Centre for
Research-based
Innovation

CRISP

Annual Report 2012

1. Summary

CRISP, the Centre for Research-based Innovation in Sustainable fish capture and Processing technology, started its research activities April 1, 2011. Since its launch, the consortium has consisted of four industry partners (Kongsberg Martime AS, Simrad, Scantrol AS, the Egersund Group and Nergård Havfiske AS), four research partners (the Institute of Marine Research, Nofima AS, the University of Bergen and the University of Tromsø), and two sponsors (Norges Råfisklag and Norges Sildesalgslag). The research of the Centre is organised in six scientific work packages:

- development of instrumentation for fish identification prior to capture
- monitoring fish and gear behaviour during fishing
- development of methods to release unwanted catch unharmed
- development of low-impact trawl gear
- adaptation of capture and handling practices to optimize catch quality and value
- analysis and documentation of the economical benefits to the fishing industry of converting to more sustainable capture techniques.

In this second CRISP year a range of new knowledge, new fishing gears and instruments for the fishing fleet have been developed as important tools for making the trawl and purse seine fisheries more sustainable. These achievements have only been possible because of extensive cooperation between the centre's industry partners and research institutes. In this early phase of the centre's existence the main focus has been to develop knowhow and components of equipment that has the potential to revolutionize fisheries worldwide when they at a later stage will be compiled into more integrated fishing systems.

The development of sonar technology is one of the focus areas of CRISP. Improved acoustic instruments will give the fishermen better tools for identification of species, quantity and fish size in schools prior to setting their gear. The research is carried out in close cooperation between Kongsberg Maritime, Simrad (KM Simrad), and Institute of Marine Research, Bergen. In order to improve the precision of the existing fisheries sonars, a new calibration method is being developed, and raw data from two parallel calibrated sonar systems as well as a multi frequency echo sounder has been compared in order to develop more precise real time measurements of school biomass. In order to develop methods for size measurements of fish in real time, raw data on herring from a side mounted standard 200 kHz split beam

echo sounder and a new wide band (170-270 kHz) sounder have been collected. This work is still in its initial phase, and results are not yet available to make conclusions about the precision of the method. A new type of fisheries sonars has been developed. This sonar is aimed at measuring fish schools inside a seine net, and will probably be on the market during 2013.

KM Simrad has also developed a trawl monitoring system combining camera and acoustic techniques. This instrument is highly welcomed by the commercial fishing fleet, and a number of systems have already been sold to the trawling industry in USA. In 2012 the monitoring system has been extended for simultaneous use of more instrument functions, including remote control of light and camera system. A new trawl eye is being developed, which together with the FS trawl sonar, may improve the skipper's ability to identify and quantify fish in the trawl opening.

In the initial phase of the development of catch and gear monitoring systems for purse seine fishing, several instrument pod designs have been built and tested in commercial fishing. The feasibility of using a cable for transfer of signals from the instrument unit on the gear to the surface for real time monitoring of fish and seine has also been tested. The pods proved able to withstand the severe mechanical and physical strains during setting and hauling the seine well. Also the cable for signal transfer seemed to tolerate the forces during fishing. During this first phase of development, the pod units were fitted with self recording underwater cameras. The main challenges proved to be optimizing the positioning of the cameras in the seine walls and maintaining directional stability.

The development of technology for high quality stereo photography of organisms passing through a trawl (DeepVision) has shown considerable progress in 2012. An integrated unit containing a stereo camera and a computer for use to a depth of 2000 m has been constructed and successfully tested on three research surveys. It was demonstrated that DeepVision can be used for accurate species and size identification of organisms passing through a trawl. This technology has the potential of significantly increasing the accuracy of acoustic fish surveys.

Presently, the catch rates of gadoids the Barents Sea are often higher than wanted, and a system for dynamic catch control is required. A number of systems have been tested in CRISP. The simplest systems use passive techniques where surplus fish are mechanically guided out of the trawl. Another system is based on the skipper's active monitoring of the catch and opening and closing a motorized gate to release unwanted fish.

The development of trawl technology to reduce the bottom impact and fuel consumption has included testing of a rigging with the trawl doors lifted off bottom. No difference in catch rates of cod was observed from alternating hauls with the trawl doors on and 10 m off the bottom. By changing from bottom to semi-pelagic trawl rigging the bottom area impacted by the trawl may be reduced by about 2/3. However, when using this technique, control of the height of each door above the bottom is essential. Development of such a system has been one focus area in CRISP, where KM Simrad

has successfully developed instruments for door monitoring, while Egersund Group has developed functional trawl doors that can be individually manoeuvred in the vertical direction. It is foreseen that the system will be operational during 2013.

Nofima in cooperation with The Nergård Group have shown that storing trawl-caught cod in live fish tanks for a short period before slaughter may substantially improve the filet quality. In 2012 the same methods were tested for haddock and saithe, species that are generally less robust than cod. The experiments showed that if handling during trawling is done gently they can be stored live for a short time with an improvement in filet quality at least as good as earlier documented for cod. At present a new cod trawler is being designed, taking into account the new concepts for improved quality through live fish storing and improved post slaughter handling of the fish, but it is not yet decided whether this new system will be contracted.

A report on the structure and profitability in the cod trawling fleet has been finalized and released. The prime 2012 activity in analyzing value adding has been an economic and structural analysis of the Norwegian purse seine fleet. It presents a survey over the most important parameters by which the economic effects of the research going on in CRISP may be monitored, both in fishing gear technology and catch processing. For the trawling fleet, the analyzes documented a considerable potential for increasing the catch values, up to 200 million NOK for the freezer trawler segment alone. The average purse seine vessel fuel costs were about half of the average trawler vessel fuel cost. However, the analysis of the purse seine fleet showed that there is great variability among the vessels, with large potential to adopt fishing strategies to reduce fuel costs.

A large variety of information activities have been carried out by the CRISP personnel during 2012. About 40 talks and lectures about the CRISP centre have been presented in national and international events, meetings and symposia. This includes the North Atlantic Seafood Conference, ICES Annual Science Conference, NorFishing and SciTech Europe. One particularly gratifying experience was that the activities of the centre were the main focus during the visit of HRH The Prince of Wales, Charles, and HM King Harald of Norway at IMR in Bergen in March 2012.

2. Vision/objectives

2.1 Vision

The Centre for Research-based Innovation in Sustainable fish capture and Processing technology aims to enhance the position of Norwegian fisheries-related companies as leading suppliers of equipment and seafood through the development of sustainable trawl and purse seine technology.

2.2 Objectives

1. To develop and implement instrumentation to identify species and sizes prior to the catching process.
2. To develop and implement instrumentation for commercial fishing to monitor fish behavior and gear performance during fishing operation
3. To develop methods and instrumentation to actively release unwanted bycatch unharmed during trawl and purse seine fishing.
4. To develop new trawl designs that minimize the environmental impact on bottom habitats and reduce air pollution.
5. To develop capture and handling practices to optimize quality and thus value of captured fish.
6. To analyze and document the economic benefits to the fishing industry resulting from implementation of the new technologies developed by the project

3. Research Plan/Strategy

The research plan of the centre includes six research and one management work packages, each of which comprises several sub-projects.

- WP 1. Pre-catch identification of quantity, size distribution and species composition
- WP 2. Monitoring fish behaviour and gear performance
- WP 3. Active selectivity and release in fishing gears
- WP 4. Low-environmental impact trawl
- WP 5. Quality improvement
- WP 6. Value adding
- WP 7. Management activities

Each work package is led by one research partner along with a counterpart leader from one of the four industry partners. Most of the work packages involve one of the research institutes and one of the industry partners. Some work packages involve more than two partners, and it is a priority to increase cooperation among more partners in several of the work packages over the coming years.

4. Organisation

4.1 Organisational structure

IMR in Bergen is the host institution and is responsible for the administration of CRISP. Within IMR, the centre is organized in a similar way as programs in the matrix structure of IMR. Most IMR personnel working on CRISP projects belong to the Observation methodology and Fish capture research groups. Scientists working on CRISP projects are therefore also involved in projects outside CRISP. Personnel working on CRISP projects for the other major research partner, Nofima, are organized in a similar way.

The Universities of Bergen and Tromsø are research partners in the consortium. Their main function is to provide formal education for PhD and MSc students who are funded by and associated with the Centre.

John Willy Valdemarsen of IMR was appointed director of the Centre from its starting date on April 1, 2011.

The board of the Centre in 2012 was as follows:
Olav Vittersø, Kongsberg Maritime AS, Simrad (Chair)
Helge Hammersland, Scantrol AS
Bjørn Havsø, Egersund Group
Kjell Larsen, Nergård Havfiske AS
Reidar Toresen, Institute of Marine Research
Heidi Nilsen, Nofima AS
Arne Johannesen, University of Bergen
Svein Ove Haugland, Råfisklaget
Turid Hiller, Research Council of Norway (Observer)

The director of the Centre acts as the secretary to the board.

Representatives of the University of Bergen and Norges Råfisklag are board members in 2011 and 2012. Mid 2013 they will be replaced by representatives from the University of Tromsø and Norges Sildesalgslag. Representatives of universities and sales organizations are alternate board members for each other.

4.2 Partners

In 2012, the CRISP consortium comprised four research partners (the Institute of Marine Research (IMR), Nofima AS, the University of Bergen and the University of Tromsø), four industry partners (Kongsberg Maritime AS, Simrad, Scantrol AS, the Egersund Group and Nergård Havfiske AS) and two sponsors (Norges Råfisklag and Norges Sildesalgslag).

IMR has relevant R&D competence in fisheries acoustic, fish behaviour, fishing gear design and operation, capture of live cod for storage in net pens, fish welfare and fishing gear selectivity. IMR also maintains infrastructure for *ex situ* and *in situ* experiments at its research stations in Austevoll and Matre and on board its three large research vessels.

