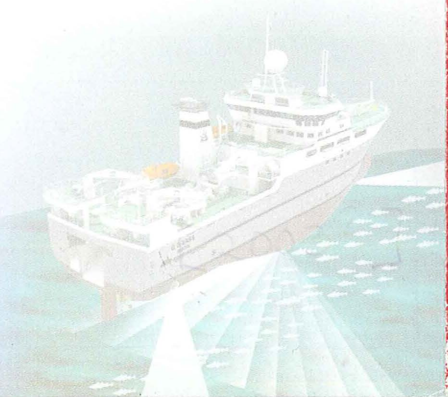
The Institute of Marine Research operates a wide-ranging programme of monitoring our marine resources. The knowledge obtained by the monitoring programme is essential input for the provision of advice about how best to manage our natural resources, which is one of our most important tasks. This requires us to know as much as possible about how species are distributed among individual stocks, how these stocks migrate and where they are located at different times of the year. We also need to know how they change in size over time, how the various stocks affect each other, how they are affected by fishing activities, and so on. Monitoring gives us a picture of the situation at a particular moment in time, as well as a basis for making both short- and long-term prognoses. These efforts provide a foundation for our ability to exploit our oceans in a sustainable and sensible way.

Large quantities of data are collected by means of a wide range of techniques, and are used to estimate stocks of fish, marine mammals and shellfish. This brochure attempts to illustrate some of the methods that we use to collect data in connection with monitoring our marine resources.

For the sake of resources management it is interesting to know the size of stocks at a given point in time, as well as the distribution of individuals in terms of sex, age-group and size. This is why we sample individual fish in order to determine their age, length, weight, sex and so on. All these data are used as input for various stock models, which enable us to analyse how stocks have evolved under the influence of fishing activities, environmental impacts and other species. Models also help us to analyse how stocks are likely to evolve in the short or long term if we stop fishing them, or if we harvest them at different intensity levels. On the basis of these analyses, we advise the fisheries authorities about how individual species should be managed through quotas and other mechanisms.



HAVFORSKNINGSINSTITUTTET
INSTITUTE OF MARINE RESEARCH
Nordnesgaten 50 – P.O. Box 1870 Nordnes
N-5817 Bergen – Norway
Tel.: +47 55 23 85 00 – Faks/Fax: +47 55 23 85 31

SENTER FOR MARINE RESSURSER
DEPARTMENT OF MARINE RESOURCES
Tel.: +47 55 23 86 50 – Faks/Fax: +47 55 23 86 87

SENTER FOR MARINT MILJØ
DEPARTMENT OF MARINE ENVIRONMENT
Tel.: +47 55 23 84 96 – Faks/Fax: +47 55 23 85 84

SENTER FOR HAVBRUK
DEPARTMENT OF AQUACULTURE
Tel.: +47 55 23 63 50 – Faks/Fax: +47 55 23 63 79

SENTER FOR KYSTSONE
DEPARTMENT OF COASTAL ZONE
Tel.: +47 37 05 90 00 – Faks/Fax: +47 37 05 90 01

FISKERIFORSKNING U-LAND
FISHERIES DEVELOPMENT RESEARCH
Tel.: +47 55 23 85 78 – Faks/Fax: +47 55 23 85 79

HAVFORSKNINGSINSTITUTTET TROMSØ
INSTITUTE OF MARINE RESEARCH TROMSØ
P.O. Box 6404
N-9294 Tromsø – Norway
Tel.: +47 77 60 97 00 – Faks/Fax: +47 77 60 97 01

FORSKNINGSSTASJONEN FLØDEVIGEN
FLØDEVIGEN MARINE RESEARCH STATION
N-4817 His – Norway
Tel.: +47 37 05 90 00 – Faks/Fax: +47 37 05 90 01

AUSTEVOLL HAVBRUKSSTASJON
AUSTEVOLL AQUACULTURE RESEARCH STATION
N-5392 Storebø – Norway
Tel.: +47 55 23 85 00 – Faks/Fax: +47 56 18 22 22

