ICES JFATB REPORT 2011

SCICOM STEERING GROUP ON ECOSYSTEM SURVEYS SCIENCE AND TECHNOLOGY

ICES CM 2011/SSGESST:10

REF. SCICOM

Report of 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] (JFATB)

9 May 2011

Reykjavik, Iceland

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2011. Report of 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] (JFATB), 9 May 2011, Reykjavik, Iceland. ICES CM 2011/SSGESST:10. 22 pp.

Contents

Executive summary

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] (JFATB) chaired by Alex De Robertis (USA) and Paul Winger (Canada), met in Reykjavík, Iceland on 9 May 2011 in conjunction with WGFTFB and WGFAST to a) capitalize on technological advances by exploring how the integration of multiple observation techniques will increase ability to detect trends/patterns in marine ecosystems and reduce measurement uncertainty, and b) facilitate links between the WGFTFB and WGFAST as well as other research organizations with expertise in behaviour and physiology. The meeting consisted of fourteen presentations of novel research that stimulated discussion on a broad range of subjects in areas relevant to the membership of both working groups.

Highlights:

- There is a recognized need for improved methods to quantify trawl selectivity across a broad range of species and sizes to help develop multispecies surveys. This may lead to improved trawl designs for multispecies surveys. A subset of WGFTFB and WGFAST members and others from outside the group have expertise that is relevant to making the transition between trawl gear used in single-species to gear that is optimized for ecosystem surveys. A formal mechanism, potentially a study group should be considered.
- The proliferation of studies using multiple instruments and instruments generating large amounts of observations necessitates continued development of analysis techniques facilitating 1) efficient processing of large datasets, and 2) the display, analysis, and synthesis of data from multiple sources.
- There is a need to refine and operationalize emerging sampling methods such as sonars and optical instruments, and to fully integrate these measurements with those from other tools such as echosounders and trawls.
- Animal behavior remains a key area of common interest for both working groups. There is a need for work on behavior to transition from observation to prediction of behaviour (i.e. from 'how to why'). This requires increased engagement with behaviorists from outside JFATB. JFATB has expertise in making observations that are of interest to behaviorists, and increased collaboration in interpretation and analysis of these datasets may provide a vehicle for progress.
- The JFATB should continue to meet, but on a triennial basis. The next meeting of the JFATB will be in 2014.

1 Terms of Reference

In response to the ICES Resolution of the 98th Statutory Meeting, 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] (JFATB) chaired by Alex De Robertis (USA) and Paul Winger (Canada), met in Reykjavík, Iceland on 9 May 2011 in conjunction with WGFTFB and WGFAST to:

a) Explore whether and how the use of multiple sampling and/or observation techniques (including acoustics, optics and direct sample collection) applied to a given issue (e.g. resource surveys, fishing gear selectivity and ecosystem impact studies.) will increase the ability to detect trends / patterns and / or reduce uncertainty;

b) Facilitate links between the WGFTFB and WGFAST and academic / research organizations outside the field of direct fisheries research to build collaborations to address behavioural and physiological data gaps.

2 Opening the Meeting

2.1 Opening and Welcome

Johan Sigurjonsson, the director of the Marine Research Institute, Iceland opened the meeting and welcomed the participants. In his address, he welcomed the participants to Iceland, and highlighted that the Joint Session carried out important work in the technological aspects of fisheries acoustics and fish capture, and highlighted the importance of this work to the fisheries which play a major role in the economy of Iceland. He expressed confidence in the work done by the working group and expressed that improved understanding will lead to more sustainable harvest of fish resources. Haraldur Einarsson, one of the meeting organizers then welcomed the participants and provided an explanation of logistics associated with the meeting. The chairs expressed their appreciation on behalf of JFATB, WGFAST and WGFTFB for the hard work on the part of the local organizing committee from Icelandic Marine Research Institute in setting up the meeting logistics, as well as our appreciation to the Icelandic Marine Research Institute and meeting sponsors for hosting the meeting.

2.2 Participants

A list of participants appears in Annex 1.

3 Introduction

The motivation for the theme of the 2011 meeting of the JFATB was that the simultaneous use of multiple sampling methodologies is becoming increasingly more common. The simultaneous use of multiple sampling techniques (e.g. trawls, acoustics, optics, remote sensing, and models) is becoming more widespread during stock abundance surveys, particularly as many surveys transition from a single-species focus to a broader focus to support the ecosystem approach to fisheries management. It is broadly recognized that all observation methods have unique strengths and limitations, and that the limitations of a single method can likely be overcome by applying multiple techniques.

The primary goal of the session was to invite presentations and stimulate discussion exploring the challenges associated with the integration of multiple observational methods, and the potential benefits of simultaneous application of multiple observational methods. The members of WGFTFB and WGFAST have long used multiple sampling methods to characterize the uncertainties associated with survey gear (e.g. trawls, acoustics): it is clear that the use of multiple methods will likely lead to a better understanding of the measurement process, and will lead to decreased measurement uncertainty and bias in existing sampling methods. In addition, increased application of multiple observational methods will likely lead to new insights, for example, by expanding surveys to incorporate additional species, and by improved characterization of animal behaviour. The ability to improve characterization of behaviour is critical. Behaviour can be viewed as a challenge, as animal behaviour introduces uncertainty in observations, which must be understood in order to make accurate measurements (e.g. of abundance) that are fundamental to fisheries management. The study of behaviour is also an opportunity to make new insights as animals use behaviour to alter how they experience the environment. There is much to be gained from an improved understanding of behavior, and it is increasingly important to be able to predict how animals will react in response to anthropogenic and natural variability of the environment.

