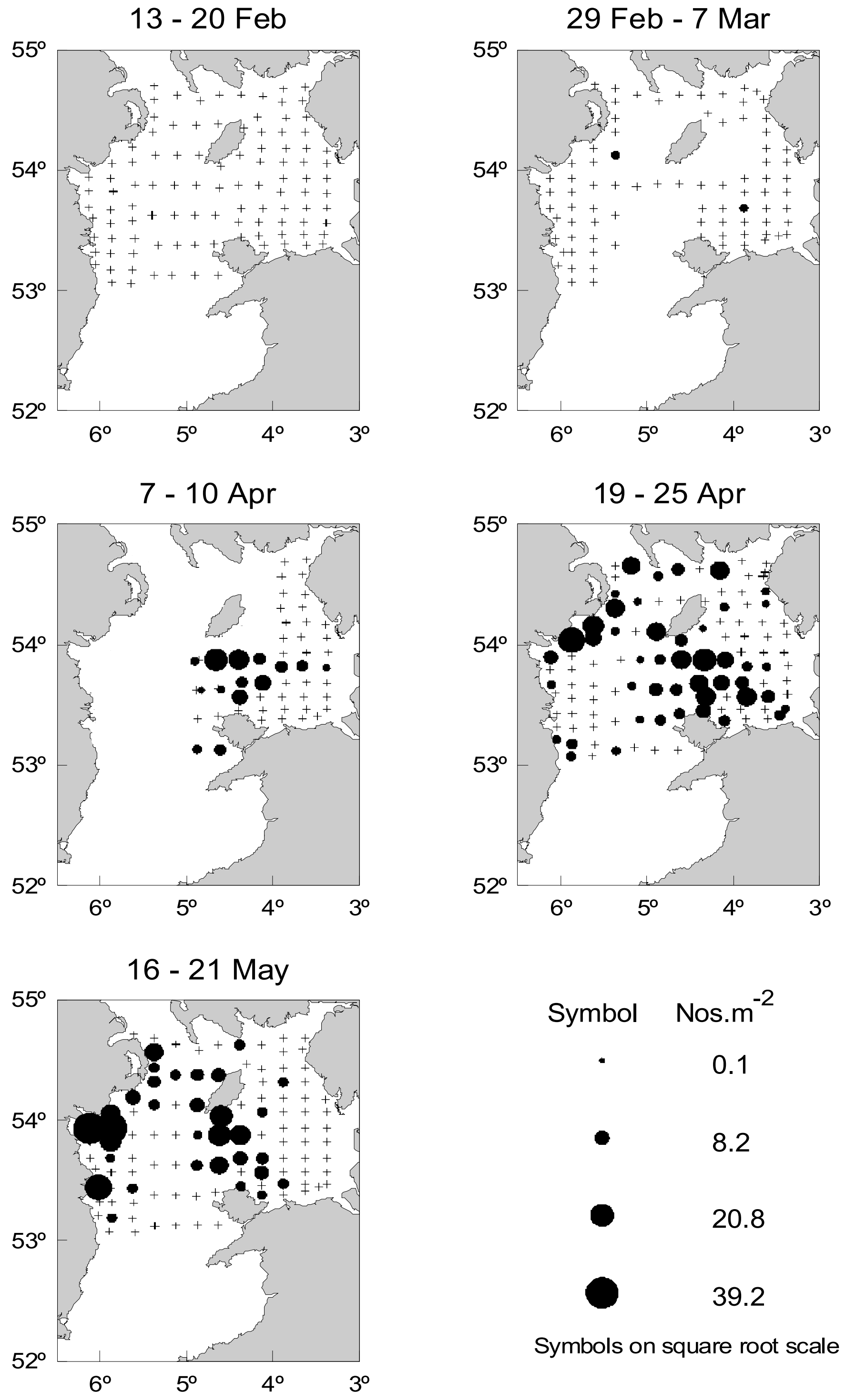


***Figure 5.29.5. Distribution (nos.m$^{-2}$) of Norwegian topknot eggs in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.29.6: Distribution of Norwegian topknot larvae in the Irish Sea*

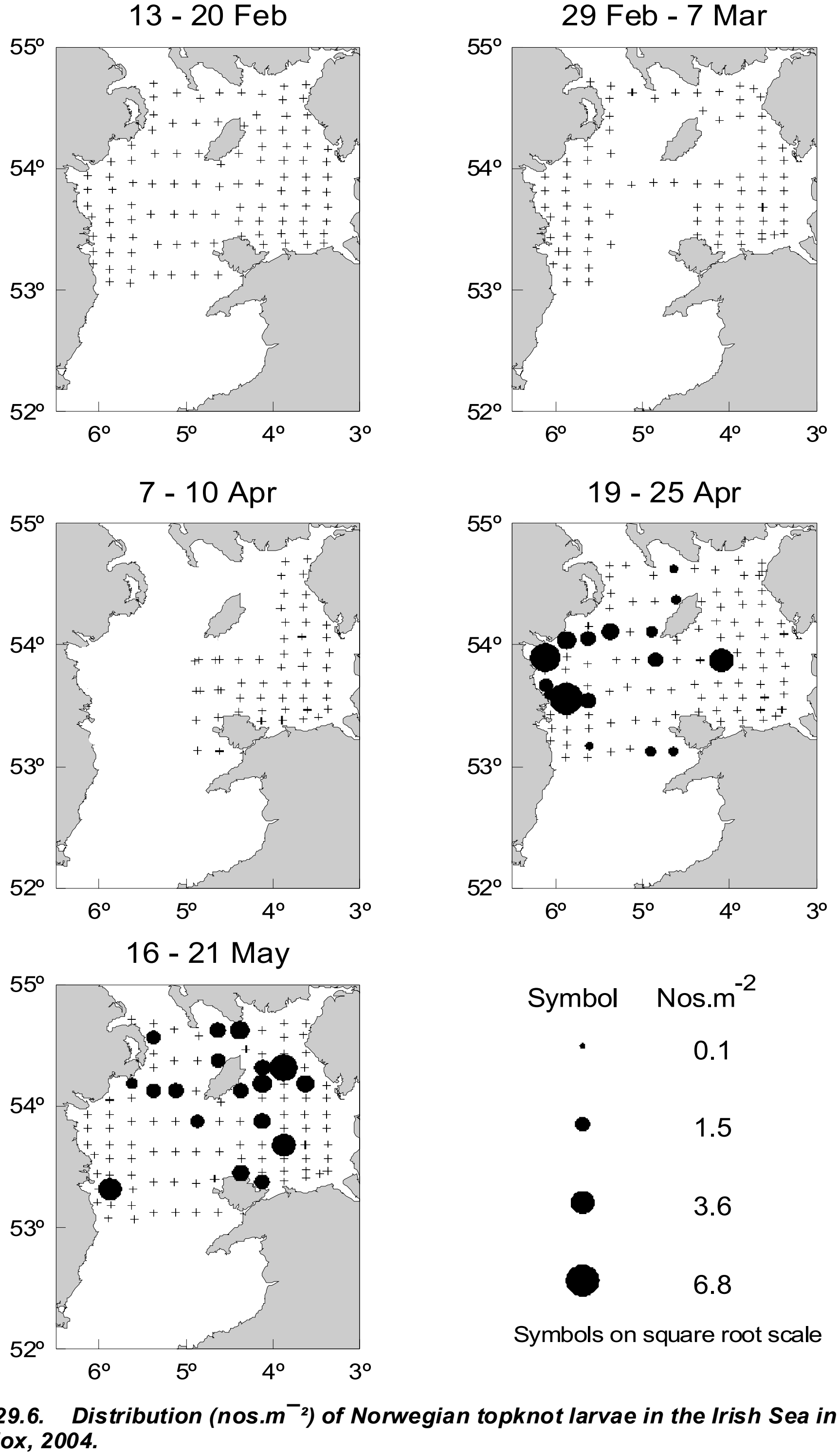


***Figure 5.29.6. Distribution (nos.m⁻²) of Norwegian topknot larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.29.7: Distribution of common topknot eggs in the Irish Sea*

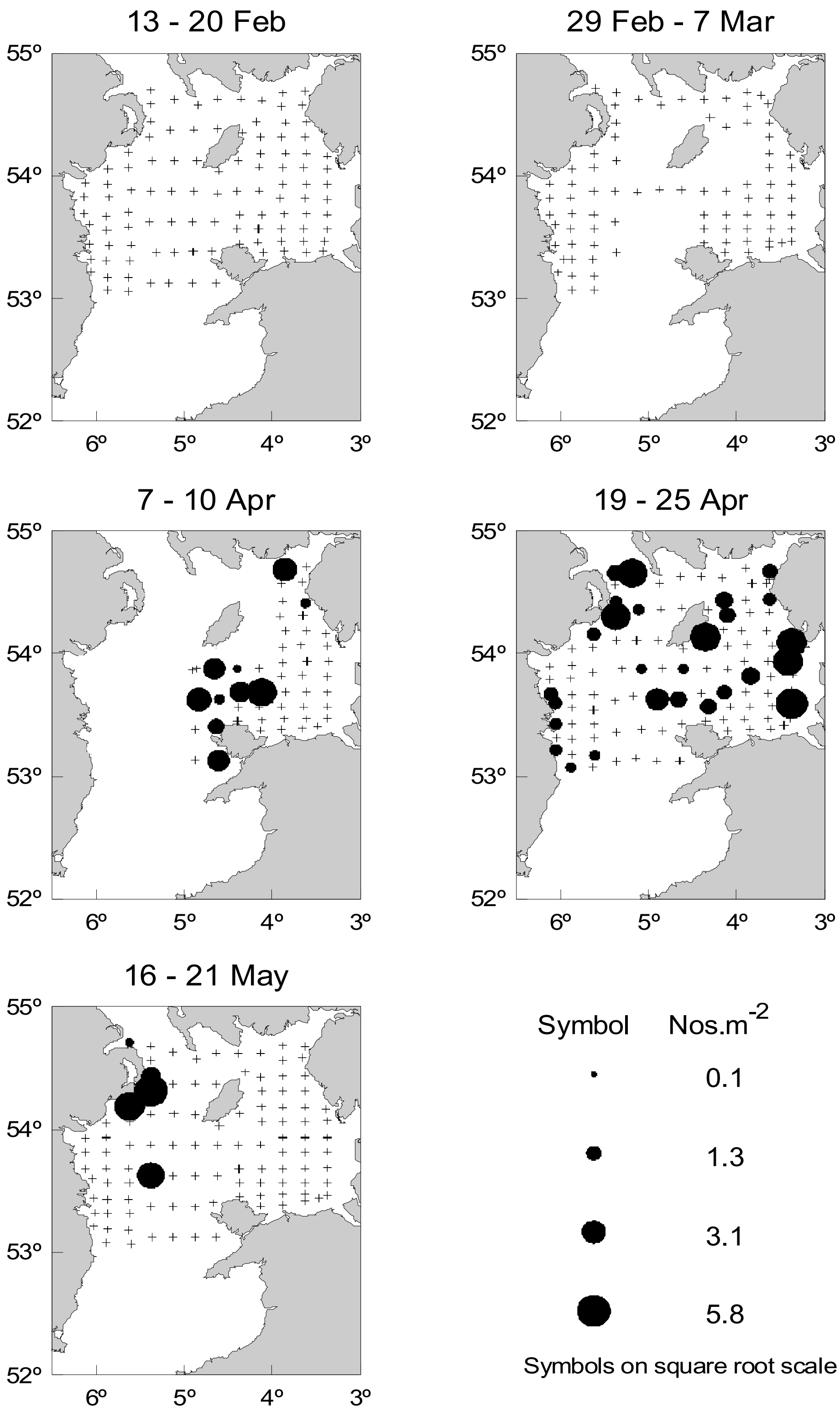


***Figure 5.29.7. Distribution (nos.m⁻²) of topknot eggs in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.29.8: Distribution of common topknot larvae in the Irish Sea*

