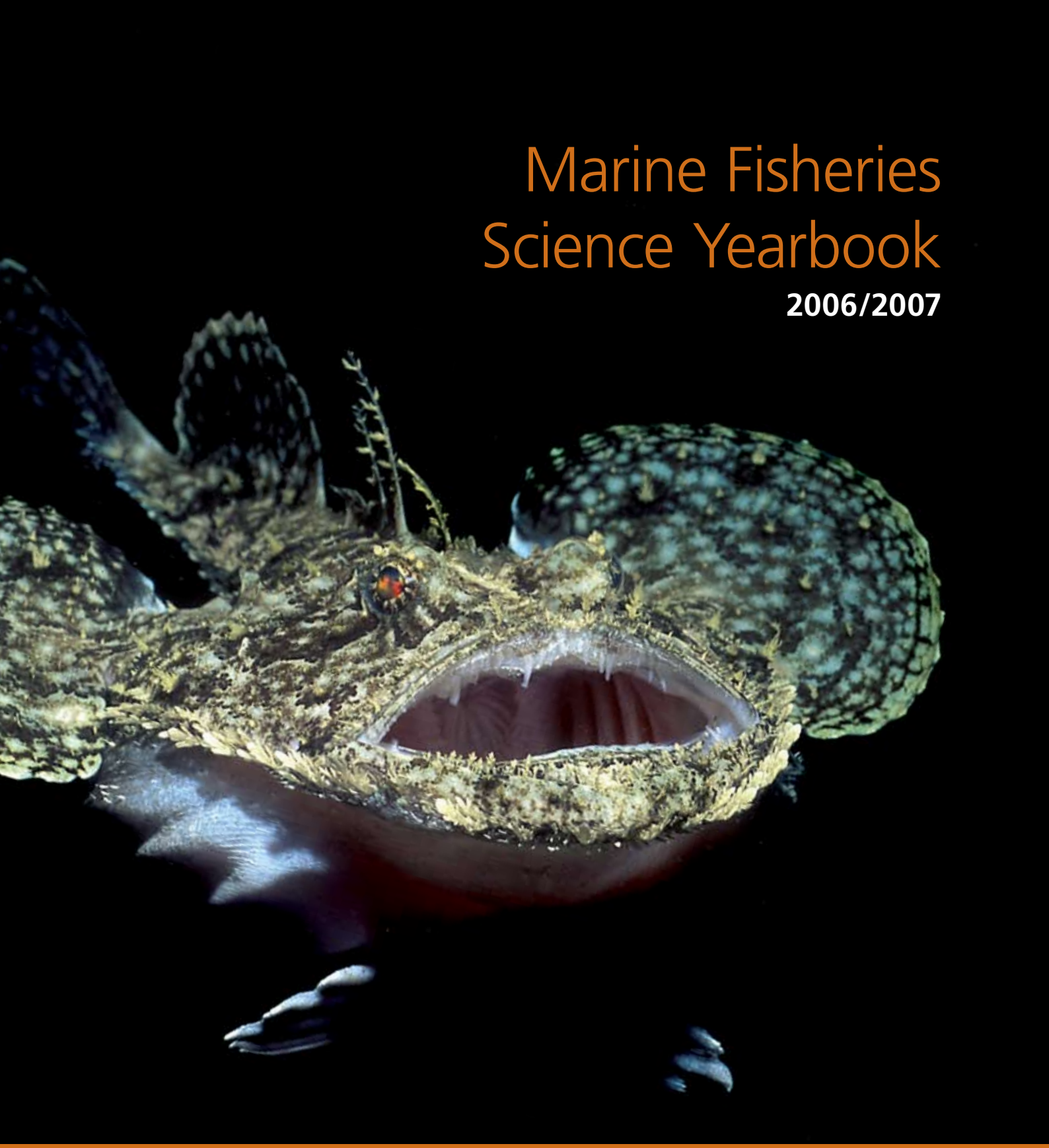
Marine Fisheries Science Yearbook

2006/2007



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Introduction

Defra funds scientific work to increase our understanding of marine fisheries. We need scientific information to develop soundly-based policies for managing fisheries in our waters and to enable us to negotiate effectively in the European Union (EU).

This yearbook highlights a range of marine fisheries science projects to illustrate the work funded from April 2006 to March 2007. As this is our first yearbook, we have also included a few projects completed in 2005/2006 to illustrate the range of research topics. We are publishing the yearbook to promote understanding of what fisheries scientists do and to help people interested in fisheries to contribute ideas for future scientific work, which will build on existing work or fill gaps. A list of all the marine fisheries science projects we funded in 2006/2007 is on pages 35–41.

We fund two long-standing types of marine fisheries scientific work:

- Fish stock monitoring and assessments provide annual information about the state of fish stocks, which feeds into international scientific advice (pages 6–9).
- Sustainable marine fisheries research includes long-term research into issues such as the status and structure of fish stocks around our coast and the impact of climate change on them (pages 10–23).

Recently we have started funding two initiatives to promote more involvement in marine fisheries science of those people with an interest in fisheries:

- The Fisheries Science Partnership, which started in 2003, charters commercial fishing vessels to do surveys of particular fish stocks or other scientific investigations. These are carried out in the normal commercial fishing grounds and using the normal gear of the chartered vessels (pages 24–29).
- The Fisheries Challenge Fund, piloted as the Ad Hoc Fisheries Science Fund, supports short-term scientific projects as well as economic and social projects suggested by organisations with an interest in fisheries (pages 30–33).

Fish stock monitoring and assessments

Stock monitoring

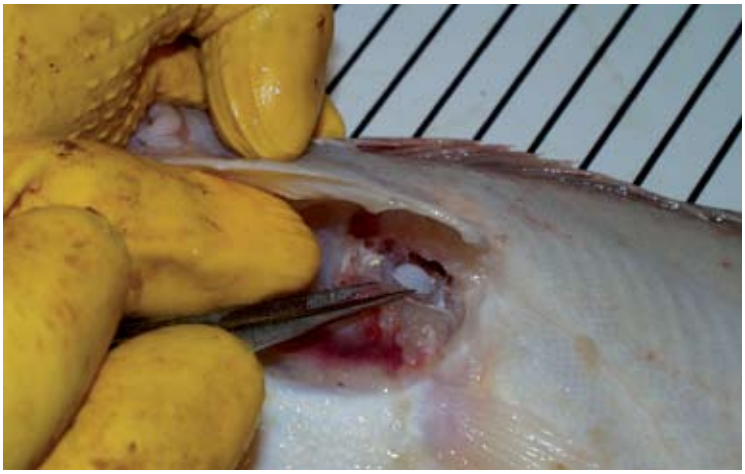
Monitoring work, involving market sampling, fishing surveys and discard sampling, is organised by national laboratories, such as the Centre for Environment, Fisheries and Aquaculture Science (Cefas). Monitoring provides the basic information used by international working groups within the International Council for the Exploration of the Seas (ICES) and the EU's Scientific Technical and Economic Committee for Fisheries (STECF) to assess the status of stocks. Their advice feeds directly into policy decisions on the management of fisheries in UK and international waters.

Market sampling

Why do we need to sample catches?

Each year, Cefas organises a large programme to sample fish caught in commercial fisheries around England and Wales as part of the UK's commitment to monitor fish stocks under the European Data Collection Regulation. The main purpose of this programme is to estimate the age composition of the catches. This information is an important part of the stock assessment calculations done by the international scientific working groups organised by ICES. The sampling involves measuring the length of a large number of fish and also taking the small ear stones, or 'otoliths', from about one in ten of the fish measured (Figure 1). By examining the otoliths under a microscope it is possible to read the fish's age.

Figure 1: Otolith being removed through the gills of a plaice so that the fish is not damaged and can still be sold.



Shellfish are sampled for size (Figure 2) and other studies provide age data.

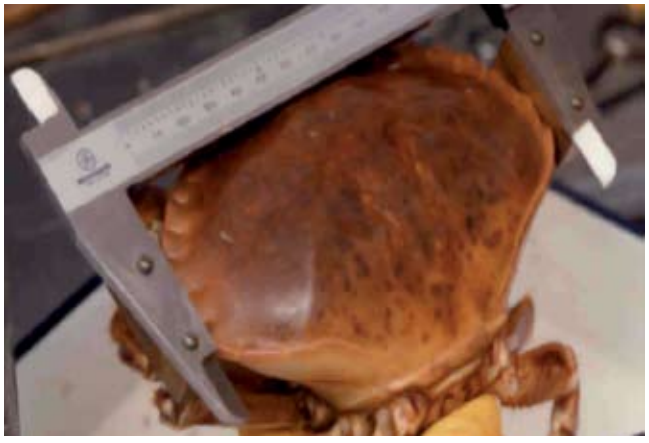


Figure 2: Measuring the carapace width of a brown crab.

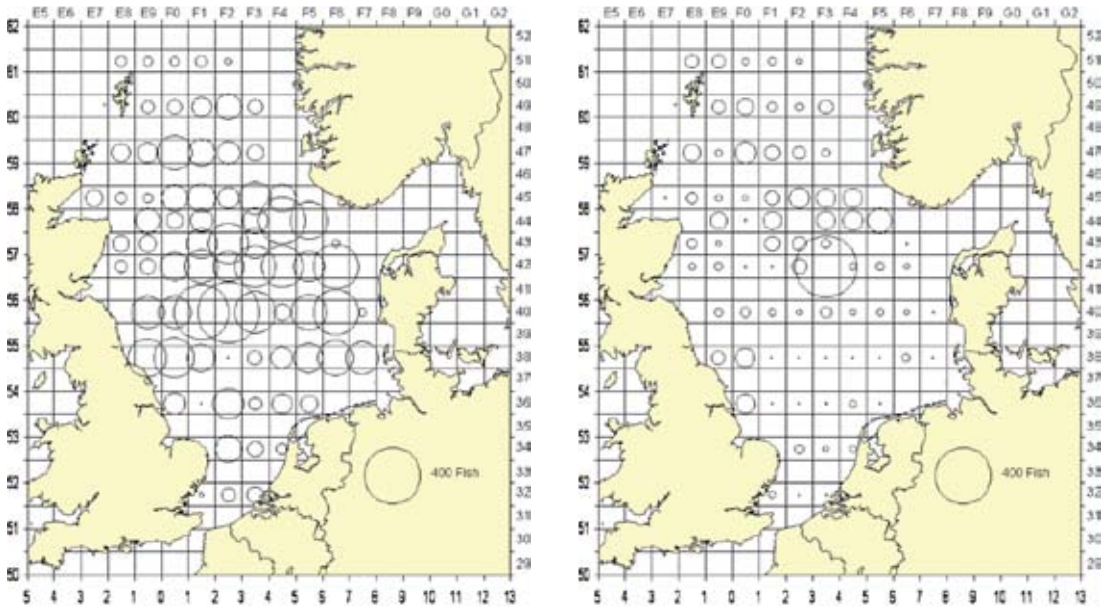
What data were collected in 2006?

A total of 226,000 length measurements and 24,500 samples for age determination were collected from finfish landings and 44,000 length measurements from shellfish. All the main fleets and gear types which contribute significantly to the English and Welsh landings were sampled during the year.

