FOCUS ON MARINE RESEARCH

3-2004

FUTURE METHODS

Technology and fisheries research

INSTITUTE OF MARINE RESEARCH
HAVFORSKINGSINSTITUTTET

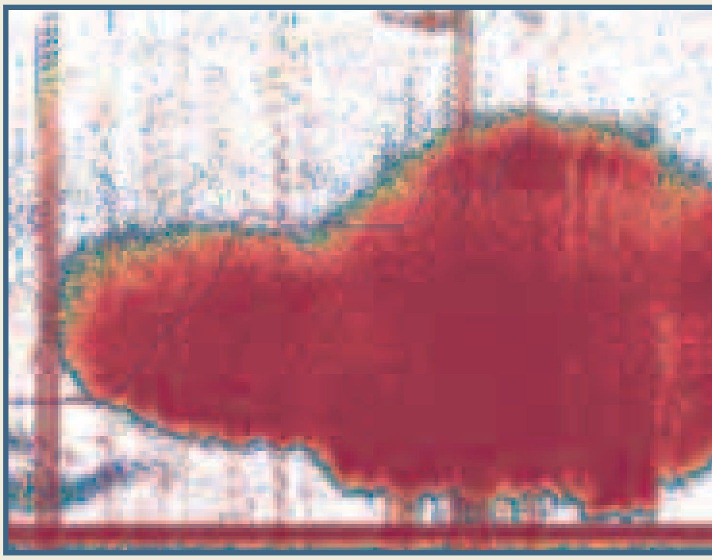
FUTURE METHODS

TECHNOLOGY AND FISHERIES RESEARCH

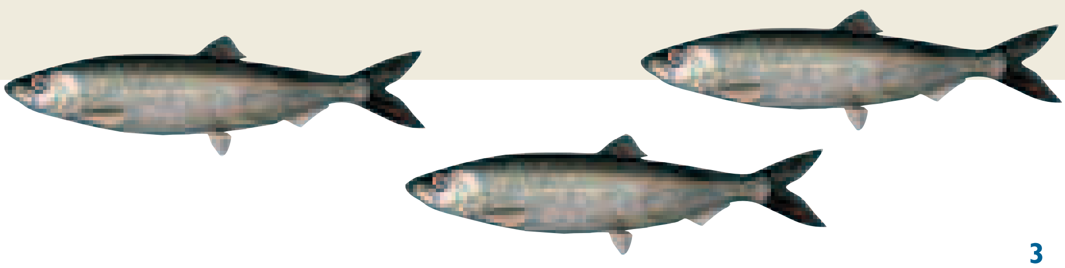
Fantasy and creativity rather than technological barriers are the limiting factors for the renewal of fisheries research. There are many challenges in fisheries management, particularly with respect to observing and monitoring the state of the ecosystem. At present, the individual stocks are at the focus of our research, but a fundamental renewal of our field methods is essential if we aim at an integrated ecosystem management. The adoption of new technologies and methodologies will be a vital tool in this task. The replacement of the old R/V "G.O. Sars" with a new vessel full of a completely new generation of technology has been a step in the right direction. In this brochure, we will show that a wide range of other types of technology is being developed, all of which will make their contribution to the total set of technological solutions for the fisheries research of the future. Another challenge, which we do not discuss here, lies in combining available technologies and methodologies into an integrated system. Should new, more efficient, but still unproved solutions replace old, inefficient methods that have provided good results over a long period of time?

In an ideal world, in ten to fifteen years we will be managing the ecosystem on the basis of a long-term perspective. Harvesting will be more selective and decisions regarding the level and pattern of culls are made in a partnership involving *industry, research and the authorities. Those who harvest the seas must make their contribution to the monitoring, and hence, the researcher will have the whole fishing fleet as a platform for its instrumentation and data acquisition. What sort of solutions can scientists suggest that would enable them to fully exploit such a situation?*

The development of new methodology for fisheries research must have three perspectives: the development of new sensors and technological solutions; the development of new platforms and communication with these; *and last but not least,* the development of strategies, systems and models for the efficient acquisition and use of the data acquired.



In this brochure we describe some of the development projects on which we are working on the basis of these perspectives. Many of them are well advanced and have already demonstrated their usefulness. Some of them could be adopted immediately (e.g. the autonomous TS measurement system) while other will be more important in the long term and in relationship to future systems for ecosystem monitoring (stationary monitoring). Our developments can also be of great value for the commercialisation of products for the fishing industry (e.g. species discrimination by means of multi-frequency acoustics).

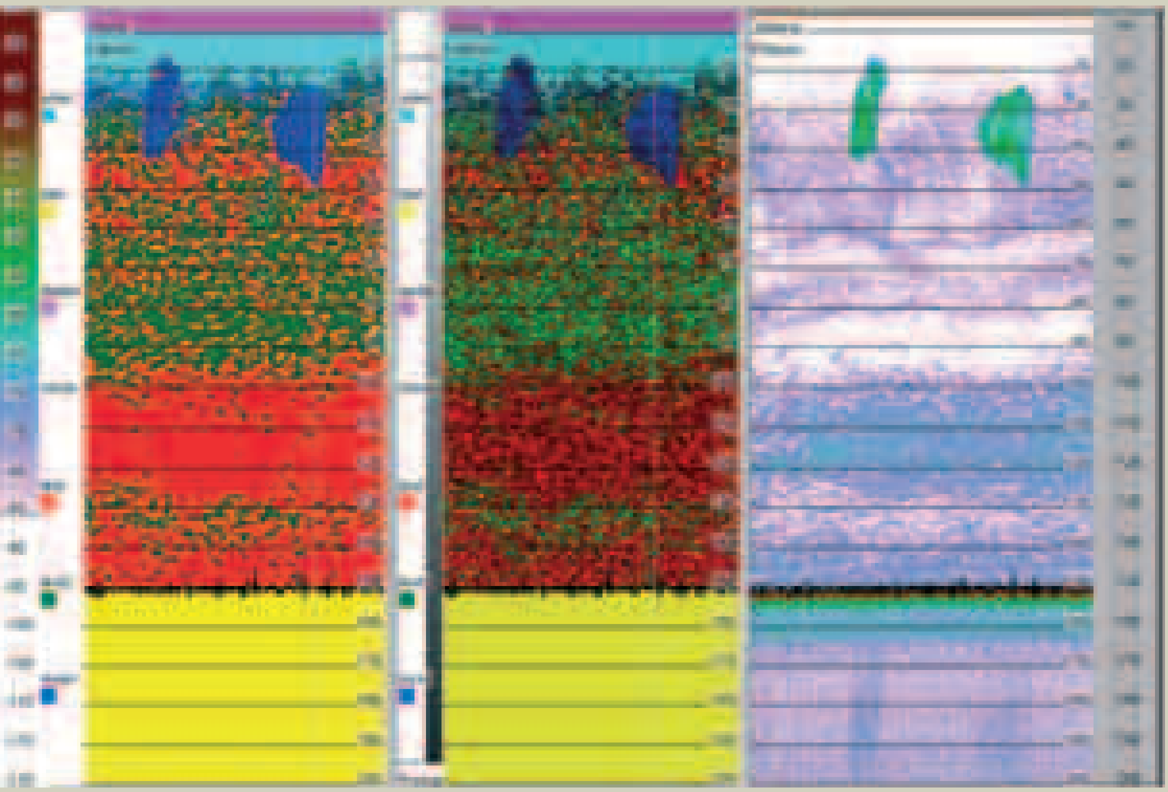


THE LATEST ECHO SOUNDER TECHNOLOGY: SIX TRANSDUCERS SEE INCREDIBLY MUCH MORE

Six echo sounder transducers mounted close together in the drop-keel of the research vessel can simultaneously transmit pulses of sound at six different frequencies, and marine scientists can now extract much more information than they could only a few years ago. Incredibly much more information, many would say, including the scientists behind the new methodology. Now we can "see", for example, the difference between copepods and krill, and we can measure the size of zooplankton with a reasonable degree of accuracy. These are some of the smallest and perhaps most important organisms in the sea, because they are "dinner" for other useful species such as herring, mackerel, capelin, blue whiting and others, as well as for all sorts of larvae and fry.

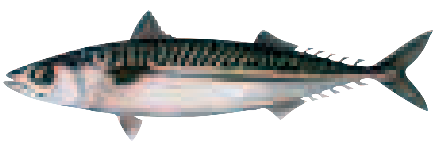
The new "G.O. Sars" was the first vessel to install the new Simrad EK 60 echo sounder, an instrument developed according to a specification of requirements drawn up by the Institute of Marine Research. This echo sounder is particularly suitable for such experiments as we have just completed, and its technology is already being used on regular cruises. The prerequisite for obtaining such detailed information from the ocean is that each of the six transducers should transmit its sound pulses without interfering with the others. These pulses are sent out at exactly the same time, and the "chirps" or pulses are equal in length, which means that the individual pulses reach the same fish or school of fish at exactly the same point in time. The echoes and the echogram image are thus directly comparable. With sound at different frequencies, we can see how marine organisms provide different responses or echo strengths to the different frequencies; and that is the "trick".

In scientific language we can speak of different "frequency responses" or response spectra. In other words, a mackerel produces a quite special response or echo at particular frequencies. Hence, observing these acoustic characteristics, we can be quite sure that the echoes come from a mackerel or shool of mackerel. In each single picture element or pixel on the echo sounder screen, researchers can now identify what the echo sounder image is showing. Identification is still not quite complete, but as mentioned above, we can see the



Bergen Multifrequency Echoanalyzer (BMEA).

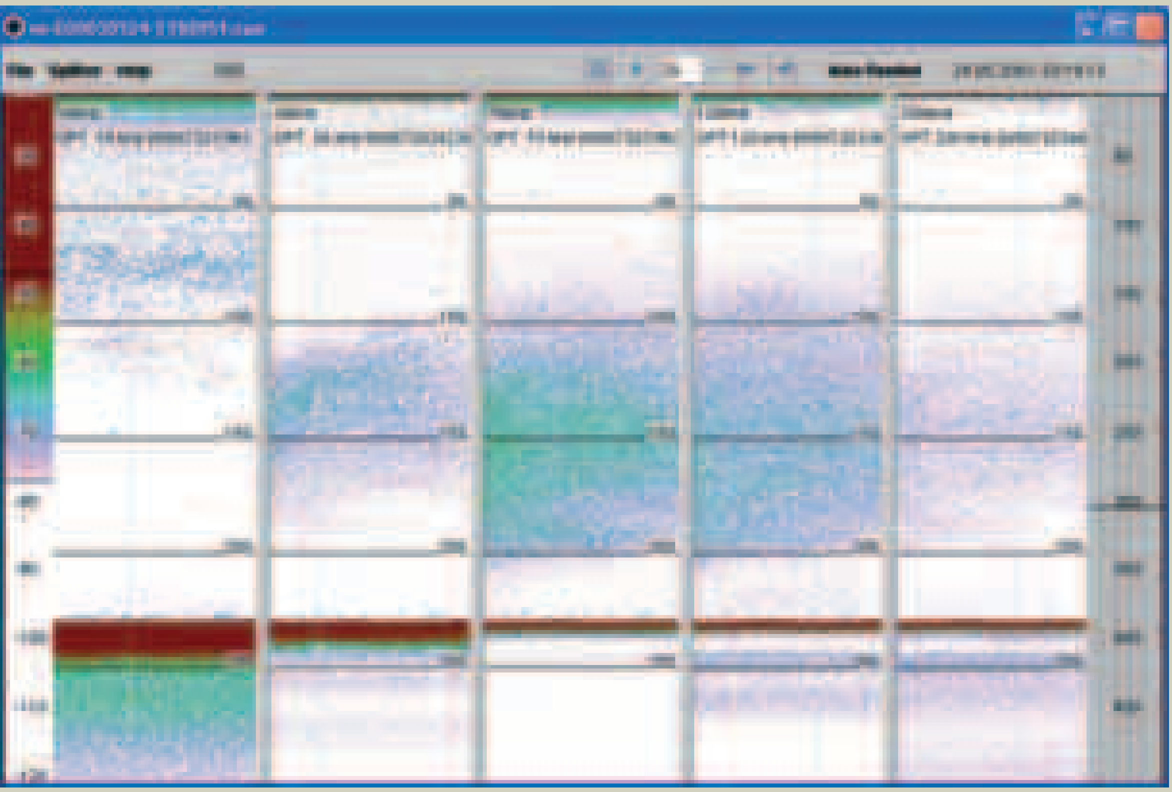
A protruding keel with acoustic transducers.