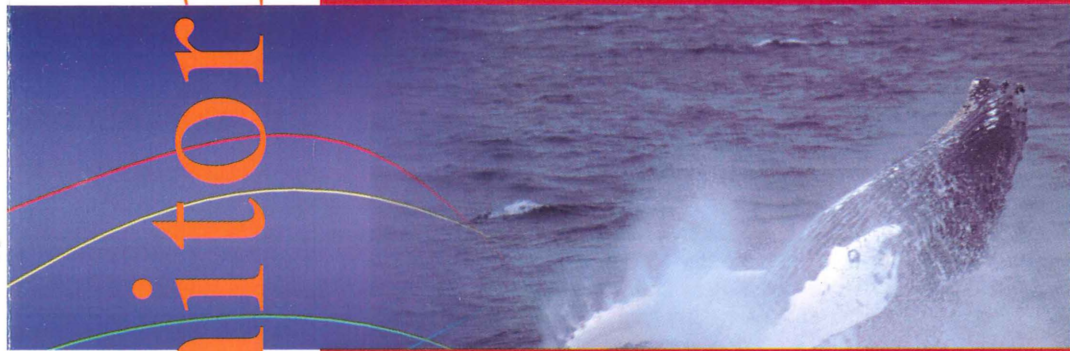
MATRE HAVBRUKSSTASJON
MATRE AQUACULTURE RESEARCH STATION
N-5984 Matredal – Norway
Tel.: +47 55 23 85 00 – Faks/Fax: +47 56 36 75 85

REDERIAVDELING
RESEARCH VESSELS DEPARTMENT
Tel.: +47 55 23 85 35 – Faks/Fax: +47 55 23 85 32

INFORMASJONEN
INFORMATION
Tel.: +47 55 23 85 21 – Faks/Fax: +47 55 23 85 86

www.imr.no

Resources monitoring



Grafisk design og illustrasjon: John Ringstad

INSTITUTE OF MARINE RESEARCH

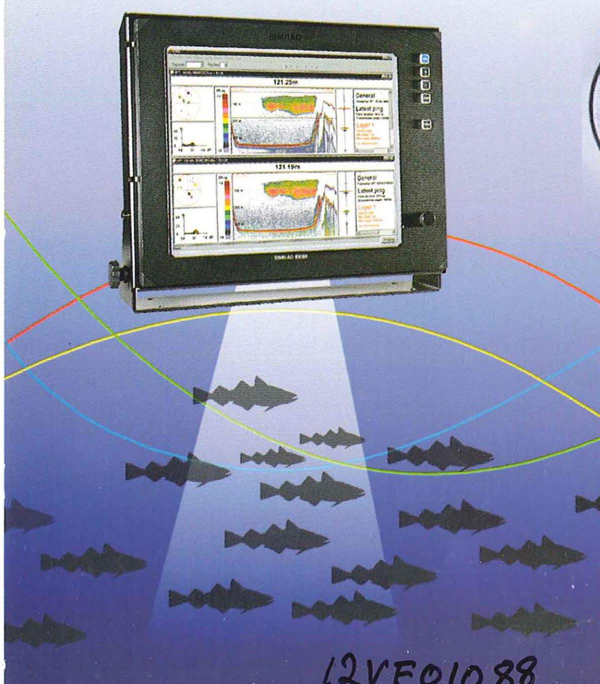
ACOUSTIC BIOMASS MEASUREMENTS

Since the middle of the previous century fishermen and fisheries scientists have been using echosounders and sonar to seek out and survey fish populations. These instruments transmit pulses of sound through the sea; the echosounder faces downwards below the vessel, while sonar "looks" ahead. Fish, and any other organisms which reflect the beam of sound, produce an echo which is picked up again by the instrument. This is recorded in the form of an echogram, which can be printed out on paper or displayed on a screen.

The strength and duration of the echoes depend on the type of fish that are being registered, and on the size of schools and individual fish. These relationships have been so well mapped out for many species that echosounders can be used to measure the amount of fish (the biomass) as long as we know which species has produced the echoes. A special instrument known as the echo integrator has been developed for this purpose.

The echo integrator continuously adds up the fish echoes along the course of the research vessel, providing an ongoing measure of the number and strength of the recorded echoes. By trawling for the fish that we have recorded, we can identify their species and size; this enables us to estimate both the number and weight of each species. In some cases, even the appearance of the echo on the echogram can be used to identify the species, but this usually needs to be done by fishing.