4 Presentations

4.1 Effects of Trawl Selectivity on Walleye Pollock Acoustic Survey Estimates in the Gulf of Alaska

K. Williams[1], C. Wilson[1] and J. Horne [2],

[1]Alaska Fisheries Science Center USA, [2]University of Washington, USA

Abstract

Midwater trawls are used in acoustic-trawl surveys to determine species and size compositions of observed fish aggregations. When catch-based estimates of size composition are not representative of the population length distribution because of trawl selectivity, the resulting abundance estimates are inaccurate. Trawl selectivity was estimated for the 2007 and 2008 Shelikof Strait walleye pollock (*Theragra chalcogramma*) acoustic-trawl survey using recapture nets, to provide selectivity estimates. Selectivity estimates were used to re-analyse acoustic survey data from 1993 to 2009 by correcting trawl catches to approximate the assumed true population length composition. Survey correction consisted of random sampling of selectivity parameters from probability distributions determined by the selectivity trials. This procedure was repeated many times to determine the effect of uncertainty in selectivity parameters on corrected survey results. The selectivity-corrected time-series resulted in an average 9% (2008) and 23% (2007) reduction in biomass relative to the uncorrected results. The selectivity correction resulted in higher abundances of juvenile pollock (ages 1–2), and a reduction in the abundance of adults (ages 3+). Survey years were more heavily influenced by the selectivity correction when more juveniles were present, as well as surveys where a greater range of length classes were captured in trawl hauls. Cohort analysis revealed a more rapid decline in abundance with age for the selectivity-corrected estimates compared to the uncorrected results, indicating potentially greater mortality rates of juvenile pollock. The implications of this analysis are discussed, and potential recommendations will be made for the implementation of trawl selectivity in survey analyses.

4.2 Detailed schooling behavior metrics revealed by multi beam sonar and optical flow tracking methods

N. O. Handegard[1], K. Boswell, S. LeBlanc, D. Tjøstheim and I. Couzin

[1] Institute of Marine Research, Bergen Norway

Abstract

Predator–prey interactions are observed in situ using imaging sonar. The prey's schooling behaviour is resolved by using optical flowfield analysis, and the predator behaviour is tracked manually. Various school properties are calculated, including relative positioning, internal behavioural correlation structures, school size, and boundary irregularity. These metrics are used compared to level of predation and methods to evaluate the effects of predation on school structure are presented.

4.3 The results of experiments of trawl catchability coefficient procedure: synthesis of fish behavior, acoustic survey and trawl sampling

O. M. Lapshin[1], Yu.V. Gerasimov, M. I. Malin[2], M. I. Bazarov[2], D. D. Pavlov[2] and I. V. Roy[1]

[1] *Federal research institute of fisheries and oceanography (VNIRO), Moscow, Russia, lapshin@vniro.ru*

[2] *Institute for biology of inland waters Russian Academy of Sciences, Borok, Russia*

Abstract

Previously studies of O. M. Lapshin (2005, 2009), and O. M. Lapshin *et al.* (2010) have shown that scientifically grounded approach to formation of algorithm on assessment of fishing gear catchability coefficient determination is such that will be based upon maximum consideration of fishery's object natural behaviour.

F. I. Baranov (1960) has understood the fishing gear active zone as the zone where catching process would be taking place and not the zone where this interaction is already taking place (Figure 1). We follow the same views and think that fish density in the active zone of fishing gear (in the zone of direct fishing) should not be used for catchability coefficient determination. Actually, this value should be of little interest to us during assessment surveys and nevertheless it could be interesting if we are to estimate the fishing gear's construction effectiveness. In this case, catch would be correlated with changed (different from natural) values of fish quantity and we would calculate an incorrect catchability coefficient and a significantly distorted value of the assessed object.

Previous multiple studies have indicated that physical fields of the survey vessel would influence the natural distribution of fish in the active zone of the fishing gear significantly. However, surveys are to be assumed to determine the actual abundance of target species unlike commercial fishery. Therefore, in order to obtain significant coefficient of trawl catchability we consider the influence of the whole fisheries complex upon natural fish aggregations, including the vessel and the fishing gear. For that, base density of fishery objects must be estimated immediately before trawling using a vessel unequipped with fish gear or some other low-noise vessel.

Aim of the work was to determine the pelagic trawl catchability coefficient. A distinctive feature of this work was realization of hydroacoustic survey in order to determine the actual fish density before the beginning to trawling.

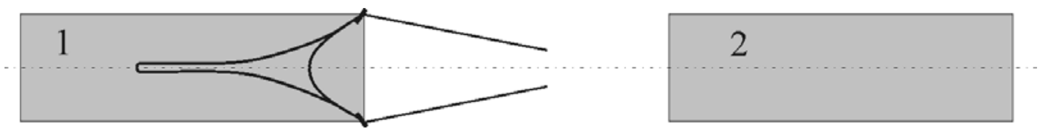


Figure 1. Survey bottom-trawl active zone (1 — traditional position, 2 — proposed position).