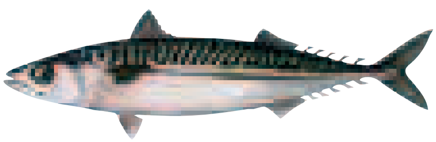
differences between large and small zooplankton, e.g. between copepods and krill. Similarly, we can easily distinguish between fish of different sizes. However, we are still unable to discriminate between fish, such as cod and haddock, that have the same sort of swim-bladder and similar body shapes, but other measurements will help here in the future. But we can distinguish between herring, blue whiting, capelin, sardines and mackerel, and this is useful information for the commercial fishing fleet. A purse seiner is already interested in this method, and is in the process of installing the new echo sounder technology.

For the moment, the Institute of Marine Research and "G.O. Sars" are the sole users of the new system, which has been developed in collaboration with Simrad. The hardware has been supplied by Simrad, while the software was developed by the Institute of Marine Research and Chr. Michelsen Research. The software also includes data-analysis programs that are capable of generating artificial or synthetic echograms directly. With a mixture of several types of organism such as herring, saithe, other small fish and plankton, in the water column, the program can now, for example "separate" these out. It will be possible to generate new echograms, which show only herring or plankton. This will give people who gather and interpret information on a regular stock monitoring cruise much easier and more rapid access to data about a given species. This ensures that they get important additional information, and gives them a rapid indication of whether they need to gather new samples with the trawl or other type of gear.

The new echo sounder technology is a good step ahead of the previous acoustics "revolution", which was based rather on image recognition. In that case, scientists taught the echo sounder (or a computer) to recognise herring or mackerel shoals, by showing the computer echo or sonar images of about a thousand shoals. This technology has been developed only so far that the machine could recognise different types of fish schools as well as a fairly experienced skipper, but now, the new multi-frequency method has brought this aspect of fisheries research a good step further. Now, it is not just the form, colour and location of the fish in the water column that are utilised, but also spectral analysis of the data. Of course, the process will not stop here. The acoustics scientists at the Institute of Marine Research are already working on even more advanced technology – but we cannot know anything more about that until it is ready to be brought into use.



Recordings of krill at 5 frequencies.



OCEAN HUB MONITORING; A NEW METHOD OF MONITORING THE ECOSYSTEM

At present, marine resources and environmental monitoring is largely based on data that have been collected by surface vessels. This process gives us a picture of the situation that can be compared with those based on previous years' observations, gradually forming a time series that tells us how the resource or the environment have changed in the course of the years.

Current data-acquisition methods hide the built-in dynamics (space and time) of physical and biological systems. Our knowledge is thus fragmented in so far as we wish to understand what is going on and to model the real situation and extrapolate the distribution and amount of resources in space and time. This type of information is important if the ecosystem, with all its complex interactions between species and vis-à-vis the environment, is to be monitored and managed.

One proposal for a solution to this problem is to utilize marine observatory technology (instrumentation that provides a continuous flow of information) in ecologically important areas (ocean hubs). This would provide time-resolved data on relationships between fish, plankton and the physical environment, and will give us a fundamentally new basis for understanding how the ecosystem operates. Such data would also supplement key information for establishing operational models that take temporal effects in important ecological processes into account.

A NORWEGIAN EXAMPLE:

The observatory technique is currently employed at international level in the study of coastal and oceanic ecosystems, using huge cable systems. However, only a single Norwegian study has made use of this technique in order to monitor resources by setting out acoustic biomass measurement instrumentation. Figure 1 shows a schematic set-up of the instrumentation needed to monitor a fjord. It consists of upwards-facing echo-sounders and side-scan sonar in addition to an acoustic current meter which measures water flow and the speed of passing shoals of fish. A pilot project has been carried out in Ofoten (Figure 2), where the immigration and emigration of Norwegian spring-spawning

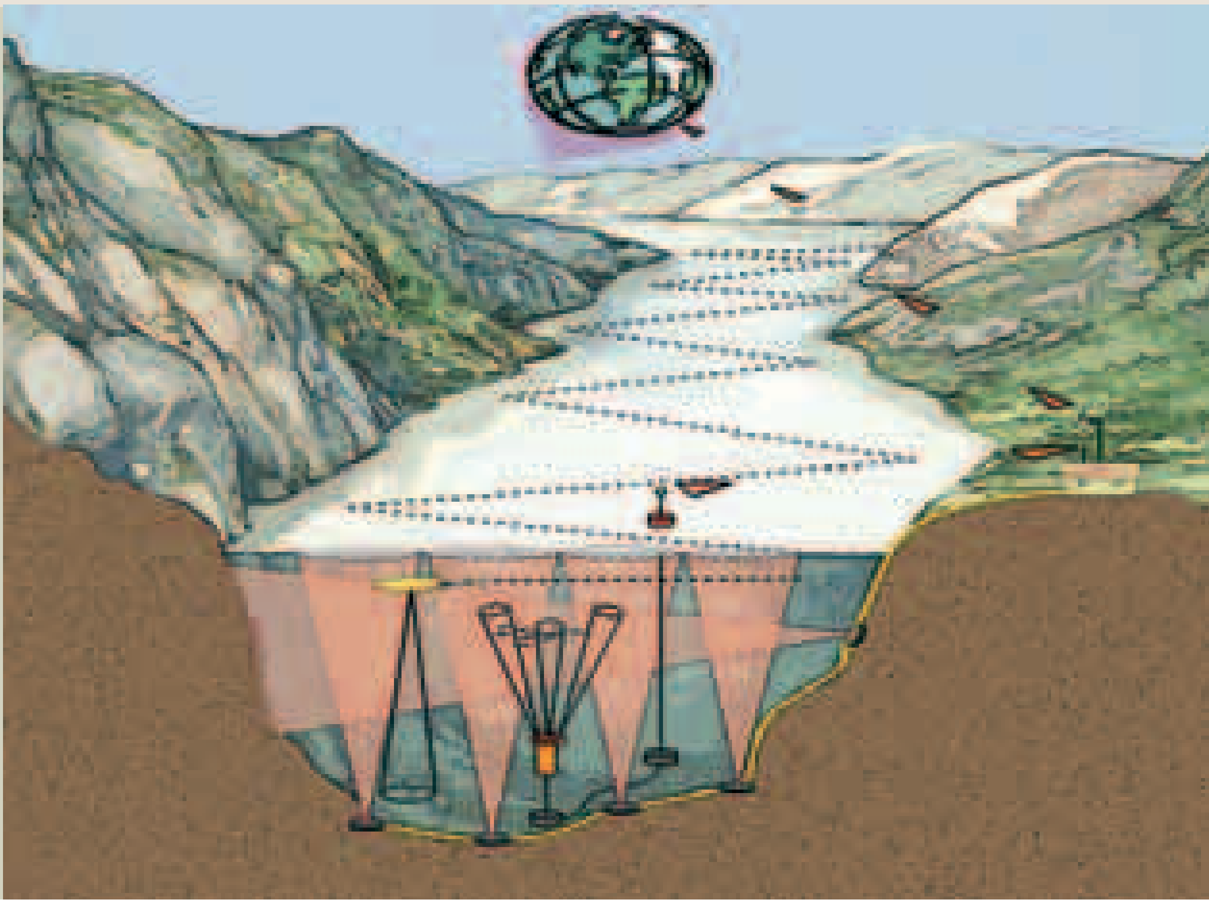


Figure 1: The acoustic observatory in the Ofoten fjord with two vertical and one horizontal sensor. An acoustic current profiler measures the speed of water masses and migrating fish. In addition, an AUV (Autonomous Underwater Vehicle) was used to patrol the area.

herring is being monitored with the aid of a system of this sort. The system is identical to that shown in Figure 1, except that in this case, there are only two echosounders on the seabed. The system can be called up by mobile telephone for a status report (Figure 3). The intention is that the data from the system should go directly to the Institute of Marine Research's data network, which it will update on an ongoing basis. In technological terms this does not present any problems, but so far, it has proved to be financially impossible. Nevertheless, the project has been extremely successful, and we are continuing to work on the technology involved.

THE FUTURE:

We believe that technology of this sort will continue to develop in accordance with two principles. Mobile autonomous systems will be deployed as needed and will remain on station for limited periods of time. Permanent platforms will form part of cable-based systems on the seabed, and will be used to monitor the most important areas in ecological terms. We have already submitted a proposal to the offshore oil industry, in which we propose to use its existing or future cable systems as an infrastructure for such an instrumentation system (Snøhvit, Ormen Lange fields). The technology is not yet fully proven, and involves a certain degree of risk at first, but we believe that advance in technology will take care of this problem. With even a limited number of platforms we would be able to acquire information that would be of decisive importance for efficient operational monitoring and modelling of the ecosystem. Such information would be continuously accessible via the cable system and would form part of an integrated monitoring system that would use all available platforms (Figure 4). Information from such systems would also be freely available on the Internet, so that industry and other interested parties would be able to examine it and utilise it.

