ICES SGFOT Report 2007

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Report of the Study Group on Fisheries Optical Technologies (SGFOT)

21–22 April 2007

Dublin, Ireland

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

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Conseil International pour l'Exploration de la Mer

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Contents

Executive summary

The Study Group on Fisheries Optical Technologies (SGFOT) held its first meeting at the Crowne Plaza Dublin Airport in Dublin, Ireland from 21–22 April 2007. Eirik Tenningen (Norway) was Chair and Terje Torkelsen (Norway) was Rapporteur. There were 19 participants from Australia, Canada, Denmark, New Zealand, Norway, Portugal, Sweden, UK and USA.

Based on the Terms of Reference, the outline for an *ICES Cooperative Research Report* was agreed and authors for the different sections suggested. The Section headings are:

- Introduction
- Optical Technologies
- Integration
- Data Processing
- Application
- Recommendations
- Glossary
- Suppliers
- References

There is a need for expertise from outside the group and possible linkages were discussed WGFAST and WGFTFB in particular. Terms of Reference for 2008 and recommendations are given in Annex 3.

1 Terms of Reference

2006/2/FTC05 A **Study Group on Fisheries Optical Technologies** [SGFOT] (Chair: Eirik Tenningen*, Norway) will be established and will meet in Dublin, Ireland from 21–22 April 2007. The Study Group will review the state-of-the-art in optical imaging and analysis technologies following these terms of reference:

a) produce a literature review of optical technology for:
  - i) target identification (e.g. species and sizes, benthic and pelagic habitat);
  - ii) behavioural characterization (e.g. orientation, reaction, small-scale dynamics);
  - iii) measurement uncertainty (related to optics, nets, and acoustics and scale differences between methods; e.g. catchability, selectability, and bycatch reduction or species identification; and measurement strategy); and
  - iv) automated data processing and visualization, and data management.

b) summarize other optical methods (current and emerging technologies) for ecosystem-based fisheries management that can be investigated further (e.g. update and expand the SCOR Technical Panel's summary);

c) recommend linkages within and outside ICES (e.g. ICES ASC theme sessions; other ICES Expert Groups; and SCOR Technical Panel (e.g. survey design,

d) consider a new Working Group on Fisheries Optics, Science and Technology;

e) consider an ICES Symposium on this subject; and

f) produce an ICES Cooperative Research Report.

SGFOT will report by 31 May 2007 for the attention of the Fisheries Technology Committee.

2 Introduction

The Study Group on Fisheries Optical Technologies (SGFOT) held its first meeting at the Crowne Plaza Dublin Airport in Dublin, Ireland from 21–22 April 2007. Eirik Tenningen (Norway) was Chair and Terje Torkelsen (Norway) was Rapporteur. Eirik Tenningen opened the meeting and reviewed the agenda. Dominic Rihan, Bord Iascaigh Mhara (BIM), was thanked for hosting the meeting.

3 Review of the state-of-the-art in optical in optical imaging and analysis technologies

To address the Terms of Reference a), b) and f) an outline for an *ICES Cooperative Research Report* was produced. The outline is given in Section 3.3. For each topic one or more authors were suggested. There were also several presentations showing the state-of-the-art within various fields of optical technologies. The abstracts are given in Section 3.1. Further, producing a review of optical technologies by country was agreed. This is presented in Section 3.2.

Linkages within and outside ICES (Terms of Reference c)) were discussed. Linkages to WGFTFB and WGFAST are established through presentation of the Study Group's work by Eirik Tenningen at the Joint Workshop of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour [WGFTFB] and the Working Group on Fisheries Acoustics, Science and Technology [WGFAST]. The outline has also been sent to the chairs of WGFTFB and WGMHM for dissemination among the group members in order to get feedback on the current content and structure. Linkages to Scientific Committee on Oceanic Research (SCOR) and Monterey Bay Aquarium Research Institute (MBARI) were briefly discussed and will be investigated further. Unfortunately, the SCOR 118 report was not available to the group at the meeting.

Terms of Reference d) and e) will be discussed on future SGFOT meetings. SGFOT recommends a theme session for the 2009 ICES Annual Science Conference on “Optical and image based technologies for ecosystem approach to fisheries management”. Chairs: Eirik Tenningen (Norway) and William Michaels (USA).

3.1 Presentations

There were several presentations at the meeting showing the state-of-the-art in optical imaging and analysis technologies. The abstracts are given below.

3.1.1 Fisheries Observing Using Video-Based Electronic Monitoring

Howard McElderry, Archipelago Marine Research Ltd., Victoria, BC Canada

Abstract:

Successfully managed fisheries must ensure that harvesting practices fit within long-term resource conservation targets and sustainability goals. In meeting these objectives, fisheries data systems must become more comprehensive. Fishery observer programs meet this need, but this approach may not be the most cost effective or practical in many instances. Recent technological solutions involving video-based electronic monitoring (EM) systems are a cost-effective and promising alternative to observers. EM-based at-sea monitoring has been successfully applied in a variety of commercial fisheries in British Columbia, Canada, for a broad suite of fishery information needs such as: fishing time and location; gear deployment and retrieval methods; catch and bycatch identification, enumeration and handling procedures; and assessing the performance of bycatch mitigation devices and procedures. Examples of various applications of the technology will be described.

3.1.2 Automating Norway Lobster Quantification using Underwater Video Analysis

Paulo Lobato Correia[1], Lau Phooi Yee[1]

IST, Instituto Superior Técnico – Departamento de Engenharia Electrotécnica e de Computadores (Depatment of Electrial and Computer Engineering – Telecommunications Section), Avenida Rovisco Pais, 1049-001, Lisboa, Portugal

Paulo Fonseca[2], Aida Campos[3]

INIAP/IPIMAR, Instituto de Investigação Agrária e das Pescas (Portuguese Institute for Agriculture and Fisheries Research), Avenida de Brasília, 1449-006 Lisboa, Portugal

Abstract:

Underwater video is being increasingly used to assess the impact of human activities in marine habitats, and as a complementary tool for the assessment of commercial stocks. But, analysing video data manually is a lengthy and tedious task. A proposal for automating the detection and quantification of the Norway lobster (*Nephrops norvegicus*) stock is presented. The detection is based on a human visual attention model. Notably, three visual attention cues are considered: intensity map (IM), edge map (EM) and motion map (MM).

