ANNUAL REPORT | 2013

CRISP

sfi Centre for Research-based Innovation

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 third 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 year 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 acoustic instruments for identification of species, quantity and fish size in schools has been one of the focus areas of CRISP since the start. This research is done by Kongsberg Maritime, Simrad in close cooperation with Institute of Marine Research, Bergen. A new and improved fishery sonar which can quantify the size of a school prior to shooting the purse seine is currently being developed. This includes development and testing of new sonar data formats, and also the development of a standard calibration procedure for fishery sonars. A new side-looking fishery sonar for school inspections both before catching and school inspections inside the closed seine, has been developed by Simrad, and enters the trial phase onboard fishing vessels from 2014. In order to estimate fish size and species composition inside schools, the main activity has been to finalize calibration methods of wide-band echo sounders, and of the development of a new transducer with a sharper beam and to determine how this can be arranged in side-view mode. Measurements of single-fish at the border of a herring school have been done with good resolution.

Kongsberg Maritime AS, Simrad, has developed an integrated information system for underwater video, trawl sonar and echo sounder information sent through a standard net-sounder cable from the trawl to the bridge. These instruments give in situ information about species and size of fish entering the trawl as well as monitoring the performance of the trawl. In addition a new trawl door sensor has been developed. This enables precise positioning of the doors in relation to the seabed. A major activity in 2013 has been to commercialize the products by designing a robust and easy-to-handle system for both commercial and scientific use. Also, the integrated information system was further developed to include two modified echo sounders (EK15) that was used to observe fish entering and passing back to the codend. This MultiSensor system has been tested to measure the height, pitch/roll and spread of the trawl doors, and also a new interface (TVI) was tested to display the door measurements.

A structural and economical analysis carried on by Nofima has shown that the purse seine fleet may increase their income by choosing harvest strategies that optimize the value of the vessel quota. This can only be done if the skipper is given tools for better control of catch and gear. It has proved difficult to build instruments hardy enough to withstand the extreme mechanical strains experienced during setting and hauling of the net, and it is difficult to obtain directional stability of instruments attached to the flexible net walls of a seine. Therefore, a prototype catch monitoring system for purse seines has been built that is launched into the net after it is shot. This platform can hold a range of selected instruments for surveillance of the catch (quantity, size, species, welfare parameters, etc.).

The Deep Vision camera system, which identifies and measures fish passing inside a trawl, underwent continued improvement and testing during 2013. A more robust and more compact in-trawl deployment frame was built and tested. Significant improvements have been made to the software used to analyze images taken by the Deep Vision cameras. The Deep Vision system underwent its first deployment inside a demersal trawl during a CRISP-sponsored cruise in April, 2013. The system proved robust, and good results were achieved even in conditions where visibility was poor. A PhD student, who worked on development of the Deep Vision system under NFR's Industrial PhD program, successfully defended his dissertation in November.

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 system, called the Excess Fish Exclusion Device (ExFED), use passive techniques where surplus fish are mechanically guided out of the trawl. The ExFED consists of a fish lock just behind a rectangular opening in the upper trawl panel covered by a mat attached only at its leading edge. A fish lock prevents the targeted quantity of fish from escaping during haul back. From 1st January 2014 the Norwegian cod trawler fleet is allowed to use the ExFED combined with a selection grid during fishing.

The development of low impact trawling technology has included work by Kongsberg Maritime, Simrad to use their acoustic communication cNODE system to control

opening and closing of hatches in maneuverable trawl doors developed by the Egersund Group, and capture evaluation of a trawl with doors lifted 10 m off bottom compared with doors having bottom contact. A new design of a ground gear having less contact and pressure on the bottom substrate was developed by the Egersund Group, and was prototype tested onboard the research vessel G.O. Sars. A controlled opening and closing of both upper hatches in the SeaFlex doors were achieved. Catch comparison indicated reduced catch efficiency of the trawl when trawl doors were lifted off bottom which was partly explained by lower fish density than during comparable experiments in 2012. The tests with the new ground gear taught us how to modify the design for further development and new full-scale testing in 2014

In CRISP, one aim is to increase the quality and the value of the raw material through altering the way the trawl is used and how the catch is treated. This can be achieved through minimizing stress during trawling, and by implementing new technologies that makes the handling of the catch more lenient. The effects of different stressors inflicted upon fish during capture and handling are specifically investigated in research carried out aboard fishing vessels as well as in controlled experimental studies such as in the CRISP large scale swim tunnel/trawl simulator. Experiments designed to look at different aspects of bleeding methods, swimming, exhaustion and recovery was carried out on gadoids in 2013. It was found that the time from catch to bleeding was the single most important factor influencing exsanguination. It was also found that swimming to exhaustion contributes to reduction of flesh quality in commercial trawling, and that the negative effect of exhaustive swimming on flesh quality can be prevented by allowing the fish to recuperate after capture.

An economic and structural analysis of the Norwegian purse seine fleet has been carried out in 2013. A model explaining the renewal process in the fishing fleet is developed. Restructuring seems to have reduced the number of vessels both among purse seiners and trawlers, but the numbers now seem to be stabilized. Our findings indicate that both the structural process and the level of quotas have led to improved profitability, and in both vessel groups it can be seen that old vessels are being replaced by new vessels. One intention of conducting detailed studies of the structural and economic development of the vessel groups addressed has been to reveal how CRISP can contribute to improve the performance of the vessels. In both groups we find heterogeneity in terms of fuel consumption and value adding. While the analyses show that innovations that reduce the fuel consumption are most important for improving the profitability of the trawlers, innovation that improves value adding will be more important for the purse seine group, as the these vessels have a much lower fuel consumption. According to our findings technology that improve the possibilities to target the part of the resources that have market optimal attributes will be important for adding value in the purse seine fleet.

The development work conducted by the CRISP partners has generated significant interests from both scientific and industry representatives from Norway and abroad, resulting in invitations for keynote addresses at scientific conferences, and involvement in national processes to implement more sustainable trawl technologies.

In 2014, CRISP attracted four female candidates to pursue Master and PhD-level studies in the traditionally male-dominated fields of fishing technology and seafood quality.

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 of the research partners 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 ORGANIZATION

4.1 Organizational 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 Marine ecosystem acoustics 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 2013 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 (till July 2013) / Helge Johnsen, Univeristy of Tromsø (from July 2013)
- Svein Ove Haugland, Råfisklaget (till July 2013)/ Heine Møgster, Norges Sildesalgslag (from July 2013)
- 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 were board members in 2011 and 2012. From mid 2013 they were 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 2013, 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 third 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 2013 representatives from the various partners participated in five 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 Hirtshals, Denmark in September where the Centre's activities to date were presented and discussed.

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 with 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 Active device for 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 on board bottom trawlers 5.2 Facility and methods for experimental investigation of fish quality	Nofima, IMR, UiT and Nergård
WP 6. Value adding	6.1 Nergård operation 6.2 Status Norwegian purse seiners	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 density and abundance measurements of schooling fish species than what is possible with current instrumentation.

There is also a definite need for more precise estimates of size and species composition of fish schools prior to shooting a purse seine. This will reduce the number of "poor" sets where catch is of the wrong species, wrong size composition or exceeds the amount that can be handled by the fishing vessel and therefore may have to be partly released. As this practice 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 for developing a new and improved fishery sonar which can quantify the size of a school prior to shooting the purse seine. This includes development and testing of new sonar data formats, and also the development of a standard calibration procedure for fishery sonars. New data formats and improved software have been delivered by the industry partner in 2013 and tested with participation by Simrad personnel in the trial surveys in March and November 2013.

A CRISP PhD student has successfully used the element data of the sonar transducer to create split beam positioning of the calibration target under sonar beam calibrations. In two fishery sonars, 40 of the 64 individual beams were successfully calibrated in the full 360 degree fan, only leaving the backwards looking beams seldom used in school analysis due to backscattering from propeller water in this sector. A new sonar calibration rig for multiple beam calibration was developed and tested in 2013. The student will also create new, synthetic vertical beam fans for a 3D representation of the school when measured at short range during the school inspection phase of the catching process. A new side-looking fishery sonar for school inspections both before catching and school inspections inside the closed seine has been further developed by Simrad, and is in the trial phase onboard fishing vessels from 2014.

In order to estimate fish size and species composition inside schools, the main activities this year have been to finalize calibration methods of wide-band echo sounders. The new wideband echo sounder has been modified and improved by the industrial partner, both with respect to the hardware, but also significant effort is now being made on the new echo sounder software. The new developments in 2013 also include the design and production of a new transducer with a sharper beam and determining how this can be arranged in side-view mode on the vessel. The method was tested with a standard 200 kHz transducer on the drop keel of G.O.Sars during a research cruise in November 2012 and a 200 kHz with sharper beam in November 2013. Horizontal, side view observations of resolved single targets at the border of herring schools have been made both using the conventional split beam echo sounder and the new broadband echo sounder with superb resolution.

