ICES WGFAST REPORT 2006

ICES FISHERIES TECHNOLOGY COMMITTEE

ICES CM 2006/FTC:01

REPORT OF THE WORKING GROUP ON FISHERIES ACOUSTICS SCIENCE AND TECHNOLOGY (WGFAST)

27–30 MARCH 2006

HOBART, TASMANIA

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

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Recommended format for purposes of citation:

ICES. 2006. Report of the Working Group on Fisheries Acoustics Science and Technology (WGFAST), 27–30 March 2006, Hobart, Tasmania. ICES CM 2006/FTC:01. 56 pp.

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Executive summary

The Working Group on Fisheries Acoustics Science and Technology (WGFAST) met at the CSIRO Marine and Atmospheric Research Laboratory in Hobart, Australia, from 27–30 March 2006. David Demer (USA) was Chair and Alex De Robertis (USA) was Rapporteur. There were 71 participants from 15 countries. The following five topics in the Terms of Reference were examined and discussions were distilled to the associated points:

Fish behaviour in response to noise and other vessel related stimuli

Recall that herring reacted more to a quiet survey vessel than to a relatively small and noisy research vessel (*WGFAST05: Sections 3.13 and 3.20*). Acoustic observations of herring were not statistically different between a quiet research vessel and a commercial fishing vessel (Section 3.1). In cases when differences are observed, it is important to determine if they are due to differences in instrument versus vessel performances (Section 3.2). It is sensible to maintain awareness of the many rationale for quiet vessels (*WGFAST05: Section 3.20*), and continue to investigate other vessel related stimuli (e.g. light and particle motion; Sections 3.4 and 10.1).

Survey techniques for demersal, epi-pelagic and shallow water species

Fish habitat may be determined from the integration of measures of seabed and physical oceanographic characteristics with the distribution of fish and invertebrates (Section 4.7). Image processing techniques developed for acoustic seabed classification may also be used to classify backscattering in the water column (Section 4.4). New software is being developed that can facilitate quasi real-time consideration of physical and biological interactions using data from a variety of sources, and in the formats in which they are collected (Section 4.6).

Acoustical species ID techniques for multi-species assessments, ecosystem studies, bycatch reduction, and objective and automated data processing

Objective remote classification of fish taxa or species can sometimes be achieved using the frequency dependence of the acoustic backscatter or image analysis techniques (Sections 5.1, 5.3, 5.5, 5.8, 5.9, 5.10, 5.11, and 5.12). The accuracy of these techniques should benefit from consideration of all relevant information such as fish depth, distance from shore, aggregation shape, physical oceanographic environment, and substrate type (Section 5.14). Probabilistic classifications, opposed to simple group assignments, provide a metric of measurement uncertainty (Section 5.6).

Instrumentation, survey design, and data analysis techniques for studying aquatic ecosystems. Notify WGFTFB, WGREGNS and PGNAPES

The major aim of monitoring programs intended for ecosystem-based fisheries management is to detect significant changes in ecosystem components and to distinguish if these changes are attributable to harvesting or changes in environmental conditions (Section 6.6). Relatively simple indicators for increases and decreases of trophic groups are of great value in ecosystem based fisheries management (Section 6.7). Uncertainty in the measurements and model parameters must be incorporated into management strategies (Sections 6.3, 6.4, and 6.5). To efficiently monitor the environment and all trophic levels, acoustic and other sensors must be increasingly deployed from alternative measurement platforms such as satellites, aircraft, buoys, seafloor landers, fishing vessels, and at predator monitoring camps. The huge and increasing volumes of data need to be processed with improved objectivity and automation (Section 6.11). Now available from Simrad are calibrated scientific multibeam echosounders (ME70) and sonars (MS70) for fish biomass estimation and behavioural observations in the water column (Sections 6.1 and 6.2). These systems provide instantaneous, broad bandwidth,

and quantitative 2-D and 3-D images of fish schools out to ranges of 100's of meters. Notify WGFTFB. Fish schools can be instantaneously imaged over large areas of the continental shelf using ocean acoustic waveguide remote sensing (OAWRS) at low frequencies (Section 6.8). While able to detect densities as low as 0.1 fish-m^{-3} to ranges of about 30 km, OAWRS has significant limitations (e.g. no vertical resolution; low or no sensitivity to fish without swimbladders; poor remote species identification; and high sensitivity to seafloor characteristics; Section 6.11).

Target strength: modelling and measurements

Lowered multi-frequency echosounder systems have been designed for improved *in situ* target strength (TS) measurements (Sections 5.5 and 7.1). Optical techniques are increasingly used for non-destructive validation of acoustic targets (Sections 7.7 and 7.8). Dominant factors modulating TS are being investigated with increasingly sophisticated acoustic scattering models, particularly in terms of the anatomical detail that is included (Sections 7.4, 7.5, 7.6, and 7.9). New methods to measure total scattering spectra and generate anatomical radiographs in hyperbaric chambers have been developed (Sections 7.5 and 7.8). More rapid progress in this area requires the combination of *in situ* and *ex situ* measurements at multiple frequencies or over a broad bandwidth; validation of acoustic targets using optical and direct sampling techniques; superficial and internal anatomical measurements using digital photography, MRI and C-T scans; and physics-based acoustic scattering models — in an iterative, complementary process (Section 7.10).

The Terms of Reference were met.

Recommendations

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

1 Terms of Reference

In response to the ICES Resolution of the 91st Statutory Meeting, the Working Group on Fisheries Acoustics Science and Technology (WGFAST) (Chair: David Demer, USA; and Rapporteur: Alex De Robertis, USA) met in Hobart, Australia from 27–30 March 2006 to:

a) examine works in the following research areas:
  i) Fish behaviour in response to noise and other vessel related stimuli;
  ii) Survey techniques for demersal, epi-pelagic and shallow water species;
  iii) Acoustical species ID techniques for multi-species assessments, ecosystem studies, bycatch reduction, and objective and automated data processing;
  iv) Instrumentation, survey design, and data analysis techniques for studying aquatic ecosystems;
  v) Target strength: modelling and measurements; and

b) Review the progress of the:
  i) Planning Group on the HAC Data Exchange Format;
  ii) Study Group on Target Strength Estimation in the Baltic Sea (SGTSEB);
  iii) Study Group on Acoustic Seabed Classification (SGASC); and
  iv) Study Group on Acoustics from Fishing Vessels (SGAFV).

WGFAST will report to the Fisheries Technology Committee at the 2006 Annual Science Conference in Maastricht, the Netherlands, between 19 and 23 September, 2006.

2 Opening the Meeting

2.1 Welcome, Logistics, and Appointment of Rapporteur

David Demer (USA), Chair of the WGFAST opened the meeting. He welcomed the attendees and expressed his appreciation to Rudy Kloser (Australia) and the staff at the Commonwealth Scientific and Industrial Research Organization (CSIRO) for their hospitality and meticulous preparations for the meeting. Nik Bax, of CSIRO then welcomed the attendees, and introduced the participants to the facilities and activities of CSIRO. He stressed the relevance of the work conducted in WGFAST to the management of natural resources in Australia. He wished the working group a productive and enlightening meeting. Fred Stein, the director of research vessels announced a tour of CSIRO's research vessel, RV "Southern Surveyor". Rudy Kloser (Australia) then described the logistics for the meeting. The Chair outlined the meeting and described invited speakers related to the ecosystem approach to fisheries management, and Nicholas Makris (USA) from Massachusetts Institute of Technology (MIT) who will present novel acoustical technology for long-range detection of fish schools. Alex De Robertis (USA) was appointed as Rapporteur.

2.2 Dedication

The 2006 meeting of WGFAST was dedicated to Cathy Goss (UK), recently retired from the British Antarctic Survey, for her consistent efforts to implement and refine many of the ideas raised in WGFAST, and for demonstrating which are practical for improving resource surveys.

2.3 Participants and Agenda

A list of the 71 participants from 15 countries appears in Annex 1.

The adopted agenda appears in Annex 2.

3 Topic 1 "Fish behaviour in response noise and other vessel related stimuli"

3.1 J. Simmonds. Inter-calibration of EK500 systems on a noise quieted Fisheries Research Vessel and a Chartered Commercial Trawler used for herring surveys

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Results of an inter-calibration exercise between *FR/V Scotia* and *F/V Enterprise* are reported. The exercise was carried out over 8 hours surveying over an extensive aggregation of herring. Scotia deployed the EK500 on a 3 m drop keel; the *F/V Enterprise* used a shallow tow body alongside the vessel. The study reports the evaluation and diagnostics required to determine the significance of the evaluation. The regression analysis explicitly includes error in the estimates in the measurements of acoustic backscatter from herring aggregations by both systems. The correlation observed in the data is explicitly included in the analysis.

3.2 H. Peña. Inter-calibration of three commercial vessels equipped with scientific echo sounders in the Norwegian Sea

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An experiment to study the performance of three calibrated EK60 echo sounders onboard commercial vessels was done in summer of 2005 in the Norwegian Sea. Two of the vessels have identical design with the transducers mounted in the keel, and the third and larger vessel has the transducers mounted in a drop keel. Each vessel followed a parallel transect at 7 and 10 knots, for a distance of 10 n.mi. at each speed. A deep layer of Blue whiting was used to compare the S_A values for the three vessels using acoustical samples of 0.3 n.mi. The results showed several problems in the acoustical data related with sonar interference, propeller cavitation and bubble attenuation. Significant differences in the S_A estimates of the three vessels were found, and a possible explanation is proposed to interpret the differences between the vessels with identical ship design.

3.3 S. Eayrs. The application of acoustic stimuli to reduce bycatch in Australia's tropical prawn-trawl fisheries

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The deliberate application of acoustic stimuli to reduce bycatch and improve trawl selectivity is an emerging area of research in Australia's tropical prawn-trawl fisheries. The use of bycatch reduction devices (BRDs) in these fisheries has been a mandatory requirement since 2000, but bycatch reduction rates typically between 5–20% indicate the need for further research. One option is to investigate the application of acoustic stimuli to elicit species-specific swimming responses. This knowledge could potentially then be used to guide bycatch away from the approaching trawl or guide them through the escape openings of a strategically positioned BRD. In this presentation the speaker describes the current status of bycatch reduction research in Australia's tropical prawn-trawl fisheries and seeks audience contribution into the potential application of acoustic stimuli to reduce bycatch.