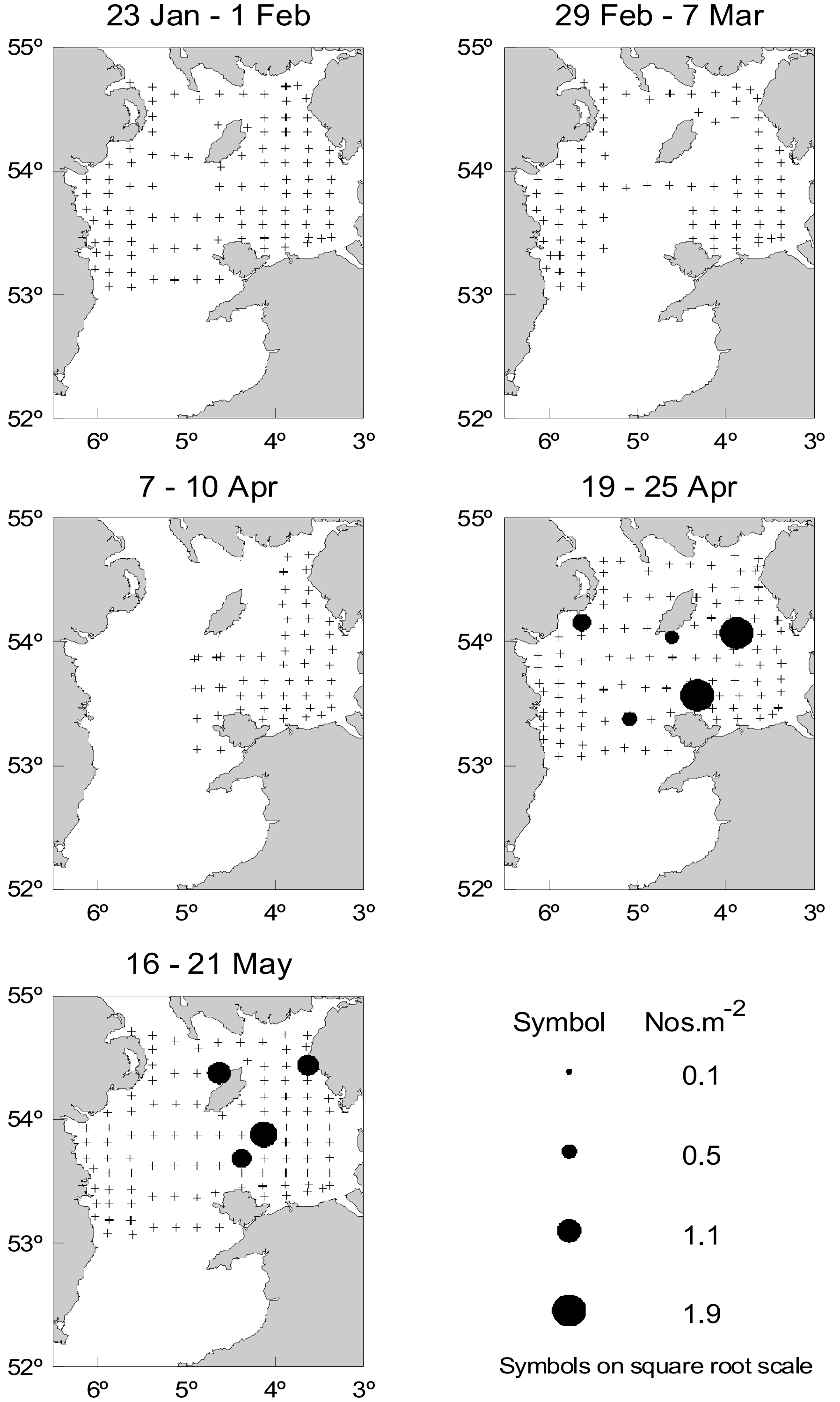


***Figure 5.29.8. Distribution (nos.m⁻²) of topknot larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.29.9: Distribution of Norwegian topknot eggs in the North Sea*

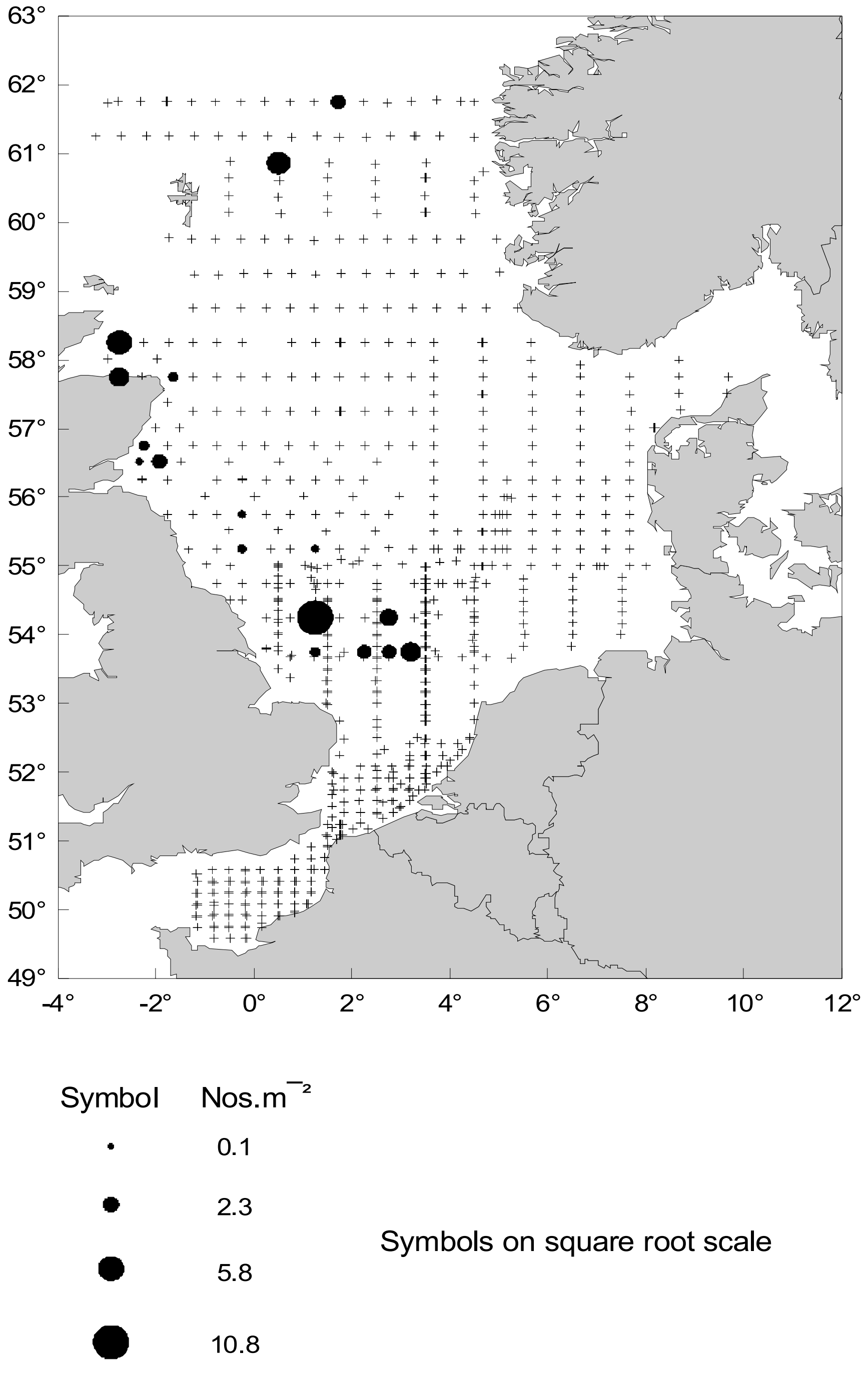


*Figure 5.29.9. Composite map of Norwegian topknot egg distribution (nos. m$^{-2}$) in the North Sea in 2004. From taylor et al., 2007.*