Results
This project element is now in its third year, and the work with respect to calibration protocols for fishery sonar and wideband echo sounders are more or less

finished. Most of the problems anticipated in the calibration of both systems (Figure 5.1 and 5.2) now seem to be solved and the work will be published soon. The calibration accuracy of fishery sonar may be slightly lower than for single beam echo sounders, and an overall accuracy of 0.5 dB (±10%) seems to be a good goal. The environmental effects on the transmitted and reflected signals are also larger for sonars than for vertical echo sounding, and so is also the backscatter variability due to target orientation relative to the sonar beam. For the broadband echo sounders, the accuracy over the entire band of frequencies is comparable to the accuracy of narrowband systems, typically 0.1 to 0.2 dB, or 2 to 4%.

Further, sonar data from scientific sonar and fishery sonar have been collected and processed on selected herring schools, with subsequent catching of the school with purse seine. About 10 successful catches were made after sonar inspections. The variability of school backscatter as the vessel moves around the school is now studied for deciding on how and when the "optimal" biomass estimate is measured, including the uncertainty of the estimate. Also, similar measurements on a 30 ton herring school inside an acoustic transparent net pen will be used to establish the conversion factor between acoustic data and biomass for Norwegian Spring Spawning herring. The results will be presented internationally in 2014, and will be further used within the sonar software itself to directly display estimated school biomass.

Figure 5.1:
The new, narrow beam broadband transducer, experimental installation at the bottom of the drop-keel of G.O. Sars.

Analysis of the target spectrum from single fish, mainly herring, has started, based on data on captive herring in net pens in Austevoll and from schools and layers recorded horizontally in the November CRISP survey. For extracting the size of individual fish, the target strength, observation aspect and individual fish frequency response are used. In order to stabilize the used model for expected frequency response as a function of rotation angle and frequency, measurements of 25 individual herring and 10 mackerel was measured in side (lateral) aspect over full 360 degrees rotation for the 200 kHz band (170 – 270 kHz) in a controlled laboratory experiment in Austevoll. These data will be tried used in size inversion process. Further, the newly produced, sharp beam transducer for the broadband echo sounder gave much better resolution at range, and seems to resolve normal wintering school densities of NVG herring at about 80 m range, looking sideways into the school. Processing of these data will be the main task in 2014.

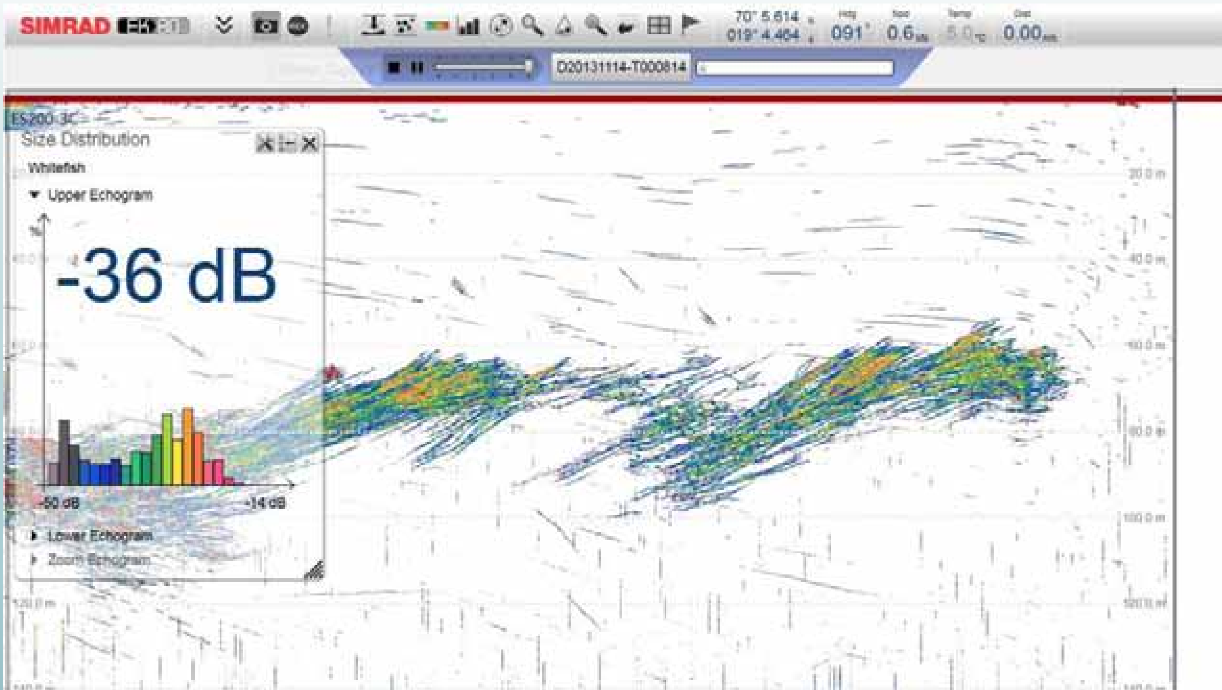

Figure 5.2:
Herring schools and layer resolved in single fish tracks on the closer edge using the new transducer.

5.2 Monitoring of fish behaviour and gear performance

Background

Kongsberg Maritime AS, Simrad, has developed an integrated information system for underwater video, trawl sonar and echo sounder information sent through a standard net-sounder cable from the trawl to the bridge. These instruments give in situ information about fish species entering the trawl, the behaviour of fish within the trawl as well as monitoring the performance of the trawl. In addition, the company has developed trawl door sensors (Simrad PX MultiSensor) giving information about the distance between the doors, distance from the doors to the seabed and roll and pitch of the doors. This enables precise positioning of the doors in relation to the seabed. The instruments have been tested during fishing trials onboard research and commercial vessels in 2012. In the analysis of the economic status of the purse seine fleet carried out in WP6 "Value adding" it has been shown that the purse seine fleet may increase their income by choosing harvest strategies that optimize the value of their limited vessel quota. This can only be done if the skipper is given tools for better control of catch and gear. There is also need for new/better instruments for management and control of the purse seine fisheries.

Figure 5.3:
Experimental catch monitoring platform, containing, echo sounders (Simrad modified EK15), camera systems (Go Pro), oxygen logger, STD and tilt logger.

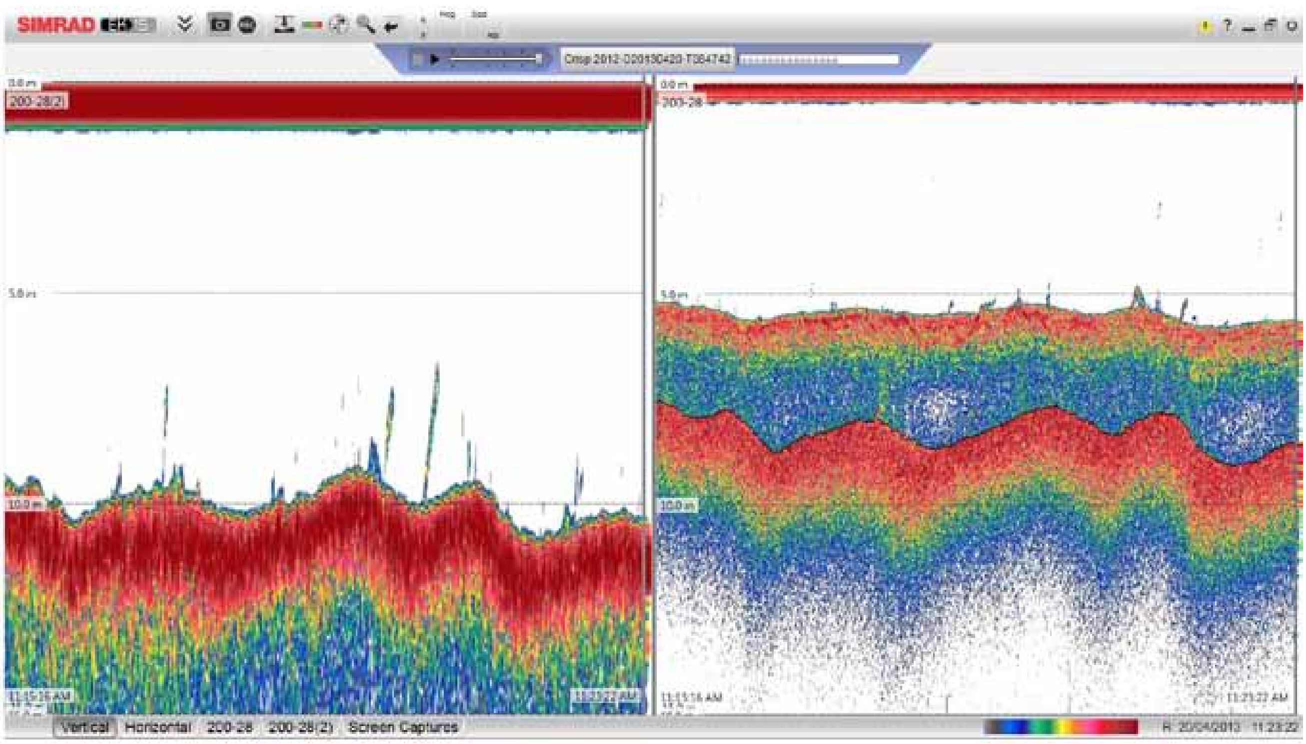

Figure 5.4:
The echograms from the modified EK15s. The echogram on the left is of the net mouth and the echogram on the right is of the extension of the trawl.

