

Fish larvae atlas of the NE Atlantic

Results from the Continuous Plankton Recorder survey 1948-2005

Sir Alister Hardy Foundation for Ocean Science

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Introduction and methods

The CPR survey records over 500 taxonomic entities and although the number of fish larvae on each sample is counted, they are not routinely identified to species or taxonomic group. The fish larvae project was an ambitious study to identify the fish larvae and transfer the results to a database incorporating the data from an earlier CPR Fish Atlas (1980, *Bull. mar. Ecol.*, 8). This required re-analysing over 10,000 archived CPR samples and recording over 32,000 identified specimens. The project has resulted in the creation of a unique fish larvae database of the NE Atlantic, North Sea and adjacent areas from 1948-2005. Young fish are some of the largest organisms sampled by the CPR survey, typically ranging from 2 mm to 50 mm (mean size ~12 mm), with the CPR (although selective) sampling a comparable part of each population from year to year. Due to the size of the fish larvae and the sampling method, they can often be damaged and identification to species level is not always possible using traditional microscopic methods (which was the method used in this project). However, advances in molecular analysis of CPR archived material now allow molecular identification of fish larvae. In terms of diversity, the CPR fish larvae database consists of 75 taxonomic groups or species, of which this atlas contains the distributions and time-series for the 7 most common taxa (excluding *Sebastes* spp. from the central and western North Atlantic) with an additional 2 included of particular current interest.

Table 1. Mapped species in the CPR fish larvae atlas

Species name	No. of records	Common name
Clupeidae	6183	herring/sardine/sprat
Ammodytidae	4404	sandeel
<i>Scomber scombrus</i>	1828	mackerel
<i>Micromesistius poutassou</i>	1161	blue whiting
<i>Limanda limanda</i>	860	common dab
<i>Merlangius merlangus</i>	763	whiting
Myctophidae	744	laternfish
Syngnathidae	107	pipefish
<i>Gadus morhua</i>	263	Cod

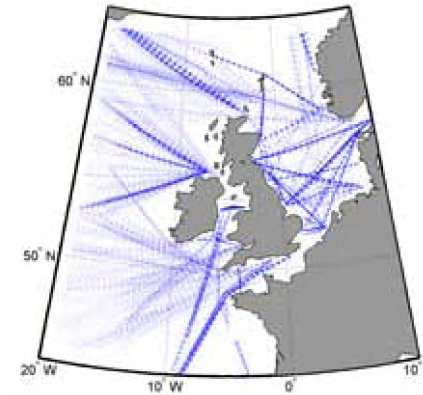


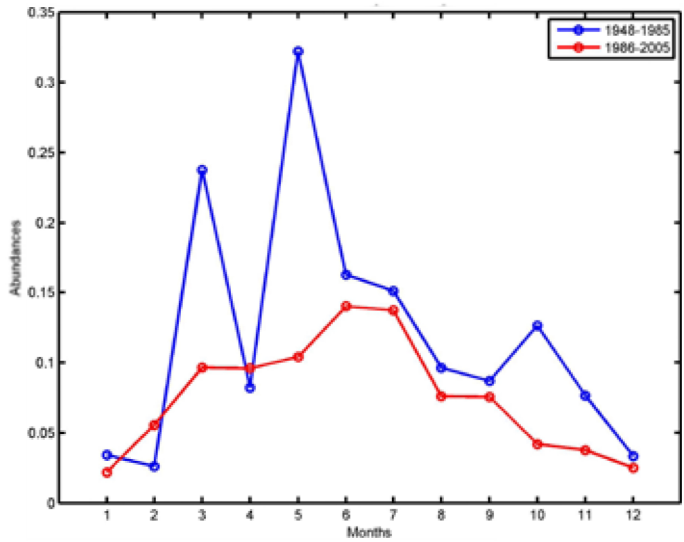
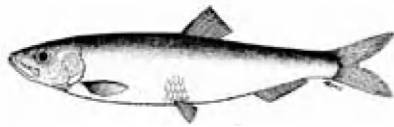
Figure 1. Distribution of CPR samples used to create the CPR fish larvae atlas.

The study area consisted of the North East Atlantic from 20°W to 10° E and 44° N to 64° N using 134,260 samples recorded over the period 1948-2005. To create the maps the data have been regularised on a grid 1°x1°. No interpolation was made with the results being based on the average number of larvae present within each grid node. With this a matrix was created (latitude x longitude x month x year x species or 21 x 31 x 12 x 58 x 14 = 6,343,344). The maps were then split into 2 time periods: 1948:1985 and 1986:2006 (pre North Sea regime shift and post North Sea regime shift) . The data have been log transformed ($\log_{10}(x+1)$).

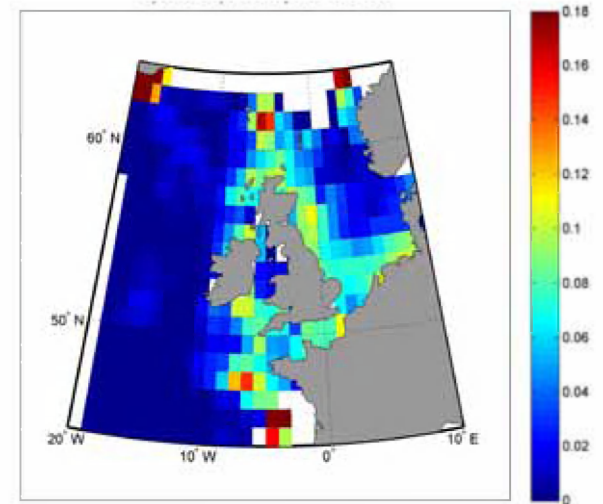
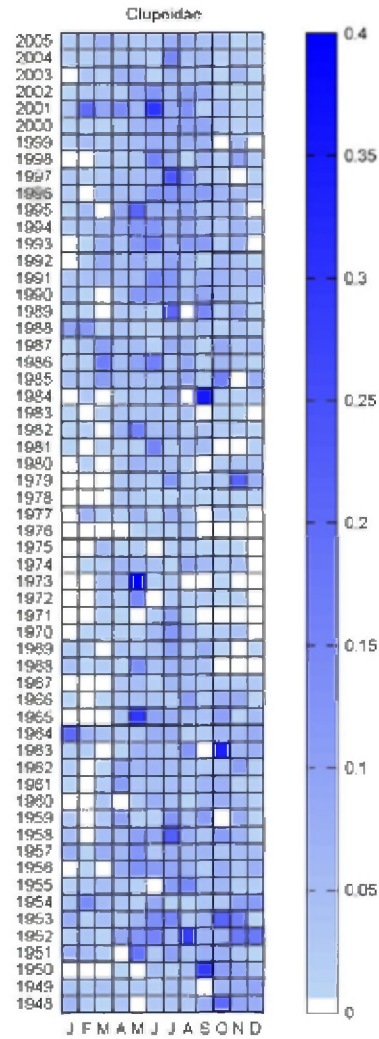