The procedure involves two main steps: first each of the three feature maps is computed; then, all candidate regions are processed and categorized in view of the Norway lobster detection. Preliminary results show that the proposed methodology is capable of reliably detecting candidate regions.

3.1.3 On the use of under-water video cameras for the development of seal-safe salmon traps

Arne Fjälling

Abstract:

A simple under-water video recording system was designed for research purposes and employed during the construction and testing of seal-safe salmon traps. The recording system consists of a self-contained and buoyant plastic trunk with a battery, a hard-disc recorder, and 4 cameras with cables of 100m length. The acquired video recordings were used to clarify how grey seals exploit traps, how salmon react to seal-hindering devices in the entrance of traps, and how escape panels for undersized fish function under different conditions. The recordings gave important information that most likely could not have been collected in other ways.

3.1.4 Report on the DFO National Workshop on survey design, database design and analysis of underwater video/photographic surveys

Stephen J. Smith and Pierre Clement: Department of Fisheries and Oceans, [1]Bedford Institute of Oceanography, Dartmouth, NS, Canada

Peter Lawton: Department of Fisheries and Oceans, Biological Station, St. Andrews, NB, Canada

Abstract:

Recent improvements in underwater video and digital technology and image analysis methods have resulted in this methodology being used to conduct regular fisheries resource surveys in a number of places. Surveys conducted in this manner can provide a non-destructive means of surveying large areas for information on: the target commercial species as well as associated species and their environment, SARA listed species and their critical habitats, and assessment of anthropogenic activities which impact on the benthic community, such as fishing, aquaculture, dredging, urbanization, log dumps, transmission cable laying and retrieval, and oil and gas exploration and extraction. The Department of Fisheries and Oceans has committed to providing scientific advice in support of ecosystem-based management and video/photographic surveys offer a means of collecting data on species/community distribution in an ecosystem context.

A national workshop on underwater video/photographic surveys was held at the Bedford Institute of Oceanography, 5–7 March 2007. The objectives of the workshop were to develop a common understanding of how underwater video/photography is being used for monitoring freshwater and marine communities and to begin to build a community of researchers within and outside of DFO to share expertise and knowledge. In addition, the participants were asked to contribute towards a DFO strategic plan for solving outstanding research problems and promoting the video/photography approach. A common theme in the presentations and subsequent discussion was that the image data was seen as only one component of the description of the benthic communities with the larger picture incorporating associated information collected from multibeam mapping, sidescan sonar, oceanographic modelling, resource surveys and commercial fishing records. Apart from the database issues of matching up these diverse kinds of data (see below) many issues concerning relating processes across the different scales from these data were also discussed. A clear consensus from the Workshop was a need for a fundamental change in how we manage the timing and interconnectivity of the diverse data (including streaming video) being collected in real time by DFO field imaging systems. Among the overarching research needs identified at the workshop was the requirement, both from benthic ecological, and marine geological perspectives, to expand the capacity of optical imaging to encompass meso-scales. Understanding patch dynamics through

a mesoscale image mosaic capability would inform appropriate survey designs for focal species, such as scallops.

3.1.5 Airborne optics

James Churnside, NOAA Earth System Research Laboratory

Abstract:

One of the big advantages of optics is that they can be deployed from an aircraft. This means that we can survey at speeds of up to 100 m/s and at a fraction of the cost of a ship survey. Over the last ten years, we have used a variety of optical systems from small aircraft to detect fish and plankton. Most of this work was with the NOAA Fish LIDAR, but we have also used active and passive imaging systems. I will present examples of data from airborne optical systems and discuss some of the strengths and weaknesses of each.

3.1.6 Update on Norwegian Lidar research

Eirik Tenningen, Institute of Marine Research, Norway

Abstract:

An overview of the status of the lidar research in Norway will be given. In 2006 an intercalibration exercise was done to calibrate the lidar return signal directly with the echosounder data onboard the commercial trawler M/S Libas. The platform for doing this as well as some results will be presented.

3.1.7 Additional presentations

In addition to the above presentations, Paul Fernandes presented visual count methods to determine the abundance of anglerfish and Rudy Kloser, Bill Michaels, Stephen Smith, Terje Torkelsen and Bo Lundgren presented various towed body solutions.

3.2 National Reviews

In order to get an overview of what is done lately within optical research, an initial national review by country was agreed. The reviews received by the time of this report are presented below. These are not complete; however they give a brief introduction to the varied field of optical technologies in fisheries research.

3.2.1 Swedish national review

Swedish national reviewWhat	How	Why	Where	Who	When	Refs	Comments
Photo identification of grey seals, using pelage pattern as a natural marker	digital SLR camera	population estimation	Baltic Sea	Swedish Museum of Natural History, Stockholm	1994–	Karlsson, O., L. Hiby, *et al.* (2005). Photo-identification, Site Fidelity, and Movement of Female Gray Seals (*Halichoerus grypus*) Between Haul-outs in the Baltic Sea. Ambio 34(8): 628–634.	
Bottom surveys	ROV´s	monitoring	Skagerrak	Göteborg University, TMBL	2000–	various	
Bottom surveys	ROV´s	monitoring	Skagerrak	Umeå University	2000–	unknown	
Individual reaction in fish to strobe light	video in aquarium and ultrasonic tags in the sea	fish behaviour	Baltic Sea	Institue of Coastal Research, Sw. B. of Fisheries	2000–	Königson, S., A. Fjälling, *et al.* (2002). Reactions in individual fish to strobe light. Field and aquarium experiments performed on whitefish (*Coregonus larvaretus*). Hydrobiologia 483: 39–55.	