NOFIMA AS possesses competence in the handling, storage and feeding of live cod, fish welfare and restitution, sensory, processing and technological quality of fish and fish products, the assessment of quality aspects of fish captured by various fishing methods, and economic competence to evaluate the socio-economic consequences of changes in fishing patterns.

THE UNIVERSITY OF BERGEN has relevant scientific and supervision expertise in general fish biology, experimental biology, fish behaviour, fisheries acoustics and fish capture. For the past six years, the Department of Biology (BIO) has led a Nordic Research School in Fisheries and Marine Biology, NMA (Nordic Marine Academy). UiB also has excellent experimental marine research facilities and a Marine Biological Station in addition to the research vessels operated jointly with IMR.

UNIVERSITY OF TROMSØ, Faculty of Biosciences, Fisheries and Economics (BFE), has particular responsibility for the development of expertise within all areas of fisheries and aquaculture research in Norway. Teaching and research focus is primarily on biological oceanography, fishery biology, assessment and management. CRISP will particularly benefit from the University's multidisciplinary expertise and approach. BFE has systematically developed competence, facilities and equipment closely related to marine and fishery biology and processing, including gear technology.

SIMRAD, which is part of Kongsberg Maritime AS (KM), has been developing tools for fishery research and commercial fisheries for more than 60 years. Simrad is a leading provider of acoustic systems for fish finding, pre-catch evaluation and catch monitors. The company has a strong tradition of innovation and a history of developing acoustic instruments in cooperation with IMR; for example, instruments for fish size detection and species identification on echo sounders. Other KM subsidiaries manufacture underwater cameras, bottom profilers, underwater telemetry links, underwater positioning systems and subsea transponders for various monitoring and regulating purpose. The company's largest contribution to the Centre will be their leading-edge expertise in acoustics, electronics and instrumentation. The company also operates an experimental acoustic tank, calibration and test facilities on its own vessel and prototypes for full-scale testing.

SCANTROL AS has developed a unique technology for taking high-quality stereo photos of fish inside a trawl (DeepVision technology), which can be used to identify species and measure their length through computerized image analysis. DeepVision may be combined with a mechanism that can subsequently retain or release organisms captured during fishing. The present status of DeepVision has partly resulted from cooperation with IMR scientists, including prototype testing on board our research vessels. The development of an instrument that can be used in commercial fisheries requires the documentation of benefits compared to traditional selectivity methods, and the optimization of design and performance under practical conditions. Cooperation with the other industry partners will be helpful in adapting DeepVision to different trawl designs and benefitting from the development of a new signal cable between the vessel and its trawl gear.

THE EGERSUND GROUP is a leading producer of pelagic trawls and trawl doors and a significant producer of purse seines for the Norwegian and Nordic markets. The company provides extensive practical experience to the Centre in the design of trawls, trawl doors and purse seines. The company in turn benefits from close cooperation with producers of gear instrumentation and technologists who have wide-ranging knowledge of fish behaviour and methods to evaluate gear performance, including access to modern research vessels. This cooperation helps The Egersund Group to develop trawl and purse seine technologies that will satisfy future requirements for green harvesting, which will be an advantage in the Norwegian and international markets.

THE NERGÅRD GROUP is one of the largest Norwegian exporters of seafood. The company focuses on maintaining local traditions and communities while sharing the sea's valuable assets with the rest of the world. Nergård has made major investments in white-fish vessels and quotas. Throughout the entire production chain the focus is on taking care of quality requirements on board, during landing, production, processing and transport - all the way to the customer. In 2008, the Nergård processing industry accounted for 30 % of herring (human consumption) production, 18 % of whitefish production and 40 % of frozen shrimp production in Norway.

NORGES SILDESALGSLAG (NSS, NORWEGIAN FISHERMEN'S SALES ASSOCIATION FOR PELAGIC FISH) is Europe's largest marketplace for first-hand sales of pelagic species. The marketplace is owned and operated by Norwegian fishermen. Approximately 2 million tonnes of pelagic fish are sold every year through NSS, which is equivalent to 2–2.5 % of global wild fish catches. The main interest of NSS in CRISP is the development of sustainable purse seine fisheries, particularly in relation to eco-labelling and certification.

NORGES RÅFISKLAG handles important national functions in the seafood trade, together with five other fish sales organisations in Norway. The organisation also plays a national role in resource management. Norges Råfisklag organises and arranges the sales of whitefish, shellfish and molluscs landed on the coast from Nordmøre in the south-west of Norway to Finnmark in the north-east. The most important species are cod, saithe, haddock and shrimps/prawns.

4.3 Cooperation between centre's partners

The six research work packages are organized under the leadership of a representative from one of the research partners, and with a counterpart assistant leader from one of the industry partners with a main interest in that work package. The work packages often involve more than two partners, especially those who involve MSc and PhD students, where the universities are a natural third partner. The four industry partners have complementary competence with minor or no overlapping business interests. A major challenge for the centre is therefore to create an environment for the development of instrumentation and fishing systems where complementary competence can be utilized efficiently to create completely new products. During this second year the various partners have continued to spend time on identifying areas of common interest and on launching cooperative efforts.

The Centre uses various arenas and methods to encourage mutual trust and to form joint projects involving CRISP's partners. An efficient arena for this is participation in research cruises organized by IMR. In 2012 representatives from the various partners participated in four such research cruises. Industry partners, with assistance from the Centre's management, have arranged meetings to discuss and plan joint development work. All of the CRISP partners participated in a two-day workshop in Tromsø in September where the Centre's activities to date were presented and discussed.

Figure 4. Official opening of the new swimming tunnel at Nofima during the workshop in Tromsø September 2012.

5. Scientific activities and results

The scientific activities in CRISP are organized in the form of six work packages, including several subprojects; the partners involved are shown in Table 5.1.

Table 5.1. Work packages with sub-projects and partners involved.

WORK PACKAGE	SUB PROJECTS	PARTNERS
WP 1. Pre-catch identification of quantity, size distribution and species composition	1.1 Biomass estimation using digital fishery sonars 1.2 Pre-catch identification and sizing of fish with broadband split-beam echo sounders	IMR, KM and UiB
WP 2. Monitoring fish behavior and gear performance	2.1 Trawl HUB for camera and acoustic systems 2.2 Catch and gear information system 2.4 Catch monitoring system in purse seine	IMR, KM and Scantrol
WP 3. Active selectivity and release in fishing gears	3.1 Visual fish classification 3.2 Device for active selection in trawls 3.3 Catch regulation in trawls	IMR, Scantrol, KM, UiB
WP 4. Low impact trawl	4.1 Manoeuvrable trawl doors 4.2 Semipelagic trawl design and rigging	IMR, Egersund Trawl, KM, UiB
WP 5. Quality improvement	5.1 Current quality conditions onboard bottom trawlers 5.2 Facility and methods for experi-men tal investigation of fish quality	Nofima, IMR, UiT and Nergård
WP 6. Value adding	1.1 Nergård operation 1.2 Status of Norwegian trawlers	Nofima, Nergård and UiT

5.1 Pre-catch identification of quantity, size distribution and species composition

BACKGROUND

Both the fishing industry and research institutes need more accurate measurements of schooling fish species than what is possible with current instrumentation. There is also a need for more precise estimates of size and species composition of a school prior to shooting a purse seine. This will reduce the number of "poor" sets where catch is of the wrong species, size composition or exceeds the amount that can be handled by the fishing vessel and therefore will have to be partly released. As these practices often result in unintended mortality of captured fish, instruments that can reduce this risk are needed for future sustainable harvesting of pelagic schooling fish with purse seine gears.

ACTIVITIES

Simrad is collaborating with IMR to develop new fishery sonars which can quantify the size of a school prior to shooting a purse seine. This includes development and testing of a new scientific data format, and also a calibration methodology tested in 2012 capable of calibrating individual beamsin a multibeam system. A PhD student is analyzing the possibility of using element data in the transducer to create new synthetic vertical beams for a 3D representation of the school at short range during the school inspection phase of the catching process. To estimate size and species composition inside schools, the main activities have been to finalize the calibration methods of wide-band echo sounders. The new EK80 echo sounder will be modified with the aim of removing limitations identified during a previous project. These include the use of a narrower beam and determining how these can be arranged in side-view modes. This was tested during a research cruise with R/V Håkon Mosby in November 2011, and further on the drop keel of G.O.Sars in November 2012. Horizontal observations into schools have been done both using the conventional EK60 split beam echo sounder and the new broadband echo sounder

RESULTS

This project element is still in the startup phase, and work is ongoing with respect to calibration systems for fishery sonars and wideband echo sounders. Most of the problems that were anticipated in the calibration

Figure 5.1. Inspection of the broadband transducer experimental installation at the bottom of the drop-keel of G.O. Sars.

of wideband echo sounders (Figure 5.1 and 5.2) now seem to be solved and the work will be published in 2013. The accuracy over the entire band of frequencies is comparable to the accuracy of narrowband systems, typically 1 to 2%. Analysis of the target spectrum from single fish, mainly herring, has started, based on data collected in net pens in Austevoll and from a few schools recorded horizontally in the November CRISP survey.

A project for post-processing of the wide-band target data has been approved and progress within this critical element was made in 2012 with further progress expected in 2013. This project can now use data from the side-looking transducer used in Austevoll, and on a limited data set from the G.O. Sars survey. Further data collection for enabling fish sizing and evaluating the associated uncertainties will be collected in Austevoll in the summer 2013, and on the March and November 2013 CRISP surveys. Finalizing the EK80 from our industry partner is critical for these surveys.