Contact persons:
Olav Rune Godø and Ruben Patel,
Institute of Marine Research

Collaboration:
Simrad A/S, NUI,
The Norwegian Defence Research Establishment

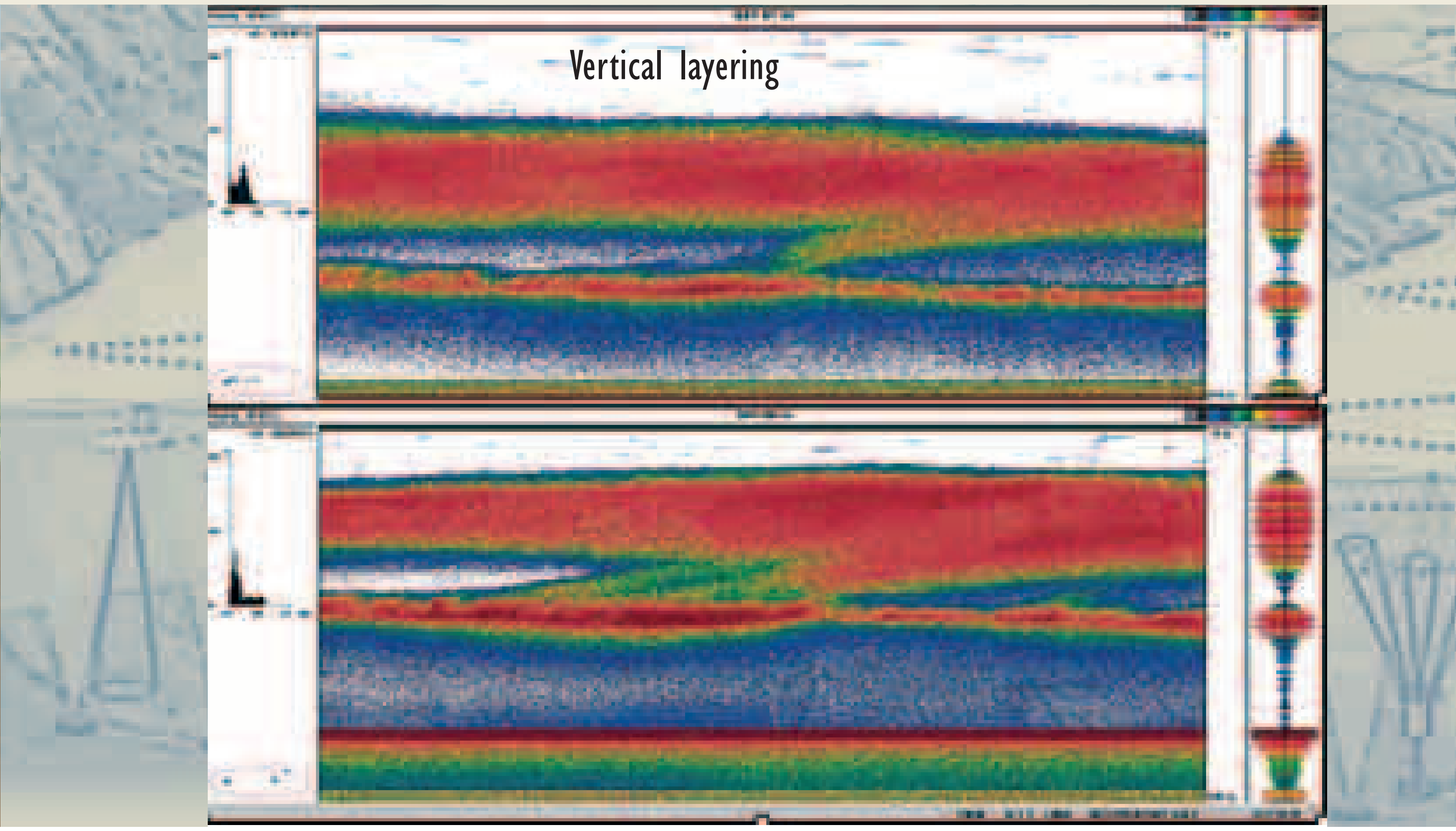
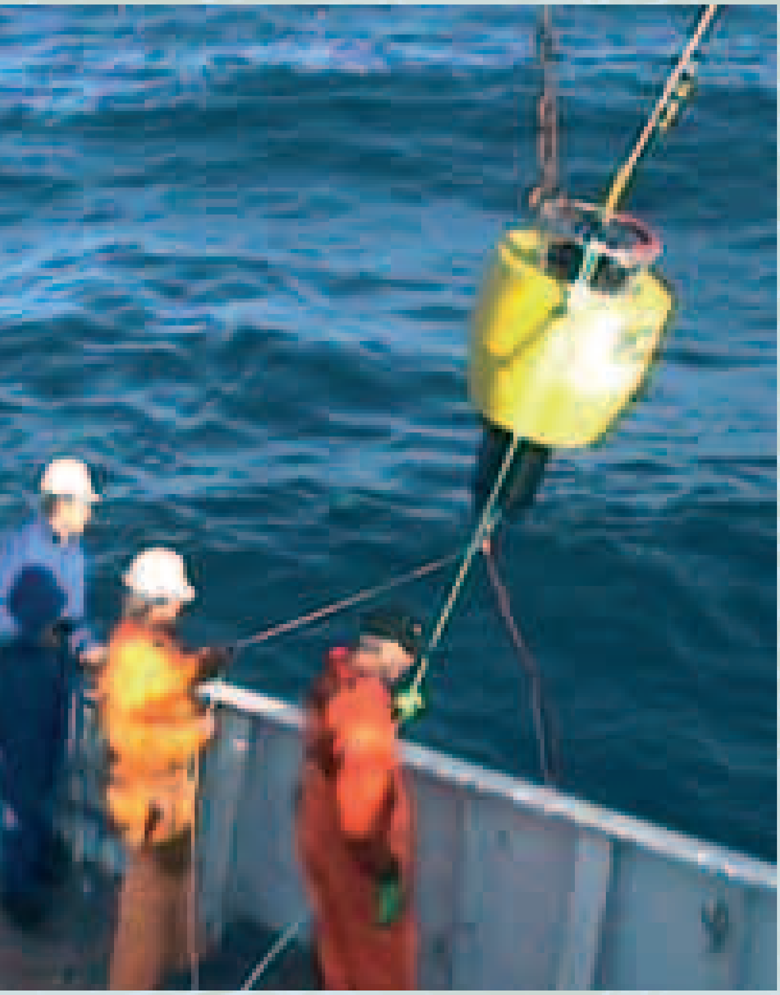


Figure 2: Echogram of herring layers in the Ofoten fjord from two transducers in different positions, showing migration between the layers.

ACOUSTIC BUOY

In order to estimate and understand how fish behave or react to a passing measurement vessel, using an echo sounder, sonar or trawl gear, we have for many years utilised a specially developed buoy. The buoy makes independent measurements with a split-beam echo sounder, and is also equipped with GPS, compass and its own computer, as well as sufficient battery power to run the instrument set for 12 to 15 hours between charges. The echo sounder transducer either hangs directly under the buoy or on a cable some 30 - 50 m below the surface vessel. The buoy also contains a radio system with antennas for data communication which enables us to control the buoy by radio, organise the collection of data and examine the echograms on board the research vessel from a distance of up to four to five nautical miles or nine kilometres from the buoy. A typical procedure is to drop the buoy and allow it to drift freely over a good registration of fish and then allow the situation to settle down for a few hours. In order to measure vessel avoidance by the fish, we then sail past as close as possible to the buoy, perhaps as little as 4 - 5 m, at the speed (and making the noise) normally made by a research vessel during a normal biomass

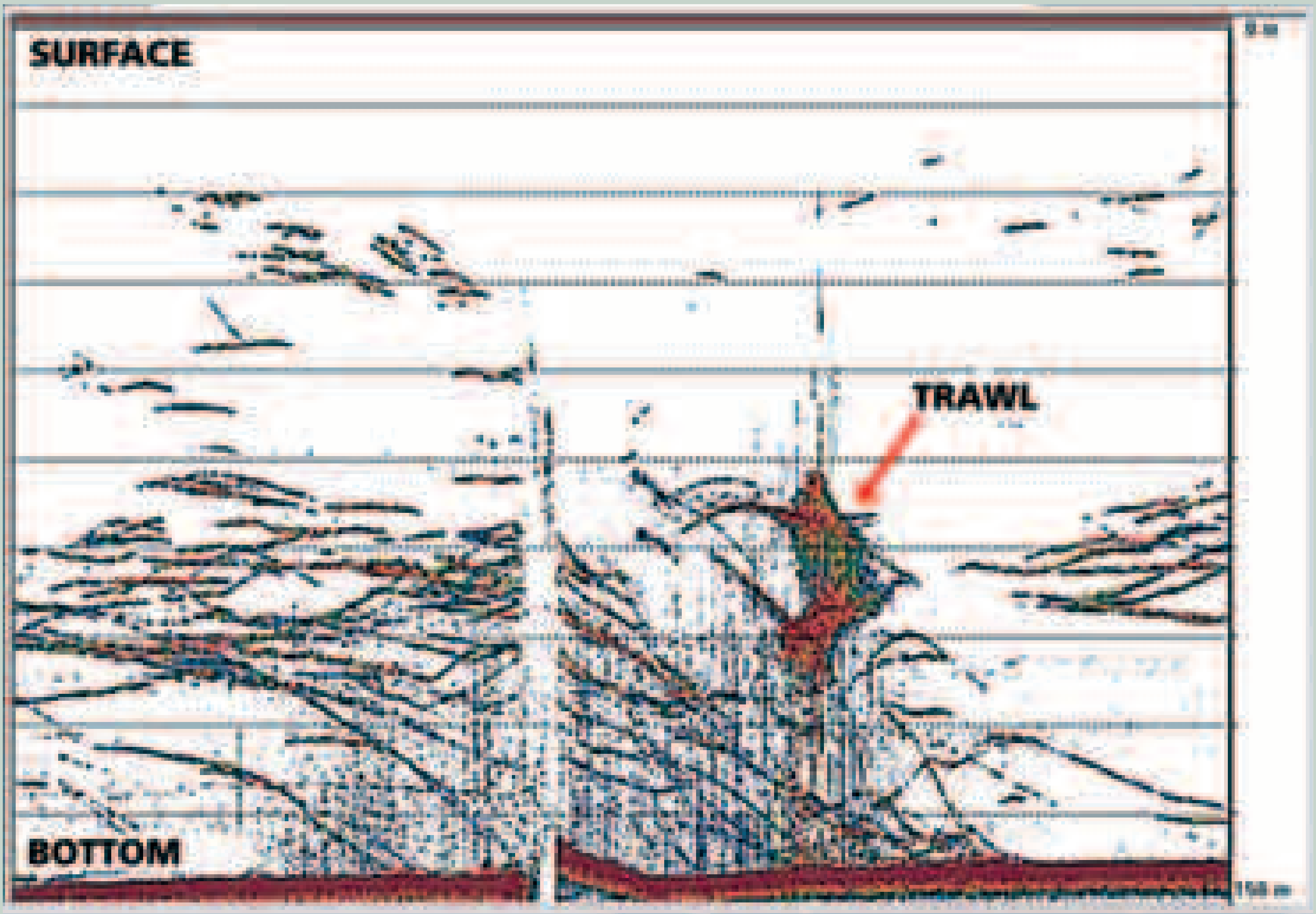


The buoy during deployment and when floating at surface.

measurement procedure. We thus study the situation and the biomass before we pass, during passage (in the “pings” that correspond to the position of the vessel’s own echo sounder), and after passing, which is more interesting when we are trawling. An example of some 150 - 200 data series collected from passages, in these cases using a bottom-trawl, is shown here. The fish clearly dive towards the bottom as the sound of the trawl warp approaches, but they also dive slightly before this happens. If the transducer hangs fairly stably during trials of this sort, we can also measure the swimming path of individual fish on the basis of such data (see separate section on this topic).

Contact persons:

Atle Totland, Olav Rune Godø,
Institute of Marine Research



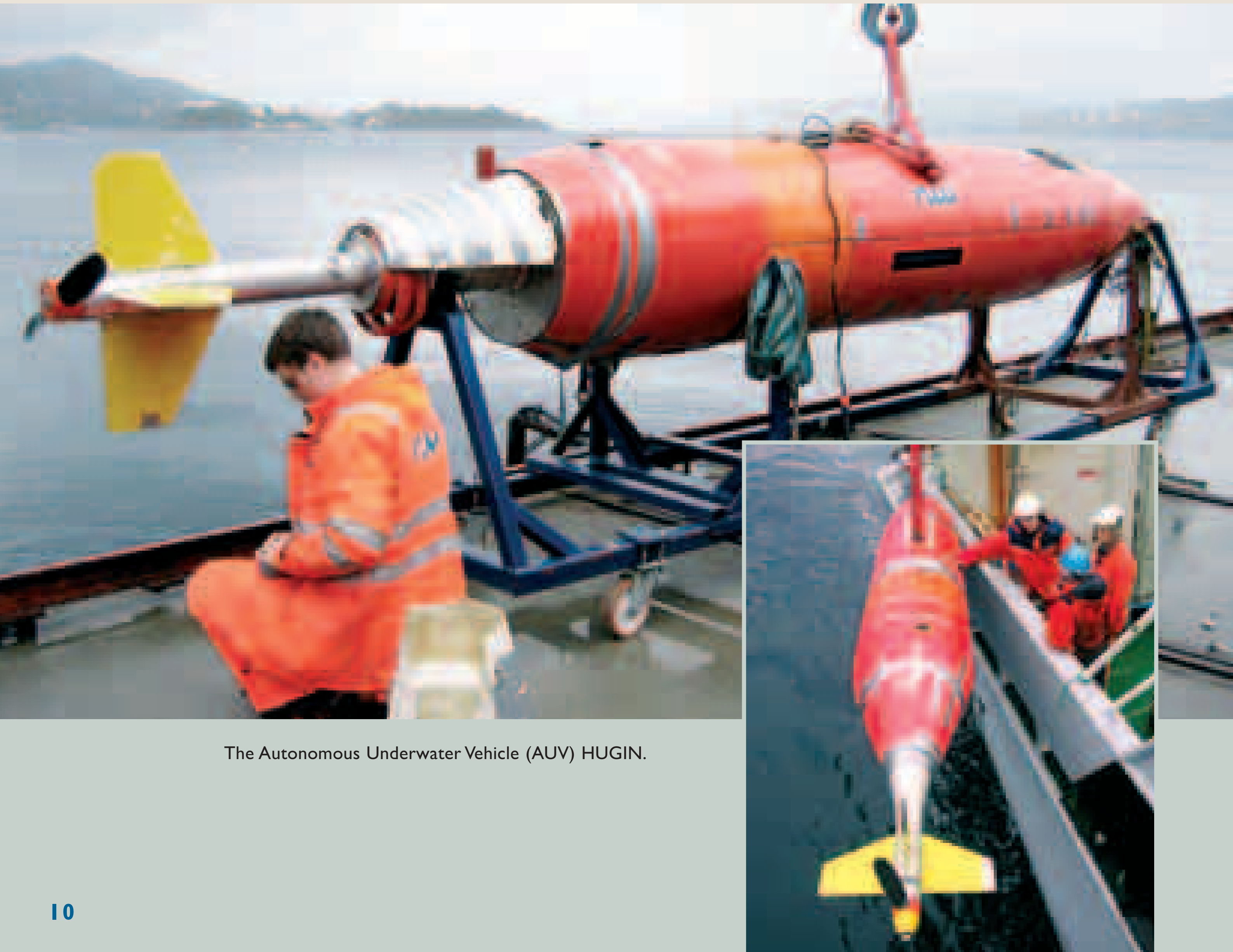
Echogram from the buoy when passed by a vessel towing a pelagic trawl.

