



**T**he Institute of Marine Research runs an extensive programme of marine environmental monitoring and research. This is intended to provide data for sustainable harvesting of living marine resources, as well as responsible use of the marine habitats in our ocean regions.

Marine environmental research involves systematic surveillance of the physics, biological production and pollution of the seas. This is done along fixed tracks, via regional coverage and data from a number of coast and fjord stations. We also largely utilise numerical models based on measurement data to create an integrated picture of how the marine environment has evolved and, to an ever-increasing extent, of how it will evolve in the future.

The high quality of our research and monitoring programmes enables the Institute of Marine Research to offer advice and premises that enable this country to manage its marine areas at ecosystem level.

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# Environmental monitoring



INSTITUTE OF MARINE RESEARCH

## CLIMATE - SEA AND COAST

We monitor the marine climate in order to see whether it is changing over time, and whether any such changes are due to natural causes or human activities. Variations in the ocean climate are of great importance for the food available to fish, their migrations and distribution and not least their growth and recruitment. This means that it is of the utmost importance always to know the state of the climate and, if possible, to be able to predict it.

In the Norwegian ocean area the climate is usually controlled by the quantity and characteristics of the Gulf Stream, which enters this region between Scotland and Iceland, and by the state of the Norwegian Coastal Current, which flows north along the coast of Norway. The characteristics which we measure are temperature and salinity of the water, i.e. its hydrographic state, which tell us most of what we need to know about the climatic condition of the sea. We make these measurements both at fixed stations and along regular tracks which cut across the most important currents.

Other conditions that need to be monitored include the quantity of water transported by the ocean currents, which is measured by current meters that remain in the sea for long periods of time. At present, these are only used at the entrance to the Barents Sea. In the fjords, both the inflow of fresh water and exchanges with coastal water have significant influences on the local climate.

Satellite measurements are another extremely important tool for climate monitoring, particularly as regards ice conditions in the Arctic. However, satellite measurements of the open sea and coastal regions are of limited value, since only the surface layer is actually measured and we do not gain any information about what is taking place in the depths of the water column.

## PLANKTON AND NUTRIENT SALTS

### Nutrient salts

Marine plants need nutrient salts in order to grow; nitrogen and phosphorous compounds are of particular importance. Some species also require silicon. When we wish to describe a marine ecosystem and estimate its potential biological production, it is important to know what nutrient salts are available in the area concerned, particularly in the upper layers of the water column, where there is sufficient light for the growth of phytoplankton (plant plankton). The oceans themselves provide a supply, while we human beings contribute unpurified wastewater, run-off from agriculture and NOx discharges to the atmosphere. An excess of nutrient salts can cause eutrophication and blooms of undesirable phytoplankton, including some dangerous species.

### Phytoplankton

Phytoplankton (algae) are food for zooplankton (animal plankton) and they form the first link in the marine food chain. Knowledge of the growth, distribution and composition of phytoplankton is essential to an understanding of their significance in marine ecosystems. Because certain species of phytoplankton are toxic, we have been running regular algae-monitoring programmes since 1981, in order to be able to provide warnings of the risk of blooms of dangerous algae in our coastal waters. Every year, from March until October, about 26 stations between the Counties of Østfold and Finnmark are monitored, and we publish information about the coastal algae situation on the Internet, at <http://algeinfo.imr.no>

### Zooplankton

Zooplankton are tiny animals that drift freely in the water column. In our waters they consist for the most part of crustaceans such as copepods and krill. These are highly important food items for fish such as herring, capelin and mackerel. In the Norwegian Sea and the Barents Sea we have been monitoring zooplankton for many years. The amount of zooplankton in a particular area, and thus the availability of the nutrients that are needed by fish, can vary quite significantly, and this is an important cause of changes in the size of important fish stocks. Climatic change and pollution can lead to more permanent changes. An understanding of the quantity and composition of zooplankton is an essential factor in calculating the potential fish production of a given region.

## EGGS, LARVAE AND FRY

We have been performing surveys of eggs, larvae and fish fry almost continuously since the end of the second world war. This is an important field of study, because it gives us a good opportunity to estimate the size of parent stocks, and provides the first indication of the size of the coming year-class.

At present, we are responsible for six annual surveys of eggs, larvae and fish fry. The process starts in January, when we catch North Sea herring larvae in a 2 metre-diameter trawl. Fishing is carried out at night so that the 20 - 30 mm larvae are unable to escape. The amount of larvae caught provides a good indication of the strength of the year-class.

The herring larvae cruise takes place every April. The whole of the Norwegian continental shelf between Stavanger and Tromsø is searched for the tiny herring larvae in order to determine the size of the parent stock. At the same time of year we survey the waters of the Lofoton Islands for the eggs of cod. This takes place at the same time as a survey of adult cod, and the measurements of the eggs indicate how far on the cod have come in the spawning process.