Progress have been made in developing post processing software for school detection with sonars, and the new data format used in the November 2012 survey seems to work well. Implementation of the new data format in the post processing software will be done during spring 2013. In the November survey good sonar data suitable for comparison between the fishery sonar SX90 and the scientific sonar MS70 was collected on about 30 herring schools of different sizes (about 50 to 4000 tons). One of the schools was subsequently caught and measured by a cooperating fishing vessel. Cooperation between a research vessel and a fishing vessel will continue in 2013. A PhD student started in August 2012. He will work with data collected by fisheries sonars, principally calibration and 3D reconstruction of fish schools using the SX90 sonar.

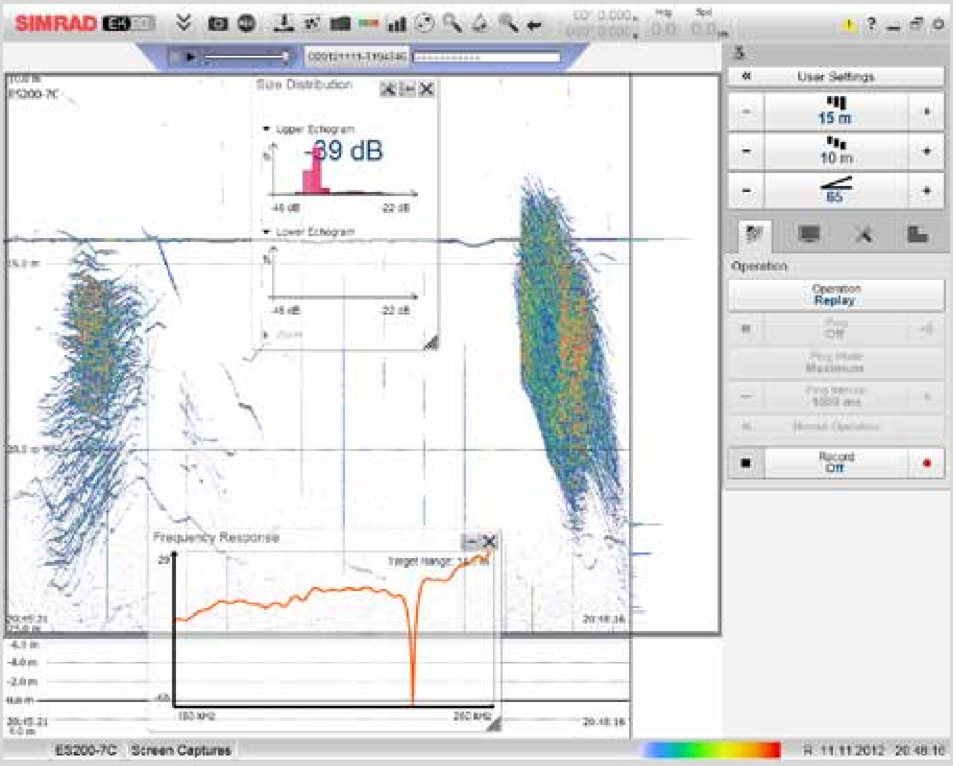


Figure 5.2. First resolved herring schools during calibration of broadband transducer.

5.2 Monitoring of fish behaviour and gear performance

BACKGROUND

At present, instrumentation placed on the gear is used to detect and monitor fish, and to measure the physical parameters of the gear. However, such instrumentation provides insufficient information about the species and size composition of the fish to enable informed decisions on whether to continue fishing on a fish registration. A major objective of CRISP is therefore to develop *in situ* instrumentation that can inform the skipper about which sizes and species are entering the fishing gear. Kongsberg Maritime AS, Simrad has developed an integrated information transfer system for underwater video and trawl sonar images sent from a trawl to the bridge through a standard net-sounder cable. The combination of visual (video) and acoustic (sonar) information is important for monitoring fish behaviour when operating in areas where high demersal fishing activity and re-suspension of bottom sediments limits visibility. The system has been tested on several research cruises and is becoming an important tool for monitoring fish behaviour in a trawl. It has also been released by Simrad as a commercial fisheries product, the FX80.

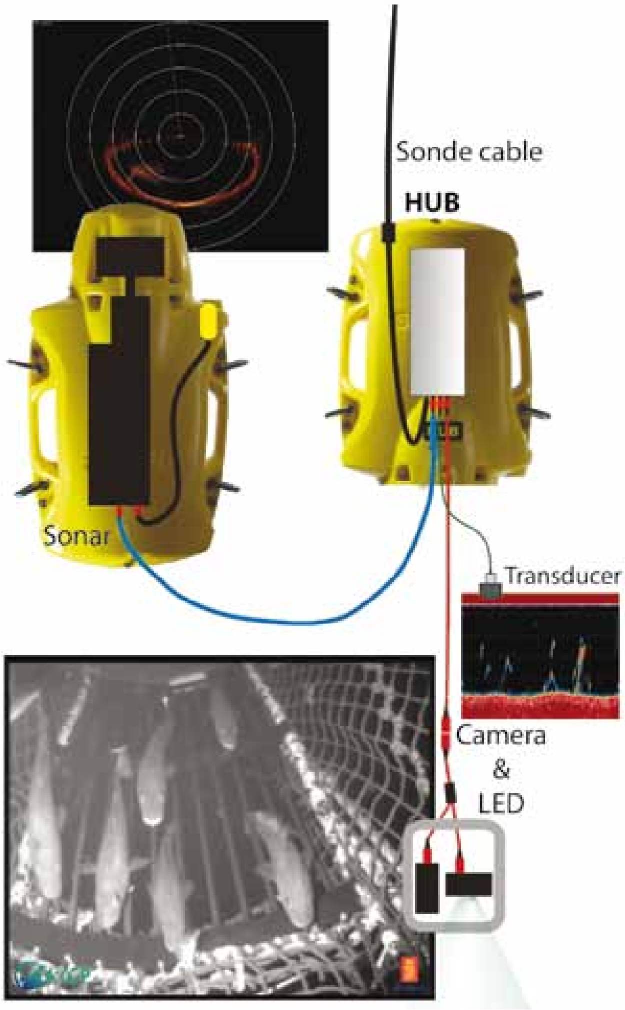


Figure 5.3. A system for observing fish and trawl behaviour by sonar, camera and echosounders.

In purse seine fishing, the identification of species, size or quality are key parameters for deciding whether to keep or release a catch encircled by the seine, but presently this can only be done by taking a physical sample of the fish. An instrument enabling catch identification at an early stage of hauling would substantially decrease the risk of unintentionally killing fish that are released because they are the wrong species, size or quality. However, instruments fitted to a purse seine are subjected to severe mechanical strains during setting and hauling, and careful considerations have to be made when designing hardware for monitoring systems for purse seine fishing.

Another challenge is to develop instruments that will improve the gear performance both in trawl and purse seine fishing. Such instruments are expected to facilitate aimed fishing and thus, lower vessel energy consumption and seabed impact.

ACTIVITIES

During fishing trials onboard research and commercial vessels an echo sounder (modified Simrad EK15) was used as a supplement to the camera and sonar system (prototype of FX80). The system consists of a unit (HUB) that arranges for communication between several computers in a network, a high-frequency sonar, a high resolution echo sounder (two transducers and a transceiver unit) and a monochrome camera with artificial light sources (Figure 5.3). The trawl sonar and HUB are mounted on the trawl's headline, with a cable connection to the camera and light source, and to the echo sounder. Both the camera and light source, and the transducers can be positioned anywhere on the trawl. During the trials conducted in 2012, the sonar and one transducer were mounted in the front part of the trawl while the camera and a second transducer were positioned in the trawl extension.

As part of reducing bottom impact and fuel consumption when trawling, a gear monitoring system for trawling with the doors off the seabed was used during fishing trials. A sensor (Simrad PX MultiSensor) was mounted on each trawl door in a special holder and was programmed to measure the distance between the doors, distance from the doors to the seabed and roll of the starboard door.

In the initial phase of developing catch and gear monitoring systems for purse seines, several instru-

