Fisheries Technology Committee **ICES CM 2003/B:06**

https://doi.org/10.17895/ices.pub.9612

Report of the

Working Group on Fisheries Acoustics Science and Technology

Bergen, Norway
18–21 June 2003

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

TABLE OF CONTENTS

TABLE OF CONTENTS

Section **Page**

1 EXECUTIVE SUMMARY

The Working Group on Fisheries Acoustics Science and Technology (WGFAST) met in Bergen, Norway, on June 18–21 2003. Seventy-five participants attended the meeting.

a) The first topic was an initial review of the possibilities and limitations of using fishing vessels to collect acoustic data for fish stock assessment. Several examples of such initiatives around the world were presented. Although the advantage of significantly augmenting the sampling frequency and coverage by using the fishing fleet was evident, several concerns were expressed about the quality of the data collected with a variety of non-adequate sampling gears and platforms, with poor or no calibration. Processing of such large volumes of data would also require the development of efficient automated tools. Given the importance of this topic and the considerable efforts that will be needed for development of appropriate methods, protocols and guidelines, WGFAST recommends that a Study Group on collection of Acoustic data from Fishing Vessels (SGAFV) be charged to review this subject and produce a Cooperative Research Report within the next thee years.

b) The 2002 ICES Symposium on Acoustic in Fisheries and Aquatic Ecology and the subsequent WGFAST discussion on the needs for research have stimulated the efforts for species identification. Several presentations were made on new approaches to extract the discriminant features from the frequency spectrum of the echoes. New instruments were tested and innovative processing algorithms were presented. The research to develop operational solutions to species identification is progressing steadily by combining numerical simulations, in situ measurement and experimental testing.

c) From the presentations on advanced technologies and platforms, it is clear that a new set of intelligent Acoustic Observation Systems (AOS) is emerging to monitor the ecosystem. Several prototypes combining optics, passive and active acoustics were developed and tested. This new technology for automated autonomous acoustic acquisition system could be applied to the problem of standardising the acoustic gears for data collection from fishing vessels. With similar fast development in platforms such as Automated Underwater Vehicles, moorings, surface-linked buoys and shore cabled systems, acoustic data collection will no longer be limited to fisheries research vessels. Efficient series of automatic data processing algorithms will be required to process and interpret the large quantity of information supplied by such networks of acoustic sensors.

d) WGFAST recommends that Dr Dave Demer, USA, becomes the WGFAST chair for 2004–2007.

e) WGFAST recommends the following topics for the 2004 meeting to review:

   i) the effectiveness of noise-reduced platforms;
   ii) the use of acoustics for evaluating ecosystem structure, with emphasis on species identification;
   iii) the statistical characterisation and utilisation of target strength (TS);
   iv) the error assessment for acoustic biomass estimates.

2 TERMS OF REFERENCE

In response to the ICES Resolutions of the 90th Statutory Meeting, the Working Group on Fisheries Acoustics, Science and Technology (WGFAST) (Chair: Yvan Simard, Canada) met in Bergen, Norway, on 18–21 June 2003 to:

a) evaluate the possibilities and limitations of using fishing vessels to collect acoustic data for fish stock assessments;
b) develop technical guidelines and standards for the collection of acoustic data for fish stock assessments.
c) examine works in the following research areas that WGFAST prioritised from the new research presented at the 2002 ICES Symposium on Acoustic in Fisheries and Aquatic Ecology:
   - developmental work and applications of echo trace spectral signatures;
   - combination of methods in acoustic applications and multi-species estimation in the context of an ecosystem approach;
   - advanced technologies and platforms;
d) review the reports of the:
   - Planning Group on the HAC (PGHAC) common data exchange format;
   - Study Group on Baltic Herring TS (SGTSEB);
   - Study Group on Acoustic Seabed Classification (SGASC).

WGFAST will report to the Fisheries Technology Committee at the 2003 Annual Science Conference.

3 MEETING AGENDA AND APPOINTMENT OF A RAPPORTEUR

The Chair opened the meeting and Stéphane Gauthier from the School of Aquatic and Fishery Sciences of the University of Washington, was appointed as Rapporteur.

The adopted agenda was

Topic 1. Assessment of possibilities of using fishing vessels for acoustic data collection for fish stock estimation. The discussion on this topic was chaired by Bill Karp, USA.

Topic 2. Developmental work and applications of echo trace spectral signatures.

Topic 3. Combination of methods in acoustic applications and multi-species estimations.

Topic 4. Advanced technologies and platform.

Review of the report of the Study Group on Acoustic Seabed Classification (SGASC).
Review of the report of the Study Group on Baltic Herring TS (SGTSEB).
Review of the report of the Planning Group on HAC common data exchange format (PGHAC).

Discussion and recommendations:

- terms of reference for next FAST meeting;
- elected new chair recommendation
- terms of reference for next Joint Session
- theme sessions for the ASC 2005 meeting.
- next acoustic Symposium.

Closure of the meeting

A list of the 75 participants appears in Appendix 1.

4 TOPIC 1 "ASSESSMENT OF POSSIBILITIES OF USING FISHING VESSELS FOR ACOUSTIC DATA COLLECTION FOR FISH STOCK ESTIMATION"

4.1 Bill Karp. Assessment of possibilities of using fishing vessels for acoustic data collection for fish stock estimation: an overview

NOAA, NMFS Alaska Fisheries Science Center, Seattle, USA. bill.karp@noaa.gov

Stock assessment scientists often lack sufficient information for characterizing the condition of commercial stocks and recommending harvest levels. Even in circumstances where reliable catch data and extensive time series of survey results are available, questions regarding temporal and spatial distribution often remain unanswered, and historic survey results may not provide the resolution necessary to support some assessment and management information needs. Data collected during routine acoustic/trawl surveys provide important time series of information for stock assessments in many countries. Most of these surveys are conducted with calibrated scientific acoustic systems installed on research vessels although chartered commercial vessels are sometimes used. Acoustic data collected during normal fishing operations have also been used for stock assessment and management. Approaches have ranged from extraction of subjective relative abundance and distribution information from uncalibrated echosounder displays to absolute biomass estimation from calibrated commercial or scientific sounders connected with data logging devices. In some cases vessel operations have been modified to improve spatial coverage. As information needs expand and instruments capable of collecting scientific-quality acoustic data become more widely available, the need to evaluate the success of these approaches and consider factors which may influence data quality has become apparent. This session will include presentations of several case studies involving collection of acoustic data from commercial vessels in support of stock assessment and management goals. We will also consider the objectives which might be addressed by these types of studies and the data quality issues associated with these objectives. Radiated vessel noise, acoustic system performance and calibration, intercalibration, survey design, data storage, analysis and interpretation, and appropriate use of data are

among the most important of these issues. Objectives may include: improved understanding of temporal and spatial characteristics (including diel and seasonal migrations, and short-term changes in availability to the fleet), understanding of fleet "foraging behaviour", habitat characterization (for adaptive sampling or post-stratification), echosign classification for adaptive bottom trawl sampling, and relative or absolute biomass estimation.

4.2 Ron Mitson. Underwater noise aspects of using commercial fishing vessels for surveys

Acoustec, 5 Gunton Avenue, Lowestoft, Suffolk NR32 5DA, UK acoustec@acoustec.co.uk

A survey vessel is the most important tool for fisheries management purposes, the essential platform carrying equipment for sampling and assessment. So it is the first consideration when looking at the potential effectiveness of commercial vessels, primarily designed for fishing purposes, to carry out research surveys. Vessels with a bad noise signature likely to cause fish avoidance behaviour need careful consideration before acceptance. Noise can be an advantage when fishing commercially if fish are driven into nets by vessel noise. But, for sampling and collection of high quality data, fish distributions should be undisturbed by noise.

Because of sampling problems due to noise, ICES asked FAST to investigate and Report 209 was produced. Maximum radiated noise levels from research vessels are recommended, to prevent fish being disturbed beyond 20 metres from the vessel. A number of research vessels have since been built which meet that criterion. For the majority of RV's currently operating, their noise signatures exceed the ICES 209 levels, often by very significant and variable amounts. The main difference between currently operating research vessels and commercial fishing vessels is the lack of noise ranging of the latter. By studying noise ranging reports scientists may be able to optimize vessel operations for minimum noise by choice of propulsion conditions but there are no immediate indications on board of radiated noise levels. Simple criteria are discussed whereby the most suitable commercial fishing vessels might be selected for research surveys, based on their likely radiated noise characteristics.

4.3 Rudy Kloser. Industry acoustics as a monitoring tool for Australian orange roughy fisheries

CSIRO Marine Research, Australia. rudy.kloser@ csiro.au

Advances in computing, post processing software and low cost digital echo sounders makes the collection and analysis of industry acoustic data a viable prospect in many fisheries. Industry acoustics data is being collected in deep-water fisheries in many countries for a range of management objectives. The value and use of the data for management depends on the harvest and monitoring strategy in place. In some cases simple qualitative indicators can be derived to assist in stock assessment or future monitoring. Planning a quantitative monitoring strategy involving industry acoustic data requires a realistic estimation of sources of error and bias. Most errors can be quantified or reduced based on past research whilst others are difficult to quantify due to unknown but strongly suspected biological and acoustic sampling biases. What appears to be useful in our deep-water situation is the balanced use of a number of low cost industry surveys complemented with other multi-frequency deep towed body and biological surveys at less frequent intervals. Difficulties arise in having the overall monitoring strategy seen as a package where the funding is clearly identified for the whole strategy and not just funding of the low cost portions.