4.4 Evaluating reactions of fish to a survey vessel using a multibeam sonar

Randy Cutter[1] and David Demer[1],

[1]Southwest Fisheries Science Center, USA

Abstract

Reactions of fish to a survey vessel and the near surface 'blind zone' can lead to bias in echosounder surveys of epipelagic fish. In this study, measurements made with a multibeam sonar were used to evaluate the reactions of schooling fish and their locations relative to a fisheries survey vessel. The pole-mounted 200-kHz array was tilted to insonify a 180° swathe encompassing the sea surface on port side to 30° from vertical on the starboard side of the vessel. Raw data were processed using the variable-aperture method and criteria for automatically filtering interference. Filtered data were then classified as fish, seabed, or sea surface, for example. Samples passing as fish were mapped spatially with respect to the vessel. Accurate interpretation of the results requires account for detection range (a proxy for the signal-to-noise ratio), and beam-steering angle and fish sizes and orientations (proxies for incidence angle and fish scattering directivity).

4.5 Species identification in seamount plumes using moored underwater video

R. O'Driscoll[1], P. de Joux, R. Nelson, G. J. Macaulay, A. J. Dunford, C. Stewart, P. Marriott, B. S. Miller

[1]NIWA, Wellington, New Zealand

Abstract

Acoustic surveys of New Zealand deep-water seamounts often show plumes up to 100 m high on the summit. Although bottom trawls on the seamount slopes catch predominantly orange roughy, species composition in the midwater plumes is extremely uncertain. In June 2010 moored underwater video cameras were deployed on the summit of the Morgue seamount (summit depth 890 m), a feature that has been closed to fishing since 2001. Cameras and lights were timed to come on for 2 minutes every 2 hours. Fish response to the mooring was monitored using vessel-mounted echosounders. Moored cameras confirmed that orange roughy were present up to 70 m above the seamount summit. Orange roughy made up 95% of the fish identified from the video. Other species observed included smooth oreo, deep-water dogfish, and squid. There was considerable vertical (depth) and temporal variability of orange roughy densities during each deployment. Orange roughy densities estimated from the video were generally consistent (within a factor of two) with acoustic estimates from the volume surrounding the camera. However, total plume backscatter varied by a factor of 25 over a period of hours, and peak acoustic densities recorded within the plume (equivalent to 20 orange roughy per m^3) were an order of magnitude higher than peak visual estimates (about 1.5 orange roughy per m^3). It is unclear whether this temporal variability in the plume is caused by fish moving into and out of the acoustic dead zone, the acoustic contribution of other species, or changes in orange roughy target strength.

4.6 Vertical distribution, movement and abundance of fish in the vicinity of proposed tidal power energy device

G. D. Melvin[1] and N. A. Cochrane

[1]Department of Fisheries and Oceans, St. Andrews, Canada

Abstract

Minas Passage located at the head of the Bay of Fundy has been identified as one of the key locations for the installation of tidal power conversion devices. Currently it is the only location with an active devise deployed on the east coast of Canada. Two systems were adopted to investigate the applicability of acoustic technology to monitor fish distribution, movement, and to quantify biomass in the vicinity of the turbine: A multibeam sonar (Simrad SM2000) and a conventional split (Simrad EK 60, 120 kHz) beam sounder. Both systems were deployed from a single pole mount just below the vessels hull depth (1.5m). Field trials indicate that combining the two systems provided enhanced qualitative and quantitative resolution of fish abundance and behaviour. Backscatter distribution suggested that there were layers of fish moving through the passage during a specific period of the tide. Fish like targets were observed within 7 meters upstream of the turbine.

4.7 Impact of seismic explorations on pelagic fish distributions as studied with fisheries sonars

H. Peña[1], R. Patel[1] and E. Ona[1],

[1]Institute of Marine Research, Bergen Norway

Abstract

Acoustic data from three consecutive surveys was analysed for study the impact of seismic shooting in one of more important fishing areas in the northwest of Norway. Standard EK60 echosounder data were collected simultaneously with data from Simrad SH80 high frequency (110–120 kHz) fisheries sonar. Sonar raw data were processed using the processing system for fisheries omnidirectional sonar (PROFOS) which is an integrated module of LSSS system. Data were replayed and each school in the sonar range were manually seed and semi-automatically grown. From multiple detections of the same school, the mean values of school morphology, school backscattering strength, swimming speed and direction were extracted. A preliminary school biomass was computed and used for relative comparison between regions and surveys. Numerous small size herring schools distributed in the upper 20 m were detected effectively by the sonar, but less efficiently by the scientific-keel mounted echosounders. During the seismic shooting period (second survey), the schools were slightly larger and increased their migration speed to a more NE direction. During the whole surveying period, the schools seemed to passively migrate out of the study area in a feeding migration to the north following the prevailing currents, at a speed of ca. 1 knot.

4.8 Investigating haul representativeness in the joint US-Canada Pacific hake acoustic survey

R. Thomas[1], K. Cooke, C. Grandin, S. de Blois, D. Chu and L. Hufnagle.

[1]*Northwest Fisheries Science Center, USA*

Abstract

Are haul samples in acoustic surveys adequately representing the associated acoustic regions with respect to size, age, etc. of the fish distribution? If not, what are some potential consequences? How do we test representativeness? To address these questions using Pacific hake (*Merluccius productus*) as a case study, a limited pilot field study was conducted in 2010 by sampling various portions of hake aggregations. The results from this field study and an accompanying review of historical data indicate sampling variability, but show no evidence of bias. Additional fieldwork and possibly a workshop are needed.