In addition to the biomass measurements themselves, acoustic methods provide a first-class overview of where individual species and stocks are to be found, and of how these measures vary during the day and in the course of the seasons. Such measurements can also take variations in environmental conditions into account.



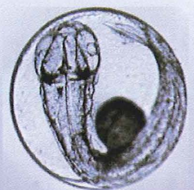
BOTTOM TRAWLING

Every year, we go on bottom-trawling cruises in the Barents Sea, the Svalbard region and the North Sea in order to map the state of, and trends in, fish stocks. The trawl net is an active fishing gear, which means that it is in motion during the fish-capture process.

We can find out how fish density varies by performing a large number of hauls of the trawl over the whole area of distribution of the stocks. During trawling of this sort it is essential to record exactly how long each trawl lasts, and to ensure that the trawl is rigged and used in the same way every time. The intention is that each haul should provide an accurate picture of the species and size distribution of the fish in the area. Fish density is estimated by dividing the number of fish in the bottom trawl catch by the area trawled. This area is calculated on the basis of how long the trawl net was fishing and the width of the trawl opening. These calculations are repeated for each length group of the species we are interested in.

The trawling system consists of the vessel itself, the towing cables, trawl doors or otter boards, bridles and the trawl net with its trawl bag or codend. The fish are guided into the codend by the trawl doors, bridles and the trawl net, but not all the fish that enter between the trawl doors end up in the codend. This is partly because different species and length groups react differently to the various parts of the trawl system, which means that we are unable to obtain a completely accurate picture of the species and size distribution of the fish in the area that we have been trawling.

Since 1984 we have been trying to eliminate sources of error in the trawling process, and in the different reaction patterns of individual species and sizes of fish.



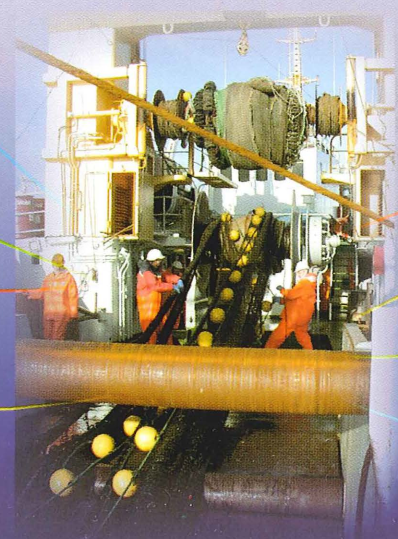
EGG CRUISES

Some species of fish, such as mackerel, are difficult to survey by means of traditional acoustic biomass measurements. This means that we have to employ alternative methods, such as measuring egg production, which allows us to estimate the size of the spawning stock. Mackerel spawn in three main areas, where we measure the amount of eggs produced and thus, in turn, the spawning stock. To be able to do this we need to know three things; how many eggs have been spawned, how many eggs an individual hen fish produces, and the sex ratio of the species.

To measure egg production we collect plankton samples in a station net that covers the whole of the spawning ground. This is done several times in the course of the spawning season. All the mackerel eggs are sorted out of the plankton samples and their developmental stage is calculated. The eggs are 1 mm in diameter, and each contains a drop of oil that provides it with buoyancy and is a source of food for the future larva.

As soon as the eggs have been spawned they are liable to be eaten by their own parents and other species. This can lead to huge losses, so we base our estimates only on the very youngest eggs. We estimate the egg production of each plankton station in terms of the number of eggs spawned per square metre. This enables us to draw a curve of egg production and to calculate the total number of eggs spawned.

Innumerable samples taken in the course of the years have shown that the spawning stock consists of a 50:50 ratio of male and female fish. This is confirmed by commercial catches and catches made by research vessels. The quantity of eggs produced by each female is termed its fecundity. This is recalculated as the number of eggs spawned per unit weight of female fish. When the total egg production is divided by the average number of eggs spawned per unit weight we get the total weight of female fish that have spawned. Multiplying this figure by two gives us the weight of the total spawning stock.



TAGGING

We have been tagging fish for many years, primarily in order to chart their migrations. We have carried out annual mass taggings of Norwegian spring-spawning herring since 1945, and of mackerel since 1969. The release and re-catch data obtained in this way have been very valuable for the management of these species. These data have been used to describe patterns of migration and determine where the fish belong to, and to estimate the size of stocks and their natural mortality rates.

