ANNUAL REPORT 2011

1 SUMMARY

CRISP, the Centre for Research-based Innovation in Sustainable fish capture and Processing technology, started its research activities on April 1, 2011. Since its launch, the consortium has consisted of four research partners (the Institute of Marine Research, Nofima AS, the University of Bergen and the University of Tromsø), four industry partners (Kongsberg Martime AS, Simrad, Scantrol AS, the Egersund Group and Nergård Havfiske AS) 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 optimise catch quality and value
- analysis and documentation of the economical benefits to the fishing industry of converting to more sustainable capture techniques.

In the course of its first year, CRISP has developed and tested several prototype products and methods that will support the development of more sustainable fishing practices.

Last summer, on the bridge of the fishing vessel "Ramoen", scientists and fishermen could watch live video showing fish inside the trawl net. For the first time it was possible to compare observations from the sonar located in the opening of the trawl net with a live video during trawling on a commercial fishing vessel. The new device, which has been developed by the Simrad division of Kongsberg Maritime AS in collaboration with the Institute of Marine Research, sends the video signal up to the boat through the same cable as the trawl sonar signals.

Scantrol AS is another of the private-sector partners in the centre. Together with the Institute of Marine Research, the company is developing a system that will automatically identify the species and size of the fish in a trawl net. After further development this system will be used to select which fish are to be retained and to release the unwanted ones.

Hatches in trawl doors that can be opened and closed are the focus of another project. Trawl doors are used to keep the net open when it is being dragged behind a fishing vessel. By individually adjusting the hatch openings during trawling, fishers can keep the doors at the correct depth, even in difficult currents, while changing course and when trawling on a slope. This project is the work of another partner, Egersund Trawl AS, while the Institute of Marine Research has tested the adjustable trawl door prototypes.

Cod kept alive prior to on board processing on the Nergård trawler M/Tr "J. Bergvoll" resulted in improved visual and biochemical product quality compared with traditional fish handling after capture with trawls.

Recent analysis suggests that the economic benefits to the Norwegian bottom trawler fleet from improved capture techniques can be significant. Fishing activity and economic performance are well documented in a milestone report recently published by Nofima AS.

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 analyse and document the economic benefits for 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 package, 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 two 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 a priority is to increase cooperation among more partners in several of the work packages.

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 programmes 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 organised in a similar way.
The Universities of Bergen and Tromsø are research partners in the consortium, and their main function is to provide formal education for PhD and MSc students who are funded and associated with the Centre.

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

The board of the Centre in 2011 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
Bjørn Eirik Olsen, 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. In 2013 and 2014 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 2011, the CRISP consortium comprised four research partners (the Institute of Marine Research, Nofima AS, the University of Bergen and the University of Tromsø), four industry partners (Kongsberg Martime 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 fisheries biology in general, and specifically for this project, 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 research vessels operated jointly with IMR.

University of Tromsø, Faculty of Biosciences, Fisheries and Economics (BFE), has particular responsibility for the development of fundamental and scientific expertise within all areas of fisheries and aquaculture research in Norway. Teaching and research focus primarily on biological oceanography, fishery biology, assessment and management. Its premises for involvement in the proposed programme of research are very good due to the University's expertise in multidisciplinary studies and practical implementation of research results. 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 photos of fish inside a trawl, which can be used to electronically identify species and measure their length, combined with a mechanism that can subsequently be used to retain or release organisms captured during fishing. The present status of the DeepVision technology 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. IMR technologists will assist in the design phase and in field tests at sea. IMR also cooperates with an extensive network of fishing gear technologists abroad, who can introduce the DeepVision technology to the global market. 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 will provide extensive practical experience to the Centre in the design of trawls, trawl doors and purse seines. The company will benefit 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. The company will co-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 biggest 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. The company employs about 500 people and has an annual turnover of about 17 billion NOK. 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 ecolabeling 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 southwest of Norway to Finnmark in the northeast. 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 first year the various partners have spent 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 2011 three to four 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 at all the Centre's activities were presented and discussed.

Figure 4.1
Cruise progress meeting on board the RV "Johan Hjort".

5 SCIENTIFIC ACTIVITIES AND RESULTS

In 2011, the scientific activities were 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 trawlere	Nofima, Nergård and UiT

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

Background
Both the fishing industry and the research institutes need more accurate schooling measurements than are possible with current instrumentation. The field also includes more precise estimates of sizes and species composition of a school prior to shooting a purse seine. Such information is valuable as a means of enclosing fewer schools in a purse seine when the potential catch appears to be of the wrong species, size composition or of a size that cannot 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 a new fishery sonar that can quantify the size of a school prior to shooting a purse seine. This includes development and testing of a new scientific data format. This development also includes calibration methodology where a new calibration rig design capable of calibrating individual beams will be produced and deployed in 2012. A physics MSc student is analysing the possibility of using element data from the transducer to create new synthetic vertical beams for a 3D representation of the school at short range during the inspection phase.

To estimate size and species composition inside schools, the main activities centre on calibration methodology of wide-band echo sounders. The EK80 echo sounder will be modified with the aim of removing limitations identified during a previous project, including the use of more and narrower beams and determining how these can be arranged in side-view modes. This was tested during a research cruise with RV "Håkon Mosby" in November 2011. During the same cruise basic comparisons between the old (EK60) and new (EK80) echo sounder technology were made.

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 of wideband echo sounders now seem to have been solved, and calibration accuracy over the entire band of frequencies utilised seems to be comparable with the calibration accuracy of narrowband systems. The results will be published in May 2012. Initial analysis of fish target spectrum has started.