AUTONOMOUS UNDERWATER VEHICLES IN FISHERIES RESEARCH

The autonomous underwater vehicle (AUV) known as HUGIN was originally developed for seabed and pipeline mapping, but it has since been equipped with scientific echo sounder for fish biomass measurement. Via an acoustic command link to the mother vessel, it can be run ahead of or under the research vessel while it makes its own biomass measurements. The vehicle is particularly useful for observing whether herring avoid the noise of a research vessel during such measurements, and for measuring cod near the bottom. At present, the vehicle can operate for about 20 hours at a speed of 2 - 4 knots, either under the command of the mother vessel via acoustic link or in pre-programmed mode, where the surface vessel does not need to follow the AUV. The version that we have used has a maximum operating depth of 2000 m.

If we operate the AUV in autonomous mode we can use the mother vessel for other tasks, and thus improve cruise efficiency . We can also run parallel cruises with the AUV and the research vessel, enabling us to cover larger areas in a shorter time, and thus giving us a better instantaneous picture of the geographical distribution of the fish.

Many of the sensors used to make marine measurements have a limited range. By using an AUV to bring the measuring instruments closer to the measurement object, we can make more detailed



The Autonomous Underwater Vehicle (AUV) HUGIN.

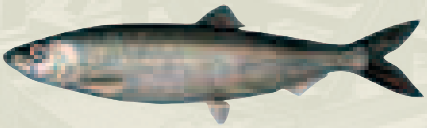
measurements than are possible from a research vessel on the surface.

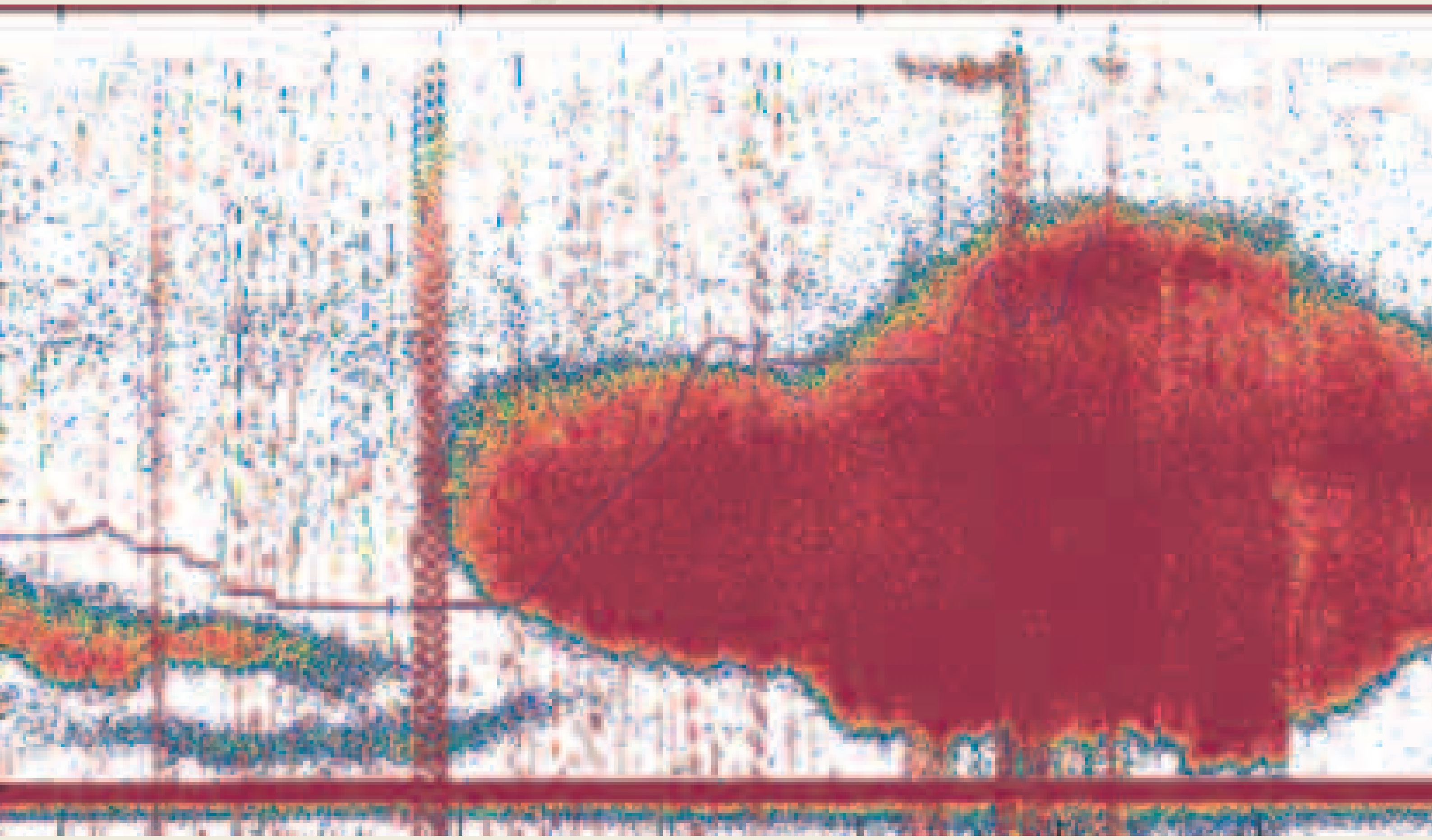
The AUV uses a propulsion system with particularly low noise level, allowing us to study biology and behaviour in the sea, with less impact on the subjects of study than would otherwise be possible. This is particularly important in photographic studies.

Compressed or packaged data can be transmitted from the AUV's sensors to the mother vessel by the acoustic link during a cruise. This enables us to look at data as they are collected in real time. In certain cases this can be important, since this gives us better control of location and data-acquisition than when the AUV is operating autonomously and the data are brought on board later. This method also allows us to decide to change operation plans and inspect interesting objects in more detail on the basis of the real-time information.

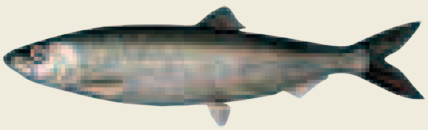
This project is a collaborative effort between Norsk Undervanns Intervensjon (NUI) in Bergen, the Institute of Marine Research and Simrad AS.

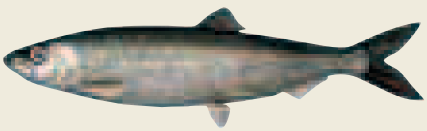
Contact persons:
Olav Rune Godø and Ruben Patel,
Institute of Marine Research





Echogram from the survey vessel showing the track of the AUV when passing through a large school of herring.



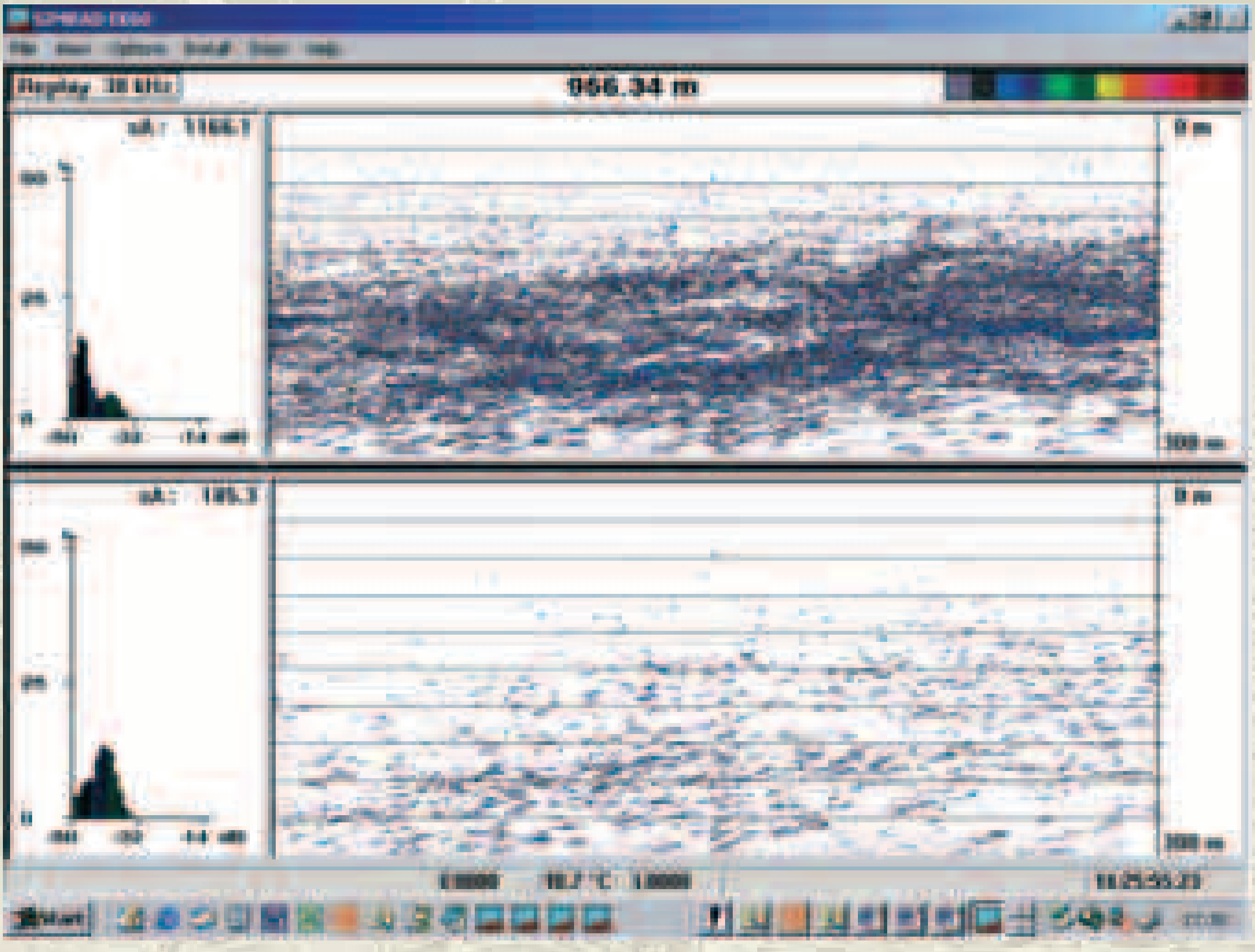


DEEP-TOWED UNDERWATER VEHICLE

In deep water, for example at depths of more than 1000 m, the resolution of echoes from fish is rather poor when observed with a hull-mounted transducer. In order to observe remote registrations more closely, and in particular in order to be able to measure individual fish, we have developed an underwater vehicle that can be towed at depths of 1000 - 1500 m, depending to some extent on the towing cable. Echo sounder, pressure and motion sensors are installed in the nose of the vehicle, which resembles a small torpedo. The challenges in this case lies in electrical power transmission and optical data communication along 7500 metres of cable, towing speed and the depth of the vehicle, and in accurate calibration of the acoustic transducers which must be able to withstand high pressures without change in performance.