4.4 Melvin, G.D., M.J. Power, and R.L. Stephenson. The development and implementation of acoustics surveys for herring stock assessment using commercial fishing vessels: A case study

St. Andrews Biological Station, Fisheries and Oceans Canada, Nova-Scotia, Canada. melving@dfo-mpo.gc.ca

In 1995 the biomass of the 4WX herring stock appeared to be declining rapidly. Within a two year period the TAC was reduced to 1/3 its former level. However, the fishing industry remained concerned that they could systematically deplete each of the main spawning components within a global TAC. To resolve this concern a series of industry conducted surveys were implemented on the major spawning areas prior to fishing. These non-quantitative surveys provided a mechanism to monitor the general abundance of spawning herring before opening the area to fishing. The subjective nature of biomass estimation led to further uncertainty of stock status. Consequently, an automated and calibrated acoustic logging system was developed and deployed aboard herring seiners for the purpose of undertaking quantitative acoustic surveys. Today these surveys play a key role in assessing the abundance of the 4WX herring stock.

4.5 Melvin, G.D. and M. J. Power. An acoustic survey design for 4WX Herring spawning components using commercial fishing vessels

St. Andrews Biological Station, Fisheries and Oceans Canada, Nova-Scotia, Canada. melving@dfo-mpo.gc.ca

Prior to 2000 the 4WX herring stock complex was assessed using input from industry based acoustic surveys and fishing excursions. Unfortunately, the data were collected in somewhat of an *ad hoc* manner. The results, while providing valuable information on the abundance of herring on specific spawning grounds, were not comparable from year to year due to restricted coverage and only provide a minimum biomass estimate of the fish observed on the day surveyed. To overcome this problem, data from the fishery were used to identify potential survey areas from the distribution of catches during the spawning season. Isolating those locations, from which more than 90% of landings containing spawning fish were reported, further reduced the area of survey coverage. Thereafter, standard random transects were selected within the survey area and a protocol established for times when fish were observed beyond the survey boundaries. Standardization of the survey area provides a means to compare observations from year to year and forms the basis for an index of abundance in years to come.

4.6 M. Angela Barbieri and José Córdova (Presented by F. Gerlotto). Description of the use of fishing vessels in multi-vessel surveys on jack mackerel *Trachurus murphyi* in Chile

Instituto de Fomento Pesquero, Blanco 839, Valparaíso, Chile. mabarbieri@ifop.cl

The jack mackerel is covering a large surface on the Chilean sea, making it difficult to perform synoptic surveys. IFOP has been conducting multivessel surveys called "rastrillo" since 1997, using between 6 to 15 fishing vessels in a simultaneous coverage. Data are acoustic abundance values and biological data such as egg and larvae collection. Some examples of "Rastrillo" surveys are presented and the results are discussed.

4.7 Richard L. O'Driscoll and Gavin J. Macaulay. Experiences with an industry vessel acoustic survey

National Institute of Water and Atmospheric Research Limited, Private Bag 14–901, Kilbirnie, Wellington, New Zealand. g.macaulay@niwa.co.nz.

An acoustic survey of spawning hoki (*Macruronus novaezelandiae*) off the east coast South Island of New Zealand was carried out from the 45.6 m factory/freezer stern trawler *F.V. Independent 1* from 2–11 September 2002. Acoustic data were collected using the vessel's Simrad ES-60 echosounder with a hull-mounted 38-kHz split-beam transducer, which was calibrated prior to the survey. Acoustic transects were run during normal commercial fishing operations, in 4–6 h "windows of opportunity" while the vessel processed large (10–20 t) catches. Commercial trawls provided biological data and information for mark identification. The survey confirmed fishers' perceptions that there were dense concentrations of spawning hoki in Pegasus Canyon. The acoustic biomass estimate of 49 000 t was 22% of the biomass observed in the main Cook Strait spawning grounds, indicating Pegasus Canyon may be a significant satellite spawning area for the eastern hoki stock. This survey successfully integrated acoustic research and commercial fishing, and the Simrad ES-60 acoustic system performed well. However, the approach described is only likely to be applicable for relatively small-scale surveys adjacent to areas of high catch rates. It was not possible to fully survey another area of interest (Conway Trough) because there were insufficient fish for the vessel to remain in the area and fish commercially. Future research will also limited by the use of a hull-mounted transducer to periods of relatively good weather. Strategies to spread fishing effort through the survey area, away from the densest concentrations, are required to improve mark identification.

4.8 Paul G. Fernandes and Dave G. Reid. The use of commercial vessels for acoustic assessments of herring on the west coast of Scotland

Fisheries Research Services Marine Laboratory Aberdeen, PO Box 101, Victoria Road, Aberdeen, AB11 9DB, UK. fernandespg@marlab.ac.uk.

Large commercial trawlers have been used to carry out acoustic surveys on the west coast of Scotland for over 10 years. The surveys are part of the International North Sea Herring Acoustic Survey (INSHAS) which takes place in July each year and involves 6 other [research] vessels and covers the whole of the North Sea and its north western approaches. Chartering a commercial vessel is essential as all other appropriate research vessels are engaged in the INSHAS at the same time. In addition, the exercise allows access to a state of the art fishing vessel and the co-operation of an experienced skipper and crew. The surveys are useful as a demonstration to the fishing industry of the mutual trust and respect by the scientific community. They also allow for the exchange of knowledge and ideas between the two parties. There is no doubt that such co-operation between industry and science is increasingly important yet still quite rare. On the other hand, there may be doubts as to the quality of the acoustic data given the stringent standards that are now expected from research vessels. This paper reviews the advantages and disadvantages of using commercial vessels for acoustic data collection based on the experiences on the west coast of Scotland.

4.9 Mariano Gutierrez T. The EUREKA Program and the feasibility of using fishing fleets for accurate Acoustic Surveys

Peruvian Marine Research Institute – IMARPE. mgutierrez@imarpe.gob.pe.

The EUREKA Program was founded in 1964 by IMARPE and private fishing companies as a way to quickly and economically collect fishery, biologic, oceanographic and acoustic information to build synoptic maps of abundance and distribution of pelagic fish but anchovy mainly, although in recent years it has also been used for the demersal fishery too. Furthermore, the program was and is being use to project the fishing quotas and activities related to fishery management. The program lasts since 39 years and has executed 65 surveys although this activity was suspended between 1982 and 1991. Specifically the EUREKA surveys are used for the following purposes:

- When a fishing quota has been reached; to analyse the possibilities to provide a new one (20%)
- To find out fishing grounds, specially during winters when all the main fishing resources tend to be distributed on wider areas (20%)
- When new oceanographic conditions menace the stability of fishing operations (10%)
- To establish if spawning seasons have finished; during these the fishing activities are closed (50%)

Nevertheless the core activity during an EUREKA surveys is to maintain acoustic log-books to describe the morphology and relative density of fish schools in sampling units of 1 n.mi. This is done by scientific observers on board of 25 to 50 fishing vessels that usually have to survey 2 transects of a length between 100 and 300 n.mi. in order to cover the whole area of distribution of the target specie. However, there are biases in the description of spatial structures of fish schools: too many observers inevitably increase the bias in abundance calculations (mostly relative values); there are different skill levels among observers, it sometimes makes really hard the data processing; it is difficult to pay close attention to the sounder's screen during the whole survey; there are different types of sounders, gain controls, ranges. Practically all sounders are analog and lack a printer.

In despite of those limitations the EUREKA Program has shown to be a cost effective and useful tool for fishery management and scientific applications such as the analysis of changes of gravity centre and inercy of the distribution patterns of assessed species; other important application consists in cluster analysis of fish size structure to detect the seasonal changes in the demography of marine populations for the further corrections of the VPA estimations. Then, the program deserves to be enhanced through the use of acoustic autonomous devices –namely some Acoustic Black Boxes or AbB- in order to collect acoustic digital data and to overcome the biases of the visual observation of echograms; then the more experienced acoustic staff can be concentrated in data analysis using software tools instead that being taking notes on board vessels. Some simple block diagrams have been drawn in order to show how those AbB would work.

Besides EUREKA there is another Program, permanent and fully operational for satellite monitoring this time (SISESAT) that could be linked to the use of AbB if their telegrams of acoustical data can be attached to those of the satellite system. The fishing activities of about 1000 fishing ships equipped in Peru with satellite buoys are monitored from IMARPE by a law issued by the government in 1998 that makes an obligation to carry this kind of equipment in order to protect the spawning seasons, nursery areas, marine sanctuaries, etc. Then it opens the possibility for the permanent use of AbB on board of at least some ships instead that for the EUREKA surveys only.

4.10 Olav Rune Godø and Atle Totland. The use of acoustically equipped trawlers to study distribution and abundance of demersal fish in the Barents Sea

Institute of Marine Research, P.O. Box 1870 Nordnes, 5817 Bergen, Norway. olav.rune.godoe@imr.no

From 1991 to 1997 a varying number of commercial trawlers participated in a late summer survey to study the distribution and abundance of demersal fish species of the Barents Sea. Each year, one to three vessels where equipped with calibrated scientific echo sounders and post processing systems. The talk emphasises on the experiences gained during these cruises and draws some lines to potential future improvements based on new and better technology.

4.11 Adrian Madirolas The role of commercial fleets in providing key data for the planning of scientific surveys: The hoki fisheries in Argentina

Instituto Nacional de Investigación y Desarrolo Pesquero, Casilla de Correo 175, B7602HSA - Mar del Plata, R. Argentina - adrian@inidep.edu.ar

Until recent years hoki (*Macroronus megallanicus*) has been an almost unexploited fish species in argentine waters and was known as a bottom fish occasionally forming near bottom schools. The decline of the hake stocks and the opening of new markets for the fishing companies turned on an increasing interest on hoki. Knowledge on the species is still not complete and important parts of its life cycle need to be further investigated. Extensive areas have to be surveyed in different times of the year and availability of research vessels is very limited, representing a real challenge for completing the "whole picture" of the hoki biology.

Agreements with fishing companies to carry out exploratory fishing experiments in not very well known areas were implemented in order to gather valuable information on the species and mainly related with the definition of possible spawning grounds in argentine waters. Echo-recordings taken from the fishing vessels during these surveys revealed the presence of large pelagic schools of hoki over the slope, possibly associated to the existence of bottom structures as submarine canyons. This observations opened new possibilities for planning acoustic research surveys targeted on hoki. Tests are being carried out to explore the possibilities of employing SIMRAD ES60 echosounders for conducting preliminary, low resolution acoustic surveys in order to produce gross estimates of the size of such concentrations. Bottom topography information extracted from the output files could also provide valuable data, since the exact location of bottom features believed to play a major role in relation to presence of the species are not completely described.