A project for postprocessing of the wide-band target data has been approved and progress within this critical element is expected in 2012. Side-view measurements of herring in controlled experiments are planned for June 2012 in Austevoll, and the first field data on herring will be collected and analyzed in November 2012.

In fishery sonar, progress have beam made in postprocessing software for school detection, but we are still waiting for the implementation of the new scientific data formats. A new calibration rig for the sonar is being developed and new calibration spheres have been produced. Two MSc students will deliver their dissertations in April and August 2012, and a new PhD student on fishery sonar will start in August 2012.

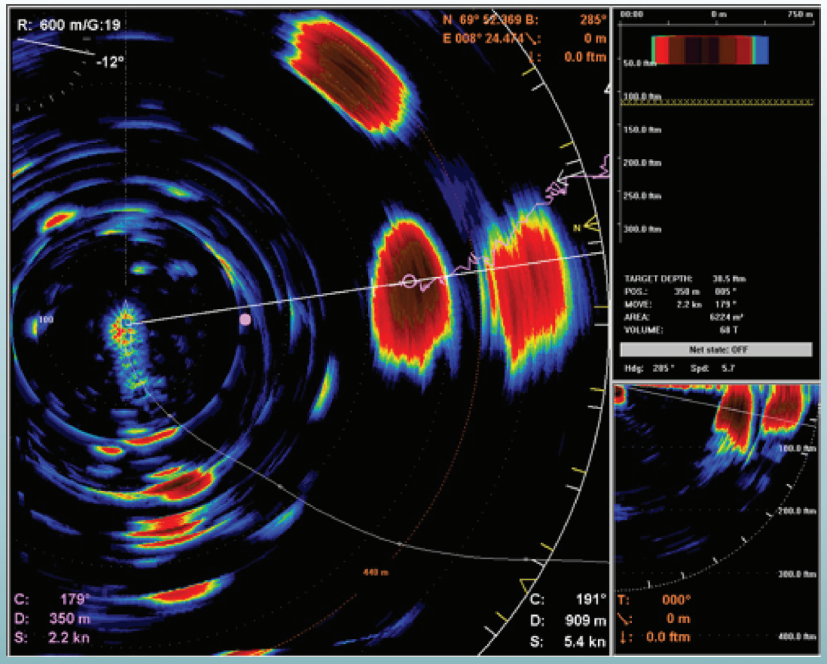

Figure 5.1:
A sonar picture that illustrates a herring school prior to capture, sliced horizontally and vertically using a SH90.

5.2 Monitoring of fish behaviour and gear performance

Background

At present, instrumentation to observe fish and 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 to be taken. A major objective of CRISP is therefore to develop in situ instrumentation that can inform the skipper about which sizes and species are entering a fishing gear, particularly trawl gears. Such instruments are expected to facilitate aimed fishing and thus also lower vessel energy consumption while fishing.

Activities

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 netsounder cable. The system consist of a unit (HUB) that arranges for communication between several computers in a network, a high-freqency sonar and a monochrome camera with artificial light sources (Figure 5.2). The trawl sonar and HUB are mounted on the trawl's headline, with a cable connection to the camera and a light source positioned anywhere on the trawl. A prototype of the system was tested on board the commercial trawler FT "Ramoen" in June 2011, and RV "Johan Hjort" in October-November 2011.

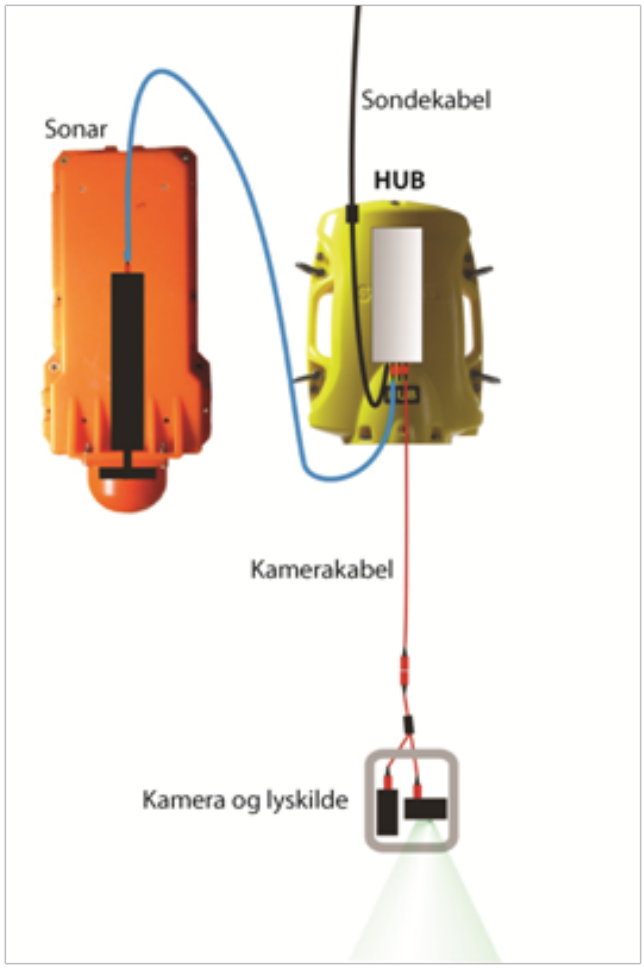

Figure 5.2:
A system for observing fish and trawl behaviour by sonar and camera.