Clupeidae (herring/sardine/sprat)

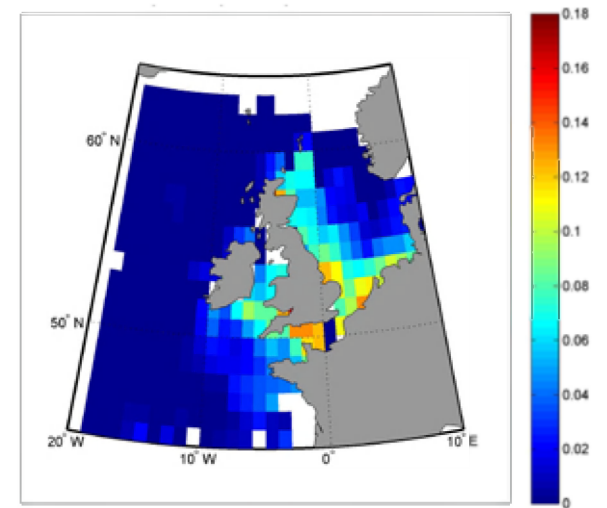
By far the most numerous fish larval group recorded by the CPR survey are the Clupeidae. In European waters Clupeidae caught by the CPR mainly comprise the herring (*Clupea harengus*), sardine (*Sardina pilchardus*) and sprat (*Sprattus sprattus*). The broad seasonal range and wide distribution reflects the multi-species composition. Most of the larvae in the south (Biscay area) are likely to be sardine (and some anchovy (*Engraulis encrasicolus*)) and those in the north (northern North Sea northwards) are herring. Intervening regions of the southern North Sea, Irish Sea and English Channel are a mixture of sprat and sardine (with the possibility of some anchovy in the German Bight). Overall, there has been a decrease in number of clupeids caught by the CPR over the last few decades and the spawning grounds have become more concentrated in the south-western North Sea and eastern English Channel perhaps reflecting an increase in sprat and sardine abundance compared to herring.



The abundance of larvae for the period 1948-1985 and 1986-2005. Monthly time series from 1948-2005.



Distribution and abundance of larvae for the period 1948-1985



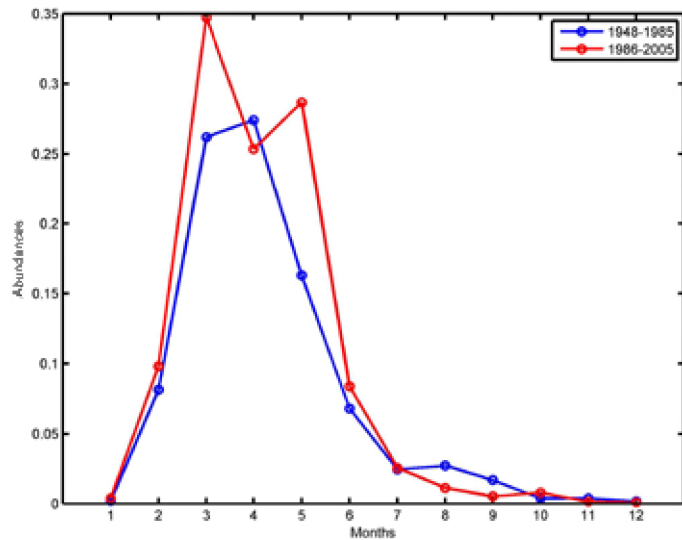
Distribution and abundance of larvae for the period 1986-2006



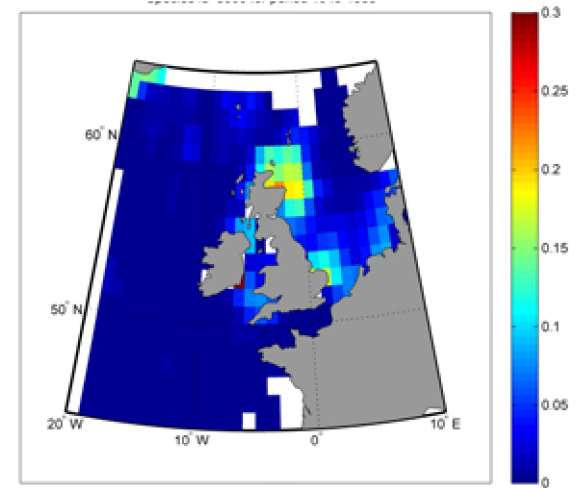
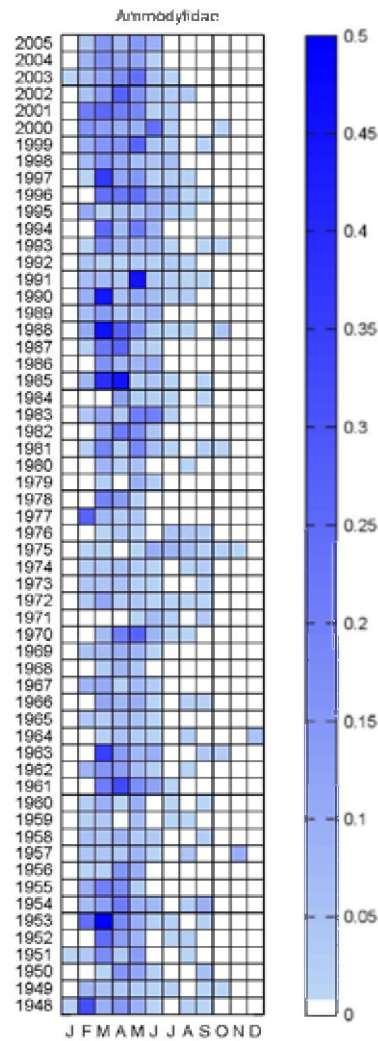
Ammodytidae (sandeel)

Young sandeels are very numerous in CPR samples and are mostly taken in shallow waters around the British Isles corresponding to the distribution of adults. The most common sandeel found on CPR samples is likely to be *Ammodytes marinus* which is most numerous during the spring. Sandeels are ecologically important to populations of fish and seabirds which rely on this species in their diet. Highest concentrations of sandeel are found off the east coast of Scotland, particularly around the Firth of Forth and off Aberdeenshire and the Shetland Islands. There is also a sizable population in areas of the southern North Sea. Generally there has been an increase in sandeel abundance recorded by the CPR survey when comparing the two time-periods, however this has declined slightly over the last few years. In an independent study using CPR samples it was observed that the average length and weight of sandeel larvae has declined quite noticeably over the last decade.