Figure 5.5:
The TVI display from Simrad, showing the PX sensor data in real-time.

larger area of a demersal trawl net mouth opening. Trawl door sensors were further tested to measure the distance between the trawl doors and the distance from the seabed, roll and pitch of each door.

A catch monitoring platform prototype for catch identification and surveillance of fish welfare parameters was built and tested on a joint cruise with WP1 onboard F/V "Artus" in 2013. This platform contained two modified EK15 echo sounders (200 kHz, 22,5o; one directed vertically and one horizontally); three Go Pro cameras (mono horizontal and stereo view) for monitoring fish schools, their density and behaviour; a CTD to monitor temperature and salinity; an oxygen logger to monitor oxygen consumption during the crowding phase; and tilt-loggers to monitor the directionality of the instruments (Figure. 5.3). In this initial phase the prototype platform was launched from a small boat floating inside the seine during pursing and hauling.

Currently, the only instruments used on the purse seine are depth sensors to monitor the gear, while evaluation of the catch is carried out by taking a physical sample of the catch. A catch monitoring platform can allow skippers to 1) identify species, size or quality of a catch encircled by the seine in order to decide whether a catch should be kept or released, 2) monitor fish welfare parameters in order to decide when slipping should no longer be allowed ("point of no return") due to risk of unintentional killing of fish, and 3) monitor gear performance during fishing. In previous years several instrument designs for monitoring the catch in purse seines were built and tested onboard purse seine vessels. These were designed to withstand the extreme mechanical strains experienced during setting and hauling of the net. Although they withstood the strains, it proved difficult to optimize the positioning of the instrument pods and to obtain directional stability of the instruments when attached to the highly flexible net walls and gear components of a seine. It was therefore suggested that catch monitoring systems for purse seines should be based on instrument platforms launched inside the net after it is shot to retrieve observations from the catch independent of the net shape and movement. Data transfer to the vessel could either be based on cabled transmission or on a wireless communication link from the seine to the bridge.

Activities
A major activity for Kongsberg Maritime A/S, Simrad in 2013, has been to commercialize the product by designing and developing a robust and easy to handle system for both commercial and scientific use.

During trials on the R/V "G.O.Sars", the integrated information system was further developed to include two modified EK15s, which were placed at the net mount area and in the extension area of a demersal trawl to observe fish entering and passing back to the codend. Simrad PX MultiSensor was further tested to measure the height, pitch/roll and spread of the trawl doors and a new interface (TVI) was tested to display the door measurements.

Commercial trials onboard F/T "Ramoen" were carried out to further test a modified EK15 with a broader beam that covers a

Results
During the R/V "G.O.Sars" cruise, the two modified EK15s gave information about the entrance pattern and the distribution of fish at the net mouth and in the extension of the trawl (Figure. 5.4). The modified EK15 in the extension also indicated when the lower panel of the trawl was damaged. In the commercial trials, the modified EK15 showed the behaviour of fish in the net mount area. The MultiSensor was a vital piece of equipment to carry out testing of a semi-demersal trawl and the new interface TVI allowed the performance of the doors to be analyzed easily (Figure 5.5).

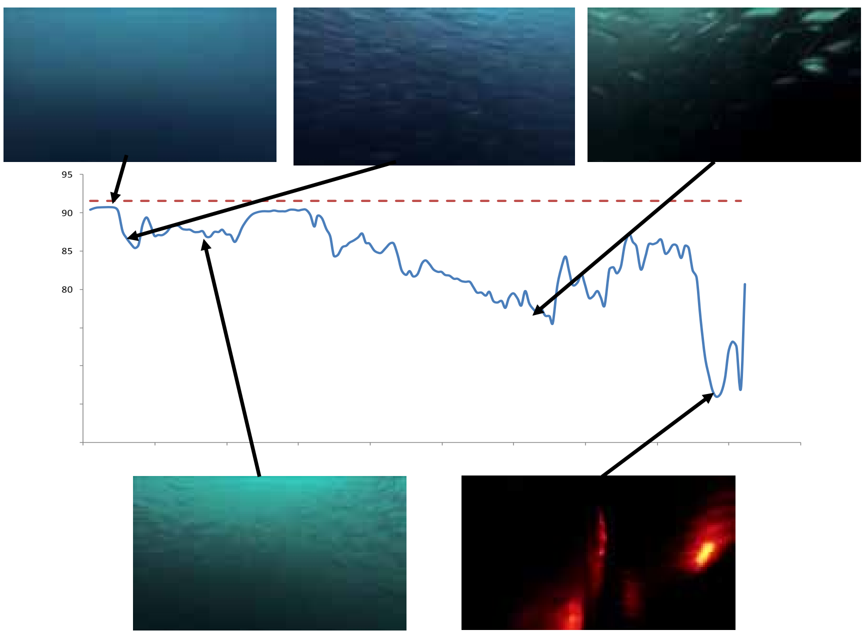

Figure 5.6:
Oxygen level inside a herring school during crowding measured from the monitoring platform clearly varied with crowding density.

Testing of the prototype instrument platform during fishing for Norwegian Spring Spawning herring gave a range of interesting observations on fish density, behaviour and welfare parameters. One restricting factor in all purse seine research, is the low number of replicates because of the large catches and the need to land catches quickly. The modified EK15s gave clear echograms of the fish school during pursing and hauling. It was anticipated that distinguishing between fish and the net would be difficult, however, initial observations indicated that this problem may be resolved. Combined observations from the echo sounders and (stereo) cameras have the potential to become a handy tool for the skipper in future catch identification and determining the crowding density of the catch. Oxygen measurements made in the seine during hauling, showed a rapid decrease of oxygen levels inside the school as crowding increased (Figure 5.6). The catch monitoring platform was only a prototype in this initial stage, and was manually operated from a small boat. In future experiments the use of a remotely operated vehicle that is controlled from the fishing vessel, easy to manoeuvre and able to hold a range of monitoring instruments would be beneficial.

Development of a gear monitoring instrument for purse seines was initiated in an adjacent project, mainly funded by the Norwegian Seafood Research Fund. The seine was monitored during hauling using a Simrad fisheries sonar (SH80), which enabled a 3D reconstruction of shape and volume of the net (Figure 5.7). A Simrad HiPAP acoustic positioning system mounted in the net walls was used to validate the sonar-based net borders. This system should be developed further into a robust gear monitoring tool, which in combination with the fish identification and monitoring platform, may provide the skipper with a robust catch and gear surveillance system.

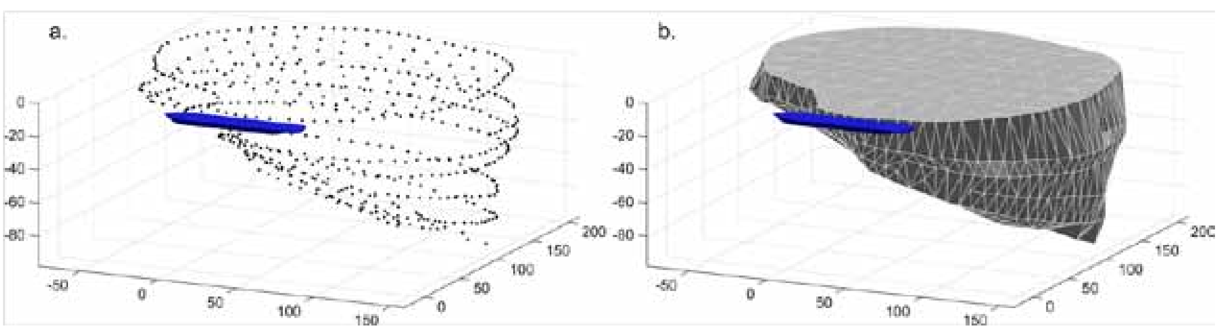

Figure 5.7:
3D reconstruction of a seine during hauling; a) 3D point cloud; b) closed triangulated surface (Tenningen, M., Peña, H., and Macaulay, G. J. Submitted to Fisheries Research.)

5.3 Active selectivity and release in fishing gears

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-valued 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 identify fish species and size, and to release unwanted catch from trawls and purse seines based on early identification of size and species inside these gears, and to develop systems that can regulate the catch in both trawl and purse seine fisheries.

High populations of Atlantic cod in the Barents Sea are currently leading to excessively large trawl catches. This leads to reduced quality when the catch exceeds the vessel's production capacity, increased risk of discarding, gear damage and safety concerns. Therefore, at the request of the industry and management authorities, a passive catch reduction system, the Excess Fish Exclusion Device (ExFED), was developed and tested in 2012. The ExFED consists of a fish lock just behind a rectangular opening in the upper trawl panel covered by a mat attached only at its leading edge. The fish lock prevents the targeted quantity of fish from escaping during haul back. Initially, the mat lies against the top panel of the trawl sealing the escape opening. As fish accumulate and fill up to the fish lock, water flow is diverted out the escape opening, lifting the mat and allowing excess fish to escape at the fishing depth. The system is mounted at a distance from the cod line selected to achieve the target size catch for the vessel.

