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Report of the Working Group on Fisheries Acoustic Science & Technology (WGFAST)

18–22 May 2009

Ancona, Italy

ICES International Council for the Exploration of the Sea

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Executive summary

The Working Group on Fisheries Acoustic Science and Technology (WGFAST) met at the National Research Council – Institute of Marine Sciences, Ancona, Italy from 19 to 22 May 2009 hosted by Antonello Sala. Rudy Kloser (Australia) was Chair and Tim Ryan (Australia) was Rapporteur. There were 62 participants from 19 countries who contributed to the five terms of reference with 43 presentations of new and exciting research.

Highlights:

Under the auspices of the Working Group on Fisheries Acoustic Science and Technology (WGFAST) 65 papers were published from the 2008 ICES sponsored Symposium on the Ecosystem Approach with Fisheries Acoustics and Complementary Technologies (SEAFACTS) in a special issue of the ICES JMS.

Topic area	Number
Invited Review – Tony Koslow	1
Ecosystem and Fisheries Monitoring	13
Remote Classification	12
Target Strength	12
Animal Behaviour	11
Data Quality and Integration	16

David Demer acknowledged the 151 reviewers, the ICES steering committee, editors John Ramster, Awie Badenhurst, and Andy Payne, David N. MacLennan, Symposium sponsors, Institute of Marine Research (Norway), Egil Ona and the authors for their efforts in ensuring a timely publication. Significant advances were reported in acoustic technologies and methods published in the ICES JMS special issue representing the combined efforts of fishery acousticians, physicists, engineers, biologists, and ecologists.

At the Ancona meeting participants built on this existing knowledge to focus on the development and application of acoustic and complementary methods to address the ecosystem approach to marine management with the following highlights.

Based on the ICES strategic plan the topic of ecosystem indicators was included in the WGFAST work plan to bridge the gap between science/management needs to use indicators of a fishery or ecosystem and how we could contribute to their measurement with acoustics and complementary technologies. The meeting highlighted the need to clearly define what was meant by an indicator and to build on the existing science and literature in this area. Based on the existing definition of an indicator and the list of indicators proposed in the European region and elsewhere a group was established to review and synthesize the role of acoustic and complementary methods to inform fisheries and ecosystem indicators and ideas for further development. At the meeting several examples were presented on the combination of acoustics and other physical and biological covariates to derive an indicator of species habitat. The use of acoustics in identifying small pelagics' juvenile habitat in the Mediterranean

presented by Marianna Giannoulaki and colleagues was a good example of the methodology required.

The topic of coastal, shelf and ocean observatories for fisheries and ecosystem monitoring: role of active acoustics for current applications, methods and technologies and future designs is an area of high need and growth among member countries. At the meeting several new technologies were outlined based on, fixed, mobile or drifting platforms with some exciting developments. For example the development of micro sounders for use on animals as observers and the use of fixed inverted echosounders for detailed temporal studies of the deep scattering layer. Based on existing technologies new signal processing methods were outlined that could extract within pulse and within beam information. The high need for biologically focused observatories (fixed and mobile) from member countries with metrics derived from automated data processing methods with appropriate data quality and management will be a focus of work within WGFAST for coming years.

The WGFAST working group discussed how it could contribute to the wider debate of anthropogenic sound impacts on fish. In particular Tony Hawkins is thanked for providing background to the topic and insights into future needs for research. In general we require more information about sound sources that are likely to cause damage (e.g. seismic, pile driver) whilst also noting, noise from ships is a chronic problem that is not easily addressed. As an example experiments on sea-based wind farms to see what particle motion is occurring would be beneficial. Preference would be to focus research on the most dangerous sound sources. For example those that could kill fish, or prevent their movement to spawn. An area where WGFAST could inform the debate would be to review fisheries acoustic devices their characteristics (e.g. frequencies, sources, directivities, pulse repetition) and place this in context with other natural and human sources to inform the debate on regulation of anthropogenic noise.

Recommendations

A complete list of the Recommendations proposed by the WGFAST can be found in Annexes 3, 4 and 5 of this report.

1 Terms of Reference

In response to the ICES Resolution of the 92nd Statutory Meeting, the Working Group on Fisheries Acoustics Science and Technology (WGFAST) (Chair: Rudy Kloser, Australia; Rapporteur: Tim Ryan, Australia) met in Ancona, Italy from 19 to 22 May 2009 to:

a) advance our understanding of new and innovative methods and technologies in applying the ecosystem approach to fisheries management and follow up on recommendations developed during the 2008 ICES SEAFACTS conference by addressing:

i. Fisheries and ecosystem acoustic indicators and the interface between observation outputs and model uptake including improved process understanding and assessment of indicator goodness of fit with ecological and fishery assessment models;

ii. Coastal, shelf and ocean observatories for fisheries and ecosystem monitoring. Role of acoustics for current applications, methods and technologies and future designs;

iii. Target strength and species identification modelling and measurement with particular emphasis on validation (optical and nets) and multi-frequency and wide band measurements;

iv. Acoustic observations (passive and active) of spatial and temporal fish behaviour (e.g. spawning, migration) and how this knowledge is or could be incorporated into models and management advice;

v. Anthropogenic sound impacts on fish: update of issues from member countries –research requirements and status of current knowledge and guidelines – potential for invited speaker.

b) review the reports of the:

vi. Planning Group on the HAC (PGHAC) common data exchange format;

vii. Study Group on Fisheries Optical Technologies (SGFOT);

viii. Study Group on Avoidance Reactions to Vessels (SGARV);

ix. Topic group on EK60 calibration.

c) Advances in the approach and interpretation of animal behaviour. Joint session with WGFTFB and WGFAST on 18 May.

WGFAST will report by 31 July 2009 for the attention of SCICOM.

WGFAST will report to the SSGESST at the 2009 Annual Science Conference in Berlin, Germany, 21 to 25 September 2009.

2 Opening the meeting

2.1 Opening and welcome to WGFAST by Rudy Kloser

Rudy Kloser, chair of WGFAST welcomed participants and thanked Dr. Antonello Sala for his efforts in hosting the meeting and the warm hospitality offered by him and his team. Tim Ryan was appointed as Rapporteur.

2.2 Participants and agenda

A list of the 62 participants from 19 countries appears in Annex 1, agenda appears in Annex 2.

3 Study group updates

3.1 Eirik Tenningen. Update on SGFOT – The Study Group on Fisheries Optical Technologies

The Study Group on Fisheries Optical Technologies (SGFOT) held its third and final meeting in Ancona, Italy on 16–17 May 2009. Eirik Tenningen (Norway) was Chair. There were 12 participants from Australia, Canada, Denmark, Germany, New Zealand, Norway, Sweden and USA.

The Terms of Reference were:

> The Study Group on Fisheries Optical Technologies [SGFOT] (Chair: E. Tenningen, Norway) will meet in Ancona, Italy from 16–17 May 2009 to:

a) Review and finalise the draft Cooperative Research Report on optical technology as agreed at the 2008 SGFOT meeting;

b) Finalise recommendations for future work within optical technology to service the ecosystem approach for fisheries management.

In response to ToR a

> The group continued the work on the report and agreed that the first complete draft will be ready by September 2009 and the final version by December 2009. A Category 1 resolution for an ICES internal publication will be submitted as part of the SGFOT report to SCICOM.

In response to ToR b

> The group had a general discussion on recommendations for future work within optical technology to service the ecosystem approach for fisheries management and the following was agreed:

- Standardising image analysing software and databases
- Develop methodology for making video analysis easier
- Video mosaicing and habitat classification
- Optical technologies for observatories
- Perception and use of light by fish
- Validation of acoustic detections

> The group has also been asked to consider a new working group on optical technologies. The following three options were agreed and passed on to WGFAST for further discussion:

- Start a new working group dealing specifically with optics
- Include optics within FAST as a complementary technology
- Change FAST to include more technologies for observation and assessment of marine living resources with emphasis on the science of observation and quantification with non extractive technologies

After some discussion on point b) it was the preferred position of SGFOT and WGFAST members to include optical systems as a complementary method within the working group. The issues that governed this decision were the common approaches between optical and acoustics, the complementary scales of observations and keeping a cohesive group together with multidisciplinary skills. Bill Karp suggested that this be discussed in more detail at the ICES September ASC meeting.

3.2 Francios Gerlotto. Update on SGFARV – Study Group on Fish Avoidance of Research Vessels

The Study Group met in Ancona, Italy, on 17–18 May 2009 to:

a) produce a review and develop recommendations for the ICES community on methods for the study of physical stimuli produced by fisheries research vessels (platform related stimuli - PRS) and evaluation of reactions by survey-targeted fish;

b) update the literature review on fish reactions and vessel produced stimuli;

c) recommend experiments to further examine the causes of fish reactions to PRS;

d) review progress of the SG according to the agenda defined in 2008.

e) review the draft of an ICES Cooperative Research Report on fish response to vessel produced stimuli, and in particular radiated sound, that will be finalized during the coming year and submitted to ICES in 2010.

The SGFARV meeting was held under the co-chairmanship of Julia Parrish and François Gerlotto and gathered 11 participants (François Gerlotto, Julia Parrish, Patrice Brehmer, Nils Olav Handegard, Dick Wood, Paul Winger, Ken Cooke, Chris Wilson, Marianna Giannoulaki, John Horne, Emma Jones).

The draft of the CRR (provisional title "Causes and consequences of fish reaction to fisheries research vessels") written during the year was submitted to the SG with the following structure:

- Introduction
- Chapter 1. A Historical Review of Underwater Radiated Noise Related to Fisheries
- Chapter 2. Platform Emissions, with Particular Attention to Sound
- Chapter 3. Fish Physiology Related to Hearing
- Chapter 4. A Review of Fish Reaction to Research Vessels, with an Emphasis on Sound-Quieted Vessels
- Chapter 5. Effects of Fish Avoidance on Assessment
- Chapter 6. Further Experiments Needed to Evaluate Fish Reaction to Research Vessels
- Chapter 7. Summary Findings and Recommendation
- Literature review
- Annexes

The draft was revised by the SG and consistent additions were recommended. A completed version will be presented at the 2009 ASC. A final draft will be prepared for approbation at the WGFAST in 2010, in preparation for submission as a CRR manuscript to the ICES Publication Committee.

A table listing all publications and relevant findings has been provisionally prepared and will be sent to authors of papers on fish avoidance in addition to Study Group members, in order to complete the observations on the different types of experiments produced in the last 30 years.

Based on work to date, research priorities were defined and listed as below:

- Research to identify which elements of the sound signature, or other vessel-produced stimuli, result in fish avoidance, both within and among systems, including but not limited to: directivity; tonality; particle motion; gradients; light; multiple stimuli; ambient noise, etc.
- Research to identify the type(s) of avoidance response and the particular environmental, ecological, and biological conditions under which response occurs, including but not limited to: habituation; cycles; species interactions; density (abundance); avoidance patterns, etc.
- Definition of avoidance indicators

The report was presented and discussed at the WGFAST meeting on 20 May.

3.3 Toby Jarvis and Geir Pedersen. Update on the calibration topic group

Toby Jarvis gave an update on the status of the calibration topic group with specific reference to documenting the calibration procedure of the Simrad EK60 echosounder. The report of the topic group will be posted on the WGFAST web site and made available to the planning groups. The calibration topic group has now concluded with a key outcome that a calibration study group is formed with the intention of commencing at the 2010 WGFAST meeting in San Diego.

3.4 David Demer: Proposed study group on calibration of acoustic equipment - SGCal

Following on from the conclusion of the calibration topic group, David Demer presented on the proposed calibration study group SGCal with the following terms of reference:

SGCal will first meet in San Diego, CA, USA, in April/May 2010 to review, summarize, and report on the literature regarding:

- Acoustic systems currently used in fisheries research and surveys;
- Theoretical principles of calibrating these instruments, and
- Methods currently being practiced

SGCal will develop recommendations for methods to be used for acoustic system calibrations including:

- Commonly used acoustic systems used in fisheries research and surveys;
- Principles of calibration, general, and specific to these selected systems; and
- Standard protocols for calibrating these systems (e.g. quantitative system characterizations through to data collections and analyses)

SGCal will prepare a report for possible publication in the *Cooperative Research Report* series including:

- Literature review of acoustic systems commonly used in fisheries science;

- Theoretical and practical principles of system calibrations of generic and selected instruments; and
- Recommended protocols for calibrating generic and selected specific acoustic instruments used in Fisheries Science.

The Study Group would exist for nominally 3 years, concluding with completion of the CRR (to update CRR 144, Foote *et al.*, 1987). The proposed schedule will be:

- May–Sep 09: SGCal recommended /adopted
- April 2010: CRR outlined and principle authors identified
- April 2011: Draft Chapters reviewed
- April 2012: Draft CRR reviewed
- Sept 2012: SGCal final report and CRR submitted

David Demer acknowledged the efforts of Toby Jarvis (Australia), Geir Pedersen (Norway) and Lars Andersen (Norway) for their contribution to the Calibration Topic Group.