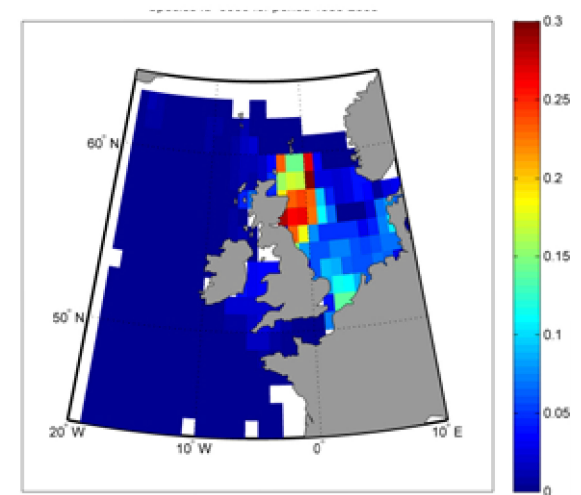




The abundance of larvae for the period 1948-1985 and 1986-2005. Monthly time series from 1948-2005.



Distribution and abundance of larvae for the period 1948-1985



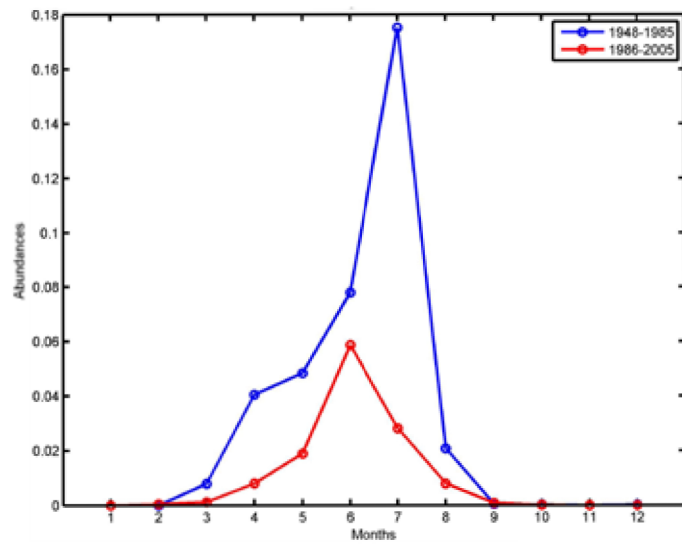
Distribution and abundance of larvae for the period 1986-2006



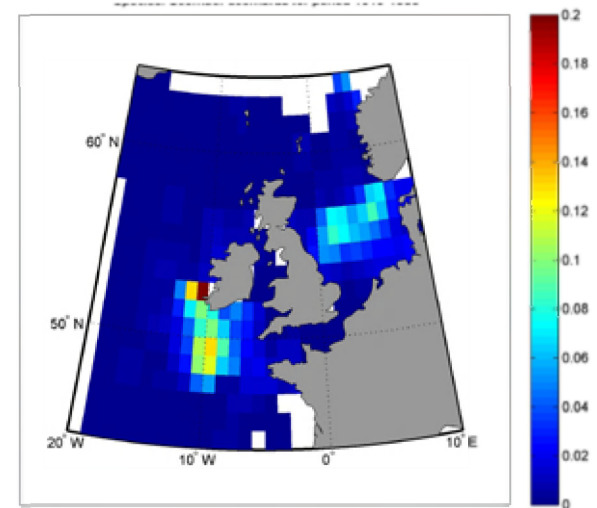
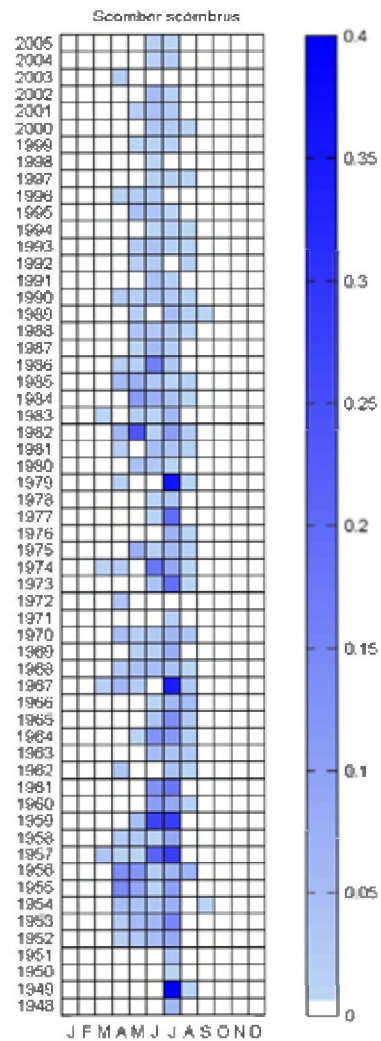
Scomber scombrus (mackerel)

Results from the CPR survey show the two separate spawning stocks of mackerel, these being in the central North Sea and to the west and south-west of the British Isles. In the North Sea mackerel larvae are caught predominately between June and August with highest numbers occurring in July (for the first period 1948-1985) and in June for the second period (1986-2005). In the Celtic Sea mackerel spawn earlier, from March to July with highest numbers occurring in April and May. Observing the overall trend, mackerel larvae have declined substantially over the last few decades reflecting the decline of first the North Sea stock and subsequently the western population.

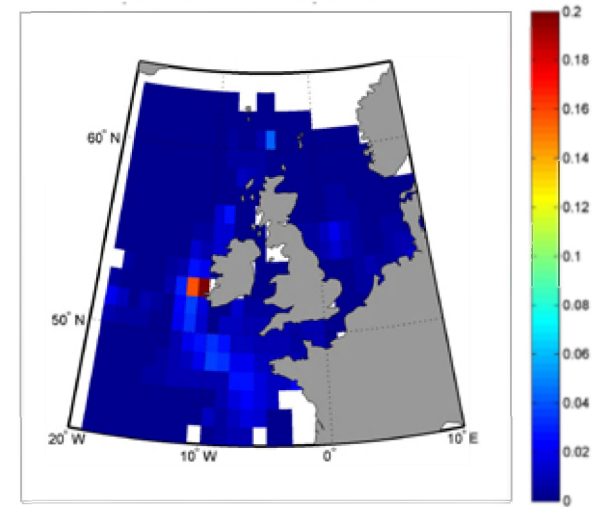




The abundance of larvae for the period 1948-1985 and 1986-2005. Monthly time series from 1948-2005.