The first successful trials of the system were carried out in 2001 from the old "G.O. Sars", on deepwater redfish in the Irmiger Sea. An example of an echogram from the underwater vehicle is shown below, with examples of registrations of individual fish and measurement strength data. The next trial of strength for this underwater vehicle will consist of measurements of deepwater fish on the Mid-Atlantic Ridge on the Mar-Eco cruise in summer 2004.

Contact persons:
John Dalen and Hans Petter Knudsen,
Institute of Marine Research

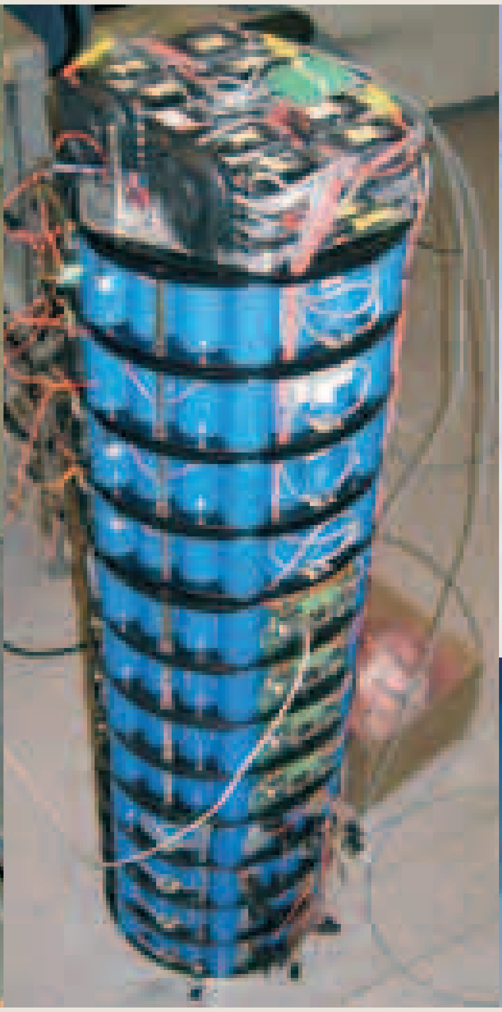


Redfish at 500–800 m depth in the Irmiger Sea, at two frequencies.

Deployment mechanism for the towed body, on the new "G.O. Sars".

DEAD-ZONE OBSERVER WILL INSPECT FISH ON THE SEABED AND MEASURE THEM IN DETAIL

The biomass of cod, haddock and other bottom-dwelling species is measured using echosounders and bottom trawls. The echosounders used by research vessels are unable to "see" and discriminate fish very close to the seabed, particularly in deep water. This is because the emitted sound pulses have a spherical shape. When the leading edge of the pulse meets the seabed the echo starts its return journey, and this powerful echo blanks out the echo from the edges of the beam, which has not yet reached the bottom. The rest of the blind zone is formed by the length of the transmitted pulse and the back-step length. The back-step is the minimum step backwards needed in order to avoid mixing the echo from the seabed with that from the fish. (The separator that discriminates fish from the seabed must be certain). We typically lose 0.5 - 2.0 m effective height over the true bottom when we measure fish in the Barents Sea. This blind zone close to the bottom is often called the "acoustic dead zone" and it increases with depth. It is a problem for acoustic stock measurements that a variable but unknown proportion of bottom-dwelling fish live within this zone. In order to gain more knowledge of this problem, and to quantify its extent, a "Dead-zone observer" has been developed in a cooperative project between NUI A/S and the Institute of Marine Research, with financial support from the Research Council of Norway.

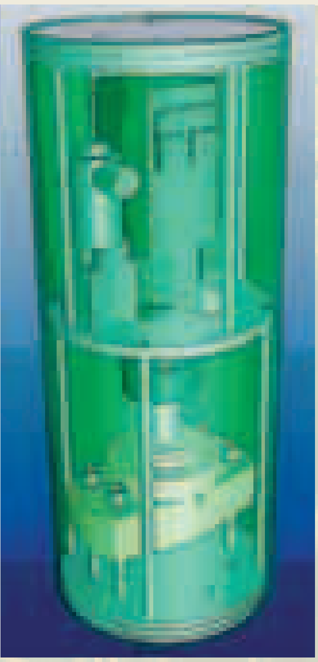
Specially developed battery, artificially buoyancy and antenna to Irridium satellite phone, tolerating pressure to 1000 m depth.

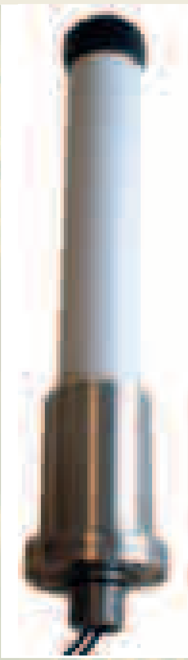
HOW IT WORKS:

The "Dead-zone observer" (see photo) is an autonomous drifting underwater vehicle equipped with an artificial swim-bladder, a large battery, echo sounder and satellite transmitter/receiver. It can dive and position itself at a given distance from the seabed and regulate this distance automatically on the basis of pressure measurements and distance measurements supplied by its own echo sounder. The instrument drifts freely over the bottom with the ocean currents and uses a modern split-beam echo sounder to measure the fish in the dead zone for later reporting to the mother vessel. The dead-zone observer lies so close to the seabed that it is capable of measure cod which are lying with their stomachs actually in contact with the bottom. If specified in the mission plan, the vehicle can also rise to the surface, determine its position via GPS, and set up two-way communication to the mother ship or to shore via an Iridium telephone link, in order to exchange information such as measurement data, position data, emergency reports or a new task plan. The device can operate independently up to one week on its batteries, while the vessel carries out its ordinary cruise activities in the same area.

Contact persons:

Egil Ona and Atle Totland,
Institute of Marine Research





AUTOMATIC TARGET STRENGTH COLLECTOR

Exact knowledge of the echo strength (target strength) of all species and sizes of fish is essential key information for producing correct biomass measurements. To collect such information is difficult, because we are dependent on favourable conditions for making target strength measurements. Firstly, to the fish need to be resolved as individual targets. Variations in length should also be small, and we should also preferably have pure samples (trawl hauls) that are not “contaminated” by other fish. Variations in echo strength for a given size of fish, due to depth, the natural behaviour of the fish or by its physiology, are other complicating factors for the development of reliableequations between echo strength and size. This is the motivation for developing an instrument that measures the echo strength from individual fish as they swim past the apparatus.

HOW IT WORKS:

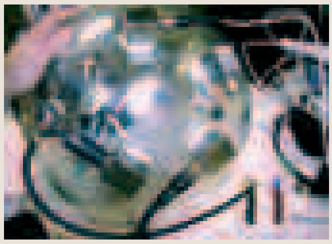
A large rig containing a digital camera and an echo sounder can be released and positioned on the seabed in an area where the target species is distributed. The echo sounder measures the echo strength of individual fish as they pass the beam, and, by means of the echo sounder data, the camera focuses and takes a picture of the fish when it is in position in front of the camera. The echo sounder contains two acoustic transducers, which “see” the fish from above and from the side.

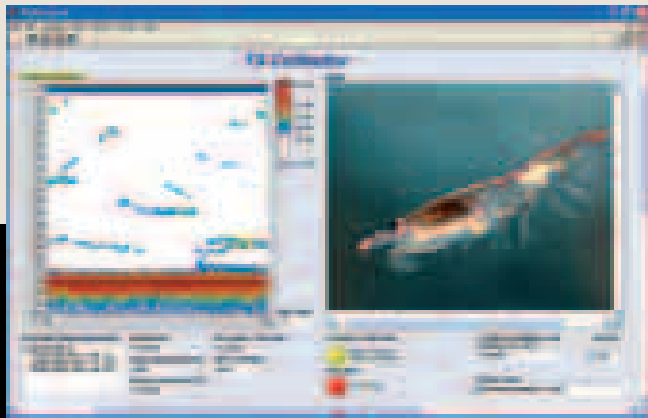
The computer-controlled system can thus measure:

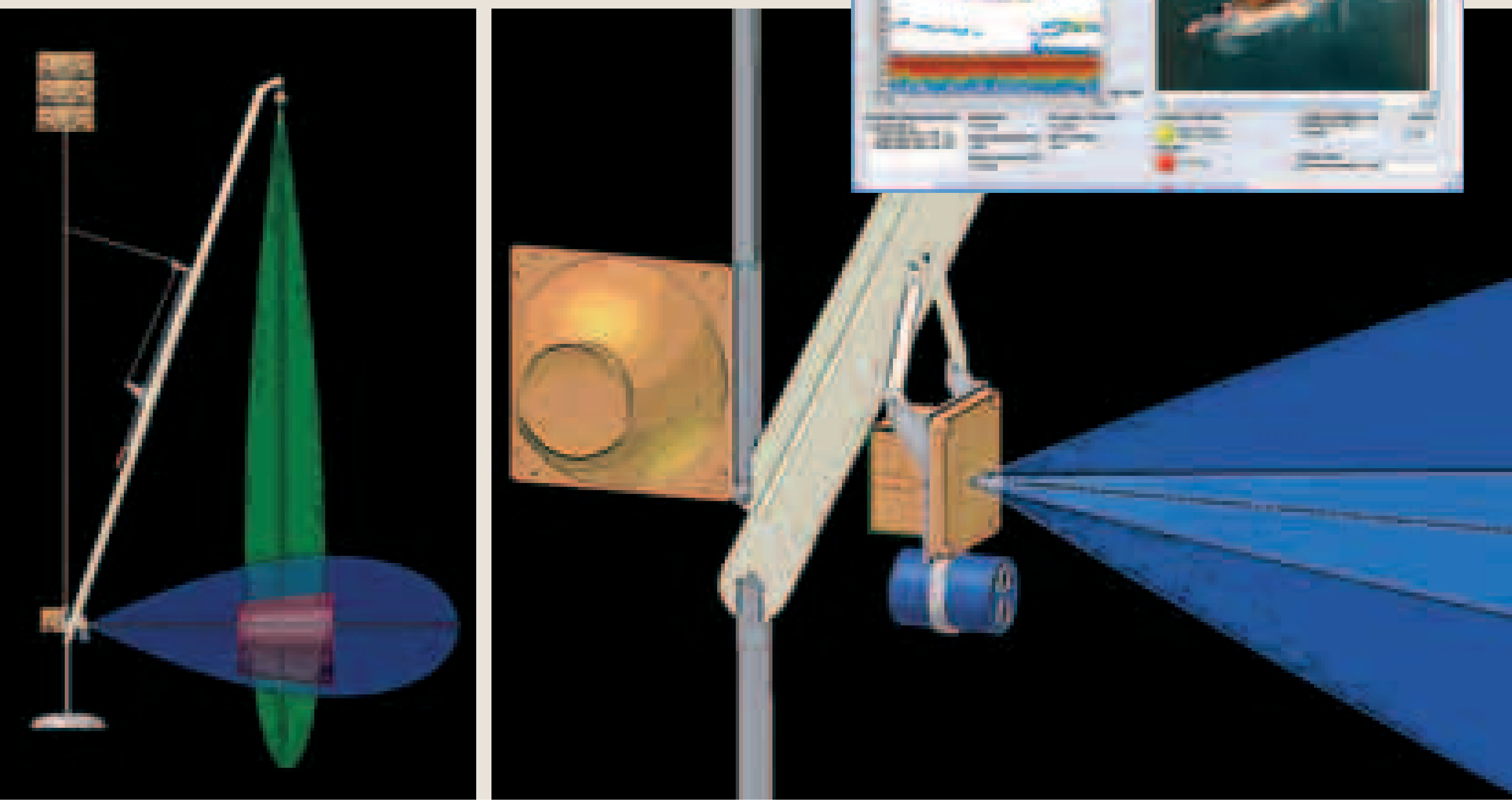
- The echo strength or target strength of the same fish during a series of pings (pulse transmissions)
- The species
- The length of the fish
- The angle of the fish relative to the transducers (tilt angle).