The formation of a study group was recommended and discussed. The terms of reference for this proposed study group appears in Annex 4.

3.5 Laurent Berger. Update on PGHAC - Planning Group on the HAC common data exchange format

Laurent Berger gave the following information regarding the terms of reference for the group.

a) Coordinate the further development of the HAC standard data exchange format;

No new development.

b) provide information on the changes in the format and its evolution;

No change in the format

c) Share information between manufacturers and users on the way acoustic data are processed and stored;

Need for validation of HAC output for several sounder manufacturers.

d) Report on how the manufacturers, developers and users see the advantages and disadvantages of HAC and future goals.

The FAST community was surveyed regarding the use of the HAC format, its advantages and disadvantages. There were 12 responses which gave the following information:

Question on HAC usage	number
Use as unique standard for hydroacoustics database	4
Use as an exchange format	2
Do not use the format	6
Would use it if manufacturers are planning to really use it (provide complete HAC files with all relevant information for later post-processing)	5

Other comments

One respondent did not see the interest of a common format and prefers open source reader programs for existing formats.

The HAC format covers existing equipments used in fishery acoustics and has several advantages with one being the ability to combine data from different equipments. The increase use of the format by manufacturers is a key point which will make the format effectively a standard. Standard shared libraries for HAC reading and basic processing would also help dissemination.

Recommendation:

There was consensus that a planning group is no longer needed and that the work of PGHAC can be maintained under the remit of WGFAST.

4 ICES 2008 symposium review

4.1 David A. Demer. Update on 2008 SEAFACTS Symposium edition of the *ICES Journal of Marine Science*

Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, e-mail: david.demer@noaa.gov

David Demer updated the group on the progress of the 2008 Symposium edition of the *ICES Journal of Marine Science*. David Demer and David N. Maclennan were guest editors. A total of 65 papers will be published, with all but three of these now available online. The submitted papers cover the following topics areas:

Topic area	Number
Invited Review – Tony Koslow	1
Ecosystem and Fisheries Monitoring	13
Remote Classification	12
Target Strength	12
Animal Behaviour	11
Data Quality and Integration	16

Publication of the journal edition is due in July 2009.

David Demer acknowledged the 151 reviewers, the ICES steering committee, editors John Ramster, Awie Badenhurst, and Andy Payne, David N. Maclennan, Symposium sponsors, Institute of Marine Research (Norway, Egil Ona and the authors for their efforts in ensuring a timely publication. FAST participants showed their appreciation, by way of applause, for David Demer and David N. Maclennan's contribution as guest editors.

5 Topic A: Fisheries and Ecosystem Acoustic Indicators and the interface between Observation Outputs and Model Uptake including Improved Process Understanding and Assessment of Indicator Goodness of Fit with Ecological and Fishery Assessment Models

5.1 Dick Wood. The Use of Sound Ranging for Defining Acoustic Signature

Bureau Veritas UK Ltd

This paper will outline how underwater noise radiation (URN) measurements are generally undertaken at a noise ranging facility to establish whether or not the vessel

is compliant with contractual URN limits. The discussion will then be extended to other noise measurements that can be acquired whilst on the range and URN data that cannot (such as vessel directivity patterns). The new draft ANSI standard on URN measurements at sea and its relevance to fisheries vessel acceptance trials will also be discussed.

5.2 Toby Jarvis and Ian Higginbottom. Future directions for Echoview

Myriax, GPO Box 1387, Hobart, Tasmania 7001, Australia

As a provider of data-processing and analysis tools to the hydroacoustic research community, we wish to present Echoview's future directions to FAST members for discussion and comment. Echoview's future priority themes are classification (the application of classes to acoustic objects), automation (the minimisation of user input to the processing procedure) and education (for both Echoview and hydroacoustic topics in general). The focus for classification is on maintaining and improving the ability to implement published algorithms, and on a new ability for objects to be "analysis aware" within the program. Automation is focused around Echoview's COM scripting capability, which not only provides the ability to automate repetitive tasks (an increasing priority with ever-expanding datasets), but also to interrogate the data and dynamically change procedures based on the results. Education is an overarching theme intended to promote user autonomy and the free flow of knowledge and ideas within the hydroacoustic community. The traditional avenues of Help documentation, e-mail and phone support, guided tutorials and directed training courses will continue to be provided, in addition to a new emphasis on web-based learning and communication resources with the advent of web meetings, webinars and the imminent release of Echoview's new website.

5.3 Giannoulaki Marianna[1], Liorzou Bernard[2], De Felice Andrea[3], Leonori Iole[4], Valavanis Vasilis[5], Machias Athanassios[6], Pyrounaki Maria Myrto[7], Tsagarakis Konstantinos[8], Roos David[9], Gramolini Roberto[10], Arneri Enrico[11]. The use of acoustics in identifying small pelagics' juvenile habitat in the Mediterranean

[1,5,6,7] Hellenic Centre of Marine Research, P.O. Box 2214, GR 71003, Iraklino, Greece; [2,9] IFREMER HMT/RH Sète, Avenue Jean Monnet, BP 171, 34203 SETE CEDEX, France [3,4,10,11] CNR-ISMAR sez. di Ancona, Sezione Pesca Marittima, Largo Fiera della Pesca, 60125 Ancona, Italy

Acoustic and satellite environmental data as well as bathymetry data were used to model the presence of sardine juveniles (Sardina pilchardus) during early summer as well as the presence of anchovy juveniles (Engraulis encrasicolus) during early autumn in the Mediterranean Sea. Acoustic data recorded with a 38 kHz split beam echosounder from the Aegean Sea (Eastern Mediterranean), the Adriatic Sea and the Gulf of Lions (Western Mediterranean) have been analyzed for this purpose. Satellite data were used as proxies to infer spatial variations of environmental factors and assess possible ecological relationships. Generalized Additive Models (GAMs) were used for modelling and subsequently applied in a predictive mode to identify those regions in the study areas and the entire Mediterranean basin that could support juveniles' presence. Model results were evaluated with the estimation of Receiver Operating Characteristic (ROC)-plots. Mapping the estimated environmental conditions indicated areas that generally agree with the known distribution grounds of anchovy and sardine, such as areas in: the Aegean Sea, the Adriatic Sea, the straits of Sicily and the coastal waters of Tunisia, the Gulf of Lions and the Catalan Sea.

5.4 Trenkel, V M. Combining acoustic and egg derived survey biomass indices for stock assessment: application to Bay of Biscay anchovy

Verena M. Trenkel, Ifremer, BP 21102, 44311 Nantes, France. verena.trenkel@ifremer.fr

A simple two-stage random effects biomass population dynamics model is presented for carrying out fish stock assessments based on survey indices using no commercial catch information. Recruitment and biomass growth are modelled as random effects, reducing the number of model parameters while maintaining model flexibility. No assumptions regarding natural mortality rates are required. The full and two nested models were fitted to anchovy in the Bay of Biscay using two survey series: one derived from acoustic observations and the other based on the daily egg-production method. The resulting relative stock biomass estimates are a smoothed comprise between the two noisy survey indices taking account of population dynamics coherence.

5.5 Ibrahima Diallo[1], Patrice Brehmer[1], and François Gerlotto[3]. Historical review of fisheries acoustics in Guinean Conakry Water: 2009 a new start. Presented by Francois Gerlotto

[1]Centre National des Sciences Halieutiques de Boussoura Conakry, République de Guinée; [2]Oceanraise, 126 Chemin des Olivettes, 34270, Saint Jean de Cuculles, France; [3]CRH, IRD UMR212, 1 Avenue Jean Monnet, 34203, Sète, France

The CNSHB is the official Guinean fisheries center since more than 20 years. We will first present quickly activities of their 65 Researchers, technicians and research vessel. Early, in the end of 1970s, the pelagic fish biomass has been estimating using conventional FAO acoustic method. Nevertheless the technology has often been blocked (devices, project, and hacker). This year a new start has been done, an acoustic team has been constituted and first survey lead with success. The pelagic fish densities are lower than over the Senegal-Mauritania upwelling area, for a total biomass estimated in 1978 around 730 000 tons in 1978, constituted by 60 % of Baliste capriscus in the deeper part of the continental shelf and on the shallower one by Chloroscombrus chrysursus and Sardinnella eba, which represent the last 40 %. The Guinean continental shelf is wide and we underline the importance of the shallow water (0–10 m), which have not been surveyed. Previous surveys have shown that the fish stock is spread from Sierra Leone to Guinea Bissao (7° to 11° North) and two seasons can be distinguished (dry/wet). Future surveys must be done in cooperation with this both countries and ideally twice per year during each season. Apart from stock assessment and spatio-temporal monitoring of pelagic fish population, we project to focus our research activity on the relation between plankton compartment and pelagic fish biomass.

5.6 Rudy J. Kloser, Gordon Keith, Rick Porter-Smith and Mike Fuller. Indicators of deepwater biotopes based on multi-beam acoustics

CSIRO, PO Box 1538, Hobart 7001, Australia

A program to map the deepwater outer shelf and slope biotopes of the Australian EEZ is underway based on fine scale acoustic multi-beam echo sounder (MBES) mapping. This region is target due to a combination of high mega-fauna diversity and human usage. Data are collected on specific research voyages as well as utilising transit voyages between ports. These MBES data are an important input into assessing assets (e.g. canyons, terraces, banks, seamounts) for regional marine planning, informing the placement of MPAs and fisheries spatial management. The acoustic data provide detailed (20 to 50 m grid) bathymetric and inferred substrate informa-

tion that can be used with other co-variates to predict mega-faunal functional groups based on physical and optical "ground truthing". A consistent approach of interpreting ecological hard and soft substrate based on the acoustic backscatter that maximises the spatial resolution whilst minimises sources of error was developed and applied. Ongoing developments in the analysis and mapping of the acoustic backscatter data are compared to a seabed scattering model, physical sampling and spatial scales of biotopes observed from video. We compare the fine scale seabed backscatter indicator with available physical and optical "ground truth" data of seabed terrain, faunal functional groups and mega-fauna diversity. Using the bathymetry and acoustic backscatter data maps of mega-faunal functional group preference with probability of predictions is estimated. The potential effect of demersal trawling to alter these predictions is discussed.

5.7 Rolf J. Korneliussen, Georg Skaret. Acoustic studies in the Antarctic Ocean with RV "G.O. Sars"

Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway

Fishery for krill is a major economical activity in the Antarctic Ocean. The increased Norwegian fishery inherently gives Norway a responsibility to contribute to the management of the marine resources in the southern ocean. During the International Polar Year 2008, RV "G.O. Sars" spent 3 months in the Antarctic Ocean to do investigations on euphausiids and other key components of the ecosystem. Major acoustic activities were to identify krill, estimate specimen size, investigate behaviour, measure target strength *in situ*, and of course verify the acoustic measurements biologically.

Krill were identified from the relative frequency response of a 6-frequency hull-mounted echo-sounder system, and specimen size was estimated acoustically by means of several acoustic scattering models implemented in an optimized framework in the post-processing system LSSS. TS-measurements were carried out using an acoustic multifrequency probe, the hull-mounted echo-sounder system, and single and multi-frequency landers that were dropped and anchored on the bottom of the sub-antarctic islands of South Georgia and Bouvet. A stereo camera was mounted on either a lander or on the probe for measurements of tilt-angles or biological verification. Behaviour and structure of krill schools were investigated by means of the quantitative 500-beam 4D-sonar Simrad MS70, and compared to echo-sounder measurements.

5.8 Patrick H. Ressler and Alex De Robertis. A multifrequency acoustic indicator of euphausiid abundance in the eastern Bering Sea

NOAA Fisheries, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, 98115, USA

An empirical classification algorithm based on backscatter differences at four acoustic frequencies (18, 38, 120, and 200 kHz) has been previously used to identify scattering from walleye pollock (_Theragra chalcogramma_) in acoustic survey data collected in the eastern Bering Sea. Pollock backscatter classified by this multifrequency algorithm compared well ($r^2 > 0.93$) with pollock backscatter classified by the traditional procedure of scrutinizing single frequency echograms.

More recently, this technique has been applied to the same survey data sets to classify backscattering from euphausiids (_Thysanoessa_ spp.), an ecologically important group of zooplankton for which there is no comparable survey time series in the eastern Bering Sea. Various solutions to the challenges encountered in developing a new

acoustic index of euphausiid abundance will be discussed. These include efforts that are now in progress to use net capture to verify classification of euphausiid backscatter, to account for the impact of spatial overlap between pollock and euphausiid aggregations on the classification process, and to develop a target strength estimate that can be used to convert the euphausiid backscatter index into units of numbers and biomass, which can be more easily interpreted in an ecological context. This multifrequency acoustic indicator will provide valuable new information on the distribution and abundance of a key group of organisms in the eastern Bering Sea ecosystem.