Distribution and abundance of larvae for the period 1948-1985



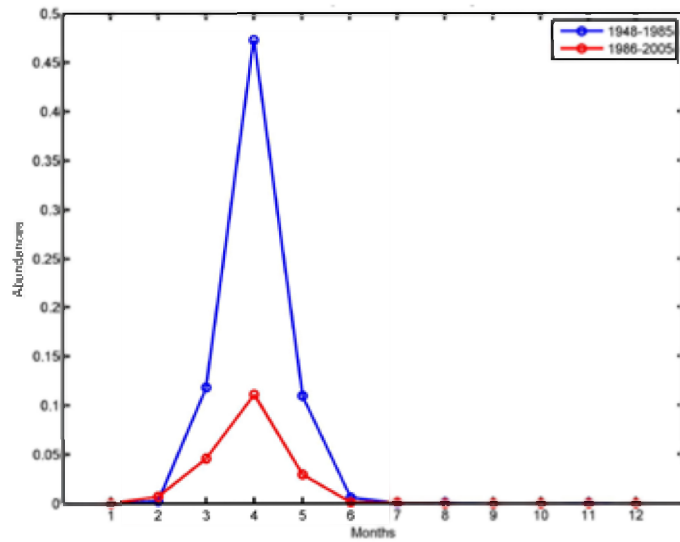
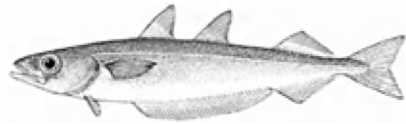
Distribution and abundance of larvae for the period 1986-2006



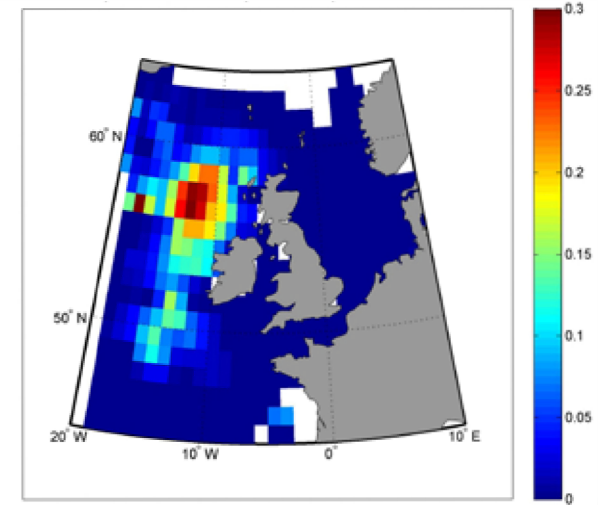
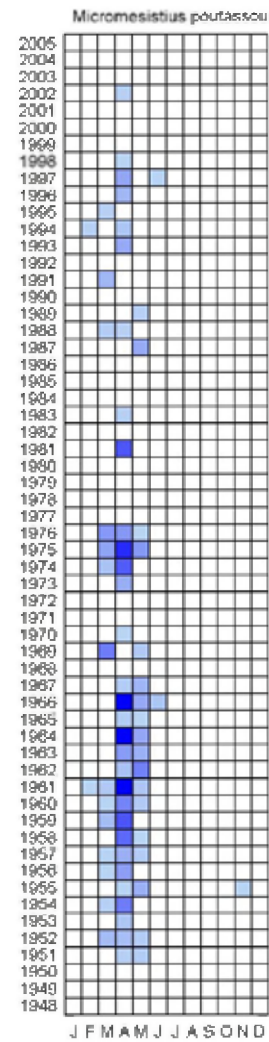
Micromesistius poutassou (blue whiting)

The blue whiting, *Micromesistius poutassou*, is a member of the gadoid (cod) family and is a common species of the north east Atlantic. The main spawning grounds are along the continental margins to the west of the British Isles. The seasonal cycle is rather short, mostly from March to May with a peak in April. Intensive fishing for blue whiting only started in the 1970s and it now constitutes an important commercial fishery with catches exceeding 1 million tonnes in the period 1998-2008. However, recruitment of the stock has fallen to a low level over the last decade. This has caused a decline in spawning stock and some strong reductions in catch quotas. Results from the CPR survey parallel this decline in spawning stock with a large reduction in fish larvae numbers over the last 3 decades (compare the plots in seasonal abundance 1948-1985 and 1986-2005).

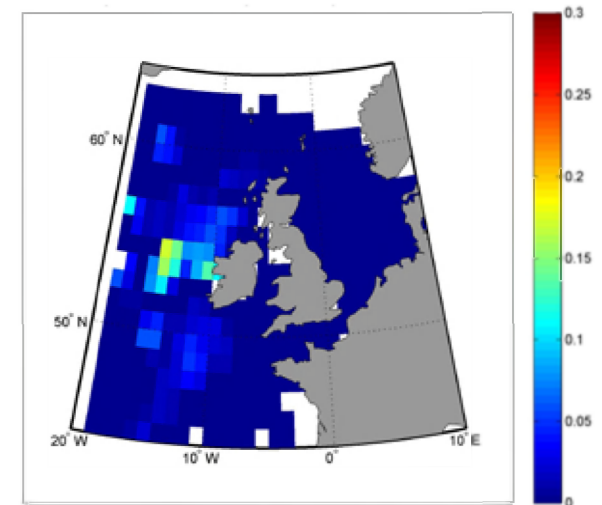




The abundance of larvae for the period 1948-1985 and 1986-2005. Monthly time series from 1948-2005.