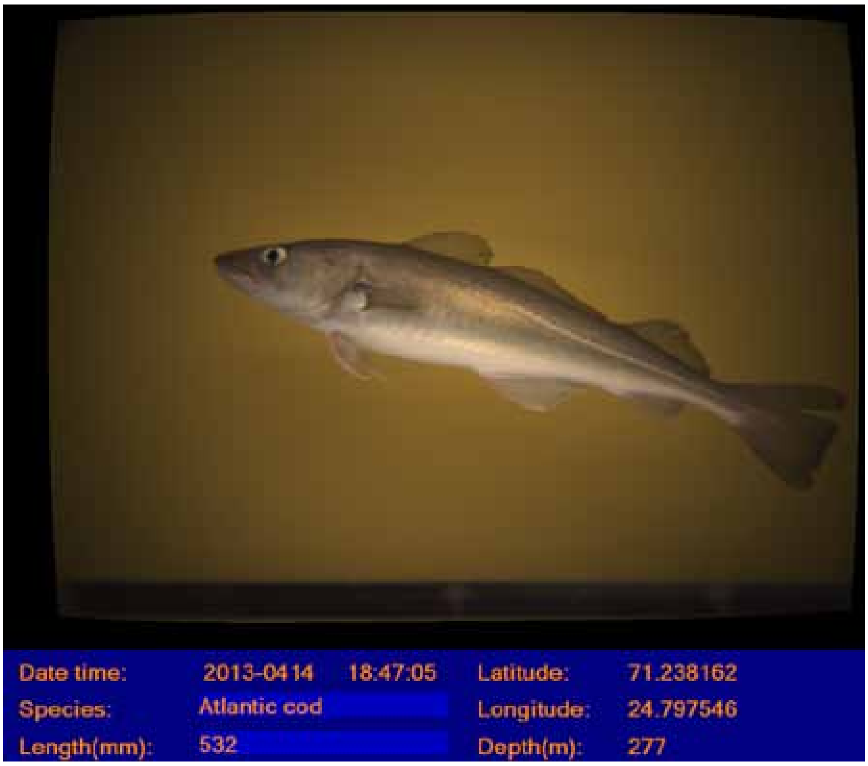

Figure 5.8:
Atlantic cod imaged and measured using Deep Vision system inside a demersal trawl in April 2013.

Activities

The Deep Vision camera system, which identifies and measures fish passing inside a trawl (Figure 5.8), underwent continued improvement and testing during 2013. Peer reviewed articles describing the system, measurement accuracy, and use during a fisheries survey were published in the Canadian Journal of Fisheries and Aquatic Sciences and Fisheries Research. Deep Vision results were also featured in a presentation at the 16th Russian-Norwegian Symposium in Sochi, Russia in September. Shale Rosen, who worked on development of the system under NFR's Industrial PhD programme, successfully defended his dissertation in November. He continues to work on Deep Vision development in a Post-Doc position at the Institute of Marine Research.

No significant changes were made to the stereo camera unit in 2013, but a new, more robust and more compact in-trawl deployment frame was built and tested (Figure 5.11). An industrial design firm was engaged in 2013 to further refine the frame design for commercial production. Significant improvements have been made to the software used to analyze images taken by the Deep Vision cameras. These include automating previously time-consuming tasks including distinguishing images con-

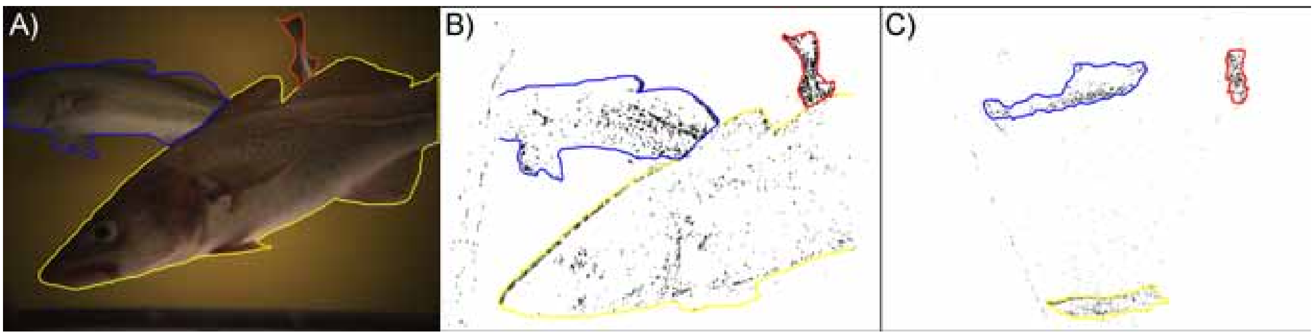

Figure 5.9:
Use of point clouds to separate overlapping fish using Deep Vision. A) Original image with three overlapping fish, each outlined in a different colour. B) Point cloud representations of the surfaces of each fish, same perspective as panel A. C) Point cloud rotated to show view from above illustrates the separation between each fish.

taining fish from empty ones; matching each image with the depth, latitude and longitude where it was collected; automating functions for measuring distances inside images and developing 3-dimensional images for improving the accuracy of length measurements. In addition, data summary tasks that previously required third-party software are now incorporated into the Deep Vision software.

Members from CRISP have participated in a technical working group established by the Directorate of Fisheries to identify technical measures to limit catch size during bottom trawling. The group consisted of members from the industry, the coastguard, fisheries management and scientist. All highlighted the need to work in close cooperation to develop systems to regulate the trawl catch.

During the trials in 2012 the ExFED worked as intended in a four-panel trawl without a grid devise; fish were released at the fishing depth. When using the ExFED behind a grid, fish were observed to escape also during haul back. It was indicated that this fish had accumulated in the section with a grid prior to haul-back. Escapement of fish during haul back (including at surface) may lead to unaccounted mortality. Therefore, the technical group recommended testing of the ExFED without a grid section. Six Norwegian vessels were therefore given exemption from the grid regulations in 2013 and 2014. The ExFED system was also tested onboard R/V "G.O.Sars" in April 2013. It was mounted in a four panel trawl without a sorting grid, and was observed using an underwater camera mounted on the trawl and also with a towed underwater-vehicle equipped with a camera. Underwater camera observations carried out by one of the six vessels mentioned above showed that the mat did not cover the escape opening properly, which led to escape of fish before the desired catch size was reached. To solve this problem, trials were carried out on F/T "Ramoen" in October 2013. Based on feedback from the six vessels and on agreement within the technical working group, the Directorate of Fisheries decided to carry out new test with the ExFED in a two-panel trawl combined with a sorting grid onboard F/T "Hermes" in November 2013, and CRISP members were invited to take part in these experiments.

Results

The Deep Vision system underwent its first deployment inside a demersal trawl during a CRISP-sponsored cruise in April, 2013 (previous trials have been carried out in pelagic trawls). The system proved robust, even as large stones; oil barrels; and a variety of other detritus were captured by the trawl. Good results were achieved even in conditions where visibility was diminished by suspended sediments at the seabed. Data collected during the cruise from both the Deep Vision and Simrad's FX80 trawl camera form the basis of a Masters Degree project in Fisheries Biology being carried out by a master student from the University of Bergen. She is using images and video from the two systems to quantify the behaviour of cod, haddock and saithe in the aft portion of a demersal trawl, with particular focus on whether the Deep Vision alters their passage rates. This knowledge will be critical to optimizing the system's design both for use in commercial fisheries and during surveys, where Deep Vision could be a truly revolutionary sampling tool.

Video observations of the ExFED mounted in a four panel trawl without a grid section showed that the system worked as intended. Fish were observed to calmly swim out through the escape opening at the fishing depth once the cod-end was filled up with the desired catch volume (Figure 5.10).

The gap observed between the mat and the escape opening during tests in the commercial fleet was verified during the "Ramoen" cruise. This was probably caused by the mat forming a convex shape over the top panel of the two-panel trawl when the meshes have a reduced opening. This forces the stiffer mat to curve even more, leading to a gap between the net panel and the mat. Adding floats on the selvage ropes on both sides of where the mat was mounted, reduced the gap. Low visibility due to sand clouds stirred up by the trawl doors and ground gear, made it difficult to document the performance and efficiency of the ExFED during these trials.

During the "Hermes" trials, floats were also used on the selvage ropes as in the "Ramoen" trial. However, low visibility again limited the video observations of the ExFED at fishing depth. During haul-back though, few fish were observed escaping though the escape opening, indicating that the ExFED was working as intended on a two-panel trawl both with and without a grid section.

During a meeting in December 2013 between the fishing industry, fisheries managers and scientists, it was agreed that all Norwegian trawlers who applied could use the ExFED combined with a grid section from 1st January 2014. It was also agreed to continue to further develop the ExFED for different trawl designs in 2014.

Figure 5.10: ExFED as observed with FOCUS underwater vehicle during the G.O.Sars cruise.

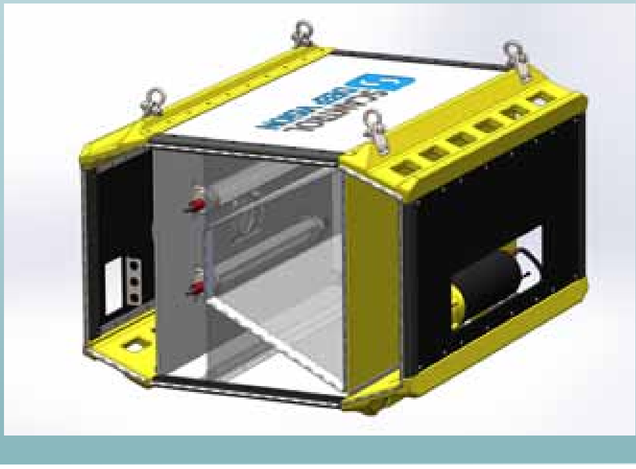

Figure 5.11: Concept drawing of new Deep Vision in-trawl deployment frame for commercial production.