Figure 5.30.1: Occurrence of scaldfish in Cefas trawl surveys

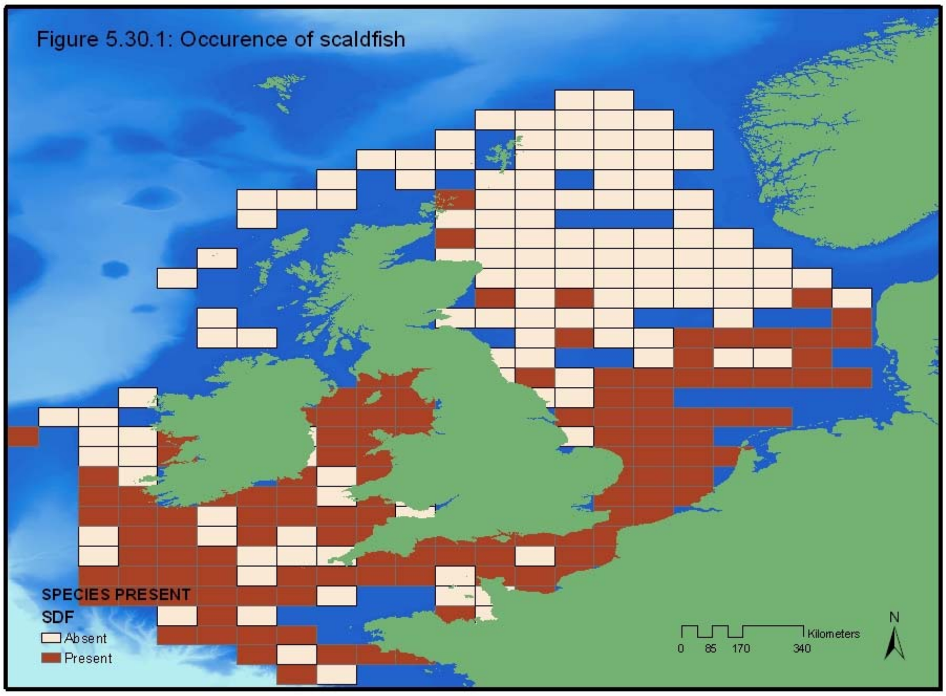


Figure 5.30.2: Occurrence of imperial scaldfish in Cefas trawl surveys

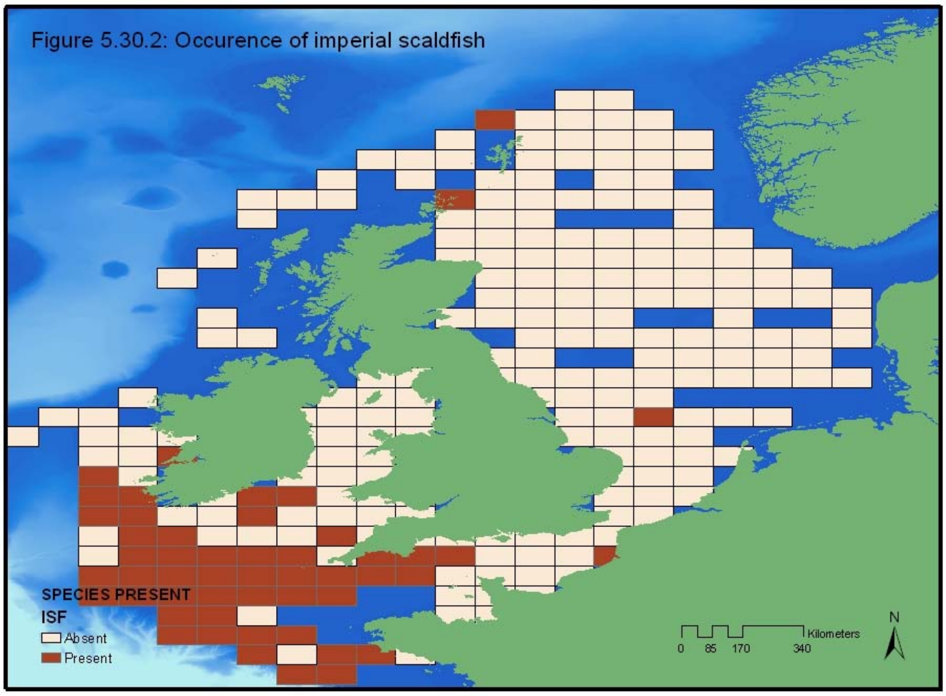

Figure 5.31.1: Occurrence of dab in Cefas trawl surveys

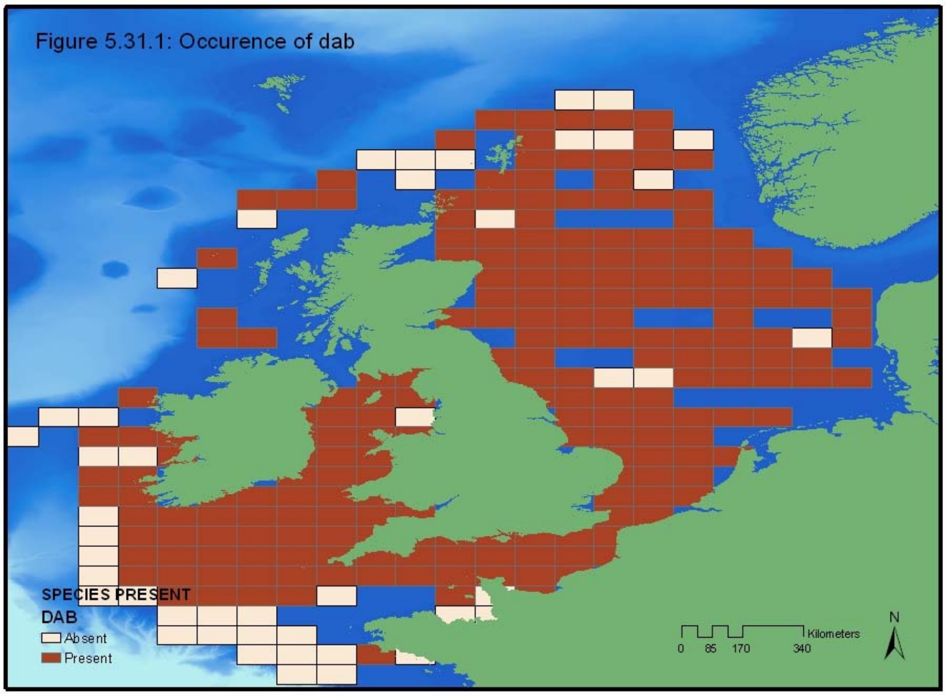


Figure 5.31.2: Occurrence of flounder in Cefas trawl surveys

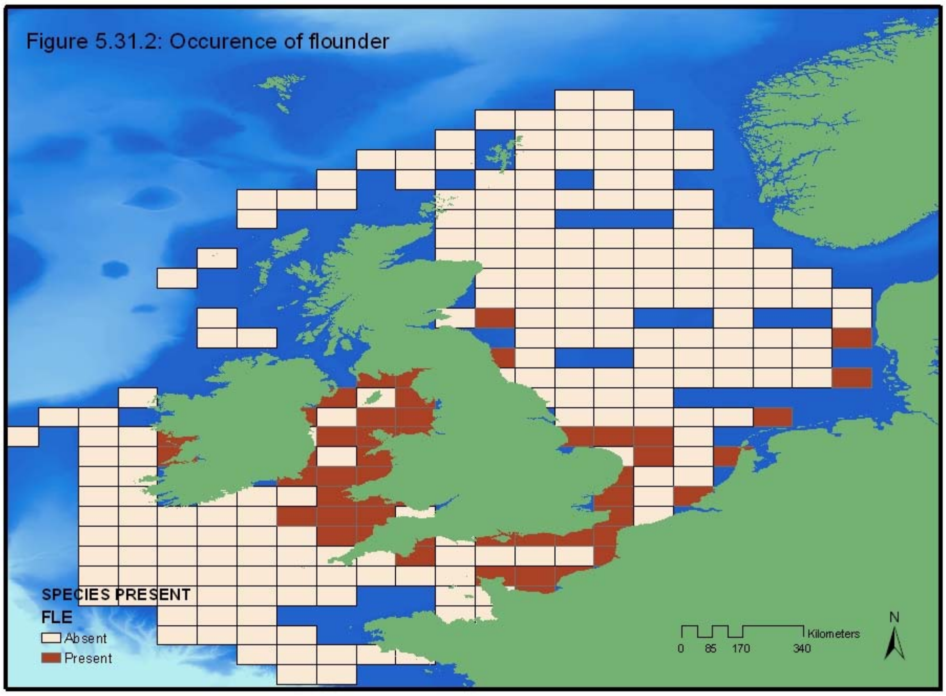

Figure 5.31.3: Occurrence of long-rough dab in Cefas trawl surveys

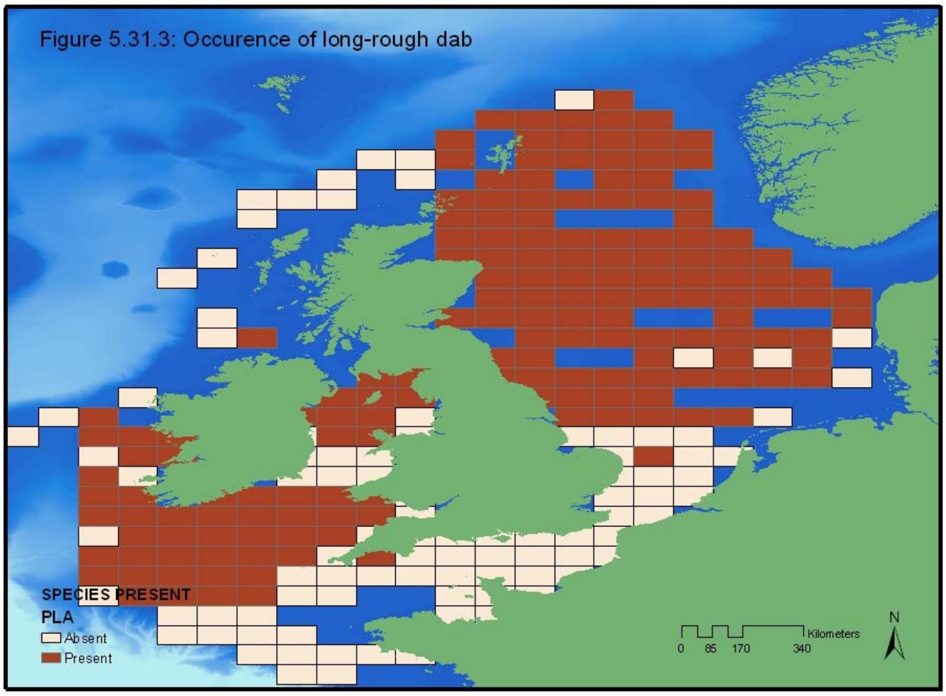