3.4 Discussion

The reactions of fish and micronekton to stimuli produced by vessels and other research platforms remains a major area of interest for WGFAST. Avoidance or attraction to research platforms due to platform-related stimuli such as radiated noise has the potential to bias abundance surveys, but adequately quantifying these potential biases remains a major obstacle. Presentations and discussion on this topic focused primarily on inter-vessel comparisons of echosounder measurements. Two such examples were presented. In one case, no difference in acoustically measured herring abundance was observed between a noise-quieted research vessel and a commercial fishing vessel. In another investigation, substantial differences in echo intensity were observed between three fishing vessels, two of which were sister ships. It was reported that inter-vessel comparisons could be improved by using regression methods that account for the error structure and serial correlation in the observations. Another important theme was the importance of monitoring instrument performance and vessel attitude to determine if observed differences are due to differential instrument performance or differential responses to the vessels.

In addition, the group explored the possibility that acoustic stimuli may be of use in deliberately modifying the behaviour of fish for the purpose of reducing bycatch reduction. Although there has been little research in this area, it was speculated that if swimbladdered fish were exposed to a sound source that will cause the swimbladder to resonate, this might produce a behavioural effect that could be used to elicit an avoidance reaction.

4 Topic 2 "Survey techniques for demersal, epi-pelagic and shallow water species"

4.1 M. Lawler. Acoustic detection of scallop and sponge habitat

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The use of single beam acoustics was investigated as a non-destructive alternative to dredging for the mapping and assessment of scallop beds for spatial management of the fishery. An area of previously un-fished seafloor known to contain a mixture of commercial scallops, dead shell, sponge and bare sand from previous scientific video and dredge surveys, was surveyed using a calibrated 120 kHz echo sounder. The raw echo data were processed in Echoview, with E1 and E2 response of the seabed calculated. An unsupervised classification approach was used to separate this data into separate classes. The video and sediment ground truth data was compared to these classes. The classes could be explained by differences in shell and sponge cover, differences in depth, and to a lesser extent differences in mean sediment grain size. Scallop habitat, as inferred from commercial scallop VMS (Vessel Monitoring System) data from the subsequent fishing season, was compared to this classified data. Scallop habitat was found to occur along the boundary of two of these classes, along the 42 m depth contour. Scallop habitat did not display a distinct acoustic signature based this simple approach. It was concluded that the use of a simple acoustic approach could not replace dredge surveys for the mapping and assessment of scallop beds for spatial management in such a spatially heterogeneous environment, however can provide useful additional information for the subsequent management of the fishery.

4.2 A. Orlowski. Acoustic classification of southern Baltic benthic habitat

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Seabed characteristics applied for classification was based on analysis of echo recordings collected aboard RV "Baltica" during regular surveys in 1995–2003 period. Hypothetical effective angle of a bottom echo $\theta'/2$, corresponding to its normalized length was applied to characterize complex seabed acoustic reflecting and scattering properties. The $\theta'/2$ values were determined for each EDSU. Classification of southern Baltic area was provided by comparison of two acoustically measured factors: statistical distribution of $\theta'/2$ and correlated depth structure within selected standard areas. Both factors are very closely related to biological characteristics of the benthic habitat. Joining them gives a wide possibility of differentiating the habitat by its basic ecological properties. The classification applied gave a unique identification and comparison of dynamics of seabed structures, useful for benthic surveys and helpful in ecologically friendly administration of the zone.

4.3 J.T. Anderson[1], R.C. Courtney[2], C. Lang[1], G.D. Fader[2]. Acoustic seabed classification using sidescan and normal incidence systems at preferred and non-preferred fish habitat sites on the Scotian Shelf

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A four year project to study the spatial utilization of benthic habitat by demersal fish species on the Scotian Shelf was initiated by the Fisheries and Oceans Canada in 2002. One of the objectives of this project was to determine the best acoustic metrics for predicting benthic morphology and structure of the seabed to better understand the linkages between habitat, benthic communities and fish. Six areas of the outer shelf banks of the Scotian Shelf were chosen for study based on historical fish catch data, to establish control. A broad suite of multidisciplinary geological, geophysical, and biological measurements were made on these sites. We present the preliminary results of the analysis and classification of sidescan sonar and wide-beam echo sounder data from two contrasting study sites on Western Bank. Based of acoustic scattering models, two metrics were derived from the sounder data: R1 – an estimate of the energy of the return in the first part of the seabed reflection and R2 – an integrated estimate of the energy following direct reflection. Principle component analysis confirmed that most of the variation of the echo sounder data lies in the R1 metric. We extracted two similar sidescan metrics: a mean backscatter evaluated over the footprint of the echo sounder and the standard deviation of backscatter estimates. K-means clustering algorithms were then used to segment the observations using various permutations of the acoustics metrics. These classifications are then compared to interpretative maps of the seabed derived using traditional and qualitative geological mapping techniques.

4.4 R. Kieser[1], W. Tesler[2], B. Buelens[3] and M. Wilson[4]. Implementation of seabed classification procedure for echogram and fish species classification

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We report on the continuation of our work on echogram and fish species classification using feature extraction and pattern classification methodologies that have proven successful in seabed classification work. Image processing techniques are used to extract features from appropriately prepared backscatter data and echograms. Selected features are submitted to principle component analysis (PCA) and K-mean clustering is applied to find acoustic classes that may or may not coincide with desired species. As a first step we accept the existence of well defined acoustic classes as an indication of classification potential. Comparison with catch results follows. We started our work by extracting fractal features from a small subset of hake survey data. Good results were reported at the 2004 ICES Annual Science Conference. We are now working with fractal and grey level features and larger data sets. Echoview and

Matlab are used for data display and selection, feature extraction, PCA and cluster analysis and the display and evaluation of results. Data handling and processing times are major issues and we have begun to implement the process in Echoview. We report on the grey level features that are now implemented in Echoview and on tests with our earlier single frequency and new multi-frequency data. Software implementation as well as classification procedures and results are presented and discussed. We think that the approach that is described here holds considerable promise for fish species ID.

4.5 M.J. Parsons[1], R.D. McCauley[1], and M.C. Mackie[2]. The use of acoustics techniques to study fish aggregations

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Coastal waters of Western Australia (WA) and their associated habitats are home to many species of demersal fish that migrate to form short-lived aggregations to spawn at the same sites over successive, predictable spawning seasons. Due to exploitation of demersal finfish spawning aggregations within the West Coast Bio-region, recent attention has been paid to passive and active acoustic techniques for assessments of these aggregations to help evaluate their sustainability. The species of fish that form spawning aggregations along the WA coastline display different acoustic and behavioural characteristics pertinent to the type of technique required in obtaining data relevant to stock assessment. This study is investigating established and developing techniques used in biomass estimation, for their precision in assessing aggregations of differing fish species. In particular, samsonfish (*Seriola hippos*), mulloway (*Argyrosomus hololepidotus*), pink snapper (*Pagrus auratus*) and dhufish (*Gaucosoma hebraicum*) are targeted. Field research involves: acquiring single- and multi-beam data from aggregations; logging recordings of spawning vocalisations; simultaneous ground truthing data; and establishing fish backscatter strengths in controlled situations. The ability to identify and measure targets using each method is being evaluated against ground truthing data and model predictions. Resulting conclusions will be used to develop a suite of protocols to promote the accurate and cost effective measurement of biomass levels for particular aggregations with species-specific characteristics.

4.6 G. Keith, R.J. Kloser and A. Williams. Integrating and visualizing epi-benthic habitat survey data

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A challenging task in analyzing and understanding data on epi-benthic habitats is that of integrating and visualizing the variety of datasets collected during surveys. Here we provide an overview of a software tool 'DataView' that enables both integration and visualization of relevant spatially explicit data, e.g. bathymetry (depth, slope and topography), acoustic backscatter (single beam and multi beam), images (video and still photography), sediments, oceanography (currents, temperature, salinity) and catches of fauna (invertebrates and fishes).

Our overview covers the sources of these data, the processing required to get data into a usable form and the ways in which these data sets can be viewed together. Emphasis is placed on data sets which can be compiled in real-time at sea and used as a basis for targeted sampling during survey. The examples provided come from a large submarine canyon off SE Australia which contains benthic habitat for aggregations of an important commercial fish, the pink ling (*Genypterus blacodes*).

4.7 Discussion

Acoustic seabed classifications are useful when defining habitat associations of living marine resources that interact with the bottom. However, seabed types are not necessarily a proxy for fish habitat. Definitions of fish habitat preferences are better determined from the integration of measures of seabed and physical oceanographic characteristics with the distribution of fishes and invertebrates. These parameters can be determined concurrently and largely using acoustic methods.

Developments in estimating seabed characteristics from acoustic measurements were reported. Two examples were presented in which acoustic measurements from the seafloor were shown to be related to the abundance of scallops and demersal fishes. It was also demonstrated that image processing techniques adopted from classification techniques used to classify backscatter from the seafloor may be applied with success to the problem of classifying backscattering in the water column. These approaches require new methods to rapidly combine large volumes of disparate data for inspection and analysis. Substantial progress on this front was reported in the form of new data viewing software, which allows viewing of a variety of data sources including video, model output, physical and biological data in the formats in which they are collected.

5 Topic 3 "Acoustical species ID techniques for multi-species assessments, ecosystem studies, bycatch reduction, and objective and automated data processing"

5.1 R.J. Korneliussen[1], E. Ona[1], I.K. Eliassen[2], Y. Heggelund[2], R. Patel[1], O.R. Godø[1], C. Giertsen[2], D. Patel[2], E.H. Nornes[2], T. Bekkvik[2], H.P. Knudsen[1], G. Lien[1]. The Large Scale Survey System – LSSS, a new post-processing system for multi-frequency echo sounder data

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Institute of Marine Research is responsible for research and monitoring of marine resources in Norwegian waters. To fulfil these tasks, IMR collects acoustic survey data from large ocean areas, and need to process these data to the best possible quality for abundance estimation. Due to the extensive field activities, most of the data is directly processed and scrutinized at sea. The Bergen Echo Integrator, BEI, was the first post-processing system with a true graphical interface to the echogram, and has been significantly improved during its 20 years lifetime. As the scientific needs for information increased, however, it has become increasingly difficult to expand the functionality of BEI, and a replacement of the system architecture is needed. Several existing post-processing systems have been considered, but none of them seemed to fit the future scientific needs. IMR therefore decided to start the development a new system, the Large Scale Survey System - LSSS. Some of the design criteria were: (1) Dynamic and scalable design; (2) Optimal quality of scrutinized data achievable within two hours of scrutinizing per day; (3) Keep much of the BEI workflow; (4) Include KORONA – multi-frequency analysis tools; (5) Computer platform independency. Some of the key features of the first version of LSSS released internally at IMR March 15 2006 are: school detection, noise removal, data convolution, data filtering, synthetic multi-frequency echograms, and species identification. Features for rapid data loading and specialized cursor trigging have been necessary when scrutinising raw echo sounder data at six frequencies. Work to expand LSSS with zooplankton inversion for operational use will start immediately after finalising LSSS V1.0.