5.4 Low impact trawling

Background
Current trawling practice is regarded as unsustainable, as it may be harmful to the seabed, takes too much bycatch and uses 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, rigging and operation of trawl gears that might achieve such objectives.

Activities
In 2013 the main focus was continued development of semipelagic trawling techniques including maneuverable trawl doors (Figure 5.12), trawl rigging and ground gear with less bottom impact than traditional bottom trawls (Figure 5.13). Additional, an important activity, which is part of a phD study, was to evaluate the capture efficiency when the trawl doors were lifted off the bottom.

The development and evaluation work was conducted during research cruises with the research vessel "G.O.Sars" along the coast of Northern Norway in April 2013 and on commercial fishing grounds in the Barents Sea with the chartered factory trawler "Ramoen" in October.

The 9 m^2 SeaFlex trawl doors developed by Egersund Trawl with hatches above and below the towing brackets were equipped with motors and a cNODE acoustic communication link, the latter being a commercial product from Kongsberg Maritime. The communication link and motorized opening and closing of the upper hatches were tested during the G.O. Sars cruise (Figure 5.14).

The capture performance of the semipelagic rigging with the trawl doors positioned 10 m above bottom, was compared with a typical bottom trawl rigging when both trawl doors had bottom contact. Such experiments were conducted in both of the experimental cruises. During the G.O.Sars cruise attempts were made to study the herding effect of the sweeps between the trawl doors and the trawl wing when these were off bottom behind the trawl doors positioned 10 m above bottom, and when the trawl doors had proper bottom contact. An acoustic transducer was attached to a towed vehicle with the purpose to monitor fish density in front of and behind the sweeps when semipelagic and bottom rigged as described above.

A groundgear consisting of 8" diameter rubber ground gear spacers in 6 m sections connected with 14" diameter steel bobbins was tested during the G.O. Sars cruise. The idea behind the new ground gear design is that the bobbins should be the bottom contact points whereas the rubber spacers between these should "float" above but close to the bottom and thus prevent loss of cod and haddock under the ground gear.

Results
The motor system and acoustic communication proved to be efficient to open and close the upper hatches on the SeaFlex trawl doors. The program, which was developed to control the degree of opening of the hatches performed as expected. The acoustic communication was via a relatively expensive HiPap system, and therefore a cheaper communication system has to be developed and implemented for commercial fishing application. Kongsberg Maritime, Simrad will follow up such development as an integrated part of development of a new generation of a trawl gear monitoring system.

Several challenges were identified during the two cruises with the semipelagic trawl rigging. The acoustic method to observe fish density behind the sweeps when trawl doors were lifted 10 off bottom and on bottom, respectively, provided limited data

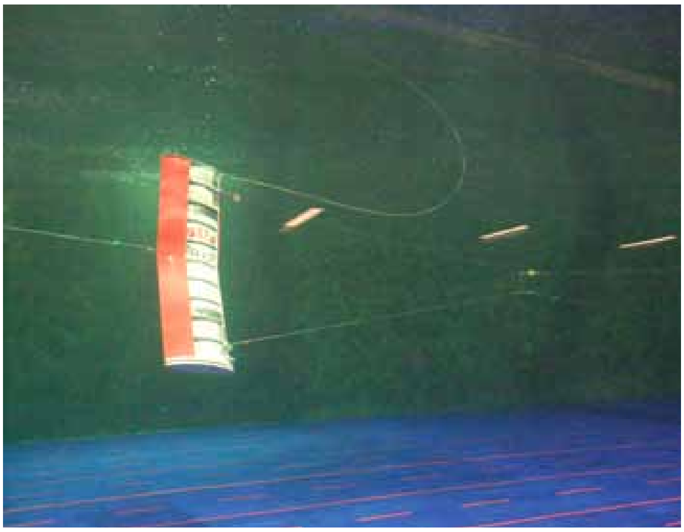

Figure 5.12:
Model of the manoevrable door when tested in the Hirtshals flume tank.

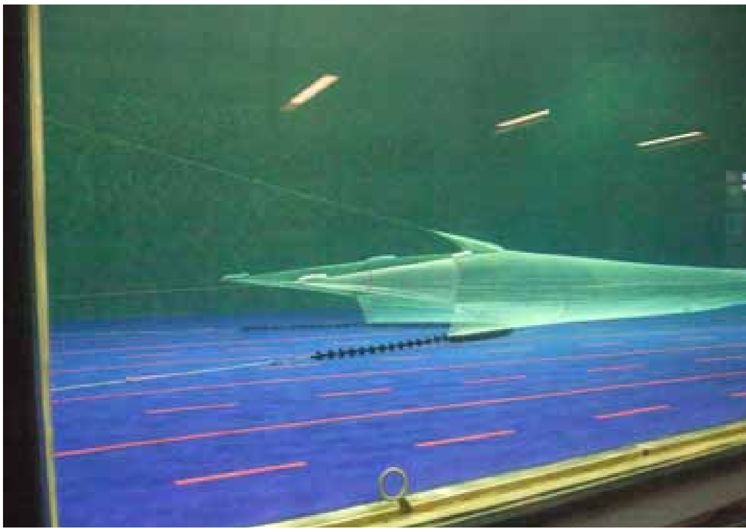

Figure 5.13:
A model of the semipelagic trawl tested with trawl doors on and off bottom (the semipelagic modus).

as the fish density was too low for proper detection, however observations of the bridles and sand clouds behind the doors were seen (Figure 5.15). The commercial testing onboard the factory trawler indicated reduced catchability when the sweeps were lifted off bottom during alternate haul comparisons. A possible explanation for this result was that fish density was lower than in the 2012 comparisons when the catch rates were comparable with doors on and off bottom, indicating that the use of semi-pelagic trawling may be limited to high density areas. The new ground gear composed of bobbins rollers and rubber spacers seemed to perform satisfactory with regard to capture performance, but an obvious weakness was that the trawl equipped with this ground gear also took in more stones with resulting damages of the bottom panel in some of the hauls.

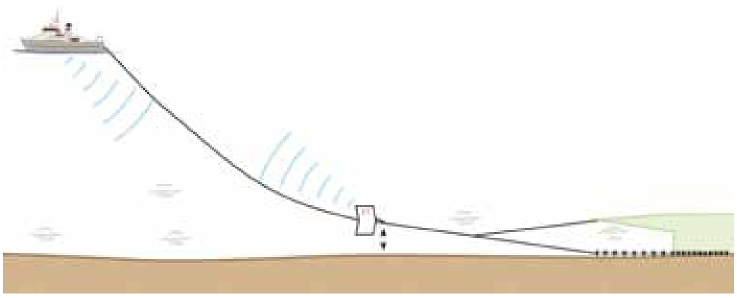

Figure 5.14:
Communication between the vessel and doors to move the doors up and down during trawling.

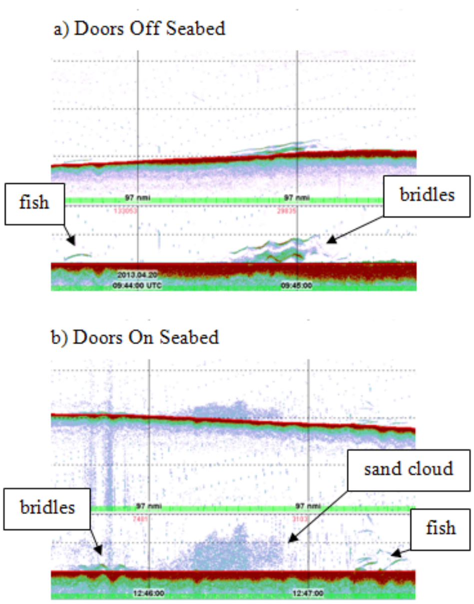

Figure 5.15:
The echograms from the towed vehicle when the doors were a) off and b) on the seabed. When the doors are on the seabed, the sand cloud was visible.

Another observation during the fishing experiments with the semipelagic rigging was that the bottom contact of the ground gear was not stable enough and therefore probably not acceptable. This observation was confirmed in flume tank experiments with a 1:12.5 scaled trawl model.

Further development of the semipelagic trawl will include a modified ground gear, stone release hole in the bottom panel behind the ground gear, insertion of a third bridle and modification of the weight arrangement in front of the ground gear. These modifications will be tested with full scale trawls during various cruises in 2014.

5.5 Quality improvement

Background
The quality of fish products are influenced by a number of factors, such as seasonal variations in feeding, temperature and spawning. The quality of the raw material is also strongly dependent on how the fish are captured. During capture the fish are exposed to a number of stressors which may reduce the final quality of the flesh, such as swimming to exhaustion, crowding in the cod end, severe barotrauma, and lack of controlled killing and bleeding. However, by keeping the fish alive and allowing it to recuperate before being slaughtered, it is possible to obtain high quality flesh from fish caught by trawl. In the CRISP project, Nergård Havfisk AS and Nofima collaborate with regard to quality improvement and value adding. It is challenging to identify and measure all the various stress factors which influence fish quality during commercial fishing, therefore, a number of stressors are investigated in controlled experimental studies in the CRISP large scale swim tunnel/ trawl simulator.