4.12 François Gerlotto. MAREA: a proposal for designing new autonomous equipments for ecological approach using acoustics aboard fishing vessels

IFOP, casilla 8-V, Valparaiso, Chile. fgerlotto@ifop.cl

An European Project has been submitted under the name "MAREA" (MARine Ecology and Acoustics) to the 6th Framework Program, with the 5 following objectives:

1) evaluate the quantity and value of the ecological information that is present in a "standard" acoustic survey data base;
2) conceive a methodology for an ecological analysis using "Rake Survey" methods;
3) conceive an Autonomous Scientific Echo Sounder (ACSES), with automatic data analysis and processing;
4) evaluate the output and define the use of the new generation of multibeam sonar for the fisheries and ecology acoustics.
5) conceive and design a special software package intended to clean up and pre-process the acoustic signal from ACSES,

The project will be detailed and discussed with the FAST members.

4.13 Discussion

Chair: Bill Karp, USA. bill.karp@noaa.gov

As a result of these presentations and the associated question and answer sessions, the Working Group became aware of the extent to which acoustic data is currently being collected from commercial vessels to address a range of research and survey objectives. In some cases commercial vessels are operated as *de facto* research vessels, often under charter to a government agency. In these instances standard practice regarding calibration, scientific survey design, biological sampling, etc. are generally followed. In many situations, however, acoustic data is collected by commercial vessels during normal fishing operations, or in association with normal fishing operations. In these cases concerns regarding instrument performance and calibration, survey design, biological sampling, data interpretation and management and other factors may arise. The need to establish protocols for calibration of acoustic systems on commercial vessels and for evaluating acoustic system performance was emphasized.

The topic of radiated vessel noise received a great deal of attention. Concerns regarding potential effects of vessel-noise-related fish behaviour on acoustic or trawl survey results should be evaluated carefully. Avoidance (and possibly herding) behaviour may depend on physiological and biological factors (some species are more susceptible than others, susceptibility may depend on spawning condition or other life history stage, depth of fish schools, etc), environmental conditions (depth, substrate type, ambient noise level) as well as vessel noise characteristics. The type of propulsion system, propeller type and condition, and hull characteristics will influence vessel noise characteristics.

The need for measurement of radiated vessel noise was discussed. Inexpensive alternatives to military noise ranges are available and it was suggested that such systems be tested and evaluated. It was also suggested that these systems may

hold promise for developing a catalogue of vessel noise signatures and identifying changes that might occur over time. Such information could also be used as a diagnostic tool when evaluating anomalous research results. It was further suggested that there is a need to develop criteria for selection of commercial vessels and a mechanism for defining technical specifications. Radiated vessel noise will be of particular concern when assessing "sensitive" species (e.g., herring) in shallow waters but may of less importance when assessing less sensitive species in deep water (e.g., orange roughy). The issue of consistency was also raised. If identical (or similar) vessels are used to collect data that will be used to develop indices of abundance, radiated noise concerns may not be as important as in cases when estimates of absolute abundance are sought.

This led to a discussion of the importance of intercalibration and the need to link data collection protocols and survey designs to scientific objectives. The use of commercial vessels for collecting acoustic data for bottom mapping and substrate classification was identified as an appropriate possibility. Since this WGFAST topic was intended to address information needs for stock assessment, it was considered important that stock assessment scientists participate in future deliberations. However, it was also recognized that acoustic data may be collected from commercial vessels to address a broader range of ecosystem monitoring objectives. Protocols for intercalibration should be established to address concerns regarding time series consistency and comparability of research results.

Working group members emphasized the importance of standards and protocols. While commercial vessels equipped with calibrated commercial sounders might be suitable for collecting data in support of some specific research and survey objectives, use of these platforms and instruments will not be appropriate in many cases. Research vessels and calibrated scientific acoustic systems will be preferred in most situations but will not always be available. Attention should also be paid to reconciliation of sources of variability between survey and industrial vessels.

In conclusion, WGFAST recognized the importance of this topic and the need for development of appropriate methods, protocols and guidelines. The members further recognized that this work could not be accomplished during annual WGFAST meetings because it would lengthen these meetings by at least two days. It was felt that this task could best be accomplished by a small group of members who would form a Study Group to:

- Review and evaluate recent and current research which involves collection of scientific acoustic data from commercial vessels,
- Develop methods and protocols for addressing specific ecosystem monitoring, stock assessment and management objectives including: acoustic system calibration and performance monitoring, characterization of radiated vessel noise, comparability of results, survey design, biological sampling, data interpretation and analysis, and data storage and management, and
- Publish background material, guidelines, methods and protocols in an ICES Cooperative Research Report.

The study group would complete its work within three years. It would meet once each year for a two-day period before the annual WGFAST meeting and conduct deliberations by e-mail during the intervening periods.

The recommendation for the formation of this study group is presented in section 8.

Ron Mitson, Andrzej Orlowski, John Horne, François Gerlotto, Bill Karp, Egil Ona, Olav Rune Godø, John Simmonds, Dave Reid, Paul Fernandes, Rudy Kloser, Gary Melvin, Van Holliday, Ian McQuinn, Robert Keiser, David Demer, Arnaud Bertrand, Michael Jech, Dezhang Chu, Yvan Simard contributed to this discussion.

5 TOPIC 2 "DEVELOPMENTAL WORK AND APPLICATIONS OF ECHO TRACE SPECTRAL SIGNATURES"

5.1 David A. Demer and Stephane G. Conti. Wide bandwidth acoustical characterizations of fish and zooplankton

Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA. David.Demer@noaa.gov

The wide bandwidth acoustical characterizations of target fish and their cohabitant species are analogous to visual identifications of objects by their colour, size, shape and morphology. To obtain such characterizations, we have employed and refined a new multi-scattering method for measuring total target strengths (TTS), or the total sound scattered in all directions, averaged over all angles of incidence. TTS measurements have been made of a variety of fish and zooplankton in highly echoic tanks using wide bandwidth projectors and hydrophones. We aim to exploit characteristics in the scattering spectra to better delineate species in echosounder data.

5.2 Anne Lebourges-Dhaussy and Johanna Balle-Beganton. Multi frequency multi model acoustic data processing: algorithm exploration through simulations

Centre IRD de Bretagne, 29280 PLOUZANE, France. lebourge@ird.fr

The purpose of this work is to extend the C.F. Greenlaw and D.V. Holliday multi frequency zooplankton characterization algorithm to a wider range of organisms and frequencies. A set of simple shape models (from the T.K. Stanton formulations) has been introduced within the algorithm: sphere, prolate spheroid, straight and bent cylinders, each with a set of different materials: fluid, elastic, rigid/fixed, gaseous. The original "truncated fluid sphere" model from D.V. Holliday remains within the models set. The influence of initial conditions and numerical parameters is presented here through the inverse processing of chosen simulated populations. The main parameters are: the size limits of the vector on which the processing is initiated, the under determination degree of the problem, the number of iterations allowed to optimize the size distribution and the Levenberg-Marquardt factor. The algorithm is then applied to a range of lower current echo-sounder frequencies, remaining however in the same "ka" range. The quality of the results obtained with the maximum number of available frequencies is compared to those produced when using less frequencies and different frequency combinations. These simulations gave also some insights on the limits of the method for some cases where the algorithm does not converge properly.

5.3 Robert Keiser. SciFish 2000 fish spectra and what we can learn from them

Robert Kieser, Fisheries and Oceans Canada, Pacific Biological Station Nanaimo, BC, Canada. KieserR@pac.dfo-mpo.gc.ca

The Scifish 2000 is the first commercial instrument for broadband fisheries acoustic measurements. It provides significant opportunities to learn about this approach through hands on use and through consideration of its internal workings. A two-week trial of this instrument on hake, herring and rockfish from the W.E. RICKER in 2001 demonstrated to us that echograms, spectra and other data could be collected reliably and that species discrimination results from real time and post processing analyses showed some promise. This lead to a collaboration with Scifish engineers that deliberately focussed on the signal processing aspects that are implemented in the Scifish 2000 rather than on its classification procedures and capabilities. Our premise was and is that the underlying data acquisition and processing must be correct before reliable classification success can be expected. As part of this work we here explore the fish spectra that are generated by the Scifish 2000 and that are the basis for its classification procedures. We also present some insights that we believe to be helpful for future work.

5.4 Natalia Gorska[1], Egil Ona[2] and Rolf Korneliussen[2]. Can we explain the frequency response of Atlantic mackerel through modelling of its backscattering?

[1]Institute of Oceanology of Polish Academy of Sciences, ul. Powstancow, Warszawy 55, PL-81 - 712 Sopot, Poland. gorska@iopan.gda.pl. [2] Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway. egil.ona@imr.no; rolf@imr.no

Models for computing the backscattering by individual mackerel and for mackerel in schools (mean backscattering characteristics) have been developed in order to explain the measured frequency responses of Atlantic mackerel within the frequency range 18 – 200 kHz. Different backscattering mechanisms have been considered. The frequency response and its sensitivity to mackerel behaviour and morphology (geometrical shape of mackerel body and backbone, their density contrasts and sound speed contrasts of compressional and shear waves) have been analyzed.

5.5 Helge Balk and Torfinn Lindem. Fish detection based on spectral differences in the echogram's range and temporal domain

Fysisk institutt, Postbox 1048, 0316 Oslo. hbalk@fys.uio.no

Single echo detection (SED) is a crucial element in most acoustic abundance estimation methods. The detected single echoes are applied to obtain the size distribution and the total abundance is obtained by scaling this distribution with the result from the echo integration. In situations with low signal to noise ratio traditional SED tend to fail. Echo from fish are overlooked while noise based fluctuations in the background are detected.