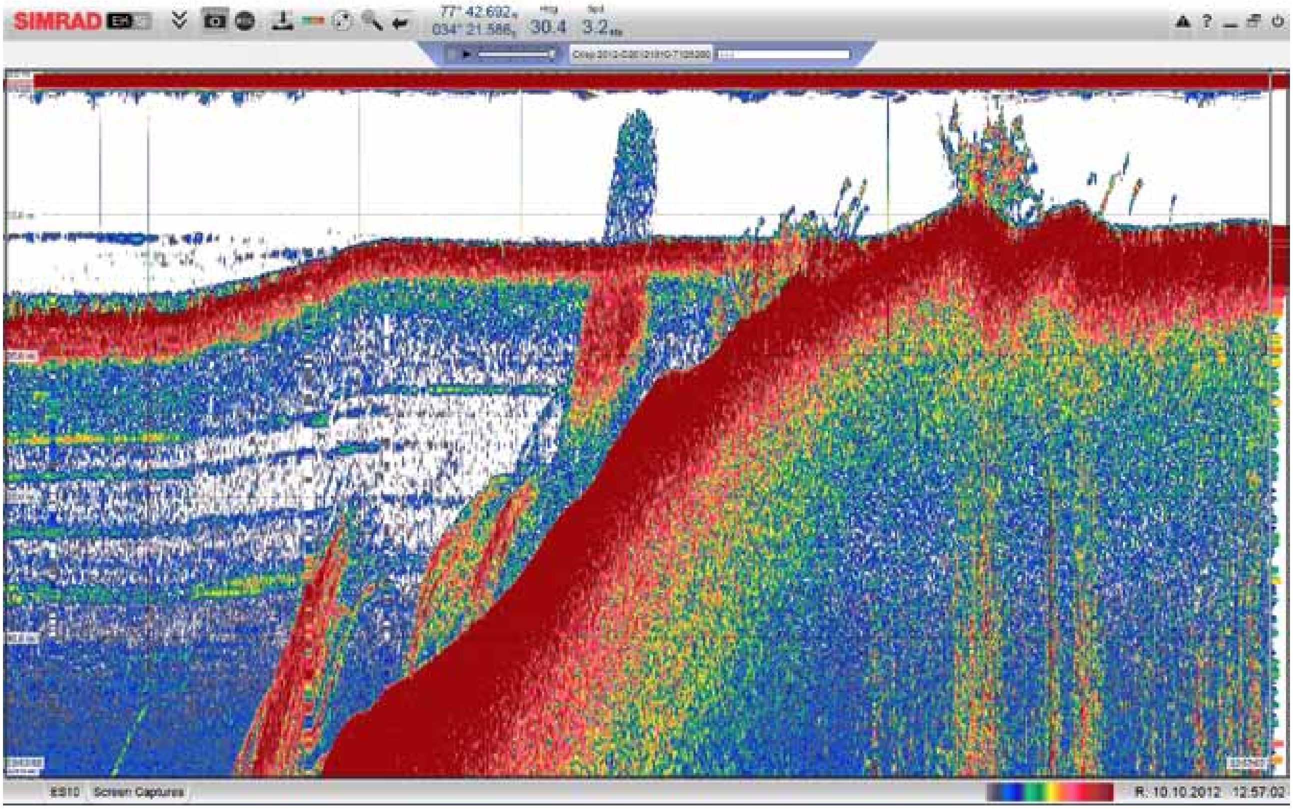


Figure 5.4. Echosounder image showing the trawl settling on the seabed. Fish can be observed above and below the groundgear.

ment pod designs have been built and tested onboard purse seine vessels. The feasibility of using a cable for transfer of signals from an instrument unit fixed to the gear to the surface for real time monitoring of fish and seine has been tested.

RESULTS

The simultaneous transfer of data from the trawl sonar, video camera and echo sounder was successful. The camera provided information about fish behaviour inside the trawl and to some extent sufficient information for species identification. The acoustic instrumentation provided information about entrance pattern and distribution of the fish inside the trawl (Figure 5.4). The echo sounder (EK15) provided useful data for studying fish behaviour in the front and aft of the trawl. As an example cod was observed to keep the same horizontal position in the back part of the trawl as in the entrance.

The gear monitoring system on the doors displayed accurate height off the seabed, distance between the doors and roll of the starboard door. The sensors gave the skipper the necessary data for positioning the doors of a demersal trawl, by adjusting the warp length, at the targeted height above the seabed. This instrumentation was crucial for the success of the comparison trials of trawling with the doors off and on the seabed.

The pods built to monitor fish and gear during purse seine fishing (Figure 5.5) proved to withstand the severe mechanical and physical strains during setting and hauling the gear well. Also the cable for signal transfer to the surface seemed to tolerate the forces during fishing. During this first phase of development and testing, the pod units were fitted with self recording underwater cameras. The main challenges proved to be to optimize the positioning of the instrument pods in the huge net walls of a seine, and to obtain directional stability of the housings.

Figure 5.5. Observation unit for use during purse seine fishing. An underwater camera is mounted in a steel frame surrounded by a polyethylene protection unit.

5.3 Active selectivity and release in fishing gear

BACKGROUND

Unwanted catches often occur in mixed trawl fisheries regulated by quotas on individual species. In some fisheries high grading, meaning that the most valuable fish are preferred leading to a risk of discarding low-value fish, has been identified as a non-sustainable fishing practice. The large catches sometimes taken by trawls and purse seines may result in burst nets and loss of catch, as well as reduced fish quality when on-board production time is too long. A major topic for CRISP is therefore to develop an interactive method capable of actively releasing unwanted catch from trawls and purse seines based on early identification of size and species inside these gears. Another challenge is to develop systems that can regulate the catch in both trawl and purse seine fisheries.

ACTIVITIES

The DeepVision in-trawl camera system, which identifies and measures fish passing inside a trawl, was further developed in 2012. A new subsea unit integrating the cameras, PC, and communication components into a single 2000 m rated cylinder was used successfully on four cruises between May and October.

Three systems have been developed and tested to limit catch sizes in demersal trawling. Two of the systems are "passive". One with a rubber mat covering an escape opening in the upper panel in front of a fish lock mounted from the top panel back toward the bottom panel. The fish lock lets fish enter the cod end but prevents them from swimming back forward (Figure 5.6 A and 5.7). As the cod end fills up with fish the water pressure in front of the accumulated fish will lift the rubber mat and let fish that have not yet entered the cod end swim out through the escape opening. The other passive system (Figure 5.6 B) consists of a section with brick meshes (rectangular meshes) and a fish lock in front of the cod end. When the cod end is filled up a catch sensor is activated and then the skipper conducts a procedure of increased speed followed by sudden reduced speed. During the latter operation the brick meshes will expand, letting the fish escape.The passive systems have been tested in a trawl both with and without a grid section. The other system is "active", with an acoustic mechanism that controls the opening and closing of a motorized gate, blocking the entrance to the cod end and opening an escape opening that fish can swim out of (Figure 5.6 C).

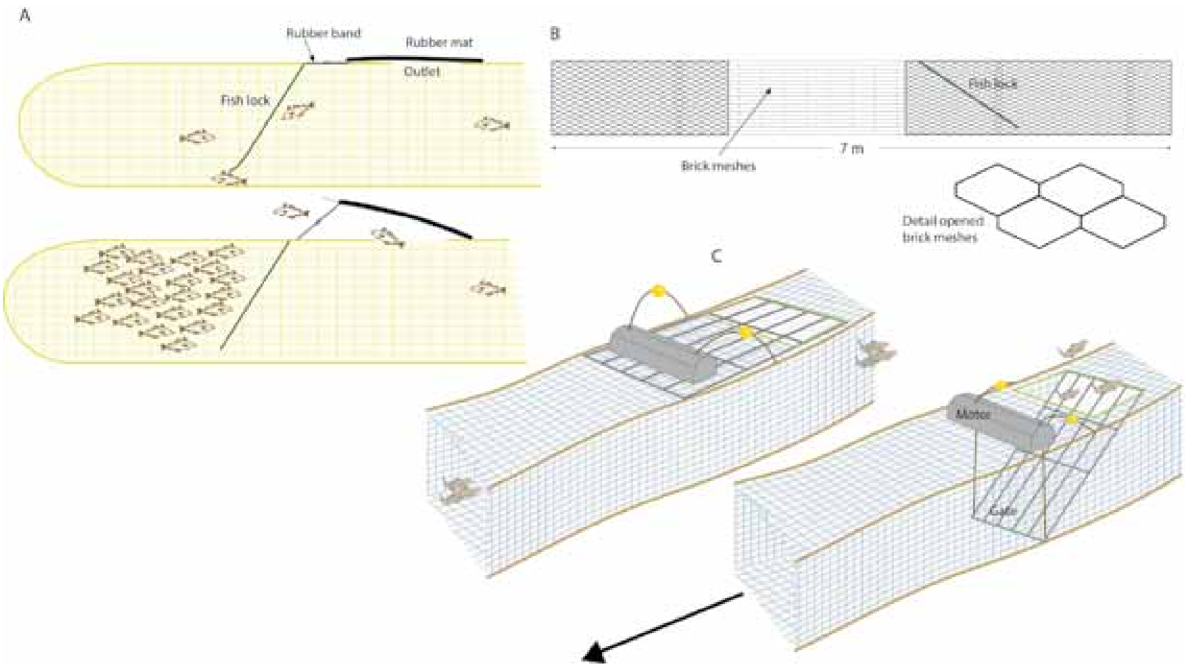


Figure 5.6. The three systems developed to release fish at depth. System A and system B are passive using a rubber mat covering a steel framed escape opening and brick meshes to create an escape opening, while system C is an active system using an acoustically activated motor to control a gate that blocks the codend and open the escape opening.

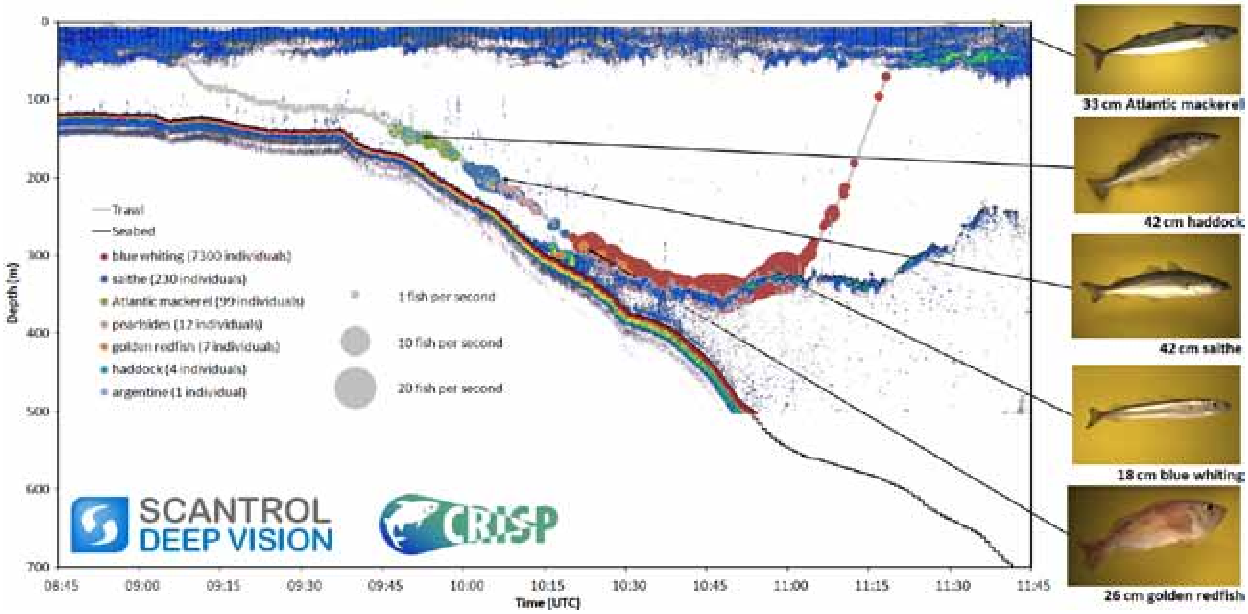


Figure 5.8. Profile of species by depth and time. Images to right of plot are the specific fish indicated on the depth profile.