In CRISP, our aim is to increase the quality and the value of the raw material through altering the way the trawl is used and how the catch is treated. This can be achieved through minimizing stress during trawling, and by implementing new technologies that makes the handling of the catch more lenient.

In commercial trawl fisheries, the hauling process is likely to damage a substantial part of the catch due to pressure on the fish when it is being hauled towards the boat and transferred from the sea into the vessel's holding bin. The size of the catch has a direct impact on the degree of injuries; especially when large hauls of fish (15-20 metric tons) are pulled up the slipway to the trawl deck. It is normal that hauls are kept in storage bins for hours before bleeding and gutting. Most of the fish in the storage bin die before bleeding, resulting in insufficient exsanguination and muscle discoloration.

Activities and results

Primary processing line
The effects of different bleeding methods and the time elapse from capture to bleeding were evaluated on Atlantic cod allowed to recover after capture. Bleeding and exsanguination, 30 min prior to gutting (two-step methods), resulted in a better exsanguination when compared to direct evisceration immediately after death. Only marginal or no significant differences between the various two-step methods were observed. The time from catch to bleeding was the single most important factor influencing exsanguination. The results indicate that Atlantic cod should be bled within 30 min after death in order to obtain proper exsanguination.To ensure efficient handling and processing of the fish and safeguarding its quality, it is desirable to establish a space saving slaughtering facility with automatic stun and bleed (for example; SI 7 COMBO, Figure 5.16) on board the trawlers. This will ensure an optimal exsanguination and best possible HES (Health, Environment and Safety) for the crewmembers. The processing line on future trawlers will have to undergo significant changes, especially regarding fish handling and processing. Currently, Nofima and SINTEF collaborate on this issue in the project OPTIPRO – Phase 1 (financed by the Norwegian Seafood Research Fund and ending in 2014) and activities and results are communicated amongst projects and scientists.

Figure 5.16:
Recent innovations from the salmon aquaculture industry are introduced to fisheries; cod are effectively stunned and bled through the Baader SI-7.

Experiments in the trawl simulator
The construction and technical installations on the CRISP large scale trawl simulator/swim tunnel was completed and used in several experiments designed to look at different aspects of swimming, exhaustion and recovery in gadoids in 2013. We also performed a pilot experiment with fish of variable fish size in the tunnel and found no effect of body length on the swimming performance of cod 60-110 cm long. We also carried out a study to compare laboratory analysis instrumentation with hand held analytical instruments for measurements of various blood parameters, as these can be very useful in field studies (e.g. aboard commercial or research vessels).

Recovery from exhaustive swimming in diploid and triploid cod
This trial was conducted to get a better understanding of the interplay between blood, muscle and liver during recovery from exhaustive swimming in cod. We also included triploid cod as a possible contrast to the diploids and acquired the help of a master student from UiT. All the results are not yet analyzed, but so far we have not found any clear difference in recovery between diploid and triploid cod. Plasma lactate increased during swimming and returned to baseline levels between 2 and 4 hours after swimming, while plasma glucose was only elevated, compared to the control level, after two hours of recovery. We found no differences between the ploidies for plasma glucose and lactate and have therefore pooled the results shown in Figure 5.17.

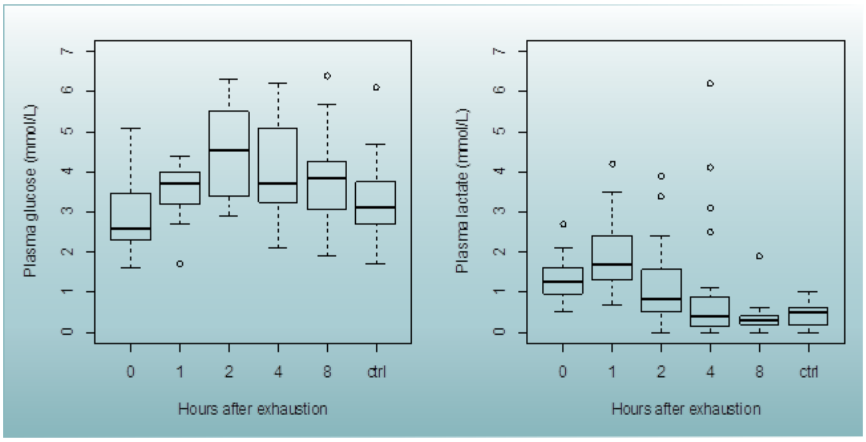

Figure 5.17:
Plasma glucose and lactate in cod during recovery from exhaustive swimming.

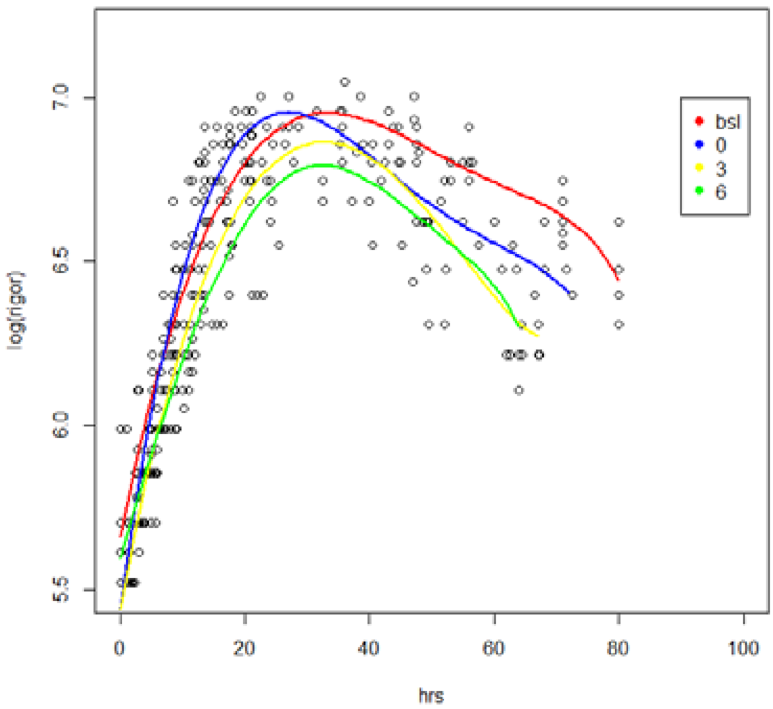

Figure 5.18:
Rigor mortis development over time in haddock immediately killed (0) or allowed to recover for 3 or 6 hours. bsl=control

Recovery after exhaustion and flesh quality in haddock

In this trial, haddock swam to exhaustion at stepwise increasing speed during several hours. We found a large variation ability/ willingness to swim (50-11600m). Recovery did not affect fillet redness or contractile force in rigor mortis, but fish killed immediately after exhaustion reached maximum rigor quicker than recovered groups and control groups (Figure 5.18). We did not manage to produce the degree of fillet redness observed in trawl caught fish in this experiment, indicating that other factors besides exhaustive swimming are of major importance to fillet redness. This investigation should thus be further pursued.

Effect of recuperation on flesh quality following exhaustive swimming in cod

The aim of this study was to investigate the role of exhaustive swimming on flesh quality in cod, using redness (blood in fillets) and development of rigor mortis as quality parameters. After swimming to exhaustion, the fish were assigned randomly to different groups and allowed to recuperate for 0, 2, 4, 6 or 10 hours before being killed. Blood and muscle samples were then collected and the fish were bled for >30 minutes. The time-course of rigor mortis was followed for 72 hours and the redness of fillets was evaluated visually. Each fillet was given a score between 0 (white) and 2 (red) according to its redness.

The fillets of the fish that were allowed to recuperate for 2 – 6 hours were redder than fish that had recuperated for 0 or 10 hours (Figure 5.19). The increase in muscle redness can be explained by redistribution of blood to the muscle to aid in the muscle lactate clearance and glycogen re-synthesis. The fish that were killed immediately after exercise (0 hours of recuperation), had higher levels of blood lactate (Figure 5.17) and entered rigor mortis significantly faster than the other fish regardless of resting time, making them unsuitable for pre-rigor handling (Figure 5.18). The differences between recuperation groups were significant. However, the isolated effect of experimental swimming on redness of fillets was not as marked as often observed onboard commercial trawlers.

In summary, we found that swimming to exhaustion contributes to reduction of flesh quality in commercial trawling, and that the negative effect of exhaustive swimming on flesh quality can be prevented by allowing the fish to recuperate after capture.