Fishing surveys

Why do we conduct research surveys?

In recent years, as some commercial catches have declined, ICES has had to rely more heavily on research vessel surveys for estimating the abundance of commercially exploited stocks. Cefas contributes towards this process through a number of annual surveys carried out on its own research vessel, *Endeavour*, and on chartered fishing vessels. The main purpose of the surveys is to maintain long-term data series on distribution and abundance of commercial species (Figure 3). They also provide useful data on species that do not have a commercial value. Research vessel surveys allow additional biological information, such as gut contents, to be collected on fish which cannot be obtained from commercial surveys or market sampling.



1980 – 2004 **2005**

Figure 3: The maps show the results from the research vessel surveys conducted in the North Sea in August each year. The size of the circles indicates the relative abundance of cod in each rectangle. The average abundance of cod in the period 1980-2004 (left panel) is compared with the abundance in 2005 (right panel).

What data were collected in 2006?

A total of 100 ship-days were devoted to four research vessel monitoring surveys in the North Sea, eastern Channel, Celtic Sea and a combined survey in the Irish Sea and Bristol Channel. A further 58 days' fishing were undertaken on chartered commercial vessels surveying for bass in the Solent and Thames, herring in the Thames, flatfish in the western Channel, and juvenile flatfish along the coast from the Humber round to the Isle of Wight.

Discard sampling

Why do we sample discards?

We need to gain as complete a picture as possible of the fish killed by commercial fisheries, so we sample the fish discarded by fishermen as well as their landed catch. Fish may be discarded because they are too small to be landed or because the fisherman does not have a quota for that species. The current discard sampling programme is designed to obtain information on the numbers and size of fish discarded, but the programme also provides more detailed data on catch rates to improve the current assessments of fishery performance. This programme is also part of the European Commission Data Collection Regulation, and there is therefore a statutory requirement for regular sampling of all segments of the fishing fleet in England and Wales.

What sampling is done?

Industry Liaison Officers (ILOs) from Cefas carry out the current discard sampling programme, sailing with a selection of fishing vessels and measuring the discarded and retained portions of the catch (Figure 4). The ILOs travel as guests of the industry and aim to observe normal fishing activities. They aim to sample 600 fishing days per year, and this is spread between all the major fleet types within English and Welsh waters. As part of this programme Cefas also carries out observer trips on vessels fishing for deep water species to the west of the British Isles.

Figure 4: Measuring discarded fish on a commercial fishing boat.

Stock assessments

What are stock assessments?

Commercial finfish and shellfish stocks are assessed by international scientific working groups organised by ICES, which meet each year. Assessments involve estimating the size and composition of the stock and providing options for the future management of the fisheries. The main data used to assess the status of the stock are the estimated numbers of fish of each age group caught by the commercial fleets. These data are obtained from the sampling programmes and provided by each country represented on each working group. Additional data, such as more detailed, catch-per-unit-effort information obtained from research vessel catches, may be used to improve the understanding of the results of the assessment.

Sustainable marine fisheries research

Defra is committed to the sustainable use and protection of our marine resources and ensuring that management decisions are based as far as possible on sound scientific information. We therefore need a range of information on the fish stocks around our coast. For example, we need to know whether there are separate spawning populations and to what extent these populations mix at different times; how the birth and death rates of fish have changed over time, and how these have been altered by fishing and by changes in the environment; and what sustainable fisheries are and how we achieve them.

Defra funds the following research areas:

- **Impact of fishing on the marine ecosystem** – to understand how fishing affects the productivity of the fish and shellfish resource and other vulnerable species and habitats in the ecosystem.
- **Effects of the environment on fish stocks** – to understand how changes in environmental conditions affect fisheries productivity.
- **Fisheries management** – to provide the tools for better fisheries management including improved understanding of the status of fish and shellfish stocks.

This work is carried out by Cefas, universities and research centres, often working in partnership. The research supports international work carried out through ICES and the STECF, as well as linking with various EU-funded research programmes.

Impact of fishing on the marine ecosystem

Developing indicators for fisheries management

To manage fisheries effectively we need to take account of the full range of the effects that fishing has on ecosystems. To support this approach we need biodiversity indicators that provide information on the state of the ecosystem, the effects of fishing pressures and the progress of management in relation to specific objectives. Such indicators are now being developed to support national and international policy commitments.

Cefas is developing and testing indicators of the effects of fishing on rare and vulnerable fish. These indicators are calculated from trends in the abundance of fish species caught during trawl surveys, and provide one way of measuring the effects of fishing on biodiversity. Since the catches of rare and vulnerable fish, such as the common ray (Figure 5), in trawl surveys are very variable from year to year, it can often take many years to detect true trends in abundance. But the number of years of monitoring needed to detect a specified change can be reduced when groups of species are used.

The power of indicators to detect trends in the abundance of rare and vulnerable species can also be improved by changes to the design of monitoring surveys. Cefas is now investigating how changes in the number and location of survey stations in the North Sea can affect the ability to detect change.

The indicators provide information on trends in marine biodiversity and indicate how biodiversity is affected by changes in fishing practices and the environment. They will allow managers to make clear and scientifically justified responses to questions about the relative impacts of fishing on marine biodiversity.

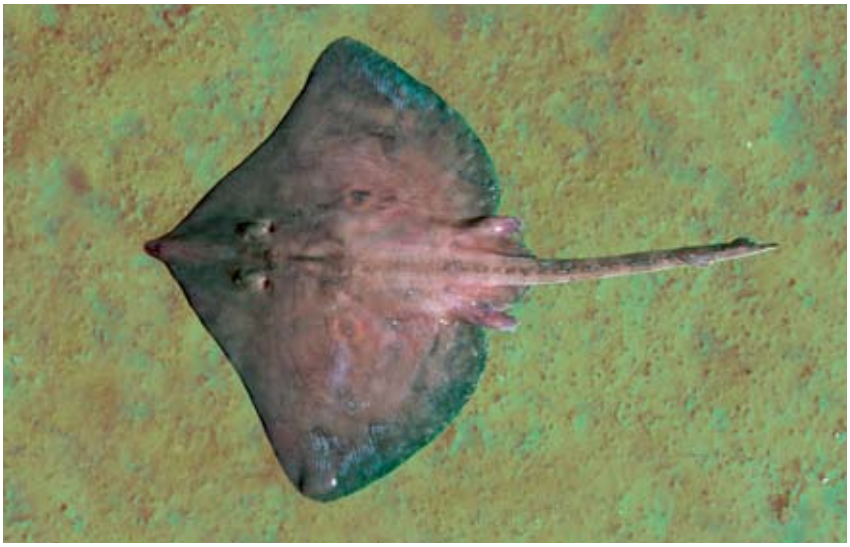


Figure 5: Common ray – a potential indicator species for monitoring the effects of fishing on the marine ecosystem.

Impacts of bottom trawling

Bottom trawls can have locally damaging effects on the seabed and many of the species that live there. Trawl doors, tickler-chains and others parts of the net may dig into the seabed, and plants and animals in the path of the net may be damaged or destroyed. However, the effects of these fishing methods over large areas of the seabed are not known.

Scientists from Cefas and the University of Wales, Bangor conducted the first large-scale study of the effects of beam trawling on different habitats in the North Sea. They used a model that took account of the effects of differences in the nature of the seabed on the communities of animals that live there, to estimate the effects of known levels of fishing activity in the North Sea. Predictions suggested that the impacts of the North Sea trawl fleet have reduced the biomass of small bottom dwelling animals by about half. The results also showed that trawling was unlikely to have an important impact on the food supply for commercial fish, even though it did have unsustainable effects on quantity and diversity of species in areas with low levels of natural disturbance. The observed effects of beam trawling in the North Sea are much smaller than would be expected if trawling effort were more evenly distributed.

Cefas is doing further work to model the effects of management actions, such as closed areas, on biomass and diversity, and to develop methods to classify habitats on the basis of their vulnerability to trawling (Figure 6).

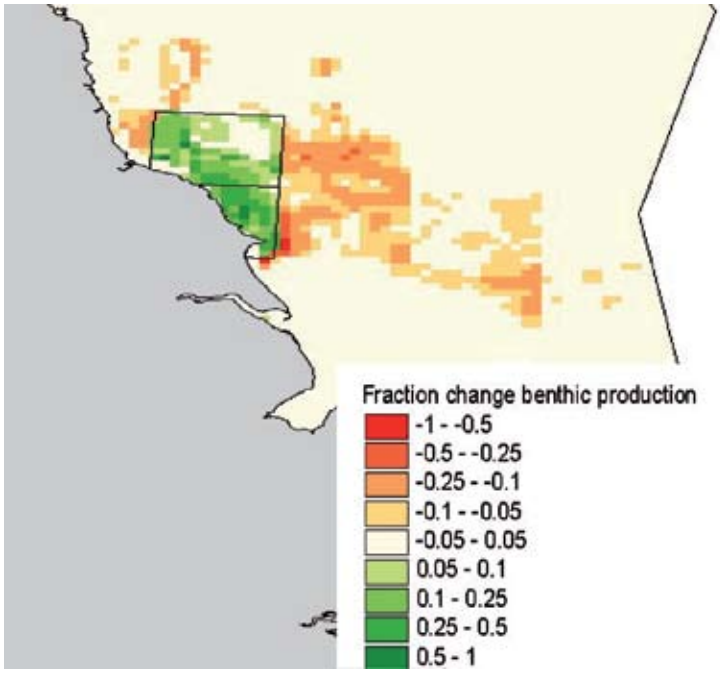


Figure 6: Predicted effects of an area closed off to fishing on the relative production of bottom dwelling (benthic) communities off the north-east coast of England. Green squares inside the closed area indicate that production increases because trawling is stopped. Orange squares in the surrounding area indicate that displaced trawling effort reduces production there. (Jan Hiddink, University of Wales, Bangor).

Beam trawling in areas with low levels of natural disturbance has a much greater impact than in more disturbed areas. The overall effects of trawling are much reduced when effort is concentrated in areas with high levels of natural disturbance. The patchy distribution of effort that results from fishermen repeatedly visiting their favoured fishing grounds will minimise the environmental impacts of trawling. It is therefore best to avoid management actions that lead to the re-distribution of trawling effort, such as area closures in favoured fishing grounds.

Reducing bycatch in fishing gear

Fishing nets often capture or damage unwanted species as well as those being sought by fishermen. A wide variety of species may be affected, ranging from simple bottom-dwelling invertebrates to fish, birds, reptiles and marine mammals. Individual animals are often fatally injured during fishing operations. The amount of such unwanted bycatch is affected by a range of factors including the design of the nets, and so there are opportunities to reduce these impacts by modifying the design of the nets.

Cefas has worked closely with fishermen and other agencies such as The Sea Fish Industry Authority (Seafish) to re-design fishing nets to reduce undesirable bycatch in fisheries where they are known to occur. Recent work has included: assessing the effects of increased mesh sizes in the southern North Sea sole gill net fishery; reducing the bycatch and discarding of juvenile whitefish in the Farne Deeps Nephrops fishery; and reducing the impact of beam trawling on bottom-dwelling communities and small non-commercial fish by using ‘benthos release panels’ (Figure 7).