Fish tracks observed in an echogram is more or less seen as thin short lines oriented in the temporal domain. Studying the frequency spectrum along the range and temporal domain reveals significant differences in situations with and without fish. Hence, filters with different cut-off frequencies can be applied to detect single fish.

Test shows that a detector based this approach is superior to traditional detectors. Tracks are detected with substantial fewer missing echoes and with less noise. This improves tractability and abundance estimation.

5.6 Paul G. Fernandes, Mosteiro, A., Armstrong, F. and Greenstreet, S. Developmental work and applications of echo trace spectral signatures

Fisheries Research Services Marine Laboratory Aberdeen, PO Box 101, Victoria Road, Aberdeen, AB11 9DB, UK. fernandespg@marlab.ac.uk

Sandeels (*Ammodytes spp*.) are not only targets of a significant industrial fishery, but are also considered to be a vital trophic component of the North Sea ecosystem, comprising large parts of the diet of seabirds and other commercially important fish. There is, therefore, a need to determine the abundance and distribution of sandeels for the purposes of fishery management, particularly if any consideration is to be taken for an ecosystems approach. At present there is no satisfactory survey method to sample sandeels which produces a global absolute abundance estimate. Acoustic surveys have been carried out, but suffer from an inability to consistently identify sandeel echo traces in an objective manner. As sandeels lack a swimbladder, their acoustic properties are very different to other fish species which occur adjacent to them. More specifically, their target strength (the ability of an individual to reflect sound) is extremely low: incorrect identification can therefore lead to massively biased estimates of abundance. However, the same property which causes this problem can be exploited to solve it, using multifrequency acoustics. We report on the development of a dual frequency algorithm which aims to identify echotraces of sandeel schools based on the observed difference in acoustic scattering at 38 and 120 kHz. The algorithm also includes a plankton filtering component and has more general applications for the identification of other non-swimbladder fish such as Atlantic mackerel. The scope for improving the algorithm for these and other such applications is discussed. Multifrequency algorithms such as these are likely to revolutionise fisheries acoustics by providing an automated, objective approach to the common problem of echo trace identification for a wide range of species. These will no doubt result in acoustic surveys being used more widely for fishery independent surveys with direct benefits for an ecosystems approach to fisheries management.

5.7 Kjell Kr. Olsen and Geir Anthonsen. Experimental work on broadband fish species identification

Norwegian College of Fishery Science, University of Tromsø, Breivika, 9037 Tromsø, Norway. kjello@nfh.uit.no

A SciFish 2000 Broadband Sonar has been applied in some trial experiment for fish species identification. By use of a specially designed measuring rig, broadband echo recordings of cod, saithe, herring and capelin have been obtained. The fish targets are measured in a net cage with monofilament roof and floor, in order to reduce unwanted cage echo. The position and behaviour of the fish is monitored by applying a SIMRAD EY500 echo sounder with overlapping beam and by use of UTV.

In each experiment a number of broad band echo signals (110–190kHz) are collected and later used for training of a neural network. The network classifies echo spectral signatures, which again is attempted to be the basis of species identification. The target classification performance are tested both on separate subsets of the echoes obtained of caged fish and on some in situ recordings of fish echoes obtained by mounting the transducers in a towed body.

The preliminary results seems to show considerable variation in the obtained echo spectra and great care have to be taken in the process for extracting echoes for training of the neural network.

The analyses of the obtained data are at the moment still continuing and any conclusion of the capability of the applied equipment and the neural network for classification have to be awaited. (More detailed results will be presented at the meeting).

5.8 Noël Diner. Multifrequency Analysis: general problem of school detection by different beamwidth opening and athwartship or alongship spaced transducers

TMSI/TP - IFREMER - Centre de Brest, BP 70, 29280 Plouzane Cedex, France. Noel.Diner@ifremer.fr

The multifrequency analysis use transducers located at different places of the hull, i.e., athwartship or alongship spaced. On the other hand, these transducers could not have the same nominal beamwidth opening. This can induce some measurement errors which level must be defined before any multifrequency analysis.

Potential errors are induced by:

- athwartship distance between transducers
- alongship distance
- difference of beamwidth opening.

The errors don't affect all types of multifrequency analysis:

- the comparison of the global Sv of the schools can be affected by the athwartship distance or directivity difference,
- the precision of the ping to ping analysis is on the other hand dependent on athwartship distances but also on alongship one, and on directivity differences.

This work has been conducted within EU SIMFAMI project.

5.9 Discussion

The numerous presentations on this second topic testify the considerable effort invested by several institutes to develop methods for identifying the various species in response to the multi-species and ecosystem approach adopted by ICES. This complex problem is approached in a more comprehensive way by combining different methods: numerical simulations, in situ measurements, controlled experiments, innovative instrumentation and data processing algorithms. Operational solutions for some conditions are already in use and will improve with the continuous upgrading of the information content of acoustic data, the gradual building large data banks of the acoustic spectral signatures for various species and taxa, and proper combination of classification algorithms and validation samples.

The new method to estimate the TTS (total target strength) based on a multi-scattering model proposed by De Rosny and Roux (2002. J. Acoust. Soc. Am.; Roux. 2000. WGFAST report.) was used to get the acoustic spectral signature of Antarctic krill, anchovies and sardines over a broad range of frequencies and compared to results of a KRM simulation model. The importance of size and reverberation properties of the echoic chamber was tested. Large diameter, shallow tanks worked well. Reverberation walls made of stainless steel, galvanised steel and glass walls were good. Tapered sides help to give an homogeneous sound field. Difference with the KRM predictions were mainly attributed to the fact that this model does not account for refraction at low frequencies.

Numerical simulations were also used to test the sensitivity of the multifrequency size-inversion method of Holliday and Greenlaw to resolve the size spectra of zooplankton having different shapes. Among the important parameters were the number of frequencies and their choice. The model resolution matrix tells if the model is able to discriminate, while a data resolution matrix tells if they contain enough information to see these differences. Numerical modelling and in situ measurements were also used to study the frequency response of Atlantic mackerel over the 18–200 kHz band. The observed increase of scattering at 200 kHz (or lower frequency for larger fish) is tentatively attributed to a contribution of the backbone, while the contribution of flesh is more important at low frequencies. The skull may also play a role.

Tests of a commercially available broadband system (110–190 kHz) to classify fish from the detected echo spectra showed that several difficulties need to be solved before such tools become effective. Among those are the problems of the varying beam patterns with frequency, the high variability associated with the position and attitude of the fish in the beam and from one fish to another, the metric used for the echo signature (Fourrier transform), the transfer functions of the target and the medium, the selection of the echoes used to train the classifying neural network algorithm. It was stressed that calibration and detailed understanding of the data and features of the system are important prerequisites to use such echo classification tool.

Image analysis filtering along both time and range dimensions of echograms were applied to single echo trace detection to improve detectability. Such data-processing algorithm presents a real potential for contributing to an automated data analysis protocol. It was however pointed out that care should be taken to the interpretation of single targets (e.g., large predators surrounding fish schools) and use of the TS values (e.g., echoes rejected from the algorithm must be considered to get the average TS). Similar algorithms could be developed to improve fish school and bottom detection. Other echogram-based spatial analysis techniques using two-frequency (38–120 kHz) Sv information were explored to automatically extract the echoes from sandlance schools from a multispecies echogram. Though this is a simple technique, several aspects need particular care. Among them were: the choice of the value of Sv difference at the two frequencies to classify the fish, the difference in pulse length at the two frequencies, the selectivity of the ground-truthing trawl, the variability of the frequency response through a school, the problem of mixed schools, the effect that different drops in signal to noise ratio with range at the two frequencies may lead to increasing misclassification with range. Another series of technical issues related to the importance of proper alignment of the transducer beams when comparing multifrequency echograms was explored with simulations. These include alongship and athwartship differences in transducer locations and variable beam widths. The error due to this misalignment varies with the metric

considered (e.g., global Sv of the school, school shape, length, etc.). Whenever possible, guidelines and corrections were proposed to minimise this effect when comparing multifrequency multi-transducer data.

Dezhang Chu, Jim Churnside, David Demer, Paul Fernandes, François Gerlotto, Mariano Guttierez, Van Holliday, John Horne, Rudy Kloser, Michael Jech, Robert Kieser, Ian McQuinn, Kjell Olsen, Egil Ona, Andrzej Orlowski, Dave Reid, Yvan Simard, and John Simmonds contributed to this discussion.

6 TOPIC 3 "COMBINATION OF METHODS IN ACOUSTIC APPLICATIONS AND MULTI-SPECIES ESTIMATIONS"

6.1 John K. Horne[1], Neal J. Williamson[2], and Jason C. Sweet[1]. Bimodal Target Strength Distributions: Fact or Fiction?

[1]University of Washington, School of Aquatic and Fishery Sciences, Box 355020, Seattle, WA 98195–5020, USA. [2]Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115–0070, USA. jhorne@u.washington.edu.

It is not uncommon that *in situ* bimodal or multimodal target strength (TS) distributions are associated with unimodal length frequency distributions from trawl catch samples. There is little explicit mention of this pattern or its causes in the literature. Bi or multimodal TS distributions are often considered contaminated with other species or that net selectivity prevented a complete representation of targets in the water column. Multimodal TS distributions could result from a single or combination of factors associated with acoustic sensors, acoustic measurements, biological sampling, acoustic processing, fish anatomy, and behaviour. We examine the prevalence and potential causes of bi/multi modality in *in situ* TS distributions using empirical and simulated TS data from Walleye pollock (*Theragra chalcogramma*) samples. If after all sampling and processing effects are minimized, can tilt account for observed multimodal TS frequency distributions? Preliminary analyses show that the presence of more than one TS frequency mode can depend on the sampling and processing of acoustic data. Some samples contain other acoustic scatterers in the water column or densities are not appropriate for single target collections. Once all potential sampling influences were removed, we found that: L/λ ratio will influence the 'sensitivity' of TS to incident angle, *in situ* fish tilt angles vary (using target tracks as a tilt indicator), and that a distribution of tilt angles can influence the shape of TS distributions.