RESULTS

The new arrangement for the DeepVision system proved to be much more robust and resistant to coming out of calibration than the system used in 2011. The frame rate was doubled to five images per second and lighting and background contrast were improved, resulting in much clearer images and improved ability to identify and measure passing fish.

Overall, 98 % of fish captured during trawling could be identified to species and lengths could be estimated for 96% of individuals. There was good agreement between measurements from the cod-end and estimates from the DeepVision system both for count by species and length. Building on promising results early in the year, the DeepVision was used on a summer survey for 0-group (young of the year) fishes. Individuals as small as 4 cm in length could be identified to species and lengths estimated from the stereo image pairs were accurate within a few mm. This application for the first time documented extreme patchiness in distribution of these small fish both vertically and along the trawl track (Figure 5.8).

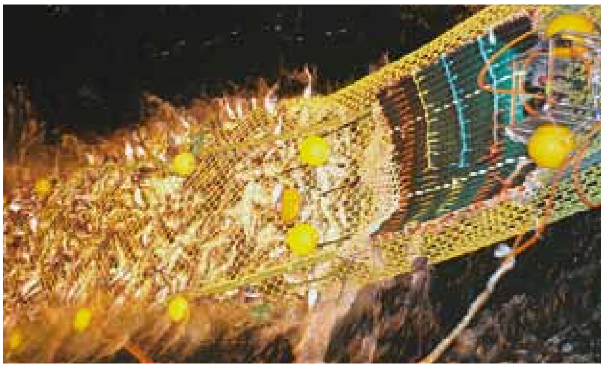


Figure 5.7. Photographs taken of the same systems as described in Figure 5.6 A.

While integrating species and size measurements from the DeepVision system with an active sorting system remains an eventual goal, development in 2012 focused on improving image quality; image processing software (including automation of length measurements); and data storage and transfer.

Video observations revealed that all three systems to limit catch sizes in demersal trawling showed potential to limit the quantity of fish. Fish were observed moving toward the cod end and calmly swimming out through the escape opening of the passive systems when cod end was filled up. System A worked as intended without a grid section; fish was released at the fishing depth. When using the passive system A behind the grid section fish were also observed to escape during haul back. There are indications that the fish observed escaping during haul back had aggregated in the grid section prior to haul back. With system B, fish were observed escaping through the brick meshes during trawling before the cod end was filled up. The gate on the active system C was lowered and raised repeatedly. Video observations showed that the gate blocked the cod end completely, guiding all fish to the escape opening where they swam calmly out of the trawl. All three systems released fish at trawling depth, which will ensure a high survival rate.

The passive systems will be further developed. The active system needs development to make it more user-friendly. Integrating the control function of the gate with the Simrad camera and communications system (FX80) is considered to solve different problems. Such problems include; clean catch mitigating measures, releasing unwanted species and length groups of fish, as well as preventing damage to the netting in the sorting section.

5.4 Low-impact trawling

BACKGROUND

Current trawling practice is regarded as unsustainable, as it may damage the seabed, take too much bycatch and use too much expensive fuel that pollutes the atmosphere. The future of trawling will thus largely depend on the development of trawling techniques that significantly reduce these negative impacts. This work-package addresses the design and operation of trawl gears that might achieve such objectives.

ACTIVITIES

A major activity has included development of motorized opening and closing of hatches in the trawl doors through communication via an acoustic link between the vessel and the trawl doors. Testing of this system was first conducted in April with the 2 m^2 experimental trawl doors on board the research vessel "Trygve Braarud". The same system was then tested in June onboard the research vessel "G.O. Sars" using the larger 9 m^2 Seaflex doors.

Development and testing of low-impact trawls has been carried out on four sea trials onboard research vessels (R/V "Trygve Braarud" and R/V "G.O. Sars") and a commercial trawler (F/T "Ramoen"). The experiments included continued testing of brick-shaped meshes in the aft trawl belly and new arrangements of rope extension between the trawl doors and the mesh section of the trawl. An important objective of the G.O. Sars cruise was to study and evaluate herding behaviour of cod and haddock in the large mesh section of a pelagic trawl. This knowledge is considered an important input for the design of the front part of trawl (the herding zone). Such studies were also part of the trial program conducted onboard F/T "Ramoen" during cruises in October and December 2012. Those cruises also included experimental fishing with a semi-pelagic rigged trawl to avoid bottom contact for the trawl doors and the sweeps connecting the trawl doors and the trawl wings (Figure 5.10 and 5.11). The semi-pelagic trawl was a slightly enlarged bottom trawl rigged with a net sounder cable which normally is used for pelagic trawling. The trials included comparative fishing for cod with the same trawl with a rigging where the trawl doors were on and off (approximately 10 meters above) bottom, respectively. Attempts were made to study horizontal herding of cod generated by the sweeps when they were on and off bottom.

Figure 5.9. 2 m^2 (upper picture) and 9 m^2 (lower picture) trawl doors equipped with hatches, which are used to adjust depth and horizontal spread.

RESULTS

The use of the acoustic communication system cNODE, developed by Kongsberg Maritime, for opening and closing of hatches in the trawl doors performed excellently during the initial tests onboard "Trygve Braarud". It was therefore decided that this system would be applied in the development of the maneuverable trawl door concept. Testing onboard "G.O. Sars" of the same system installed on the larger 9 m^2 trawl doors identified some challenges with respect to functioning of the motor system used to open and close the hatches.

During the "G.O. Sars" cruise in June conducted close to the Bear Island, neither cod nor haddock were distributed in the pelagic zone and were thus not accessible for capture with a pelagic trawl. The planned study of herding behaviour in the frontal zone of the large mesh pelagic zone was therefore not conducted as planned during the cruise.

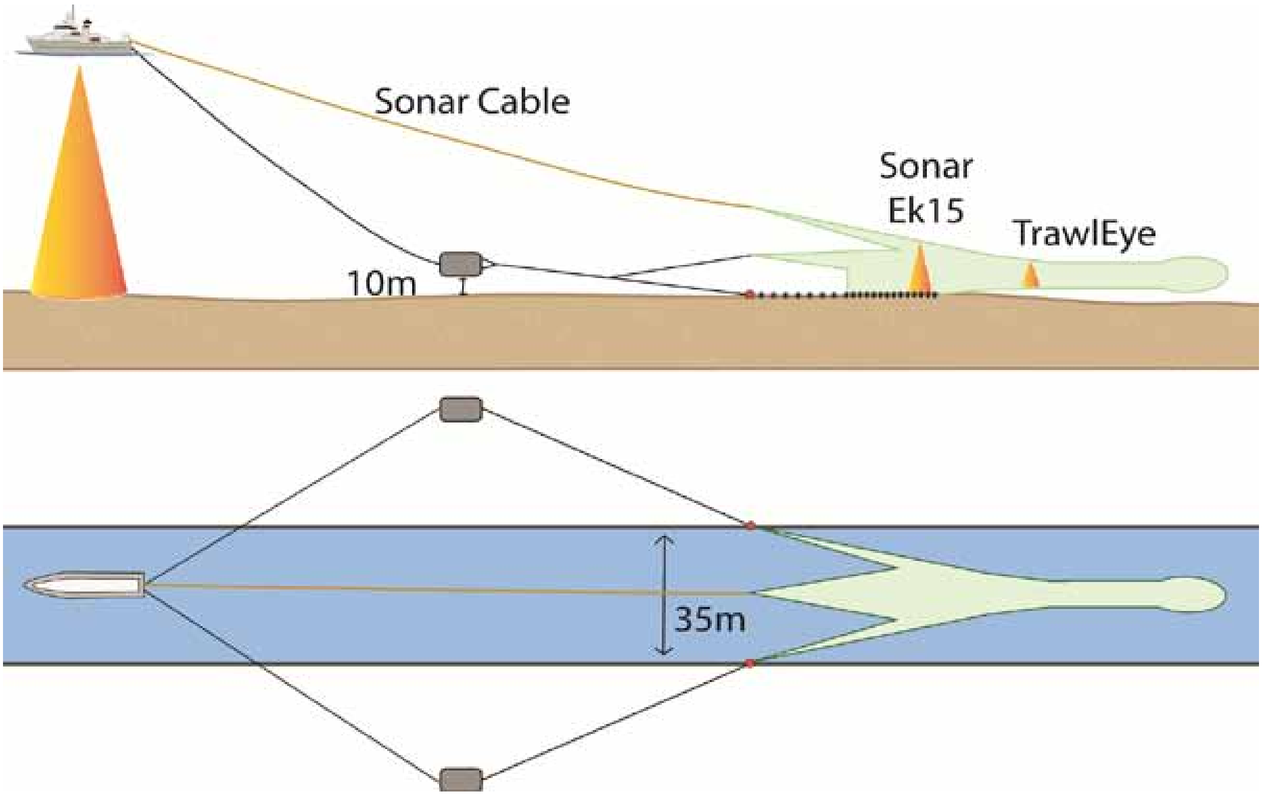
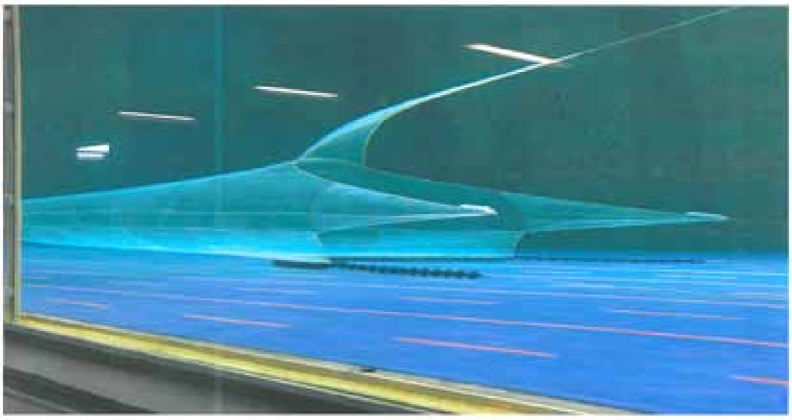


Figure 5.10. Rigging of the semipelagic trawl with the doors 10 m above seabed.