A B C

Figure 7: Trials with a modified benthic trawl or 'benthos release panel' (Photo A) designed to allow the enhanced release of non-target bottom dwelling species. Photo B shows trawl without panel and photo C shows trawl with panel.

Fishermen are naturally cautious about using new fishing methods which may reduce their catches, but some net modifications may have other benefits. For example, use of the 'benthos release panel' has the added advantage of improving the quality of the landed catch. In the past, there has been little incentive for fishermen to adopt and use new gears, but Defra has been working with fishermen to promote their uptake.

Effects of the environment on fish stocks

Impacts of climate change on fish recruitment

Long-term changes in the marine environment are now widely recognised as affecting marine ecosystems and fisheries. Fluctuations in environmental conditions can affect the distribution of fish and their growth and survival, while longer-term climatic change may ultimately lead to larger changes in marine ecosystems, by affecting ocean currents and production patterns.

To understand all these effects and plan for the future, we need to have data covering long timescales and large sea areas. We also need to improve our understanding of the fine-scale processes that affect individual fish. Cefas scientists are therefore studying how large-scale changes in plankton affect the growth and survival of fish eggs and larvae and developing better models to predict the dispersal patterns and growth of eggs and larvae.

Working with the University of East Anglia, Cefas has developed genetic probes to identify cod, haddock and whiting eggs that previously have been very difficult to distinguish visually. They have applied these new methods to map spawning areas of commercial species and have recently begun to use them in stock assessments. They also plan to use the genetic methods to identify fish eggs and larvae in stomachs of predators to investigate their diet and so predict how any future changes may affect the long-term sustainability of fish stocks.

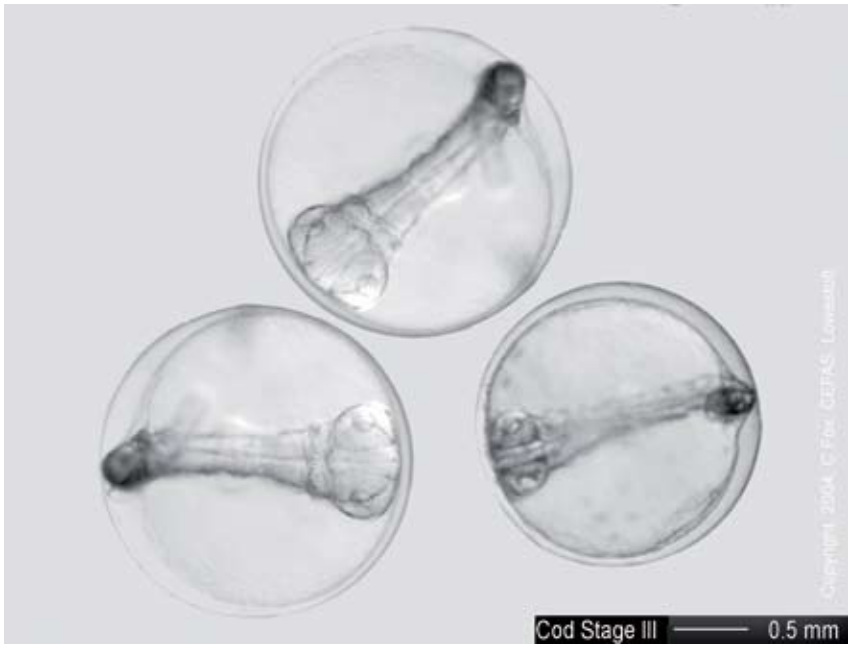


Figure 8: Cod eggs after about nine days of development.

A better understanding of how the physical marine environment affects the growth, development and survival of fish during the critical, early, stages of their life history will allow better predictions of stock abundance, and the development of strategies that promote long-term sustainability of fish stocks.

Changes in the distribution of cod

The collapse of the Grand Banks cod population was associated with changes in the geographical distribution of these fish. The numbers of fish decreased and they became concentrated in a smaller area. This meant that the fish were more vulnerable to the effects of fishing and to pressure from predators. This raises the question of whether a similar pattern may be occuring in the North Sea.

Scientists have looked at the numbers of young cod caught during surveys of the North Sea between 1977 and 2002 to identify the areas where most of the North Sea cod were found. The total area where cod are found has decreased dramatically since the 1980s when cod were very abundant, to recent years when the cod population is much smaller. In the 1980s, the cod population was very evenly spread, with cod in almost all (90%) of the survey area. Now cod are only found in less than half (45%) of the survey area.

Cefas scientists have found that the distribution of cod is linked to water temperatures at the bottom of the sea. When there is a large population of cod, not all the fish can fit into the area where the seawater temperature is most favourable for growth and so some fish will spread into less suitable areas. As the numbers of cod decrease the entire population can remain in the areas where seawater temperature is most favourable to fish growth and so a small cod population tends to be found in a smaller area, as observed on the Grand Banks.

Scientists are very concerned that as the climate changes the amount of favourable habitat available to cod may decline. If this results in the cod stocks being concentrated into a smaller area, it may make the stock more vulnerable to fishing and predation. Coupled with the known decline in the cod population, this means that the ability for the cod stocks to recover could be seriously damaged.

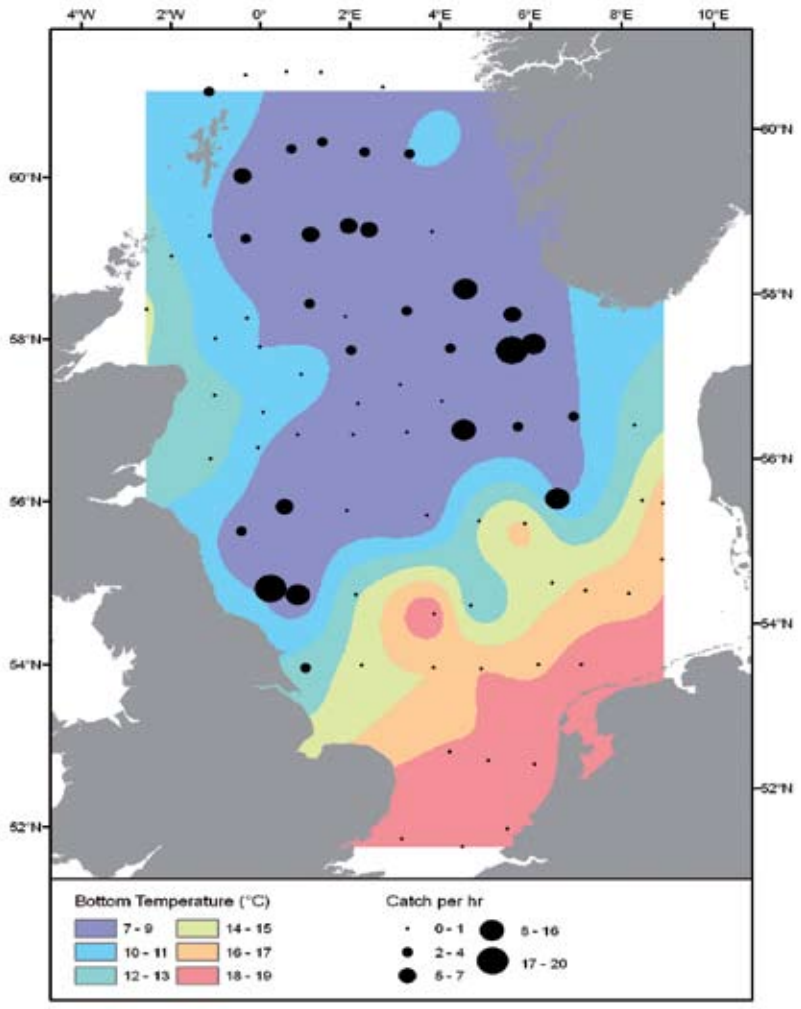


Figure 9: Temperature of the North Sea near the seabed overlaid with distribution of two year-old cod from the Cefas autumn groundfish survey in 2002. The highest concentrations of cod occur in areas that correspond closely with their optimal growth temperature (between 7-8 degrees Celsius).

Plankton fluctuations and their effect on fish stocks: the role of the Continuous Plankton Recorder Survey

The decline in Atlantic cod, salmon and other fish observed since the mid-1980s in the North Sea (Figure 10) has, in addition to heavy fishing pressure, been related to changes observed in the plankton community. Plankton, including Calanus, provides food for larval fish at a crucial time in their life cycle.

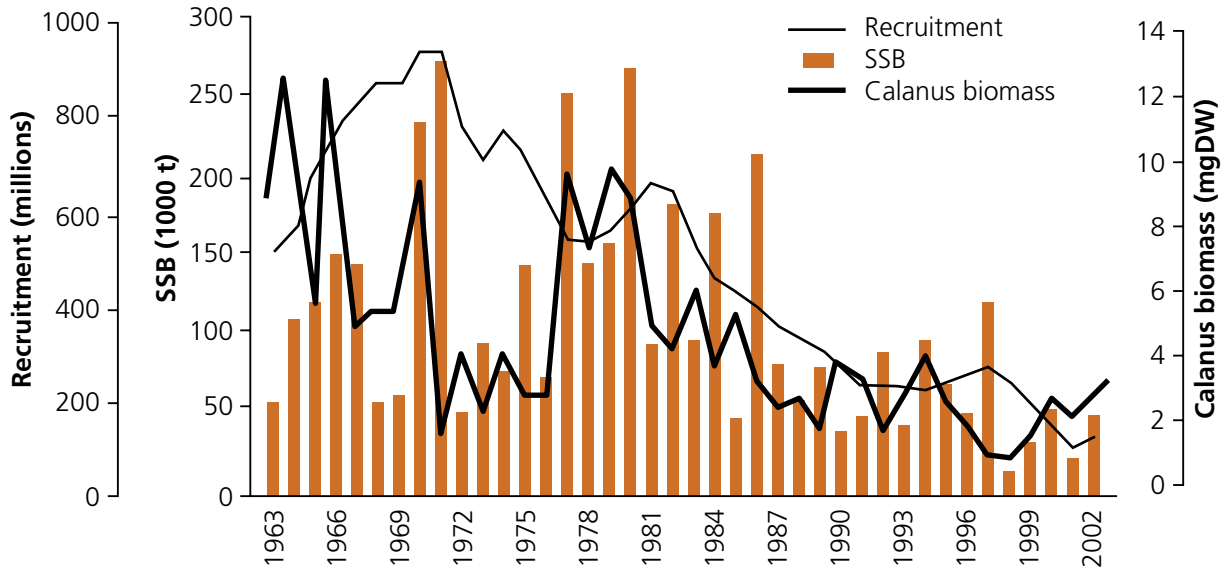


Figure 10: Production of spawning stock biomass (SSB) and recruitment of cod in the North Sea between 1963 and 2002 (ICES data). Calanus biomass is also shown.

Analysis of plankton data from the Continuous Plankton Recorder (CPR) (Figure 11) survey (the longest and the most geographically extensive marine biological survey in the world) has shown that plankton biodiversity has increased in the North Sea, a change that appears to be related to global warming. As a consequence of this change the food value of the plankton has reduced with a knock-on impact on fish recruitment.