5.9 L. Berger and C. Scalabrin. Improving bottom detection by combining multibeam and multifrequency echosounder, impact on echo-integration close to the bottom

Ifremer, BP 70, 29280 Brest, France

Bottom detector provided by sounder manufacturer on fishery echosounder can lead to ambiguous bottom detection on slopes or fish when located close to the bottom, alternative methods can improve the results. In this presentation we will provide an update of ongoing developments combining multi-frequency and multibeam echosounder for automated bottom detection, methods will be evaluated in terms of NASC of layers close to the bottom.

5.10 François Gerlotto [(1)], Arnaud Bertrand [(2)] and Mariano Gutierrez [(3)]. Analysis of the changes in spatial distribution and population structure of the jack mackerel Trachurus murphyi in southern Pacific during the period 1980–2009

[(1)]IRD, CRH, Sète, france, [(2)]IRD, Lima, Peru, [(3)]TASA, Lima, Peru

The oceanic jack mackerel Trachurus murphyi occupies a wide area in the southern Pacific Ocean, from the coast of Chile and Peru until New Zealand and Tasmania. This population is heavily exploited and landings were above 5 million tons during the 1990s and up to 15 million tons in 1993. Since the early 2000 the biomass has significantly decreased and questions arose on the possible collapse of the population.

The population has been studied since the 1970s when the soviet fleet exploited it. Chile and Peru have developed acoustic and oceanographic surveys since the 1980s, and additional data are collected by the industrial fishery (Soviet then Russian, Chinese, Cuban, etc.).

The analysis and synthesis of these acoustic data bases and environment data allowed a hypothesis on the dynamics of the jack mackerel population abundance and distribution according to fishing pressure and habitat condition. Depending on the biomass of the population and the environmental conditions, in particular along the coast, fish occupy differently the Pacific Ocean. In periods of high abundance and when favourable habitat extend toward the coast (deep oxycline and low predation pressure), sub populations (and spawning zones) are observed along the South American coastline at north of 30°S and south of 35°S as well as all along the 40°S latitude from America to New Zealand. When abundance decreases and/or the potential habitat is restricted by the presence of a shallow oxycline and a high abundance of predators (in particular the jumbo squid) the fish tend to leave first the peripheral areas (west and north-east) and concentrate on its "ecological optimum habitat", defined by the hydrological and biotic characteristics along 40°S and between 90°W and 110°W. The concept of metapopulations may apply to the jack mackerel.

5.11 Thomas Laloe [(1)] and François Gerlotto [(2)]. A mathematical method for separating groups of schools recorded by multibeam sonar

[(1)]Université Montpellier 2, Montpellier, France, [(2)]IRD, Sète, France

A hundred schools of anchovies (Engraulis ringens) recorded in Peru using a Reson Seabat multibeam sonar have been used to test a new mathematical method of discrimination. We use an unsupervised learning method based on a L_1 quantization by a nearest neighbour approach.

In order to remove any effect of school dimension a 3D portion of each school has been used as sample. The results show that schools were separated into two major groups, mostly depending on internal characteristics. Some statistical analysis was done on the groups and showed significant differences between the major variables and especially the overall dimensions (length, height, width, volume and surface) and the number of holes inside the schools. The results indicate that the method is convenient for an automatic discrimination of school characteristics.

No relationship between the two groups and environmental data has been done, for the too small dimension of the sample.

5.12 Discussion on fisheries and ecosystem indicators

The discussion on this topic was synthesised to the following issues:

- The topic of indicators was included based on the ICES strategic plan and the need to bridge the gap between science/management needs to use indicators and how we could contribute to the measurement of them with acoustics and complementary technologies.
- There was a need to clearly define what was meant by an indicator and to build on the existing science and literature in this area.
- Based on the existing definition of an indicator and the list of indicators proposed in the European region and elsewhere they should form the basis of our investigation into how we could measure them with acoustics and complementary technologies.

Based on this discussion the following terms of reference were distilled:

a) Ecosystem approach to fisheries management: metrics, indices and indicators. (Topic Group). (Contact Verena.Trenkel@ifremer.fr)

b) Summarise how acoustic and complementary methods can and are addressing fisheries and ecosystem-based management needs.

c) Review and synthesis of the role of acoustic and complementary methods to inform fisheries and ecosystem indicators and ideas for further development.

6 Topic B: Coastal, Shelf and Ocean Observatories for Fisheries and Ecosystem Monitoring. Role of Acoustics for Current Applications, Methods and Technologies and Future Designs

6.1 Dick Wood. The Use of Sound Ranging for Defining Acoustic Signature

Bureau Veritas UK Ltd

This paper will outline how underwater noise radiation (URN) measurements are generally undertaken at a noise ranging facility to establish whether or not the vessel

is compliant with contractual URN limits. The discussion will then be extended to other noise measurements that can be acquired whilst on the range and URN data that cannot (such as vessel directivity patterns). The new draft ANSI standard on URN measurements at sea and its relevance to fisheries vessel acceptance trials will also be discussed.

6.2 John K. Horne, Richard B. Kreisberg, and David H. Barbee. Adding active acoustics to the MARS observatory

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To demonstrate the utility of active acoustics as a core instrument for cabled ocean observatories, a 38 kHz Simrad EK-60 echosounder was packaged and connected to the Monterey Accelerated Research System (MARS) observatory in Monterey Bay at a depth of 875 m. The Deepwater Echo Integrating Marine Observatory System (DEIMOS) integrates the EK-60 with commercial electrical conditioning and communications hardware in a Benthos glass sphere to provide a surface-controlled instrument package with real time display. The MARS node supplies power (48/375 VDC) and an Ethernet (10/100 base-T) connection over a 56 km cable originating at the Monterey Bay Aquarium Research Institute (MBARI). Rackmounted computers within MBARI are used to control DEIMOS, serve data to the web, and to transmit data for analysis and archiving. At pulse rate of 0.2 Hz, 50 Mb of raw data are collected every three hours. ER-60 and data server operating displays can be accessed, controlled, and rebooted using remote interface software and an Ethernet connection. Within the upper 400 m, the water column contains three scattering layers which undergo diel migrations. Individual larger targets are found below the scattering layers. DEIMOS was attached to the MARS node using the ROV Ventana in late February and will remain in the water until fall 2009.

6.3 Patrice Brehmer [(1)], Gorka Sancho [(2)], Erwan Josse [(3)], Marc Taquet [(4)], Stratis Georgakarakos [(5)], David Itano [(6)], Gala Moreno [(7)], Pierre Palud [(8)], Vasilis Trygonis [(5)], Riaz Aumeeruddy [(9)], Charlotte Girard [(10)], John Dalen [(11)], Laurent Dagorn [(12)], François Gerlotto [(13)]. Monitoring fish communities at drifting FADs: an autonomous system for data collection in an ecosystems approach

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An increasing proportion of landings by tuna purse seine fishing vessels are taken around drifting Fish Aggregating Devices (FADs). Although these FADs and their use by the fishing industry to capture tropical tuna have been well documented, operative tools to collect data around them are now required. Acoustic, video, photographic and visual data were collected on fish aggregations around drifting FADs in offshore waters of the western Indian Ocean. Multibeam sonars, multifrequency echosounders, pole-mounted digital video camera and an automated 360° rotating digital photographic camera were deployed from a vessel in the vicinity of FADs, and compared to underwater visual census made by divers. Two prototypes of instrumented buoys equipped with scanning sonar were tested providing positive results on their feasibility and operability. Acoustics methods combined with digital underwater video represent interesting possibilities to remotely study the composition and behaviour of these fish aggregations. The acoustic methods allowed the accurate description of the spatial organisation and dynamics of individual fishes, schools and biotic scattering layers around the FAD, but species identification was difficult. *In situ*

visual, photographic and video observations permitted species identification within a range of 0 to ~ 25 m. However, underwater visual observations were more efficient compared to the photographic and video cameras at detecting the presence of certain fish species around FADs. Obviously both methods are complementary, since the acoustic methods could not identify most fish species and could not detect the presence of small fishes found less than 5 meters under the FAD. These fishes represent a small part of the overall biomass of fish aggregations but they are part of the biodiversity of pelagic ecosystems and may play a major role in ecological processes associated with FADs. The opportunity to incorporate observation tools into the development of future autonomous instrumented drifting buoys for remotely monitoring fish diversity and abundance in the pelagic ecosystems is presented based on our case study. The perspective of autonomously collecting large amounts of basic information useful for ecological and fisheries studies on fish aggregations in the open sea or coastal pelagic environment is emphasized.

6.4 M. Iglesias (1), J. Miquel (1), J. Ariz (2), A. Delgado (2), and N. Díaz (1). Acoustic selectivity in tropical tuna

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Spanish tuna fleet operates in the intertropical waters of the Atlantic, Indian and eastern Pacific oceans having as target species Yellowfin (Thunnus albacares) and Skipjack (Katsuwonus pelamis), annual catches amounting to around 250,000 tones. Tropical tuna caught by purse-seine are mainly obtained through two types of set, over free schools and over artificial floating objects (Fish aggregating devices, FAD). Currently, catches obtained with either mode of fishing are around 50%. Catch of juvenile Yellowfin and Bigeye (Thunnus obesus) by purse-seine FADs operations is considered to be harmful for the stock. The latter is not a target species and is barely caught when the fishery is performed over free schools. Practical methods to reduce the proportion of juvenile tuna catch are needed. Acoustic technology has been used to estimate size and species of the tuna gathering around FADs, based on their target strength (TS). TS varies among species, is considered to be a function of size and is highly dependent of the swimbladder. Skipjack has not swimbladder. Data acquired from fishing vessels in the Indian Ocean in 2005 were processed and from these results a new approach to the problem taking into account the sample design, the tuna behavior and the use of new technology (multifrequency) is proposed.

6.5 Svetlana Kasatkina and Pavel Gasyukov. Some statistical considerations for processing acoustic survey data as factors affecting reliability of abundance estimation

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Length and species compositions based on trawl sampling performed in the acoustic survey polygon are traditionally used to estimate age structure of fish population as well as to estimate conversion factors (as fish backscattering cross-sectional area summed over its length frequency distribution) for converting integrated volume backscattering area to area fish density. These estimations are the principal information for estimating acoustically- derived total fish abundance and abundance indices by age groups as the input data to stock-assessment models.

Different methods for calculating length and species frequencies within survey stratum were tested including traditional methods and methods based on the assumption of the certain probability distribution function (i.e. Atchison method). The highly skewness of distribution functions for acoustic observations (i.e. few extreme values and a large proportion of zero values) was also tested by authors.

The influence of the above mentioned factors on the reliability of abundance values was traced by estimating fish length distributions, mean weighted target strength and abundance by age groups. The developed simulation model was applied to estimate the min variance value as a criterion for testing. Statistical considerations are illustrated by data processing from Baltic acoustic surveys. The results show that statistical methods significantly influence on absolute values and abundance dynamics by years and age groups. This fact is important for VPA tuning using abundance indices from acoustic survey.

6.6 David A. Demer[1], George Randall Cutter[1], and Laurent Berger[2]. Within-beam acoustic measurements of seabed range, slope, hardness, and roughness: examples using multi-frequency EK60 and multibeam ME70 data

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The Simrad EK60 can be configured with multiple, split-aperture, single-beam transducers operating at different frequencies; the scattering spectra allows classifications of both water column and seabed scatter. The Simrad ME70 has multiple configurable beams in the frequency range of 70–120 kHz and can be operated in Bathymetric and Fisheries Modes; volume backscatter can be sampled in Bathymetric Mode and bathymetry can be sampled in Fisheries Mode. Therefore, the echo intensity and phase data from both the EK60 and ME70 systems allow concurrent and thus efficient sampling of fish and their seabed habitat. Here, we describe methods to process the echo amplitude and phase data from multiple split-aperture beams to estimate seabed range, slope, roughness, and normalized surface scattering strength (a hardness metric), and relate these to nearby fish. We also compare bathymetry data collected with the ME70 operating in Bathymetric and Fisheries Modes from the same area of the Bay of Biscay.

6.7 J. Michael Jech and J. Godlewski. Observations of Atlantic herring using DIDSON sonar

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Acoustic observations of Atlantic herring (Clupea harengus) were made with a Dual-frequency Identification Sonar (DIDSON) during the Northeast Fisheries Science Center's annual herring survey in September 2009. The DIDSON was mounted, looking forward, on a tow vehicle with simultaneous stereo video and downward-looking 38-kHz Simrad echo sounder. Herring aggregations were located via hull-mounted EK500 echo sounders and the tow vehicle was deployed and towed at about 2 knots, positioned above and in herring aggregations. Acoustic and optical data were streamed via fibre-optic cable to the lab for real-time viewing. DIDSON data were processed using Myriax Echoview software. Initial processing was set to detect individual targets and track these targets over time. Target detection provided estimates of echo density, which were compared to measures of volume backscatter from the hull-mounted systems. These comparisons can provide estimates of herring target

strength. Target tracking provided measures of herring behavior, both natural and influenced by the tow vehicle.