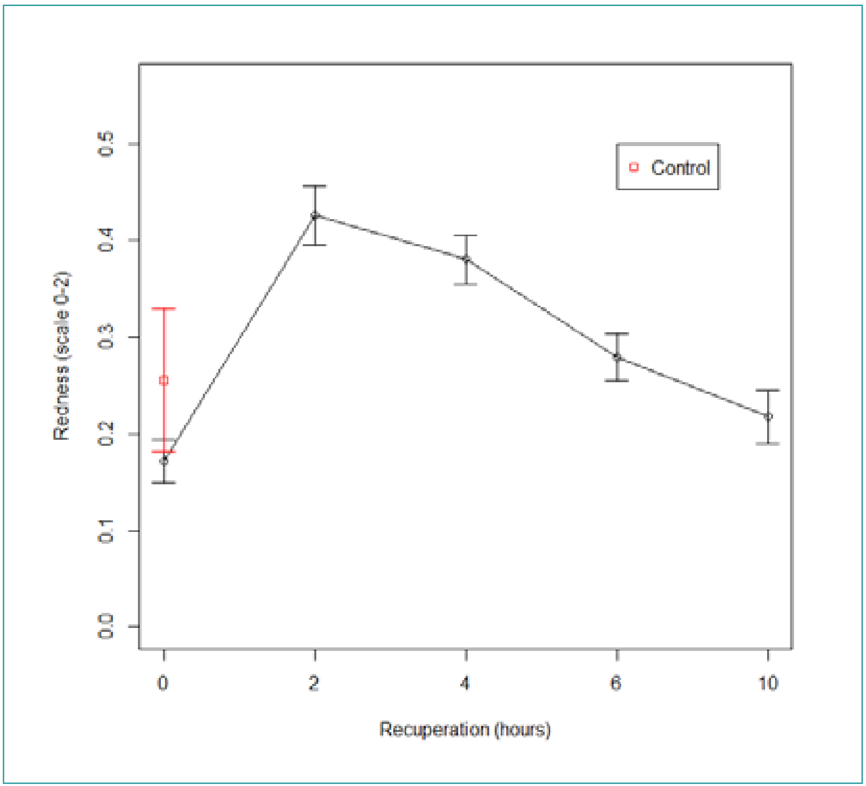

Figure 5.19:
Redness scores (0-2) for fillets as the fish were allowed to recuperate. Values are presented as means ± SE.

Figure 5.20:
Cod sampled during recuperation after being swam to exhaustion in the trawl simulator.

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 in two groups of vessels – ground fish trawlers and the purse seine fleet. A basic analysis of the economic status of the Norwegian trawler fleet was conducted in 2011 and an analysis of the economic status of the Norwegian purse seine fleet in 2013.

Activities

The primary activity in 2013 in WP6 has been the economic and structural analysis of the Norwegian purse seine fleet. Both vessel groups studied in CRISP are in the middle of a renewal process where several new vessels entered the Norwegian fishing fleet. This process is addressed and a model explaining the renewal process in the fishing fleet is developed. 2013 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 vessels in both vessel groups. The numbers now seem to be stabilized and in both vessel groups it can be seen that old vessels are being replaced by new vessels (Figures 5.21 and 5.24). Our findings indicate that both the structural process and the level of quotas have led to improved profitability that has put the owners in a position where they could order a new vessel. One intention of conducting detailed studies of the structural and economic development of the vessel groups addressed has been to reveal how CRISP can contribute to improve the performance of the vessels. In both groups we find heterogeneity in terms of fuel consumption and value adding. An important finding in the purse seine study is that there is variation within the group of value adding that relates to prices achieved. In order to understand this variation it is important to study how different attributes related to fish impact price and how to choose harvest strategies that optimize value of a limited vessel quota. This indicates that improvement is possible by learning from vessels performing well. However, based on the studies we conclude that innovations that reduce the fuel consumption

Figure 5.21:
FF Hopen, belonging to Remøy Fiskeriselskap AS. Hopen is a trawler built in 2013 and have quotas for demersal fish and shrimp.

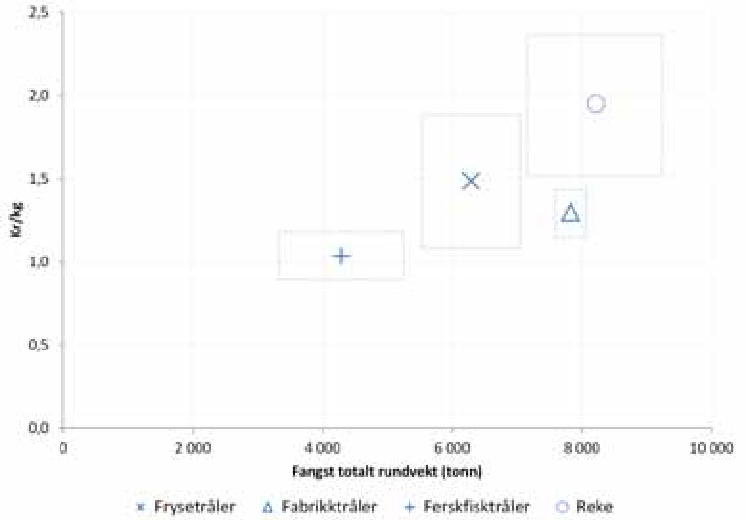

Figure 5.22:
Fuel costs per kg fish caught for codfish trawlers in 2010.

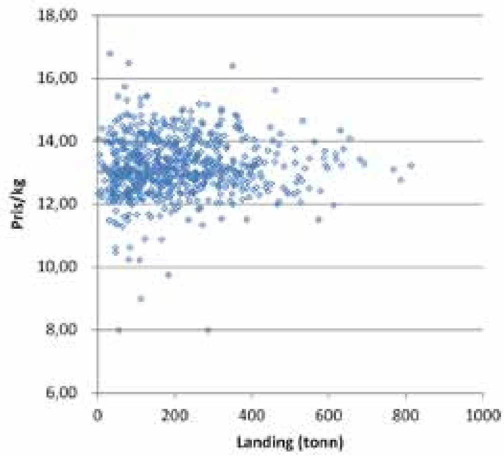

Figure 5.23:
Price obtained per kg mackerel delivered plotted against landed volume for vessels with purse seine license in 2010.

are most important for the trawlers (Figure 5.22). As the fuel consumption is very low among the purse seiners, innovation that improves value adding will be important for this vessel group (Figure 5.23). According to our findings technology that improve the possibilities to target the part of the resources that have market optimal attributes will be important for adding value in the purse seine fleet.

As new vessels are entering the fleet we will analyse how this will impact both fuel consumption and value adding in the two groups. We will also study how new technology developed in the CRISP project are implemented in the fleet and impact on vessel performance.

Figure 5.24:
FF Fiskebas, a new ocean going purse seine vessel built in 2014. It belongs to the company Fiskebas.

6 INTERNATIONAL COOPERATION

CRISP intends to cooperate with international research institutions when such cooperation is beneficial for joint development and introduction of sustainable fishing technology outside Norway. The industry partners in CRISP are all Norwegian owned, and they all have their production activities based in Norway. They are therefore reluctant to involve foreign partners that can share knowledge of product development with foreign potential industry competitors.

Introduction of new fishing technology and marketing of products developed within CRISP by the industry partners have to be legalized by fishing management authorities in the countries where any new technologies should be implemented. CRISP's focus is for a major part on environmental friendly trawl technology for cod fish in the Barents Sea. These resources are managed jointly by Norway and Russia, and therefore involvement of scientific experts from Russia with CRISP activities has been given priority by the centre management. A Russian fishing gear expert participated in the research cruise with R/V "G.O.Sars in May 2013, and the centre director participated in a meeting between high-level fishing organizations from both Norway and Russia in August 2013. The Deep Vision technology has generated interest from several research institutes globally and consultations with them are ongoing. An expert on underwater acoustics from NMFS, Seattle, USA participated in the November 2013 survey and is involved in tutoring one of the PhD students of CRISP, on sonar calibration. The student will also have an extended stay with the tutors institute in Seattle over 6 months, starting in January 2014.

In the work-package on quality improvement, a veterinary student from the University of Nottingham, School of Veterinary Medicine and Science, United Kingdom finished her year 3 research project dissertation in spring 2013. Her work was performed in the CRISP trawl simulator in 2012, entitled "A comparison of the critical swimming speed (Ucrit) of farmed and wild-caught Atlantic cod (Gadus morhua)". In the same work package, an experiment was performed in collaboration with Centre for Environment, Fisheries and Aquaculture Science (Cefas), United Kingdom. The experiment was performed in Tromsø in summer 2013, and investigated temperature influences on swimming activity in wild-caught northern Atlantic cod, which will be compared to previous data on swimming activity in Atlantic cod from the North sea.

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.

Ragnhild Svalheim was employed by Nofima AS as a PhD student from 1. April 2013. Her study focus on how muscles of captured fish are restored during the post capture phase.

Wenche Haver Vigrestad is a master student at University of Bergen, conducting a study related to fish behaviour during passage of a trawl till they pass through the Deep Vision system. Another master student from University of Bergen, Rachael Morgan, is analyzing video material to see if crowding to different densities during purse seine capture may causes short or medium term changes in swimming behavior of herring. A third master student associated with the quality improvement project at Nofima is Tonje Jensen.

8 COMMUNICATION AND DISSEMINATION ACTIVITIES

In 2013 outreach activities have been extensive like in previous years. This includes lectures about CRISP activities and results in national and international scientific meetings. The CRISP director participated as an invited keynote speaker at a minisymposium arranged jointly by ICES, SEAFDEC and FAO in Bangkok in May 2014 dealing with Impact of Fishing on the Environment. The CRISP industry partner Scantrol AS presented the Deep Vision concept developed by the centre at the ICES annual science conference in Reykjavik. The centre was presented in the March issue of the magazine International Innovation. CRISP staff has presented its idea and achievement at a bilateral Norwegian- French marine science cooperation meeting, at a meeting discussing cooperation between Norwegian and Russian fishermen associations and at the WEFTA (West European Fish Technologists Association) conference in Tromsø in October 2013.