Figure 5.11. A bottom trawl equipped with an upper tongue to be lifted with the net-sounder cable when towed with a semipelagic rigging.



Both haddock and cod were distributed very close to the bottom (hardly visible on the echo sounder) during the time of the research cruise. This confirmed earlier observations that cod and haddock migrate vertically both diurnally and seasonally and are thus relatively infrequently distributed off bottom in distributions that can be captured efficiently with a pelagic trawl. To some extent these observations changed the priority of which trawling system should be developed within CRISP. Future effort will be focused on development of a semi pelagic trawl rigging where the trawl doors and most of the sweeps are lifted off the bottom, but the trawl will be designed to tolerate light bottom contact. Bottom impact from the ground gear will be minimized by utilizing shorter and lighter gears than what those used on standard demersal trawls.

The catch rates of cod taken by the semi-pelagic trawl designed by Egersund Trawl were similar when rigged with the trawl doors 10 m off bottom as when the trawl doors and sweeps had bottom contact. The door spread was approximately 10 % less when the doors were towed off bottom compared with the doors on bottom. The vertical opening of the trawl was slightly increased (approximately 10 %) when towed in the semi pelagic fishing mode. It is, however, uncertain whether the cod were efficiently herded inward by the sweeps in either of the two rigging configurations. The methods used to monitor horizontal fish movement in front of the trawl were not conclusive. Further studies will therefore focus on methods to study and evaluate horizontal herding in front of a trawl, rigged with trawl doors on and off bottom. Among the commercial trawler fleet, there is an increasing awareness that a semi-pelagic rigged trawl is a technically feasible way of trawling, resulting in comparable catch rates of several demersal species, and that this method at the same time reduces fuel and environmental impact on the bottom habitat.

5.5 Quality improvement

BACKGROUND

White-fish species caught by trawling has quality challenges related to the raw material. This work-package aims to increase product quality and value through altering the way the trawl is used and how the catch is treated. This can be achieved through minimizing stress during trawling, but particularly by implementing new technologies that makes the handling of the catch more lenient.

Several of these technologies have been developed in capture-based aquaculture for cod and in new harvest procedures for salmon (pumping directly from the cod-end, keeping the fish alive on-board and developing automated individual slaughtering and bleeding). The work-package will generate data and knowledge on the handling tolerances of three major white-fish species (cod, haddock and saithe).

During commercial fishing, there are limited opportunities for identifying, measuring and predicting the importance of the various stress factors which are known to influence fish quality. There are also limited possibilities for manipulating these factors to test if quality improvements can be made. To increase the knowledge about fishery generated stress an experimental swim tunnel where we can isolate and study the effects of the different stressors inflicted upon fish during capture and handling in controlled experimental studies will be built. Most importantly, these studies will also include time-course measurements of stress and quality-determining biological parameters, thus providing crucial new knowledge on these mechanisms and at the same time improving our toolbox when investigating these processes in commercial fisheries.

ACTIVITIES

In June 2012, a 10-day cruise was performed with a commercial trawler (M/T "J. Bergvoll"). Haddock was captured in five hauls close to Bear Island (74.00 N, 19.00 E) at depths of 124 ± 9 meter and bottom temperature of 4,2 ± 0,5 °C and saithe were captured in six hauls along the coast of Finnmark and Troms counties (70.50 N, 17.00 E) at depths of 229 ± 70 meter and bottom temperatures of 6,3 ± 0.4 °C. Trawl catches of haddock at Bear Island were on average 20.8 ± 4.5 tonnes for average tow duration of 1.69 ± 1.3 hours. The fishery targeting saithe resulted in average trawl catches of 4.9 ± 2.4 tonnes during towing duration averaging 4.41 ± 0.9 hours. A total of 222 saithe and 212 haddock were sampled for analysis of quality-related parameters.

In 2012 the CRISP swimming tunnel (Figure 5.12) was completed. As a first priority the physical properties of the swim tunnel were optimized. This included optimizing water speed and water flow, the procedures for sampling exhausted fish, and the installation of underwater cameras. A pilot experiment was also performed with groups of Atlantic cod to evaluate the use of acoustical telemetry 3-dimensional acceleration tags in the tunnel system. These tests demonstrated the feasibility of us-

Figure 5.12. The CRISP large-scale swim tunnel was established in an 11 meter diameter outdoor tank at the Tromsø Aquaculture Research Station. Photo by Jon Are Berg Jacobsen (Nofima).

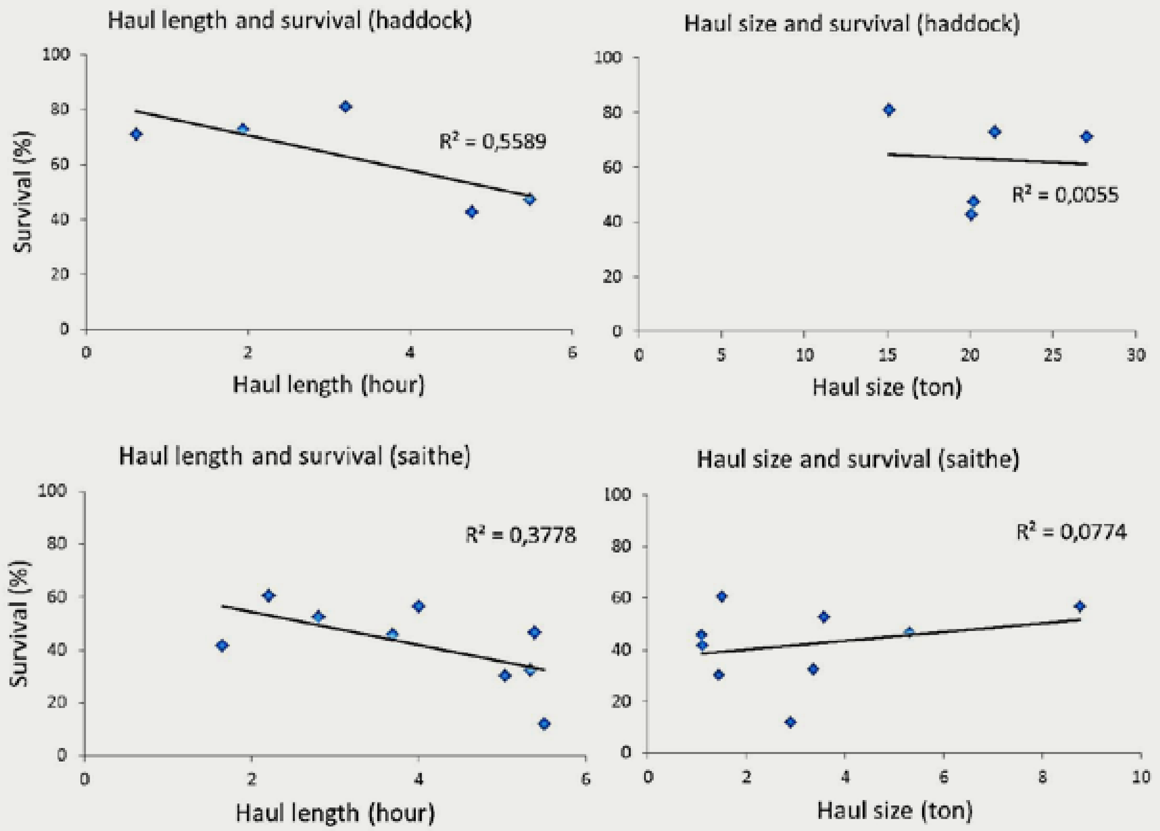


Figure 5.13. The relationship between haul duration, haul size and survival of haddock and saithe during recovery.

ing acoustical telemetry in the system and will be important for evaluating individual activity levels (which can be related to physiological quality parameters).

RESULTS

Survival on board is essential for increasing the value of the catch. Only variations in the haul duration influenced the survival rate of both haddock and saithe (Figure 5.13). There was a significant negative correlation between haul duration and survival during live storage. The survival of fish decreased with increased haul duration.

The main reason for reduced quality and price of fillets is their redness (caused by blood in the capillary veins). The fish collected from the processing line (normal production) showed increased discoloration of fillets when compared to fish that were stored live for 6 hour. This suggests that the majority of the red discoloration was removed from the muscle during on-board recovery in tanks. The fillets were considerably lighter and had less blood filled veins (see figure 5.14 and 5.15 below).