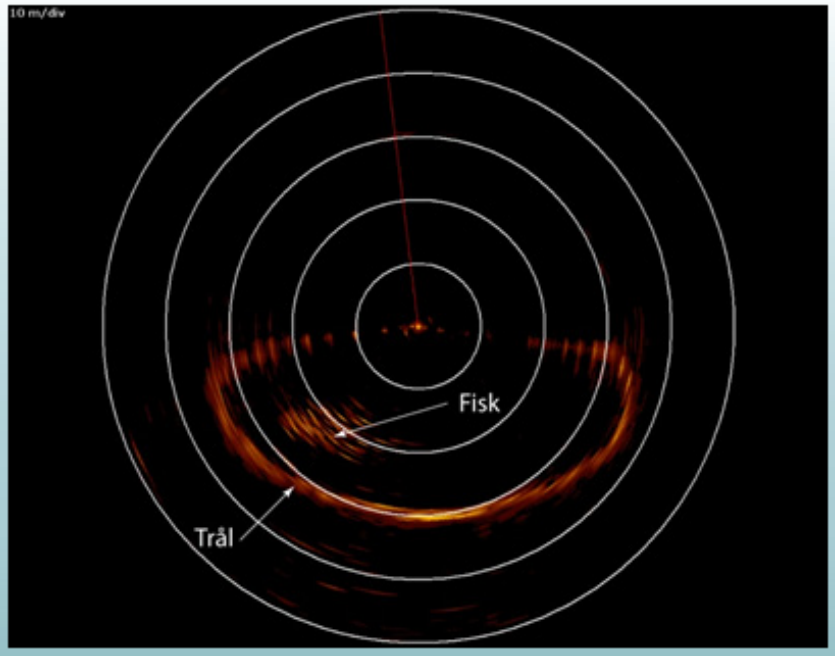

Figure 5.3:
Sonar picture of the trawl mouth and entering fish.

Figure 5.4:
In situ camera observation of cod in front of a sorting grid.

Results

The simultaneous transfer of data from the trawl sonar and video camera was successful. Methods for arranging and handling the cable between the HUB on the trawl headline and the camera positioned further back on the trawl was identified as a major challenge that needs to be improved.

The camera provided excellent information about fish behaviour inside the trawl and to some extent sufficient information for species identification. Fish behaviour in front of a sorting grid offered valuable insights into when such devices are operational and when they are not. The quality of the *in situ* observations was very high.

Mainly as a result of the convincing prototype tests, Kongsberg Maritime AS has already won an order for seven systems for commercial fishing vessels in the United States, for delivery in 2012.

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 highgrading, 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

In cooperation with IMR, Scantrol has developed a photo identification system (DeepVision technology) that can classify individual fish in terms of species and length. The system consists of two cameras that take high-quality horizontal stereo images using flashing light diodes of objects passing through the trawl. The pictures are stored on a harddisc with the option of online transfer to the vessel and display through a netsounder cable. Scantrol has developed software that automatically measures length and identifies species displayed on a screen ?? (Figure 5.5). In 2011 methods for analysing how to improve length measurements weredeveloped, as well as prototype design and testing on how the device best can be installed inside the trawl. The tests were conducted on board RV "Johan Hjort" in October–November 2011.

The aim is to adapt DeepVision technology for use in both commercial fishing and research. A major challenge is therefore to develop a system that has the capacity to handle both high catch rates and a wide range of size and species compositions. Studies of fish behaviour inside the trawl, particularly as they pass the DeepVision system, are fundamental knowledge for the development of a functional unit. A scientific application of the system is the DeepVison unit inside the trawl as illustrated in Figure 5.6, which among other functions will verify species and sizes of acoustic registrations as the fish are passing.

A system for regulating trawl catches was tested onboard FT "Ramoen" in June 2011. The system consisted of a door mounted in the upper panel of the trawl-net in front of a sorting grid. When the leading edge of thedoor was closed by means of an acoustic release mechanism, the passage of fish to the codend was blocked and entering fish could escape through a vent in the upper panel.

Results

The design of the DeepVision unit tested on board RV "Johan Hjort" displayed promising performance with regard to handling, fish passage and installation in the after part of a trawl. This prototype design will therefore be modified to create a functional unit. There was a good correlation between the length distribution of the catch and length estimates made by the DeepVision technology.

Figure 5.5:
High-quality photo of a saithe inside DeepVision.