SWEDISH NATIONAL REVIEWWHAT	HOW	WHY	WHERE	WHO	WHEN	REFS	COMMENTS
Water suspended particles, long (years) and short term	Backscatter Turbidity Sensors	eutrophication, environmental	Baltic Sea, Skagerrak, Öresund	Göteborg University	2000–	Tengberg A., E. Almroth and P.O.J. Hall (2003). Resuspension and its effect on organic carbon recycling and nutrient exchange in coastal sediments: In-situ measurements using new experimental technology. Journal of Experimental Marine Biology and Ecology, 285–286: 119–142.	
Two dimensional oxygen photographs at the sediment-water interface	Planar Optodes	eutrophication, environmental	Baltic Sea, Skagerrak, Öresund	Göteborg University	2000–	Glud R.N, A. Tengberg, M. Kühl, P.O.J. Hall, I. Klimant and G. Holst (2001) An in situ instrument for planar O2 optode measurements at benthic interfaces. Limnology and Oceanography, 46(8): 2073–2080.	
Local bottom survey and bottom lander functioning	Scanning video	Eutrophication, environmental	Baltic Sea, Skagerrak, Öresund	Göteborg University	2000–	Karegeprgos A.P., H.G. Kaberi, A. Tengberg, V. Zervakis, P.O.J. Hall and CH.L. Anagnostou (2003) Comparison of particulate matter distribution, in relation to hydrography, in the mesotrophic Skagerrak and the oligotrophic northeastern Aegean Sea. Continental Shelf Research, 23, 1787–1809.	

Swedish national reviewWhat	How	Why	Where	Who	When	Refs	Comments
Counting and measuring migrating salmon in fish ladders	video	management	3 norhern rivers	hydropower companies	2002–	unknown	
Optical oxygen measurement, long (years) and short term	One Point Optodes	eutrophication, environmental	Baltic Sea, Skagerrak, Öresund	Göteborg University	2002–	Tengberg A., J. Hovednes, J. H. Andersson, O. Brocandel, R. Diaz, D. Hebert, T. Arnerich, C. Huber, A. Körtzinger, A. Khripounoff, F. Rey, C. Rönning, S. Sommer and A. Stangelmayer (2006).Evaluation of a life time based optode to measure oxygen in aquatic systems. Limnology and Oceanography, Methods, 4, 7–17.	
Evaluation of experimental fishing gear	video in the sea	seals&fisherie	Baltic Sea	Institue of Coastal Research, Sw. B. of Fisheries		Lunneryd, S. G., A. Fjälling, *et al.* (2003). A large-mesh salmon trap; a way of mitigating seal impact on a coastal fishery. ICES Journal of Marine Science 60: 1194–1199.	low light conditions

Swedish national reviewWhat	How	Why	Where	Who	When	Refs	Comments
Experiment on how seals detect fish	video in seal aquarium	seals&fisheries	Kerteminde	Institue of Coastal Research, Sw. B. of Fisheries	2004	Hultgren, M. (2003). The detection of fish in experimental fish traps by harbour seals (*Phoca vitulina*) – is vision more important than hearing and touch? Department of Marine Ecology, Göteborg: 18pp.	dominance
Methods to estimate trout populations, and fish length, in streams	stereo video	management	northern rivers	Umeå University	2004–	unknown	
Regular photographs at sediment-water interface	Planar Optodes	Eutrophication, environmental	Baltic Sea, Skagerrak, Öresund	Göteborg University	2004–	Glud R.N., F. Wenzhofer, A. Tengberg, M. Middelboe. K. Oguri and H. Kitazato (2005) Distribution of oxygen in surface sediments from central Sagami Bay, Japan: In situ measurements by microelectrodes and planar optodes. Deep Sea Research I, 52: 1974–1987.	
Experiment on how Coregonids react to differing mesh size in leader nets	hydroacoustics + video in the sea	seals&fisheries	Baltic Sea	Institue of Coastal Research, Sw. B. of Fisheries	2005	forthcoming	matching data from sources

Swedish national reviewWhat	How	Why	Where	Who	When	Refs	Comments
Experiment with seal-safe entrances in fish traps	video in seal aquarium	seals&fisheries	Kolmården	Institue of Coastal Research, Sw. B. of Fisheries	2005	Björnstad, G. and A. Fjälling (2005). Obstacles to prevent grey seals (*Halichoerus grypus*) from entering static fishing gear. ICES Annual Science Conference, Aberdeen, UK.	dominance among seals
Non-lethal methods for fish stock assessment – a pilot study using hydroacoustics and video technology	hydroacoustics + video in ponds	management	Drottningholm	Stockholm University	2005	Ogonowski, M. (2005). Non-lethal methods for fish stock assessment – a pilot study using hydroacoustics and video technology. Department of Systems Ecology. Stockholm, Stockholm University. Master Thesis: 17pp.	
Experiment on how seals detect fishing gear	self-triggered cameras in the sea	seals&fisheries	Baltic Sea	Institue of Coastal Research, Sw. B. of Fisheries	2005	Fjälling, A., J. Kleiner, *et al.* (2007). Evidence that grey seals (*Halichoerus grypus*) use above-water vision to locate baited buoys. NAMMCO Scientific publications 17: 25pp. In press.	