5.2 E. Tenningen[1] and A. Lisovskiy[2]. Analysing lidar data in the acoustic post-processing program LSSS

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The objective of our work was to make lidar (Light Detection and Ranging) data available to a larger group of users through a proper post-processing program being able to read both Norwegian and Russian lidar data. The new Large Scale Survey System (LSSS) was chosen as a good alternative as this will be widely used for post-processing of acoustic data. It is also good to operate with the same lidar data format in Russia and Norway. By converting the lidar data to the Simrad ER60.raw format we are able to replay the data in ER60 that is also the format accepted by LSSS. Some adjustments still need to be done to LSSS before it can be properly used for lidar data and the recommendations for a lidar module within the program is given. The main problem being the lack of option to turn off the TVG function as the lidar TVG function is fundamentally different from the acoustic TVG function. Light propagation and sound propagation differ in nature, but the use of the same post-processing program can make it easier to combine the two techniques.

5.3 N. Mortimer[1], R. Kloser[2] and T. Koslow[1]. Methodologies for characterisation of mesoplankton using multi-frequency acoustics and discrete *in situ* plankton samples

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Insights into spatial and temporal distribution of mesoplankton (0.1 to 20 mm in length) have been explored using multi-frequency acoustic techniques combined with discrete sampling of the water column, and automated data processing techniques. The study used the Tracor Acoustic Profiler System (TAPS) operating at 265, 420, 700, 1100, 1800, 3000 kHz combined with a specially designed Discrete In-situ Plankton Sampler (DIPS) that collects 6 samples within the water column at targeted depths. The TAPS attached to DIPS was operated at a fixed range of 1.5 m with a 5 litre sampling volume. We present our work in progress comparing the plankton samples to the observed values of acoustic reverberation (Sv dB re 1 m^{-1}), how this process can be automated along with key factors for the successful use of high frequencies given low densities of plankton generally obtained in the oligotrophic waters off Western Australia, their patchy distribution and potential heterogeneity of scattering types.

5.4 J. Young, A. Hobday, T.E. Ryan and R.J. Kloser. Micronekton distribution off eastern Australia from nets and acoustics

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The spatial heterogeneity of micronekton was investigated at three oceanic sites off eastern Australia – one near to the continental shelf, one over a seamount and one well offshore — using nets and acoustics. An opening-closing mid-water trawl sampled the water column at discreet depths from 600 m to the surface. Simultaneous recordings of acoustic backscatter were made using a 38 KHz Simrad echosounder. Net sampling showed that micronekton biomass did not differ significantly between these sites, a conclusion supported by the acoustic data. However, the vertical distribution of the micronekton differed at the seamount with a concentration of micronekton between 400 and 700 m. We found that although species composition changed between regions the relative biomass was remarkably constant except over the Britania Seamount where there was a significant increase at depths between 300 and

400 m. Acoustic backscatter was also similar between the three regions studied although relative backscatter was significantly higher at depths between 400 and 700 m depth along the edge of the seamount than it was in the open ocean.

5.5 T.E. Ryan and R.J. Kloser. Application of a dual frequency acoustic probe to aid species identification during industry vessel surveys

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A dual-frequency (38 and 120 kHz) battery operated acoustic system (DropTS) deployable to 1500 m has been developed specifically for use on industry vessels to address questions of species identification and *in situ* target strength. The system was deployed during a June 2005 industry-based vessel-mounted acoustic survey of spawning orange roughy (*Hoplostethus atlanticus*) at the Cascade Plateau, a deepwater seamount south east of Tasmania. School marks were first observed using the calibrated vessel-mounted echosounder (Simrad 38 kHz ES60) and then targeted by lowering the DropTS system within 50–150 m above the seafloor and slowly drifting. The absolute mean school mark backscatter (Sv), spatial location, relative dB differences between frequencies and observations of fish reaction to the DropTS system were used in combination to successfully identify major species groups. A key finding of this study was that the DropTS system was able to test and in some cases refute our initial interpretation of species composition of acoustically observed school marks from the vessel-mounted surveys.

5.6 J.K. Horne[1], C.I.H. Anderson[2], and J. Boyle[3]. Objective classification of multifrequency backscatter

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When attempting to acoustically identify aquatic organisms the first step is to classify echoes from targets into groups. Approaches used to discriminate backscatter categories analyse target intensities, characterize echo envelope shapes, or use image analysis techniques to combine the previous two methods. Target classification success is dependent on species' distribution and composition, material properties of the animals, classifying algorithm, and potentially operator experience. In an effort to increase objectivity of classifying target intensities, we used unsupervised mixture modelling to identify probabilistic clusters within multi-frequency backscatter data. The models were determined using Expectation Maximization, which iteratively computes the posterior probabilities and then recalculates latent models until convergence is reached. The use of probability distributions for each pixel provides an objective classification of targets. Two examples are presented: 5 frequency data from the Mid Atlantic Ridge as an unknown, diverse species community; and 3 frequency data from the Bering Sea as a known, limited species community. Results from both examples extract features that are recognizable by eye: ringdown, noise spikes, missed pings, biological layers, patches, and the bottom. Potential applications include noise removal, bottom identification, and species or species group discrimination. Next steps include refining the classification algorithm (e.g. model initialization, convergence criteria, and cluster distance measurements) and sensitivity analysis.

5.7 A. De Robertis[1] and I. Higginbottom[2]. A technique for echosounder background noise removal and estimation of signal-to-noise ratio

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We have developed a simple and effective post-processing technique for the estimation of echosounder background noise levels and signal-to-noise ratios during active pinging. This method is a refinement of previous work by other investigators and assumes that noise is dominant in a portion of the acoustic measurement. The method provides repeated noise estimates over short time intervals without user intervention, which is beneficial in cases where background noise changes rapidly. Once an estimate of noise is available, it is straightforward to make first order corrections for the effects of noise and to estimate the signal-to-noise ratio in order to evaluate the effects of background noise on echo integration and target strength measurements.

Noise correction and the use of signal-to-noise based thresholds has the potential to improve inferences from acoustic measurements in lower signal-to-noise situations such as when surveying from noisy vessels, using higher frequencies, surveying at longer ranges, and when working with weak acoustic targets such as invertebrates and fishes lacking swim bladders. The method is particularly beneficial when using multiple frequencies for classification of acoustic backscatter, as these methods require high signal-to-noise ratios at all frequencies of interest for unbiased measurements. The methods have been implemented in SonarData Echoview, a commercially available software package for echosounder data analysis.

5.8 I.H. McQuinn[1], D. Carrier[2], A. Raymond[1], J.L. Beaulieu[1] and J.F. Gosselin[1]. Defining Marine-Mammal Essential Habitat in the Gulf of St. Lawrence using multi-frequency acoustic classification

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Many organisations worldwide are involved in the definition and description of essential habitat for a myriad of species on various spatial and temporal scales to address various conservation objectives. Describing essential habitats for wide-ranging species such as marine mammals that can extend over large ocean basins and that can be spatially and temporally dynamic represents a particular challenge. Many marine-mammal species, including some found on endangered-species lists, visit the Gulf of St. Lawrence in the summer to feed on concentrations of forage fish and zooplankton. Feeding habitat suitable for large cetaceans can be found dispersed over large areas throughout the Gulf (211,000 km^2). Mapping the food resources within such a large area requires extensive sampling coverage, for which hydroacoustics is particularly well suited. Multi-frequency acoustic data has been collected during several large-scale multidisciplinary surveys throughout the Gulf of St. Lawrence (74 survey days in 2005). The dB-difference technique was used to classify 38 and 120 kHz data to macro- and meso-zooplankton (e.g. euphausiids, calanus) and pelagic and semi-pelagic fish (e.g. herring, capelin, redfish). The distributions of these forage species were compared to geo-referenced marine mammal distributions on the scale of the northern Gulf of St. Lawrence. For this purpose, a suite of applications has been developed enabling the partially automated batch processing of large acoustic datasets for large-scale mapping and spatial analysis.

5.9 S. Neville[1], S. Mackinson[1], J. Preston[2], R. Kieser[3] and W. Tesler[4]. Remote species identification using image based classification (presented by R. Kieser)

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The purpose of this communication is to report on the development of ideas to adapt seabed classification algorithms for acoustic species identification. Textural analysis of sonar images of fish schools originated with the success experienced in acoustic classification of seabed sediments. The promise of this novel approach of adapting the process of acoustic seabed classification to species identification has been demonstrated with hake, rockfish, and plankton (Tesler, Kieser, and Preston, 2004). This previous study focused on one particular aspect of image classification (fractal dimension) but there are several other aspects to be optimised before the full potential of acoustic species identification can be realised. The present study will investigate data recorded at multiple frequencies, optimise methods for clustering and classifying species, and identify the most appropriate method for dividing up school images within echograms. The successful optimisation of target classification algorithms at the appropriate temporal and spatial scales will, at the very least, enable identification of targets to groups of species, with the possibility of full fish species identification.

5.10 T. Jarvis, N. Kelly and E. van Wijk. Multifrequency hydroacoustics at the Australian Antarctic Division

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The Australian Antarctic Division's (AAD) Southern Ocean Ecosystems program (SOE) has been using multifrequency echosounders to undertake scientific research in the Southern Ocean since 1980. The aims of SOE are to understand the structure of Southern Ocean ecosystems, the limits for sustainable harvesting, the sources of variability and their influence on biological productivity. Much of this work ties in with the directions of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). The AAD currently operates a 90 m icebreaker, the RSV *Aurora Australis*, outfitted with a Simrad EK60 echosounder system linked to hull-mounted transducers at frequencies of 12, 38, 120 and 200 kHz. From this platform we have conducted small-scale acoustic surveys to study localised krill abundance and flux, large-scale acoustic surveys to quantify krill distribution and biomass, and adaptive acoustic surveys to characterise the pelagic biota in relation to the marine ecosystem as a whole. Increasing efforts are being made to integrate the wide range of physical and biological datasets collected since 1980 in order to address our key aims. To this end, the acoustics team within SOE have been developing an approach to data processing and analysis that strives to be robust, objective and automated where possible. The real challenges lie in generating information from the acoustics data that is timely, ecologically meaningful and readily accessible by other researchers.