6.8 David A. Demer and Josiah Renfree. A self-contained, micro-echosounder for long-term autonomous profiling of acoustic scatterers from a variety of platforms

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A 190 kHz micro echosounder (EchoTag) has been developed for long-term, autonomous deployments on buoys, gliders, floats, animals, or numerous other sampling platforms. The EchoTag was designed to be lightweight (1.6 kg), small (length = 225 mm, width = 110 mm, height = 64 mm), deployable to depths of 800 m, and can collect data for over one year. The EchoTag can autonomously sample volume backscattering strength (Sv; dB) versus range to approximately 150 m. The EchoTag features a saltwater switch and a temperature sensor. The temperature is used to estimate sound speed and absorption data for each transmission. The EchoTag was initially deployed from mid-November 2008 through mid-February 2009, at a depth of 150 m, on the LTER CCE-01 mooring to sample the temporal dynamics of fish and zooplankton abundance in the California Current. The EchoTag transmitted three 85.1 W, 1.33 ms pulses hour-1, on the hour, with a 2 second interval, upward at an angle of ~17.5° from the vertical. For each transmission, the EchoTag sampled Sv every 168 μs from the deployment depth of 150 m to the sea surface (7539 samples transmission-1). Scattering from aggregations of fish and zooplankton were classified using echo-amplitude statistics. Also, an analysis of the of the sea-surface echo amplitude revealed a spectra of flat-to-rough conditions, modulated by diel and seasonal atmospheric conditions, and storms.

6.9 Patrice Brehmer (1), Thang Do Chi (2), Thierry Laugier (3), François Galgani (4), Francis Laloë (5), François Gerlotto (1), Audrey M. Darnaude (2), Annie Fiandrino (3), Ivan Pablo Caballero (1), Mouillot David (2). Field investigations for managements and conservation of shallow water lagoons: practices and perspectives

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Coastal lagoons are highly heterogeneous in space and time for both abiotic and biotic variables. This heterogeneity complicates the assessment of their ecological status. Yet, this information is of paramount importance for the monitoring and the preservation of these fragile ecotones and the resources and services they sustain. In this paper we propose an integrative approach for the evaluation of the ecological status of coastal lagoons, based on diagnostic indicators from all major ecosystem compartments from sediment to fish; giving technical and scientific basis for monitoring and management of local environmental issues. In three independent shallow water lagoons, eutrophication states were evaluated. This information was then crossed with data on macrobenthos and fish taxonomic diversity abundance then with ecotoxicological tests enabled to map areas with effects of contaminants. These lagoons were found as different ecological states. One lagoon was found to be in good state but the two others were not, however two opposite lagoon states were situated on the same watershed but with different effluent and water renewal charac-

teristics. There was a limited impact of the eutrophication level on the fish diversity, but not on the macrobenthos populations and relative fish abundance. Atherina boyeri appears to be the more sensitive to eutrophication than others lagoon fish species. Monitoring such complex systems needs to combine numerous data collected independently and continuously. On the basis of our works, we propose a continuous monitoring system in real time, providing simultaneously biotic and abiotic data. The use of diagnostic indicators, risk estimator and GIS representation will simplify the interactions between scientists and managers which allows improving the efficiency of analyses and advices. A rational management needs to coordinate the scientific investigations, after integrative analysis of lagoon potential uses, i.e. taking into account their impact on the ecological organization and functioning. We present an organizational lagoon management model, through what we propose the (i) centralization of the information, (ii) to bring out a priority of use for each lagoon (between conservation, restoration and/or several modes of sustainable exploitation), and (iii) looking for a 'global ecosystem health' status for a holistic approach, integrating eutrophication state, but also ecotoxicological status, fish and birds compartments through their diversity, abundance and behaviour.

6.10 Rudy Kloser (1). Update of an Integrated Marine Observing System for Australia and potential for inclusion of acoustic observatories in phase II

(1) CSIRO Marine and Atmospheric Research, Hobart, Tasmania, Australia

Update of observatories in Australia with potential to include Acoustic backscatter was presented.

6.11 Carla Scalabrin. Update of IFREMER acoustic observatories.

Update of observatories used at IFREMER.

6.12 Bo Lungdren. Shallow water habitat mapping

Overview of a shallow water habitat mapping program using combination of video, imaging sonar and low cost side scan sonars.

6.13 Eirik Tenningen, Olav Rune Godø, and Terje Torkelsen. New landers for monitoring ecosystem dynamics and biodiversity

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Institute of Marine Research have developed a new series of benthic landers that serves as multisensor platforms with focus on advanced collection of acoustic and photographic data. One of the landers is to be deployed outside the Vesterålen area; an area of particular ecological importance for the fisheries because it hosts fish spawning areas and is a corridor for migration of mature fish and drifting fish larvae. The area also contains considerable amounts of cold-water coral reefs, including the large and protected Røst reef. The echosounders will cover the full vertical depth as well as the area surrounding the coral reefs by using vertical and horizontally directed transducers. This gives an overview of plankton and fish biomass in the water column and in the reef habitat. A camera satellite platform is to be placed closer to the reef to give visual information from the reef. A current profiler, sediment trap and sensors measuring temperature, salinity, light, ambient noise will contribute to characterising the physical and biological environment. The lander is cabled to a power and communication buoy at the surface enabling real-time access to the sensors and data.

6.14 Yvan Simard[1,2] and Nathalie Roy[1]. Fixed location acoustic observatories: an example with conventional ADCPs and autonomous hydrophones in St. Lawrence whale feeding grounds

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Within the framework of an ecosystem approach initiative to understand the functioning of the St. Lawrence large marine ecosystem (LME) for generating krill-rich feeding habitats for the endangered Northwest Atlantic blue whales and other rorquals, acoustic observatories were set up along the general circulation pattern transporting the krill. Acoustic Doppler current profilers (ADCP, 307 kHz) were deployed to monitor currents and relative volume backscattering strength (Sv_r) over 8 months in the upper 120 m or 240 m of the water column at 5 stations. Three of the moorings were also equipped with AURAL autonomous hydrophones to record the vocalizations of the rorquals over the basin. Diel vertical migrations (DVM) of the scatterers occurred regularly, even under ice during winter, and the duration of the day/night phases perfectly tracked the photoperiod, except in Spring. At that time, an increase in weak scatterers over the insonified water column, likely associated with the peak production period, was observed for one month. The Sv_r time-series was analyzed separately for 3 DVM phases in an effort to account for the recruitment of scatterers from deeper depths during the night and isolate migrant and non-migrant Sv_r. Time-series of rorquals presence around the stations were obtained from the frequency of their specific vocalizations in the recordings of the autonomous hydrophones. The coupling of the above information with the current profile series allowed inferences on krill transport modes in the system, which will serve to identify the ultimate forcing processes. This project shows the interest of simple acoustic observatories to clearly evidence LME structuring processes over a large continuum of time-space scales, which are involved in the proper functioning of the trophic exchanges through the food web.

6.15 Discussion on observatories.

The discussion on observatories was distilled to the following points:

- Most fixed observatories do not currently use or plan to use backscatter acoustics.
- Need to more clearly demonstrate the results of backscatter acoustics to the wider science community for uptake.
- A lunch time meeting chaired by Y Simard discussed the need for a publication to highlight the key results of backscatter acoustic observatories.
- The 2010 terms of reference should look at observatory metrics, standardisation, and automated methods in more detail.
- Need to include both fixed and mobile observations into an overall observation strategy.
- Good links between members and the other groups such as South Pacific RFMO, CLIOTOP and the Southern Ocean Sentinel program to include backscatter acoustic observations.

Based on this discussion the following action items and terms of reference were distilled:

d) That a topic group established to write a review of acoustic observatory results and submit in an appropriate cross disciplinary journal (lead Y. Simard).

e) F. Gerlotto and N. Handargard will update on interactions with the South Pacific RFMO and CLIOTOP respectively at the next meeting.

f) Suggested ToR for 2010 meeting:

Observing (system) technologies -- Observatories (fixed and mobile) – metrics, data processing, automated methods, data quality, and management. (Presentation Session)

7 Topic C: Target Strength and Species Identification Modeling and Measurement with Particular Emphasis on Validation (Optical And Nets) and Multi-Frequency and Wide Band Measurements

7.1 J.K. Horne[1], J.M. Jech[2], D. Chu[3], C.S. Clay[4], D.T.I. Francis[5], N. Gorska[6], D.V. Holliday[7], B.A. Jones[8], A.C. Lavery[9], D.B. Reeder[10], K. Sawada[11], and T.K. Stanton[12]. Comparing backscatter model predictions from fish and zooplankton

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A workshop examined advantages and constraints of acoustic backscatter models when predicting target strengths of fish and zooplankton. Eighteen people participated in the workshop representing nine backscatter models and six countries. Prior to the workshop, all participants were sent identical data files containing anatomical outlines and material properties of an Atlantic herring (*Clupea harengus*), an Atlantic cod (*Gadus morhua*), an Atlantic Mackerel (*Scomber scombrus*), and a decapod shrimp. All organisms were modeled as a function of length, incident tilt angle (0^o to 90^o), and frequency (12 to 420 kHz). Target strength predictions for Atlantic herring as a function of frequency varied by up to 20 dB among models. Backscatter curves were flat across fish lengths at lower frequencies. As frequency increased, the number of peaks and nulls in backscatter curves increased in all models but locations of nulls differed between models. Backscatter intensity directionality differed among models and increased at higher frequencies. Variation in krill model predictions was lower than those from fish. The number and intensity of peaks and nulls increased with increasing frequency and angles off broadside in dorsal and lateral planes. The combination of higher than anticipated backscatter variability with animated discussions among participants highlighted differences in data treatment and modelling approaches. Workshop recommendations included: modelling standard targets, agreeing on data handling, accuracy of material properties, and documentation of models along with their advantages and constraints.

7.2 Michael Jech[1], John Horne[2], Dezhang Chu[3], Clarence Clay[4], Trevor Francis[5], Natalia Gorska[6], Van Holliday[7], Ben Jones[8], Andone Lavery[9], Benjamin Reeder[10], Kouichi Sawada[11], and Tim Stanton[9] Comparison of acoustic models for standard shapes

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Backscatter model accuracy as a function of frequency (12-400 kHz), target length, and target angle (90° broadside to 0° end-on) were compared among seven models using four standard targets with exact (Modal Series Solution) or approximate analytical solutions in four target classes. Models compared included: Kirchhoff Approximation (KA), Boundary Element Method (BEM), Deformed Cylinder Model (DCM), Distorted Wave Born Approximation (DWBA), Kirchhoff-ray Mode (KRM), Phase-tracking Distorted Wave Born Approximation (PT-DWBA), and Fourier Matching Method (FMM). Standard targets were a homogeneous sphere, a homogeneous prolate spheroid, a homogeneous finite cylinder, and a spherical fluid shell. For each target, target classes included: rigid fixed, pressure release, gas, and weakly scattering. Overall, the BEM matches the exact solutions for standard shapes but is computationally intensive. The KA, KRM, and DCM predict the structure and magnitude of backscattering response curves near normal incidence, have the advantage of reduced computational loads, but decreased accuracy at increasing angles off-broadside. Though computationally intensive, FMM model predictions matched the exact solutions for the homogeneous spherical targets. Weakly-scattering targets were problematic for all but DWBA models as the DWBA models are designed for this boundary condition. All other models predicted maximum target strengths but locations and amplitudes of nulls differed by up to 5 kHz and 10 dB or more, respectively, for weakly-scattering targets. Comparison of model predictions to standard target solutions provides a base for model evaluation and appropriate application.

7.3 Sandra L. Parker-Stetter[1], and John K. Horne[1]. Evaluating multifrequency acoustics for Bering Sea squid assessment

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Fishery-independent abundance estimates of squid biomass in the Bering Sea are not conducted despite the importance of squid in marine mammal diets and a mandated need to set squid bycatch limits for the walleye pollock fishery. In August 2007 we surveyed nekton aggregations using 38, 70, and 120 kHz echosounders and a midwater trawl to examine the potential to acoustically discriminate squid from fish and zooplankton. Nineteen candidate aggregations were sampled for species composition, target identification, and squid life history information. In the absence of single targets, we use supervised and unsupervised amplitude-based techniques to discriminate targets. Unsupervised backscatter (Sv) frequency distributions, frequency-pair differencing, maximum amplitude, or relative backscatter strength techniques alone cannot be used to separate squid from walleye pollock. Supervised versions of

the same approaches allow an analyst to create reference backscatter categories from validated samples. Initial supervised results show increased discrimination between krill, walleye pollock, and squid. If successful, this approach will be applicable to multispecies discrimination.