Figure 5.31.4: Occurrence of witch in Cefas trawl surveys

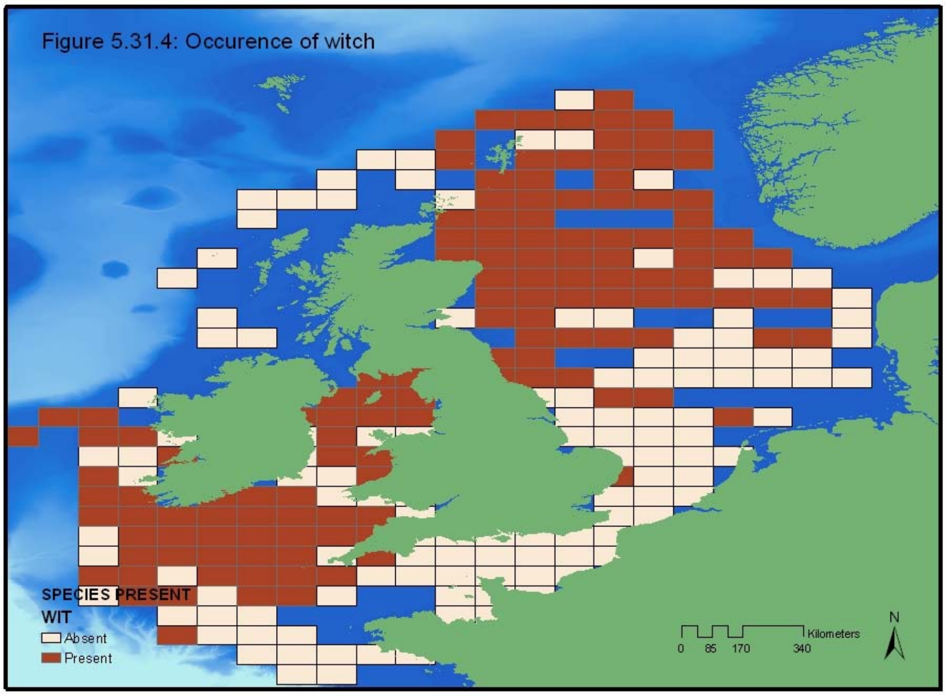

Figure 5.31.5: Distribution of witch larvae in the Irish Sea

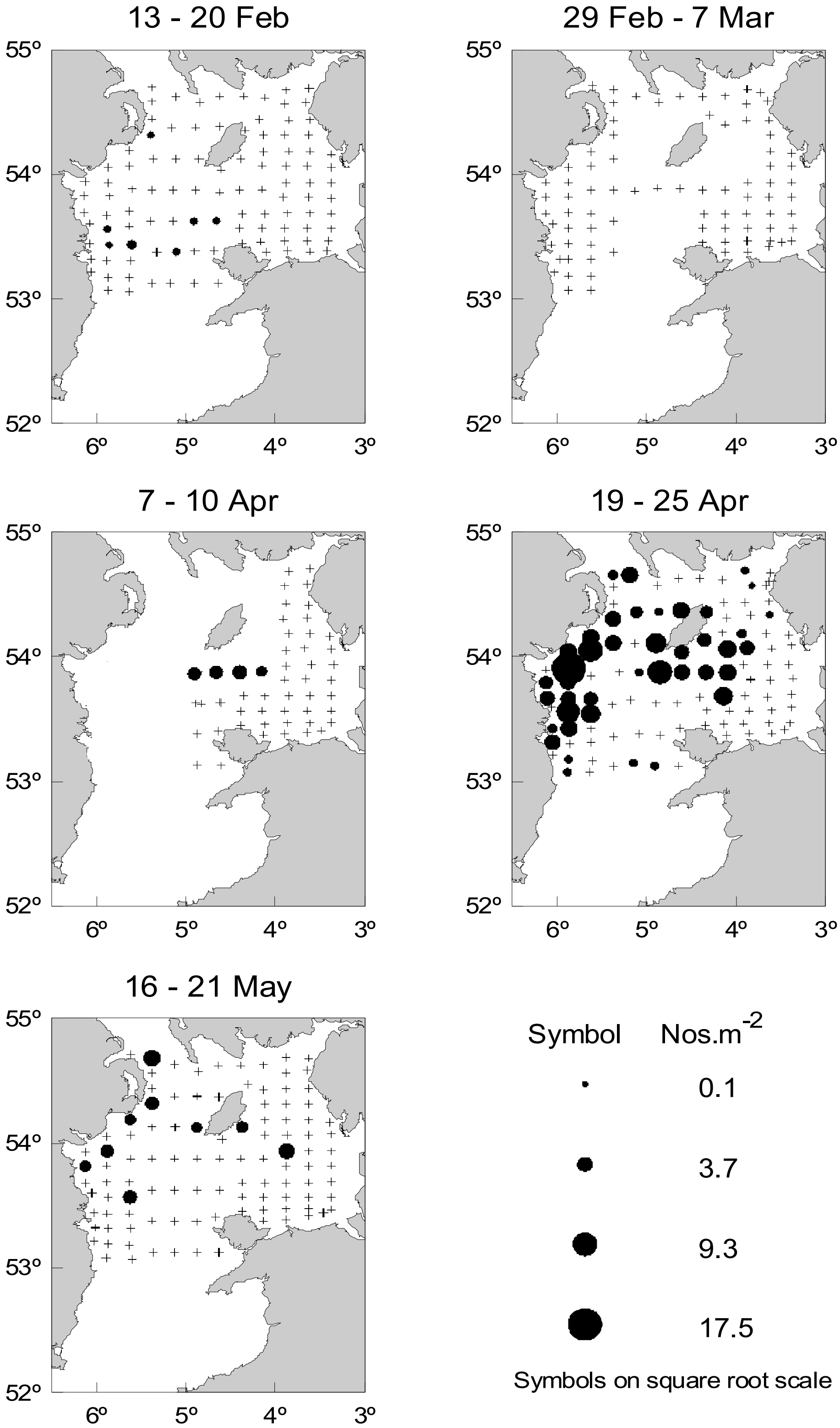


***Figure 5.31.5. Distribution (nos.m⁻²) of witch larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

Figure 5.31.6: Distribution of witch larvae in the North Sea

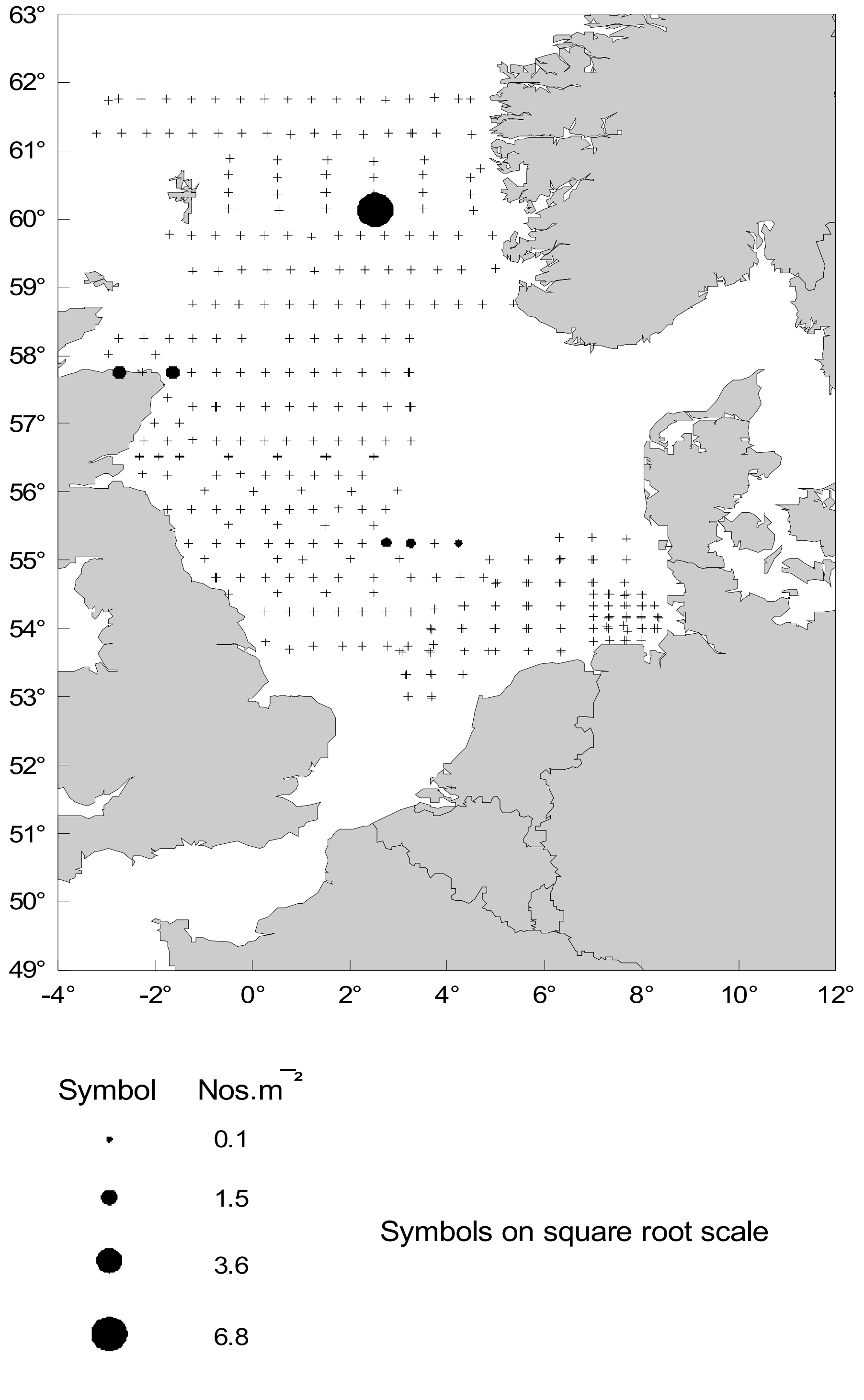


*Figure 5.31.6. Composite map of witch larval distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