5.11 R.L. O'Driscoll. Report of the second meeting of the CCAMLR Subgroup on Acoustic Survey and Analysis Methods

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Mackerel icefish (*Champsocephalus gunnari*) are an important fishery in Antarctic waters, managed by the Commission for the Conservation for Antarctic Marine Living Resources (CCAMLR). Historically, icefish abundance has been assessed by bottom trawl surveys, but because the species is semi-pelagic, a significant proportion of the biomass may occur away from the seabed. There is reluctance about using acoustics for estimating icefish abundance because of considerable uncertainty associated with target strength and mark identification. The CCAMLR Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) met in Hobart on 23-24 March 2006 to review issues with respect to acoustic surveys of icefish, namely: (i) frequency-specific definition of icefish target strength; and (ii) classification of volume backscattering strength attributed to icefish versus other taxa. Results of the SG-ASAM meeting will be reported, with particular attention to the suitability of using the "dB differencing" method of separating krill from non-swimbladder fish like icefish.

5.12 M. Kang. Comparison of real and simulated school echoes for retrieval of characteristics of the distribution structure of fish schools

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The purpose of this study was to use simulation techniques to extract useful information about the internal structure of fish schools for species identification. The simulated schools were layer-shaped with parameters width, length, and height. The position of each fish in a school was determined by the separation between it and the neighbouring fish in the vertical, horizontal and front-back directions. Target strength was calculated from the body length and tilt angle of an individual fish, which in turn were determined by the application of normalized random numbers. A simulated echo wave was produced using a maximum value of 1 and a given carrier frequency and regarded as a single echo element. When fish positions corresponded with simulated acoustic beams, echo elements corresponding to insonified fish were generated. An echo of a single fish was produced by multiplying the echo element and the echo amplitude of a fish. Echoes of a school were obtained by combining all of the single fish echoes within a given sample interval in the range dimension in each ping. An envelope of school echoes was finally attained via calculation of the Root Mean Square. The envelope was then converted to S_V by adding a 20logR TVG term and dividing by a coefficient for multiple echoes. For analysis, an amplitude spectrum was used to extract characteristics of the distribution structure of a fish school. The size, body length, orientation, and distribution depth parameters of real schools such as walleye pollock (24*24*80 m, 8±0.24 cm, -5±15º, 20–100 m) and herring (40*250*110 m, 33.2±2.4 cm, 0±10°, 50–160 m) were used to simulate echoes of schools. A result for two schools was that echo amplitudes of real school echoes were lower than those of simulated ones. It was also found that walleye pollock school displayed a partly irregular distribution pattern in the spectrogram, on the other hand herring showed rather uniformed pattern.

5.13 M. Wilson. Recent developments and future plans for automated acoustic data processing in SonarData Echoview

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Echoview is being enhanced to meet key requirements of the fisheries acoustics community: automatic processing of very large datasets, the standardisation of processing procedures and the operation of remote autonomous data processing systems. The core requirements of these applications are similar and can be summarised as a set of algorithms for feature extraction together with flexible, feedback-based automation and classification tools. Features extracted from data are likely to encompass a broad range from purely abstract statistical features to others with significant physical meaning such as indices of data quality. Recent additions made to Echoview allow prototyping of basic automated data processing procedures and analysis exports. Features generated using Echoview's existing virtual echogram functionality can be automatically exported. The key to further development will be enabling "awareness" of extracted features within Echoview and providing decision-making functionality that allows the definition and application of decision rules. Crucial to this process will be the ability to automatically assign class-related metadata to all relevant objects based on the decisions made. In this presentation we will outline some of our initial developments and provide a summary of the information and feedback that are required from the community in order to expedite development of these capabilities.

5.14 Discussion

This session was motivated and directed by ICES' requirements to transition from single species management to ecosystem-based fisheries management. Five invited speakers, two from the Convention of the Conservation of Marine Living Resources (CCAMLR), one from the Australian Antarctic Division (AAD), and two from the Commonwealth Science and Industry Research Organization (CSIRO) gave talks to better define the ecosystem approach to fisheries management, and to identify requirements for data, its quality and management.

Overexploitation of a single target species has been shown to result in systematic changes in populations of other marine living resources, indicating that ecosystem management is warranted. The invited speakers reported some successes in defining and implementing ecosystem-based management in the Southern Ocean and Australia. The CCAMLR and AAD presentations provided an overview of how ecosystem-based fisheries management is being practiced in an international context. The major aim of all these monitoring programs intended for ecosystem management is to detect significant changes in ecosystem components and to distinguish if these changes are attributable to harvesting or changes in environmental conditions.

A recurring theme in the presentations and subsequent discussions was that collection, processing, and management of large numbers of high quality observations are crucial for meaningful ecosystem based fisheries management. Expectedly, acoustic technologies were identified as means for providing cost-effective observations of many ecosystem components over large and small geographic areas and time scales. Less obvious is that acoustic and other sensors must be increasingly deployed from alternative measurement platforms such as satellites, aircraft, buoys, seafloor landers, fishing vessels, and at land-based predator monitoring camps to efficiently monitor the environment and all trophic levels. In this regard, the efforts of CCAMLR to standardly collect, process, archive, and internationally share such data and their derived indices in a standardised fashion should be noted, if not mimicked by ICES.

CCAMLR is responsible for the acquisition, compilation, analysis and dissemination of data on all fishery and research activities conducted on exploited, dependent and related species in the circum-Antarctic Southern Ocean. Member nations have long-term ecosystem research and monitoring programs that cooperatively supply these data from ship- and land-based measurements. The data include: (i) fisheries data (e.g. catch and effort data, observer data); (ii) research data (e.g. CCAMLR Ecosystem Monitoring Program data); (iii) survey data; (iv) marine debris data; (v) physical data (e.g. bathymetry and sea-ice extent); and (vi) reference data (e.g. species lists, vessel registers, and maps). The data are managed by CCAMLR's

Secretariat and are central to the formulation of scientific advice on the management of fisheries and marine living resources within CCAMLR's Convention Area.

Discussed were the types of ecological indicators that can be produced from acoustic and other measurements techniques. It was emphasized that even relatively simple indicators for increases and decreases of trophic groups are of great value for ecosystem based management.

To reduce uncertainty about the effects of management actions on components of the ecosystem, we must utilize and integrate many different types of information. Speakers reviewed many types of indicator data currently being collected and used to support the ecosystem approach to fisheries management. Discussion centred on how to deal with conflicting information from different indicators. Also discussed were the issues of understanding the effects of illegal fishing; identifying good indicators of ecosystem processes; and coping with changes in the environment that are not easily predictable. In regard to all of these issues, incorporating uncertainty in measurements and model parameters was identified as a vital area for future work.

It has become clear that strategies for multi-species assessments and ecosystem studies require further development, and the tools for associated data collection and analysis need to be more accurate and efficient. Huge and increasing volumes of data are being collected from traditional and alternative research platforms in support of multiple species assessments, and these data need to be processed with improved objectivity and automation. A leap in this direction was made with a new multi-frequency data post processing system designed for efficient multi-species assessments during large-scale surveys. The software exploits the frequency specific sound scatter to discriminate various target species; thus, an increase in the number of frequencies will generally improve species discrimination. It was shown that probabilistic classifications of multi-frequency backscatter data may be more informative than simple group assignments. In general, however, multi-frequency methods of backscatter classification can be limited by background noise and the benefits of a method for noise estimation and correction were demonstrated. Other presenters showed that image analysis techniques are also promising. The accuracy of all these techniques should benefit from consideration of all relevant information such as fish depth, distance from shore, aggregation shape, physical oceanographic environment, and substrate type.

While necessarily embracing more data processing automation, the group cautioned that automated analyses require considerable attention to quality control. In this regard, one promising avenue of research is to calculate classification probabilities and other data quality metrics when estimating species groups from acoustic data. In addition, it was suggested that environmental parameters such as wind speed and vessel motion may provide additional metrics of data quality.

6 Topic 4 "Instrumentation, survey design, and data analysis techniques for studying aquatic ecosystems"

6.1 L.N. Andersen, S. Berg, O.B. Gammelsæter, and E.B. Lunde. Status for the new Scientific Multibeam Systems MS/ME70

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In 2003 Simrad in collaboration with IMR and IFREMER started development of two new scientific multibeam systems ME70 and MS70. ME70 is a downwards looking multibeam echo sounder with a configurable fan of split beams developed in collaboration with IFREMER. MS70 consists of up to 500 single beams forming a matrix looking to the side of the vessel and is developed in collaboration with IMR. Both systems are operating within the frequency band 70–120 kHz and are characterized by large dynamic range, low side lobes, stabilization, and calibration utilities. The development project is now in the final stage and status including challenges and potentials for the two types of instruments will be presented.

6.2 J. Dalen[1], H.P. Knudsen[1], E. Ona[1], R. Korneliussen[1], R. Patel[1], M. Dahl[1], L.N. Andersen[2], and S. Berg[2]. The new MS70 multi-beam sonar; some preliminary data from the first sea trials

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The new multi-beam sonar, MS70, is horizontally observing sonar yielding very high spatial resolution when operating all 500 beams, covering the frequency band 75–112 kHz. The sonar has undergone some sea trials from RV "G.O. SARS" during December 2005 and January 2006. Our presentation include some of the results obtained during the first trials, in order to keep the ICES FAST working group informed about the sonar particulars and the overall project progress. Topics covered will be sonar performance objectives, calibration methods, and preliminary results from calibration and shoal data acquisition. Examples of raw data acquisition from stationary vessel and moving vessel on small and large schools of pelagic fish are given. An organizing sketch for a data acquisition and post processing system under development will also be presented.

6.3 D.G.M. Miller. CCAMLR: Strategies and international efforts in ecosystem-based fisheries management

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A brief history is provided to illustrate the current context of ecosystem-based fisheries management (EAF) globally. The need to make EAF operational is emphasised in order to improve ecosystem knowledge and to provide for scientifically-based management to address uncertainty associated with natural ecosystem dynamics. The development of EAF within CCAMLR is offered as an illustration of current best practice along with some perceived threats to its success and the political realities associated with international fisheries management in general. Particular emphasis is given to the role of science as well as other operational considerations aimed at ensuring effective EAF.

6.4 D.C. Ramm. CCAMLR Data and their use in ecosystem-based fisheries management

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The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) is responsible for the acquisition, compilation, analysis and dissemination of data on all fishery and research activities conducted on exploited, dependent and related species in the circum-Antarctic Southern Ocean (CCAMLR's Convention Area). The data are managed by CCAMLR's Secretariat and are central to the formulation of scientific advice on the management of fisheries and marine living resources within CCAMLR's Convention Area.