4.9 Acoustic data from fishing vessels: what scientific information can be obtained from the Peruvian jack mackerel fishery?

[1]F. Gerlotto, M. Gutierrez, E. Josse and A. Aliaga

[1] *IRD, France*

Abstract

The use of fishing vessels as source of acoustic data for scientific research has been considered since the 1990s. We present some results from the example of the acoustic information provided by the jack mackerel fishing industry in Peru. The first step consisted in selecting the fishing vessels according to a series of criteria that are discussed. Once the "optimal" fishing vessels selected, we used the acoustic data from these ships to perform analyses on the fishing activity and the spatial distribution of the fish. The cost of such work was evaluated as approximately one hour of technician work for processing one day of vessel activity. We show that exploiting the acoustic data of these ships give a series of new informations. For such observation we analysed the echograms of the fishing boats in their three phases: transit to the fishing grounds, exploration-exploitation and transit to the harbour. The fish biomass and spatial distribution are studied, calculating a biomass of half million tons. We showed that there is no direct correlation between the actual biomass and the catch per unit of effort (cpue): the relationship is only observed at larger scales. The diameters of clusters of schools and clusters of vessels are measured (respectively 2.7 and 3.5 nautical miles). Finally relationships between the fish distribution and the major environmental variables are detailed. We conclude that acoustics from fishers is of a much higher quality than expected and is likely to answer many questions still out of reach from standard scientific surveys.

4.10 New tricks for old dogs: behavioural observations of spiny dogfish *Squalus acanthias* in front of a trawl grid in a raised footrope silver hake *Merluccius bilinearis* trawl

David M. Chosid[1], Michael Pol[1], Mark Szymanski[1], Frank Mirarchi[2], and Andrew Mirarchi[2]

[1] *Massachusetts Division of Marine Fisheries, New Bedford, USA*

[2] *Fishing Vessel Barbara L. Peters, 67 Creelman Dr., Scituate, MA 02066, USA*

Abstract

A spiny dogfish *Squalus acanthias* excluder grate (grid) within the extension of a silver hake (whiting) *Merluccius bilinearis* trawlnet was designed and tested in Massachusetts Bay, USA between October 2008 and August 2009 using a live-fed underwater video camera. Grates with 50 mm spacing were investigated for effects from colour (white or black), angle, and direction (leading to a top or bottom escape vent). Spiny dogfish numbers were greatly reduced for all gear configurations based on video observations and data collected from the codend, whereas target species were caught in commercial quantities. Four tows (of various gear configurations) resulted in spiny dogfish blockages in front of the grate. Spiny dogfish movements were categorized for swimming direction, impingement on the grate, and body twist location. No differences were seen in behaviours for grates of different colours or exit location. The reduction of spiny dogfish led to increases in the quality of marketable catches, likely reductions in non-target species mortality, and decreases in the codend catch handling times.

4.11 Out with the old, in with the new: development of an HD underwater camera system to observe the harvesting techniques of commercial species (short presentation)

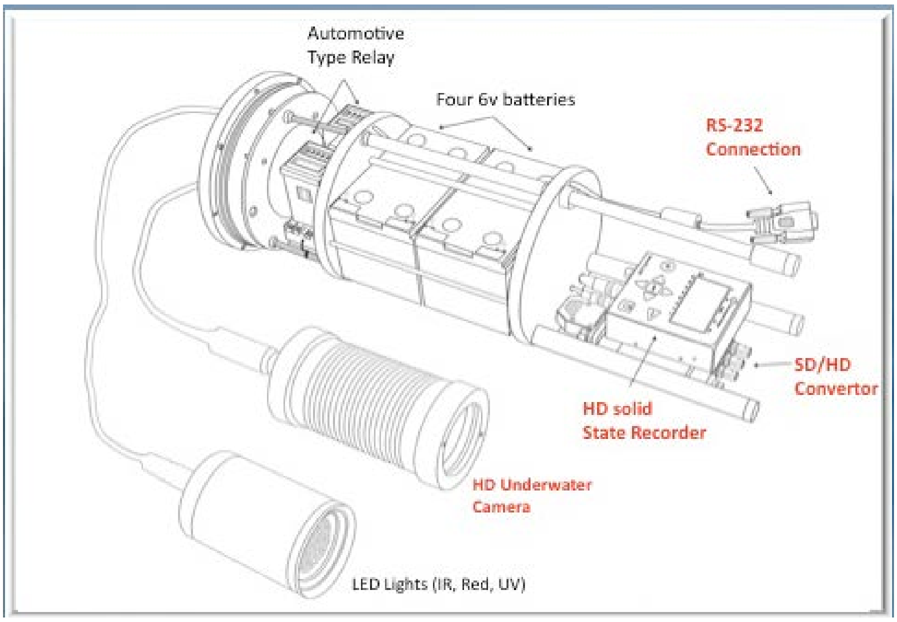
M. Underwood[1], P. Winger[1] and G. Legge[1]

[1]*Fisheries and Marine Institute of Memorial University of Newfoundland*

Abstract

The commercial fishery is an expensive industry and requires a multitude of resources to move the product from the ocean to the consumer. Fuel costs and unintentional species caught in harvesting gear have come under considerable scrutiny in recent years, encouraging harvesting gear to become more efficient and species selective. However, prior to any gear modifications, a better understanding of the species behaviour and interaction to the harvesting gear is required. The use of an underwater camera system to quantify species behaviour in relation to capture gear is a relatively new application to the fishery, and has only recently been developed to incorporate high definition (HD 1080i/720p) digital technology. Inspired by cameras used in remotely operated vehicles (ROVs), the system designed for this research was developed to observe fish behaviour, and is ideal for capturing objects in motion as they relate to operating trawls. Our laboratory study results revealed that HD video could offer significantly improved image quality by up to 20% and allow characteristics of objects as thin as 4 mm to be observed underwater from 4.0 m away. Although

developed for otter trawl research, the camera system is highly flexible and can be applied to stationary gear, such as pots or traps, and other forms of mobile gear.