The system operates independently on its own battery, and is capable of taking as many as 30,000 photos and associated acoustic measurements before being brought to the surface. We expect to be able to use the new instrument on shrimps and krill as well as fish.

Contact persons:
Egil Ona, Terje Torkelsen and Atle Totland, Institute of Marine Research





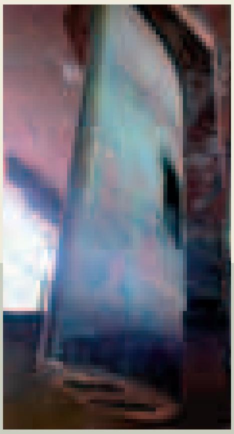


Steering system in the vehicle to decide coincident data for camera and acoustics.

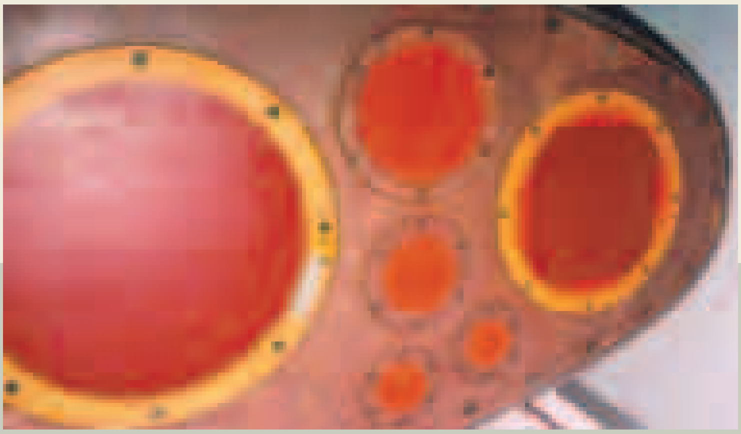
DROP KEELS FOR MORE ACCURATE ACOUSTIC REGISTRATIONS IN BAD WEATHER

In bad weather, air is thrown or whipped down into the sea surface layers, and a research or fishing vessel beating forward in high sea is also pounding a lot of air under its keel. Air is a perfect reflector of acoustic energy, and layers of air, either in the form of small bubbles or as larger air flakes, effectively blocks the echo sounder or sonar signal. In particular near the sea surface the density of air bubbles are high, but decrease rapidly with increasing depth. Mounting of acoustic equipment on a large drop keel which may be deployed 2–4 meters under the bottom of the vessel have over the last 10 years significantly improved the accuracy in acoustic measurements on research vessels. Examples of simultaneous registrations from a conventional transducer mounting and a transducer mounted on the keel are shown below. Measurement conditions and especially the scrutinizing of a mixture of several fish species is very much improved with a keel transducer mounted on a drop keel. The experience made in the early 1990s at IMR has lead to such installations on all new research vessels. The new "G.O. Sars" has even 2 instrument keels with acoustic instrumentation, and the fishing industry has also recently adopted the idea. The first fishing vessel with a drop keel is being built in 2004, with echo sounder and sonar mounted in their most favourable positions.

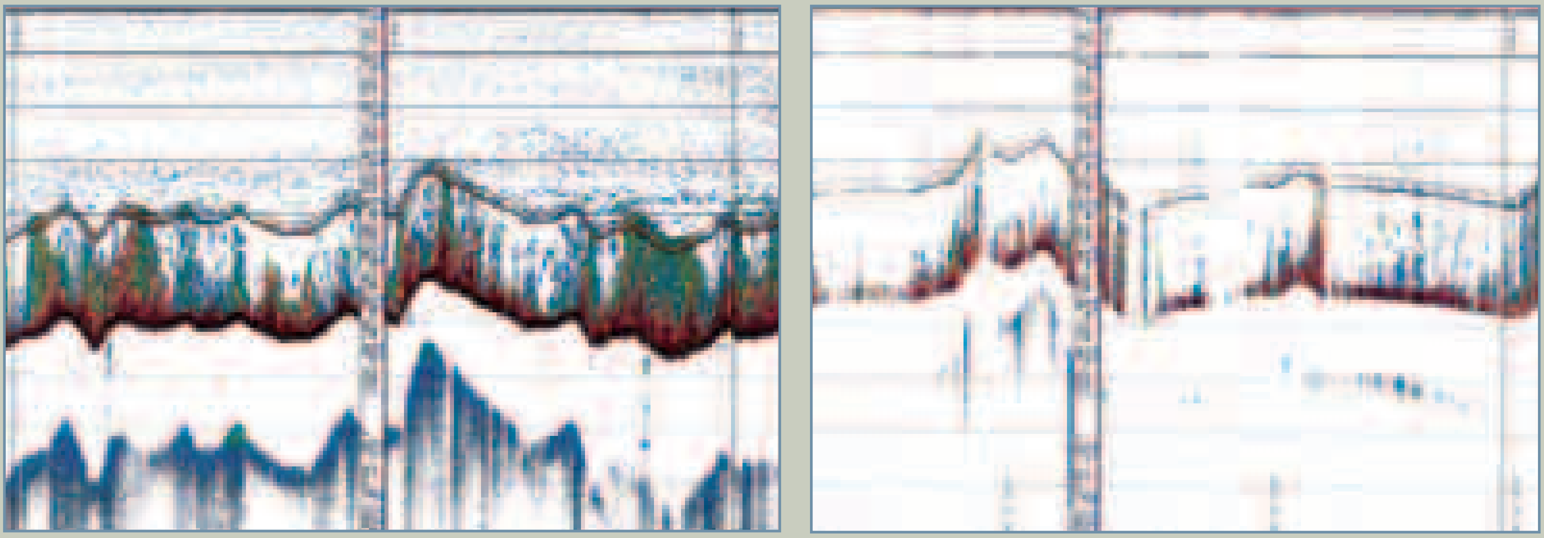
Contact persons:
Egil Ona and Hans Petter Knudsen,
Institute of Marine Research



The protruding keel.



Transducers for 6 EK60 with frequencies from 18–364 kHz.



Simultaneous echograms, with and without the protruding keel, in bad weather.

ACOUSTIC TARGET-TRACKING METHODS

Reliable biomass measurement depends on our ability to assess and understand the behaviour of fish. Acoustic target tracking has been used to measure the swimming or avoidance paths of thousands of fish during trawling operations with bottom trawl. A modern split-beam echo sounder, which for this purpose has been mounted in a drifting buoy, (see relevant section) signals the position of individual fish every time that the echo sounder recognises the fish as an individual target. Depending on the depth, the pulse rate may range from one to ten pulses a second. If we join up the positions of a single individual, we are able to extract information about its behaviour or swimming path. One of the main problems is to integrate individual measurements from one and the same fish into reliable trajectories. If the trajectory of two fish crosses each other, it will often be difficult to distinguish between them after passage. Once we have connected the individual measurements into a three-dimensional track, our developed methods are used to calculate the swimming speed and direction of the fish. There is often "noise" in the measurements, for instance because the transponder platform has moved. In such cases we need robust filters to get rid of this noise, so that the real swimming speed and direction are apparent. Since the echo strength of the fish is measured by the same system, we can also determine and sort out swimming tracks to a certain extent on the basis of the size of the fish.

Contact person:
Nils Olav Handegard,
Institute of Marine Research

Figure 1

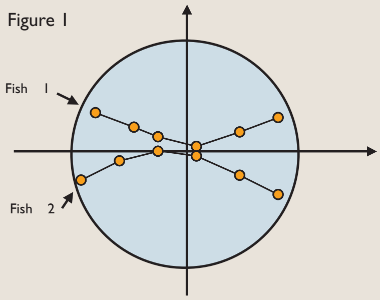
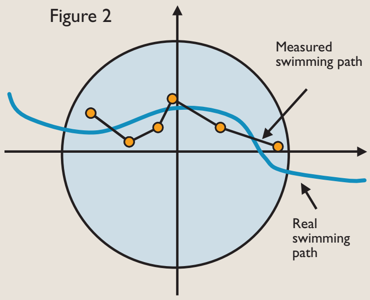
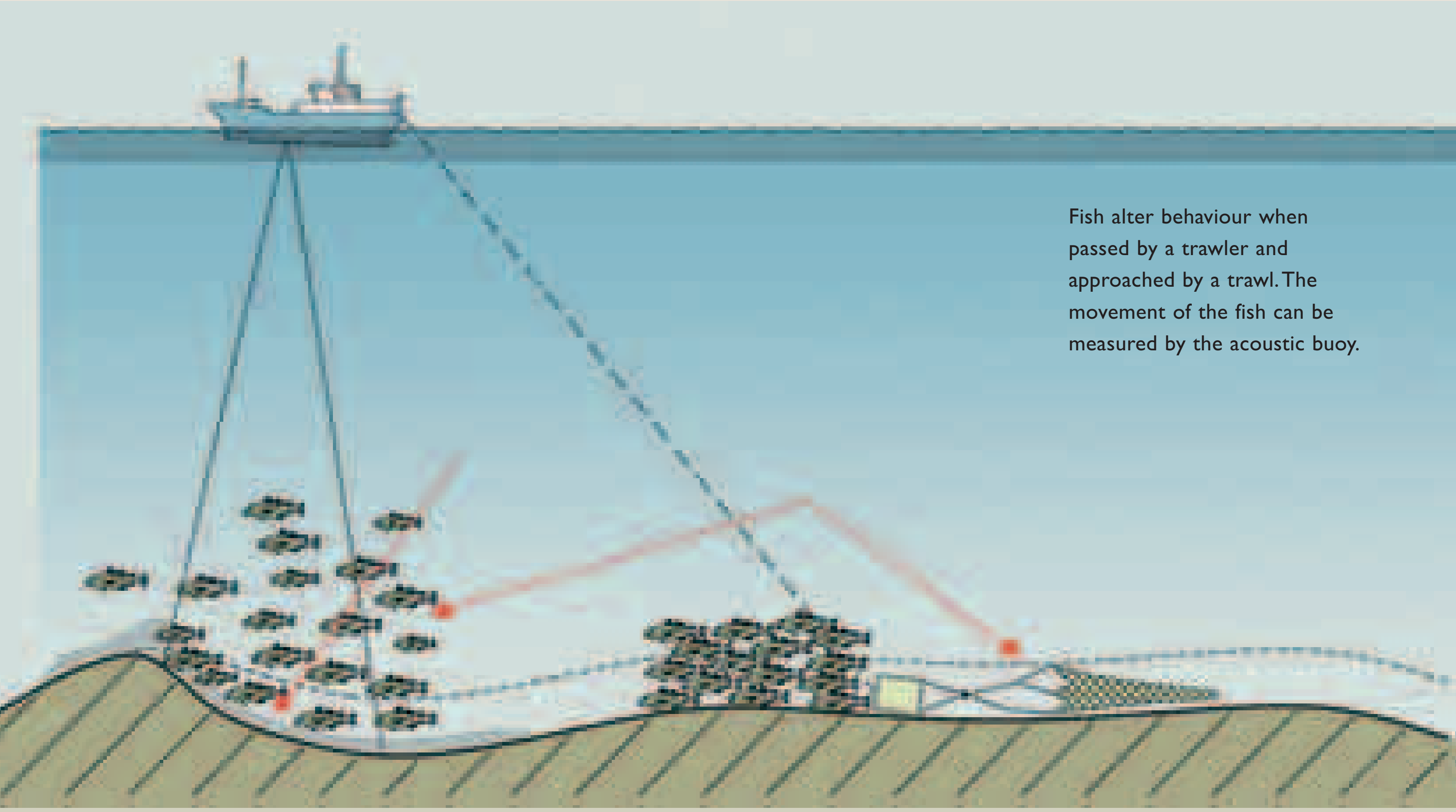