The data include: (i) fisheries data (e.g. catch and effort data, observer data); (ii) research data (e.g. CCAMLR Ecosystem Monitoring Program data); (iii) survey data; (iv) marine debris data; (v) physical data (e.g. bathymetry and sea-ice extent); and (vi) reference data (e.g. species lists, vessel registers, maps etc.). Some fisheries data are processed and used by the Secretariat in *quasi* real time to determine fishery closures and/or areas as directed by Conservation Measures in force.

The use of these data in ecosystem-based fisheries management will be outlined.

6.5 A. Constable. Yield modelling for ecosystem-based management of Antarctic krill and fish

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The Scientific Committee for the Conservation of Antarctic Marine Living Resources (SC-CAMLR) developed a precautionary approach for assessing yield of krill, given the ecosystem approach specified in the Convention on the Conservation of Antarctic Marine Living Resources. This approach was later modified to apply to fish stocks as well. The underlying principles of the approach were to assess long-term annual yield that would satisfy the objectives of the convention despite the uncertainties in estimates of biomass of the target species and the associated population parameters. The ecosystem conservation objectives of CCAMLR were made operational by setting target and limit reference points that accounted for the needs of predators of krill and fish. This presentation will elaborate how the ecosystem objectives of CCAMLR were made operational, how the SC-CAMLR incorporates knowledge of biomass and population parameters into its assessments and how the ecosystem-approach is now being expanded to take better account of the needs of predators.

6.6 B. Fulton. Ecosystem based fisheries management in theory and practice in Australia.

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Ecosystem-based fisheries management (EBFM) is an area that is growing rapidly, both with regard to legislative requirements and the tools needed for its implementation. Within Australia the focus has been on developing reliable tools for each step in the adaptive management cycle, particularly with regard to monitoring, assessment and decision making. To date these tools have included (i) the identification of robust ecological indicators of the effects of fishing (for use in monitoring), (ii) ecological risk assessments for Australian fisheries (as an assessment method) and (iii) harvest control rules (to aid in tactical fisheries management decisions). These tools are also being backed up by the application of integrated ecosystem-level management strategy evaluations (MSE). Based around sophisticated simulation models, MSE allows for the testing of these new tools for EBFM, as well as a wider range of strategic management options.

6.7 R.J. Kloser and B. Fulton. Model evaluation of acoustic monitoring requirements for the ecosystem approach to fisheries

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The increased number of over-fished resources with impacted habitats and ongoing overcapacity in the worlds fishing fleets is well reported. This situation has lead to the adoption of an ecosystem approach to fisheries (EAF) to aid the traditional single species management approach. The implementation of EAF will require better governance and greater demands on our knowledge of the marine ecosystem beyond that of the targeted species. To achieve this, more knowledge about multi-species assemblages their trophic interactions and biomasses as a minimum will be required to monitor performance of EAF. In practice observational sampling for EAF will depend on the overall management arrangements for the fishery but a guide to the most useful indicators can be aided by modelling.

We present an ecosystem model of two Australian areas that highlights the dominant functional groups which provide the greatest information and the basic indicators to monitor change and direction. The ability of acoustic data to provide both quantitative and qualitative indicators over a range of trophic levels and large spatial and temporal scales is appealing. Using the ecosystem model we test the ability of acoustic data to provide quantitative metrics incorporating measurement uncertainty. The performance of acoustic indicators is presented as work in progress along with the development of acoustic systems and the experimental regions where we are applying them.

6.8 N.C. Makris[1], P. Ratilal[2], D.T. Symonds[1], S. Jagannathan[1], S. Lee[1], and R.W. Nero[3]. Fish population and behaviour revealed by instantaneous shelf-scale imaging

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Until now, continental shelf environments have been monitored with highly localized line-transect methods from slow-moving research vessels. These methods significantly under-sample fish populations in time and space, leaving an incomplete and ambiguous record of abundance and behaviour. We show that fish populations in continental shelf environments can be instantaneously imaged over thousands of square kilometres and continuously monitored by a remote sensing technique in which the ocean acts as an acoustic waveguide. The technique has revealed the instantaneous horizontal structural characteristics and volatile short-term behaviour of very large fish shoals, containing tens of millions of fish and stretching for many kilometres.

6.9 P.H. Ressler[1], G.W. Fleischer[1], and V.G. Wespested[2]. Acoustic & video observations used in the development of a commercial vessel-based survey methodology for widow rockfish (*Sebastes entomelas*)

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Widow rockfish is an important West Coast fish stock that has suffered dramatic reductions in abundance. Unfortunately, for future stock assessments the established bycatch index has ceased to be a reliable measure of abundance due to changes in fishing patterns. In response, a government-industry ad hoc working group was convened to develop an abundance index methodology for long-term monitoring of widow rockfish. The group selected a series of potential study sites along the coast identified by local fishermen as historic fishing grounds for widow rockfish. The group also reviewed techniques and determined that acoustics was the best tool for these surveys. As proof of concept, selected sites off central Oregon, USA were surveyed in March 2005 using standard single frequency (38 kHz) fishery acoustics methods and a towed camera sled deployed off a commercial fishing vessel. Our initial results suggest that despite variability within the sites, these fish exhibited a reasonable degree of temporal persistence and site fidelity over the study period. Spatially, the 0.1 to 0.3 nautical mile transect spacing used to survey the widow rockfish aggregations confirmed that fine-scale sampling of the study sites is probably necessary due to observed patchiness of widow rockfish schools. We had mixed success in the use of our camera sled to identify acoustically detected widow rockfish schools suspended in the water column, in many instances due to fish avoidance. Based on our initial experiences, sampling and assessment challenges of this long-term monitoring index and prospects for future fieldwork and analyses will be discussed.

6.10 C. Robinson and J. Gómez-Gutiérrez. Pacific sardine behaviour as inferred by acoustics related to tidal fronts in Baja California, Mexico

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It is known that schooling fish respond to different stimuli, changing school parameters such as density, swimming speed, orientation, etc. Moreover, schooling fish may change location, abundance and swimming depth according to food abundance and predator presence. In this study, the responses of the Pacific sardine (*Sardinop sagax*) in relation to the tidal dynamics were investigated in a semi tropical lagoon in the west coast of Baja California, Mexico. In this work we used a Simrad 120 kHz split beam echosounder along four transects (2 km long and separated by 2.5 km) and continuously recorded sea surface temperature and chlorophyll-a during spring and neap tides. Results show that fish under two contrasting tidal status (spring vs. neap tides), small pelagic fish responded differently. In more heterogeneous environment, with food concentrated along tidal fronts in spring tides, small pelagic fish swim in more compacted groups, swim in large groups, covered less area and were more abundant when variability in temperature increase (this was related to the number of fronts). In a more homogeneous environment during neap tides, small pelagic fish swim more separately, covered more area (more dispersed), swim in small groups, and swim in deeper stratum.

6.11 Discussion

Speakers were invited to discuss new multibeam and long-range sonars that are now available for improving investigations of aquatic ecosystems, The discussion focused primarily on recent developments in commercially available calibrated scientific multibeam echosounders and sonars for biomass estimation in the water column (namely, the Simrad SMS systems), and a low-frequency system for instantaneous continental shelf-scale imaging (OAWRS).

Simrad's new generation of echosounder (ME70) and sonar (MS70) systems are designed to measure fish abundance in the vicinity of the bottom and to observe fish near the sea-surface, respectively. Acceptance tests of the first installed versions of these instruments are underway in France and Norway, respectively. Initial calibration of IMR's MS70 system has been efficiently conducted using standard sphere methods originally developed for echosounder systems. The SMS control software includes the calibration routines. The group recognized that these new systems have significant potential for studies of school behaviour and vessel avoidance. To be overcome are substantial challenges associated with the collection, storage and analysis of the huge volumes of data produced by these instruments.

Nicholas Makris (USA), a keynote speaker from MIT, presented recent developments in technology based on ocean acoustic waveguide remote sensing (OAWRS) for imaging of fish populations over large scales (tens of kilometres). The technology was originally developed for military purposes. When tested to investigate geologic features of the seafloor, initial results indicated transient sources of backscattering at long-ranges. This unexpected result led to an experiment comparing OAWRS backscatter with backscatter from a conventional echosounder to determine if this scattering could be related to the presence of fish populations. This experiment revealed that schools of fish could be instantaneously (less than a minute) imaged over large areas of the continental shelf. There are currently plans for further work in the USA, including comparing the technique with echosounder data collected during an acoustic survey of herring.

This technology and its application to mapping fish and observing their behaviour was of great interest to the membership of WGFAST, and a lengthy discussion of the technique followed. The topics of this discussion ranged broadly. One point of discussion related to the abundance threshold at which fish can no longer be detected, which is estimated to be ~ 0.1 fish m^{-3}. In addition, it was pointed out that there is no vertical resolution and that it is difficult to identify species responsible for the signal, and that that this information must be inferred from other methods such as echosounders, optics, and trawls. The possibility that species could be identified based on the behaviour of schools was raised.

The current equipment used for OAWRS is large in size, and the possibility was raised that a smaller system could be developed with shorter arrays by using higher frequencies, although detection ranges would be reduced due to increased attenuation. At ranges of up to about 20–30 km, it is possible to detect signals from fish within one meter of the bottom and the surface. The slope of the seafloor was identified as an issue that can affect the performance of the technique, and areas with flat bottom slopes are the most likely candidates in which this technique can be applied optimally.

Another topic of discussion was further development of combined acoustic and optical methods to census depleted species occurring at low abundances. One suggestion to improve video ground truthing was to use a pelagic trawl with an open cod end to concentrate the fish for video imaging while allowing the fish to escape unharmed. Aggregation patterns of fish species differs with environmental conditions such as time of day and tidal conditions and this should be exploited when planning both the timing and design of these surveys.

7 Topic 5 "Target strength: modelling and measurements"

7.1 E. Ona, I. Svellingen, R. Skeide, R. Pedersen and A. Totland. The TS-probe, a new tool for improved in situ target strength measurements of fish and zooplankton

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A new pressure stabilized echo sounder probe for target strength measurements in deep water or at close range is presented. The probe carry three Simrad EK60 echo sounders, connected to pressure stabilized transducers, and can be operated on 6500 m optical cable down to about 1500 meters depth, using a heave-compensated winch. For keeping the transducers always pointing vertically, independent of cable angles, the transducers are mounted on a motorized, revolving platform. Digital angle sensors monitor transducer orientation, and an electronic compass also monitoring transducer rotation movements. The motors can rotate the transducer platform to about $\pm 30^o$ in two opposite directions, and can therefore also be used in accurate calibration exercises. Examples of target strength data and calibration results from the first sea trials will be presented.