Regarding the swim tunnel, the water speed measurements inside the tunnel with the current set-up show that the water speed can be controlled from zero to about 3 knots. The water speed can also be kept with an acceptable spatial and temporal variation in the water flow properties. A pilot experiment was performed with groups of Atlantic cod to evaluate the use of acoustical telemetry 3-dimensional acceleration tags in the tunnel system. These tests demonstrated the feasibility of using acousti-

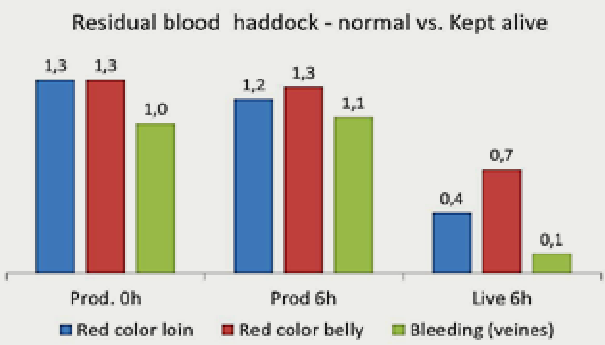


Figure 5.14. Fillets of haddock from standard production "direct gutting" 6 h post-harvest (right) and from haddock kept alive for 6 h and bled by cutting the throat prior to production (left).

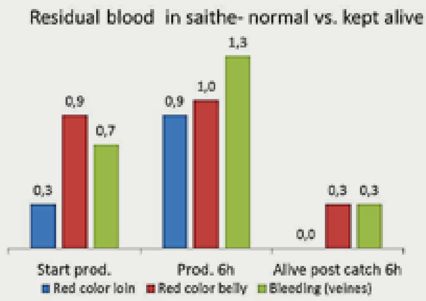


Figure 5.15. Fillets of saithe from standard production "direct gutting" 6 h post-harvest (left) and from saithe kept alive for 6 h and bled by cutting the throat prior to production (right).

cal telemetry in the system and will be important for evaluating individual activity levels (which can be related to physiological quality parameters). We have also performed an experiment comparing the swimming abilities and blood physiology of farmed and wild-caught Atlantic cod. This demonstrated the operation scope of the tunnel and that the system design can exercise all fish to full exhaustion (Fig 5.16).

The swim tunnel experiment with farmed and wild-caught Atlantic cod found that blood lactate level in physically exhausted cod was weakly correlated to fish swimming performance. That is, blood lactate levels in exhausted fish were comparable regardless if the fish were actually exhausted at a low or high swimming speed. Interestingly, the levels were generally lower than what is seen in Atlantic cod taken by trawl, giving us new knowledge on the relative contribution of exhaustion alone on some important quality determining parameters.

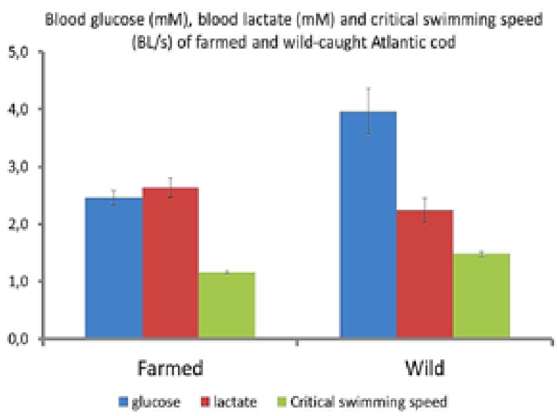


Figure 5.16. A comparison of blood glucose, blood lactate and critical swimming speed in groups of 3 kg farmed- and wild-caught Atlantic cod when swam to exhaustion in the CRISP large-scale swim tunnel.

5.6 Value adding

BACKGROUND

Strategies for harvesting wild fish resources depend on several factors, including the migration pattern of the target species and choice of fishing technology. This work package focuses on how technical developments resulting from CRISP activities will contribute to value adding. A basic analysis of the economic status of the Norwegian trawler fleet conducted in 2011 was followed by an analysis of the economic status of the Norwegian purse seine fleet in 2012.

ACTIVITIES

The prime 2012 activity in WP6 has been the economic and structural analysis of the Norwegian purse seine fleet, and writing of the report "Ringnot: Struktur og lønnsomhet" ("Purse seine: Structure and profitability"), which will be published in 2013. The report will contain five sections: (1) Introduction, (2) Fleet structure, (3) Catch, (4) Profitability and capital structure, and (5) economic assessments of CRISP activities. 2012 was also used to further develop the work how to estimate the economic value of CRISP activities related to the trawler fleet. A quality assessment system developed by independent agents used by fishing companies and buyers to set market prices is set up for estimating the value adding of CRISP activities.

RESULTS

Restructuring seems to have reduced the number of purse seine vessels to a stable 80 from 2008. Good economic performance, with operating margins between 25 and 30 % (2005-2010), has lead to extensive contracting of new vessels and reduced the average vessel age from 27 years in 1997 to 18 years in 2011. About 75 % of the fleet is built after 1993. The vessel size did also increase during the same period, and the average vessel length is now 66 meters. The six most important species have the desired quality and availability only at certain times of the year. This makes the fishery activity during time periods very high, followed by time periods with low or no fishing activities. The average purse seine vessel fuel costs were 4.8 million NOK in 2010, which is about half of the average trawler vessel fuel cost. However, the analyzes showed that within the purse seine fleet segment, there was a high variability among the vessels in the fuel consumption per kg fish caught (Figure 5.17), and that there was no apparent relation between fuel costs and catch rates. This indicates that there is great potential to adopt fishing strategies to reduce fuel costs.

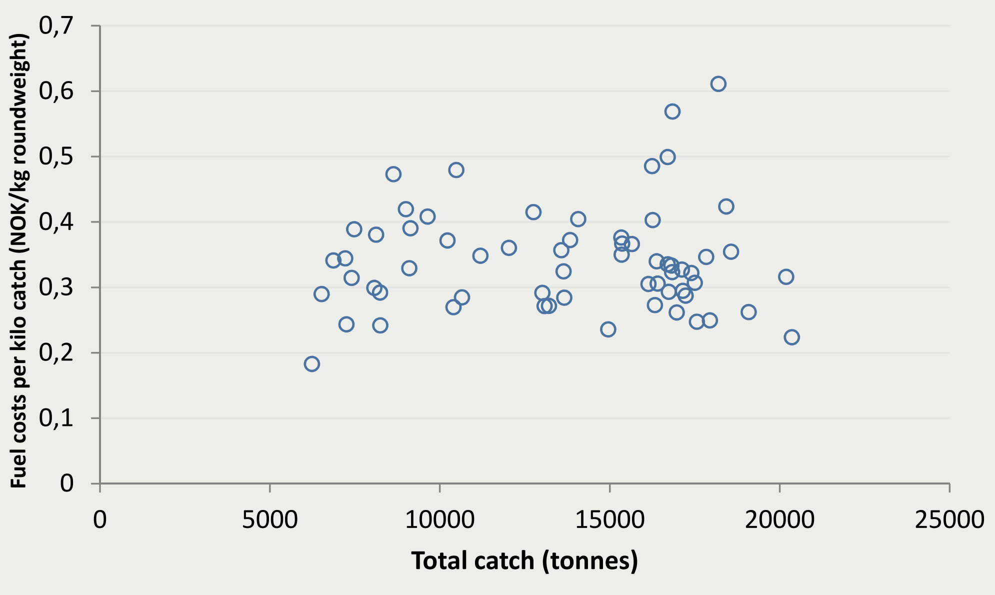


Figure 5.17. Fuel costs per kilo catch for purse seine vessels in 2010.

6. International cooperation

CRISP intends to cooperate with international research institutions when such cooperation can beneficial for joint development and introduction of sustainable fishing technologies in countries outside Norway. The companies who participate in CRISP sometimes compete with foreign enterprises with similar products on the same market segment. They are therefore somewhat reluctant to share new knowledge about new equipment developed within CRISP with potential competitors.

As introduction of new trawl technology for cod fisheries in the Barents Sea requires agreement about technical regulations with Russia, a Russian researcher participated as an observer on a research cruise conducted by IMR in the Barents Sea. Similarly, acoustic experts from research institutes in Seattle, US and Aberdeen, UK have been invited to develop and test the new sonar technology for pre-catch identification. The Deep Vision technology is of major interest for foreign research institutes and an arrangement to test and evaluate this technology during a research cruise in the US is planned for 2013.

Figur 6.1. Russian researcher Alexander Pavlenko participated on a research cruise.

7. Recruitment

The scientific staff working for CRISP is employed by IMR, Nofima AS, University of Bergen and University of Tromsø. Work for the centre is assigned as part of their job responsibilities.

In 2012 two MSc students finalized thesis related to WP 1 “Pre-catch identification”.

IMR jointly with the University of Bergen recruited a PhD student (Melanie Underwood) in the field of fish behaviour related to trawling. IMR also recruited a PhD student (Sindre Vatnehol) in the field of pre-catch acoustics.

University of Tromsø recruited a postdoc researcher (Anders Karlsson) to work on quality improvement. In 2012 the University of Tromsø recruited an MSc student (Jan Tore Didriksen). He is submitting his master thesis, related to WP 5.1 “quality improvement”, in May 2013.

Nofima recruited a PhD student in 2012 who will start her scientific work in spring 2013 working with fish quality.

Figure 7.1. PhD student Melanie Underwood working on trawl deck onboard RV G.O.Sars.

8. Communication and dissemination activities

Figure 8.1. HRHs Prince Charles and King Harald in dialogue with the director of CRISP, John Willy Valdemarsen, the director of IMR, Tore Nepstad, and director of Norges Sildesalgslag, Johannes Nakken, onboard the pelagic trawler M/S "Brennholm".