Figure 5.31.7: Distribution of long-rough dab larvae in the Irish Sea

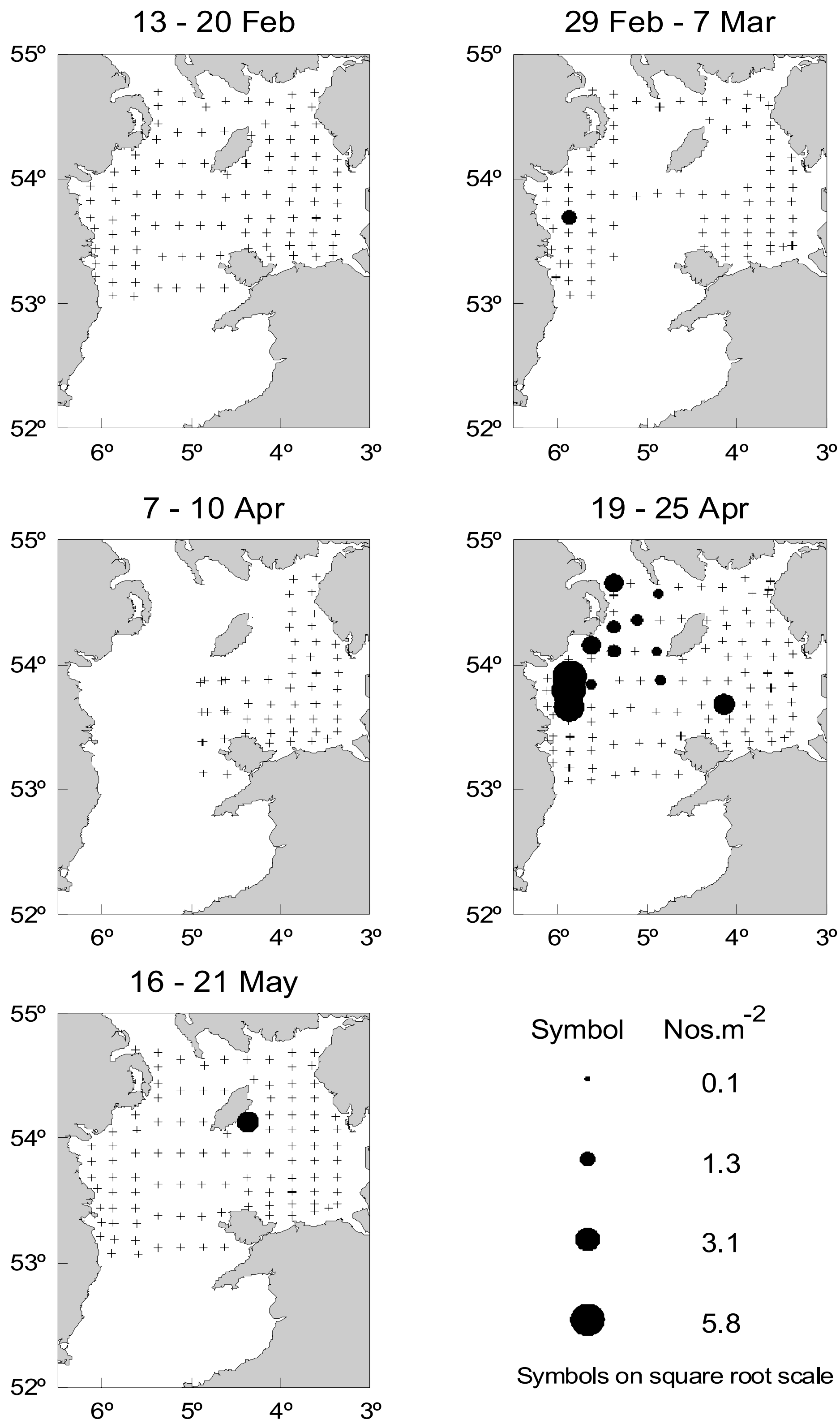


***Figure 5.31.7. Distribution (nos.m$^{-2}$) of long rough dab larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

Figure 5.31.8: Distribution of long-rough dab larvae in the North Sea

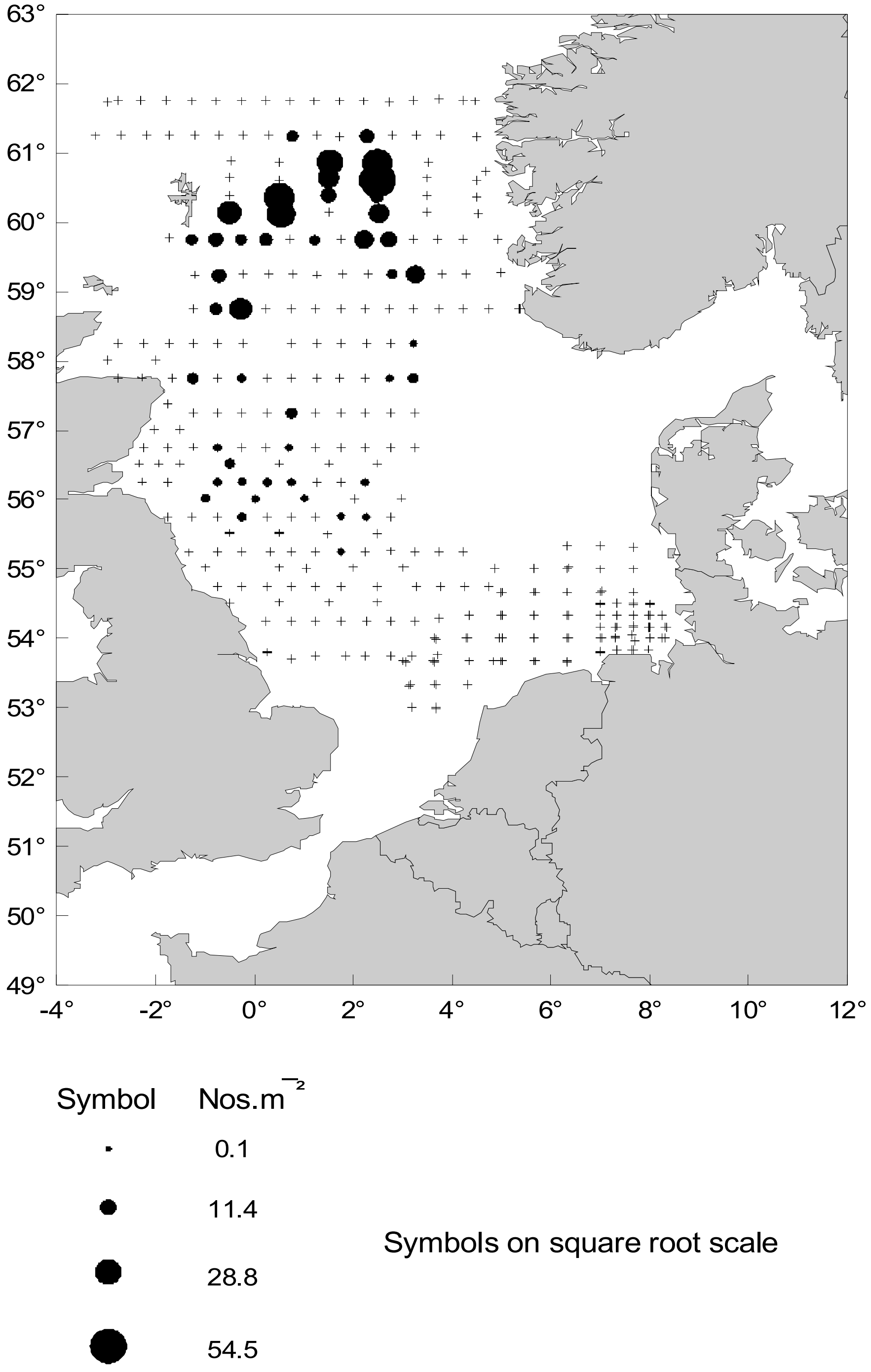


*Figure 5.31.8. Composite map of long rough dab larval distribution (nos. m$^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