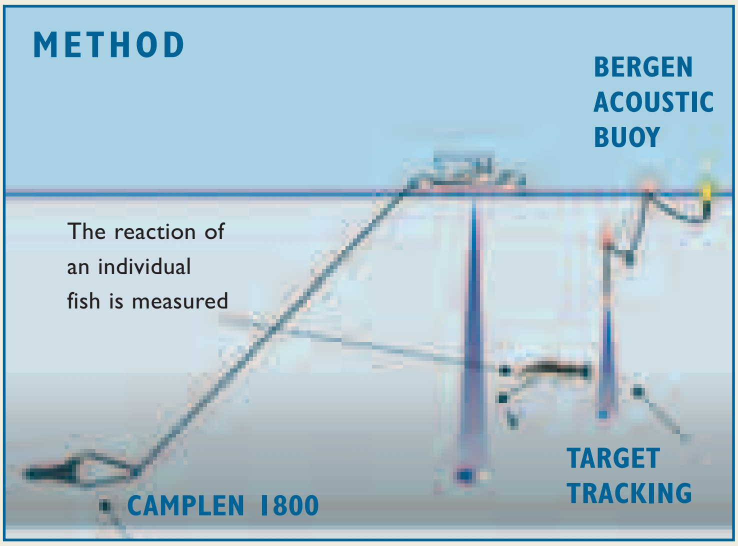
Figure 2

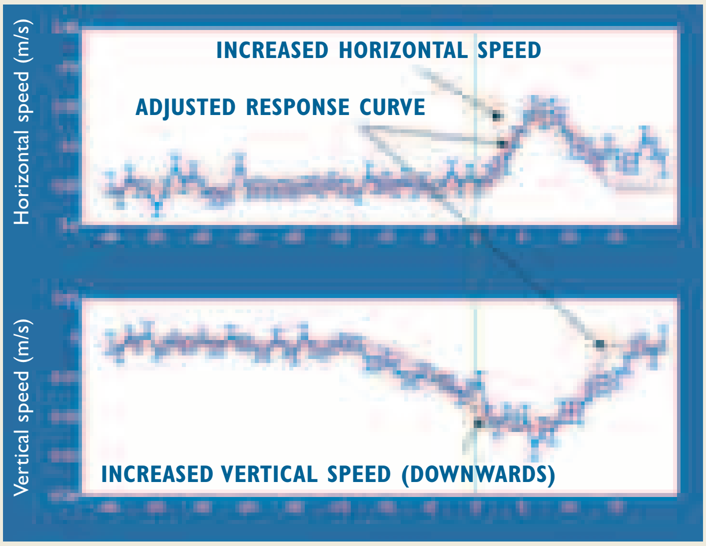


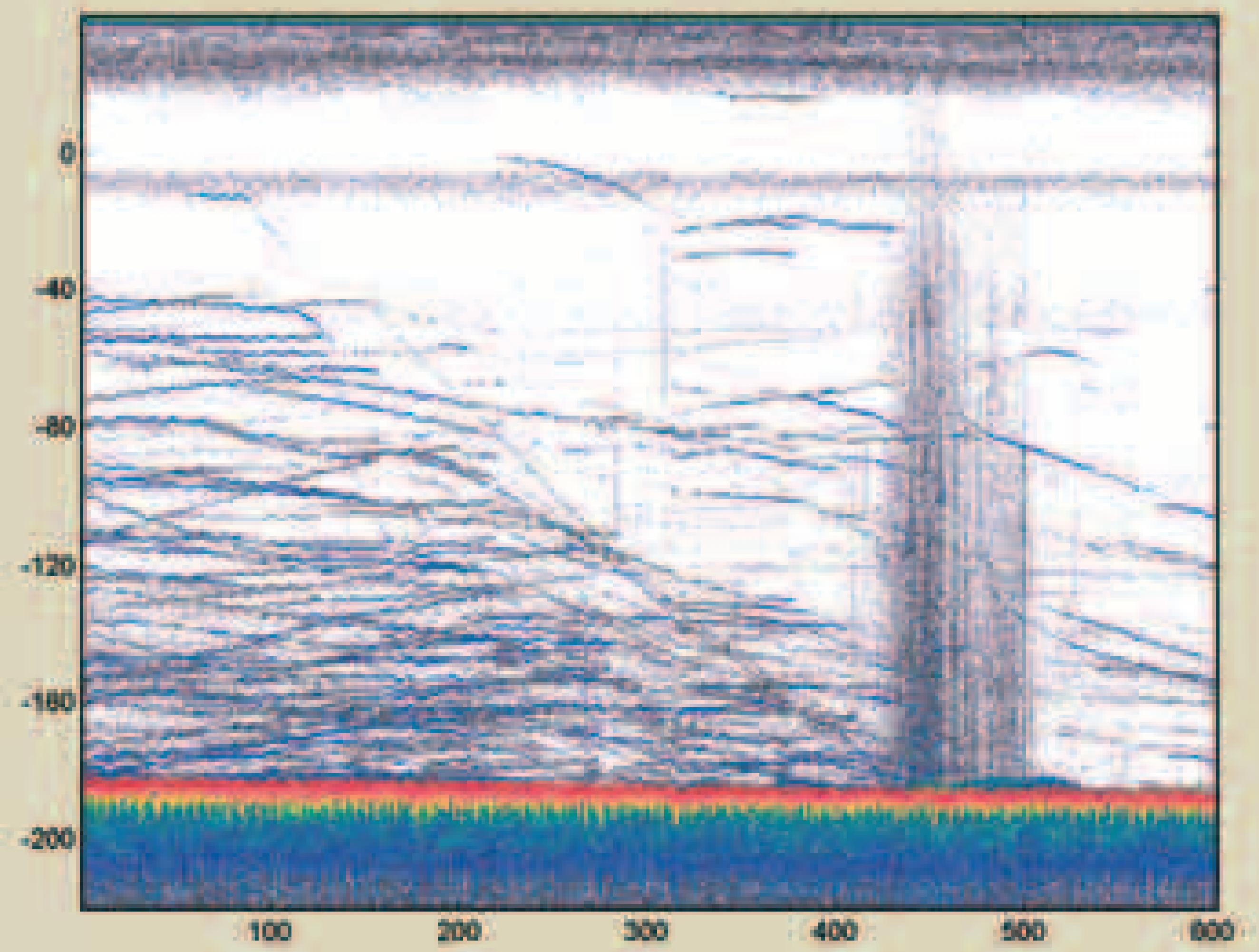
An advanced filtering method helps deciding the real swimming path.



Fish alter behaviour when passed by a trawler and approached by a trawl. The movement of the fish can be measured by the acoustic buoy.







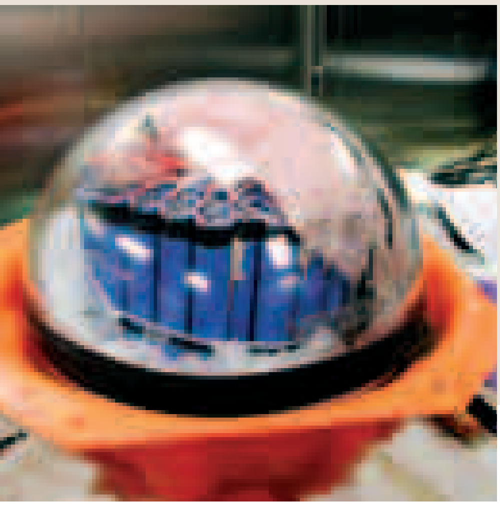
Echogram from the buoy during passage of a bottom trawl. We see traces of individual fish. The trawl sensors emit noise when the trawl passes, at ping numbers 420–520.

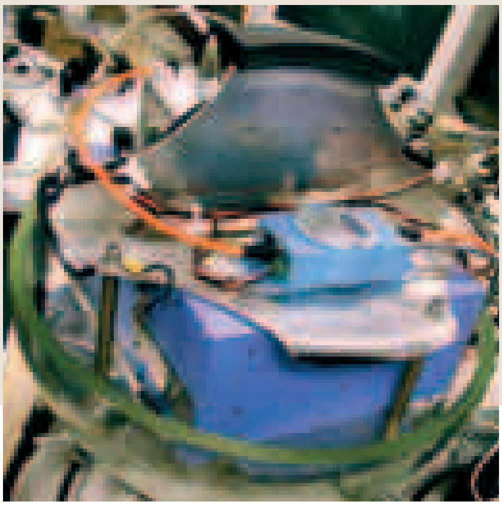
LANDER FOR AUTOMATIC COLLECTION OF MARINE DATA

We often want to study the distribution and movements of fish at a given location over shorter or longer periods of time. For short periods, we have developed a system that can be released and sinks to the bottom, and which will automatically rise to surface after a preset time interval. This equipment logs and stores large quantities of data, e.g. from an echo sounder, cameras, temperature and current recorders, etc. The “brain” of the system (central computer) is programmed with mission plan so as to optimise date collection with given battery capacity. Following initiation of the mission plan the platform is launched in the decided position. A heavy weight takes the lander to the bottom, or to a suitable depth, where it remains while data are recorded. The unit, i.e. the upper part of it minus the weight, is subsequently brought to the surface by sending a powerful acoustic pulse to the release mechanism. This disconnects the weight, and the platform floats to the surface where it is recovered. The transponders on the lander can be mounted facing upwards, downwards or horizontally. The unit can also be positioned in the water column by means of a mooring line from the bottom, or hanging from a buoy on the surface. The equipment has been tested on herring in the Ofotfjord, and three units will be deployed on the Mid-Atlantic Ridge during the MAR-ECO cruise.

Contact persons:
Olav Rune Godø and Terje Torkelsen,
Institute of Marine Research

Collaboration:
Simrad A/S, NUI,
The Norwegian Defence Research Establishment





LIDAR FOR SURVEYING MARINE RESOURCES

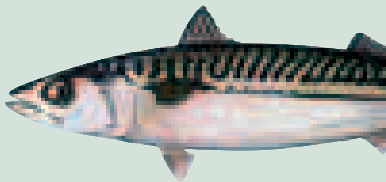
Lidar is the acronym for Light Detection And Ranging, and the technique is used for a wide range of remote sensing purposes, ranging from police laser speed controls to weather observations, and most recently, marine research. By installing a lidar instrument in an aircraft, we can survey large areas of the ocean in a short time. The Institute of Marine Research has joined forces with the Norwegian University of Science and Technology (NTNU), and with the financial support of the Research Council of Norway, we have developed and built a lidar instrument that can be used on both aircraft and the Institute's research vessels.

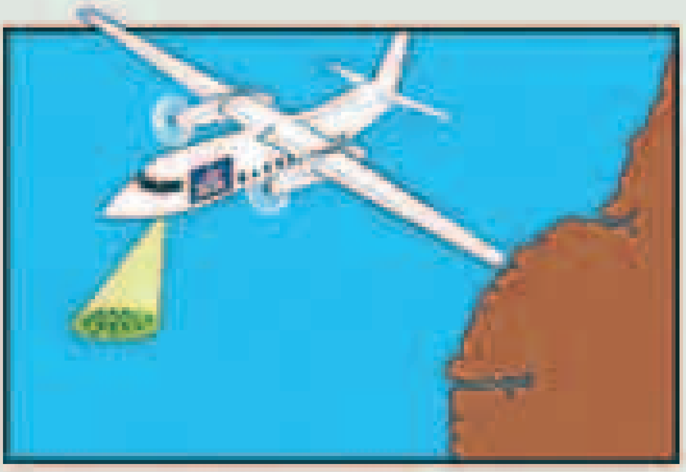
The equipment is installed in an aircraft, which flies at an altitude of 300 metres and a speed of some 180 knots. Its laser emits very short pulses (about 15 nanoseconds long) of green light (532 nanometres) towards the surface of the sea. Some of the light is reflected from the surface, while some penetrates it and is reflected by fish, plankton or other objects. A negative lens in front of the laser spreads the light and creates a circle of light with a diameter of about 5 m on the surface. The receiver consists of a telescope that points in the same direction as the laser. This picks up the reflected light and passes it on to a photon counter, which transforms it into an electrical signal. This signal is digitised and store in a computer together with the GPS position. These data form the basis of echograms like those generated by an echo sounder. Under ideal condition, the system can "see" down to depths of about 50 metres.