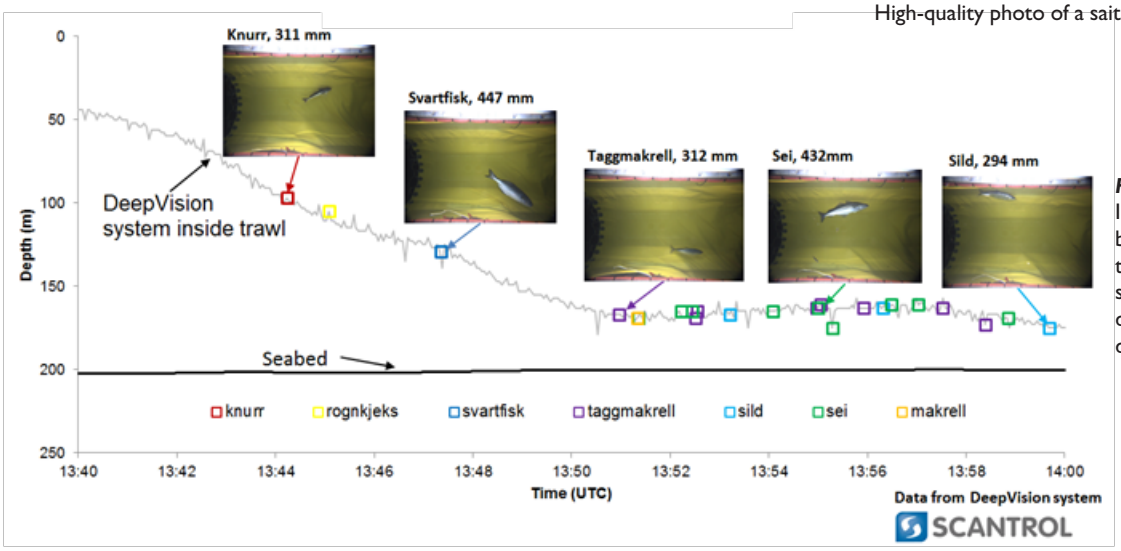

Figure 5.6:
Information collected by DeepVision during trawling, showing species and size distribution at various depths.

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 workpackage addresses the design and operation of trawl gear.

Activities

A major activity in this work package has focused on the development of manoeuvrable trawl doors initiated by Egersund Trawl AS. This has included design, production of models and testing in the Hirtshals Flume Tank followed by functional testing at sea of small (2 m^2) and larger (9 m^2) trawl doors equipped with hatches above and below the towing brackets (Figure 5.7). The smaller doors were tested on board a 50' vessel, MS "Fangst", and the larger doors on board RV "Johan Hjort" in October/November 2011.

The MS "Fangst" trials also included prototype testing of a new pelagic/semi-pelagic trawl concept designed with longitudinal ropes in the forward part and hexagonal meshes turned 45 or 90 degrees to attain a mesh configuration similar to a brick wall in the after part of the trawl. This after trawl part was also tested as the aft belly part of a 704 m circumference pelagic trawl during the "Johan Hjort" cruise in October–November.

Results

The performance tests with both the small and large trawl doors reduced door spread by 40% when all hatches were fully open. The surface area of the hatches is 20% of the trawl door surface. The horizontal spread of the same trawl door set can be adjusted in commercial fisheries when a trawler uses different trawls sizes on the same fishing trip (e.g. demersal and pelagic trawls) or when fishing with different warp lengths. The trawl doors were tilted inwards or outwards when the upper or lower hatches respectively were opened. An inward tilt produces an upward movement of the doors while an outward tilt moves them downwards. Individual adjustment of the hatches can therefore be used to adjust the depth of each door independently.

It was also shown that little power was needed to open/close the hatches in a towing situation. The necessary systems, including motorization, control and communication to open/close hatches, will be developed in cooperation between Kongsberg Maritime AS and Egersund Trawl AS.

The new trawl design tested in a smaller version onboard MS "Fangst" displayed promising performance and the concept will be further developed and tested on fishing grounds. The performance of the brick-shaped meshes was also worth developing further for testing in fishing situations.

Figure 5.7:
2 m^2 (left) and 9 m^2 (right) trawl doors equipped with hatches, which are used to adjust depth and horizontal spread.

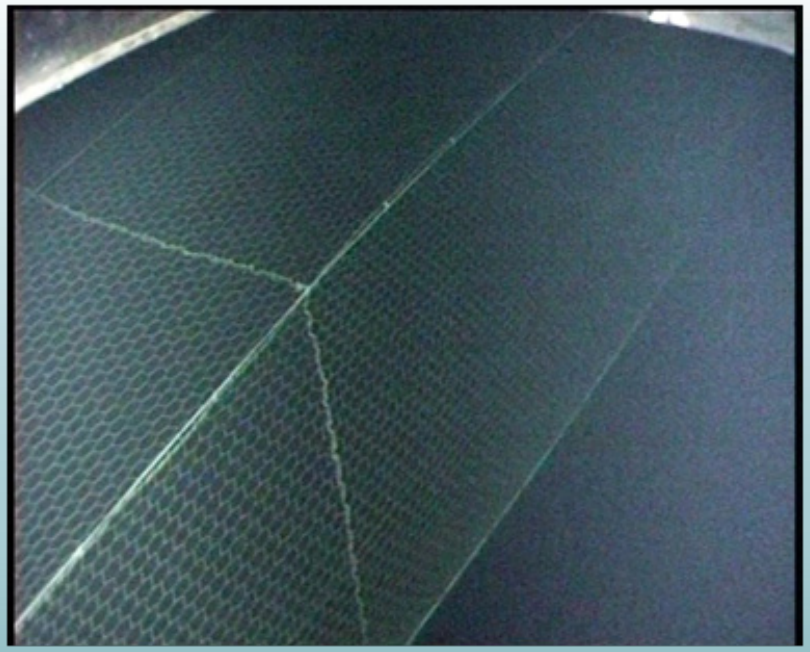

Figure 5.8:
Aft trawl belly made from brick-shaped meshes.

5.5 Quality improvement

Figure 5.9:
Investigation of fish recovery rates on the deck of the commercial trawler MT "J.Bergvoll" (Nergård AS).

Background
The main objective of this work-package is increased value-adding through improved product quality. This will be achieved through the implementation of procedures and technology for minimal stress during capture and handling, optimised live storage of fish onboard, and automated individual slaughtering and bleeding of fish for processing in a state of physiological recovery. Such practices are already in use in capture-based aquaculture and slaughtering of farmed fish, and technology transfer from aquaculture to fisheries is therefore a key aspect of this work. This implementation will not only offer increased value-adding through improved product quality, but will also imply improved ethical standards of the industry.