4.12 Behavioural interactions between flatfish and commercial groundgear on the Newfoundland Grand Bank

M. Underwood[1], P. Winger[1], G. Legge[1] and S. Walsh[2]

[1] *Fisheries and Marine Institute of Memorial University of Newfoundland*

[2] *Department of Fisheries and Oceans, Canada*

Abstract

The yellowtail flounder (*Limanda ferruginea*) fishery on the Newfoundland Grand Bank is currently limited by bycatch restrictions, in particular non-recovering American plaice (*Hippoglossoides platessoides*). In recent years, behavioural research of target species and their interactions to the harvesting gear have led to gear modifications that reduce bycatch. In preparation for gear modifications, *in situ* camera work was conducted on the Grand Bank, during June, 2010 and April, 2011, to observe and quantify the relationship between flatfish behaviour and harvesting gear. A high definition (HD 1080i/720p), digital camera system developed for this research was secured onto the headline of a commercial flatfish trawl. Individuals of different size classes were observed entering the mouth of the trawl, then analysed using Observer XT 10. It is anticipated that behavioural differences between species and sizes will lead to a trawl designed to reduce American plaice bycatch and undersized yellowtail flounder.

4.13 Interactions between nekton and zooplankton aggregations and individual baleen whale predators in temperate and polar environments

J. D. Warren[1], S. E. Parks, A. S. Friedlaender and D. P. Nowacek

[1] Stony Brook University, USA

Abstract

Acoustic backscatter surveys conducted in April – June 2010 in the Northwest Atlantic Ocean and Western Antarctic Peninsula sampled nekton (herring, sand lance) and zooplankton (copepods, Antarctic krill) aggregations over small temporal (minutes to hours) and spatial (meter to kilometer) scales. Concurrently, the movement and behavior of individual right (North Atlantic) and humpback (North Atlantic and Antarctic) whale predators was measured using visual sightings and instrumented suction-cup tags placed on the animals. Identification of scatterer type was possible using multiple acoustic frequencies along with video and net tow sampling for ground-truthing. In some cases, estimates of in situ prey numerical density can be made which combined with the predator behavior can allow us to estimate energy transfer in these ecosystems at the level of an individual foraging whale.

4.14 Snapshots from Icelandic research on fishing technology and fisheries acoustic

Ólafur Arnar Ingólfsson[1], Páll Reynisson[1], Haraldur Arnar Einarsson[1], Einar Hreinsson[1], Sigurður Þór Jónsson[1], Birkir Bárðarson[1], Hjalti Karlsson[1], Þorsteinn Sigurðsson[1]

[1] Marine Research Institute, Iceland

Abstract

The presentation gives a briefing of recent research activities within fishing technology and fisheries acoustics in Iceland. The Marine Research Institute has put considerable effort into buying and building specialized equipment for direct observation of fishing gear and fish behaviour, environmental effects due to fishing as well as equipment for acoustic projects.

In the presentation, a short summary is given of recent work on species and size selection with both static and mobile fishing gear, catching efficiency, fish passage below groundgear of a commercial trawl, attraction and trapping of cod, attraction of krill and fish by using LED lights and direct observations of large mesh capelin trawls.

The presentation also covers a summary of the Icelandic acoustic surveys on redfish, capelin, herring, pearlside and mackerel in addition to other projects; such as cooperation with the fishing fleet to estimate distribution and abundance of the capelin stock, bootstrapping the uncertainty of winter survey echo abundance estimates of Icelandic-Greenland-Jan Mayen capelin, zooplankton studies with acoustics and Video Plankton Recorder (VPR), exploration of the submarine geology and habitats, bathymetry, classification of sediment types and mapping of cold water coral areas.

5 Synthesis and Discussion

The major themes addressed during the meeting included:

- What can we learn from use of multiple methods?

  Improvements in understanding of 'primary' sampling methods (e.g. trawls, acoustics).

  Utility of improved understanding of behavior.

- How can use of multiple techniques address new requirements (e.g. ecosystem approach, good environmental status)?
- Quantification of trawl selectivity and its effects on multispecies surveys
- Progress in the study of behaviour
- How to encourage participation from outside WGFTFB/WGFAST?
- The future of the joint session

From the presentations and ensuing discussion, it was clear that integrated use of multiple sampling methods is proliferating. Major developments include the routine use of multiple acoustic frequencies for improved interpretation of acoustic backscatter measurements, combined use of sonars and echosounders, combined optical and acoustic measurements, and use of trawl-mounted optical instruments. High-quality acoustic measurements from fishing vessels are now possible due to the proliferation of digital echosounder technology and processing methods for systems on commercial vessels, which may allow for integration of fisheries acoustics techniques in a broad range of studies due to wider accessibility.