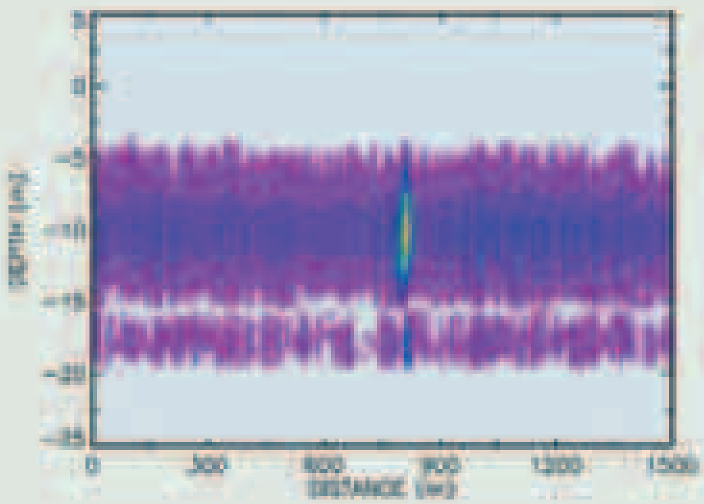
The point of using lidar mounted in an aircraft rather than traditional acoustic methods such as echo sounders or sonar instruments is that it lets us cover large areas in a short time. The method also means that the fish do not try to avoid the vessel, which is a serious problem when we are carrying out measurements on fish that swim close to the surface. The project was originally designed for surveys of mackerel stocks in the Norwegian Sea. Shoals of mackerel are often found close to the surface. Because the mackerel does not have a swim bladder it returns an extremely weak echo to acoustic instruments. A well-developed swim bladder produces about 95% of the echo in some species.

Other applications of lidar include surveys of herring, fish larvae and plankton close to the surface.

Contact persons:
Olav Rune Godø and Eirik Tenninga,
Institute of Marine Research

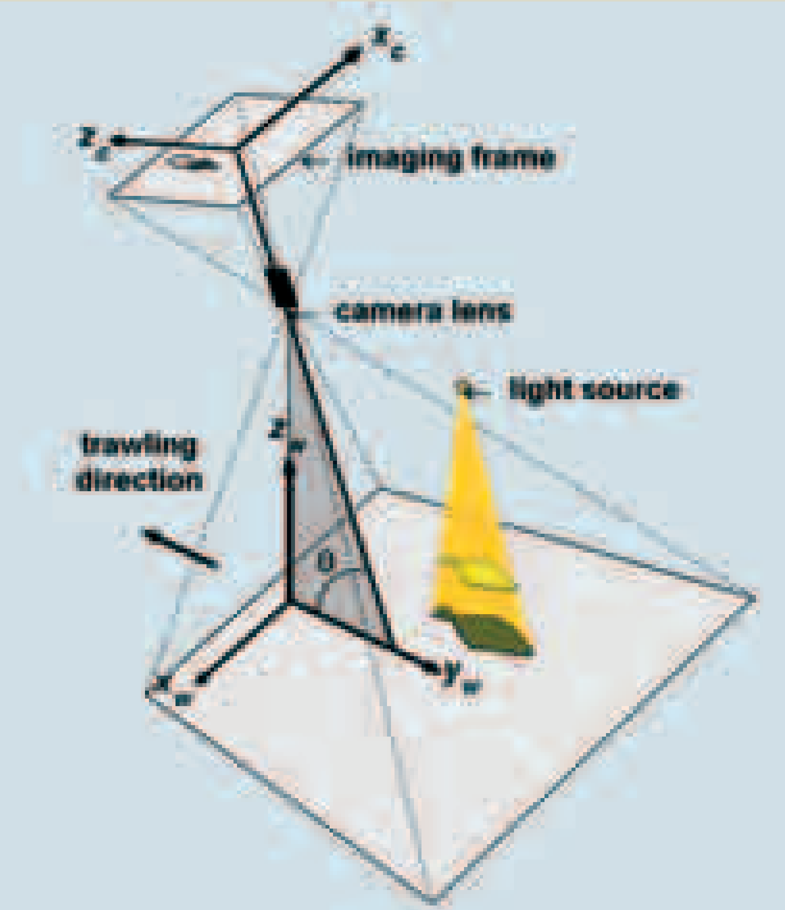






AUTOMATIC MEASUREMENTS OF FISH FROM TRAWL VIDEOS

During a Greenland halibut cruise near Svalbard in 2002, a video camera and light sources were mounted on the top of a bottom trawl, so that video recordings could be made of the area ahead of the trawl opening at depths of up to 500 metres. The set-up is illustrated in Figure 1. The recordings were promising, and we continued with trials of automatic video-based recording and measurement of fish. How can we measure the length of a fish by camera? Will a small fish close to the lens not appear to be the same size as a large fish that is near the bottom? The trick involved here is that using an artificial light sources enables us to see both the fish itself and its shadow. Such double information enables us to calculate the position of the fish in three dimensions, which in turn lets us calculate, for example, its length and speed. The technique can be verified by comparing the distribution of lengths obtained by the video recordings with the distribution based on the catch taken by the trawl, and the results so far have been promising. We can also study behaviour, for example how many fish go under, into, or to the side of the trawl, and how such behaviour is related to the size of the fish. Such measures of catchability are important when we are trying to determine the size of a stock on the basis of trawl catches. Another problem is whether the fish arrive in "clumps" or are evenly spread out. In order to obtain a more quantitative answer to this question, we are currently analysing the statistical distribution of distance between pairs of fish as they pass the camera. A distribution corresponding to randomly distributed fish appears to be the situation for Greenland halibut. Used in conjunction with other modern measurement techniques, the video system seems likely to make an important contribution to better stock measurement in the future.

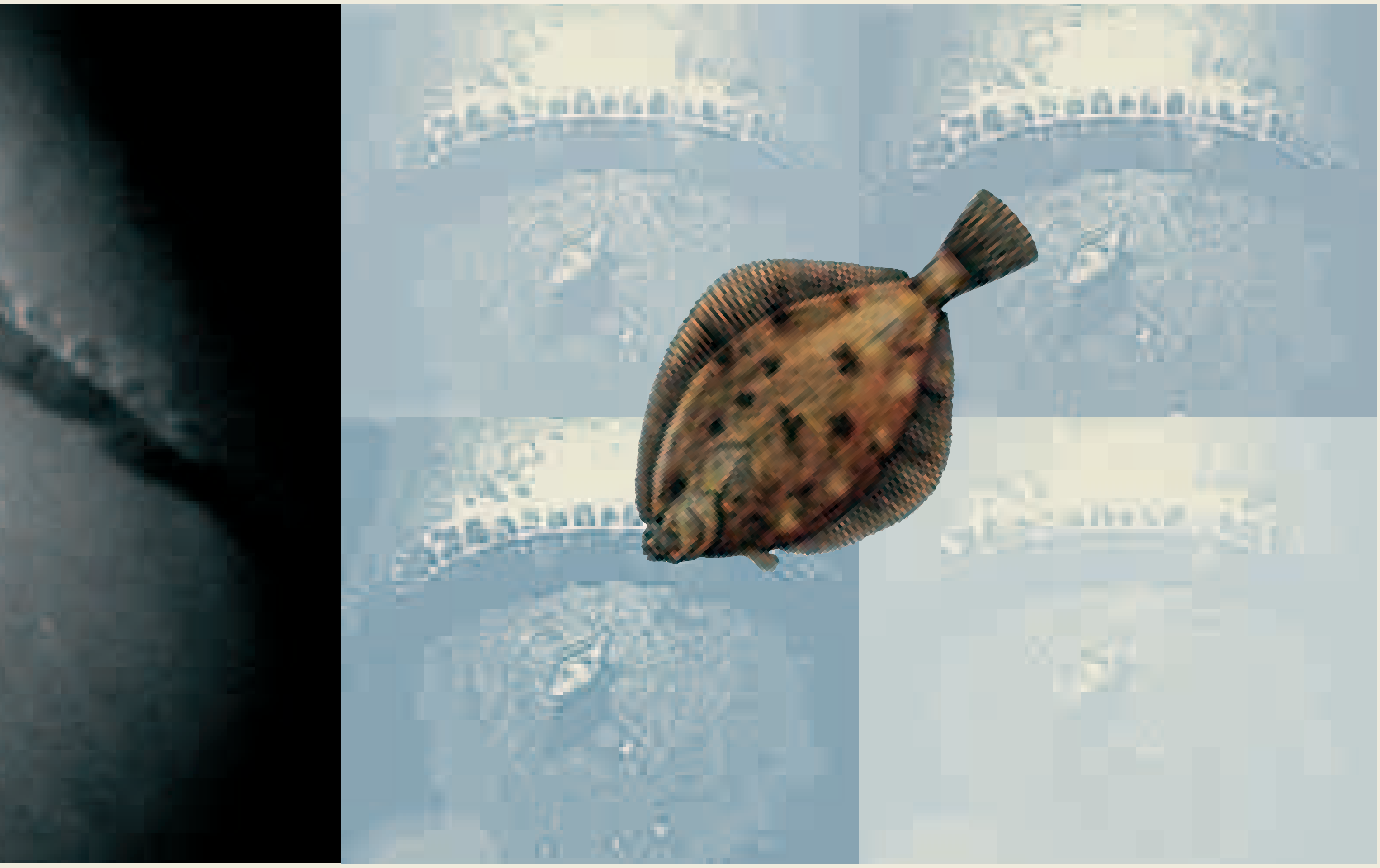


Figur 1

AUTOMATIC MEASUREMENTS:

How can we automatically determine when it is a fish that enters the field of view of the video camera, rather than a stone on the seabed or another sources of “noise”. And how can we measure the fish automatically? A trick we use here, is that if the object does not move, we can predict from one image of the seabed what the next one will look like, when we know the camera geometry and the speed of the vessel. When the predicted image is subtracted from the actual image, in principle there ought to be no contrast left in the differential image. A fish in motion will be predicted wrongly, and the contrast in the differential image will increase whenever a fish is present. When a fish has been detected, we can automatically locate and determine the shape of the fish shadow by identifying the darkest parts of the image. We then draw a rectangular image round the shadow, with its maximum intensity over the shadows and zero intensity everywhere else. We know that the fish must be somewhere between the shadow and the light source, and we search at different heights above the seabed within this volume. For any given height, we calculate what the shadow rectangle should look like. The correct height is defined as being where we have the best correlation between the parts of the image and the shadow rectangle. When the height is known we can calculate the length of the fish. A successful example is shown in Figure 2.

Contact person:
Alf Harbitz,
Institute of Marine Research



HAVFORSKINGSINSTITUTTET
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

www.imr.no

HAVFORSKINGSINSTITUTTET, TROMSØ
Sykehusveien 23
P.O. Box 6404
N-9294 Tromsø – Norway
Tel.: +47 55 23 85 00
Faks/Fax: +47 77 60 97 01

HAVFORSKINGSINSTITUTTET, FLØDEVIGEN
N-4817 His – Norway
Tel.: +47 37 05 90 00
Faks/Fax: +47 37 05 90 01

HAVFORSKINGSINSTITUTTET, AUSTEVOLL
N-5392 Storebø – Norway
Tel.: +47 55 23 85 00
Faks/Fax: +47 56 18 22 22

HAVFORSKINGSINSTITUTTET, MATRE
N-5984 Matredal – Norway
Tel.: +47 55 23 85 00
Faks/Fax: +47 56 36 75 85

REIARLAGAVDELINGA
RESEARCH VESSELS DEPARTMENT
Tel.: +47 55 23 68 49
Faks/Fax: +47 55 23 85 32

INFORMASJONEN
INFORMATION
Tel.: +47 55 23 85 21
Faks/Fax: +47 55 23 85 55
E-mail: informasjonen@imr.no

CONTACT PERSONS

Egil Ona
Tel.: +47 55 23 84 55
E-mail: egil.ona@imr.no

Olav Rune Godø
Tel.: +47 55 23 86 75
E-mail: olav.godo@imr.no

www.reinelinjer.no rl0452