7.2 A. Dunford. Target strength measurements of southern blue whiting.

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Recent southern blue whiting (*Micromesistius australis*) *in situ* target strength (TS) results are presented. The data were collected from the subantarctic waters off southeastern New Zealand. Comparisons are made with Kirchhoff swimbladder modelling results and the TS – fish length relationship used for New Zealand stock-assessment surveys; TS = 21.8 log10 (fork length) – 72.8, at 38 kHz. The results suggest that the current stock assessment relationship underestimates adults TS.

7.3 R.J. Kloser[1] and G. Macaulay[2]. Can multi-frequency *in situ* target strength measurements be used to infer species and their length in the Australian blue grenadier fishery (*Macruronus novaezelandiae*)?

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Critical to interpreting *in situ* target strength data is determining if measurements are representative of the population being surveyed. Issues that need to be resolved include species identification, depth, length, weight, orientation, sex and condition. In this example species identification was obtained using industry and research vessel trawling, school behaviour and multi-frequency acoustic methods. To explore the expected species specific and length specific frequency differences a Kirchhoff approximation gas-filled swimbladder model showed that including lower frequencies improved the length and species discrimination. In the talk we compare the model output to the multi-frequency (18, 38, 70 and 120 kHz) *in situ* target strength measurements. The resulting interpreted *in situ* target strength of blue grenadier is very much greater than values for the same species in New Zealand. We outline our steps to either resolve the large *in situ* TS range or propose a strategy to interpret the acoustic survey data acknowledging that there may be different interpretations.

7.4 G.J. Macaulay[1] and R.J. Kloser[2]. Acoustic models of orange roughy (*Hoplostethus atlanticus*).

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Collecting *in situ* data from orange roughy is difficult, requiring specialised equipment and skills. Moreover, recent reviews of orange roughy target strength have made it clear that correct target identification is the single most important aspect of robust *in situ* target strength estimates. Orange roughy are often found in close proximity to other species of similar target strengths and a number of different interpretations can be placed on any given *in situ* dataset when extracting orange roughy target strength. To assist with resolving the target identification problem, an anatomically detailed scattering model has been applied to orange roughy at 38 and 120 kHz at a range of tilt angles. The results from the model are presented and compared to *in situ* measurements at the same frequencies, and implications for (re)analysis of orange roughy *in situ* data discussed.

7.5 J.K. Horne[1], K. Sawada[2], K. Abe[2], D. Barbee[1], and Y. Takao[2]. Swimbladders under pressure: anatomical and acoustic responses by walleye Pollock

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Pressure influences echo intensities of swimbladdered fish through changes in swimbladder volumes and surface areas. Volume reduction is expected to correspond to Boyle's law (volume α pressure^{-1}) but the resulting deformation in swimbladder surface area will largely determine target strength at geometric scattering frequencies. We used dorsal and lateral radiographs of juvenile walleye pollock (*Theragra chalcogramma*) in a pressure chamber to image swimbladders from ambient to a maximum of 5 atmospheres pressure. As pressure increased, dorsal swimbladder surface areas decreased at a constant rate among the three individuals. Swimbladder volume reduction rates were similar among individuals but less than that predicted by Boyle's law. Compression of swimbladders occurred dorsal-ventral, anterior-posterior, and laterally. Resulting swimbladder shapes became more spindle-like as pressure increased. KRM predicted target strengths at 38 kHz and 120 kHz decreased more rapidly at three atmospheres above ambient than at lower pressures.

7.6 J.M. Jech[1], R. Gamble[2], R.H. Towler[3], and John K. Horne[3,4]. Towards a standardized data format of digital anatomy and morphometry for acoustic scattering models

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Accurate predictions of acoustic scattering by fish and zooplankton require accurate digital representations of the organism body and its scattering features. The use of acoustic scattering models is common for characterizing backscatter, increasing accuracy of abundance estimates, and improving remote species identification. Acoustic scattering models use digital measurements of anatomy and all models require analogue or digital images to be converted to digital information that conforms to the particular scattering model. Because of the utility and increased use of scattering models, we anticipate that libraries of digital anatomies exist for a number of species but are stored in a variety of formats. We are developing a data format that can be used to manage and archive digital images of aquatic organisms. Data and meta-data are stored in the Hierarchical Data Format (HDF5), which is an open-source and platform-independent format. A common data format will improve our ability to share data and ease comparisons of acoustic scattering within and among species. Our HDF5 data format will be described and examples of predicted backscatter by the Kirchhoff Ray mode model will be given. Feedback on the utility of a common data format and improvements to the format will be solicited.

7.7 G.W. Fleischer[1], P.H. Ressler[1], K. Cooke[2] and R. Kieser[2]. Examination of *in situ* target strength of Pacific hake (*Merluccius productus*)

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Measurements of *in situ* target strength (TS), made in an area of Pacific hake concentrations off southwest coast of Vancouver Island, British Columbia, will be will be reviewed and compared to values predicted from an established TS-length relation. Attempts to define the *in situ* target strength characteristics of Pacific hake typically suffer from the ability to find appropriate day and night concentrations of hake at moderate depths. Collectively, past studies are consistent within their results, though variability in their measurements suggests further refinements are in order. Our work takes advantage of conditions of rather shallow, isotypic aggregations of homogenous-sized Pacific hake and includes comparisons of acoustic measurements made of these fish during day and night-time, as well as comparisons of backscatter measurements at various vessel speeds; corroboration of the source of the backscatter was made by physical capture. The conditions that characterized the hake during acquisition of *in situ* measurements and used to develop a relation must necessarily be assumed to be the same for subsequent application in any given survey — deviations from those behaviours present in the fish used in developing the relation (e.g. tilt angle distributions) and those encountered during a survey will induce errors in the length-specific predicted TS values. This examination of predicted hake TS values is important in that acoustic coast-wide surveys of Pacific hake, used to assess the fish's distribution and abundance, depends on the application of a reliable TS-length relation. Error in the predicted TS values will affect the overall uncertainty in the derived abundance estimates.

7.8 D.A. Demer, S. Conti, B. Maurer, and L. Asato. Rockfish scound scattering spectra

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Marine sport fishing in Southern California is a huge industry that must be monitored and managed by non-lethal fish surveying techniques if it and the associated rockfish stocks are to be maintained. Because numerous species of rockfish coexist in areas covering millions of square nautical miles, residing near or on the bottom at depths of approximately 80 to 300 m, and are low in numerical-density, both acoustical and optical sensors are used. Within the essential habitat, sound scattering spectra is used to acoustically resolved fish near the seafloor, identify rockfish, and estimate their abundances. A combination of modelling, and both *ex situ* and *in situ* measurements are used to characterize the frequency dependence of sound scatter from the rockfish versus coexisting species. The recently developed multi-scattering technique for measuring total target strength (TS) is applied. A hyperbaric multi-scattering tank has also been developed for making these measurements as a function of pressure. Also, a hook and line technique has been developed to measure rockfish TS versus pressure, and fish species and length, at frequencies of 18, 38, 70, 120, and 200 kHz. TS versus length regressions are compared to published relationships. Reduced TS versus the product of the acoustic wave number and the fish length yields a rockfish spectral signature used for their remote identification. Validation of this survey technique is often difficult due to fish avoidance reactions to a remotely operated vehicle.

7.9 N. Gorska. Modal based deformed cylinder modelling of Baltic herring backscatter (presented by J. Horne)

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A reliable target-strength (TS) – length relationship is required to improve acoustic-based estimates of Baltic herring abundance. The Modal Based Deformed Cylinder Model is used to investigate the sensitivity of herring backscatter to biological, acoustical, and environmental parameters. Herring target strengths decreased with depth due to swimbladder compression. Influences of fish morphology and frequency on depth dependent target strengths are analyzed numerically. Relative contributions of anatomical structures to total backscatter are discussed. This modelling exercise improves understanding of the variability of Baltic herring TS observed in different acoustic surveys (measured backscatter of herring from different parts of the Baltic Sea differed by up to 10 dB).

7.10 Discussion

Target strength (TS) is used to scale echo-integration measurements into biological units such as biomass. This is often a crucial parameter and source of uncertainty for abundance surveys using acoustic methods. Progress was reported in the development of lowered multi-frequency echosounder systems designed for *in situ* TS measurement. As contamination from other species remains an important source of *in situ* TS uncertainty, it is important to verify the identities and measure the sizes of acoustic scatterers. Multiple optical techniques were proposed for non-destructive validation of acoustic targets.

There were several reports of apparent regional differences in TS of the same fish species, and resolving these issues will improve the ability to manage these living marine resources effectively. For this and other reasons, dominant factors modulating TS are being investigated with increasingly sophisticated acoustic scattering models, particularly in terms of the anatomical detail that is included. Also, the importance of swimbladder compression on TS was highlighted and broadly discussed. In this regard, new methods to measure total scattering spectra and generate anatomical radiographs in hyperbaric chambers were presented.

The consensus of the working group is that more rapid progress in this area requires the combination of *in situ and ex situ* measurements at multiple frequencies or over a broad bandwidth, validation of acoustic targets using optical and direct sampling techniques, superficial and internal anatomical measurements using digital photography, MRI and C-T scans, and physics-based acoustic scattering models — in an iterative, complementary process.

8 Review of the Reports of the Study and Planning Groups

8.1 Study Group on Acoustic Seabed Classification (SGASC)

John Anderson (Canada) reported on the activities of the Study Group on Acoustic Seabed Classification (SGASC). An ICES cooperative research report on acoustic seabed classification is nearing completion and an initial draft has been completed. The final meeting of the study group occurred immediately following WGFAST. The SGASC concentrated on final revisions to the draft CRR during the meeting. There are 13 authors, 11 of which are from WGFAST. A copy of the draft has been sent to ICES, and the final report and activities of the study group should be completed within approximately 4 months.

8.2 Study Group on Collection of Acoustic Data from Fishing Vessels (SGAFV)

The ICES Study Group on the Collection of Acoustic data from Fishing Vessels (SGAFV) held its third and final annual meeting at the CSIRO Marine Laboratory, Hobart, Tasmania, Australia, prior to the 2006 meeting of WGFAST. The meeting was chaired by Bill Karp (USA). Tim Ryan (Australia) was rapporteur. The Chair opened the meeting by thanking CSIRO and introducing those present. The study group then reviewed the agenda and discussed the goals of the meeting.