7.4 Geir Pedersen [(1)], Hector Peña [(2)], and Egil Ona [(2)].. Target strength of some standard, and some not-so-standard, targets in fisheries acoustics using the finite element method

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The finite element method (FEM) is used to calculate target strength of standard targets in fisheries acoustics as a function of frequency and incident sound angle. These targets include spheres, spheroids, and cylinders using different boundary conditions, representing different physical properties of the scatterer. Target strength is also calculated for swimbladder models, chilean jack mackerel (Trachurus symmetricus murphyi), obtained from magnetic resonance imaging. The target strength estimated using FEM is compared with results from other scattering models, results from the swimbladder calculations are also compared with *in situ* measurement data. Some of the greatest advantages using numerical methods like FEM that they can be used at both low and high acoustic frequencies, can handle wide-band pulses, and with no constraints on incidence sound angle relative to the scattering object. It can also in theory handle scattering from all parts of a fish, like its swimbladder, flesh, and bone (fluid-structure interaction). The full potential of accurate fish models from imaging techniques like MRI may be exploited using these numerical methods. The largest downside is that these types of methods are computing expensive. Comparison between the results obtained using FEM and other models shows in general good agreement.

7.5 Sascha M.M. Fässler [(1)], Hector Peña [(2)], and Geir Pedersen [(3)]. Depth-dependent target strength of herring modelled using MRI scans of swimbladders under pressure

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Changes in swimbladder volume and shape of Norwegian spring-spawning herring (Clupea harengus) with pressure were examined by MRI scans of the fish in a purpose-built pressure chamber. The high-resolution three-dimensional reconstructions of the swimbladders were used to compute the tilt angle averaged target strength (TS) at various depth intervals. Transverse sections of 7 fish were scanned with a pixel volume resolution of 1x1 mm in cross section and 1 mm in the axial direction. Swimbladder contours of each transverse section were obtained by two methods: (1) manual tracing, and (2) automatic detection based on a pixel value threshold. Differences between the two methods were examined. Based on the digital contours, a mesh of nodes was created that defined the swimbladder surface for every herring and depth interval. A numerical model was used to compute the backscatter of the swimbladders as a function of fish orientation at 38 kHz. Model results were compared to an extensive set of *in situ* TS values and simple depth-dependent average TS regression formulae are suggested.

7.6 Lucio Calise. Short-range measurements with the Simrad EK60 echosounder with emphasis on calibration accuracy

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Acoustics, signal theory and practical measurements with modern scientific split-beam echosounders indicate that limited hardware bandwidths and approximations in digital processing may affect the measurements, especially if made at short range from the transducer. This is relevant for field calibrations and numerous applications *in situ* and ex situ when performed on targets at short range. The short-range performance of the 38, 120 and 200 kHz Simrad EK60 scientific echosounders were investigated in a large laboratory tank by comparing the actual range and the theoretical target strength of standard targets with the respective measured values by the echosounder itself. Theoretically, range correction for the 38 kHz system is found to be needed to reduce the potential bias in calibration exercises and related TS measurements. For the 120 and for the 200 kHz systems, the measured range delay leads to a theoretical TS error smaller than the claimed systematic error in standard calibrations inside 4 m. Some observed contradictions between theory and measurements were found. The range errors effects on the TS results were not clearly verified. Due to the parameters and processing in EK60 calibration, the short-range errors affect only the single target measurements, while the volume backscattering data remain stable.

7.7 Gareth L. Lawson, Andone C. Lavery, Timothy K. Stanton, and Peter H. Wiebe. Recent advances in multi-frequency and broadband acoustic scattering techniques for the study of zooplankton and fish

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Single-frequency acoustic scattering measurements are often insufficient for the quantification of biologically-relevant quantities like animal abundance or size in heterogeneous scatterer communities. In cases where the scatterer community is reasonably simple and the frequencies employed appropriately positioned relative to relevant characteristics of the frequency response of the dominant scatterers, multi-frequency methods can provide accurate quantification of animal parameters. Such conditions are often not met, however, particularly in the study of zooplankton. In more complex communities, broadband measurements can provide substantial improvements in classification by more fully characterizing the frequency spectrum of scatterers present. Broadband measurements additionally provide enhanced spatial resolution, through pulse compression signal processing techniques. Here, we briefly review applications of a multi-frequency system (43, 120, 200, 420 kHz) in the very different zooplankton communities of two regions in the Antarctic and northwest Atlantic, highlighting both the strengths and limitations of such systems. Next, we present more recent studies employing two heavily modified off-the-shelf sidescan sonar systems spanning frequency bands of 1.7 to 100 kHz and 150 to 600 kHz, with some gaps. Field applications of these systems in the northwest Atlantic confirm their respective abilities for resonance fish classification and the discrimination of copepods from turbulent oceanic microstructure, and hence for the accurate estimation of animal size and abundance. Together these studies demonstrate the power of broadband techniques for the discrimination and quantification of scatterers, and the potential of such techniques for ecological and management applications.

7.8 Adam J. Dunford, Richard L. O'Driscoll (1), Stephane Gauthier and Gavin J. Macaulay. Fishing for answers on hoki target strength. Presented by Richard L. O'Driscoll

National Institute of Water and Atmospheric Research Limited, Private Bag 14-901, Kilbirnie, Wellington 6241, New Zealand.

Target strength (TS) of New Zealand hoki (Macruronus novaezelandiae) has been researched for over 15 years using swimbladder models and *in situ* measurements. Data from swimbladder modelling and *in situ* measurements made in Australia suggest higher values of TS than those observed *in situ* in New Zealand. In an attempt to resolve this discrepancy, acoustic measurements were made on line-caught hoki as they were slowly brought to the surface. Target strength data were successfully collected from three hoki (98–104 cm TL), all on the same line, at about 65 m depth for 8 minutes. The modal target strengths of the three fish were -40 to -44 dB, which were consistent with previous *in situ* TS data from NZ, but were generally lower than swimbladder model results and *in situ* values from Australian hoki. However, there was considerable variability between TS estimates from individual fish (greater than 30 dB), and peak TS values (-25 dB) were much higher than modal values.

7.9 Gavin J Macaulay. The acoustic near-field of fish

National Institute of Water and Atmospheric Research Ltd

It is well known that TS measurements of fish should be conducted in the far-field of the transmitting transducer; formulae exist to estimate this range. It is also well known that the scatter from fish has a near-field region where the pressure does not decay inversely with range. However, little work has been done on the near-field of complex acoustic scatters such as fish and guidelines on working ranges are not readily available. Examples of the need to work at close range includes obtaining photographic images of ensonified fish for visual verification of species, conducting surveys in very shallow water, and making ex-situ TS measurements in small tanks. Some experiments have produced results that suggest the near-field of fish could be larger than a similarly sized transducer.

Numerical models of the scattered pressure field from fish-like objects have been used to estimate the range at which the pressure field satisfies far-field conditions. Guidelines for calculating near-field ranges for fish are proposed.

Two aspects that complicate the interpretation of the results are the assumed origin of radiation from the scattering object and the effect of using a relatively large transducer as the receiver. These arise because the scattering object cannot be treated as a point source, nor the receiving transducer as a point receiver and impose additional restrictions on suitable working ranges.

7.10 Nils Olav Handegard (1), Cato Svellingen (2), Darren White (2), Jan Tore Øvredal (1) and Jens Christian Holst (1). Trawl meter - an automated sampling device for fish

(1) Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway; (2) Scandinavian Controltrol Systems AS, Sandviksbodene 1C, 5035 Bergen, Norway

A new instrumented cod-end is developed and presented. The trawl is towed with an open cod-end which includes a vision system taking high quality colour images of fishes and other organisms passing. The pictures are analysed in real-time by image analysis techniques, and the objective is to automatically identify species and measure the size of individual fish. By undulating the trawl in the water column, 3D size

and species dependent profiles can be estimated. The potential for this technology for scientific trawling and acoustic surveys is discussed. This is especially relevant for species ID in acoustic surveys, 3D ecosystem descriptions and estimating biomass indices of fish species with poor acoustic characteristics, like mackerel. We suggest the system to be used for estimating recruitment indices of mackerel. Other applications of the instrumented cod-end include automatic species and size dependent real-time sorting in commercial fisheries.

7.11 Tim E. Ryan, Rudy J. Kloser and Matt Sherlock. Recent advances in optically measured fish parameters to augment TS measurements from a net-attached Acoustic-Optical System

(1) CSIRO Marine and Atmospheric Research, Hobart, Tasmania, Australia

The recent addition of stereo digital SLR cameras to a net-attached Acoustic-Optical System (AOS) has enabled accurate measurement of fish length, inclination and bearing to augment TS measurements. This system was trialled during a 2008 commercial fishing voyage that targeted the deep-water species, blue grenadier (*Macruronus novaezelandiae*). Optically measured fish metrics were able to be directly linked to concurrent TS measures in 23 instances. How representative these measures are of the schooling population and any potential measurement bias is explored with the larger non synchronised data sets of 3431 blue grenadier TS measures, 642 tracked fish and optically derived metrics from 210 fish. We compare the observed target strength and orientation distributions with existing *in situ* TS estimates and those derived from a model. Future enhancements to improve acoustic-optical synchronisation and optimise the ability to link optical and acoustic measurements in space and time will be discussed.

7.12 Discussion on target strength led by J. Horne

The discussion on target strength and in particular the formation of a study group was led by J. Horne and is distilled as follows.based on the following question:

"Is it timely to revisit TS with a new study group and production of a CRR, noting that the 10 year old CRR does not include modelling."

Suggested ToR for a modelling based look at TS:

Review, summarize, and report:

i) Backscatter models and measurements currently used in fisheries research;

ii) Principles underlying backscatter models; and

iii) Data and methods used to implement model calculations;

Comments on formation of a study group was as below:

- Suggestion to broaden out ToR to include modelling and validation and emphasis iterative combination of both.
- Also suggestion to look at effects of behaviour although study group could become to broad in scope. Ability to document uncertainty and variablity in existing study group that could then have uptake for people who have concerns regarding behavioural effects.
- Concerns were raised about having both calibration and target strength study groups running in parrallel.

- Lunchtime meeting will be held with interested participants to discuss further.

Based on discussions it was concluded to defer decision about a study group till the April 2010 meeting and given the high importance of the topic to have it retained in the 2010 ToR as below:

- Target strength and species identification modeling and measurement with particular emphasis on validation (optical and nets) and multi-frequency and wide band measurements; (JH Presentation session)

8 Topic D: Acoustic observations (passive and active) of spatial and temporal fish behaviour (e.g. spawning, migration) and how this knowledge is or could be incorporated into models and management advice

8.1 Ruben Patel[1] Hector Peña[1] Inge Kristian Eliassen[2] and Egil Ona[1]. New software application to visualize and process omnidirectional multibeam sonar data from schooling fish. Presented by Hector Peña.

[1]Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway; [2]Christian Michelsen Research, P.O. Box 6031, NO-5892 Bergen, Norway.

A new sonar application was designed and can run as a stand-alone application or as a module in Large Scale Survey System (LSSS) software. The module reads raw omnidirectional multibeam sonar data as stored from the scientific output from the Simrad SH80 sonar (110-122 kHz). The present functionalities include replay of sonar data and school interpretation. When running inside LSSS, and if echo sounder data is available, the module allows simultaneously display and sonar data overlay in map and echo sounder views. Also is displayed the beam parameters for each ping in a numerical view together with the school tracking data collected *in situ*. Semi-automatic school detection and tracking algorithms are in development and verified with field school tracking data. Future work includes the processing of data from other sonar (i.e. SP90, SP70, SX90), sonar calibration, processing other beam configurations and improving visualization (multi-ping and 3D).

8.2 Frank R Knudsen[1], Anthony Hawkins[2], and Olav Sand[3]. Effects of diel interactions between sprats and mackerel in a marine lough upon acoustic measurements of fish abundance

[1]Simrad, P.O. Box 111, 3191 Horten, Norway [2]Loughine Ltd, Kincraig, Blairs, Aberdeen, AB12 5YT, Scotland [3]University of Oslo, Department of Molecular Biosciences, P.O. Box 1041 Blindern, 0316 Oslo, Norway

Diel changes in fish behaviour may affect acoustic estimates of fish abundance. Studies in Lough Hyne (Ireland), a marine lake, showed the presence of large numbers of sprat (Sprattus sprattus) and mackerel (Scomber scombrus). The sprats formed dense schools during the day and dispersed into the water column at night. Acoustic estimates of sprat abundance revealed that the estimated biomass at night was more than double the biomass during the day. We have considered whether the lower estimates during day time resulted from acoustic shadowing due to aggregation of the fish into dense schools. However, no decrease in echo energy was evident from the tops to the bottoms of the schools, and there was no reduction in the sea bed echo beneath the schools. Acoustic shadowing was therefore not responsible for the diel differences in the estimates of abundance. Instead, we suggest that the target strength of individual sprats diminished during the day as a result of attacks from predatory mackerel. We

observed echoes from gas released by the sprats as mackerel herded the fish into dense plumes close to the sea bed. Compression of the gas remaining within the swim bladder as the fish were moving deeper would also reduce swim bladder volume. Finally, negative buoyancy due to reduced swim bladder volume may in addition have forced the fish to change tilt angle to compensate for sinking. All these effects will reduce the target strengths of individual fish and lead to underestimation of fish abundance based on daytime surveys.