Swedish national reviewWhat	How	Why	Where	Who	When	Refs	Comments
Two dimensional pH photographs at the sediment-water interface	Planar Optodes	Eutrophication, environmental	Öresund	Göteborg University	2005–	Såhl H., A. Glud, C.R. Schröder, I. Klimant, A. Tengberg and R. Glud (2006) Time-resolved pH imaging in marine sediments with a luminescent planar optode. Limnology and Oceanography, Methods, 4: 336–345	
Study on behaviour of seals and salmon in set traps	video	seals&fisheries	Baltic Sea	Institue of Coastal Research, Sw. B. of Fisheries	2006	under way	data processing
Evaluation of escape panels in set traps for Coregonids	video	seals&fisheries	Baltic Sea	Institue of Coastal Research, Sw. B. of Fisheries	2006	MA thesis under way	
Evaluation of feeding as a means to reduce seal interaction with fisheries	video	seals&fisheries	Baltic Sea	Institue of Coastal Research, Sw. B. of Fisheries	2006	grey	
Aerial surveys of moulting of grey seal, counting seals from photographs	digital SLR camera	monitoring	Baltic Sea	Swedish Museum of Natural History, Stockholm	2006	under way	financial
Study on effect on benthos from trawl wings in fishery for Nephrops	ROV´s	environmental	Skagerrak	Göteborg University	2006	unknown	

3.2.2 Portuguese national review

How	Why	Where	Who	When	Refs	Comments
SIT video camera on trawl gear	Species & grid observation	Portuguese south coast	Portuguese Inst. Agriculture & Fisheries Res.	2001–2002	None	
SIT video camera on trawl gear	Species & grid observation	Portuguese Northwestern coast	Portuguese Inst. Agriculture & Fisheries Res.	2003	None	
SIT video camera on trawl headline	Nephrops grounds survey	Portuguese south coast	Portuguese Inst. Agriculture & Fisheries Res.	2005	Working doc to SGFOT	Images used for a first attempt to automatic counting of bottom organisms
ROV – Remote Operated Vehicle, model Hyball 400 (from IMAR)	Species observation	Portuguese south coast	CCMAR, University of Algarve	1998–2002	Borges, T.C. co-ord. (2001). Estrutura da Comunidade e variabilidade espaço-temporal dos recursos do Talude Continental superior na Algarve" (BIOPESCAS). *Relatório Final à Fundação para a Ciência e Tecnologia*. 36pp+annexes.	This model works ok only in very good weather, since is very sensitive to currents due to small size.
Lateral sonar E-Sea Scan 800 (from IPIMAR)	Bottom observations (fisheries impact)	Portuguese south coast	CCMAR, University of Algarve	2000	Borges, T.C. co-ord. (2001). Estrutura da Comunidade e variabilidade espaço-temporal dos recursos do Talude Continental superior na Algarve" (BIOPESCAS). *Relatório Final à Fundação para a Ciência e Tecnologia*. 36pp+annexes.	
Deep water video camera (from National Underwater Research Center (NERC) of UCONN, USA)	Benthic species observation	Portuguese south coast	CCMAR, University of Algarve	2001		Very little image definition

Two-manned Submersible “DELTA” (from UCONN, USA)	Species and bottom observations (fisheries impact)	Portuguese south coast	CCMAR, University of Algarve	2004	Morais P., Borges T.C., Carnall V., Terrinha P., Cooper C. & Cooper R. (*in press*). Trawl-induced bottom disturbances off the south coast of Portugal: direct observations of the “Delta” manned-submersible on the Submarine Canyon of Portimão. *Marine Ecology*, *XX: xx–xx*.	Very expensive!

3.2.3 US national review

Underwater optical technologies have been utilized in the USA in support of fisheries management for visual observations of marine animals from various platforms (e.g. divers, towfish, landers, moorings, ROVs, AUVs). Operational objectives for implementing underwater optical technologies have focused primarily on the identification and enumeration of marine organisms primarily for improving population estimates (e.g. ranging in size from plankton-fish-marine mammals), verifying species composition from remote sensing data (e.g. acoustic backscatter), to understanding behavioral patterns that causing variability in the population estimates. Recent mandates in the USA have emphasized the needs to implement integrated optical-acoustical technologies for marine habitat characterization. Research progress is ongoing in the areas of video mosaic of habitat, stereo video imagery, automated optical imaging recognition, high resolution laser imaging (i.e. range-grated lasers for holography), remote imaging technologies beyond the dynamic range of conventional optics (laser-line scanning, high frequency sonar imaging), and integration of georeferenced optical data into an integrated GIS ocean mapping initiative. Aerial optical technologies (LIDAR) is also readily utilized for surveying fish and marine mammals.

3.2.4 Norwegian national review

What	How	Why	Where	Who	When	Refs	Problems
Lidar Target Strength measurements on mackerel	Lidar and video camera	Research	Austevoll	Institute of Marine Research	2002	Tenningen, E., Churnside, J.H., and Slotte, A., Wilson, J. 2006. Lidar target strength measurements on northeast Atlantic mackerel (Scomber scombrus). ICES Journal of Marine Science, 63: 677–682.	
Mackerel distribution during summer feeding	Airborne lidar (light detection and ranging)	Monitoring	Norwegian Sea	Institute of Marine Research	2002–	ICES	Weather dependent and depth limitations. Still under development.

WHAT	HOW	WHY	WHERE	WHO	WHEN	REFS	PROBLEMS
Catchability of Greenland halibut with bottom trawl	SIT-camera and video recorder	Stock assessment and monitoring	Norwegian continental slope	IMR, Research group on Deep sea species	2002–2005	Albert, O.T., Harbitz, A., and Høines, Å.S., 2003. Greenland halibut observed by video in front of survey trawl: Behaviour, escapement, and spatial pattern. Journal of Sea Research, 50: 117–127. Albert, O. T., Harbitz, A., Larsen, R.B., and Karlsen, K.-E. 2006. Spatial structure and encounter rate of Greenland halibut in front of bottom-trawls. pp 147–151 in: Ross Shotton (Ed.): Conference on the Governance and Management of Deep-sea Fisheries (part 2), FAO Fisheries Proceedings 3/2, 487 pp. Salberg, A.B., Harbitz, A., and Albert, O.T., in subm Use of shadow to detect and quantify the size and 3D movement of fish above the sea floor. Submitted to IEEE Journal of Oceanic Ingeneering.	Need constant artificial light at depth >600m. Artificial light reduce catch rates