Distribution and abundance of larvae for the period 1948-1985



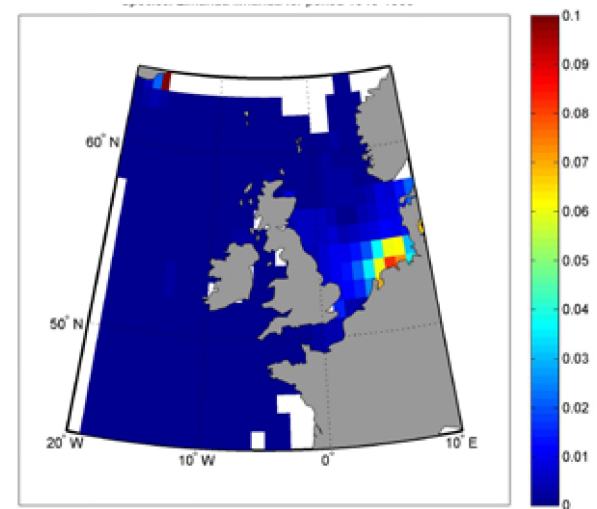
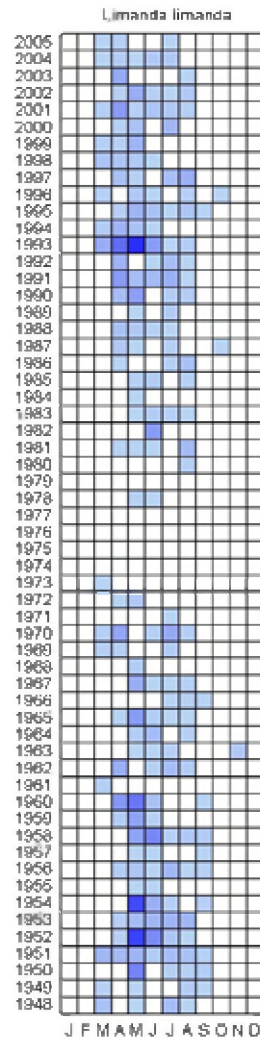
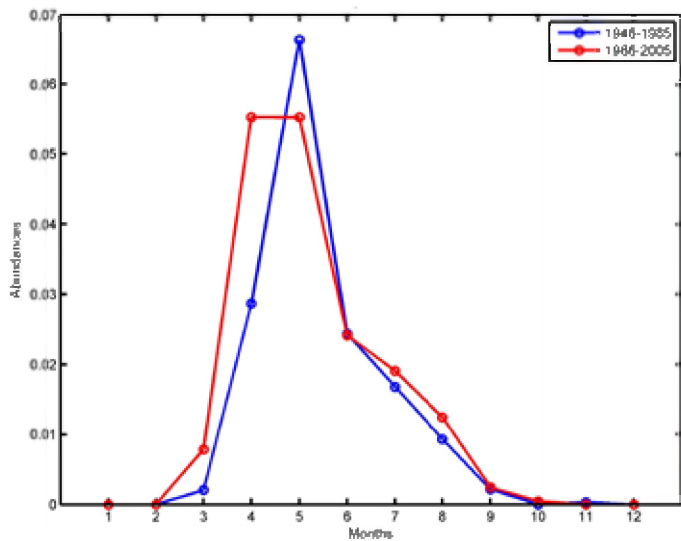
Distribution and abundance of larvae for the period 1986-2006



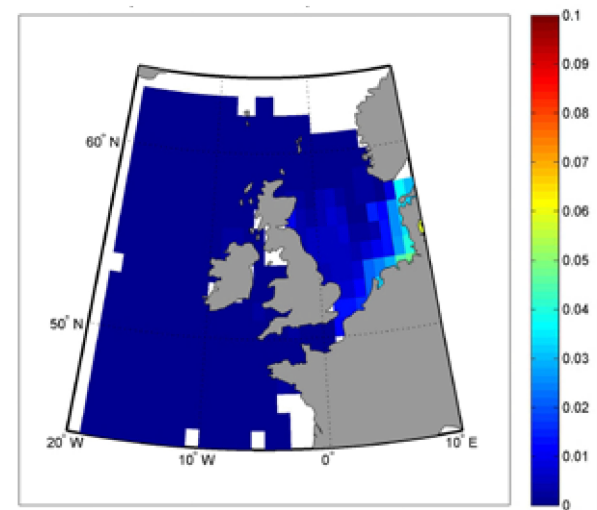
Limanda limanda (common dab)

Dab are an abundant species in the North Sea with the CPR results showing the main larval concentrations in the shallower areas of the eastern coastal margins. Comparing the two time periods, the abundance of dab larvae has recently become more dispersed away from the concentration shown in the German Bight in the earlier period. Their seasonal occurrence has also shown a slight shift to earlier spawning in the more recent period. Generally, the stock status of dab is not formally assessed and until recently the species was underexploited and not fished as a primary food source. With the decline in larger flatfish species such as sole and plaice, dab sales in the United Kingdom have increased by 50% over the last few years.





Distribution and abundance of larvae for the period 1948-1985



Distribution and abundance of larvae for the period 1986-2006

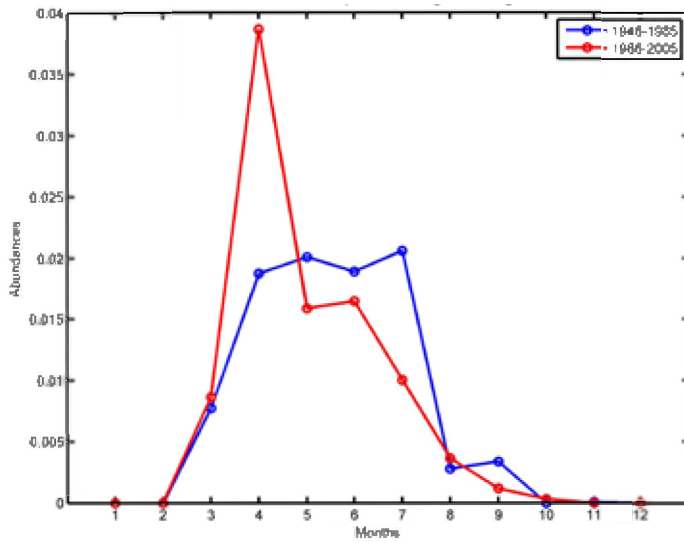
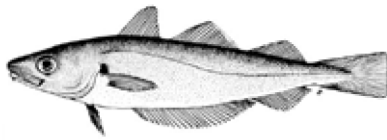
The abundance of larvae for the period 1948-1985 and 1986-2005. Monthly time series from 1948-2005.