8.3 Sarine Manoukian[1] and Gianna Fabi[1]. 3D visualization of fish aggregation using EM3002 Multibeam Echosounder

[1]CNR-Istituto di Scienze Marine, Sede di Ancona, Largo Fiera della Pesca, 60125 Ancona, Italy

Fish aggregation is important in terms of biology, ecology, fisheries. Measurement/quantitative analyses of gregarious movement behaviors remain relatively rare. Measurements of fish aggregations are often difficult, particularly in pelagic environments or shallow areas where strong hydrodynamics and/or river input can increase water turbidity. Vertical acoustic surveys in shallow waters have usually limitations related to the sampled volume, the background noise, the surface reverberation and the two dimensional output. These restrictions become even more critical in the investigation of the spatial behaviour of fish aggregation. On the other hand, a multibeam echosounder allows to enlarge the acoustic sampling volume and gives detailed data on the school shape, behaviuor, and distribution integrating the third dimension, but difficulties can persist in the discrimination between fish echoes and bottom/surface echoes. Kongsberg Simrad EM3002 is a high-resolution multibeam echosounder using frequencies of up to 300 kHz discriminating objects of 10 cm and besides the technical and operational improvements, this new system extends the functionality of multibeam echosounders to cover 3D imaging of biomass and other acoustic reflectors that might be present in the water column. 160 acoustic beams are sampled digitally with a spatial resolution of 15 cm for each ping, creating a digital image of a slice of the water mass under the transducer. This new feature makes the EM3002 perfect for surveying of fishery habitats, offering simultaneous and co-registered data collection of bathymetry, seabed backscatter imagery and water column backscatter obtaining very detailed seafloor acoustic image and giving information on fish aggregation.

8.4 Julian B. Burgos[1] and John K. Horne[1]. Environmental influences on distribution patterns of walleye pollock (*Theragra chalcogramma*). Presented by John K. Horne

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Statistical models can quantify influences of physical and biological factors on spatial distribution patterns of pelagic and semi-demersal fishes. We examined relationships between walleye pollock distributions and environmental variables in four surveys in the eastern Bering Sea using 2 km elementary sampling distance units (ESDUs) and metrics derived from landscape ecology. Factor analysis indicated that distributions can be characterized using patch size, vertical distribution, spatial aggregation, and packing density. Generalized Additive Models (GAMs) were used to examine relationships between these factors and environmental variables: sea surface temperature (SST), SST gradient, SST local variability, bottom temperature (BT), thermocline depth, sea surface salinity, chlorophyll-a concentration, prey index, time of day, and location. During summer surveys walleye pollock acoustic density was positively

related to bottom depth and bottom slope. Higher densities were observed in locations with SST values above 6°C and BTs above 1°C. In winter, walleye pollock density increased with bottom depth, but decreased with SST. ESDUs with higher density were related to larger patches, higher levels of aggregation, higher packing densities, and vertical distributions closer to the bottom. Consistent relationships were also observed between patch size and bottom slope, SST slope, bottom depth, and between spatial aggregation and SST and BT. Time of day was a good predictor of spatial distribution, indicating that walleye pollock undergo a diel cycle. Inconsistent relationships between small-scale (ESDU) distributions and environmental covariates suggest that walleye pollock spatial patterns are determined by local densities and vertical migrations.

8.5 Thomas Weber[1], Tyler Clark[1], and Maurice Doucet[2]. ME70 Seafloor Characterization and 4D Water Column Visualization

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[2]Institute of Oceanology of Polish Academy of Sciences, ul. Powstancow, Warszawy 55, PL-81-712 Sopot, Poland.

The Simrad ME70 multibeam echo sounder has the potential to conduct simultaneous seafloor and mid-water analysis. This talk will examine one approach to seafloor mapping and bottom characterization using a standard water column mode, which utilizes split-beam processing to realize several independent bottom detections per beam. The limitations of this approach - including the maximum grazing angle for which split-beam processing is useful - will be discussed. Examples of water column data visualizations, and raw data extraction, using a new software tool developed by IVS-3D, will also be presented.

8.6 Discussion on acoustic observations of fish behaviour

As background to the discussion it was noted that 4 talks were presented in the Joint FTFB and FAST session that is summarised in

http://www.ices.dk/workinggroups/ViewWorkingGroup.aspx?ID=201.

The focus of the discussion was on how our observation and measurements of behaviour may be used in the ecosystem approach to management. Issues that were discussed included:

- Scale of variability and trying to correlate scale of biological distribution to environmental is difficult. Suggests it is better to look at larger scale.
- Behaviour is the interface between the fish and the environment. All the behavioural parameters are an indicator of the interaction between fish and environment. Acoustic surveys may give new metrics to understand the dynamics between fish and their environment. If this is correct then fish behaviour needs to be observed all the time, and fishers are best placed to observe this.
- Given the importance of understanding behaviour for our interpretation of observations it was proposed to include a behaviour topic in the 2010 ToR as follows:

Proposed ToR for 2010:

- Behavioural metrics, indices and indicators of the status of fish populations from acoustic information collected by research and fishing vessel and other stationary and mobile platforms (FG presentation session).

9 Topic E: Anthropogenic Sound Impacts on Fish: Update of Issues from Member Countries – Research Requirements and Status of Current Knowledge and Guidelines

9.1 Tony Hawkins[1] (Invited speaker). The effects of human generated sounds on fish

[1]Loughine Ltd

Sound is important for many aquatic organisms, including fish. Sound is used by fish for communicating, navigating, seeking out prey and avoiding predators. Hearing is an everyday sense, detecting the many changes that are taking place around the fish. This paper will draw together knowledge on the importance of underwater sound to fish and to the effects of sounds upon them, whether those sounds occur naturally, are made by the fish themselves, or result from human activities.

There is currently particular concern over the effects of human-generated sound on fish. However, very little direct information is available. The sources include sounds from ships, sonar systems, pile drivers, wind-turbines, and seismic air-guns. Findings suggest that human-generated sounds, even from very high intensity sources, may have no effect in some cases but in others result in effects that range from small and temporary shifts in behaviour to immediate death. For a variety of reasons it is difficult to extrapolate from one set of results to another. The present paper discusses the various sources, the potential effects of sound on fish and the results from several recent experimental studies, and points out areas for future research which may lead to better understanding of the effects of human generated sounds on fish.

9.2 Donovan, C. R., Harris, C.M., and Harwood, J. A simulation-based method for quantifying and mitigating the effects of anthropogenic sound on marine fauna

Centre for Research into Ecological and Environmental Modelling and Sea Mammal Research Unit, University of St Andrews

The SAFESIMM (Statistical Algorithms For Estimating the Sonar Influence on Marine Megafauna) algorithm is a software tool for estimating the potential effects of anthropogenic noise on marine fauna. SAFESIMM can also be used to compare the effectiveness of different strategies for mitigating the effects of anthropogenic sound by determining the risk associated with these strategies under a range of scenarios. For example, a proposed military sonar trial can be analysed with SAFESIMM to determine the likely effects of changes in operational parameters (such as the trial location and time of year, or the source level, frequency and duty cycle of the sonar) on the risk to marine fauna.

9.3 Yvan Simard[1,2], Nathalie Roy[1] and Richard Lepage[2]. Characteristics of underwater noise marine life are exposed to along a medium traffic seaway: The St. Lawrence Seaway.

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[2]Marine Sciences Institute, University of Québec at Rimouski, Rimouski, Québec G5L 3A1, Canada

The effect of anthropogenic noise on marine life is a growing concern in several regional ecosystems as well as in whole ocean basins. Initially, the objects of concern were marine mammals, which are known to strongly rely on their acoustic tools for communication and echolocation. Now, increasing knowledge evidences that noise may also affect important functions of fish behaviour, namely during reproduction or for sensing their environment. With the increase of anthropogenic uses of the marine ecosystem, especially the growing transportation of world merchandises through shipping, the noise levels were shown to double every decade since the sixty's in some areas where measurements were available. Despite its importance, we still know very little of the ambient noise characteristics in most of the highly used habitats by marine mammal and fish. Obvious areas requiring assessments of the present noise levels are habitats along major world transport seaways. This paper summarizes recent multi-year investigations of noise characteristics on a major continental shipping route of North America, the St. Lawrence Seaway, especially in the traditional whale feeding ground of the Saguenay–St. Lawrence Marine Park. Results are compared to other areas where similar information is available.

9.4 Discussion on Anthropogenic Sound Impacts on Fish

The FAST working group discussed how it could contribute to the wider debate of anthropogenic sound impacts on fish. In particular Tony Hawkins is thanked for providing background to the topic and insights into future needs for research. In general we require more information about sound sources that are likely to cause damage (e.g. seismic, pile driver) whilst also noting, noise from ships is a chronic problem that is not easily addressed. As an example experiments on sea-based wind farms to see what particle motion is occurring would be beneficial. Preference would be to focus research on the most dangerous sound sources. For example those that could kill fish, or prevent their movement to spawn. An area where WGFAST could inform the debate would be to review fisheries acoustic devices their characteristics (e.g. frequencies, sources, directivities, pulse repetition) and place this in context with other natural and human sources to inform the debate on regulation of anthropogenic noise.

For the fisheries acoustic part, what is needed is to bound the impacts of echosounders by describing: a) the characteristics of our "fisheries acoustics" emissions (pulse duration, type, frequency, bandwidth, SL (pp, 0-p, and rms), repetition rate), b) their differences (if any) relative to other echosounders and impulsive sounds (e.g. seismic, pile driving), c) the proportion of acoustic FRVs in the whole fleet of vessels using echosounders, and d) a comparison of this "fisheries acoustic footprint" with the other anthropogenic and biological footprints (essentially clicks and pulse tones from odontocetes, and some dolphin high-freq. whistles) in terms of the contribution to overall noise levels, impacted ranges, and duty times.

Based on this discussion the following recommendation was distilled:

- Based on our use of active sound in the ocean there is a need to review and document its footprint and place this in context with other natural and anthropogenic sources and the relative impact on marine biota.
- Review and documentation of fisheries acoustic devices their characteristics (e.g. frequencies, sources, directivities, pulse repetition) and place this in context with other natural and human sources. (invited speaker – topic group--review)

To achieve this it is suggested that a small group is formed and report to the WGFAST in April 2010.

10 WGFAST Business

10.1 Target strength of redfish (Update from Mick Jech)

The Planning Group for Redfish Surveys (PGRS) was established in 2009 to plan and report on redfish surveys conducted in the North Atlantic: Irminger and Norwegian Sea. The PGRS group chair (P. Benjamin) has made a request to FAST to participate in a workshop with the following draft objectives:

- Review published research relevant to the determination of acoustic target strength of beaked redfish (*Sebastes mentella*);
- Review ongoing work relevant to the determination of acoustic target strength of beaked redfish;
- Propose a target strength equation for *S. mentella* based on the best available scientific knowledge; and
- Describe and recommend additional research which may be required to improve the target strength equation.

Currently there are 3 TS-length relationships used by various countries with differences in abundance of up to 2.5. There is a perceived need for a robust and agreed upon TS equation. The PGRS has proposed a workshop for 2010 and have made a request for FAST assistance and to take the leading role.

The meeting endorsed that Mike Jech continues to interact with the PGRS and to attend the workshop and provide feedback from FAST members.

Some points on the terms of reference from the meeting included:

- that uncertainty in target strength measurements be included in the ToR and may require further research
- Request for best linear regression and best scientific knowledge are contradictory given the 20logL relationship is a first order estimate. One recommendation is that they should consider variability and this might show existing models are statistically the same.
- Suggest invitations be sent out to identified individuals to attend which will help them raise internal funding.

Recommendation that Mike Jech be the contact for redfish target strength with PGRS and to update WGFAST as appropriate.

10.2 Retiring members

It is with pleasure that we acknowledge two active WGFAST participants, John Anderson and Andrea Orlowski who have now retired. John's contributions to WGFAST was acknowledged and in particular his chairing of the study group that produced a CRC report on seabed classification. Andrea was acknowledge. for his enthusiasm and wonderful hosting of the WGFAST meeting in 2004 and pioneering work on seabed classification and acoustic ecology. We look forward to continued interaction over the coming years.

10.3 Dates for 2010 meeting

At the invitation of David Demer of the NOAA Southwest Fisheries Science Centre WGFAST have been invited to meet in San Diego in 2010. WGFAST recommends that this meeting occurs between 26 and 30 April. Nominal structure will be for the study groups to meet on 26 and 27 April and for the main WGFAST meeting to run from 27 to 30 April.

10.4 WGFAST 2011 meeting

WGFAST has received an invite to Iceland for the 2011 joint meeting between WGFTFB and WGFAST.

10.5 Awards

At the combined WGFTFB and WGFAST meeting Kjell Olsen was nominated for the ICES award in recognition of support given to ICES as one of the founders and past chair of the WGFAST working group and contributions to all levels of ICES during his carrer. WGFAST members were advised to send letters of support to the awards committee by the 1 June. Francois Gerlott prepared the FAST supporting documentation.