Figure 5.31.9: Distribution of dab larvae in the Irish Sea

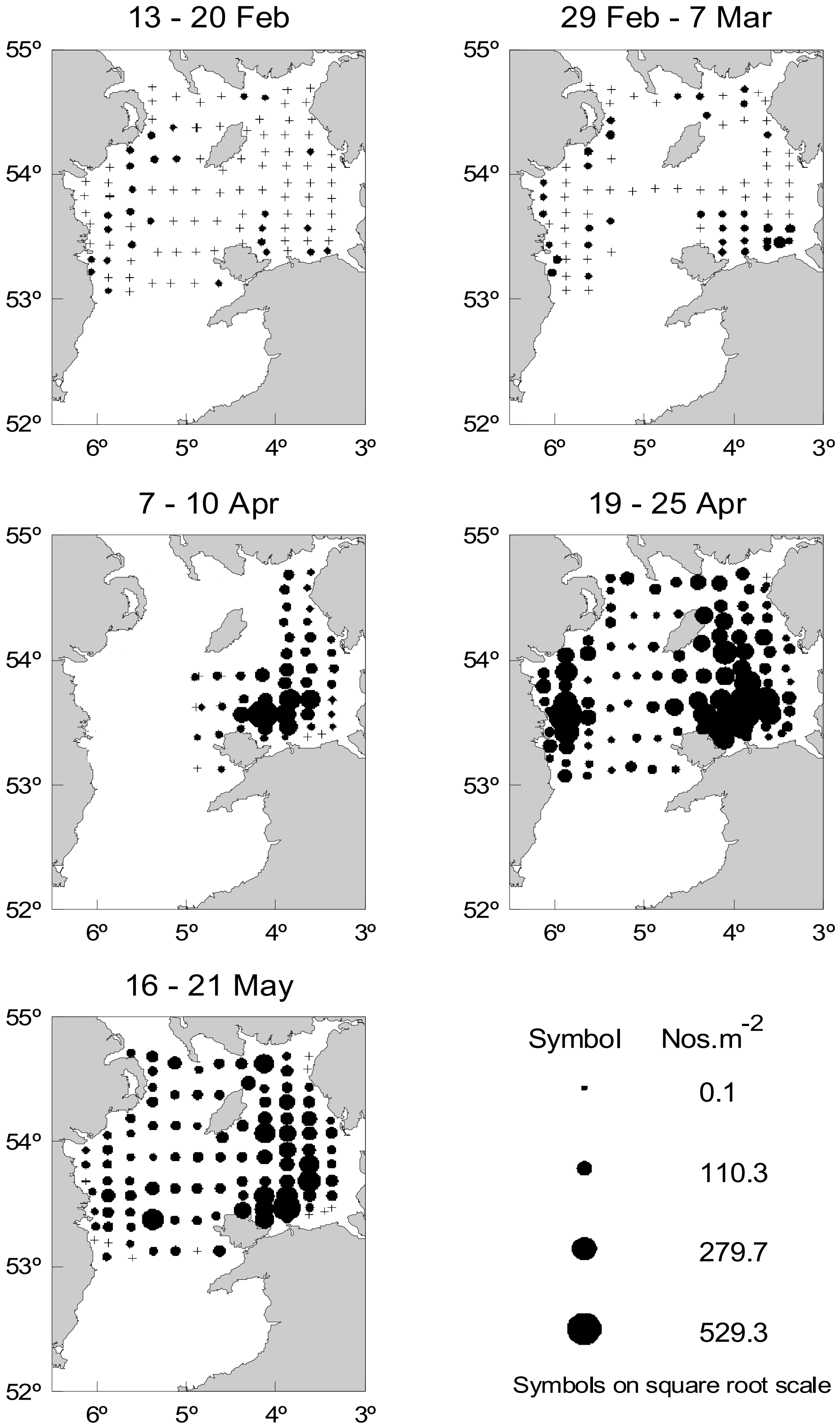


***Figure 5.31.9. Distribution (nos.m⁻²) of dab larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

Figure 5.31.10: Distribution of dab larvae in the North Sea

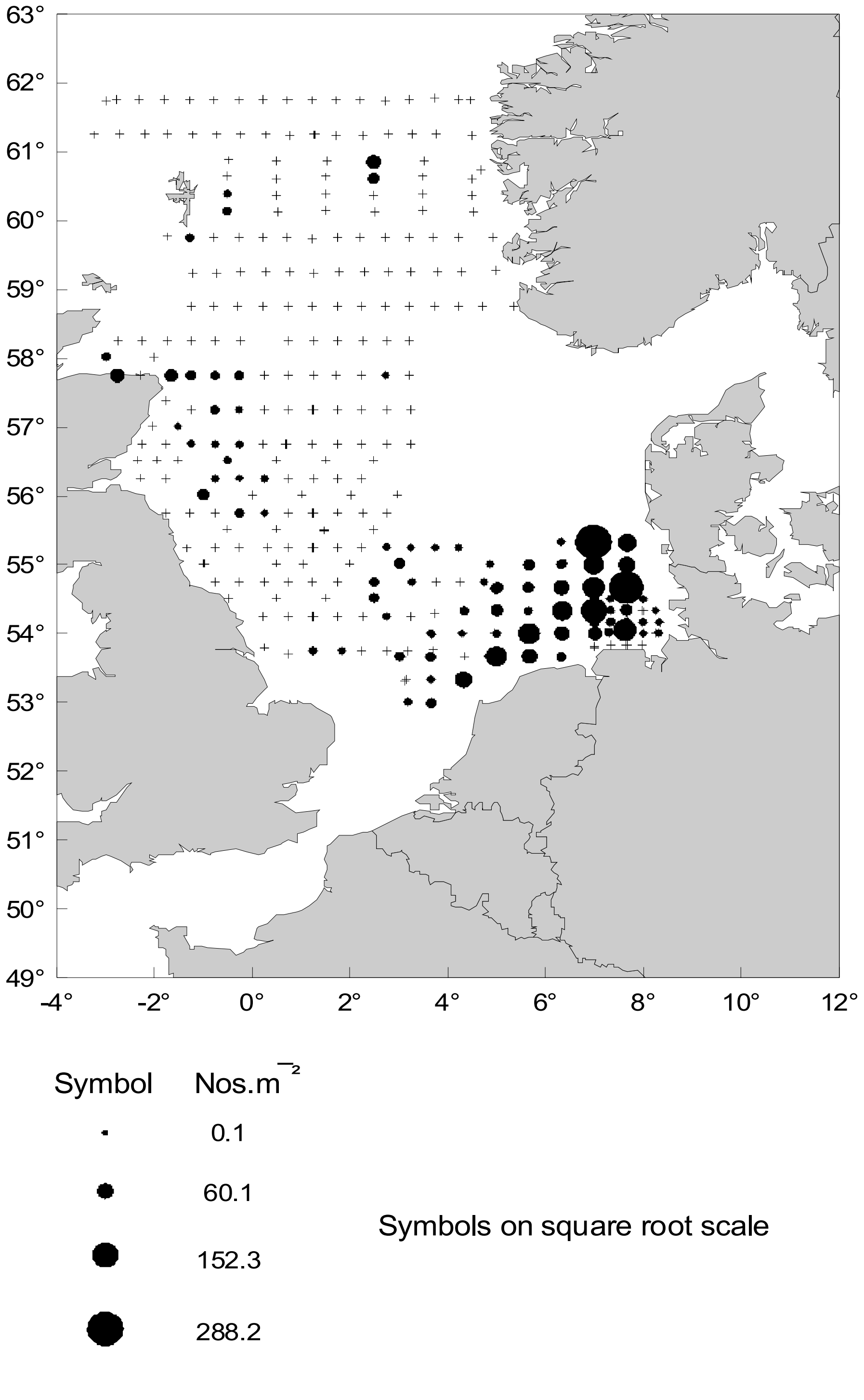


*Figure 5.31.10. Composite map of dab larval distribution (nos. $m^{-2}$) in the North Sea in 2004. From Taylor et al., 2007.*

Figure 5.31.11: Distribution of flounder larvae in the Irish Sea

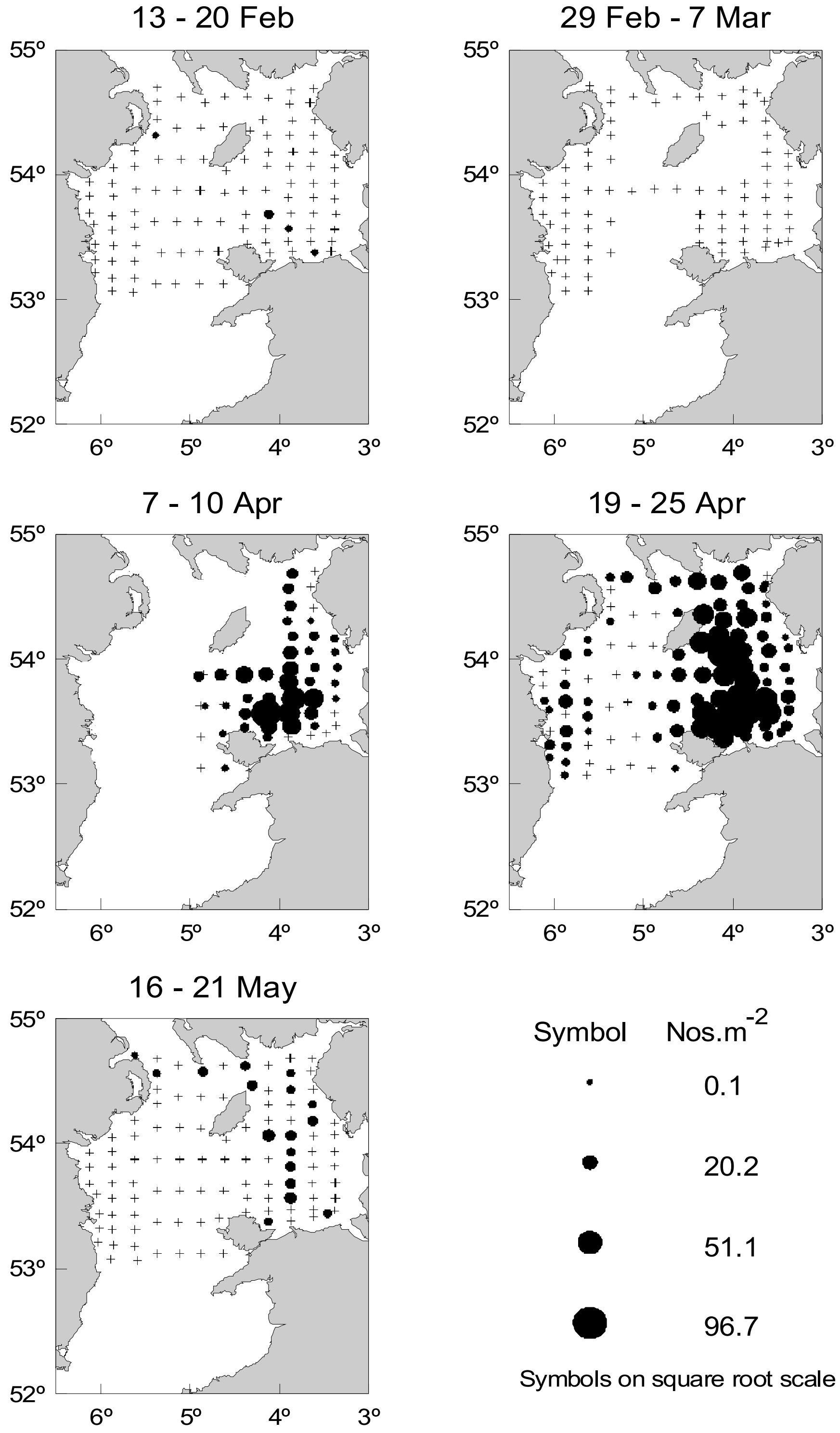


***Figure 5.31.11. Distribution (nos.$m^{-2}$) of flounder larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.32.1: Occurrence of solenette in Cefas trawl surveys*