Activities
To produce new high-quality products it is essential to thoroughly implement the various mechanisms that govern quality. Capture, transfer, transport and pre-processing procedures are the initial stages in the production line . Quality flaws incurred at these stages will reduce product quality throughout the processing chain, and thus have the potential to reduce profitability. Differences in catch and handling methods have significant impacts on the sensory organoleptic quality of raw materials with consequences for product yield, quality, shelf-life and profitability. During capture and handling, fish undergo several types and degrees of physiological stress which are associated with lowered quality. Improved quality can thus be obtained if levels of stress and physical damage can be reduced during harvesting and pre-processing.

A 10-day research cruise was performed with a commercial (Nergård AS) trawler in the Barents Sea (73.00 N, 33.00 E). Fishing operations were performed in the same way as during normal commercial fishing. This also included that the catch was sometimes kept for some time in the cod-end of the trawl pending the processing of the previous catch, resulting in extended trawl duration, increased fish mortality and reduced quality. A total of ten hauls were studied, with 412 fish being sampled for analysis of quality-related parameters.

During capture and handling, fish suffer several forms and degrees of physiological stress, which may lead to poorer product quality and profitability. During commercial fishing, however, there is limited opportunity for identifying, measuring and predicting the relative importance of such stress factors, or of manipulating them in order to test whether quality improvements can be made.

In this activity we are building an experimental swimming tunnel in which we can isolate and study the effects of the different stressors inflicted on fish during capture and handling under controlled experimental conditions. Importantly, this will also include time-course measurements of

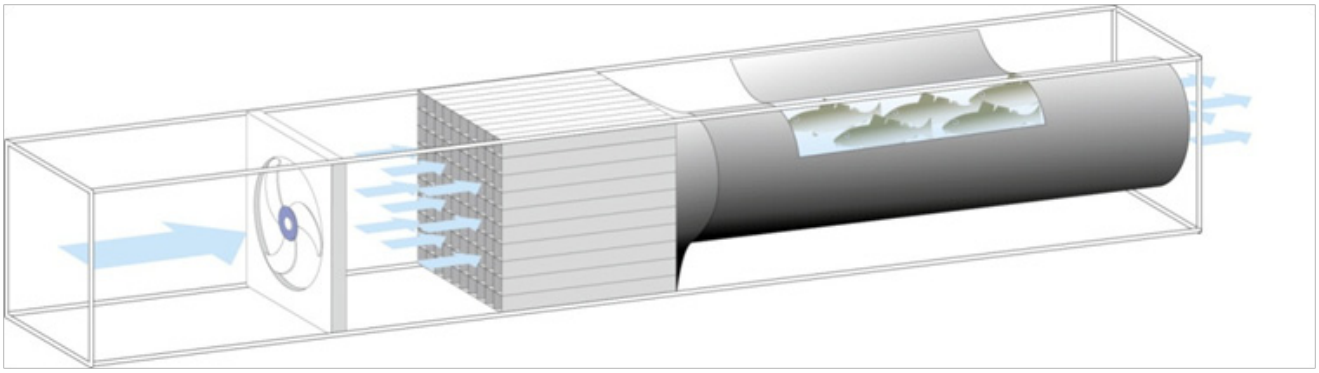

Figure 5.10:
Sketch of the large swimming tunnel for experimental studies of live fish. The swimming tunnel will be about 6 x 0.9 x 0.9 m and have a total weight in air of about 800–940 kg. It will be placed inside a sea-cage at Tromsø Aquaculture Research Station outside Tromsø, Norway.

Table 5.2:
Data from a 10-days cruise on board the commercial trawler MT "J. Bergvoll".

Haul-time (hours)	Haul size (tonnes)	Survival/haul (%)	Fish weight (grams)	Fish length (cm)	Fish condition (k-factor)
5.05 ± 1.05	15.84 ± 4.49	73.2 ± 16.6	3593± 1335	73.8 ± 9.1	0.85 ± 0.13

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.

A main goal for the period autumn 2011 - spring 2012 was the planning and construction of a fully functional, large-size fish swimming tunnel to be used for controlled experimental studies with live fish. We have performed a literature search and produced estimates for the construction and optimal flow functionality of the tunnel, and purchased a suitable propeller pump with electronic controls. A test construction using a 80 cm diameter polyethylene (PE) pipe has been made in collaboration with local industry. Drawings of a PEmodel and an alternative aluminium version of the swim tunnel have been made and a quotation for the production of these was received by the end of 2011.We have also identified suitable instrumentation for physical monitoring/control (water speed and flow conditions, cameras, oxygen etc) and for fish measurements (fish telemetry) including a dialogue with the Centre for Environment, Fisheries and Aquaculture (Cefas, UK) and Thelma Biotel (Norway). Live wild-caught Atlantic cod for the 2012 experimental programme have been purchased and are being kept in a sea cage at Tromsø Aquaculture Research Station, where we have also made an agreement for locating the swimming tunnel.

Another main goal for autumn 2011 to spring 2012 was to recruit a PhD student, and an agreement was made with the University of Tromsø. The agreement includes that salary and costs of employment will be covered by the University as a 4-year PhD grant, which will include one year of teaching duties during this period. The open position was announced in Norway and through international channels/databases between September 16 and October 28. Despite an extension of the application deadline and a total of 28 applicants, none were considered fully qualified. As a result, a new agreement was suggested that involved changing the PhD position to a 3-year post-doc position. By the end of 2011, this agreement had been approved by the relevant faculty and was awaiting formal final approval.