6.2 Stéphane Gauthier and John K. Horne. Acoustic Characterization and Differentiation of Pelagic Fish Species in the Gulf of Alaska and Bering Sea

University of Washington, School of Aquatic and Fishery Sciences, Box 355020, Seattle, WA 98195–5020, USA. sgau@u.washington.edu

Kirchhoff Ray Mode (KRM) backscatter models were used to characterize the acoustic properties of the pelagic fish community in the Gulf of Alaska and Bering Sea. Our goal was to identify species-specific characteristics and metrics that facilitate discrimination using acoustic techniques. Five fish species were analyzed: Atka mackerel (*Pleurogrammus monopterygius*), capelin (*Mallotus villosus*), eulachon (*Thaleichthys pacificus*), Pacific herring (*Clupea pallasii*), and walleye pollock (*Theragra chalcogramma*). Eulachon and Atka mackerel do not have swimbladders. Acoustic backscatter was estimated as a function of insonifying frequency, fish length, and body orientation relative to the incident wave front. Relative amplitude differences and the effects of tilt on the target strength (TS) of each species were assessed by measuring tilt-averaged TS within broad length ranges. The effect of morphological variability was indexed using the ratio of mean reduced scattering length (RSL) over its standard deviation. Frequency-dependent backscatter characteristics were examined and the potential usefulness of target strength differencing between carrier frequencies was tested. Our results indicate that differences in acoustic characteristics exist among these species, especially between swimbladdered and non-swimbladdered fish. Echo intensities were variable within and among species. Morphological variability was low only at $L/\lambda < 10$. Target strength differencing can be used to discriminate species such as Walleye pollock and capelin but results are variable and the technique may not be appropriate for all species.

6.3 Bo Lundgren and Rasmus Nielsen. Progress regarding processing data on ex-situ measurements of wideband reflectance of gadoids

Danish Institute for Fisheries Research, Dep. of Marine Fisheries, North Sea Center, P.O. Box 101, DK-9850 Hirtshals, Denmark. bl@dfu.min.dk

Progress on the techniques used to precisely align optics and acoustics to measured the location of the fish in the beam and its tilt angle in experiments on wideband reflectance of gadoids were presented.

6.4 C. Goss. Acoustic surveys of icefish used to complement stock assessment with bottom trawls

British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET

The stock of mackerel icefish (*Champsocephalus gunnari*), living on the continental shelf of the sub-Antarctic island of South Georgia, has been assessed using bottom-trawl surveys either annually or biennially since the mid-eighties. The surveys have provided essential information for stock management to the group of Antarctic Treaty Nations that are allied under the Convention for the Conservation of Antarctic Marine Living Resources. In 2001/2002 both Russian and UK vessels undertook concurrent surveys for icefish at South Georgia. As well as trawl methods both teams used acoustic techniques, with Simrad EK500 systems operating at 38 and 120 kHz on the two vessels, both during hauls and between stations. A workshop in 2002 brought together teams from the two vessels to explore the similarities and differences between the surveys and discuss how much of the variation between the vessels was due to differences in the fishing gear used and how much was due to natural spatial/temporal variability of the stock.

The acoustic surveys indicated that icefish were not only living near the seabed, but that a significant portion of icefish biomass was located in the water column. Thus the traditional approach using bottom trawls resulted in biased estimates of standing stock below the true value: acoustic estimates are ~ 1.5 times higher. Regular acoustic surveys would improve the stock estimates and understanding of the biology of this species, but will require the development of new survey designs and protocols.

6.5 Arnaud Bertrand[1], Marceliano Segura[2], Mariano Gutierrez[2] and Luis Vasquez[2]. Did the 1997–1998 ENSO event have a major impact on the abundance and distribution of pelagic fishes in the Peruvian waters?

[1]*Institut de recherche pour le développement (IRD) c/o Escuela de Ciencias del Mar, UCV, Av. Altamirano 1480, Casilla 1020, Valparaiso, Chile. arnaud.bertrand@ird.fr.* [2]*Instituto del Mar del Perú (IMARPE) Gamarra y General Valle s/n Chucuito, La Punta Callao, Peru.*

In the eastern boundary current systems, pelagic fish abundance, distribution and behaviour are strongly influenced by seasonal, interannual and decadal climate variations. Among these environmental changes, the El Niño Southern Oscillation (ENSO) is considered to be one of the major variation sources. In Peru, the ENSO event always produced a diminution of the observed biomass of anchovy. However this decrease can be followed by a slow or a rapid stock recuperation.

In Peru, the Instituto del Mar del Perú (IMARPE) performs regular acoustic surveys to monitor the distribution and the abundance of the main pelagic resources. In order to study in more details the evolution of the ecosystem and to record information allowing an adapted fisheries management, the sampling rate was increased to follow the strong 1997–1998 El Niño event. In the present study we used data from six surveys carried out between September 1997 and March 1999 to examine the consequences of the 1997–1998 ENSO event on abundance, spatial distribution and behaviour of the main pelagic species: anchovy, sardine, jack mackerel and mackerel.

Results allowed to highlight bias in direct and indirect fish biomass estimation related to fish availability to acoustics and fisheries. Furthermore we showed that to understand the effect of an ENSO event on the pelagic fish population various factors occurring at different scales should be considered: (1) the inter-decadal regime (decadal scale); (2) the strength and the duration of the ENSO event (inter-annual scale); (3) the population condition before the event (inter-annual scale); (4) the fishery pressure (annual scale); (5) the adaptation of the reproductive behaviour (intra-annual scale); (6) the presence of local upwelling (local scale).

6.6 Discussion

To explore the reasons for discrepancy between trawl catches and acoustic data, backscattering simulations from a KRM model were combined with in situ target tracking to look at the influence of the tilt of fish in the beam on the distribution of TS measurements. Results showed that the bimodal TS distributions, that are often frequent despite unimodal fish length distributions, could result from tilt effects possibly due to avoidance reactions. Variability was however high. Comments pointed out that such tilt effects depend of frequency and of fish species, and care should be taken when inferring TS changes (log scale) to biomass changes (linear scale). The interpretation of the slope of the fish trajectory as the actual fish tilt is another potential source error. Simulations were also used to explore the possibilities of using the spectral signature of fish to differentiate the main species in a northern pelagic community, given variations in length, tilts, and presence of swimbladder. Such simulations of multi-species ecosystem taking into account the inherent variability were very useful to explore the possibility to extract discriminant acoustic features. Result showed that a set of such potential features could be established, especially to discriminate swimbladdered and non-

swimbladdered fish, but the high variability introduces a level of uncertainty that should not be underestimated.

Optics and acoustics were profitably combined in a carefully designed experimental set-up to extract the accurate measurements required to progress in the interpretation of wideband fish echoes, as stressed in topic 2. This setup was built to precisely measure the location of the fish in the beam and its tilt angle in wideband experiments. The aim is to derive correcting factors for the frequency spectrum of the echoes to take into account the position of the fish in the beam and the variation of the beam width with frequency. The system was tested with calibration spheres. Influence of the near field of the fish may sometime be of concern.

An experiment comparing trawl and acoustic estimates of icefish in Antarctic was made. It pointed out several sources of uncertainty of both gears such as the determination of the effective area swept by the trawl (door or wing spread), the TS of icefish and the echo classification. Efforts in comparing trawl and acoustic estimates are also underway within a EU project. The use of pelagic fish distribution maps obtained from fishing fleet acoustics showed that changes in biomass estimates in a El-Nino climatic/ecosystem context could be related to changes in availability due to changing ecosystem conditions. This example stresses the importance of acoustics to address the ecosystem approach to fisheries adopted by ICES, and the large potential of collaboration with the fishing fleet to tackle this problem, as was topic 1 emphasised.

John Dalen, David Demer, François Gerlotto, Rudy Kloser, Rolf Korneliussen, Robert Kieser, Ian McQuinn, William Michaels, Kjell Olsen, Egil Ona, Andrzej Orlowski, Dave Reid and Yvan Simard contributed to this discussion.

7 TOPIC 4 "ADVANCED TECHNOLOGIES AND PLATFORMS"

7.1 John Hotaling and Jim Meehan. The new United States NOAA Fisheries Research Vessel

NOAA Fisheries, USA. John.Hotaling@noaa.gov.

An overview of the new United States NOAA Fisheries Research Vessel with emphasis on all of the quieting and acoustic survey features being employed. Our new ship is under construction and much of the equipment has been factory tested and installed in the ship, which is still on the launch ways until September. We would like to show examples of the features by pictures and present the noise attenuating issues and our approach to the solutions for developing an ICES compliant vessel.

7.2 James H. Churnside. Recent advances in airborne Lidar

NOAA Environmental Technology Laboratory, R/E/ET2, 325 Broadway, Boulder, CO 80305, USA. James.H.Churnside@noaa.gov.

I will report on several recent results using airborne lidar. Several studies comparing lidar with acoustics have been completed. Correlation between the two techniques varies from about 55% to about 99%; the difference seems to depend mainly on the time difference between the surveys. Lidar target strength values have been measured for mackerel. Results of a mackerel survey in the Norwegian Sea will be described. An imaging component has been developed. The images can resolve individual fish, and examples of Pacific salmon will be presented. The contrast-to-noise for a typical image was measured to be about 3 in the raw image, increasing to about 23 with simple filtering techniques. Simultaneous measurements of sea-surface temperature and ocean colour are now available from the same platform. A sea-surface salinity measurement is under development.

7.3 Godø, O.R., Patel, R., and Torkelsen, T. Monitoring ocean hubs with advanced acoustic instrumentation

Institute of Marine Research, P.O. Box 1870 Nordnes, 5817 Bergen, Norway. olav.rune.godoe@imr.no.