11 Recommendations

11.1 Terms of Reference for the 2010 WGFAST meeting

The discussion on the terms of reference for the next WGFAST meeting resulted in the following recommendations:

The Working Group on Fisheries Acoustics, Science and Technology [WGFAST] (Chair: Rudy Kloser, Australia) will meet in San Diego, USA from 13:00 hrs Tuesday 27 April to Friday 30 April 2010:

a) In response to the ICES strategic plan 2009–2013, WGFAST will document how acoustic and complementary methods will contribute to the goals of an ecosystem approach with benthic and pelagic observations to improve assessment and management of living marine resources, understanding mechanisms and processes of change and stability, and parameterise and evaluate models of ecosystem structure and function.

1. Ecosystem approach to fisheries management: metrics, indices and indicators. (Topic Group). (Contact Verena.Trenkel@ifremer.fr contact prior to the 2009 ASC for input)

    a. Summarise how acoustic and complementary methods can and are addressing fisheries and ecosystem-based management needs.

b. Review and synthesis of the role of acoustic and complementary methods to inform fisheries and ecosystem indicators and ideas for further development.

2. Observing (system) technologies -- *Observatories* (fixed and mobile) – metrics, data processing, automated methods, data quality, and management. (Presentation Session)

3. Target strength and species identification modeling and measurement with particular emphasis on validation (optical and nets) and multi-frequency and wide band measurements; (Presentation session)

4. Behavioural metrics, indices and indicators of the status of fish populations from acoustic information collected by research and fishing vessel and other stationary and mobile platforms. (Presentation session –F. Gerlotto)

5. Review of long time series survey programs including acoustic and complementary technologies and implications for assessment/ecological model data assimilation. (Presentation session)

b) Based on our use of active sound in the ocean there is a need to review and document its footprint and place this in context with other natural and anthropogenic sources and the relative impact on marine biota.

6. Review and documentation of fisheries acoustic devices their characteristics (e.g. frequencies, sources, directivities, pulse repetition) and place this in context with other natural and human sources. (invited speaker – topic group--review)

c) review the reports of the:

7) Study Group on Calibration of Acoustic Equipment (SGCal) (DD); and

8) Study Group on Avoidance Reactions to Vessels (SGARV) (FG).

9) Receive an update of the PGRS Red Fish Target strength meeting (MJ).

10) Receive an update of the MAAS program (NH)

11) Receive update of the observatories publication topic group (YS)

12) Receive an update of the ICES anthropogenic sound working group (TH)

WGFAST will report by 31 July 2010 for the attention of the SCICOM Steering Group on Ecosystem Surveys Science and Technology.

11.2 Study, Planning and Topic Groups

Recommendation: WGFAST recommends that SGCal, David Demer (USA), Chair, work towards an ICES Cooperative Research Report and meet in San Diego USA from 26 April to 12:00 hrs 27 April. The result of their meeting to be reported to the WGFAST on 29 April 2010.

Recommendation: WGFAST recommends that SGFOT, Eirik Tennigen, Chair, complete their CRR and present the final report at the April 2010 meeting and that optical technologies be included in WGFAST activities as a complementary technology.

Recommendation: WGFAST recommends that SGARV, Francois Gerlotto (France) and Julia Parish (USA), Co-Chairs, finalise a ICES Cooperative Research Report and meet in San Diego USA from 26 April to 12:00 hrs 27 April. The result of their meeting to be reported to the WGFAST on 29 April 2010.

Recommendation: That the planning group PGHAC is dissolved and duties retained within WGFAST.

Recommendation : That a topic group on observatories be formed (Y. Simard) to prepare a review publication on acoustic observatories and future needs and report to 2010 meeting.

Recommendation: That a topic group be established on fisheries and ecosystem indicators (V. Trenkel) to prepare a review publication of the contribution by acoustic and complementary technologies and report to the 2010 meeting.

11.3 Theme Sessions for the ICES 2010/2011 Annual Science Conference

Recommendation: in our continuing effort to contribute to the ICES Annual Science Conferences, WGFAST proposes the following Theme Sessions for the 2010 Annual Science Conferences:

SGFOT and WGFAST recommend a theme session on "Optical and image based technologies for ecosystem approach to fisheries management" be proposed for the 2010 ASC. Convener: Eirik Tenningen (Norway).

WGFAST in collaboration with other assessment and survey based expert groups recommend a theme session in 2010 on the ecosystem-based fisheries management information needs from surveys: metrics, indices and indicators. Conveners – to be determined.

11.4 Closure of meeting

Rudy Kloser closed the meeting by thanking Antonello Sala for his great efforts in hosting the meeting, noting that to host a joint session is a very big task. Rudy Kloser thanked Tim Ryan for his work as Rapporteur. The session discussion leaders, subgroup leaders and all presenters and participants were thanked for their contributions to the working group.

Annex 1: List of participants

Name	Surname	e-mail	Institute	Nation
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Annex 2: Agenda

Tuesday May 19th

08:50 Housekeeping

09:00 Study Group update

09:40 Topic Group update

09:50 Calibration Study Group ToR

10:10 SEFACTS publications

10:20 Morning Tea Break

Topic E Anthropogenic Sound Impacts on Fish: Update of Issues from Member Countries –Research Requirements and Status of Current Knowledge and Guidelines

10:50 A D Hawkins. (Invited speaker) The effects of human generated sounds on fish.

11:10 FAST contribution

11:30 FAST contribution ToR

11:50 Donovan, C. R., Harris, C.M., and Harwood, J. A simulation-based method for quantifying and mitigating the effects of anthropogenic sound on marine fauna.

12:10 Yvan Simard, Nathalie Roy and Richard Lepage. Characteristics of underwater noise marine life are exposed to along a medium traffic seaway: The St. Lawrence Seaway

12:30 Lunch Break

14:00 Dick Wood. The Use of Sound Ranging for Defining Acoustic Signature.

14:20 FAST contribution

Topic D Acoustic observations (passive and active) of spatial and temporal fish behaviour (e.g. spawning, migration) and how this knowledge is or could be incorporated into models and management advice

14:40 Ruben Patel, Hector Peña, Inge Kristian Eliassen, and Egil Ona.. New software application to visualize and process omnidirectional multibeam sonar data from schooling fish.

15:00 Frank R Knudsen, Anthony Hawkins, and Olav Sand. Effects of diel interactions between sprats and mackerel in a marine lough upon acoustic measurements of fish abundance.

15:20 Sarine Manoukian and Gianna Fabi. 3D visualization of fish aggregation using EM3002 Multibeam Echosounder.

15:40 Afternoon Tea Break

16:00 Julian B. Burgos and John K. Horne. Environmental influences on distribution patterns of walleye pollock (*Theragra* chalcogramma).

16:20 Thomas Weber, Tyler Clark, and Maurice Doucet. ME70 Seafloor Characterization and 4D Water Column Visualization.

16:40 Discussion

17:00 Discussion FAST ToR

17:20 Close

Wednesday May 20th

08:50 Housekeeping

Topic A: Fisheries and Ecosystem Acoustic Indicators and the interface between Observation Outputs and Model Uptake including Improved Process Understanding and Assessment of Indicator Goodness of Fit with Ecological and Fishery Assessment Models

09:00 Toby Jarvis and Ian Higginbottom. Future directions for Echoview.

09:20 Giannoulaki Marianna, Liorzou Bernard, De Felice Andrea, Leonori Iole, Valavanis Vasilis, Machias Athanassios, Pyrounaki Maria Myrto, Tsagarakis Konstantinos, Roos David, Gramolini Roberto, Arneri Enrico. The use of acoustics in identifying small pelagics' juvenile habitat in the Mediterranean.

09:40 Trenkel, VM. Combining acoustic and egg derived survey biomass indices for stock assessment: application to Bay of Biscay anchovy.

10:00 Ibhaima Diallo, Patrice Brehmer, and François Gerlotto. Historical review of fisheries acoustics in Guinean Conakry Water: 2009 a new start.

10:20 Morning Tea Break

10:50 Rudy J. Kloser, Mark Lewis, Tim Ryan, Caroline Sutton and Jock Young. Mapping the distribution and abundance of mirconekton fish at basin scales – potential and challenges.

11:10 Rolf J. Korneliussen, Georg Skaret. Acoustic studies in the Antarctic Ocean with RV "G.O. Sars".

11:30 Patrick H. Ressler and Alex De Robertis. A multifrequency acoustic indicator of euphausiid abundance in the eastern Bering Sea.

11:50 Berger, L., and Scalabrin, C.. Improving bottom detection by combining multibeam and multifrequency echosounder, impact on echo-integration close to the bottom.

12:10 François Gerlotto, Arnaud Bertrand and Mariano Gutierrez. Analysis of the changes in spatial distribution and population structure of the jack mackerel Trachurus murphyi in southern Pacific during the period 1980-2009.

12:30 Lunch Break

14:00 Thomas Laloe and François Gerlotto. A mathematical method for separating groups of schools recorded by multibeam sonar.

14:20 Indicators FAST

14:40 Indicators FAST

Topic B: Coastal, Shelf and Ocean Observatories for Fisheries and Ecosystem Monitoring. Role of Acoustics for Current Applications, Methods and Technologies and Future Designs

15:00 John K. Horne, Richard B. Kreisberg, and David H. Barbee. Adding active acoustics to the MARS observatory.

15:20 Patrice Brehmer, Gorka Sancho, Erwan Josse, Marc Taquet, Stratis Georgakarakos, David Itano, Gala Moreno, Pierre Palud, Vasilis Trygonis, Riaz Aumeeruddy, Charlotte Girard, John Dalen, Laurent Dagorn, François Gerlotto. Monitoring fish communities at drifting FADs: an autonomous system for data collection in an ecosystems approach.

15:40 Afternoon Tea Break

16:00 M. Iglesias, J. Miquel, J. Ariz, A. Delgado, and N. Díaz. Acoustic selectivity in tropical tuna.

16:20 Svetlana Kasatkina and Pavel Gasyukov. Some statistical considerations for processing acoustic survey data as factors affecting reliability of abundance estimation.

16:40 David A. Demer, George Randall Cutter, and Laurent Berger. Within-beam acoustic measurements of seabed range, slope, hardness, and roughness: examples using multi-frequency EK60 and multibeam ME70 data.

17:00 J. Michael Jech and J. Godlewski.. Observations of Atlantic herring using DIDSON sonar.

17:20 Close

Thursday May 21st

08:50 Housekeeping

Topic B Coastal, Shelf and Ocean Observatories for Fisheries and Ecosystem Monitoring. Role of Acoustics for Current Applications, Methods and Technologies and Future Designs

09:00 David A. Demer and Josiah Renfree. A self-contained, micro-echosounder for long-term autonomous profiling of acoustic scatterers from a variety of platforms.

09:20 Patrice Brehmer, Thang Do Chi, Thierry Laugier, François Galgani, Francis Laloë, François Gerlotto, Audrey M. Darnaude, Annie Fiandrino, Ivan Pablo Caballero, Mouillot David. Field investigations for managements and conservation of shallow water lagoons: practices and perspectives.

09:40 Rudy Kloser, Update of an Integrated Marine Observing System for Australia and potential for inclusion of acoustic observatories in phase II.

10:00 Carla Scalabrin Update of IFREMER acoustic observatories.

10:20 Morning Tea Break

10:50 Eirik Tenningen, Olav Rune Godø, and Terje Torkelsen. New landers for monitoring ecosystem dynamics and biodiversity.

11:10 Yvan Simard and Nathalie Roy. Fixed location acoustic observatories: an example with conventional ADCPs and autonomous hydrophones in St. Lawrence whale feeding grounds.

11:30 Observatories

11:50 Observatories ToR

12:10 Observatories ToR

12:30 Lunch Break

Topic C: Target Strength and Species Identification Modelling and Measurement with Particular Emphasis on Validation (Optical and Nets) and Multi-Frequency and Wide Band Measurements

14:00 J.K. Horne, J.M. Jech, D. Chu, C.S. Clay, D.T.I. Francis, N. Gorska, D.V. Holliday, B.A. Jones[8], A.C. Lavery, D.B. Reeder, K. Sawada, and T.K. Stanton. Comparing backscatter model predictions from fish and zooplankton.

14:20 Michael Jech, John Horne, Dezhang Chu, Clarence Clay, Trevor Francis, Natalia Gorska, Van Holliday, Ben Jones, Andone Lavery, Benjamin Reeder, Kouichi Sawada, and Tim Stanton Comparison of acoustic models for standard shapes.

14:40 Sandra L. Parker-Stetter, and John K. Horne· Evaluating multifrequency acoustics for Bering Sea squid assessment.

15:00 Geir Pedersen, Hector Peña, and Egil Ona.. Target strength of some standard, and some not-so-standard, targets in fisheries acoustics using the finite element method.