It was broadly recognized that integration of multiple data types and large volumes of digital data (e.g. optical and acoustic instruments, satellites and models) will require sophisticated methods and software packages so that the data can be effectively visualized, analysed and synthesized. Methods for visualization and analysis of single data streams are progressing, but methods for synthesis of multiple measurement types are as of yet, more limited. This is a major challenge for the near future, and will be critical to address new and emerging requirements (e.g. ecosystem approach to fisheries management, good environmental status) that span many taxa and trophic levels. The development of methods for rapid integration and visualization of multiple is a field that is still in its infancy, and promises to become an increasingly important area of fruitful activity.

There was substantial consideration of uncertainly introduced by trawl selection in acoustic-trawl surveys, and this was identified as an important avenue of research needed to support multispecies surveys. Members were challenged to quantify the catch efficiency of their survey trawls. It is becoming increasingly clear that trawl selectivity has important effects on acoustic-trawl surveys, and a call was made for JFATB members to collaborate on this issue. It was pointed out that trawls used for sampling are often based on designs used in commercial fisheries, and the best trawl for a survey may be quite different, as the goals of surveys and fisheries are quite different.

Behaviour remains a central area of work for both WGFAST and WGFTFB, and an important ongoing theme in the joint session. It is important to be able to monitor how behavioural reactions change under realistic situations, for example how behaviour changes with animal size, time of day and depth. There was evident progress towards increased statistical rigor in behaviour analysis, which has progressed from description of behaviour to quantification of behaviour with estimates of variance. However, studies of behaviour are still largely based on 'what, not why', and it was recognized that progress in this area require engagement with experts outside the JFATB. The overall consensus was that there have been difficulties in attracting participation from others outside WGFAST and WGFTFB, and that this is an area for future work. There was substantial discussion as to how this could be achieved, and it was recognized that the primary expertise of JFATB is in making high-quality observations in marine ecosystems, which will be of interest to behaviourists. Making behaviourists from outside JFATB aware of these measurements may stimulate collaboration and engagement from outside WGFAST and WGFTFB.

Finally, there was an open and frank discussion regarding the future of the JFATB. Prior to the meeting, there was some concern that WGFAST and WGFTFB may have drifted apart over the last years, and that a joint meeting was less relevant than in the past. In addition, it was pointed out that the larger meeting puts additional strain on the hosts. It was questioned whether the joint session should be continued in future. It was decided that the issue would be discussed in the meetings of WGFAST and WGFTB that immediately followed the JFATB. After these discussions were completed, the chairs of WGFTFB and WGFAST reported that the membership of the working groups recognized the value of the JFATB and wanted to continue the joint meeting in future. In order to accommodate the joint meeting of WGFTFB with FAO, it was recommended that future meetings of JFATB should be scheduled on a triennial basis, with the next meeting in 2014. Chris Wilson (USA) was identified as one of the session chairs for the 2014 meeting.

Annex 1: List of participants

Last name	First name	e-mail	Affiliation	Country
Buglioni	Gabriele	g.buglioni@ismar.cnr.it	National Research Council, Institute of Marine Science (CNR-ISMAR),	Italy
Catchpole	Tom	thomas.catchpole@cefas.co.uk	Cefas	UK
Einarsson	Haraldur	haraldur@hafro.is	Marine Research Institute	Iceland
Engås	Arill	arill.engas@imr.no	Institute of Marine Research	Norway
Hermann	Bent	bhe@aqua.dtu.dk	National Institute of Aquatic Resources	Denmark
Ingólfsson	Ólafur Arnar	olafur@hafro.is	Marine Research Institute	Iceland
Lapshin	Oleg	lapshin@vniro.ru	Research Institute of Fisheries & Oceanography	Russia
Larnaud	Pascal	pascal.larnaud@ifremer.fr	Ifremer	France
Santos	Juan	juan.santos@vi.ieo.es	Instituto Español de Oceanografía	Spain
Valdemarsen	John Willy	john.valdemarsen@imr.no	Institute of Marine Research	Norway
van Marlen	Bob	bob.vanmarlen@wur.nl	IMARES	Netherlands
Algrøy	Tonny	tonny.algroy@simrad.com	Simrad, Kongsberg	Norway
An	Heui Chun	anhc1@nfrdi.go.kr	National Fisheries Research & Development Institute	Korea
Andersen	Lars Nonboe	lars.nonboe.andersen@simrad.com	Simrad	Norway
Arregi	Luis	larregi@azti.es	AZTI	Spain
Axenrot	Thomas	thomas.axenrot@fiskeriverket.se	Institute of Freshwater Research, Swedish Board of Fisheries	Sweden
Bardarson	Birkir	birkir@hafro.is	Marine Research Institute Iceland	Iceland
Bavouzet	Gérard	gerard.bavouzet@ifremer.fr	Ifremer	France
Behagle	Nolwenn	nolwenn.behagle@ird.fr	IRD (Institut of Research for the Development)	France
Berger	Laurent	laurent.berger@ifremer.fr	Ifremer	France
Bethke	Eckhard	eckhard.bethke@vti.bund.de	Institute of Sea Fisheries (vTI)	Germany
Björnsson	Höskuldur	hoski@hafro.is	MRI Reykjavík	Iceland
Boyra	Guillermo	gboyra@azti.es	AZTI Tecnalia	Spain
Calise	Lucio	lucio@imr.no	Institute of Marine Research	Norway
Chu	Dezhang	dezhang.chu@noaa.gov	NOAA/NMFS/NWFSC	USA
Churnside	James	james.h.churnside@noaa.gov	NOAA ESRL	USA
Condiotty	Jeff	jeff.condiotty@simrad.com	Kongsberg	USA