Some areas take up a unique position in the ecosystems being of extreme important for one or several fish stock. The processes and dynamics taking place in these hubs are, however, often scarcely known. The main reason is that monitoring marine resources are normally based on quasi synoptic surveys that covers the total distribution of the stock during a time of minimum dynamics.

We demonstrate in this paper that stationary acoustic observatory technology can produce results of great importance for ecosystem monitoring. Our test instrumentation was located at the inlet of the Ofoten fjord, a major wintering area

for herring. The instrumentation constituting the Ocean Hub consists of two 38 kHz upward looking echo sounders, a sideward looking 12 kHz sonar and an upward looking 200 kHz ADCP.

In special cases when a stock passes narrow passages, such instrumentation can monitor biomass flux, and over time, stock abundance. Generally, monitoring the dynamic properties of marine organisms like vertical distribution and migration, migratory speed and direction, and species interaction will probably be more important. In our test case we demonstrate all these features and in addition we show that observatory approaches may give insight in behavioural dynamics that we did not know about on beforehand.

7.4 David A. Demer and Derek Needham. Multi-instrumented autonomous buoys for ecosystem assessments

Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, U.S.A. David.Demer@noaa.gov.

Multi-instrumented buoys have been developed and will be deployed to characterize the spatial, temporal, and size distributions of tuna and other fish beneath and surrounding fish aggregating devices (FADs) used by the U.S. purse seine fleet fishing in the equatorial Pacific. These distributions will be related to concurrent observations of environmental conditions and predator-prey interactions. Ultimately, results from this research may be used to assist fishing and management efforts to develop/modify purse seine fishing strategies to minimize by-catch and ensure the long-term sustainability of FAD-based tuna fisheries in the tropical Pacific. We intend to use multiple-frequency echosounders, in-situ target strength measurements, and echo-integration processing methods to quantify the abundance, dispersion, and temporal variability of tuna and other fish beneath and surrounding multiple FADs. Information from beneath the FADs will be collected using autonomous and remotely-monitored multi-instrumented buoys. Each buoy includes a three-frequency scientific echosounder system, a passive-acoustical preamplified hydrophone, underwater video camera, data logging and control computer, GPS, multi-port serial adapter, 900 MHz spread-spectrum radio modem with antenna, radar transponder or reflector, strobe light, AGM battery, solar panels, and power control circuitry. The buoy is a variant of a design that has been successfully deployed in the Southern Ocean to describe krill abundance and dispersion, environmental conditions, and predator activities in an area around Cape Shirreff, Livingston Island, Antarctica.

7.5 Egil Ona, Terje Torkelsen, Ingvald Svellingen, Ronald Pedersen, and Geir Pedersen. The autonomous TS collector; a new tool for in situ target strength measurements on fish

Institute of Marine Research, P.O. Box 1870, 5817, Bergen, Norway. egil.ona@imr.no

A new, autonomous platform for collecting detailed, in situ target strength data on single fish is presented. A full description of the technical details of the platform is shown. This includes a dual transducer, 38 kHz, Simrad split beam echo sounder, an underwater single frame digital camera system and a computer with data collection and systems control software. Power to run the echo sounder, camera and computer is supplied by an external battery. The platform can be mounted on the bottom in a fixed rig, or hang as a buoy system from the surface. A horizontal observing, wide-angle, split beam transducer has a field view in the same volume as the camera, and is used to analyse the water volume in front of the rig. A second, vertical observing transducer for dorsal target strength collection is mounted 10 meters above this volume. When a fish is entering the observation volume, it will be measured and analysed by real-time target tracking software, the will camera zoom to a correct distance, and a digital picture of the target will be taken when a favourable position is reached. Thus, a data set consisting of one track, i.e., 10 – 50 TS measurements is obtained, with a corresponding digital picture of the target. From the photographic data, along with accurate ranges measured by the split beam, fish species, size and tilt angle can be extracted. The digital picture is immediately transferred to the computer hard disk, and typically 10.000 pictures can be taken before the system is retrieved. Typical operation time with the existing batteries is 7 – 10 days.

7.6 Egil Ona[1], Atle Totland[1], and Terje Vedeler[2]. The deadzone observer; a new tool for observing fish close to the seabed

[1] Institute of Marine Research, P.O. Box 1870, 5817, Bergen, Norway. egil.ona@imr.no, atle.totland@imr.no. [2] Norwegian underwater intervention, (NUI A/S), Gravdalsveien 245, P.O. Box 23 Ytre Laksevaag, 5848, Bergen, Norway. tve@nui.no.

A new, vertically migrating, autonomous platform for collecting detailed information on fish distribution close to the seabed is presented. A full description of the technical details of the platform is shown. This includes a 200 kHz Simrad split beam echo sounder, computer with data collection and vehicle control software, battery and communication systems. The deadzone observer has its own “swimbladder” or buoyancy regulator, which is designed to keep the

observer at a fixed distance, say 20 meters above the seabed, while freely drifting with the current. According to its mission plan, it will ascend to the surface and communicate with its host (land or research vessel) over a full two-way, Iridium communication system. After transmitting a set of status parameters, system parameters may be changed, and a new mission plan can be transferred. Typical operation time with the existing batteries is 7 – 10 days. Preliminary test results of the observer are presented.

7.7 Daniel Foster Doolittle and Mark Robert Patterson. Proof of concept: neural network classification of fishes using high frequency side scan sonar deployed from a Fetch-class Autonomous Underwater Vehicle

Virginia Institute of Marine Science, College of William & Mary, P.O. Box 1346, Gloucester Point, Virginia 23062–1346, USA. mrp@vims.edu

There is a direct link between the quality of fisheries data and the effectiveness of fisheries management. We approach this challenge through the creation and demonstration of a novel stock assessment tool. The technique uses a Radial Basis Function Artificial Neural Network classifier, using a 50 component image feature vector, to discriminate and enumerate selected fish species from high-resolution sidescan sonar images acquired with a Fetch-class Autonomous Underwater Vehicle (AUV). To demonstrate this technology, we have trained the classifier to successfully discriminate sharks (*Carcharias taurus*) and jacks (*Caranx hippo*) from other species. Data were acquired using a 600 kHz sidescan sonar (Marine Sonic Technology Ltd.) deployed from the AUV, and a conventional towfish. AUV deployment was found to have the following advantages over a towfish: useful images can be gathered by an AUV under rough seas, when the heave in a towfish cable could result in distorted imagery; the AUV was immune to boat electrical noise that produces artifacts in sonar images; and auxiliary sensors (video, CTD, O_2, pH) can be used on the AUV to simultaneously characterize the water column and bottom type during surveys. Fish avoidance reactions are also lessened with use of AUVs. AUVs equipped with analysis tools such as the one presented here, will provide scientists a new tool to unobtrusively document fish stock behaviour and population size, thus yielding data that may help to better tune stock assessment models. We also predict such tools will become valuable in the delineation and characterization of essential fish habitat.

7.8 Hugh Young[1] and Stephen Phillips[2]. Survey Autonomous Semi Submersible (SASS) Technology

[1]Hugh Young & Associates, Makaira, Mead End Road, Swat SO41 6EE, UK. [2]Seaspeed Technology Ltd., 2 City Business Centre, Basin Road, Chichester, PO19 2DU, UK. hyoung@makaira.freeserve.co.uk.

A UK consortium are developing **Error! Bookmark not defined.**Survey Autonomous Semi-Submersible (SASS) vehicles to replicate the data-gathering capability of a ship and hence reduce ship's time and cost, remove sensors from noise and pollution, remove personnel from danger, and provide radio/acoustic relays between surface and submerged AUVs and ROVs. The design criteria are, low capital and running costs, easy handling, and low noise. Most of these objectives are relevant to FAST, and enable the greater use of trawlers as discussed under Topic 1.

SASS involves an unmanned submerged torpedo-like body running below waves with a strong upright strut penetrating the water surface. The strut provides buoyancy, air for propulsion and radio frequency coverage for communications and positioning. It also aids launch and recovery. The engine is located on top of the strut above the waterline to reduce radiated engine noise, the vehicle is fitted with a large slow turning propeller to reduce cavitation, and the hull shape reduces flow noise. Quiet cruising speeds up to 12 knots under prime mover are possible, and for virtually silent operation electric propulsion is available for speeds up to 4 knots, with battery recharged by prime mover.

A full-scale 5.5 metre vehicle will be ready for demonstration in early August 2003.

7.9 Fernandes, P.G.[1], Stevenson, P.[2], and Brierley, A.S.[3] Proposals for the use of autonomous underwater vehicles in fisheries independent surveys

[1]Fisheries Research Services Marine Laboratory Aberdeen, PO Box 101, Victoria Road, Aberdeen, AB11 9DB, UK. fernandespg@marlab.ac.uk. [2]Southampton Oceanography Centre, Empress Dock, Southampton SO14 3ZH, UK. pst@soc.soton.ac.uk. [3]Gatty Marine Laboratory, University of St Andrews, Fife, KY16 8LB, UK. andrew.brierley@st-andrews.ac.uk.

Autonomous underwater vehicles (AUVs) are unmanned submarines which can be pre-programmed to navigate in three dimensions under water. The technological advancements required for reliable deployment, mission control, performance and recovery of AUVs have developed significantly over the past ten years. This paper considers how

AUVs could be employed in fishery independent surveys, principally as platforms for acoustic sensors. Compared to traditional research vessel platforms, AUVs are able to sample previously impenetrable environments such as the sea surface, the deep sea and under sea ice. By deploying AUVs to any depth, the optimum range to the target species can be chosen so as to be close enough to obtain a good signal to noise ratio, yet far enough to conduct benign remote sensing. Deployment of the AUV at depth also confers the advantage of whole water column coverage and enables surveying to be conducted largely unconstrained by the vagaries of weather. Furthermore, AUVs are typically small, very quiet, and have the potential to operate at low cost. Examples of how these traits may be utilised in fisheries surveys are given with reference to previous work and to potential future applications. Specifically, three types of acoustic survey are considered: a survey for herring in the North Sea; a survey for krill in Antarctica; and a deep sea survey for orange roughy. These are considered with and without research vessel support. Before many of the more prospective applications can be accomplished however, advances in AUV power source technology are required to increase the range of operation. The paper ends by examining this problem and reviewing other developments which are required to address many of the disadvantages currently inhibiting the wider application of AUVs in fisheries surveys.