What	How	Why	Where	Who	When	Refs	Problems
Catchability of Greenland halibut with bottom trawl	Set of several synchronised cameras for still pictures	Stock assessment and monitoring	Norwegian continental slope	IMR, Research group on Deep sea species	2004–	Albert, O. T., Salberg, A. B., Zaferman, M., and Tarasova, G.P. 2006. Effects of artificial light on trawl catch and behaviour of Greenland halibut in front of trawls. pp 142–146 in: Ross Shotton (Ed.): Conference on the Governance and Management of Deep-sea Fisheries (part 2), FAO Fisheries Proceedings 3/2, 487 pp	Measurments of camera tilt angle and height, and degree of overlap between frames. Still under development
Age determination of Greenland halibut	Microscope video camera	Stock assessment and monitoring	Norwegan and Barents Seas	IMR, Research group on Deep sea species	2003–	Albert, O. T., Salberg, A. B., Høines, Å., and Harbitz, A. 2005. Bias in age reading of Greenland halibut calls for new assessment strategy. WD 8, ICES AFWG 19–28 April 2005. (ICES ACFM:20/2005). 23 pp.	
Automatic estimation of shrimp (*Pandalus borealis*) length by image analysis	Still image digital camera	Automatic length at age estimation	Norwegian and Barents Sea	IMR, Research group on crustaceans etc.	2003–	Harbitz, A. 2007. Estimation of shrimp (*Pandalus borealis*) carapace length by image analysis. ICES Journal of Marine Science Advance Access. Doi: 10.1093/icesjms/fsm047	Must develop video/imaging technique on transport bands to benefit from efficiency. Data material to examine robustness wrt more sex stages and trawl hauls exist.

WHAT	HOW	WHY	WHERE	WHO	WHEN	REFS	PROBLEMS
Automatic estimation of age from otolith images	Still image digital camera	Stock assessment and monitoring	Norwegian and Barents Sea	IMR, Age readers, stock assesment people	2007–		Core prediction, segmentation of year zones. 2-year project
Automatic separation of cod and coastal cod by shape analysis of outer otolith	Still image digital camera	Stock assessment and monitoring	Norwegian and Barents Sea	IMR, Age readers, stock assesment people	2004–2006	Stransky, C., Baumann, H., Fevolden, S.E., Harbitz, A., Høie, H., Nedreaas, K., Salberg, A.B., Skarstein, T. Separation of Norwegian coastal cod and Northeast Arctic cod by outer otolith shape analysis. Submitted to Journal of Fisheries Research, 2007	Diversity between fjords. 3-year project DAAD-NRC
Various trawl and pot catchability experiments	Still image and video		Norwegian and Barents Sea	Institute of Marine Research	Ongoing	Several	
Plankton Assessment	Optical plankton counter	Plankton ID and abundance	Norwegian and Barents Sea	Institute of Marine Research	2007		

3.2.5 New Zealand national review

Underwater camera systems at the National Institute of Water and Atmospheric Research Ltd (NIWA), New Zealand

David Bowden, Jim Drury, Peter Hill, Richard Nelson, Richard O'Driscoll[1]

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Marine underwater cameras are used increasingly by NIWA as cost-effective non-destructive tools for seabed investigations throughout the New Zealand EEZ. Several groups across NIWA operate a range of underwater camera types in scientific and commercial applications including habitat mapping, monitoring marine protected areas, stock assessment of commercially harvested species, and studying the environmental effects of fishing and aquaculture.

Underwater camera systems used by NIWA include diver-operated cameras, towed camera platforms which are suspended below, or towed behind, a surface vessel, and cameras mounted on remotely-operated vehicles (ROVs).

The principal design criterion for underwater camera systems is operational depth: pressure housings are specified for a maximum working depth and can operate at any depth down to that limit. A consequence of greater depth capability is increased weight, which in turn makes deeper-rated systems impractical for use from smaller inshore vessels. Here, we group all NIWA camera systems into 4 categories defined by maximum operating depth:

- Shallow-water: <50 m
- Coastal: <200 m
- Middle Depths: <1000 m
- Deep-water: <6000 m

Shallow-water camera systems (<50 m)

Most systems in this depth category are diver-operated still and video cameras, generally rated to depths less than 30 m. There are also a number of lightweight drop cameras ('Splashcams'). Both diver-operated and drop systems are used in a range of roles including biosecurity and biodiversity surveys, aquaculture monitoring, and studying fish and invertebrate behaviour. In addition, there are two more specialised shallow-water systems:

The DUV (directional underwater video) system is a simple video-only platform with scaling lasers, a depressor weight and fins for directional stability. It is designed for quantitative survey of reef fish populations.

The Foveaux Strait system is a still camera platform using a 5 Mp Nikon 5000 compact camera and rated to 50 m which is used to monitor oyster habitat and abundance. The system currently incorporates a low-resolution monochrome video camera which is used only for seabed orientation.

Coastal camera systems (<200 m)

NIWA has two towed video camera systems in this category: a Tritech Typhoon system and a BEVIS video sled system, both of which operate on umbilical cables in depths <200 m. These systems are used in a wide range of projects. There is also an ROV-mounted high-resolution video rated to depths of 150 m.

Middle-Depths camera systems (< 1000 m)

NIWA has one camera system in this category. This is a digital stills camera system used primarily for scampi (*Nephrops*) surveys but which has also been deployed in the Ross Sea (Antarctica), on seamounts, and as a back-up for the DTIS deepwater system. The system does not have a video camera. There is no data feed to the surface, allowing the system to be deployed on non-conducting cables, and depth is tracked via an acoustic netsonde. The camera is a 5 Mp Nikon 5000 digital compact camera controlled by a simple time-lapse circuit. Although image quality is adequate for present uses, this camera model is now obsolete and will need to be updated in the near future.