Last name	First name	e-mail	Affiliation	Country
Copland	Phil	coplandp@marlab.ac.uk	Marine Laboratory, Aberdeen	Scotland
Cutter	George	george.cutter@noaa.gov	Southwest Fisheries Science Center	USA
De Robertis	Alex	alex.derobertis@noaa.gov	Alaska Fisheries Science Center	USA
Demer	David	david.demer@noaa.gov	Southwest Fisheries Science Center	USA
Domokos	Réka	reka.domokos@noaa.gov	PIFSC, NOAA	USA
Fässler	Sascha	sascha.fassler@wur.nl	IMARES	Netherlands
Forland	Tonje Nesse	tonje@ift.uib.no	University of Bergen, Department of Physics and Technology	Norway
Francis	Chopin	francis.chopin@fao.org	FAO	Italy
Garcia	Jose Fernandez	jose.fernandez@vi.ieo.es	IEO	Spain
Gerlotto	Francois	francois.gerlotto@ird.fr	IRD	France
Giannoulaki	Marianna	marianna@her.hcmr.gr	HCMR	Greece
Goncharov	Sergey	sgonch@vniro.ru	Russian federal research institute of fisheries and oceanogr	Russia
Gorska	Natalia	oceng@ug.edu.pl	University of Gdańsk, Institute of Oceanography	Poland
Handegard	Nils Olav	nilsolav@imr.no	Insititute of Marine Research	Norway
Hans Polet	Hans	hans.polet@ilvo.vlaanderen.be	ILVO-FISHERIES	Belgium
Higginbottom	Ian	ian@myriax.com	Myriax Pty Ltd	Australia
Horne	John	jhorne@u.washington.edu	University of Washington	USA
Hreinsson	Einar	eihreins@hafro.is	UNAK/MRI Iceland	Iceland
Idczak	Jakub	kubid@wp.pl	University of Gdańsk, Institute of Oceanography	Poland
Jarvis	Toby	toby.jarvis@echoview.com	Echoview	Australia
Jech	Mike	michael.jech@noaa.gov	NOAA/NMFS/NEFSC	USA
Jonsson	Sigurdur Thor	sigurdur@hafro.is	Marine Research Institute	Iceland
Josse	Erwan	erwan.josse@ird.fr	IRD	France
Karlsson	Hjalti	hjalti@hafro.is	Marine Research Institute	Iceland
Karp	Bill	bill.karp@noaa.gov	NOAA - AFSC	USA
Kasatkina	Svetlana	ks@atlant.baltnet.ru	AtlantNIRO	Russia
Kloser	Rudy	rudy.kloser@csiro.au	CSIRO	Australia
Korneliussen	Rolf	rolf.korneliussen@imr.no	Institute of Marine Research	Norway
Kracker	Laura	laura.kracker@noaa.gov	NOAA	USA
Krag	Ludvig	lak@aqua.dtu.dk	National Institute of Aquatic Resources	Denmark

Last name	First name	e-mail	Affiliation	Country
Laczkowski	Tomasz	tomlacz@mir.gdynia.pl	Sea Fisheries Institute in Gdynia	Poland
Le Bouffant	Naig	naig.le.bouffant@ifremer.fr	Ifremer	France
Lebourges-Dhaussy	Anne	anne.lebourges.dhaussy@ird.fr	IRD	France
Lee	Kyounghoon	khlee71@nfrdi.go.kr	National Fisheries Research & Development Institute	Korea
Lilja	Juha	juha.lilja@rktl.fi	Finnish Game and Fisheries Research Institute	Finland
Lundin	Mikael	mikaellundin1@hotmail.com	Swedish Board of Fisheries	Sweden
Macaulay	Gavin	gavin.macaulay@imr.no	IMR	Norway
MacLennan	David	maclennan22@aol.com	Marine Science Scotland	UK
McDonald	Daniel	mcdonald@bim.ie	Irish Sea Fisheries Board	Ireland
McQuinn	Ian	ian.mcquinn@dfo-mpo.gc.ca	Maurice Lamontagne Insttute	Canada
Melvin	Gary	gary.melvin@dfo-mpo.gc.ca	Fisheries and Oceans	Canada
Moderhak	Waldemar Ryszard	moderhak@mir.gdynia.pl	Sea Fisheries Institute	Poland
Nilsson	Hans	hans.nilsson@fiskeriverket.se	Swedish Board of Fisheries	Sweden
O'Driscoll	Richard	r.odriscoll@niwa.co.nz	NIWA	New Zealand
Ona	Egil	egil.ona@imr.no	Institute of Marine Research	Norway
O'Neill	Barry	oneillb@marlab.ac.uk	Marine Laboratory Aberdeen	UK
Patel	Ruben	ruben@imr.no	Insititute of Marine Research	Bergen
Pavlenko	Alexander Alexandrovich	pavlenko@pinro.ru	PINRO	Russia
Pedersen	Geir	geir.pedersen@cmr.no	Christian Michelsen Research AS	Norway
Pena	Hector	hector.pena@imr.no	IMR	Norway
Peña	Marian	marian.pena@ba.ieo.es	IEO	Spain
Pol	Michael	mike.pol@state.ma.us	Mass. Division of Marine Fisheries	USA
Reynisson	Páll	pall@hafro.is	Marine Research Institute	Iceland
Rihan	Dominic	dominic.rihan@ec.europa.eu	European Commission	Brussels
Romain	Suzanne		Romain consulting, inc	USA
Ryan	Tim	tim.ryan@csiro.au	CSIRO	Australia
Sala	Antonello	a.sala@ismar.cnr.it	CNR-ISMAR	Italy
Samedy	Valérie	valerie.samedy@cemagref.fr	Cemagref	France