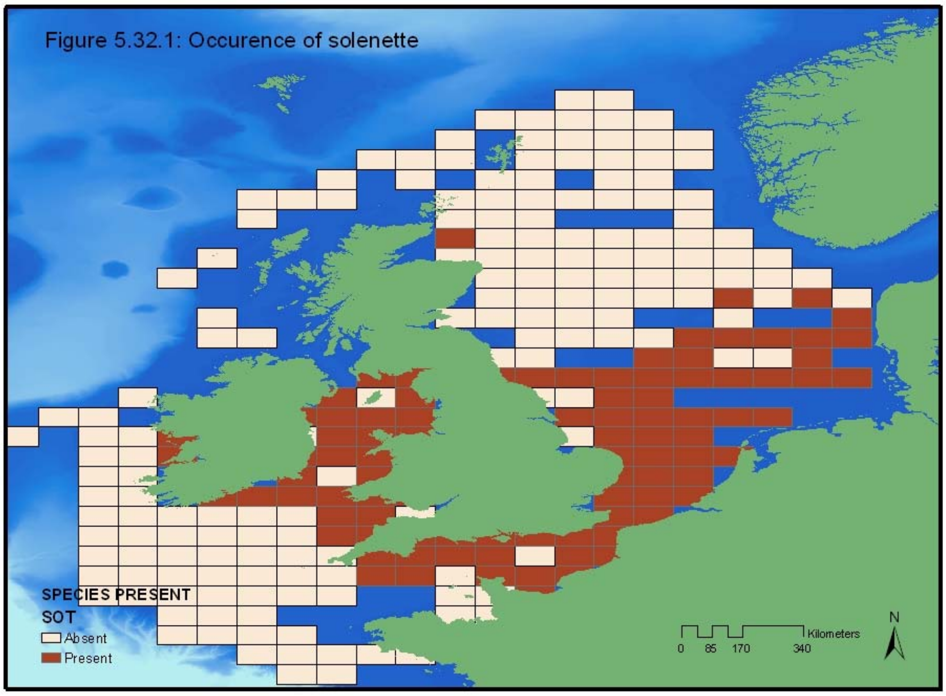


Figure 5.32.2: Occurrence of sand sole in Cefas trawl surveys

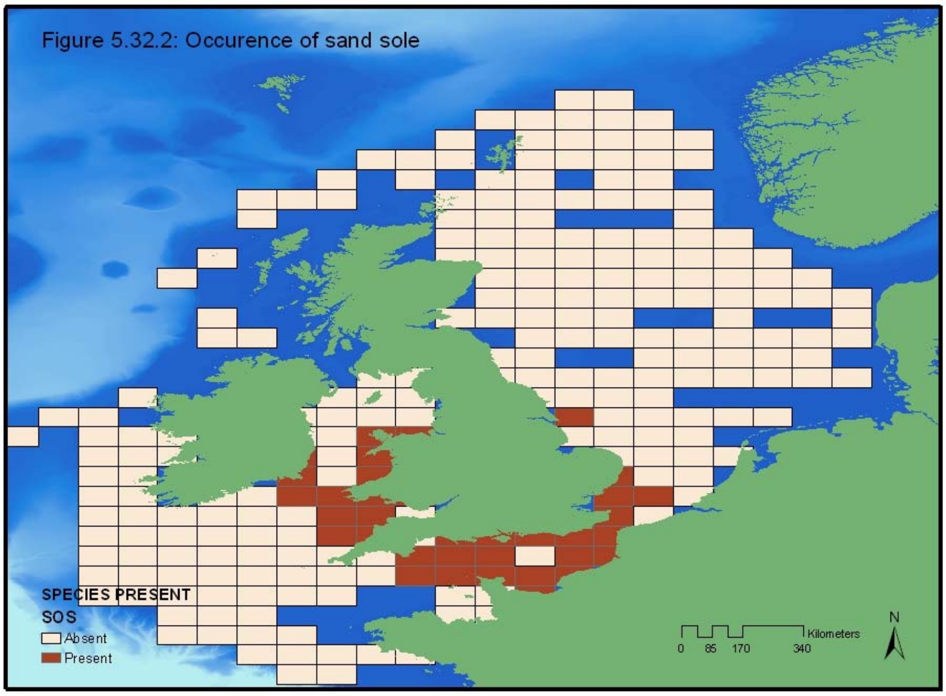

Figure 5.32.3: Occurrence of thickback sole in Cefas trawl surveys

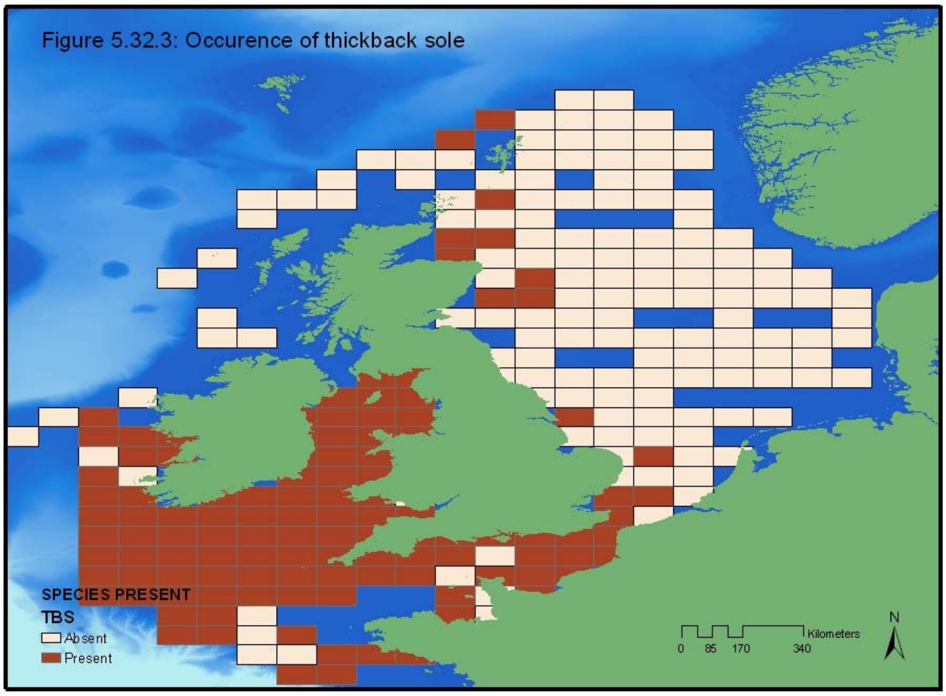

*Figure 5.32.4: Distribution of solenette eggs in the Irish Sea*

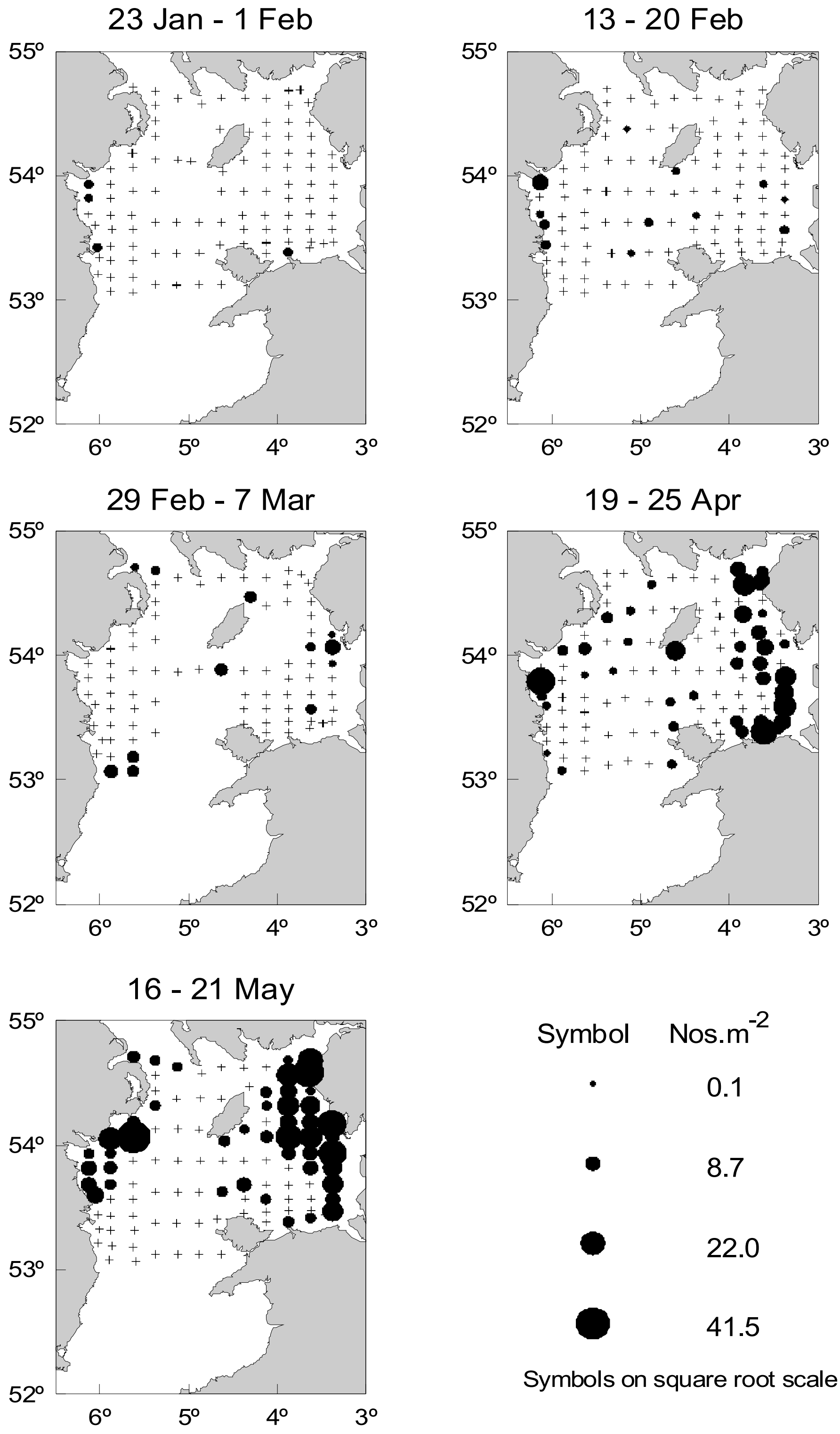


***Figure 5.32.4. Distribution (nos.m⁻²) of solenette eggs in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.32.5: Distribution of solenette larvae in the Irish Sea*