15:20 Sascha M.M. Fässler, Hector Peña, and Geir Pedersen. Depth-dependent target strength of herring modelled using MRI scans of swimbladders under pressure.

15:40 Afternoon Tea Break

ICES Tech Group

16:00 Karp

18:00 Close

Friday May 22nd

08:50 Housekeeping

Topic C: Target Strength and Species Identification Modeling and Measurement with Particular Emphasis on Validation (Optical And Nets) and Multi-Frequency and Wide Band Measurements

09:00 Lucio Calise. Short-range measurements with the Simrad EK60 echosounder with emphasis on calibration accuracy.

09:20 Gareth L. Lawson, Andone C. Lavery, Timothy K. Stanton, and Peter H. Wiebe. Recent advances in multi-frequency and broadband acoustic scattering techniques for the study of zooplankton and fish.

09:40 Adam J. Dunford, Richard L. O'Driscoll, Stephane Gauthier, and Gavin J. Macaulay. Fishing for answers on hoki target strength.

10:00 Gavin J Macaulay. The acoustic near-field of fish.

10:20 Morning Tea Break

10:50 Nils Olav Handegard, Cato Svellingen, Darren White, Jan Tore Øvredal, and Jens Christian Holst. Trawl meter - an automated sampling device for fish.

11:10 Tim E. Ryan; Rudy J. Kloser. Recent advances in optically measured fish parameters to augment TS measurements from a net-attached Acoustic-Optical System.

11:30 Jech –Target Strength red fish

11:50 Target Strength/ Model

12:10 Target Strength/ Model ToR

12:30 Lunch Break

14:00 Fair opening address

15:00 FAST 2010 ToR

14:40 FAST 2010 ToR

17:00 Close

Annex 3: WGFAST draft resolution for 2010

The **Working Group on Fisheries Acoustic Science and Technology** [WGFAST] (Chair: Rudy Kloser, Australia) will meet in San Diego, USA from 27 to 30 April 2010 to:

a) In response to the ICES strategic plan 2009–2013, WGFAST will document how acoustic and complementary methods will contribute to the goals of an ecosystem approach with benthic and pelagic observations to improve assessment and management of living marine resources, understanding mechanisms and processes of change and stability, and parameterise and evaluate models of ecosystem structure and function.

1. Ecosystem approach to fisheries management: metrics, indices and indicators. (Topic Group). (Contact Verena.Trenkel@ifremer.fr)

    a. Summarise how acoustic and complementary methods can and are addressing fisheries and ecosystem-based management needs.

    b. Review and synthesis of the role of acoustic and complementary methods to inform fisheries and ecosystem indicators and ideas for further development.

2. Observing (system) technologies -- *Observatories* (fixed and mobile) – metrics, data processing, automated methods, data quality, and management. (Presentation Session)

3. Target strength and species identification modeling and measurement with particular emphasis on validation (optical and nets) and multi-frequency and wide band measurements; (Presentation session)

4. Behavioural metrics, indices and indicators of the status of fish populations from acoustic information collected by research and fishing vessel and other stationary and mobile platforms. (Presentation session)

5. Review of long time series survey programs including acoustic and complementary technologies and implications for assessment/ecological model data assimilation. (Presentation session)

b) Based on our use of active sound in the ocean there is a need to review and document its footprint and place this in context with other natural and anthropogenic sources and the relative impact on marine biota.

6. Review and documentation of fisheries acoustic devices their characteristics (e.g. frequencies, sources, directivities, pulse repetition) and place this in context with other natural and human sources. (invited speaker – topic group--review)

c) Review the reports of the:

7. Study Group on Calibration of Acoustic Equipment (SGCal) (DD); and

8. Study Group on Avoidance Reactions to Vessels (SGARV) (FG).

9. Receive an update of the PGRS Red Fish Target strength meeting (MJ).

10. Receive an update of the MAAS program (NH)

11. Receive update of the observatories publication topic group (YS)
12. Receive an update of the ICES anthropogenic sound working group (TH)

WGFAST will report by 30 June 2010 for the attention of the SCICOM Steering Group on Ecosystem Surveys Science and Technology.

Supporting Information

Priority:	Fisheries acoustics and complementary technologies provide the necessary tools and methods to implement the ecosystem approach to fisheries management within ICES and research into their application and further development is vital.
Scientific justification	Term of Reference a) In response to the ICES strategic plan 2009–2013, WGFAST will document how acoustic and complementary methods will contribute to the goals of an ecosystem approach with benthic and pelagic observations to improve assessment and management of living marine resources, understanding mechanisms and processes of change and stability, and parameterise and evaluate models of ecosystem structure and function. 1. Ecosystem approach to fisheries management: metrics, indices and indicators. (Topic Group). (Contact Verena.Trenkel@ifremer.fr) a. Summarise how acoustic and complementary methods can and are addressing fisheries and ecosystem-based management needs. b. Review and synthesis of the role of acoustic and complementary methods to inform fisheries and ecosystem indicators and ideas for further development. 2. Observing (system) technologies -- Observatories (fixed and mobile) - metrics, data processing, automated methods, data quality, and management. (Presentation Session) 3. Target strength and species identification modeling and measurement with particular emphasis on validation (optical and nets) and multi-frequency and wide band measurements; (Presentation session) 4. Behavioural metrics, indices and indicators of the status of fish populations from acoustic information collected by research and fishing vessel and other stationary and mobile platforms. (Presentation session) 5. Review of long time series survey programs including acoustic and complementary technologies and implications for assessment/ecological model data assimilation. (Presentation session) b) Based on our use of active sound in the ocean there is a need to review and document its footprint and place this in context with other natural and anthropogenic sources and the relative impact on marine biota. 6. Review and documentation of fisheries acoustic devices their characteristics (e.g. frequencies, sources, directivities, pulse repetition) and place this in context with other natural and human sources. (invited speaker - topic group--review) WGFAST will report by 30 June 2010 for the attention of the SCICOM Steering Group Ecosystem Surveys Science and Technology
Resource requirements:	No new resources will be required for consideration of this topic at WGFAST annual meeting. Having overlaps with the other meetings of the Working, Planning, Study and Topic Groups increases efficiency and reduces travel costs; undertake additional activities in the framework of this group is negligible.
Participants:	The Group is normally attended by some 60–70 members and guests.
Secretariat facilities:	None.
Financial:	No financial implications.

Linkages to advisory committees:	
Linkages to other committees or groups:	The work in this group is closely aligned with complementary work in the FTFB Working Group. The work is of direct relevance to PGHAC, SGTSEB, SGASC, and SGAFV, PGSPUN, PGRS, PGHERS, WGBIFS and PGAAM.
Linkages to other organizations:	

Annex 4: SGCal draft resolution for 2010

The **Study Group on Calibration of Acoustic Instruments in Fisheries Science** (SGCal), chaired by David Demer, USA, will be established and will meet in San Diego, CA, USA, on 26–27 April 2010 to:

a) Review, summarize and report on the literature regarding:
   i. Acoustic systems currently used in fisheries research and surveys;
   ii. Theoretical principles of calibrating these instruments, and
   iii. Methods currently being practiced;

b) Develop recommendations for methods to be used for acoustic system calibrations including:
   i. Commonly used acoustic systems used in fisheries research and surveys;
   ii. Principles of calibration, general and specific to these selected systems; and
   iii. Standard protocols for calibrating these systems (e.g. quantitative system characterizations through to data collections and analyses); and

c) Prepare report for possible publication in the *Cooperative Research Report* series including:
   i. Literature review of acoustic systems commonly used in fisheries science;
   ii. Theoretical and practical principles of system calibrations of generic and selected instruments; and
   iii. Recommended protocols for calibrating generic and selected specific acoustic instruments used in Fisheries Science.

The SGCal will provide a brief report to WGFAST on 29 April and will report by 30 June 2010 for the attention of WGFAST and SCICOM. The Study Group will exist for nominally 3 years, concluding with completion of ToR c.

Supporting Information

Priority	Acoustic data is currently being collected from a variety of acoustic systems in many countries to address a range of ecosystem monitoring and stock management objectives. The ICES CRR covering this topic (CRR 144, Foote *et al*., 1987) is now more than 20 years old. While much of the theoretical principles are still relevant, some need to be expanded to include currently used technologies (e.g. multibeam and broad bandwidth systems), and methods and standard protocols for calibrating these instruments need to be updated. There exists an urgent need to evaluate this work and to develop recommendations for protocols appropriate for calibrations of acoustic systems used in fisheries research and surveys. This need has been identified by a number of ICES member countries and observer countries and has been conveyed to WGFAST and FTC.

Scientific Justification	Action Item 1.10, 1.12.5, 1.14, 3.13 – a Action Item 1.13.1, 1.13.4, 1.13.5 – b Action Item 6.3 - c Term of reference a: The ICES reference for acoustic system calibrations needs review and revision to be useful to practitioners of fisheries acoustics for stock management. The first step in this process is to review, summarize and report on the literature regarding the acoustic systems that are currently used in fisheries research and surveys. The theoretical principles for calibrating these instruments must be capitulated, and the methods currently being practiced must be evaluated. Term of reference b: Based the literature review, the Expert Group must make recommendations to the ICES community for standard protocols to be used for acoustic system calibrations. These protocols must cover the calibrations of all commonly used acoustic systems used in fisheries research and surveys, or be generic enough for calibrating other systems not specifically considered. The protocols must be practical and based on solid theoretical principles; and Term of reference c): There is a recognized need to comprehensively document the current theory and recommended practice of acoustic instrument calibrations for use in Fisheries Science, and publish them in an easily accessible ICES CRR report. WGFAST and FTC continue to recognize the difficulty of addressing these needs during full working group sessions and support the continuation of this study group comprised of experts to develop recommended methods and guidelines without delay. This Study Group will meet three times.
Resource requirements	No new resources will be required for consideration of these topics at the relevant group meetings. Having overlaps with WGFAST meetings, this SG will draw on a larger resource pool of experts which will increases efficiency in completing the objectives and reducing travel costs.
Participants	It is expected that circa twenty five scientists from six ICES and three observer countries will initially participate in the study group. History has shown this number will likely decline to about half that number as the meeting progress, and about one fourth may be active in authoring the report. Interested industry representatives, both hardware and software suppliers) should be actively invited to participate.
Secretariat facilities	None.
Financial	No financial implications. Having overlaps with other meetings of expert groups of FTC increases efficiency and reduces travel costs.
Linkages to Advisory Committees	There are no direct linkages to the advisory committees but the work is of relevance to ACFM.
Linkages to other organisations	No direct linkages, however, depending on the outcome organizations such as FAO will be interested in the results.
Linkages to other Committees or Groups:	WGFAST. This work should have relevance to many working, groups carrying out stock assessment of many semi-demersal and pelagic species in many ICES countries.

Annex 5: Recommendations

Recommendation	Action
1. The Working Group on Fisheries Acoustics, Science and Technology [WGFAST] (Chair: Rudy Kloser, Australia) proposes to meet in San Diego, USA from 13:00 hrs Tuesday 27th April to Friday the 30th April 2010:	
2. WGFAST recommends that SGCal, David Demer (USA), Chair, work towards an ICES Cooperative Research Report and meet in San Diego USA from the 26th April to 12:00 hrs 27th April. The result of their meeting to be reported to the WGFAST on the 29th April 2010.	SGCal
3.WGFAST recommends that SGFOT, Eirik Tennigen, Chair, complete their CRR and present the final report at the April 2010 meeting and that optical technologies be included in WGFAST activities as a complementary technology.	SGFOT
4. WGFAST recommends that SGARV, Francois Gerlotto (France) and Julia Parish (USA), Co-Chairs, finalise a ICES Cooperative Research Report and meet in San Diego USA from 26th April to 12:00 hrs 27th April. The result of their meeting to be reported to the WGFAST on the 29th April 2010.	SGARV
5. WGFAST recommends that the PGHAC, Laurent Berger (France), Chair, is dissolved and duties retained within WGFAST.	PGHAC
6. WGFAST recommends that a topic group on observatories be formed (Y. Simard) to prepare a review publication on acoustic observatories and future needs and report to WGFAST in the April 2010 meeting.	
7. WGFAST recommends that a topic group be established on fisheries and ecosystem indicators (V. Trenkel) to prepare a review publication of the contribution by acoustic and complementary technologies and report to the 2010 meeting.	
8. WGFAST recommends that Mike Jech contribute to a workshop organised by PGRS on redfish target strength and report back to WGFAST in April 2010	PGRS
9. The WGFAST proposes the following Theme Sessions for the 2010 Annual Science Conference: - Theme session on Optical and image based technologies for use in the ecosystem approach to fisheries management. - WGFAST in collaboration with other assessment and survey based expert groups recommend a theme session in 2010 on the ecosystem-based fisheries management information needs from surveys: metrics, indices and indicators.	SGFOT, SSGESST
10. WGFAST and WGFTFB hold a joint meeting in Iceland in 2011 on behaviour.	WGFTFB