Deep-water camera systems (<6000 m)

NIWA's deep-towed imaging system (DTIS) contains a digital SLR still camera and a high resolution video camera capable of 6000 m depths. A unique feature is an innovative data communications scheme that allows the use of a standard 10.5 mm diameter single core CTD cable for live video and system control functions. On any voyage both DTIS and CTD operations are possible from a single winch and cable. Real time slow scan video, depth and altimeter data are transmitted up the 8000 m long tow cable while full speed high resolution video (HDTV) is recorded onto tape underwater. The recovered tapes provide images of excellent clarity and detail. An operator GUI provides controls for lights, video and still cameras.

DTIS SPECIFICATIONS

Cable type:	Rochester 1-H-422A single core steel armoured cable, 10.5 mm diameter.
Maximum cable length:	8500 m (Note – longer lengths may be possible; 8500 m is the longest length over which the system has been tested).
Vehicle dimensions:	2.25 m long **x** 1.05 m wide **x** 1.65 m high.
Vehicle construction:	50 x 50 x 6.3mm angle and 16mm diameter solid round, 316 stainless steel.
Typical towing speed:	less than 1 knot.
Maximum depth:	6000 m
Video camera:	Sony HCR-HC1E high definition camera (1080 lines).
Video tape duration:	63 minutes.
Video lighting:	Two Deep Sea Power & Light halogen totaling 450 W,
	OR one Deep Sea Power & Light HMI 400 W, dimmable.
Still camera:	Canon 350D.
Electronic flash:	Cluster of three Canon 580EX inside Benthos 25 cm diameter glass sphere housing.
Flash recycle time:	4 seconds.
Underwater housings:	Custom built from 2250 duplex stainless steel.
Battery power:	Deep Sea Power & Light pressure balanced lead-gel batteries, two 48 V and one 24 V providing 120 V

Battery duration:	2.3 hours with HMI video light on full power, 4.6 hours with HMI video light on half power.
Acoustic altimeter:	Tritech PA200.
Depth sensor:	SeaBird SBE50.
Video overwriter:	Decade Engineering BOB-4.
Data communications:	Modified DSL modems and video codecs providing 384 Mbps. Real time video frame rate 3 fps. Transparent RS232 data link of 9600 bps.
Video monitor:	Sony MFM-HT75W.
Operator interface:	LabView GUI providing functions for video lights on/off, video lights power output, video record on/off, video camera focus in/out, video camera zoom in/out, still camera manual fire, still camera time-lapse fire.

The first DTIS system has been fully operational since mid 2006 and has more than met expectations. A second system, incorporating minor modifications, is currently under construction and is due to be completed in May 2007.

3.2.6 Scottish national review

WHAT	HOW	WHY	WHERE	WHO	WHEN	REFS	COMMENTS
Nephrops TV survey	Towed sled with colour video and still camera (35 med mer)	Assessment of Nephrops abundance	North Sea and West Coast	FRS Marine Lab	Summer	ICES, WGNSSK, WGNSDS & WKNEPHTV reports	
Nephrops behavior around creels	Low light video(ROS CCD) and infra-red lights	Research	North Sea and West Coast	FRS Marine Lab	Ongoing	None	Illumination problems, short range of I-R lights
Fish behaviour observations on commercial nets	Low light underwater video(ROS CCD) and acoustic video	Improving technical measures	North Sea and West Coast	FRS Marine Lab	Ongoing	ICES & EU Reports - e.g PREMECS, RECOVERY	Effects on net geometry when operating near cod-end, sand clouds, data volume and interpretation
Fish behaviour observations on survey nets	Low light underwater video(ROS CCD), colour video and acoustic video (Seabat, 455Hz)	Catchability studies	North Sea	FRS Marie Lab	Ongoing	Grey - ICES	Image quality when not using lights, depth limitations due to light levels, data volume and interpretation
Alternative baited camera survey methods	Digital stills camera (Kongsberg) and low light video (ROS CCD)	Management	North Sea	FRS Marine Lab	Ongoing	None	Corrosion on connectors due to method of operation, data volume, fish ID
Monkfish TV survey	Towed body with colour video and lights	Assessment of monkfish abundance	Rockall Bank	FRS Marine Lab	Okt. 07	None	Area coverage
Fish acoustic Target Strength and species identification studies	Low light CCD stereo camera	Research in support of assessment of herring abundance	North Sea	FRS Marine Lab	Ongoing		Fish avoidance of frame, visible range

WHAT	HOW	WHY	WHERE	WHO	WHEN	REFS	COMMENTS
Habitat surveys of Rockall Bank – Lophelia, closed areas	Drop frame with colour video and digital stills camera	Protection of vulnerable habitats	Rockall Bank & Anton Dohrn	FRS Marine Lab and JNCC	Ongoing	DTI and JNCC Reports	Vulnerability of system in poor weather, accurate positioning of frame
Habitat surveys – disposal sites, SACs etc	Drop frame with colour video and digital stills camera	Monitoring of human impacts	North Sea and West Coast	FRS Marine Lab	Ongoing		
Habitat degradation and trawl impact surveys	Diver-held colour video cameras, small ROV	Research towards area closures	North Sea and West Coast	FRS Marine Lab			
Trawl impact studies	Laser line and underwater camera	Building models of trawl impacts					
Counting and measuring migrating salmon in fish ladders	Colour video used previously, possibly replaced by electronic counters and Didson sonar considered	Assessment of freshwater fish stocks	Scottish rivers	FRS Pitlochry			
Observations of schooling herring behavior in degraded environments	Stereo camera systems on drop frame	Impact of anthropogenic disturbance on coastal eco-systems	Oresund and Tysfjorf	Scottish Association for Marine Science	Ongoing?	Ethofish project	Not known
Studies of deep-sea fish population and behaviour	Digital stills, video and sonar on free-fall landers	Deep sea ecology	Atlantic, Pacific and others	Aberdeen University – Oceanlab			
St Andrews?							
Stirling University?							
Shetland College?							