Major agenda items and meeting goals were agreed upon as follows:

- Review draft chapters for the final SGAFV report (to be published as an ICES Cooperative Research Report;
- Agree on any necessary changes in the structure and content of the final report; and
- Agree on a schedule for updating chapter text, drafting new material, and completing the report editing process.

The SGAFV Terms of Reference (ToRs) are:

- Review and evaluate recent and current research which involves collection of scientific acoustic data from commercial vessels;
- Develop standardized methods and protocols for collection of acoustic data to address 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

- Prepare background material, guidelines, methods and protocols for publication in the Cooperative Research Report series.

Reviews of key sections of the final SGAFV report were then conducted.

- Introduction (Lead authors Martin Dorn, USA; Richard O'Driscoll, New Zealand. Presented by Martin Dorn);
- Study requirements (Lead authors Rudy Kloser, Australia and Shale Rosen, USA. Presented by Rudy Kloser);
- Fishing vessels as sampling platforms (Lead authors Ron Mitson, UK and John Dalen, Norway. Presented by John Dalen);
- Instrumentation and remote operation (Lead Authors Gavin Macauley, New Zealand; Atle Totland, Norway; Olav Rune Godø, Norway. Presented by Gavin Macauley);
- Biological sampling (Bill Karp, USA);
- Issues regarding cooperative research with industry (Hector Peña, Norway); and
- Analysis, processing, and data management (Lead authors Gary Melvin, Canada and Tim Ryan, Australia. Presented by Tim Ryan)

Study group members discussed numerous changes in the text and minor changes in document structure. Agreed-upon changes were documented by the rapporteur and will be incorporated in the next draft by individual chapter authors.

The chapter originally entitled "analysis, processing, and data management" will be split into two separate chapters entitled "data collection and management" and **"**data processing and analysis", some sections from the original chapter will be transferred to other sections of the report and some sections from other chapters will be transferred to the new chapters.

The data collection and management chapter will highlight the need for development of an operations manual for each industry acoustics study and provide suggestions for topics to be covered. References and URLs for example documents (such as the Alaska Fisheries Science Centre's protocols for industry acoustic data collection or the ICES PGHERS field manual) will be provided.

Chapter titles and order were revised as follows:

Executive summary

1. Introduction

2. Study requirements

3. Vessels as sampling platforms

4. Instrumentation

5. Data collection and management

6. Biological sampling

7. Data processing and analysis

8. Cooperative research issues.

9. Recommendations*

Annex 1. Abstracts (or references) for industry acoustics studies presented at the 2003 WGFAST meeting and at the SGAFV Meetings in 2004 and 2005.

* The Study Group discussed various options for including recommendations in individual chapters and/or combining them in separate sections. The Chair agreed to seek guidance on this issue from the ICES Publications Committee

The Chair emphasized the importance of reaching agreement on a schedule for submitted a complete, edited manuscript to the ICES Publication Committee. All present agreed to adhere to the following schedule:

- Chapter authors will incorporate agreed-upon changes and update chapters by 15 May 2006
- Chair will review updated chapters and distribute edited comprehensive draft to authors by 30 June 2006
- Lead authors will review full document and suggest final changes and edits to the Chair by 30 July 2006
- Chair will submit complete final draft to ICES Publications Committee by 30 August 2006

The Chair agreed to seek guidance from the Publications Committee on style, format, and timing and to keep authors informed on these issues.

Finally, SGAFV members discussed the importance of maintaining a focus on industry acoustics among community members. Suggestions included proposing a theme sessions at a future ICES ASC and/or including a theme session on this topic at the 2008 ICES acoustics conference.

8.3 Study Group of Target Strength Estimation in the Baltic Sea (SGTSEB)

John Horne (USA) reported on the activities of the Study Group on Baltic Herring TS (SGTSEB). The study group on Baltic Herring target Strength has met since 2001, and the activities of the group are coming to a close. John reviewed the activities of the study group and stated that the group is now ready to complete its work. He presented an outline for potential contents of a report of the activities of the study group, which includes the following major topics:

- Current Status of Baltic Herring Target Strength Use
- Literature Review of Herring Target Strength
- Factors Potentially Affecting Target Strengths of Baltic Herring
- Protocol for Target Strength Measurements
- Backscatter Modelling of Baltic Herring
- *In situ* TS measurements of Baltic Herring
- Conversion of Acoustic Size to Fish Size for Baltic Herring and Sprat

Portions of this report have been written under the activities of the study group, and some have been published in both the primary and secondary literature. There was substantial discussion as to whether a cooperative research report on the subject is warranted. In discussion, it was stated that there is no more time for additional work. Alternatively, it was suggested to have a special session on Baltic herring at the 2007 ICES Annual Science Conference; this would be a helpful way to disseminate the activities of the study group to a wider audience.

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

David A. Demer (USA) presented a report from the Planning Group on HAC common data exchange format (PGHAC) on behalf of the group’s Chair, Laurent Berger (France). The current version of the HAC format is described in ICES CRR 278 which is available at: http://www.ices.dk/pubs/crr/crr278/crr278.pdf. This document contains extensive technical documentation of the HAC format for use in fisheries acoustics. The WGFAST expressed its appreciation for the extensive work that has been conducted by the members of PGHAC.

The ICES Planning Group on the Common data exchange format (PGHAC) worked in correspondence to address the following Terms of Reference:

a) Coordinate the further development of the HAC standard data exchange format;
b) Provide information on the changes in the format and its evolution;
c) Share information between manufacturers and users on the way acoustic data are processed and stored;
d) Review the final version of tuples for multi-beam echosounders; and
e) Review the development of a tuple for acoustic trawl geometry instruments.

The following results have been achieved, listed relative to the aforementioned Terms of Reference:

Item b):

- The current version of the HAC format is described in the ICES Cooperative Research Report N°278; this document corresponds to the exhaustive definition of HAC format that can be used for existing echosounders used in fishery acoustics.

Items a), d) and e):

- Sounder and channel tuples dedicated to the new Simrad multibeam systems ME70/MS70 have been slightly modified to cover latest adjustment on the systems, the final revision will be made in next report (the final approval of the systems at Ifremer and IMR is planned in autumn 2006).
- A proposal of a “trawl geometry” tuple has been made by Ifremer, it covers the measurements produced by the main sensors used on trawls, and it may become of great interest in order to correlate the catch with the quantitative estimate given by the new multibeam systems.

Item c):

- SIMRAD: HAC output; small adjustments expected in the next EK60 version;
- MARPORT: currently no HAC output;
- BIOSONICS: currently no HAC output;
- FURUNO: HAC output, but needs to be validated;
- SciFish: Echoview compatible HAC output on 2100 broadband systems; and
- Echoview: HAC support; now includes the single target tuple.

9 Recommendations

9.1 New WGFAST Chair

Recommendation: WGFAST has nominated Rudy Kloser (Australia) for Chair of the ICES Working Group on Fisheries Acoustics Science and Technology from 2007 to 2009. Rudy is an internationally recognized leader in this field, long-term member of WGFAST, and has consistently provided valuable contributions to the working group and its study groups. With outstanding expertise in both fisheries acoustics and applications in ecology, Rudy will expertly guide WGFAST towards a practical definition and implementation of ecosystem-based fisheries management.

9.2 Terms of Reference for the 2007 WGFAST meeting

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

Recommendation: WGFAST recommends that the Working Group on Fisheries Acoustics Science and Technology (Chair: Rudy Kloser, Australia) meet in Dublin, Ireland (Host and dates to be confirmed), in April 2007 to:

a) examine work in the following research areas as proposed at the 2006 meeting:
- i) Fish behaviour in response to vessel- and other platform-related stimuli;
- ii) Survey techniques for epi-benthic, epi-pelagic, and shallow water species;
- iii) Species identification techniques (e.g. acoustic, optical and nets) for multi-species assessments, bycatch reduction, and automated data processing;
- iv) Target strength modelling and measurement; and

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); and
- iv) Study Group on Collection of Acoustic data from Fishing Vessels (SGAFV).

9.3 Study and Planning Groups

Recommendation: WGFAST recommends that the PGHAC should continue its work via correspondence.

Recommendation: WGFAST recommends that SGTSEB, John Horne (USA), Chair, conclude its work in 2007. The results of the group's investigations have been, or will be disseminated through primary literature, opposed to publishing a CRR. Additional work on the subject will be vetted via a related theme session at the 2007 ICES ASC.

Recommendation: WGFAST recommends that SGASC, John Anderson (Canada), Chair, and SGAFV, Bill Karp (USA), Chair, conclude their work in 2007, each with publication of associated ICES Cooperative Research Reports.

9.4 Terms of Reference for the 2007 WGFAST-WGFTFB Joint Session

Recommendation: WGFAST recommends that WGFAST and WGFTFB meet jointly in Dublin, Ireland, in April 2007. The Terms of Reference are to be mutually decided by the new Working Group Chairs.

9.5 Theme Sessions for the 2007 Annual Science Conference

Recommendation: In its continuing effort to contribute to the ICES Annual Science Conferences, WGFAST proposes the following three Theme Sessions for the 2007–2008 Annual Science Conferences:

- Theme session on the changes of the characteristics of Baltic herring (LR/FTC/BC);
- Theme session on noise and other vessel related stimuli for fish behaviour (FTC); and
- Theme session on optical technologies for data to support ecosystem-based approaches to fisheries management (FTC-WGFTFB/WGFAST/MHC-WGMHM).

9.6 2008 ICES Acoustics Symposium

The 2008 Symposium of Fisheries Acoustics Science and Technology will be held form 16–22 June, 2008 in Bergen Norway. The Conveners for the meeting are Egil Ona (Norway), Rudy Kloser (Australia), and David Demer (USA).

10 Miscellaneous

10.1 Topic Group on Vessel Noise and Fish Behaviour

At the 2006 meeting in Hobart, the WGFAST had a plenary discussion about vessel noise and various motivations for fish behaviour in response to vessels during the Topic Session: "Fish behaviour in response to noise and other vessel related stimuli". A smaller Topic Group met at the request of ICES to review the procedures and practices of noise specification on active research vessels. This Focus Group was charged with several objectives:

- to consider the archival of existing noise specifications and their acquisition parameters;
- to solicit documentation about research vessels being built by ICES member countries, particularly sound characteristics;
- to recommend a set of measurements, data and reports that should be archived with ICES following the noise testing of any survey vessels from an ICES nation;
- to tabulate lessons learned in regard to procedures and data collection since ICES CRR 209;
- to make recommendations as to what more should be done in this regard, such as whether or not a new Study Group should be formed at this time.