Results

The results of the cruise were promising and supportive with regard to the main objective of this work package. Differences in the size and duration) of each haul clearly influenced the survival rate of Atlantic cod during recovery (Table 5.2 and Figure 5.11). This suggests that survival will be even higher (presumably close to 100%) if the fish are pumped onboard and haul-size is limited to a maximum of 10-12 tonnes.

Atlantic cod captured during commercial trawling are more exhausted than those caught, for example, by Danish seine. In trawl-captured fish that are not kept alive, muscle and blood pH decline rapidly (c.f. red box-plot in Figure 5.12), with 6 of 15 fish being dead at 30 min following capture and all being dead at 2 hours post-capture. In contrast, in cod that were transferred directly to a live storage tank following capture, the pH rose, with near-normal resting blood pH levels being restored within six hours (c.f.

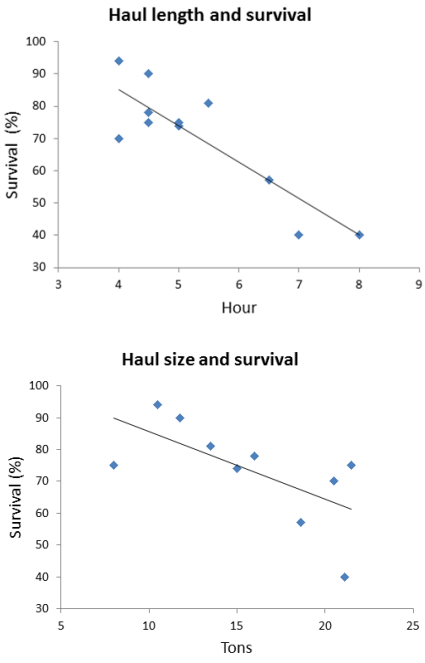

Figure 5.11:
Correlation between survival and haul-length (hours, left panel) and survival and haul-size(tonnes, right panel) on a commercial trawler.

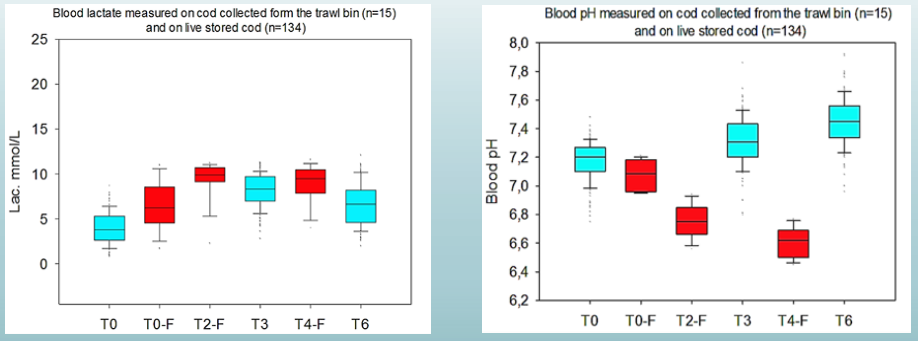

Figure 5.12:
Blue squares: Point of slaughter in hour (T0 = 0 h,T3 = 3 h and T6 = 6 h) after recovery. Red squares: Point of slaughter at the processing line (T0-F = 0 h, T2-F = 2 h and T4-F = 4 h).

blue box-plots in Figure 5.12). There were no clear differences in blood lactate levels (right panel above), presumably because lactate is rapidly produced in fish muscle but has a slow clearance rate during recovery.

Fifty-three blocks of 20-40 kg fish from different hauls and different stages were also sampled for thawing, production and quality evaluation. The preliminary evaluation revealed large differences between cod produced under normal conditions (i.e. from dry storage tanks) and those kept alive (Figure 5.13). The differences are large both in visual terms (photos) and when judged by experienced graders (scale from 0 to 2).

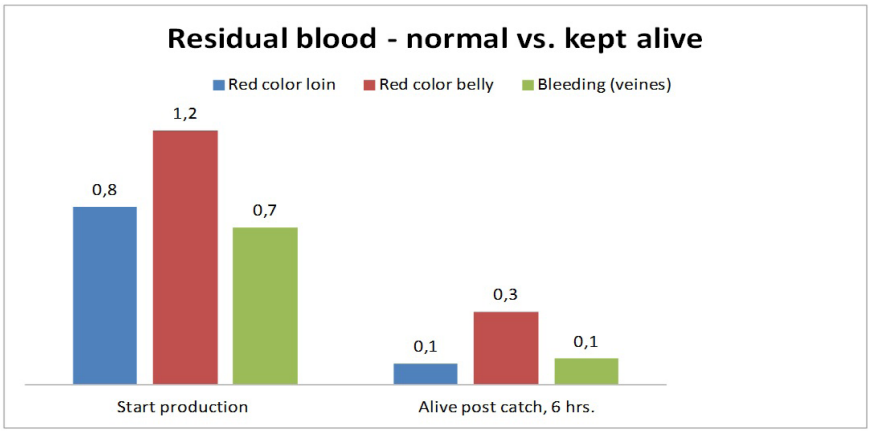

Figure 5.13:
Sensory evaluation of residual blood in fillets from early normal production (left) and after being kept alive for six hours (right).

Figure 5.14:
Fillets from normal production (left) and fillets after being kept alive for six hours prior to production (right).