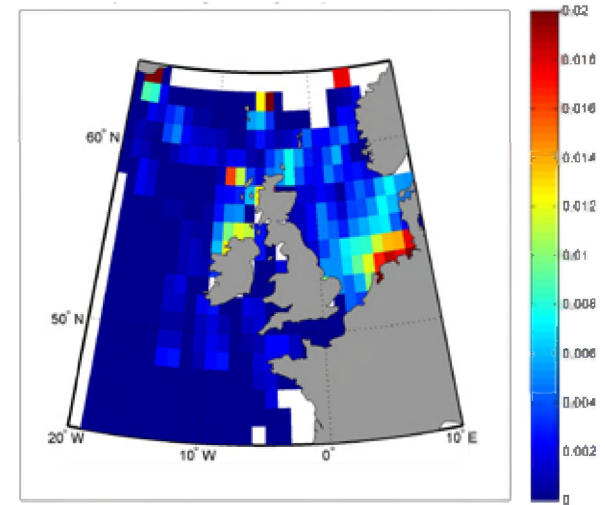
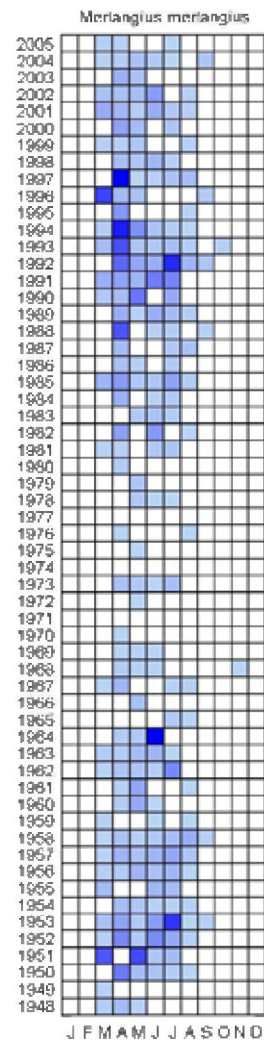
Merlangius merlangus (whiting)

Whiting is one of the most numerous and widespread gadoid species found in the North Sea. CPR results show a fairly widespread distribution around the British Isles with highest concentrations in the south-eastern North Sea. Comparing the two time-periods there is evidence for increased larval abundance in the English Channel and to the south of Ireland. Overall, numbers of larvae declined from the mid-1960s then increased from the 1980s but again reduced in the most recent decade. The spawning season is quite extended, mostly from March to July, with a prominent peak in April in the North Sea in the early 1990s. Until fairly recently whiting was a low valued catch but has become more commercially important with the general decline in other fish stocks. In the North Sea, whiting is one of the main predators of other commercial fish species such as Norway pout, sprats, sandeel, young herring, cod, and haddock.

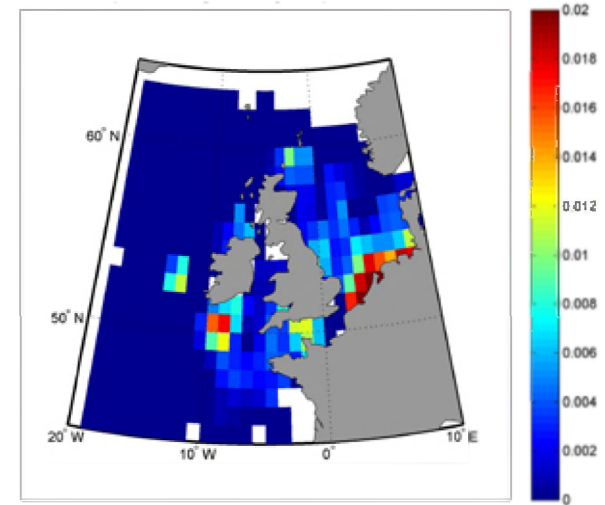




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Distribution and abundance of larvae for the period 1948-1985



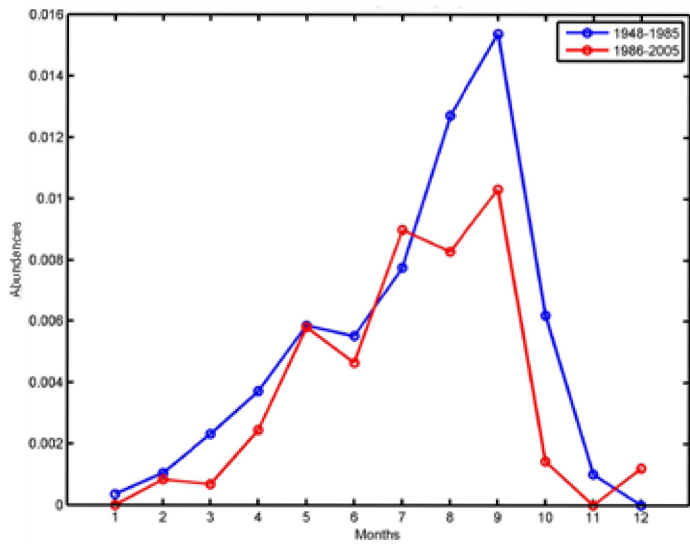
Distribution and abundance of larvae for the period 1986-2006



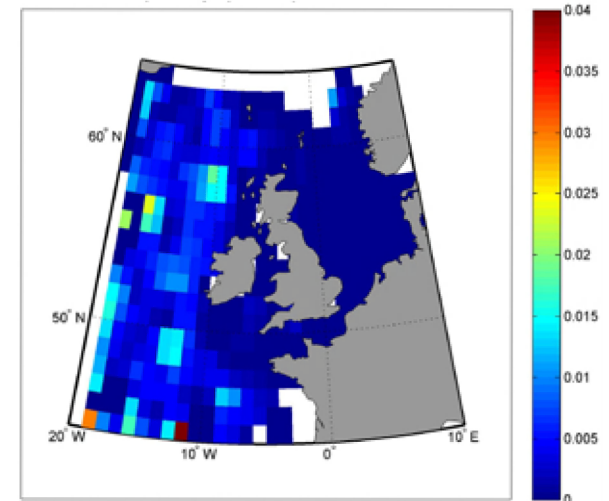
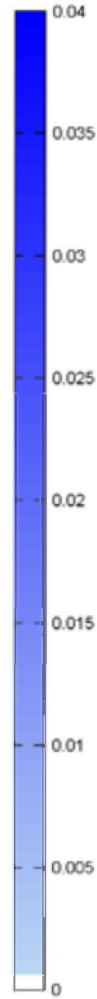
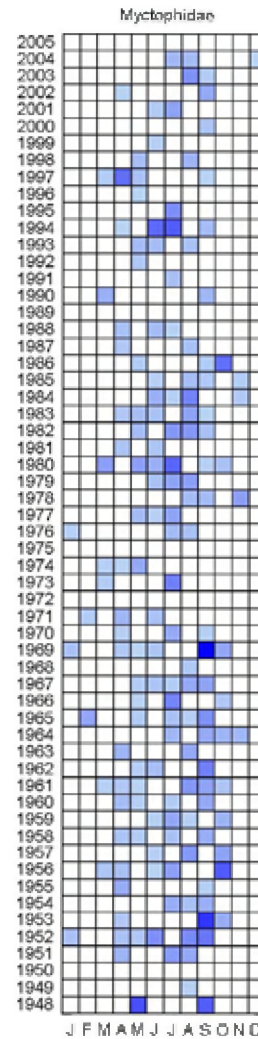
Myctophidae (lanternfish)