7.10 Iain Goodfellow[1] and Richard Bates[2]. Visualisation of water column returns from a Reson multibeam system using TOUCAN

[1]AMS, Unit D1, Marabout Industrial Estate, Dorchester, Dorset DT1 1YA, UK. iain.goodfellow@amsjv.com] [2]School of Geography and Geosciences, University of St. Andrews, St Andrews, Fife, Scotland KY16 9ST.

Assessment of pelagic resources is difficult in open water situations and commonly relies on net surveys, limited acoustic measurements and trawl/landing statistics. A new generation of acoustic technologies is now available that could offer significantly improved methods for stock assessment. These methods include 3D imaging and characterisation of mid-water targets using multibeam sonar.

This report investigates the use of acoustic technology for making estimates of zooplankton biomass and zooplankton group identification using multibeam sonar for mapping zooplankton (esp. *Calanus*) as well as using new sonar processing programmes for acoustic signature acquisition and evaluation.

7.11 J. Michael Jech[1] and Dezhang Chu[2]. Comparisons of Simrad EK500 and EK60 Echo Sounder Calibrations

[1]NEFSC, 166 Water St., Woods Hole, MA 02543, USA. michael.jech@noaa.gov [2]WHOI, Woods Hole, MA 02543, USA. dchu@whoi.edu.

As technology improves, new hardware and software replace outdated systems. From a long-term survey perspective, comparisons of standard and new echosounders must be quantified to determine if these changes will alter acoustic estimates. The Simrad EK500 has been the state-of-the-art scientific echo sounder for surveying marine fish stocks and the Simrad EK60 is its successor. Calibrations of EK500 and EK60 echo sounders were conducted using the standard target method at the acoustic calibration facility on the Iselin Dock in Woods Hole. Both echosounders were calibrated using the same 38 kHz, 12^{o} beamwidth, split-beam transducer in order to compare split-beam determined angles and target strength measurements relative to known measurements. Angular locations computed by the echo sounders and recorded by LOBE programs (versions EK/EY500 5.XX and 1.0.0.5) and Sonar Data's Echoview were compared to directly measured angles. The directivity pattern of an ideal circular piston was fit to the experimental data, and both the split-beam determined and newly compensated values of target strength were compared.

7.12 Laurent Berger. Some methods and tools to automate calibration procedure

IFREMER, BP 70, 29280 Plouzane, France. Laurent.Berger@ifremer.fr.

Multi-frequency analyses may imply calibration of up to six vertical scientific echosounder transducers on Fishery Research Vessels.

Some methods and tools can be used to automate calibration procedure and to gain time:

1) automatic positioning of spherical sphere in the beam with step motors to determine the transducer beam pattern
2) automated echo-integration of sphere response for calculation of the offset on transducer gain
3) calibration on bottom echo

7.13 Discussion

The design of the USA NOAA FRV was presented, with a special emphasis on the effort made to respect the ICES recommendation for noise-reduced FRV. A unique propeller design was implemented with 5 blades, a bulb tip to prevent tip cavitation, adjustable pitch and attachable blades. The Navy designed the engine mounting. Generators and motors are all soft mounted. The need to synchronise all acoustic gears with a dedicated synchroniser was mentioned. Seven new USA FRV are planned for the near future.

The exploration of the possibilities of aircraft Lidar to map the distribution of pelagic fish and zooplankton in upper water column (top 20–30 m) and comparisons with acoustics were pursued. Good correlations with fish, especially on a school-to-school basis, were obtained. The choice of appropriate signal threshold levels appears to be problematic for zooplankton density estimation. First measurements of Lidar TS of fish were reported. The possibility of Lidar to detect wakes of marine mammals and transient ecosystem features such as internal waves was mentioned. Unfavourable conditions for Lidar applications (limited to clear waters only) are fog, rough seas and surface bubbles.

The large possibilities of acoustic observation systems (AOS) to monitor several components of the ecosystem was clearly demonstrated by real-time long-term monitoring of a Norwegian fjord using a sonar, two bottom-mounted EK60 systems and ADCP current profilers. Long time-series of bioflux could then be obtained as well as detailed information of fish behaviour (swimming, vertical migrations, predator-prey interactions, etc.) and interaction with the other components of the ecosystem (zooplankton preys and predators). Such information could be used to determine the best dates for biomass assessment surveys. The need for regular ground truthing of the acoustic observations and for water mass measurements (e.g., with CTD profiles) was mentioned. The addition of passive acoustic devices could be helpful to monitor presence of predators. More information on fish ventral TS relative to dorsal TS will be required to properly use such measurements with upward-looking echosounders.

Another type of AOS in development, called the autonomous TS collector, combined a echo-triggered camera with a programmed split-beam echosounder to automatically get in situ TS and tilt measurement of fish. The incorporation of the same programmable echosounder in a vertically migrating platform makes another autonomous AOS that can be use for several purposes, notably for close measurements near the bottom. Similarly, an example of AOS mounted on surface buoys with optical and passive acoustic sensors and data links to the coast was presented. All these AOS presentations show the emergence of new intelligent acoustic tools to monitor the fish and their ecosystem, which will likely be spreading rapidly through the ICES community. The presentations on non-traditional remotely controlled autonomous platforms to collect acoustic data, such as AUV (autonomous underwater vehicles) or ASV (autonomous semi-submersible vehicles) also evidenced the rapid development in this field. The availability of such new research platforms to a larger number of institutes in the near future is increasingly becoming a reality. Proposal for research surveys made with such platforms were already submitted to funding agencies. With this multiplication of the data collection possibilities, the development of efficient processing and interpretation tools for the mass of data collected will the next task to tackle. The same point was made in topic 1 for the handling of the eventual large data sets collected from a fishing fleet acoustic program. Though a few presentations explored some aspects of the question, namely 3D visualisation tools, this is issue deserves much more effort and could become a productive topic for next meetings.

Additional presentations and discussions on data processing by the new Simrad EK60 echosounder and its calibration took place during the meeting. They should result in more detailed descriptions of the data handling in the technical information provided by the manufacturer. A presentation on automatic calibration systems was made, including an exploration of the possibility of calibrating with the seafloor echo. This latter possibility was discouraged because of the sensibility of the seafloor echo to angle of incidence and because of bottom echo changes over time.

Arnaud Bertrand, Dezhang Chu, Jim Churnside, Jeff Condiotty, David Demer, Paul Fernandes, François Gerlotto, Van Holliday, John Horne, Rudy Kloser, Michael Jech, Robert Kieser, Ian McQuinn, Gary Melvin, William Michaels, Egil Ona, Andrzej Orlowski, Dave Reid, Yvan Simard, and John Simmonds contributed to this discussion.

8 REVIEW OF THE REPORTS OF THE STUDY AND PLANNING GROUPS

8.1 Planning Group on the HAC (PGHAC) common data exchange format

The PGHAC group met on 17 June in Bergen. The WGFAST acknowledged the report of the planning group presented by Dave Reid. The 2003 PGHAC report will be presented in separate ICES document. New tuples for the EK60, platform attitude and water speed and vessel log were worked out. The possibility of using the HAC format for acoustic seabed classification and multibeam sonar were discussed. The convergence towards an efficient comment exchange format seemed to be very close. It was suggested that the next report to WGFAST should demonstrate the use of the HAC format for handling data from several different sources.

All information on the HAC standard data format should be consolidated in a unique updated report that will be available on Internet during next year. PGHAC will work by correspondence in the next year.

8.2 Study Group on Baltic Herring TS (SGTSEB)

The SGTSEB group met on 17–18 June in Bergen. Bo Lundgren presented its report, which will be available in a separate ICES document. The Study Group pursued its modelling and experimentation on Baltic herring TS. Considerable progress has been made to account for all physiological, morphological, environmental and behavioural factors affecting TS variability. It was suggested that all these factors should not be expressed as sum but as variables of a multivariate function. The inclusion of a term on lipid content and gonad development may be possible, except for some period of the year where the information is insufficient. The new TS formulation would not help to solve the inconsistent biomass estimation. On the contrary, it would produce lower estimates.

The SGTSEB will conclude its work by writing an ICES Coop. Res. Rep. that should be published by the end of 2004.

8.3 Study Group on Acoustic Seabed Classification (SGASC)

The SGASC group met in Bergen on 17–18 June. John Anderson presented the report of the Study Group. The meeting attracted much more participants than expected: forty-one members from eleven countries. This initial meeting was essentially dedicated to the determination of the work plan. The Group decided to produce an ICES Coop. Res. Rep. to review the present state of acoustic seabed classification. A draft of the table of content of the report was outlined during the meeting. The need of external expertise to cover some chapters of the report was acknowledged. The report of the SGASC will be available in a separate ICES document.

9 RECOMMENDATIONS

9.1 Formation of the Study Group on Collection of Acoustic Data from Fishing Vessels

The following recommendation was proposed in conclusion of the discussion on topic 1.

Recommendation: WGFAST strongly recommends that a Study Group on Collection of Acoustic Data from Fishing Vessels [SGAFV] (Chair: W. Karp, USA) be established and meet in Gdnyia, Poland, on April 16–17 2004 to:

a) Review and evaluate recent and current research which involves collection of scientific acoustic data from commercial vessels,
b) Develop methods and protocols for addressing specific ecosystem monitoring, stock assessment and management objectives including: acoustic system calibration and performance monitoring, characterisation of radiated vessel noise, comparability of results, survey design, biological sampling, data interpretation and analysis, and data storage and management, and
c) Publish background material, guidelines, methods and protocols in an ICES Coop. Res. Rep.