Outreach about CRISP activities has been comprehensive during 2012. Approximately 40 lectures have been given by CRISP staff in national and international meetings. CRISP related work has been described in at least 75 articles and programs in national and international media. The idea behind CRISP, its activities and results have been promoted in several exhibitions and meetings (North Atlantic Seafood Conference in Oslo, ICES Annual Science Conference in Bergen, Nor-Fishing in Trondheim and SciTech Europe in Brussels). At Nor-Fishing, all CRISP partners promoted their participation in the centre. The activity within the centre was also the main focus during a visit to Bergen and the Institute of Marine Research by the His Royal Highness Prince of Wales Charles accompanied by King Harald.

APPENDIX 1: Personell

NAME	INSTITUTION	MAIN RESEARCH AREA	SEX
Key Researchers			
Torbjørn Tobiassen	Nofima	Quality improvement	M
Kjell Midling	Nofima	Quality improvement	M
Øyvind Aas-Hansen	Nofima	Quality improvement	M
Tone Friis Aune	Nofima	Quality improvement	F
Stein Harris Olsen	Nofima	Quality improvement	M
Leif Akse	Nofima	Quality improvement	M
Bent Dreyer	Nofima	Value adding	M
Thomas Larsen	Nofima	Value adding	M
Marianne Svorken	Nofima	Value adding	F
Kathryn Donelly	Nofima	Information logistics	F
John Willy Valdemarsen	IMR	Low impact trawling, centre management	M
Arill Engås	IMR	Low impact trawling/Instrumentation	M
Egil Ona	IMR	Sonar technology and fisheries instrumentation	M
Hector Pena	IMR	Sonar technology and fisheries instrumentation	M
Aud Vold	IMR	Purse seine technology	F
Helge Johnsen	UiT	Quality improvement	M
Ragnar Olsen	UiT	Quality improvement	M
Arne Johannessen	UiB	Researcher training, recruitment	M
Key technicians, research institutes			
Asbjørn Aasen	IMR	Trawl technology	M
Jan Tore Øvredal	IMR	Engineering, instrument development	M
Kjartan Mæstad	IMR	Information logistics	M
Turid Loddengård	IMR	Centre management - economy	F
Anne-Britt Skar Tysseland	IMR	Engineering, data handling	F
Ronny Jakobsen	Nofima	Quality Improvement	M
Tor H Evensen	Nofima	Quality Improvement	M
Key personell, industry partners			
Ole Bernt Gammelsæter	Kongsberg Group	Sonar technology and fisheries instrumentation	M
Lars Nonboe Andersen	Kongsberg Group	Sonar technology and fisheries instrumentation	M
Olav Vittersø	Kongsberg Group	Management, board leader	M
Thor Bærhaugen	Kongsberg Group	Monitoring fish and gear	M
Tor Herman Gunhildstad	Kongsberg Group	Monitoring fish and gear	M
Helge Hammersland	Scantrol	Visual fish classification	M
Darren Hammersland-White	Scantrol	Visual fish classification	M
Bjørn Havsø	Egersund Group	Low impact trawling	M
Arvid Sæstad	Egersund Group	Low impact trawling	M
Trond Nedrebø	Egersund Group	Low impact trawling	M
Roy Skulevold	Egersund Group	Low impact trawling	M
Vidar Knotten	Egersund Group	Low impact trawling	M
Kjell Larsen	Nergård Havfiske	Quality improvement and value adding	M
Tommy Torvanger	Nergård Havfiske	Value adding	M
Visiting Researchers			
Jonil Ursin	The University of Nottingham	Veterinary student	F

Postdoctoral researchers with financial support from the Centre budget

NAME	FUNDING	RESEARCH AREA	SEX M/F	DURATION	NATIONALITY
Anders Karlsson	University of Tromsø	Fish physiology	M	3 years	Norwegian

PhD students with financial support from the Centre budget

NAME	NATIONALITY	PERIOD	SEX M/F	TOPIC
Melanie Underwood	Australian	7.5.2012–6.5.2016	F	Capture behaviour
Sindre Vatnehol	Norwegian	1.9.2012–30.8.2015	M	Sonar technnology

PhD students working on projects in the centre with financial support from other sources

NAME	FUNDING	RESEARCH AREA	PERIOD	SEX M/F	NATIONALITY
Shale Rosen	Industry scholarship, Research council	Visual fish classification, fish behaviour	2009–2013	M	USA

Master Students

NAME			PERIOD	SEX M/F	NATIONALITY
Jan Tore Didriksen	University of Tromsø	Quality improvement	2012–2013	M	Norwegian

APPENDIX 2: Funding

Funding 2012

	PARTNER	AMOUNT
The Research Council		12 058
The Host Institution	Institute of Marine Research	4 034
Research Partners	Nofima	1 400
	University of Bergen	282
	University of Tromsø	882
Enterprise partners	Kongsberg Maritime AS	5 958
	Egersund Group AS	2 129
	Scantrol AS	1 882
	Nergård Havfiske AS	581
Public partners	Sildesalgslaget	100
	Råfisklaget	100
		29 406

Costs 2012

	PARTNER	AMOUNT
The Host Institution	Institute of Marine Research	11 239
Research Partners	Nofima	5 653
	University of Bergen	882
	University of Tromsø	882
Enterprise partners	Kongsberg Maritime AS	5 958
	Egersund Group AS	2 129
	Scantrol AS	1 882
	Nergård Havfiske AS	581
Public partners*	Sildesalgslaget	100
	Råfisklaget	100
		29 406

APPENDIX 3: Publications 2012

Journal papers

Karlsen, K. M., Hermansen. Ø, and Dreyer, B. 2012. Ecolabeling of seafood: Does it affect the harvesting patterns of Norwegian fishermen? Marine Policy, 30(2012), s. 1123–1130.

Karlsen, K.M, Andreassen, O., Hermansen, Ø., and Dreyer, B, 2012, Sustainability challenges in seafood supply chains, Ocean & Coastal Management (in press).

Rosen, S., Engås, A., Fernø, A., and Jørgensen, T. 2012. The reaction of Shoaling adult cod to a pelagic trawl; implication for commercial trawling. ICES Journal of Marine Science, 69: 303-312.

Reports

Anon 2012. CRISP Annual Report, 18 pp.

Breen, M., Isaksen, B., Ona, E., Pedersen, A.O., Pedersen, G., Saltskår, J., Svardal, B., Tenningen, M., Thomas, P.J., Totland, B., Øvredal, J.T., and Vold, A., 2012. A review of possible mitigation measures for reducing mortality in purse-seine fisheries. ICES CM 2012/C:12, 20 pp.

Engås, A,. Jørgensen, T., Øvredal, J. T. and Aasen, A. 2012 Toktrapport nr. 1 fra forsøk ombord på F/T Ramoen, juni 2011:Testing av fallem for å begrensefangstmengden under tråling. Rapport fra Havforskningen 2-2012.

Engås, A,. Jørgensen, T., Øvredal, J. T. and Aasen, A. 2012.Toktrapport nr. 2 fra forsøk ombord på F/T Ramoen, juni 2011: Kommersiell testing av undervannskamera og trålsonar for in situ signaloverføring fra trål til fartøy. Rapport fra Havforskningen 3-2012.

Larsen, T.A and Dreyer, B. 2012. Struktur og lønnsomhetsanalyse av norske torsketrålere. Nofima 12/2012.

Larsen, T.A., Dreyer, B., and Hermansen, Ø., 2012, To invest or not – Renewal of the Norwegian bottom trawler fleet. Paper presented at IIFETs conference, Tanzania, Dar Es Salaam, 16th–20th July.

Pena, H., and Ona E. 2012. Improved methods for mapping distribution and abundance of pelagic fish schools with omnidirectional fishereries sonar. ICES CM 2012/F:10.

Svardal, B., Pedersen, G.,Thomas, P. J. Pedersen, A. O., Totland, B., Øvredal, J.T., Tenningen, M., Vold, A., Isaksen, B. and Saltskår J. 2012 Instrumentering for trenging i not Forstudie. CMR-12-F10738-RA-1.

Valdemarsen, J. W., Nedrebø, T., and Sæstad A. 2012. Resultater fra fullskala testing av funksjonelle egenskaper til 9 m2 pelagiske tråldører med justerbare luker om bord i F/F “Johan Hjort” i oktober-november 2011. Rapport fra Havforskningen 5-2012.

Valdemarsen, J.W. 2012. Styring av tråldører og observasjoner av nytt trålkonsept på CRISP-tokt med F/F “Trygve Braarud” 23.–28. april 2012. Rapport fra Havforskningen 24-2012.

Vatnehol, S. 2012. Modellering av det spredte lysfeltet fra en rigid kule med innfallende lydfelt fra en akustisk sylinder array. Master thesis, University of Bergen, June 2012.

Valdemarsen, J. W., Engås, A., Aasen, A., Øvredal J.T., Rosen, S., Bærhaugen, T. and Sæstad, A. 2012. Studier av mursteinsmasker i trål, tester med Deep-Vision og in situ overføring fra kamera og trålsonar på tokt med F/F “Johan Hjort” i 2011. Nytt fra Havforskningen, 12-2012.

Valdemarsen, J.W. and Mæstad, K. 2012. Nyvinninger i kø for nystartet senter. Havforskningsnytt 2-2012.

Valdemarsen, J.W., Vittersø, O., Hammersland, H. and Havsø, B. 2012. Innspill til Hav21. Teknologiutvikling for bioøkonomisk bærekraftig høsting av marine ressurser.

CRISP Annual Report 2012

Editing by Institute of Marine Research
Photos: CRISP
Graphic design: Harald E. Tørresen, IMR

Bergen, 2013


INSTITUTE OF MARINE RESEARCH
HAVFORSKNINGSINSTITUTTET
NORGES SILDESALGSLAG
NERGÅRD
SCANTROL
KONGSBERG
NORGES RÅFISKLAG
Egersund Group
Fishing - Aquaculture - Trade
Nofima