Figure 11: The Continuous Plankton Recorder (CPR). The CPR machines are towed at a depth of about 7 metres along regular routes at monthly intervals. The CPR works by filtering plankton from seawater over long distances (up to 500 nautical miles) on a moving filter band of silk. The filter silk band is wound through the CPR on rollers and stored on a cassette until analysed in the laboratory.

New measures of copepod (a type of zooplankton which is a major food source for fish) biomass have been derived from CPR samples for use in ecosystem models that will be applied to fisheries research. The results show that although plankton diversity has increased, overall plankton biomass has decreased due to the decrease of the larger Calanus species, with a decline of 70% in total Calanus biomass between the 1960s and the post 1990s (Figure 12).

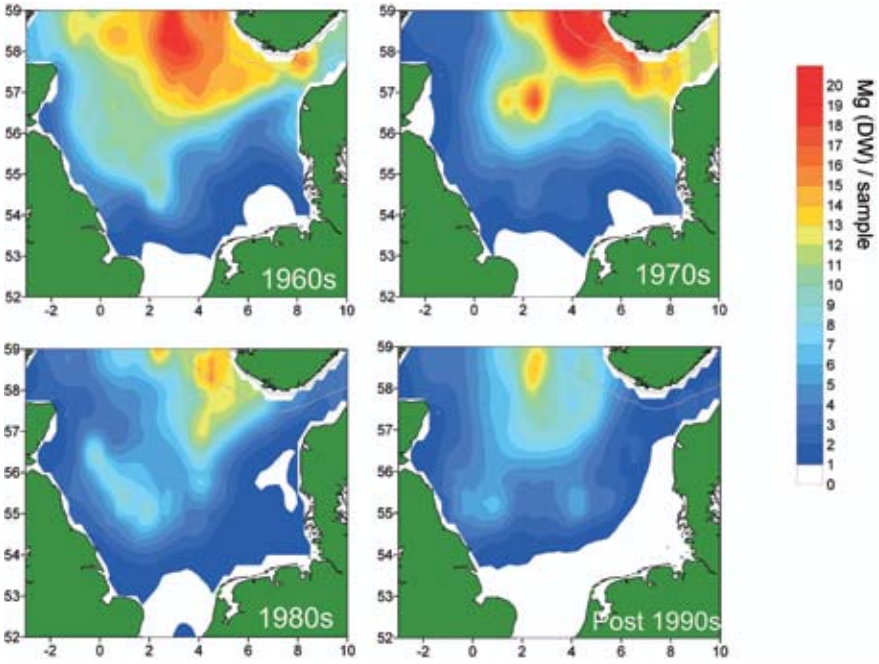


Figure 12: Total Calanus biomass in the North Sea in the 1960s, 1970s, 1980s and 1990s.

Scientists from the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) are collaborating with the fisheries community to investigate relationships between changes in quantity, quality and seasonal timing of plankton and the poor fish recruitment seen in recent years. Such failures in recruitment lead to fishery closures and cuts in total allowable catches, for example, in sandeel, Norway pout and herring. The CPR is also able to sample fish eggs and can detect changes in the spawning of some fish species.

Fisheries management

Management of thornback rays in the southern North Sea

Skates and rays are vulnerable to fisheries because they grow slowly, do not mature until they are quite old and produce few offspring. Thornback rays, which can live for 15 years and grow up to a metre in length, do not breed until seven to nine years old and about 70 centimetres long. If too many rays are caught before they reach this age and size, then stocks may be threatened. Common skate is now rarely caught in the northern North Sea and the distribution of thornback ray has reduced and abundance declined. The catches of rays and skates around the UK by UK vessels have fallen from around 9,000 tonnes in 1972 to 3,300 tonnes in 2005. ICES (International Council for the Exploration of the Sea) advises that targeted fisheries should not be permitted, and bycatch in mixed fisheries should be reduced to the lowest possible level.

Cefas has been doing research to increase our understanding of thornback rays, especially their seasonal migrations, to help develop management measures to conserve them.

The Thames Estuary is one of the last strongholds for thornback rays in the North Sea. Previous studies, using simple label tags, suggested that rays form local populations that remain in the Estuary for most of the year. However, Cefas has used electronic data storage tags to find out more about the extent and pattern of the seasonal movements of these rays. Electronic data storage tags include an electronic chip that records the fish's depth and

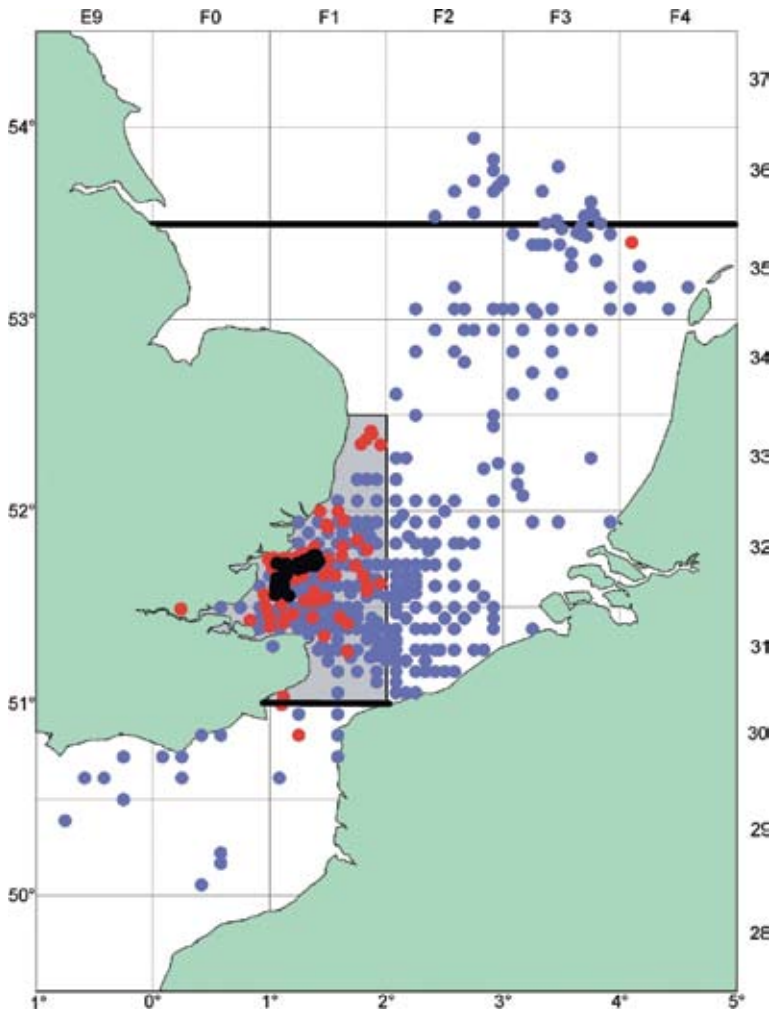
the temperature of the surrounding water. The data from returned tags allow the scientists at Cefas to work out where the fish have travelled during their annual migrations.

Figure 13: Thornback ray marked with a data storage tag.

During the study, 197 rays were tagged. One hundred of these were recaptured and the tags returned – many by fishermen. Cefas found that the rays' movements are more widespread than scientists previously thought. Although most of the tagged rays were caught in the Thames Estuary, where they lay their eggs during spring and summer, they found that the rays migrated more widely into the southern North Sea and eastern Channel mainly during the winter.

This work has allowed Cefas to make more accurate and realistic predictions about the potential effects of different fisheries management measures, such as area or seasonal closures to fishing, for conserving rays and the impacts these may have on other local fisheries.

Figure 14: The black dots show the area where the tagged thornback rays were released in the Thames estuary. The red dots show where fish were recaptured and blue dots show the total extent of their migrations throughout the year.



Management approaches for shellfish stocks

The growth of shellfish and the numbers in an area may vary widely over relatively small distances and this can affect catch rates and productivity of fisheries. Fishing effort is also likely to be targeted at patches with high densities of shellfish and this will have implications for the effects of exploitation on the overall stock. Many shellfish such as scallops move very little and are therefore particularly vulnerable to over-exploitation. Spatial management plans such as closed or restricted areas may well be suitable strategies for these stocks but they require a detailed understanding of the geographic distribution of the stocks.

Cefas scientists are developing models of shellfish stocks and fisheries that take account of spatial factors and which will be used to evaluate different approaches for monitoring, assessing and managing stocks. Whilst the approaches may be applied to all shellfish species, our current research is mainly looking at scallops and crabs and involves collecting data from these fisheries to develop the models. For example, surveys of scallop stocks in the western Channel are providing information on population densities and growth rates, and data from logbooks and the Vessel Monitoring System (VMS) provide information on the distribution of fishing activity for scallops in the same area.

Figure 15: Deploying scallop dredges on the Cefas research vessel, *Endeavour*.

Data collected during this project will be used in the models which in turn will provide a basis for working out the best management strategies for the stocks such as permanent or variable closed areas. Also, where there is enough information, the models will be used, for example, to assess the likely effects of a closed area for fishing on a particular scallop stock and fishery. This modelling approach allows scientists to evaluate the potential costs, benefits and trade-offs of alternative management options.

Brown crab populations

The brown or edible crab, (*Cancer pagurus*), (Figure 16) is distributed continuously from northern Norway to Morocco, with greatest abundances recorded around the British Isles and northern France. The English Channel currently supports the most valuable brown crab fishery in Europe, landing over 10 000 tonnes per year. An understanding of the number of populations, and dispersal levels between populations, is fundamental for management of sustained exploitation and sound conservation of commercial marine fisheries. Failure to accurately identify distinct population units can lead to local overfishing and ultimately to severe decline in the fishery.

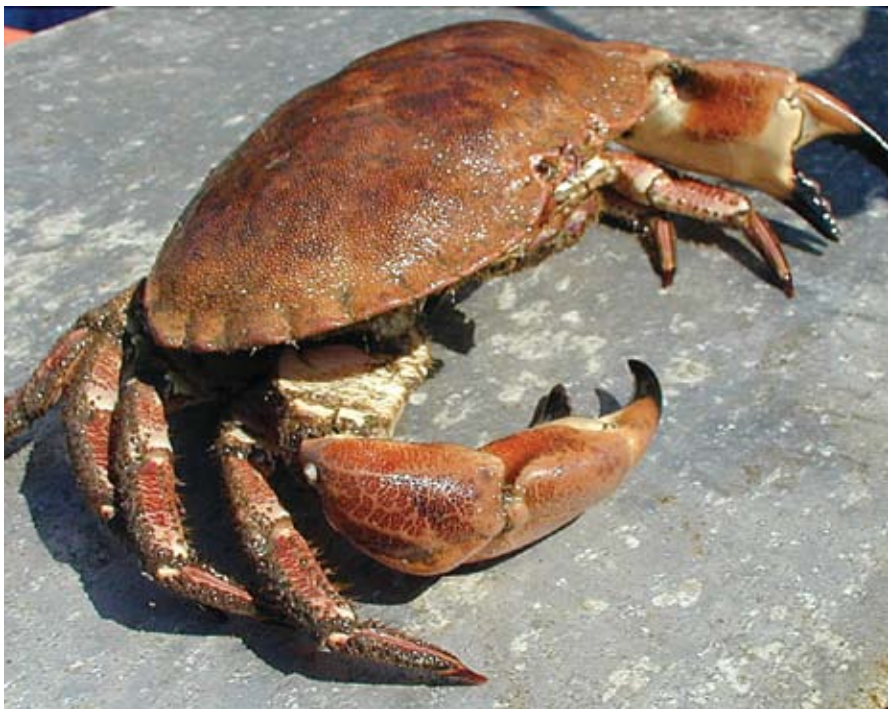


Figure 16: The brown or edible crab.