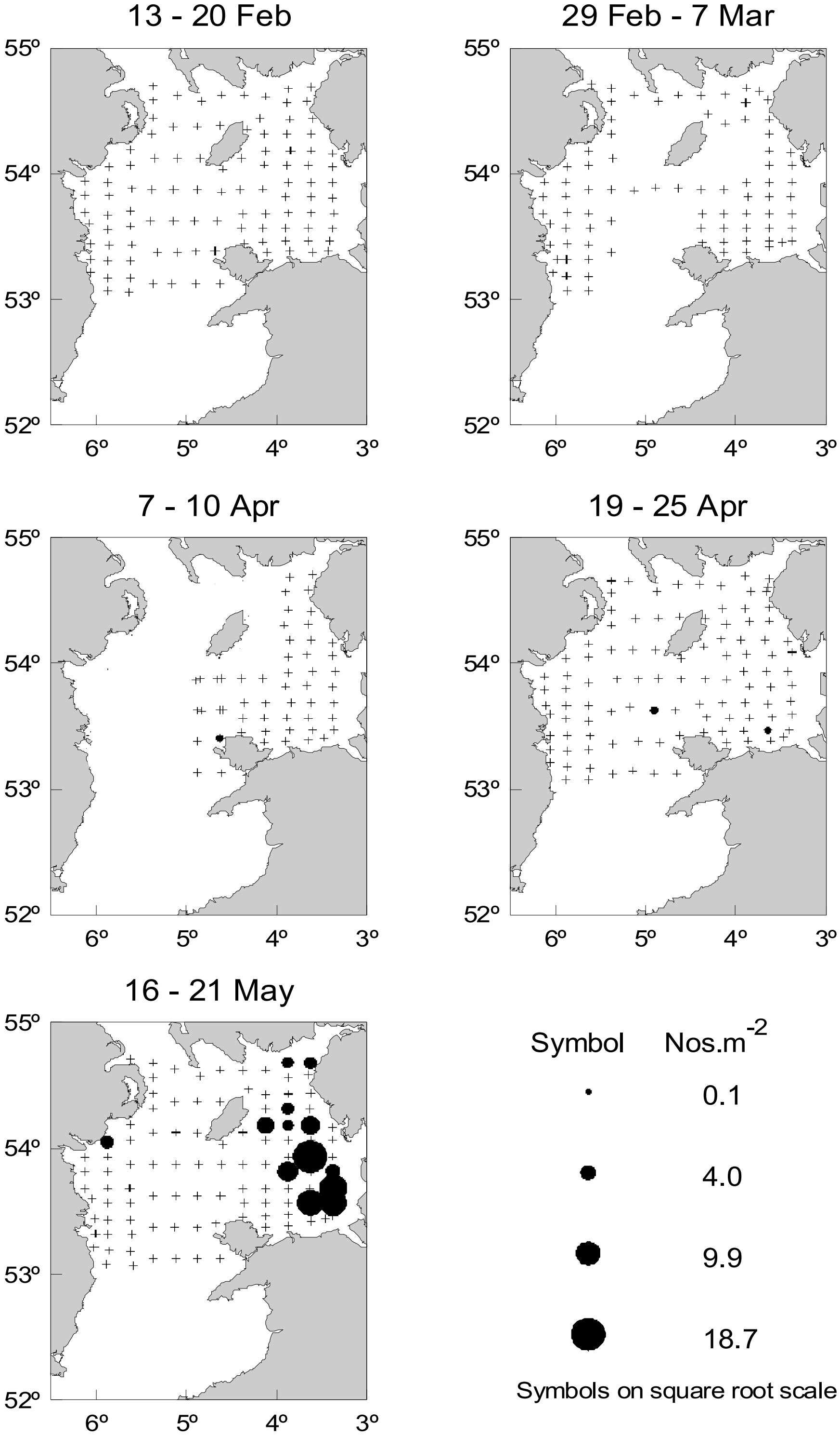


***Figure 5.32.5. Distribution (nos.m⁻²) of solenette larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.32.6: Distribution of thickback sole eggs in the Irish Sea*

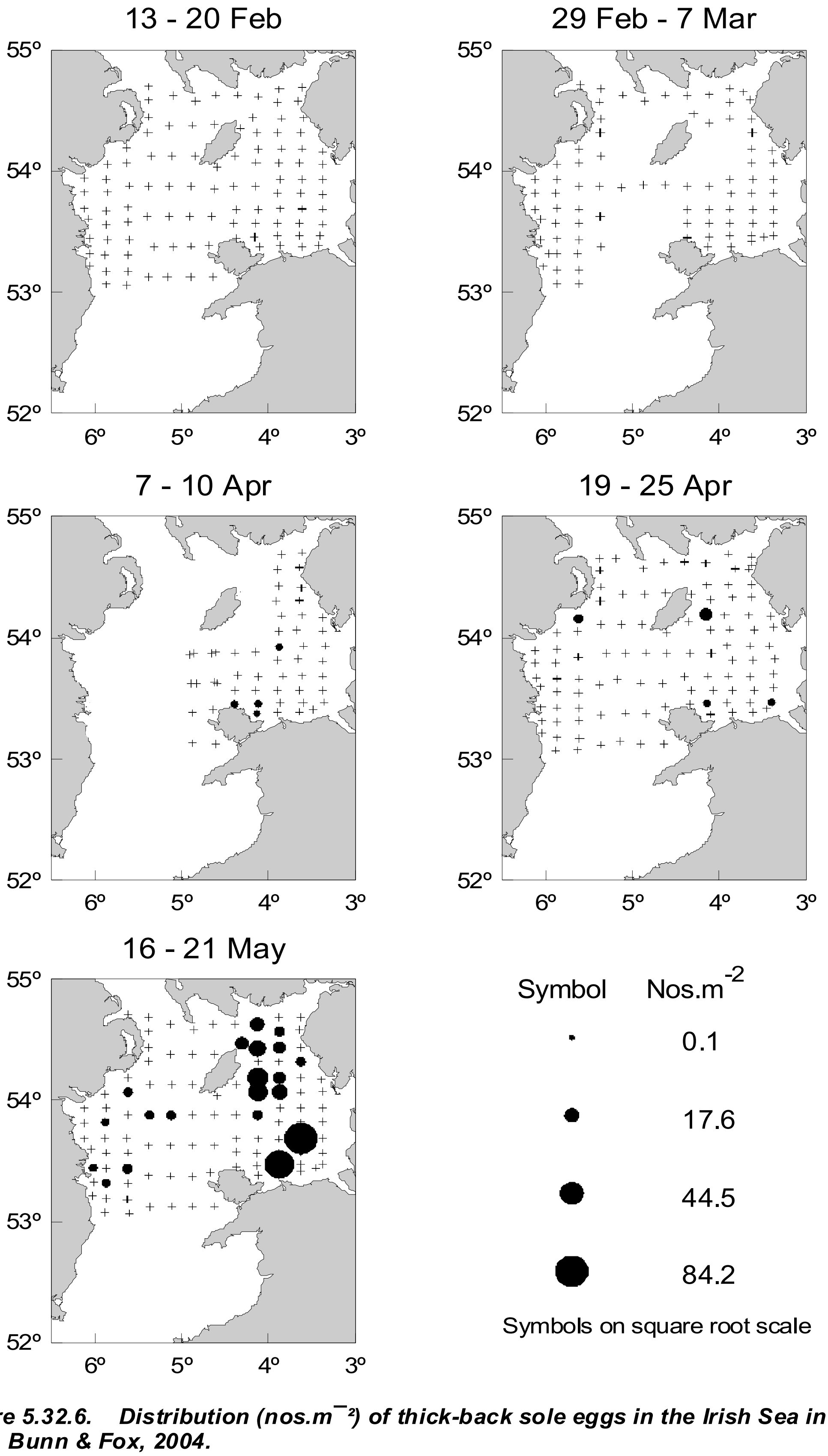


***Figure 5.32.6. Distribution (nos.m⁻²) of thick-back sole eggs in the Irish Sea in 2000. From Bunn & Fox, 2004.***

*Figure 5.32.7: Distribution of thickback sole larvae in the Irish Sea*

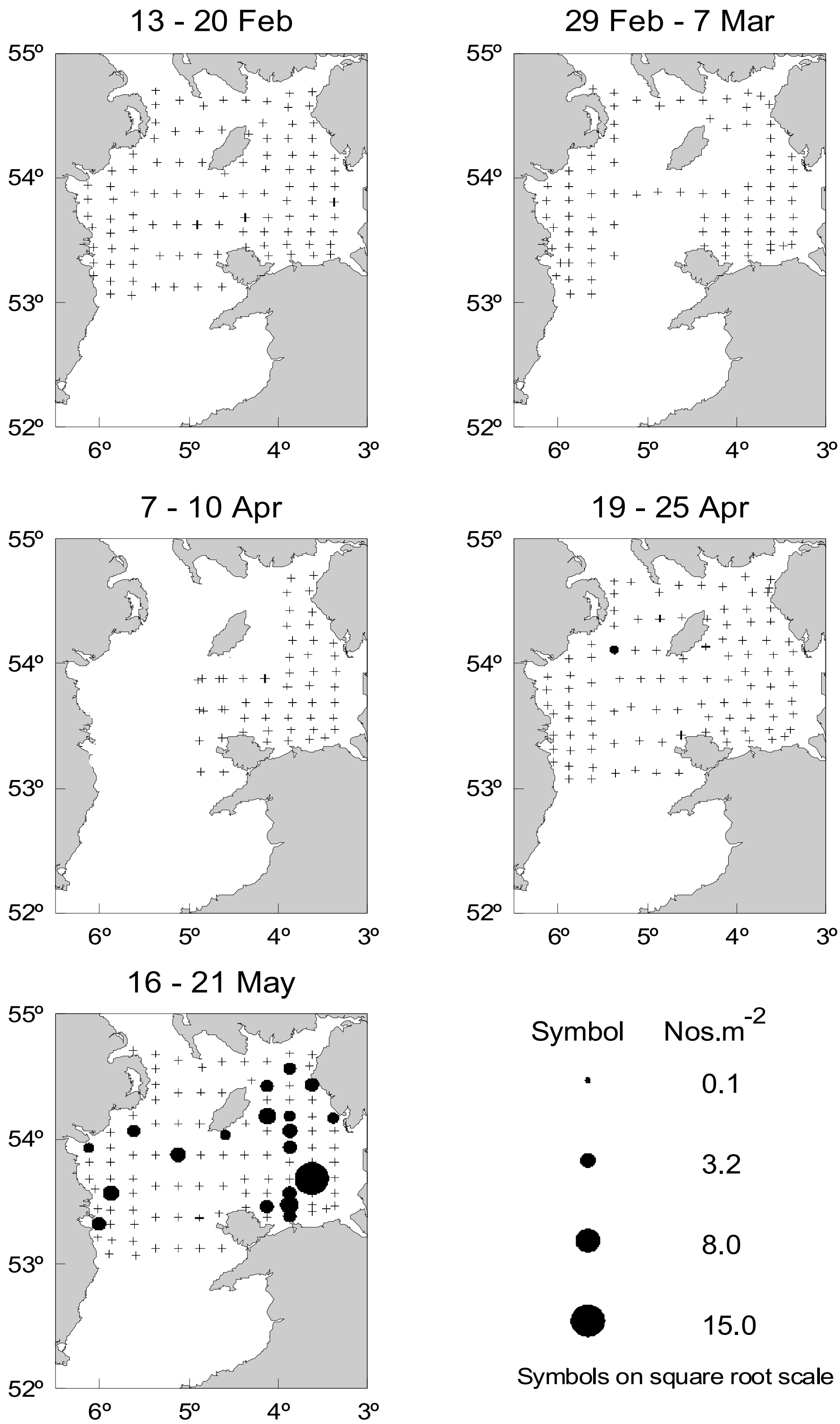


***Figure 5.32.7. Distribution (nos.m$^{-2}$) of thick-back sole larvae in the Irish Sea in 2000. From Bunn & Fox, 2004.***