3.2.7 Canadian national review

WHAT	HOW	WHY	WHERE	WHO	WHEN	REFS	COMMENTS
Bottom Surveys – Rockfish, flatfish species	ROV	Monitoring	Pacific Coast	Pacific Biological Station, Nanaimo, B.C. DFO	2003,2005, 2007	Yamanaka, K.L.et. al. 2006. Can. Sci. Adv. Secr. Res. Doc. 2006/077: 68 pp.	Fish response, quantification of area swept or on line transect, data management, efficient image and data processing, habitat classifier
Bottom Surveys – Rockfish, flatfish species	Submersible	Monitoring	Pacific Coast	Pacific Biological Station, Nanaimo, B.C. DFO	2000, 2003, 2005	See above	See above
BC Finfish Aquaculture BC Finfish Aquaculture Waste Control	ROV	Monitoring	Pacific Coast	Pacific Biological Station, Nanaimo, B.C. DFO, Aquaculture industry and consultants	2006	Proposal	Still concept
Coastal habitat inventory, New Brunswick/Bay of Fundy	Drift Camera	Monitoring	Bay of Fundy	Biological Station, St. Andrews NB DFO	1997–	Posters plus: Strong, M.B. and P. Lawton. 2004. Can. Tech. Rep. Fish. Aquat. Sci. 2553.; Parrot, R. and M.B. Strong. 2003. Geol. Surv. Can. Open File Report.; Lawton, P. A.D. MacIntyre, D.A. Robichaud and M.B. Strong. 2005. Can. Manuscr. Rep. Fish. Aquat. Sci. 2718;	
Scallop settlement and density from enhancement study	Towed camera sled	Monitoring	Gulf of St. Lawrence	Gulf Fisheries Science Centre, Moncton NB. DFO	2001–2005	Posters, presentations	

WHAT	HOW	WHY	WHERE	WHO	WHEN	REFS	COMMENTS
Nearshore habitat, Nova Scotia	Drop/towed camera	Monitoring	Nova Scotia	Bedford Institute of Oceanography, Dartmouth NS DFO	2005–	In prepn	
Lobster survey in Lobster Bay Nova Scotia	Drift camera	Monitoring	Nova Scotia	Bedford Institute of Oceanography, Dartmouth NS and Biological Station, St. Andrews NB DFO	2006–	In prepn	Data processing, image analysis
Haddock habitat study	Towed camera	Experimental	Nova Scotia	Bedford Institute of Oceanography, Dartmouth NS		Posters, in prepn	

WHAT	HOW	WHY	WHERE	WHO	WHEN	REFS	COMMENTS
Trawl impact, dredge impact studies	Towed camera	Monitoring	Newfoundland, Nova Scotia	Bedford Institute of Oceanography, Dartmouth NS, Northwest Atlantic Fisheries Centre, St. John's NL, DFO		Gilkinson, KD; Gordon, DC; MacIsaac, KG; McKeown, DL; Kenchington, ELR; Bourbonnais, C; Vass, WP. ICES J. Mar. Sci. Vol. 62, no. 5, pp. 925–947. Aug 2005; Gilkinson, KD; Fader, GBJ; Gordon Jr., DC; Charron, R; McKeown, D; Roddick, D; Kenchington, ELR; MacIsaac, K; Bourbonnais, C; Vass, P; Liu, Q. Cont. Shelf Res. Vol. 23, no. 14–15, pp. 1315–1336. 2003.; Kenchington, E.L.R., Gilkinson, K.D., MacIsaac, K.G., Bourbonnais–Boyce, C., Kenchington, T.J., Smith, S.J., Gordon Jr., D.C. 2006 J. Sea Res. 56 (3), pp. 249–270	

What	How	Why	Where	Who	When	Refs	Comments
Scallop surveys	Towed camera	Monitoring	Bay of Fundy,Southwest Nova Scotia	Bedford Institute of Oceanography, Dartmouth NS	2003–	Posters plus Smith, SJ; Mc-Keown, D; Lundy, M; Gordon, D; Anderson, J; Strong, M; Power, M. Journal of Shellfish Research [J. Shellfish Res.]. Vol. 25, no. 1, p. 308. Apr 2006. (still in development)	Survey design, data processing, image analysis
Capelin Spawning Beds	ROV	Monitoring	Newfoundland	Northwest Atlantic Fisheries Centre, St. John's NL, DFO	2005–2006	Poster	Data processing, image analysis

3.2.8 Russian national review

WHAT	HOW	WHY	WHERE	WHO	WHEN	REFS	COMMENTS
Mackerel schools and plankton layer recording	Airborne lidar	Monitoring	Norwegian Sea	PINRO, Giprorybflot, P.P. Shrsov Institute of Oceanography RAS	2001–2005	Several	Weather dependent
Assessment and behavior studies of Greenland Halibut	Autonomous underwater video	Assessment and behaviour		PINRO		Several	
King crab survey	Video	King crab abundance estimation		PINRO	2006–	Several	
Pelagic fish shoals	Video	Structure		PINRO		Several	
Target strength *in situ*	Video, laser underwater television and acoustic	Experimental		PINRO		Several	

3.3 ICES Cooperative Research Report Outline

The Study Group engaged in extensive discussions regarding the outline of an *ICES Cooperative Research Report* on optical technologies. Agreement was reached on the following draft report outline, although it was understood that changes would likely be made as the work of the Study Group proceeds. It was agreed that that text would be drafted by 20 May 2008 and would be presented at the SGFOT meeting in Bergen, Norway 14–15 June 2008.

Introduction

Objective of study group/report

Who?