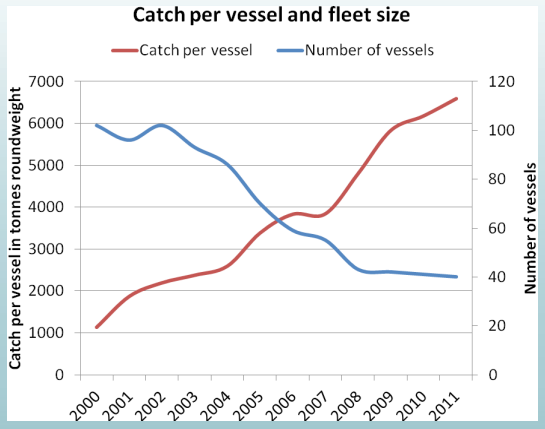

Figure 5.15:
Catch per vessel and fleet size.

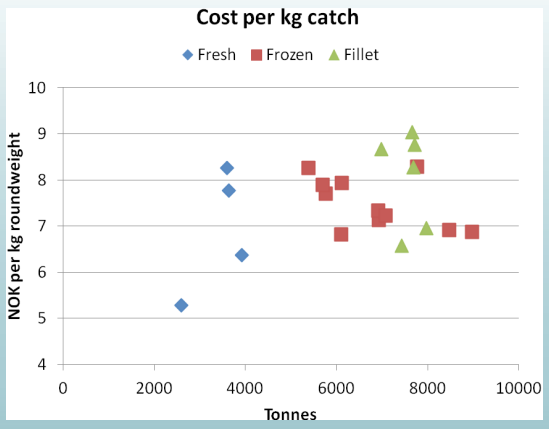

Figure 5.16:
Operating costs per kg catch in 2009.A sample of fresh fish trawlers, freezer trawlers and processing trawlers.

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 study for this evaluation is an analysis of the economic status of the Norwegian trawler fleet.

Activities
The prime 2011 activity in WP6 has been the writing of the report "Norske torsketrålere: Analyse av struktur og lønnsomhet", concerning the structure and profitability of the trawler fleet. The report comprises five sections: (1) Introduction, (2) Description, (3) Catch, (4) Structure and profitability, and (5) Economic assessments of possible technological innovations following other CRISP activities.

Results
An important finding has been the observation of a major structural change in the trawler fleet. As the number of trawlers declines, catch per vessel increases (Figure 5.15). The average age of the trawler fleet is 19 years, which indicates that renewal of the fleet is an urgent issue, with major consequences for and impact on the choice of technology. Another finding of the study is large variations with regard to catch rates, utilization of the vessel, fuel consumption and value adding. Differences in running costs may be as much as NOK 3 per kg fish captured for comparable trawlers, which suggest that there is great potential for improvements (Figure 5.16).

In the report we estimate the increase in annual landing value for the freezer trawler fleet alone to be between 100-150 million NOK on the basis of the 2010 statistics. The assumption is technological innovations will be implemented on all freezer trawlers, and that the market will willing to pay an additional NOK 1 per kilo on cod and haddock landings, and NOK 0.5 per kilo on saithe landings in return for improved quality.

The fuel consumption was estimated to be NOK 350-400 million in 2010. A 10% reduction in fuel consumption resulting from technological innovations would therefore save the industry around 35-40 million NOK.

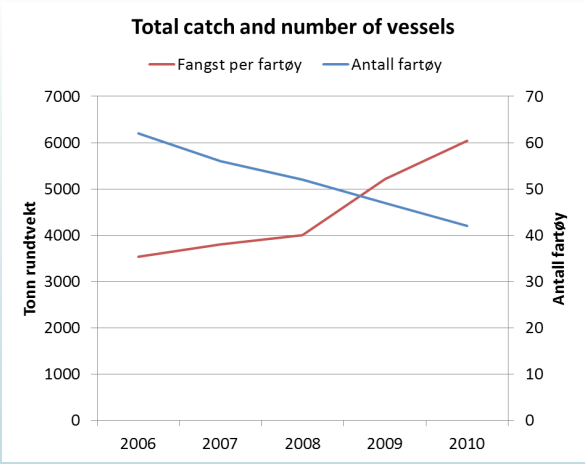

Figure 5.15:
Total catch and number of vessels.

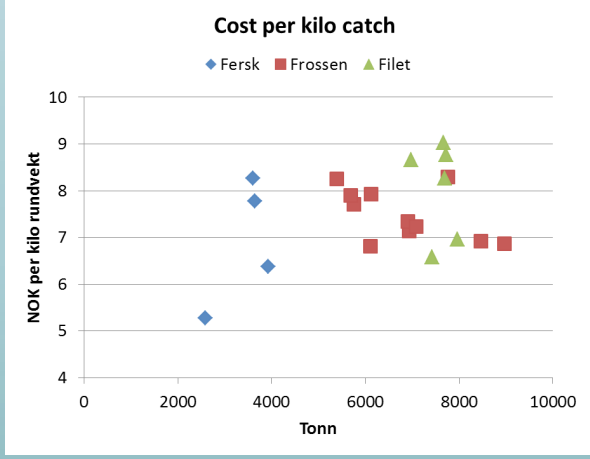

Figure 5.16:
Operating costs of a sample of fresh fish trawlers, freeze trawlers, and processing trawlers per kilo catch in 2009.

6 INTERNATIONAL COOPERATION

CRISP intends to cooperate with international research institutions when such cooperation can be beneficial for joint development and introduction of sustainable fishing techniques in countries outside Norway. The international fishing gear research community was informed about CRISP at the FAO/ICES FTFB (Fish Technology and Fish Behaviour) working group meeting in Reykjavik in May 2011. The CRISP director participated in a consultation process in London March 2011 arranged by the Prince Charles International Sustainable Unit to develop a program Towards Global Sustainable Fisheries. A scientist from PINRO in Russia has been invited to participate in a CRISP research cruise in 2012.