Whilst there have been progressive changes in the management regulations for brown crabs in recent years, there are no satisfactory data available on underlying population structures. As a result brown crabs in the Channel, northern Biscay and Western Approaches are, by default, regarded as belonging to a single population for management purposes.

Genetic (DNA) markers are excellent tools for examining population structure that might otherwise remain hidden due to the difficulty of implementing standard ecological methods, such as mark and recapture or behavioural observations, in the marine environment. This research project carried out by Royal Holloway College, University of London, aims to develop and employ DNA markers to investigate firstly, the number of discrete genetic populations of brown crabs in the English Channel and secondly, to assess crab dispersal patterns in relation to geographic distance, ocean currents and variation of conditions between years. Genetic population patterns will then be compared against management practices to contribute to the conservation and management of the brown crab.

Cod stock structure in the North Sea and English Channel

Most cod stocks in European and UK waters are at historically low levels of abundance and several are subject to recovery plans that aim to re-build spawning stock biomass to levels at which the stocks may be fished sustainably. There is increasing evidence that cod populations are made up of smaller sub-stocks which may be identified from the geographic area they live in or their genetic composition. These sub-stocks may be very important for the species' genetic diversity and its chances of recovery. However, current assessment and management is done on a scale that does not take account of these population sub-stocks and hence may not be successful.

Cefas, working with the Fisheries Research Services (FRS) Aberdeen, has re-analysed data from historic cod tagging experiments to investigate how stocks in the North Sea appear to be sub-structured. The work showed that cod sub-stocks have a relatively limited range of movement and distribution.

Cefas scientists have also used electronic data storage tags to study the behaviour of cod in the eastern Channel and southern North Sea. During 2005 tags were recovered from fish that had been at large for over 6 months since being released off Hastings in November 2004, and it is possible to re-construct their movements. For example, one cod was re-captured near Eastbourne in November 2005. Although the release and re-capture positions are very close, reconstruction of the migration shows that, this fish migrated into the western Channel (ICES area VIIe) and spent 6 months living in the Hurd Deep (Figure 17). During this time it grew 20cm which indicates that it was feeding well.

The results of these studies have clear implications for the way cod stocks may be managed. The way the stock divides into smaller groups (sub-stocks) suggests that management measures tailored to specific regions are likely to be more effective than blanket measures applied to large areas. The study of cod in the English Channel shows that geographic landmarks may not be the most appropriate boundaries for deciding management measures.

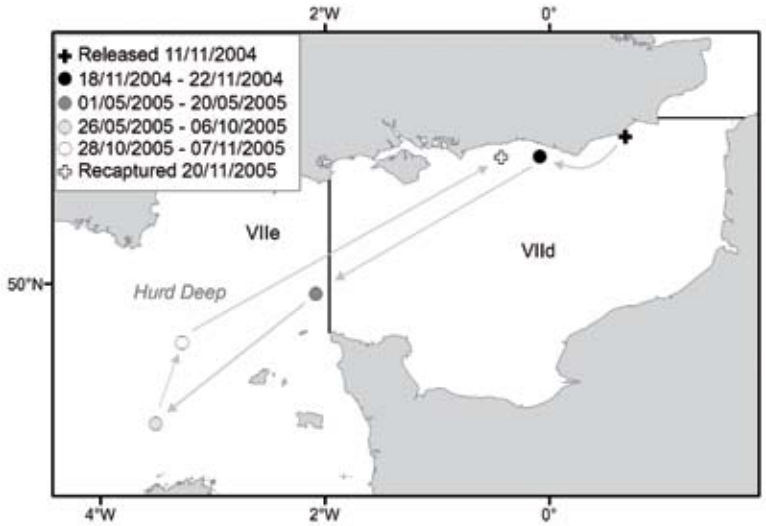


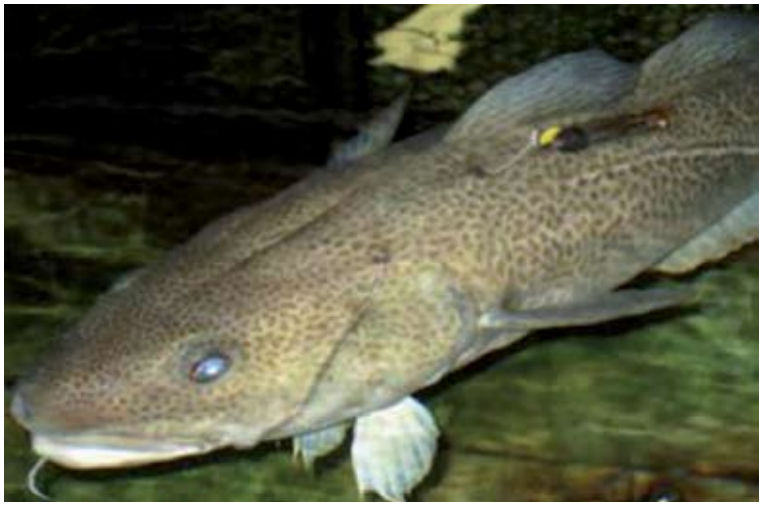
Figure 17: Reconstruction of the migration of a cod released near Hastings in November 2004 and recaptured near Eastbourne a year later. Round symbols show the estimated locations of the cod during its time at liberty.

Tools for studying fish in the wild

If we are to be able to predict how the size and distribution of fish stocks may change and to manage them sustainably, we need to know where the fish may be found, when they are there and what they are doing in relation to their environment. But studying the behaviour of fish at the bottom of the sea is very difficult, and new tools and techniques are required to conduct such investigations.

Cefas scientists have previously developed innovative electronic tags which record information on the environment around the fish while it is at liberty and allow the movements of the fish to be reconstructed. They are continuing to miniaturise these tags, and their latest generation of tags is about half the size of previous ones. This will enable them to investigate the behaviour of a wider range of fish species and sizes in more detail than ever before. They have also developed a new electronic sensor which can record jaw movements of free swimming fish (Figure 18). This will provide detailed information about the timing, duration and location of feeding and will also allow scientists to investigate how feeding changes in relation to local environmental conditions.

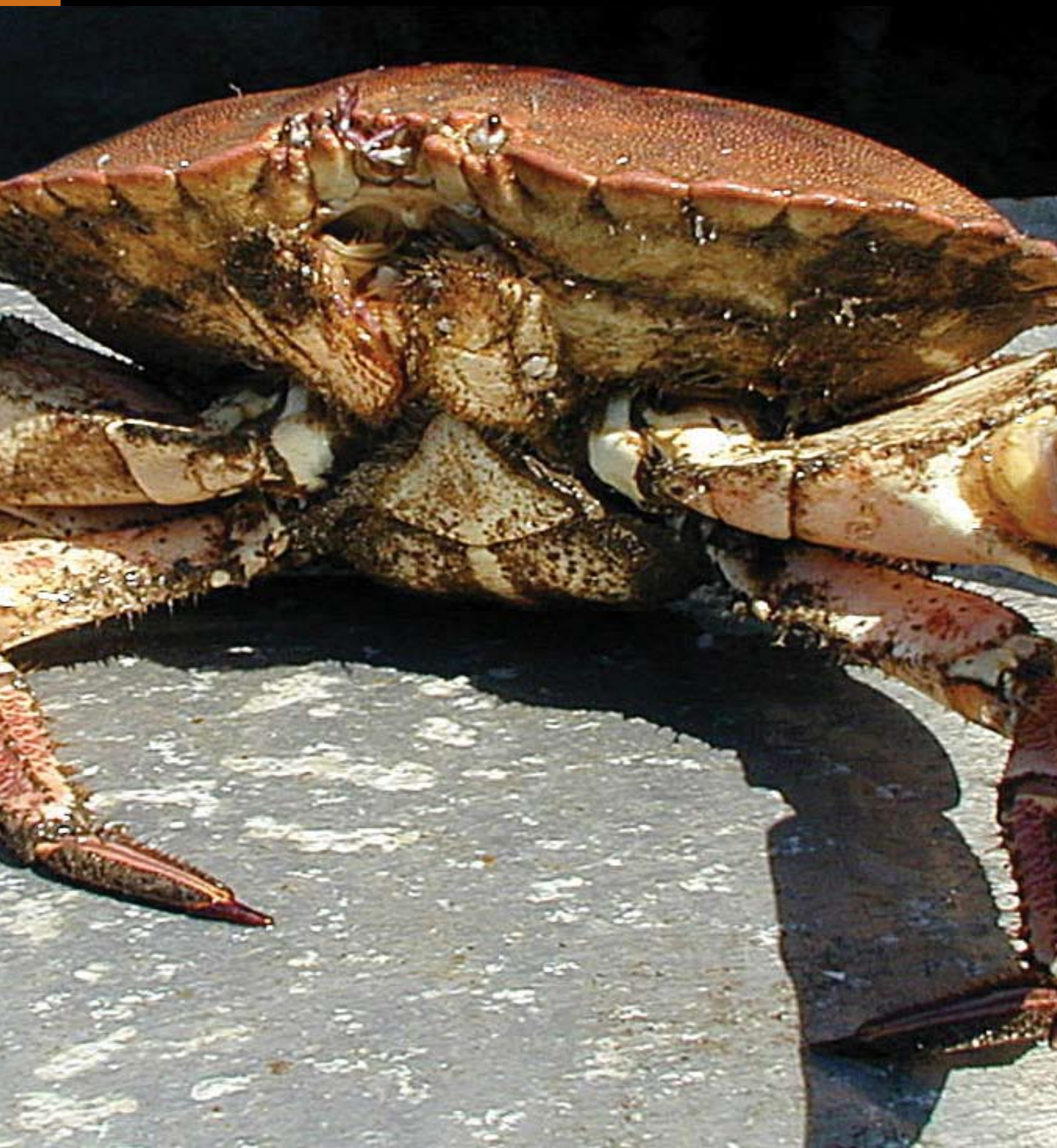
Figure 18: A cod equipped with a jaw movement sensing tag.



Cefas scientists are also developing acoustic methods to map the preferred habitats and abundance of important fish species. They have used a novel method which can distinguish between different types of seabed to show the locations of sediment occupied by sandeels (an important prey for predatory fish like cod) on the Dogger Bank. The new system translates echoes from the seabed into acoustically distinct seabed 'categories'. At night, when sandeels bury themselves in the sediment, an extra 'category' can be detected in areas where many sandeels have buried themselves. This suggests that buried sandeels alter the acoustic signature of the seabed.