ToRs

Scope

SCOR

(Mention: Satellite, Bioluminescense)

Optical technologies

Cameras

- IR
- ISIT
- SIT
- CCD
- ICCD
- CMOS

Lidar

External lighting

Plankton counters

Didson sonar

Laser line scanning

Range gated lasers

Holography

Photo cells

Hyperspectral imaging

Integration

Platforms

Cables

Electronics

- Multiplexing

- Ethernet
- Data transmission

Ancillary sensors

Software (e.g. LabView, Matlab, R, event logs)

Synchronisation

Recording media

Geo location

Data processing

Stereo cameras

- Depth from stereo camera

Image analysis (image enhancement, correction, VMS, Optimus)

- Target recognition
- Tracking

Image interpretation (e.g. VARS)

Data compression and file formats

Data management

Meta data

Intelligent sampling (adaptive sampling)

Calibration

Measurement uncertainty

Applications

Visual surveys

- Line transects
- Quadrate
- Stationary equipment

Fishing gear performance

Lidar survey

Supporting acoustic measurements

- Species recognition
- Target strength related studies in situ
    - Angle distribution
    - Anatomical imaging
    - Morphometric

Behaviour

- Ecology
- Avoidance
- Interaction with fishing gear

Fishery observation

Communication

Catch sampling

Habitat classification

- Pelagic
- Benthic
- Community structure

Recommendations

Working group?

Future

Glossary

Including acronyms

Suppliers

Simple list

References

Style: ICES Journal

Annex 1: List of participants

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Annex 2: Agenda

Study Group on Fisheries Optical Technologies (SGFOT) Meeting Agenda.

Meeting Place: Crowne Plaza, Dublin Airport, Dublin, Ireland

Saturday 21 April 2007

10:00 Welcome and housekeeping

10:30 Fisheries Observing Using Video-Based Electronic Monitoring

Howard McElderry

10:50 Automating Counting of Norway Lobster Using Underwater Video Analysis

Paulo Lobato Correia, Lau Phooi Yee, Paulo Fonseca and Aida Campos

11:10 On the use of under-water video cameras for the development of seal-safe salmon traps

Arne Fjälling

11:30 Coffee break

11:45 Report on the DFO National Workshop on survey design, database design and analysis of underwater video/photographic surveys

Stephen J. Smith, Peter Lawton and Pierre Clement

12:05 Airborne Optics

James Churnside

12:25 Update on Norwegian Lidar Research

Eirik Tenningen

12:45 Discussion

13:00 Lunch

14:00 Literature review

- Target identification
- Behavioural characterization
- Measurement uncertainty
- Automated data processing and visualization, and data management

15:30 Coffee break

15:50 Literature review, continued

17:00 Close

Sunday 22 April 2007

09:00	Welcome
09:15	Video/Visual/TV survey
	Paul Fernandes
09:35	Platform development
	Presentations by *Bill Michaels, Bo Lundgren and Terje Torkelsen*
10:15	Discussion
10:30	Coffee break
10:50	Discussion on current and emerging optical methods for ecosystem-based fisheries management that can be investigated further
11:30	Discussion on linkages within and outside ICES
12:00	Future meetings and work to be done
12:30	Lunch
14:00	Report structure
15:00	Coffee Break
15:20	Report and updating terms of reference
16:30	Meeting sum up
17:00	Meeting closed

Annex 3: SGFOT Terms of Reference for the next meeting

The **Study Group on Fisheries Optical Technologies** [SGFOT] (Chair: E. Tenningen, Norway) will meet in Bergen, Norway from 14–15 June 2008 to:

a) Evaluate progress of the review of optical technology as agreed on the 2007 SGFOT meeting and finalise cooperative report structure;

b) Review the outcome of the recent relevant conferences (e.g. Oceans 2007);

c) Discuss recommendations for future work within optical technology to service the ecosystem approach for fisheries management

SGFOT will report by 31 July 2008 for the attention of the Fisheries Technology Committee.

Supporting Information

PRIORITY:	The current activities of this Group will lead ICES into improved techniques for surveying marine living resources and methods for improving existing survey strategies. Consequently, these activities are considered to have very high priority.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	The group's work is of relevance to the ICES Action Plan 1.2, 1.10, 1.12, 1.13 and 1.14. Terms of reference a): The group will continue to review the state-of-the-art in fisheries optical technologies. Several countries are conducting or have recently completed significant studies in this area and the subject will benefit from a review of progress and an evaluation of the results obtained. A review of more recent work will determine the best approaches and strategies for future development. Terms of reference b): There are several relevant conferences on the topic of optical technologies. The group will review these in order to find relevant technologies and authors for the ICES Cooperative Research Report. Terms of reference c): Optical technologies for surveying fisheries resources, improving other techniques for surveying fisheries resources, and or characterizing fish behaviour are increasing in their accessibility, popularity, and value to to fisheries management. The group will discuss recommendations within this field for future work.
RESOURCE REQUIREMENTS:	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
PARTICIPANTS:	The Group is normally attended by some 20–25 members and guests.
SECRETARIAT FACILITIES:	None.
FINANCIAL:	No financial implications. Having overlap with other meetings of expert groups of FTC increases efficiency and reduces travel costs.
LINKAGES TO ADVISORY COMMITTEES:	There are no obvious direct linkages with the advisory committees.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	There is a close working relationship with WGFAST and WGFTFB.
LINKAGES TO OTHER ORGANIZATIONS:	None.

Annex 4: Recommendations

RECOMMENDATION	ACTION
1. SGFOT recommends a theme session for the 2009 ICES Annual Science Conference on “Optical and image based technologies for ecosystem approach to fisheries management” *Chairs:* Eirik Tenningen (Norway) and William Michaels (USA)	ICES FTC Chair
2. SGFOT recommends that the draft ICES Cooperative Research Report structure is disseminated amongst relevant ICES expert groups for comments	Chairs of WGFTFB, WGFAST, WGMHM, WGNEPH