June sees the start of the capelin larvae surveys in the southern Barents Sea. The quantity and distribution of the capelin larvae tell us where spawning has taken place, and how successful it has been. A couple of months later comes the annual capelin fry survey in the Barents Sea, which we carry out in collaboration with Russian fisheries scientists.

Between 1986 and 1991 we carried out surveys of the eggs and larvae of several other species in the Institute of Marine Research's Egg and Larvae Programme (Norwegian acronym: HELP). Now we wish to launch a new HELP programme in order to see whether the results that we obtained 20 years ago are still applicable.

## CORAL REEFS

Norwegian coral reefs are the home of a huge range of invertebrate species. The reefs also attract many fish, which makes them important for the longlining and gillnet fisheries. Since there is often a high level of offshore activity near these reefs, they need to be mapped and monitored in order to prevent them from being damaged.

In 1997 we started an annual programme of mapping the coral reefs. All the observations have been gathered into a database and can be visualised by means of geographical information systems (GIS). By the end of 2002, the database contained 768 individual observations, all of which will be made available to the general public. Along the edge of the continental shelf between Stad and Lofoten, and on the shelf itself, we have identified several important large coral areas, among them Røstrevet, Iverryggen, Sularevet, Storneset and Storegga.

We intend to gradually start monitoring the coral reefs as well. The best way to do this will be to use a remotely-operated vehicle (ROV) to take video films and still pictures of the reefs. Another possibility would be to develop acoustic methods of monitoring the size of individual reefs. Multi-beam echosounders installed in autonomic underwater vehicles (AUVs) programmed to cruise close to the seabed can produce very high resolution charts, and such methods may be suitable for monitoring coral reefs.

We have also documented damage to these reefs. The most important culprit here is bottom trawling, but certain types of offshore activity can also damage reefs; for example the paths of underwater pipelines and other installations on the seabed. This is why the Ministry of Fisheries issued regulations in 1999 that forbid the deliberate destruction of coral reefs, and require fishermen to be take particular care. Bottom trawling is now forbidden near Røstrevet, Iverryggen and Sularevet.

More information about our coral reef surveys and other activities concerning deepwater corals can be found on our Internet site: [www.imr.no/coral](http://www.imr.no/coral)

## POLLUTION

We do research on pollution caused by organic environmental toxins, oil, radioactivity, and nutrient salts.

This type of research is important for several reasons. People who buy Norwegian seafood naturally want to know how pure it is. If we find that level pollution levels are rising, we need to let the authorities know so that they can try to prevent such rises from being repeated.

Many organic environmental toxins are produced by industry and agriculture, and what we are most anxious about are compounds that accumulate in organisms and in the food chain. These can affect the normal functioning of the immune system, for example, while some of them are also carcinogenic. This is why we need to know what our food contains, and how levels of toxins in nature are changing in the course of time.

Norway has an important offshore petroleum industry, which discharges large quantities of waste materials such as the produced water which comes up from the well with the oil. This is dumped directly into the sea in extremely large quantities (120 million tonnes in 2002) that may have implications for marine life.

We have found that the natural reproductive processes of fish are affected by certain chemical compounds known as alkylphenols, which are found in produced water. When fish ingest small quantities of such compounds, the roe (eggs) develop much later than they ought to do. The female cod spawn about three weeks too late, which means that their larvae and fry have difficulty in finding food. In nature, this is a serious matter. The organs that produce the milt of the male fish also develop more slowly than normal.

## MONITORING MODELS

We utilise dynamic models in our monitoring programmes. Such models consist of sets of equations that offer a simplified version of how complex natural systems evolve. The models start out with a description of the current system, which they extrapolate into the future with the aid of the equations, under the influence of external driving forces. Models do not replace observations. Their role is to fill the gaps between sparse observations, since it is impossible to measure all marine environmental variables at all times.

A good example is a regional model of physical circulation, which models currents, temperatures and salinity in a particular ocean region. The equations are derived from the physical laws of nature. The external driving forces in this case include winds, tides, warming and cooling and freshwater from rivers. A model of this sort can also be extended to deal with parts of the ecosystem such as nutrient salts and phytoplankton.

During the past few years, modelling has become increasingly useful as a component of monitoring systems. One reason for this is that the quality of models is improving, through the use of better formulated equations, better descriptions of the driving forces involved, and faster computers. At the Institute of Marine Research we use models to monitor the inflow of water to the North Sea and the Barents Sea, the transport of eggs, larvae and fry of important fish species, and long-distance transport of pollution. An extended model system is being used in the North Sea to monitor primary production, including that of toxic algae.