Last name	First name	e-mail	Affiliation	Country
Sigurdsson	Thorsteinn	steini@hafro.is	Marine Research Institute	Iceland
Simard	Yvan	yvan_simard@uqar.qc.ca	ISMER-UQAR	Canada
Stepputtis	Stepputtis	daniel.stepputtis@vti.bund.de	Institute for Baltic Sea Fisheries	Germany
Taylor	J. Christopher	chris.taylor@noaa.gov	NOAA Ocean Service	USA
Thomas	Rebecca	rebecca.thomas@noaa.gov	Northwest Fisheries Science Center	USA
Toliusis	Sarunas	sarunast@gmail.com	Fishery research and science department	Lithuania
Trenkel	Verena	vtrenkel@ifremer.fr	Ifremer	France
Underwood	Melanie	melanie.underwood@mi.mun.ca	Fisheries and Marine Institute	Canada
Urmy	Samuel	urmy@uw.edu	University of Washington	USA
Vincent	Benoit	benoit.vincent@ifremer.fr	Ifremer	France
Warren	Joseph	joe.warren@stonybrook.edu	Stony Brook University	USA
Wespestad	Vidar	vidarw@frontier.com	Aleutian East Borough	USA
Wilson	Christopher	chris.wilson@noaa.gov	NOAA Fisheries, Alaska Fisheries Science Center	USA
Winger	Paul	paul.winger@mi.mun.ca	Fisheries and Marine Institute	Canada

Annex 2: Agenda

The Joint Workshop on Fishing Technology, Acoustics and Behaviour (JFATB) Meeting Agenda

Meeting Place: Grand Hotel, Reykjavík, Iceland, 9 May 2011

Time	Presenting author and title
8:45	Housekeeping – Host
9:00	Introduction – Alex De Robertis, Paul Winger
9:10	Christopher Wilson, NOAA Fisheries, Alaska Fisheries Science Center, Seattle, USA
	Effects of Trawl Selectivity on Walleye Pollock Acoustic Survey Estimates in the Gulf of Alaska
9:30	Nils Olav Handegard, Institute of Marine Research, Bergen, Norway
	Detailed schooling behaviour metrics revealed by multi beam sonar and optical flow tracking methods
9:50	Oleg Lapshin, VNIRO, Moscow, Russia
	The results of experiments of trawl catchability coefficient procedure: synthesis of fish behavior, acoustic survey and trawl sampling
10:10	Randy Cutter, Southwest Fisheries Science Center, San Diego, USA
	Evaluating reactions of fish to a survey vessel using a multibeam sonar
10:30–11:00	**Coffee**
11:00	Richard O'Driscoll, NIWA, Wellington, New Zealand
	Species identification in seamount plumes using moored underwater video
11:20	Gary Melvin, Department of Fisheries and Oceans, St. Andrews, Canada
	Vertical distribution, movement, and abundance of fish in the vicinity of proposed tidal power energy conversion device.
11:40	Hector Peña, Institute of Marine Research, Bergen, Norway
	Impact of seismic explorations on pelagic fish distributions as studied with fisheries sonars
12:00–13:30	**Lunch**
13:30	Rebecca Thomas, Northwest Fisheries Science Center, Seattle, USA
	Investigating haul representativeness in the joint US-Canada Pacific hake acoustic survey
13:50	Francois Gerlotto, Sète, France
	Acoustic data from fishing vessels: what scientific information can be obtained from the Peruvian jack mackerel fishery?
14:10	Mike Pol, Massachusetts Division of Marine Fisheries, New Bedford, USA
	New tricks for old dogs: behavioural observations of spiny dogfish *squalus acanthias* in front of a trawl grid in a raised footrope silver hake *merluccius bilinearis* trawl
14:30	Melanie Underwood, Fisheries and Marine Institute, St. John's, Canada
	Out with the old, in with the new: development of an HD underwater camera system to observe the harvesting techniques of commercial species (short presentation)
14:40	Melanie Underwood, Fisheries and Marine Institute, St. John's, Canada
	Behavioural interactions between flatfish and commercial groundgear on the Newfoundland Grand Bank
15:00–15:30	**Coffee**
15:30	Joseph Warren, Stony Brook University, Southampton, USA
	Interactions between nekton and zooplankton aggregations and individual baleen whale predators in temperate and polar environments.

Time	Presenting author and title
15:50	Olafur Arnar Ingolfsson, Marine Research Institute, Reykjavík Iceland
	Snapshots from Icelandic research on fishing technology and fisheries acoustic
16:10–17:00	**Discussion**

Annex 3: Recommendations

Recommendation	For follow up by:
JFATB recommends that the WGFTFB and WGFAST meet jointly, in April / May 2014. The Terms of Reference are to be mutually decided by the Working Group Chairs and designated joint session chairs.	SSGESST, WGFTFB, WGFAST