By allowing scientists to study fish behaviour in great detail, and by linking this to detailed maps of the presence of important food like sandeels, this work will help to explain how the behaviour of predatory fish relates to their immediate environment, such as the availability of food, the temperature and water depth. Also, it will help to explain how often fish need to feed in the wild to remain healthy and to reproduce. For example, by mapping the distribution and abundance of sandeels, it will also be possible to assess the reasons for the fluctuations in sandeel numbers and how industrial fishing for sandeels may impact on the distribution and population structure of cod and other species.

The Fisheries Science Partnership



The Fisheries Science Partnership (FSP) encourages fishermen and Cefas scientists to work together. The programme also involves fishermen in the planning of scientific studies. The programme, which started in 2003:

- provides information from commercial fishing operations on key stocks, to supplement the data used in ICES assessments;
- addresses issues raised by fishermen on scientific assessments or on stocks not currently assessed; and
- investigates new scientific methods and more environmentally friendly or selective fishing methods.

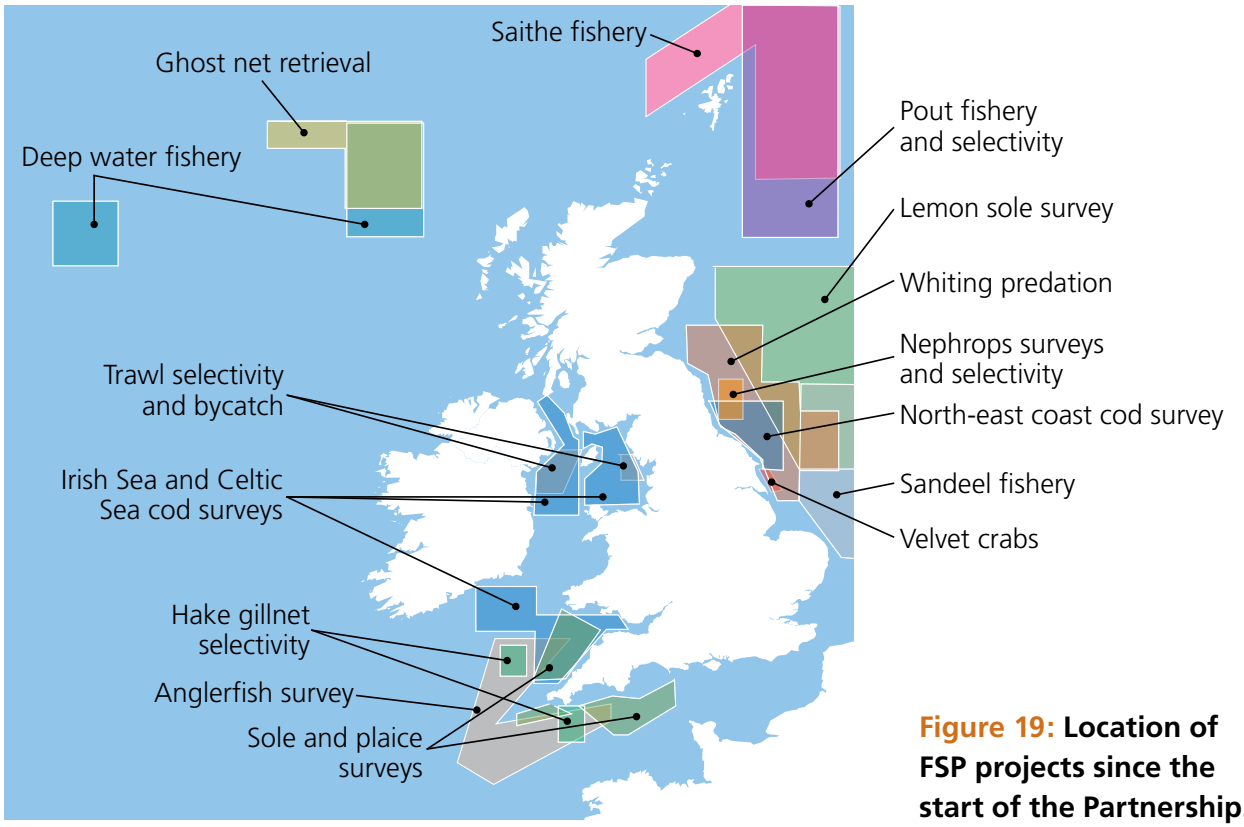


Figure 19: Location of FSP projects since the start of the Partnership.

Western anglerfish survey

A time-series of surveys was carried out recently from the fishing vessels *Billy Rowney* and *Twilight III* to provide data on the distribution, catch rates and length distribution of anglerfish and other species caught simultaneously using commercial gear off south-west England.

The surveys showed that megrim tend to dominate the catches, followed by anglerfish *(Lophius piscatorius)*, lemon sole and sole (Figure 20). There are smaller catches of another species of anglerfish *(L. budegassa)*, hake and cod. Both anglerfish species are widespread, though not equally abundant throughout the survey area, and strong year classes tend to be fished down quite quickly.

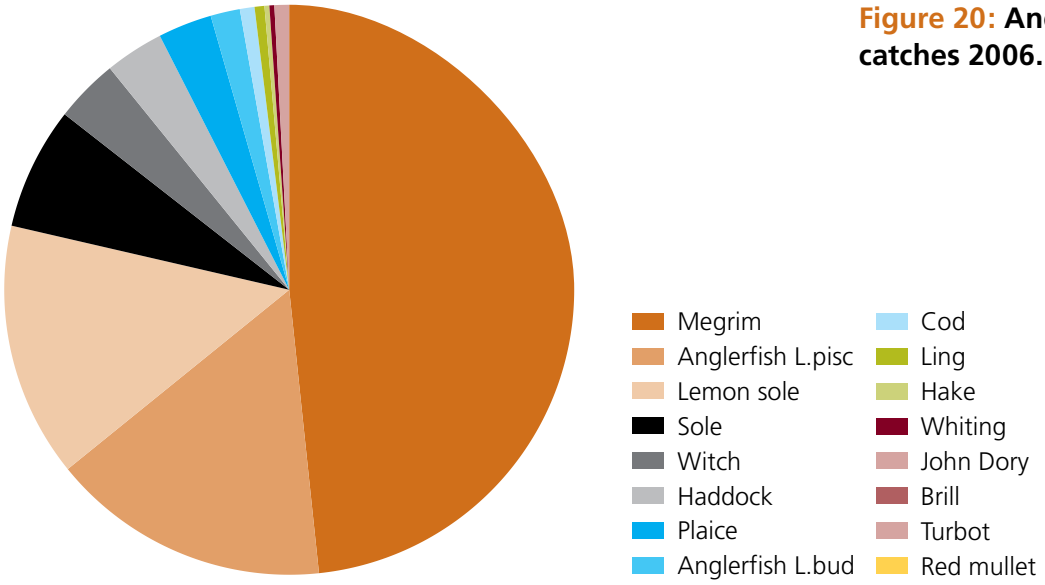


Figure 20: Anglerfish survey catches 2006.

Irish Sea roundfish

Surveys were carried out for cod, haddock and whiting in the western Irish Sea in 2004, 2005 and 2006. They were designed to provide time-series data on catch-rates, distribution and age compositions of these species. The commercial whitefish otter trawler *Isadale* and the mid-water trawler *Benaiah IV* were used for the surveys.

Cod were found mainly in the North Channel, Clyde closure, Irish coastal waters south of Dundalk Bay, and scattered in small patches in the eastern Irish Sea especially off Morecambe Bay and off the Scottish coast. Haddock tended to be found mainly in the western Irish Sea, North Channel and around the Isle of Man in the eastern Irish Sea. As in previous surveys whiting were scarce in the western Irish Sea and North Channel.

The age compositions of cod, haddock and whiting in the western and eastern Irish Sea in the 2004-2006 FSP roundfish surveys showed a truncated age composition with few fish more than 5 years old.

A **B** **C**

Figure 21: Cod (A), haddock (B) and whiting (C).

North-east coast cod

A time-series of surveys of north-east coast cod was constructed to provide annual comparative information on distribution, relative abundance and size/age composition of cod, and to obtain additional information on distribution, relative abundance and size/age composition of whiting and haddock off the north-east coast of the UK.

The fishing vessel *Emulator* mainly conducted this time-series survey, in autumn. Catch rates of the three roundfish species cod, haddock and whiting were reasonably stable though cod and whiting tended to be further inshore than haddock (Figure 22). The age distributions suggested that there was a good 2005 year class of cod, and the strong 1999 year class of haddock is still evident, as are the stronger 1999-2001 year classes of whiting.

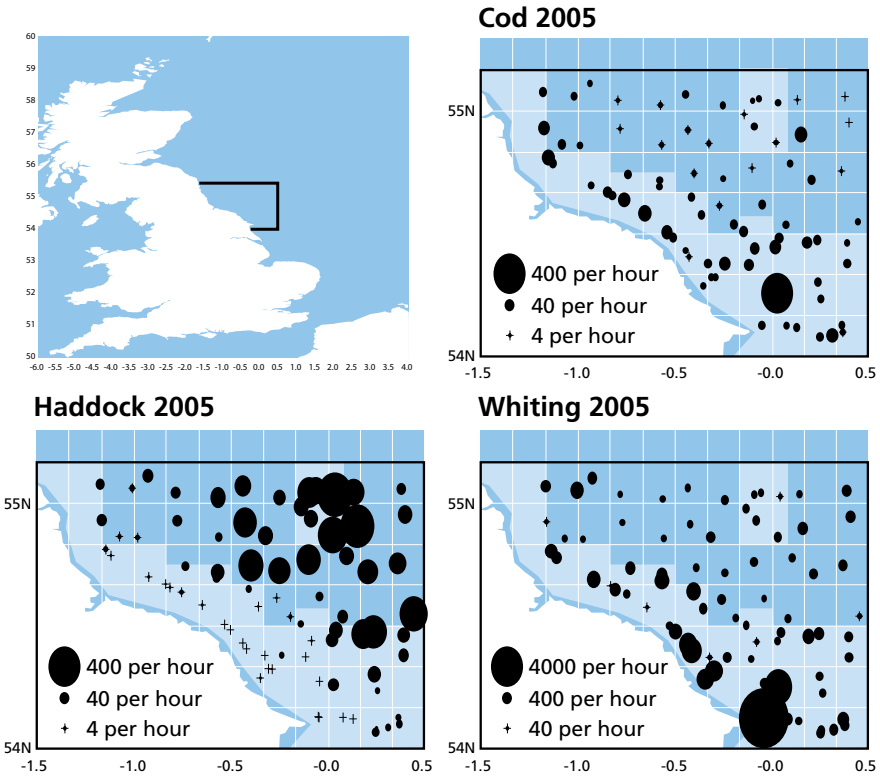


Figure 22: Distribution of cod, haddock and whiting during the 2005 FSP north-east coast cod survey. Note the different scale of the distribution of whiting. Light blue shaded areas are mostly hard ground.