7 RECRUITMENT

The scientific staff working for CRISP are employed by IMR and Nofima and are assigned to part-time project work for the Centre.

In 2011 two MSc students became involved in project work related to WP 1 "Pre-catch identification". Nofima, in cooperation with the University of Tromsø, was unable at its first attempt to recruit a PhD student for WP 5 "Quality improvement".

University of Bergen in collaboration with IMR has started a process to recruit a PhD student in the field of fish behaviour related to trawling.

In collaboration with Nofima, the University of Tromsø has recruited a postdoc researcher to work on quality improvement.

8 COMMUNICATION AND DISSEMINATION ACTIVITIES

A webpage for CRISP has been created under www.imr.no. Several news items about CRISP activities have been released, including information from the opening ceremony and innovative results from research cruises organised by the Centre. News from press releases were cited on least 34 occasions in Norwegian media, including webpages. Details of projects have been published on the webpage in a series called Rapporter fra Havforskningen.

CRISP was presented at a joint FAO/ICES working group (FTFB), and at the annual meeting of the trawler group of Fiskebåtrederenes Forbund in Ålesund. CRISP has also held meetings with representatives of FHF and the Directorate of Fisheries in order to inform these organisations about its activities and to initiate projects of common interest. Underwater observation using cameras, which is a core CRISP activity, has also been presented at a seminar during the 22nd Fishing Exhibition in Denmark. The chair of the CRISP board also gave a lecture about how new technology can minimize conflicts at "Sjømatkonferansen" in Bergen in September 2011.

APPENDIX: I

AI Personnel

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
Tone Friis Aune	Nofima	Quality improvement	F
Bent Dreyer	Nofima	Value adding	M
Thomas Larsen	Nofima	Value adding	M
Marianne Svorken	Nofima	Value adding	F
John Willy Valdemarsen	IMR	Low impact trawling, centre management	M
Arill Engås	IMR	Low impact trawling	M
Terje Jørgensen	IMR	Low impact trawling	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
Kathryn Donelly	Nofima	Information logistics	F

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
Tore 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
Thor Nedrebø	Egersund Group	Low impact trawling	M
Roy Skulevold	Egersund Group	Low impact trawling	M
Kjell Larsen	Nergård Havfiske	Quality improvement and value adding	M
Tommy Torvanger	Nergård Havfiske	Value adding	M

Name	*Funding*	*Research area*	*Sex M/F*	*Duration*	*Nationality*
Stein Harris Olsen	UiT	Quality improvement	M	2011-2013	Norwegian

PhD students with financial support from the Centre budget

Name	*Nationality*	*Period*	*Sex M/F*	*Topic*
Under recruitment				

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

Name	*Funding*	*Topic*	*Sex M/F*	*Period*	*Nationality*
Shale Rosen	Industry scholarship, Research council	Visual fish classification, fish behaviour	M	2009-2012	USA

Master degrees

Name	*Topic*	*Sex M/F*	*Period*	*Nationality*
Didrik Vartdal	Sonar technology	M	2011-2012	Norwegian
Sindre Vatnevol	Sonar technology	M	2011-2012	Norwegian

APPENDIX: 2

Funding

Funding	**Amount**	**Amount**
The Research Council		5442
The Host Institution (name)	IMR	4479
Research Partners*	Nofima	1125
	University of Bergen	193
	University of Tromsø	471
Enterprise partners*	Kongsberg Maritime AS	2951
	Egersund Group AS	2786
	Scantrol AS	2055
	Nergård Havfiske AS	503
Public partners*	Sildesalgslaget	100
	Råfisklaget	100
		20205

Costs

The Host Institution (name)	IMR	8832
Research Partners	Nofima, University of Bergen University of Tromsø	2878
Enterprise partners	Kongsberg Maritime AS	2951
	Egersund Group AS	2786
	Scantrol AS	2055
	Nergård Havfiske AS	503
		20005

ATTACHMENT 3

A3 Publications

Journal Papers

Rosen, S., Engås, A., FernøA., and Jørgensen, T. 2012. The reactions of shoaling adult cod to a pelagic trawl: implications for commercialtrawling. – ICES Journal of Marine Science, 69: 303–312.

Reports

Valdemarsen, J. W., Engås, A., Vold, A. 2011. Teknologiutvikling vil gjøre fiskeriene mer miljøvennlige. Pp. 108-110 i: I Agnalt, A.-L., Fossum, P., Hauge, M., Mangor-Jensen, A., Ottersen, G., Røttingen, I., Sundet, J.H., Sunnset, B.H. (Eds.) Havforskningsrapporten 2011, Fisken og havet, særnummer 1-2011. Havforskningsinstituttet, Bergen.

Valdemarsen, J.W., Øvredal, J.T., Aasen, A. 2011. Testing av dynamiske egenskaper til pelagiske tråldører med luker over ogunder tauebrakett som kan åpnes gradvis hver for seg. Rapport fra Havforskningen 17-2011, Havforskningsinstituttet, Bergen, 7 pp.

Valdemarsen, J.W., Øvredal, J.T., Aasen, A. 2011. Ny semipelagisk trålkonstruksjon (CRIPS-tråLen). Innledende forsøk i august-september 2011 om bord i M/S "Fangst". Rapport fra Havforskningen 18-2011,Havforskningsinstituttet, Bergen, 17 pp.

Larsen, T. og Dreyer, B., 2011, Norske torsketrålere - en næringsøkonomisk analyse, Rapport Nofima, in press.