Lanternfish are common in CPR samples from the oceanic North Atlantic and make up a substantial portion (up to 65%) of all oceanic fish biomass worldwide. They include several taxa with the common feature of having photophores (bio-luminescent organs) distributed over their body surface. A substantial proportion of the specimens taken by the CPR Survey in the north east Atlantic were pearlsides (*Maurolicus muelleri*) with myctophids (e.g. *Myctophum punctatum*) being more common in the more southerly sampled areas. Comparing the two time-periods, lanternfish populations seem fairly stable with their extended spawning period (due to the several taxa included) peaking in September, this having changed little over time. Although lanternfish are not commercially exploited, they are a major source of food for many marine animals. They are an important link in the food chain of many regional ecosystems, particularly those in oceanic waters, and are heavily predated on by whales, dolphins, large pelagic fish such as salmon and tuna as well as seabirds. Lanternfish have a diel vertical migration following the zooplankton on which they feed. These migrations are responsible for a large part of the deep scattering layer.

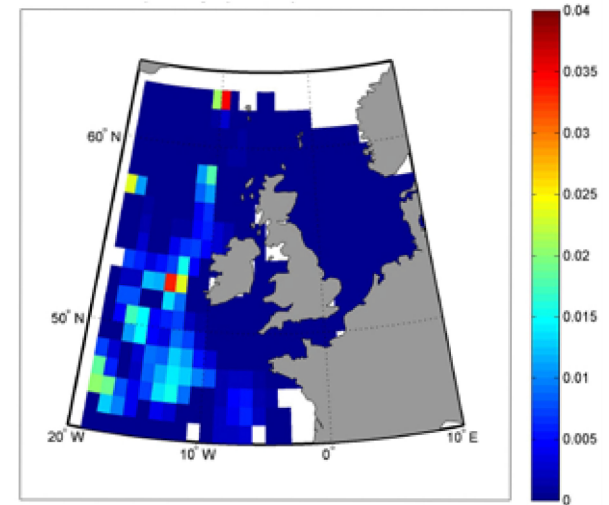




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Distribution and abundance of larvae for the period 1948-1985



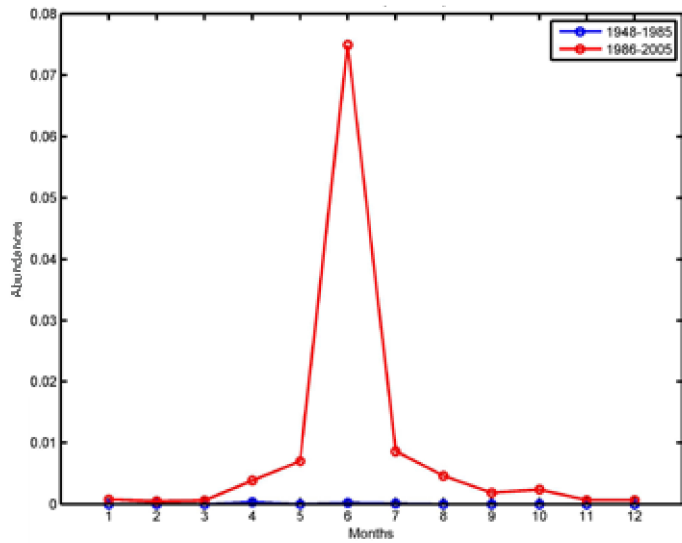
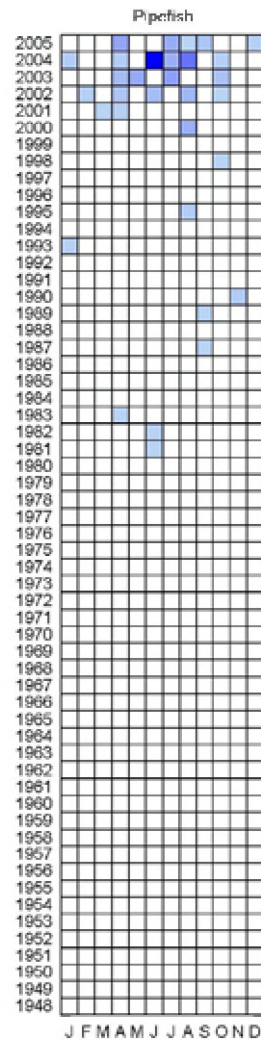
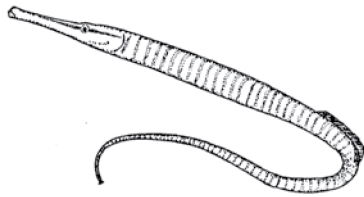
Distribution and abundance of larvae for the period 1986-2006



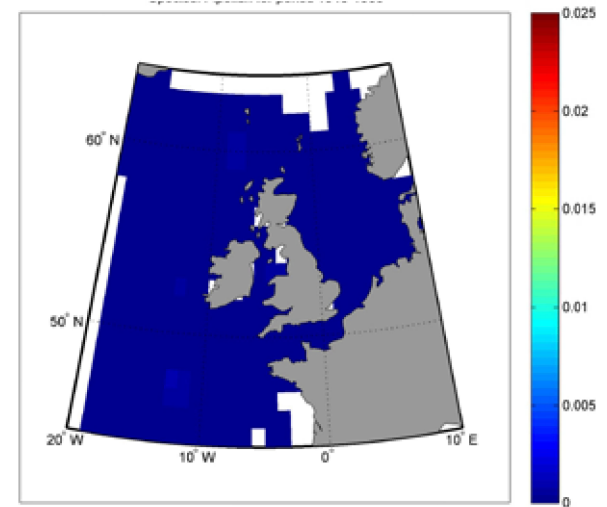
Syngnathidae (Pipefish)

Prior to the marked increase of pipefish in the north east Atlantic since 2000, young pipefish were caught only occasionally in the CPR survey. They ranged in length from 5 mm to 70 mm. Most pipefish were found to be the snake pipefish (*Entelurus aequoreus*) which are mainly found off the continental shelf west of the British Isles with abundance peaking in June. The current interest in pipefish is due their recent increase, which may have ecological implications for their predators, particularly for seabirds; only in the last decade have snake pipefish been recorded in the diet of many species of seabird. Although relatively abundant, pipefish are not an ideal food resource for seabirds due to their low energy yield compared with sandeels which are the preferred prey of various seabirds such as puffins and kittiwakes. These changes, in association with climate warming, have been implicated in the decline in breeding success of many seabird colonies off the east coast of the British Isles. The reason for the recent increase in abundance of pipefish is not yet fully understood.