Hake selectivity

This project examined the selectivity of hake gill nets used by UK fishermen off Cornwall using the commercial netter *Carol H* in October and November 2005.

The project was initially proposed by the fishing industry to demonstrate that the fishery takes very few small hake, and was developed further with Cefas to include experiments to estimate the selectivity characteristics of the nets.

The experiment was carried out by comparing the catches in nets of mesh size 80, 100, 120 and 140mm used at the same time at two fishing grounds. Additional 120mm nets were shot to obtain further data on size composition of hake. Hake taken by the 120mm nets were mainly in the length range 60–90cm. This contrasts markedly with the international fishery landings in 2004 which were mainly of much smaller fish.

Three separate trials with the four mesh sizes showed that the average size of hake caught in the net increased with increasing mesh size, and that the 120mm mesh used by the fishermen off the south-west coast retains few hake less than 60cm long.

Figure 23: Hake.

North Sea whiting

A survey was carried out by the trawler *Nimrod* in August and October 2006 to investigate the stomach contents of whiting, in particular the predation of whiting on juvenile cod, off the north-east coast of England and the south-east coast of Scotland.

The amount of whiting caught varied considerably over the surveyed area, from about 1500kg to less than 5kg (four fish) in an hour long survey. Commonly fished whiting grounds over soft sediment produced the biggest catches.

Over half of the whiting stomachs were empty. Where stomachs were not empty, the main contents were small crustaceans in August and fish in October (Figure 24). Fish eaten were often non-commercial prey species such as pipefish or hagfish, although gadoids and clupeoids (fish of the herring family) were also eaten. Just 45 gadoids were found in whiting stomachs out of a total of more than 2,500 prey items, these were identified as whiting or poor cod. No cod were found in whiting stomachs, and this finding was likely to be influenced by the very low numbers of cod and codling in the survey area.

Figure 24: Stomach contents of whiting.

Yorkshire coast crustaceans

This project used commercial fishing traps to analyse the variations in catch rates of velvet swimming crab *(Necora puber)* (Figure 25) and other commercially important crustaceans in the Bridlington Bay area.

Bridlington fishermen used the *Hollie J* and the *Magdalene Ann* to carry out a potting survey between Flamborough Head and north of Spurn Point, and around the Rough gas field. The survey was designed to provide coverage of potential velvet crab, brown crab and lobster habitat within the area exploited by the potting fleet primarily operating from Bridlington. The areas around the Rough gas field and just south of Flamborough Head yielded poor catches of velvet crabs, well below commercially viable levels (Figure 26). Highest catches of lobsters were taken towards the southern part of the survey at Withernsea. Some of the fleets in the Rough gas field area provided good catches of lobsters, probably helped by the long soak times of pots.

Figure 25: Velvet crab.

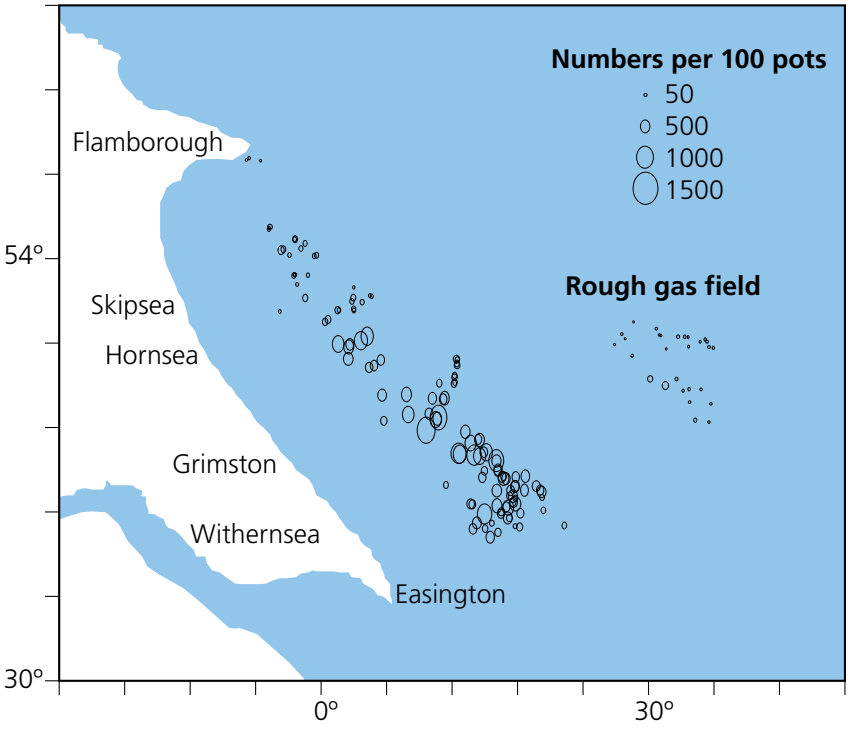


Figure 26: Estimated numbers of commercial sized velvet crab per fleet.

The Fisheries Challenge Fund

The Fisheries Challenge Fund was introduced in 2005 in response to the 'Net Benefits' report by the Prime Minister's Strategy Unit. It funds short-term scientific projects as well as economic and social projects suggested by organisations with an interest in fisheries.

Definition of fisheries groupings for the development of long-term management plans for demersal fisheries in ICES Subarea VII

This work was proposed by the Cornish Fish Producers Organisation on behalf of the North Western Waters Regional Advisory Council (NWWRAC). It is being carried out by Cefas.

To move towards sustainable fisheries we need to develop long-term management plans that have buy-in from the fishing industry.

The area covered by the NWWRAC contains fishing activity of significance to sectors of the UK fishing industry. The NWWRAC is keen to develop long-term management plans for the fisheries in its area.

This study draws together fish stock and fishing fleet data for the Irish Sea, the English Channel and the Celtic Sea (ICES Subarea VII). Using data from 2003-2005, fleets will be grouped into 'fishery units/fisheries' comprising groups of fishing vessels fishing in the same area for which the catch composition is similar. A key part of the project is for scientists and the NWWRAC to decide together what are sensible and manageable fishery units.

The fish stock and fleet data will then be used to identify and characterise fisheries that are potential candidates for long-term management proposals. The results of the study will identify further research needed on the consequences of proposed management actions.

Figure 27: Local fishing fleet – Newlyn.

Exploration of harvesting strategies for achieving long-term sustainability for the North Sea mixed demersal roundfish fisheries

This work was proposed by the National Federation of Fishermen's Organisations (NFFO) on behalf of the North Sea Regional Advisory Council (NSRAC). It is being carried out with support from Cefas scientists.

Important drivers for future European fisheries policy are commitments made at the 2002 World Summit on Sustainable Development. At the Summit, European Union member states committed themselves to maintaining or restoring fish stocks, to levels that can produce Maximum Sustainable Yield (MSY) by 2015. MSY is the largest long-term average catch that can be taken from a fish stock without impairing the stock's ability to replenish itself.

The NSRAC and Defra are keen to explore the potential short-term and long-term advantages, and disadvantages, of different levels of fishing aimed at achieving MSY; when MSY can be achieved; and whether MSY can be achieved at the same time for all species within a mixed demersal fishery.

This project will use computer models to simulate different fishing levels designed to achieve MSY. The project team will then explore the effects of these different fishing levels on fish stocks and on fish catches and revenues for fishing fleets targeting demersal roundfish (cod, haddock and whiting) in the North Sea.

The results from this project will help Defra, the NFFO and the NSRAC to put together proposals to the European Commission on achieving MSY for North Sea demersal fisheries.

Figure 28: Haddock.

Diffuse source pollution trial, Fal, Cornwall

The Fal river and estuary are important shellfish growing sites supporting both the common mussel farms (*Mytilus edulis*) and the wild native oyster fishery (*Ostrea edulis*). The water quality of the Fal has decreased gradually over the past ten years from category A (meaning the shellfish are safe for human consumption) to category B (meaning the shellfish must undergo purification treatment before consumption) and recently the water quality has suffered a seasonal downgrade to category C (where the shellfish must be re-laid for two months to meet category A or B). Point source pollution (pollution that can be individually traced to a source) has decreased over the past decade meaning that diffuse sources of pollution (pollution resulting from the release of a variety of substances in many different situations) are responsible for the continuing degradation of water quality. Accurately identifying diffuse sources and being able to prioritise them is a fundamental requirement of the Water Framework Directive and one which affects all rivers, estuaries and coastal waters throughout the European Union.

This project is being carried out by Environmental Tracing Systems for the Westcountry Rivers Trust with help from the Environment Agency, Falmouth and Truro Port Health Authority and the Truro Harbour Authority. The project will study the source or sources of bacterial contamination that affects water quality and in particular the mussel and oyster fisheries. The study will use innovative tracing and source typing technology to identify whether the bacterial contamination is human or animal in origin. Once the source of the pollution is known or better understood, DNA tracers will be used to label the main or potential diffuse sources to understand the circulation and impact of these sources in the estuary.

A **B**

Figure 29: A) The native oyster *Ostrea edulis*; B) The native mussel *Mytilus edulis.*

List of marine fisheries science projects 2006/2007

Sustainable marine fisheries research projects

Movements of rays in ICES Subarea IV in relation to special protected areas (MF0148)
Reported as 'Management of thornback rays in the southern North Sea'

To describe the movement of individual rays in the Thames estuary by using electronic tags and to relate ray movement and distribution to spatial and temporal patterns of fishing effort. To use the combined data to assess the effect of closing particular areas.

Field trial of genetic probes for the identification of gadoid eggs (MF0151)
Reported as 'Impacts of climate change on fish recruitment'

To field test a semi-automated, genetically-based egg identification method developed under former project MF0146 'Genetic identification of fish eggs by species specific DNA markers for use in stock biomass assessment'.

Validation and testing of biologically-based movement models for North Sea plaice and implementation in management and assessment (MF0152)

To develop spatially-structured stock assessment models for plaice in the North Sea that take account of seasonal changes in geographical distribution, availability of fishing gear and fishing effort in order to provide better advice on management options for fish stocks and fisheries.

Linking the behaviour, spatial dynamics and the environment of cod and ray populations to evaluate fisheries scenarios (MF0154)
Reported as 'Cod stock structure in the North Sea and English Channel'

To incorporate environmental and biological datasets into a model of fish migration in order to develop a more comprehensive understanding of the response of cod and ray stocks to changes in the environment and fisheries.

Electronic telemetry tags: development of behaviour sensors for fish (MF0155)
Reported as 'Tools for studying fish in the wild'

To provide information about the feeding behaviour of marine fish in relation to the environment and to use this to improve multi-species and ecosystem models. To identify the location of spawning that is necessary for understanding stock identity and dynamics.

Pilot study for fishery-independent monitoring of cod recovery in the Irish Sea by means of egg production surveys (MF0160)
Reported as 'Impacts of climate change on fish recruitment'

To evaluate the application of genetic egg identification methods within a full annual survey of gadoid spawning. To provide high-resolution data on the distribution of spawning by cod and other species in 2006.

Development of integrated systems for shellfish data collection, assessment and management (MF0229)
Reported as 'Management approaches for shellfish stocks'

To develop frameworks for the provision of advice on shellfish stocks, integrating the processes of data collection, assessment and management.