The lifetime of the Study group will be 3 years. SGAFV will report to the WGFAST at his annual meetings in 2004, 2005 and 2006. The Study Group will report by 31 July 2004 for the attention of the Fisheries Technology Committee. The draft final report should be submitted WGFAST and FTC at their 2006 annual meetings.

9.2 Next WGFAST Chair

Paul Fernandes, who was in charge of co-ordinating the replacement of the WGFAST Chair, reported that he received only one application for the job. Dr Dave Demer, USA, was unanimously acclaimed for his acceptation of the new 3-year mandate as WGFAST Chair.

Recommendation: WGFAST recommends that Dr Dave Demer, USA, becomes the WGFAST Chair for 2004–2006.

9.3 Terms of reference for 2004 WGFAST meeting

The discussion on the terms of references for the next WGFAST meeting resulted in the following recommendation.

Recommendation: WGFAST recommends that the Working Group on Fisheries Acoustics Science and Technology

(Chair: D. Demer, USA) meets in Gdynia, Poland, on 20–21 and 23 April 2004 to:

a) examine works in the following research areas:
   i) effectiveness of noise-reduced platforms;
   ii) using acoustics for evaluating ecosystem structure, with emphasis on species identification;
   iii) statistical characterisation and utilisation of target strength (TS);
   iv) error assessment for acoustic biomass estimates.
b) review the reports of the:
   i) Planning Group on the HAC (PGHAC) common data exchange format;
   ii) Study Group on Baltic Herring TS (SGTSEB);
   iii) Study Group on Acoustic Seabed Classification (SGASC);
   iv) Study Group on Collection of Acoustic from Fishing Vessels (SGAFV).

9.4 Terms of reference for 2004 WGFAST-WGFTFB Joint Session

In accord with WGFTFB, the following theme is proposed for the 2004 Joint Session.

Recommendation: WGFAST and WGFTFB recommend that the two Working Groups (Chairs: D. Demer, USA, and N. Graham, Norway) meet for a Joint Session in Gdynia, Poland, on 22 April 2004 to review:

a) the questions raised at ICES Symposium Fish Behaviour in Exploited Ecosystems, held in Bergen in June 2003;
b) methods for estimating abundance of semi-demersal species, including combining trawl and acoustic estimates;
c) methods to observe fish behaviour in relation to fishing gears.

9.5 Theme Session for the 2005 Annual Science Conference

In its continuing effort to contribute to the ICES Annual Science Conferences, WGFAST proposes the following theme for the 2005 Annual Science Conference.

Recommendation: Since acoustics is a unique non-selective and non-intrusive tool to look at aquatic ecosystems structures in continue over a broad range of scales, and in response to the increasing need for efficient tools to conserve the ecosystem context in studying and managing fish populations, WGFAST recommends that a Theme Session on *"Three-dimensional classification and characterisation of pelagic ecosystem"* be established for the 2005 Annual Science Conference, with Arnaud Bertrand, France, as one of the convenors.

9.6 Next acoustic symposium

A brief discussion on the planning for the next acoustic symposium ended the meeting. Several possible themes such as stock assessment with sonars, fish essential habitat assessment, integration of systems, automated acoustic data collection and processing, acoustic observation systems were suggested. The discussion concluded with the following recommendation.

Recommendation: WGFAST recommends that an Organisation Committee be formed before the 2004 meeting to start planning the next Acoustic Symposium, expected for 2007.

10 MISCELLANEOUS

A proposal for exploring the possibilities of Lima, Peru, as the location for the 2005 meeting was submitted by François Gerlotto, France.

11 CLOSURE OF MEETING

On behalf of all members, the Chair thanked the local hosts at the Institute of Marine Research in Bergen, Norway, Egil Ona and his organisation committee, for their generous hospitality and efficient organisation. The meeting was then closed.

APPENDIX 1: LIST OF PARTICIPANTS TO THE 2003 WGFAST MEETING IN BERGEN, NORWAY

Name	**Country**	**E-mail**
Anderson, John	Canada	andersonjt@dfo-mpo.gc.ca
Andersen, Lars Nonboe (*Non-member)*	Norway	lars.nonboe.andersen@simrad.com
Archibald, Pete (*Non-member)*	USA	pete.archibald@oakmgmt.com
Axenrot, Thomas (*Non-member)*	Sweden	thomas.axenrot@system.ecology.su.se
Balk, Helge (*Non-member)*	Norway	helge.balk@fys.vio.no
Berger, Laurent (*Non-member)*	France	laurent.berger@ifremer.fr
Bertrand, Armand	France	arnaud.bertrand@ird.fr
Bertrand, Sophie (*Non-member)*	France	sophie.bertrand@ucv.cl
Boyra, Guillermo	Spain	gboyra@pas.azti.es
Chu, Dezhang (*Non-member)*	USA	dchu@whoi.edu
Churnside, Jim	USA	james.h.churnside@noaa.gov
Condiotty, Jeff (*Non-member)*	USA	jeff.condiotty@simrad.com
Dalen, John	Norway	john.dalen@imr.no
Demer, David	USA	david.demer@noaa.gov
Didrikas, Tomas	Sweden	tomas@system.ecology.su.se
Diner, Noël	France	noel.diner@ifremer.fr
Doolittle, Daniel F. (*Non-member)*	USA	danield@vims.edu
Fernandes, Paul G.	UK	fernandespg@marlab.ac.uk
Gauthier, Stéphane (*Non-member)*	USA	sgau@u.washington.edu
Georgakarakos, Stratis (*Non-member)*	Greece	Stratisg@aegean.gv
Gerlotto, François	France	fgerlotto@ifop.cl
Godo, Olav R.	Norway	olavrune@imr.no
Goodfellow, Iain (*Non-member)*	UK	iain.goodfellow@amsjv.com
Goss, Cathy (*Non-member)*	UK	cg@bas.ac.uk

Name	Country	E-mail
Greig, Tony (*Non-member)*	UK	t.greig@marlab.ac.uk
Gutierrez, Mariano	Peru	mgutierrez@imarpe.gob.pe
Higginbottom, Ian (*Non-member)*	Australia	ian@sonardata.com
Holliday, Van	USA	van.holliday@baesystems.com
Horne, John	USA	jhorne@u.washington.edu
Hotaling, John (*Non-member)*	USA	john.hotaling@noaa.gov
Jech, Mike	USA	michael.jech@noaa.gov
Josse, Erwan (*Non-member)*	France	erwan.josse@ird.fr
Karp, Bill	USA	bill.karp@noaa.gov
Kieser, Robert (*Non-member)*	Canada	kieserr@pac.dfo-mpo.gc.ca
Kloser, Rudy	Australia	rudy.kloser@csiro.au
Korneliussen, Rolf	Norway	rolf@imr.no
Lapshin, Oleg M. (*Non-member)*	Russia	oleg.lapshin@mtu-net.ru
Lebourges, Anne (*Non-member)*	France	lebourge@ird.fr
Lundgren, Bo	Denmark	bl@dfu.min.dk
Macaulay, Gavin (*Non-member)*	New Zealand	g.macaulay@niwa.co.nz
Madirolas, Adrian (*Non-member)*	Argentina	adrian@inidep.edu.ar
McLelliam, M. Cameron (*Non-member)*	USA	mcfish@lincoln.midcost.com
McQuinn, Ian	Canada	mcquinni@dfo-mpo.gc.ca
Melvin, Gary	Canada	Melving@mar.dfo-mpo.gc.ca
Michaels, William	USA	william.michaels@noaa.gov
Michalsen, Kathrine	Norway	kathrine@imr.no
Mitson, Ron	UK	acoustec@acoustec.co.uk
Mortimer, Nick (*Non-member)*	Australia	nick.mortimer@csiro.au
Olsen, Kjell Kr.	Norway	kjello@nfh.uit.no
Ona, Egil	Norway	egil.ona@imr.no

Name	**Country**	**E-mail**
Orlowski, Andrzej	Poland	orlov@mir.qdynia.pl
Patchell, Graham (*Non-member)*	New Zealand	gjp@sealord.co.nz
Patterson, Mark R. (*Non-member)*	USA	mrp@vims.edu
Pedersen, Geir (*Non-member)*	Norway	geir.pedersen@imr.no
Pena, Hector (*Non-member)*	Chile	hector.pena@ifm.vib.no
Pena, Marian	Spain	marian@ba.ieo.es
Ramos, Fernando	Spain	fernando.ramos@cd.ieo.es
Reid, Dave	UK	reiddg@marlab.ar.uk
Rosen, Shale (*Non-member)*	USA	srosen@gma.org
Scalabrin, Carla (*Non-member)*	France	carla.scalabrin@ifremer.fr
Severin, Vladimir	Russia	severin@atlant.baltnet.ru
Shvetsov, Faust (*Non-member)*	Latvia	shvetsov@latfri.lv
Simard, Yvan	Canada	simardy@dfo-mpo.gc.ca
Simmonds, John	UK	j.simmonds@marlab.ac.uk
Smith, Leon (*Non-member)*	Faroe Islands	leonsmit@frs.fo
Solli, Haakon (*Non-member)*	Norway	haakon.solli@simrad.com
Stenersen, Erik (*Non-member)*	Norway	erik.stenersen@simrad.com
Stensholt, Boonchai K.	Norway	boonchai@imr.no
Strods, Guntars (*Non-member)*	Latvia	phoxinus@latfri.lv
Torkelsen, Terje (*Non-member)*	Norway	terje.torkelsen@imr.no
Totland, Atle (*Non-member)*	Norway	atle.totland@imr.no
Young, Hugh (*Non-member)*	UK	hyoung@makaira.freeserve.co.uk
Walsh, Steve	Canada	walshs@dfo-mpo.gc.ca
Wilson, Chris (*Non-member)*	USA	chris.wilson@noaa.gov
Wilson, Matthew (*Non-member)*	Australia	matt@sonardata.com