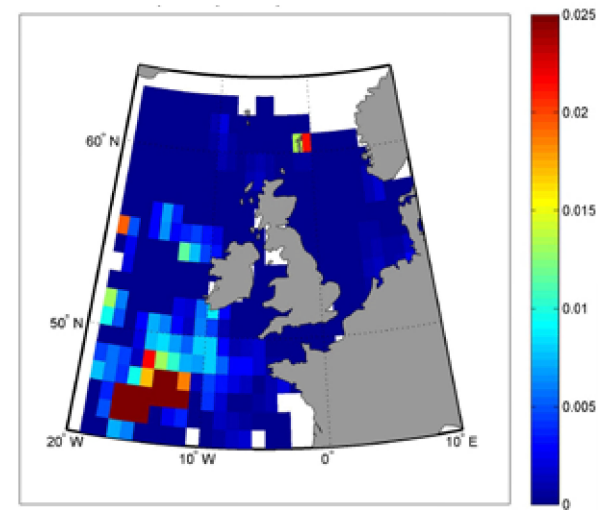




The abundance of larvae for the period 1948-1985 and 1986-2005. Monthly time series from 1948-2005.



Distribution and abundance of larvae for the period 1948-1985



Distribution and abundance of larvae for the period 1986-2006



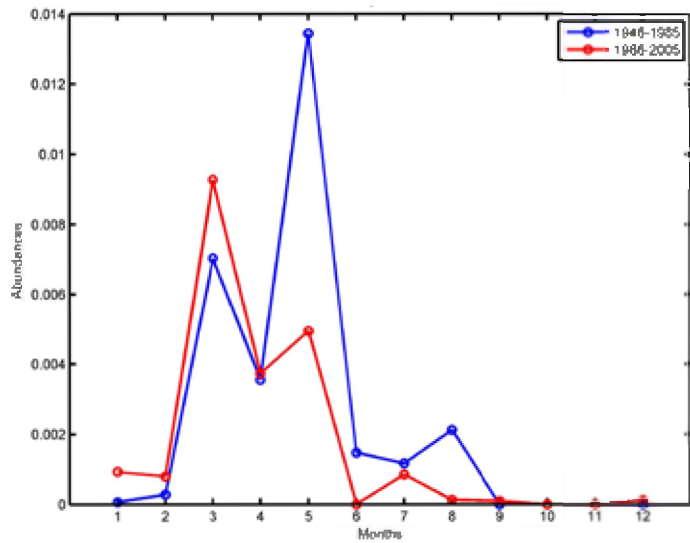
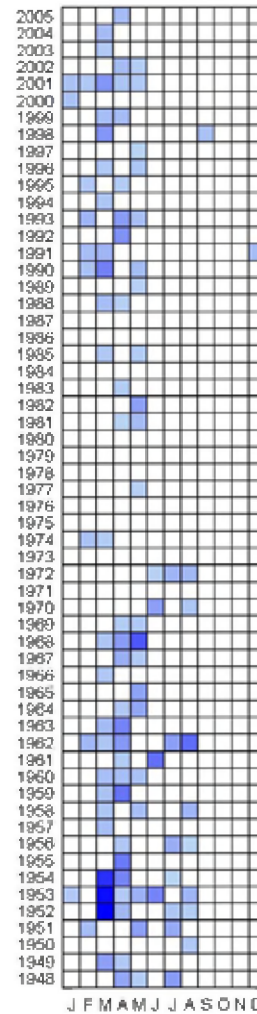
Gadus morhua (Atlantic cod)

Although cod spawn around the entire North Atlantic basin they are infrequent in CPR samples. They are included in this atlas for current interest due to their high commercial value in fisheries. In the North Sea larvae were found mostly from March to July with maximum numbers occurring between March and May. Overall, there has been a decline in numbers of larvae taken by the CPR, particularly in the 1970s and a northwards shift in distribution. This is consistent with a northerly displacement of a relatively cold water species in response to the long-term warming trend.

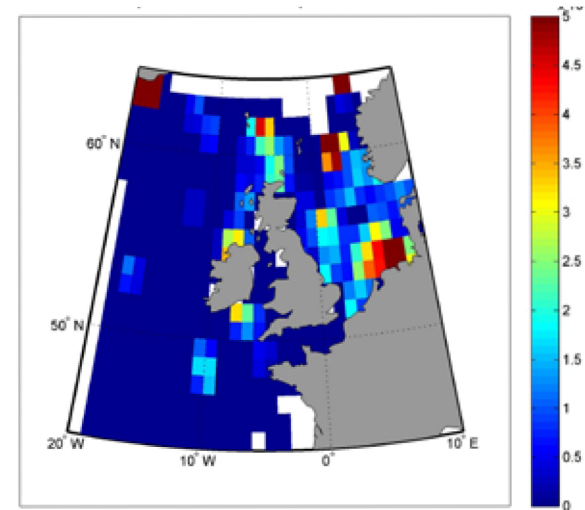




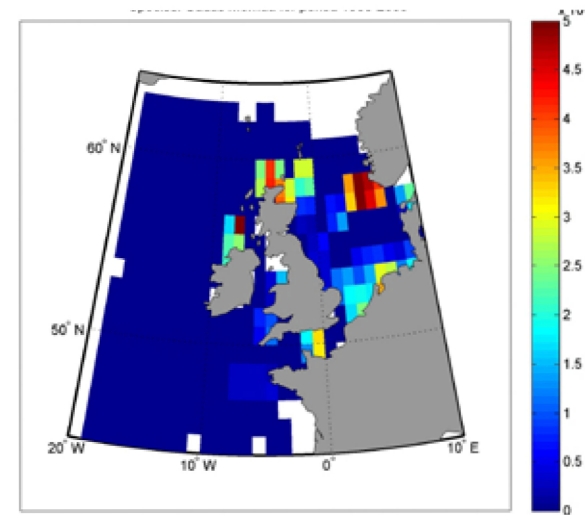
Gadus morhua



The abundance of larvae for the period 1948-1985 and 1986-2005. Monthly time series from 1948-2005.



Distribution and abundance of larvae for the period 1948-1985



Distribution and abundance of larvae for the period 1986-2006

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