APPENDIX: I

Personell

Key Researchers

Name	*Institution*	*Main research area*	*Sex*
Torbjørn Tobiassen	Nofima	Quality improvement	M
Kjell Midling	Nofima	Quality improvement	M
Øyvind Aas-Hansen	Nofima	Quality improvement	M
Stein Harris Olsen	Nofima	Quality improvement	M
Leif Akse	Nofima	Quality improvement	M
Bent Dreyer	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
Gavin Macauley	IMR	Sonar technology and fisheries instrumentation	M
Rolf Korneliussen	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		F
Atle Totland	IMR	Sonar technology and fisheries instrumentation	M
Ronald Pedersen	IMR	Sonar technology and fisheries instrumentation	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 Rasmus Kvamme	Kongsberg Group	Monitoring fish and gear	M
Helge Hammersland	Scantrol	Visual fish classification	M
Darren Hammersland-White	Scantrol	Visual fish classification	M
Bowei Tong	Scantrol	Visual fish classification	M
Shale Rosen	Scantrol	Visual fish classification	M
Hege Hammersland-White	Scantrol	Visual fish classification	F
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
Terje Eriksen	Egersund Group	Low impact trawling	M
Monica Langeland	Egersund Group	Low impact trawling	F
Kjell Larsen	Nergård Havfiske	Quality improvement and value adding	M
Tommy Torvanger	Nergård Havfiske	Value adding	M
Torgeir Mannvik	Nergård Havfiske	Fish quality/fishing	M

Postdoctoral researchers with financial support from the Centre budget

Name	*Institution*	*Research area*	*Sex M/F*	*Period*	*Nationality*
Anders Karlsson	Universitetet i Tromsø	Fish physiology	M	3 years	Norsk

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
Ragnhild Svalheim	Norwegian	1.4 2013- 31.3. 2016	F	Fish quality

Master Students

Name	*Nationality*		*Sex M/F*	*Period*	*Nationality*
Wenche Haver Vigrestad	IMR	Fish Behaviour	F	2013-2014	Norwegian
Rachael Morgan	IMR	Fish Behaviour	F	2013-2014	British
Tonje Jensen	Nofima	Quality improvement	F	2013-2014	Norwegian

APPENDIX: 2

Funding

Statement of Accounts 2013

All figures in 1 000 NOK

Funding		**Budget**	**Account**
The Research Council		10 000	10 000
The Host Institution (name)	IMR	7 000	13 446
Research Partners*	Nofima	1 199	1 305
	University of Bergen	350	290
	University of Tromsø	1 200	613
Enterprise partners*	Kongsberg Maritime AS	3 480	11 941
	Egersund Group AS	1 250	2 736
	Scantrol AS	1 202	1 804
	Nergård Havfiske AS	1 000	295
Public partners*	Sildesalgslaget	100	100
	Råfisklaget	100	100
		26 881	42 630

Costs

		Budget	**Account**
The Host Institution (name)	IMR	13 450	19 746
Research Partners	Nofima,	3 449	3 705
	University of Bergen	1 000	940
	University of Tromsø	2 050	1 463
Enterprise partners	Kongsberg Maritime AS	3 480	11 941
	Egersund Group AS	1 250	2 736
	Scantrol AS	1 202	1 804
	Nergård Havfiske AS	1 000	295
Public partners	Sildesalgslaget	0	0
	Råfisklaget	0	0
		26 881	42 630

ATTACHMENT 3

Publications

Journal papers

Olsen, S.H., Sjurdur, J., Tobiassen, T., Heia, K., Akse, L., Nilsen, H. 2014. Quality consequences of bleeding fish after capture. Fisheries Research 153, 103–107.

Olsen, S.H., Tobiassen, T., Akse, L., Evensen, T.H., Midling, K.Ø. 2013. Capture induced stress and live storage of Atlantic cod (Gadus morhua) caught by trawl: Consequences for the flesh quality. Fisheries Research 147: 446-453.

Rosen, S.P., Jørgensen, T., Hammersland-White, D., Holst, J.C. 2013. DeepVision: a stereo camera system provides highly accurate counts and lengths of fish passing inside a trawl. Canadian Journal of Fisheries and Aquatic Sciences 70(10): 1456-1467.

Rosen, S., Holst, J.C. 2013. DeepVision in-trawl imaging: Sampling the water column in four dimensions. Fisheries Research 148: 64-73.

Reports and ICES contributions

Larsen, T. A., Dreyer, B. 2013. Ringnot – Struktur og lønnsomhet. Tromsø: Nofima 2013 (ISBN 978-82-8296-111-0) 25 s. Nofima rapportserie (34/2013).

Macaulay,G., Ona, E., Calise, L., 2013. Progress on broadband acoustic investigations of individuals and schools. ICES FAST WG, San Sebastian, Spain, from 16–19 April 2013

Peña, H., 2013. Improved methods for data processing from omnidirectional fisheries sonar for studying pelagic fish schools. ICES FAST WG, San Sebastian, Spain, from 16–19 April 2013

Valdemarsen, J.W. 2013. CRISP - Annual Report. Ber: Havforskningsinstituttet 2013 24 s.

Valdemarsen, J.W. 2013. Improving commercial trawling and purse seine practices. International Innovation 2013 s.66-68.

Valdemarsen, J.W. 2013. Rapport fra CRISP-tokt med F/F “G.O.Sars 10.-24. april 2013. Bergen: Havforskningsinstituttet 2013 19 s. Rapport fra havforskningen nr. 17-2013.

Valdemarsen, J.W. Aasen, A., Øvredal, J.T. 2013. Forsøk med Styrbare tråldører og Deep Vision enhet om bord i “Fangst” 19.-24. juni 2013. Bergen: Havforskningsinstituttet 2013, 15 s.

Vatnehol, S., Totland, A., Ona, E. 2013. Calibration trials on a omni-directional fishery sonar with the split-beam method. ICES FAST WG, San Sebastian, Spain, from 16–19 April 2013.

Contributions in workshops and meetings

Midling, K.Ø., Olsen, S.H. 2013. Machine killing and bleeding in one operation. 43rd WEFTA Conference; 2013-10-09 - 2013-10-11.

Olsen, S.H., Tobiassen, T., Akse, L., Evensen, T.H., Midling, K.Ø. 2013. Capture induced stress and live storage of Atlantic cod (Gadus morhua) caught by trawl: Consequences for the flesh quality. 43rd WEFTA Conference; 2013-10-09 - 2013-10-11.

Rosen, S.P., Underwood, M., Engås, A., Eriksen, E. 2013. DeepVision: an in-trawl stereo camera makes a step forward in monitoring the pelagic community. The 16th Russian-Norwegian Symposium. Sochi, Russia.; 2013-09-10 - 2013-09-12.

Suuronen, P., Valdemarsen, J.W. 2013. Low-Impact and Fuel Efficient (LIFE) Fishing Challenges, opportunities and some technical solutions. LIFE minisymposium; 2013-05-06 – 2013-05-10.

Svorken, M., Isaksen, J.R., Larsen, T.A., Dreyer, B. 2013. Research and innovation on fish capture and pre-processing on bottom trawlers: An economic assessment from CRISP activities. 43rd WEFTA Conference; 2013-10-09 - 2013-10-11.

Svorken, M., Larsen, T.A., Isaksen, J.R., Dreyer, B. 2013. The Norwegian cod trawlers. An economic assessment. 43 WEFTA Conference; 2013-10-09 - 2013-10-11.

Valdemarsen, J.W., 2013. CRISP - teknologiutvikling for bærekraftig høsting. HI’s Fagdag; 2013-01-09 - 2013-01-10.

Valdemarsen, J.W. 2013. CRISP- a Norwegian industry research cooperation model to develop sustainable fishing technology. French- Norwegian Marine Seminar; 2013-06-
25 - 2013-06-26.

Valdemarsen, J.W. 2013. Development focus on trawl to reduce environmental impact within CRISP. 2nd FAO GHG Workshop; 2013-05-04 - 2013-05-05.

Valdemarsen, J.W. 2013. FoU arbeid for et mer miljøvennlig trålfiske. Samarbeidsmøte norsk-russisk fiskeindustri; 2013-06-03 - 2013-06-04.

Valdemarsen, J.W. 2013. Målinger i trålredskap. Hva gjør vi i CRISP og hva skal vi gjøre om 5 år? Marine Acoustic Workshop; 2013-01-15 - 2013-01-18.

Vold, A. 2013. CRISP – en ny stor satsing i Barentshavprogrammet. Programmøte i Barentshavprogrammet; 2013-10-14.

Vold, A. 2013. CRISP – en stasing på teknologiutvikling for fiskeflåten. Foredrag for Innovasjon Norge ved HI; 2013-10-17.

Internet publications

Valdemarsen, J.W. 2013. Improving commercial trawling and purse seine practices. www.imr.no/crisp/en [Internett] 2013-04-01.