Spatial and temporal genetic structuring of edible crab populations (MF0230)
Reported as 'Brown crab populations'

To provide important genetic information on crab stock structure in the English Channel in order to enhance crab stock assessment and management advice.

Fisheries interactions (MF0322)

To provide improved understanding of the impact of current and alternative management strategies on mixed fisheries, and to provide a robust range of strategies for potential management objectives, consistent with the precautionary approach.

Multi-species fisheries management: a comprehensive impact assessment of the sandeel fishery along the English east coast (MF0323)

To produce a spatially explicit multi-species model in which the dynamics of sandeels and their predators can be explored in relation to a range of local management options.

The Continuous Plankton Recorder survey: fisheries investigations (MF0430)
Reported as 'Plankton fluctuations and their effect on fish stocks: the role of the Continuous Plankton Recorder Survey'

To provide details of phytoplankton variation over an extended time frame in order to monitor responses to climate change and pollution. To investigate links between CPR data and long-term changes in fish stocks in order to develop new approaches to fisheries management and conservation strategies.

Detecting predation of fish eggs and larvae (MF0432)

To investigate post-settlement mortality, due to predation, of commercial fish species such as cod and plaice. Changes in the abundance and distribution of predators, possibly linked to processes of climate change, have the potential to inflict increased mortality on the early life history stages of commercial fish species and thus can damage stock viability or inhibit stock recovery.

Changes in growth in cod as an indicator of climate change (MF0433)

To obtain time trends in the onset of growth in cod in the spring and autumn each year using historical collections of otoliths from the southern North Sea and Norwegian coastal waters. To enable predictions of the impact of climate change on growth of cod populations in the North Sea.

ICES/GLOBEC project office (MF0434)

To support the ICES/GLOBEC (Global Ocean Ecosystem Dynamics) project office which exists to help with implementing the cod and climate change programme strategic plan and other co-operative international studies on the effects of climate change on the marine ecosystem.

Fishing impact on benthic communities – phase 2 (MF0729)
Reported as 'Impacts of bottom trawling'

To provide advice on the validity of listings of marine fishes and invertebrates as vulnerable, endangered or critically endangered by fishing. To test the effectiveness of existing fishing surveys to provide information on these listed species.

Development and testing of ecological indicators and models to monitor and predict the ecosystem effects of fishing (MF0731)
Reported as 'Developing indicators for fisheries management'

To provide a basis for selecting indicators of the ecological effects of fishing, for advice on the utility of indicators proposed by other groups, and to establish an ecosystem-based approach to fishery management.

Monitoring, impact and mitigation of marine mammal bycatch (MF0736)

To develop a greater understanding of the extent of bycatch and its impact on marine mammal populations to better inform management strategies. To develop and test mitigating measures to reduce or eliminate marine mammal bycatch.

Gear technology, discard reduction, and environmentally-friendly fishing studies (MF0738)
Reported as 'Reducing bycatch in fishing gear'

To evaluate the efficacy of mandatory technical measures in the brown shrimp fishery. To further analyse the discard database, providing tools which will enable identification of discarding 'hotspots' (spatial, temporal, or gear-associated). To maintain updated knowledge on global developments in the field of environmentally-friendly fishing methods.

Management of marine finfish fisheries and monitoring under the EU data collection regulation (Memorandum of Understanding: Schedule MA)
Reported as 'Changes in the distribution of cod'

To provide the best scientific advice on the status of finfish stocks of interest to the UK, through monitoring and assessment of the most important commercial stocks.

Details of sustainable marine fisheries research projects are at www.defra.gov.uk/research/project_data/Default.asp

Fisheries Science Partnership projects

The projects undertaken in 2005/06 and 2006/07 are listed below (*indicates a time-series project that will be run for three or more years; otherwise the survey year is given).

North Sea lemon sole and plaice*

To evaluate the composition of catches across the North Sea lemon sole and plaice fishing grounds in summer, and in particular to examine the linkage with cod in relation to the cod recovery plan and associated effort control.

Western Channel sole and plaice*

To produce a time-series of surveys in the western English Channel to provide information on distribution patterns of sole, plaice and other commercial bycatch species, trends in numbers and age composition of sole and plaice, and information on the bycatch of species such as cod.

Western anglerfish*

To produce a time-series of surveys to provide data on the distribution, catch rates and length distribution of anglerfish and other species caught simultaneously using commercial gear off south-west England.

Western Edge ghost nets and lines

To conduct a retrieval survey for, and to attempt to determine the impact of, lost and abandoned 'ghost' nets and lines in deep water, including at and around the Porcupine Bank (2005/06 and 2006/07).

East Greenland cod

To carry out a trawl survey of cod in selected areas to the east of Greenland (2005/06).

Irish Sea roundfish*

To carry out fishing surveys aimed at cod, haddock and whiting in the western and eastern Irish Sea.

North-east coast cod*

To construct a time-series of surveys of north-east coast cod to provide annual comparative information on distribution, relative abundance and size/age composition of cod, and to obtain additional information on distribution, relative abundance and size/age composition of whiting and haddock off the north-east coast of the UK.

Hake selectivity

To examine the catch composition and selectivity of a range of static gears for hake in south-west UK fisheries (2005/06).

Western cod

A 'one-off' survey of western cod, to determine whether it was feasible to build a time-series of catches (2005/06).

North Sea whiting

To analyse the stomach contents of North Sea whiting to find out about their diet, and to see if there have been any changes to their diet since the last large-scale stomach survey in 1991. The project looks at the potential predation of whiting on cod, which, if frequent, may have adverse effects on cod recovery (2006/07).

Yorkshire coast crustaceans

To analyse variations in the catch rates of velvet swimming crab (*Necora puber*) and other commercially important crustaceans in the Bridlington Bay area, using commercial traps (2006/07).

Eastern Channel cod

To identify and map spawning aggregations of cod in the eastern Channel and to tag mature, spawning fish in these groups by traditional, non-electronic means (2006/07).

North-east coast squid fishery

To map the distribution of squid caught by trawl, and the catches and bycatches taken during a night-time experimental jig fishery (2006/07).

Western English Channel squid fishery

To map the distribution of squid catches and to record catches and bycatches in the English Channel using lures, jigs, gurdies and dedicated lighting (2006/07).

Details and reports for all completed FSP projects are at www.cefas.co.uk/FSP

Fisheries Challenge Fund projects

Investigation of potential fisheries for razorfish and other bivalves in the eastern Irish Sea

The objective of the project was to identify any potential future fishery for bivalves in the eastern Irish Sea. The project involved a review of available information and vessel-based surveys of the fishery areas.

Desk study of possible long-term management approaches to North Sea fisheries which reflect stakeholder objectives

A desk study of possible long-term management approaches to North Sea fisheries which reflect stakeholder objectives. Regional Advisory Councils have used the information to help develop long-term management plans for key commercial stocks.

Feasibility study of mapping key fishing areas in the North Sea

Consultation exercise to help the North Sea Regional Advisory Council to collect information that helped fishers to take a strategic approach to spatial planning.

Margin of tolerance: the accuracy of on-board catch estimates

The project investigated the feasibility of complying with an 8% margin of tolerance rule. The weight of fish estimated by observers was compared with that estimated by the skipper of the vessel to assess whether the margin of tolerance allowed between the logbook entry and landing declaration was realistic.

UK observer trips in the westerly gillnet fishery for anglerfish

Investigation into whether the ban on deep sea gill nets should apply to all deep sea gill netting. The project involved observer trips in the anglerfish fishery in ICES Subarea VI.

Model showing the vessel-level financial and economic impacts of restrictions on the whitefish fleet fishing in the north-east of England

The project created a model to analyse the behaviour of fishermen with limited quota and days at sea.

Trans-national albacore tuna trolling pilot project phase 1

A study to observe long line practices for albacore tuna. The objective of this research is to identify a viable alternative and sustainable fishery that will result in a reduction of fishing effort on pressured ground fish stocks currently targeted by the vessels to be involved in the study.

Exploration of harvesting strategies for achieving long-term sustainability for the North Sea mixed demersal roundfish fisheries

Adaptation of a model to investigate harvesting strategies for cod, haddock and whiting. The project will assist the North Sea Regional Advisory Council to develop long-term management objectives for these stocks.

Feasibility study into inshore potting for fish

Study to investigate alternative designs for pots to increase the proportion of finfish caught. Designs may aid diversification of fisheries and reduce costs compared with netting for finfish.

Cornish fishing activity mapping project

Conducting a baseline study of fishing activity in Cornwall. The information will help the Cornish Fish Producers Organisation with strategic spatial planning.

Definition of fisheries groupings for the development of long-term management plans for the demersal fisheries in ICES Subarea VII

Study to develop matrices of stocks and fishing activity to identify key fishing links in ICES Subarea VII. This will help the North Western Waters Regional Advisory Council to develop long term management objectives in Subarea VII.

Socio-economic study of North Sea fisheries and fishing communities

A project to help identify key factors that determine resilience and vulnerability of communities to changes in fishing legislation. A framework of socio-economic information will be created to help the North Sea Regional Advisory Council to assess the social and economic effects of the European Commission proposals on North Sea fishing communities.

Diffuse source pollution trial, Fal, Cornwall

Use of a new DNA technique to trace the sources of pollution in the River Fal, Cornwall. The results will help mussel and oyster fishermen to address pollution issues.

Feasibility study into the development of open water shellfish farming; a case study of Lyme Bay, South Devon

This project will determine the legal and regulatory framework, the technical and economic feasibility, and the environmental and socio-economic effects of developing large-scale shellfish farming operations in open sea coastal waters, using Lyme Bay as a case study.

Use of lobster/crab pots as a resource by other shellfish: scoping study for methodology and viability

The project will involve fishermen investigating the effect of laying bait on juvenile lobsters and crabs. The results could help to determine management strategies such as pot density.

West of Scotland long-term management plans: definition of fishing activity by area, species and nationality

The project will enable the North Western Waters Regional Advisory Council to develop long-term management proposals for its area of competence on a fishery and area basis. The project aims to inform that process by providing appropriate descriptors for fisheries in ICES Subarea VI.

Details of Fisheries Challenge Fund projects are at www.defra.gov.uk/fish/science/index.htm

Department for Environment, Food and Rural Affairs

Nobel House
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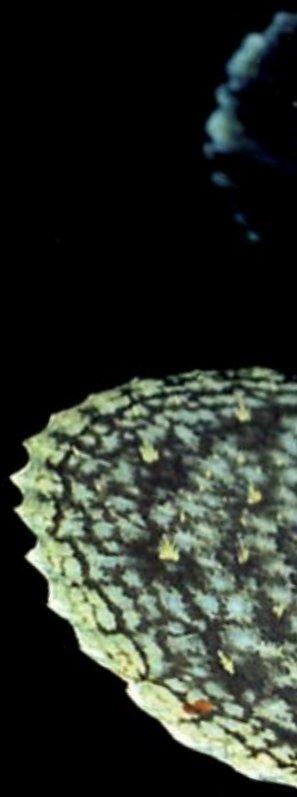

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London SW1P 3JR

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