Herring are tagged in coastal waters just after they spawn in March and April, and mackerel in May and June, for the most part off the west coast of Ireland. The herring and mackerel are fitted with identical 20 x 5 x 1 mm steel tags with an engraved code, but the methods employed are slightly different. Tagging herring involves the use of a purse seine vessel which catches schools of herring in a net and brings suitable quantities of them on board for storage in tanks. Individual herring are netted out of the tank and held firmly, their length is noted against the tag code and the tag is injected into the abdomen. The herring are collected in a container and returned to the sea in batches of 300. Mass tagging of mackerel also requires a purse seiner, but the fish are caught on lines and put into small containers. Mackerel are tagged in the flesh instead of the abdomen, in order to avoid damaging the roe or milt, since some of them have not yet spawned. Then they are released one at a time back into the sea. In other respects the process is identical to that used for herring.

Re-catches of tagged fish are logged by means of metal detectors installed on fish-processing machinery which is monitored by us. A large proportion are also identified by magnets mounted in offal tanks and in fish-meal and fish-oil plants, while a few are found by individual hobby fishers. The re-catch data from the metal detectors are most useful. They give us reliable data about the position and amount of the catch, while analyses of the fish provide biological data such as length, weight and age. In the course of the next few years, the tagging technology itself, the geographical areas monitored and the seasons involved may all be changed.

VISUAL TECHNIQUES

Monitoring marine mammals usually involves visual methods of determining their numbers. We use three methods: complete counts, strip transect counts and line transect counts. We have also carried out photographic identification of whales. Individual members of such species as the common seal and the grey seal are often distributed over large areas of the coast. If the total stock is not too great, we can try to make a complete count. Aircraft are very useful in such cases, as they also help to eliminate double counting.

Only in a few cases are we able to count the whole stock. We usually have to count the number of individuals in a randomly selected sub-area and then estimate the total number in the whole region. Strip transect counting involves selecting the sample areas by laying out course lines (transects) through the area. During the counting process we sail along the transects and register everything we see within a given distance of the vessel, and then estimate the density inside the strip.

A line transect count is a generalisation of the strip transect method, and it requires every single individual along the transect to be seen, including those that are eventually scared off by the vessel. This method is particularly useful for estimating stocks of whales, which are counted from an on-board observation platform. Many species of whale have individual patterns of colour or other features that allow us to catalogue them. We have been following some of the oldest individuals for twenty or thirty years.

Visual techniques are also making their way into counts of individuals under water. The most widely used technique is visual counting of king crabs and other benthic (seabed) organisms. Trials have also been carried out using a laser to count schools of mackerel near the surface. This technique is still under development.

NEW METHODS

In the future, the ecosystem will be the focus of our monitoring activities, and this will increase the demands being made on the technological and strategic aspects of our fieldwork. Developments will take place in four fields: sensors, platforms, strategy and modelling.

There will be powerful developments in acoustic sensors, which will be capable of measuring both movements and species and size composition in addition to density. This will be due to the use of a wider range of frequencies, broad-band techniques and measurements of speed of sound (Doppler techniques). Optical sensors will become more important. Image analysis will confirm acoustic signals and traditional techniques will be supplemented by laser cameras, which penetrate further and are more capable of judging size and distance.

Suitable platforms are of decisive importance for our ability to make observations at the right place and the right time. There will be developments in autonomous buoys, vessels and fixed installations, which will revolutionise our understanding of ecosystem dynamics. Sensor development also opens up the prospect of installing advanced acoustic sensors on board fishing vessels and ships in regular traffic. This will provide us with a continuous flow of data that will enable us to monitor ecosystems throughout the year.

Such developments will have impacts on our data-acquisition strategy. Our basic surveys will be carried out by our own vessels, with some help from modern commercial fishing boats. For the rest of the year, the ecosystem models will be provided with data from fishing vessels and stationary platforms. Discrepancies between models and observations will mean gathering additional data in order to modify the models.

Given these large quantities of data of widely ranging origin and quality, we will have to develop modelling tools that will be capable of exploiting such information in an optimal manner. Some information will give us the real species and size-group density, while other elements will provide only migration speed, for example. The new sensors will provide data that can be used to modify the models, while accumulated experience will offer a basis for improving them.