All members of the Topic Group agreed that it would be most desirable to include the noise signatures of all active research vessels in the archive. Data currently at ICES are in the form of hard copy noise ranging reports with no accompanying 'raw' data files. The intention for the present is for these reports to be available on request in PDF format. There is probably no logistical reason why the raw data files could not be made available because the keel, bow and stern levels are usually measured at the ranges. However, to effectively archive vessel noise measurements, the types and formats of these data needs to be defined. It was agreed that the archiving of raw measurement data would not be the highest priority at this time.

The Topic Group recommended however that a standard archive should include more than 1/3 octave data. It was pointed out that tones and transient noise (work on vessel, intermittent pumps) may be important, and therefore should be included with the archived information. Given that there is not a full understanding of all the stimuli that may affect fish behaviour, noise signatures should be archived at the highest resolution available.

It was recognized that a full description of vessel radiated noise, including how sound is distributed around vessels, is also desirable. However, the effects of directivity on fish behaviour must be more fully investigated before recommending that these extensive measurements be required. The question of measuring noise radiation patterns is important and this might best be achieved by approaching noise ranges for data they have measured on some of the noise-reduced vessels. Failing this, some reasonable results have been obtained in the past when vessels staffed by members of the FAST community have used relatively simple equipment for bow to stern pattern measurements (keel might be more difficult). However, results from such procedures must be related in some way to the 'official' noise-ranging measurements.

Noise Ranging:

Given that access to naval ranges is rare, the availability of other systems for the measurement of noise signatures may provide us much needed data. Portable ranging units may be sufficient, but they must be calibrated against standard installations. For comparison purposes, it is very important to standardize procedures, such as the depth of the hydrophone placement and the bottom depth. Also, since very low frequencies (infrasound between 1–20 Hz) may be an issue, there is a need to find ways to effectively measure them.

Hull mounted hydrophones may be useful to monitor the noise spectra of a ship. However, since it is not obvious how these measurements correlate with far-field spectra, their most useful application may be to detect the differences or changes over time. In the same light, long term routine monitoring of machinery and other source of continuous and transient noise by local sensors may provide a means of producing an index of performance.

Lessons Learned:

In discussing the lessons learned from the seven or so noise-reduced vessels built to ICES CRR 209 levels, the Topic Group thought it important to summarizes the known benefits of noise-reduced research vessels. One major benefit is the greatly increased signal-to-noise ratio in echosounder data, considerably increasing target detection ranges, especially at higher frequencies. This is particularly important with the increasing use of multi-frequency analysis techniques, which require low noise at all frequencies, although particularly at higher frequencies. This purpose may be served by the preferential reduction of higher frequency vessel noise, which in some cases may be more tractable than reduction of the entire vessel noise spectrum.

Having a standard is also useful for creating awareness of the problem and for providing arguments for fixing or screening noisy vessels. Having noise-reduced research vessels gives researchers a tool to help further understand the mechanisms of avoidance. It helps reduce the overall noise in the sea and improves the comfort and wellbeing of the crews on board.

Although there is evidence that sound is important, some surprising results from the small number of available experiments suggest that we don’t fully understand all the mechanism that may influences fish behaviour, e.g. is sound the primary and only stimulus? There does not appear to be a linear relationship between the stimulus (signal intensity) and the outcome (fish reaction) and this must be elucidated. There are other possible platform-related stimuli (PRS) that need to be considered, as well as the rates at which they arrive at the fish (gradients). One possibility is that as overall noise is reduced, the startle affect on fish may increase due to an increase in the noise gradient. Other factors that may influence the fish reaction include biological state, species, the incident angle, changes in the medium, changes in bottom depth and type, tonal and transient variations. Further unknowns include how fish locate the source, does the pressure (displacement) wave produced from moving vessel have an effect and are particle velocities detected?

Governments have paid a premium for ships to be built to the CRR 209 standard but have proved remarkably reluctant to sponsor experiments to test the efficacy of the noise reduction. Work concentrated on reducing vessel radiated noise has allowed us to know more about the vessel but much less is known about their effects on fish. These are not easy questions to answer due to the large variety and variability of fish responses, however more results are urgently required to move forward. We must persuade countries to engage their noise-reduced vessels in experiments designed to further our knowledge of the effects that noise has on targeted fish species.

One possible avenue toward understanding is the modelling approach. What is the behavioural model and can it stand up to experimentation? It was recognized that it may be very difficult to develop a model, but that postulating a model may lead to a better understanding of the issues. One difficulty is that there are many factors that lead to the observed behaviour and its variability and that some of these factors are not easily quantifiable.

Another approach would be the monitoring and measuring of PRS to build a baseline. Although we don't know at this time all the stimuli which will have a significant effect, a first step would be to generate a list of required items to be monitored and measured that is wider than just noise. All suspected sources of stimuli should be monitored in order to study the vessel as a source of stimuli, knowing that noise and other PRS can change over time. In conjunction with monitoring and measuring PRS comes the necessity to monitor and measure fish avoidance. There is a need for recommendations on methodologies for measuring fish reactions to vessels.

Is it appropriate at this time to update CRR 209? There is a need to refine certain specifications, i.e. the resolution of the sound spectra. Low frequencies (infrasound 1–20 Hz) and particle acceleration are detected by fish but their effects are not considered. Machinery noise is tonal in content and it is clear from narrowband measurements that some tones exceed the CRR 209 levels by a large amount. When CRR 209 was prepared it was felt that sound intensity over the fish hearing bandwidth was probably the stimulus causing the fish avoidance behaviour. It was also realised that there was no easy way to introduce limits to tonal noise which would be acceptable to shipyards, as at that time there was considerable apprehension about meeting the ICES standard. French noise measuring ranges produce graphs which superimpose tones at 1 Hz resolution over the third octave measurements. This is a superior method to giving narrowband results separately.

However, defining specifications without knowledge is not appropriate. Since the Topic Group could not precisely define all the parameters that should be specified, it was felt inappropriate to require that additional parameters be specified in the standard at this time. CRR 209 was recognized as an important reference point in time which has been and continues to be invaluable in allowing us to move forward. Before adding to the specifications given in CRR 209, there is a need to answer the question: how is sound reduction linked to reduced fish avoidance? There is a need to be broader than CRR 209 and go to the next step. A Study Group may be useful in defining that next step.

General Conclusions:

The Topic Group made several general conclusions:

- the problem must be broken down into two issues: behavioural aspects and physical aspects (propagation of sound and other stimuli and their measurement);
- there needs to be a review to improve our understanding of fish hearing and their reaction to sound. To accomplish this we need to include scientific expertise from outside WGFAST, e.g. hearing experts;
- the creation of a Study Group could be a useful means of stimulating research.

Recommendations: As a means of moving forward, the Topic Group recommends that a Study Group be formed, with François Gerlotto (France) as Chair, and charged with stimulating research aimed at understanding when and under what situations fish avoid research vessels. The Terms of Reference are to:

i) Produce a literature review as a reference for our present understanding of fish hearing and their reaction to stimuli;

ii) Elucidate and expand the list of the possible platform-related stimuli (PRS) produced by research vessels that could elicit avoidance reactions in the targeted species;

iii) Produce a review of methods for measuring avoidance to aid in the design and development of new methods to independently monitor fish reaction to PRS;

iv) Generate a list of required items to be monitored and measured on research vessels, wider than just noise related;

v) Design explicit experiments to further examine the causes of fish reactions to PRS; and

vi) Produce an ICES Cooperative Research Report.

10.2 Topic Group on Optics

The Topic Group on Optics (TGO) met in both plenary and sub-group sessions to review of the state-of-the-art in optical imaging and analysis technologies. Rudy Kloser (Australia) facilitated the discussions. David A. Demer (USA) was rapporteur. Sub-group participants included: Yue Li (Australia), Eirik Tenningen (Norway), Ruben Patel (Norway), Miles Lawler (Australia), John Anderson (Canada), Adam Dunford (Canada), François Gerlotto (France), Yvan Simard (Canada), Bill Karp (USA), Rudy Kloser (Australia), and Bo Lundgren (Denmark).

At the WGFAST in 2005, David Somerton (USA) recommended the formation of a Study Group (SG), with linkage to WGFTFB, to develop video analysis techniques. He recommended that the SG look at the need and commonality for video analysis software development, and develop automated video/still object recognition software.

In plenary at the WGFAST in 2006, the TGO considered the state-of the art in optical imaging and analysis technologies relative to the ICES community's ecosystem approach to fisheries requirements in these areas. Contributions to the discussion were also submitted from in-absentia members David Reid (UK), David Somerton (USA), Roger Cogan (Australia) and Van Holliday (USA), and included in the group's deliberations. The sub-group considered a study group, ASC theme sessions, and linkages with other groups.

The TGO noted the recent Report of the NMFS Workshop on Underwater Video Analysis, edited by David Somerton (USA) and Christopher Gledhill (USA). The report summarized efforts in the USA to analyze video data. The TGO also noted that there was a National Workshop in Australia in 2000 chaired by Euan Harvey (Australia) and Mike Cappo (Australia). This workshop focused on video sensing of the size and abundance of targeted and non-targeted fauna in Australian fisheries. Moreover, the ICES Habitat Committee recently held a meeting on optics for habitat mapping.

The TGO discussed that ecosystem investigations require measurements of biomass biodiversity, species specific information including behaviour, growth and ecology, and gear efficiency. Some applications of optical techniques include studies of: plankton, nekton, epi-benthos, physical seabed attributes, gear operations, and chemical and bulk density properties. Optical sensors can measure bulk material properties such as: bioluminescence, fluorescence, single wavelength and multi-spectral absorption, and many others.

The TGO noted that optical techniques can be used to directly study multiple aspects of the ecosystem, and can provide information not available from acoustical techniques. Also, the Working Groups on Survey Design and Survey Methods may need non-acoustic instruments. Therefore, François Gerlotto (France) asked whether WGFAST is the appropriate place to consider optical technologies, and if the group has the requisite expertise? Given the common problems encountered with acoustical and optical methods such as data management, pattern recognition and measurements of uncertainty, the TGO decided that the SG should reside in WGFAST. Moreover, it was thought that WGFAST should continue to expand consideration of non-acoustical sampling methods, such as optics.

The TGO noted that characterizing and improving catchability, selectivity, and bycatch or target identification are common requirements of WGFTFB and WGFAST, and all three issues can be addressed with optical techniques. The TGO also noted that the linkage between WGFTFB and WGFAST needs some glue, and optical techniques may be that glue. The TGO noted that WGFAST and WGFTFB should be connected with the scientific questions related to catchability and selectivity, and should gather outside expertise as needed. The TGO then discussed whether a SG on Optics needed to be related to WGFAST or WGFTFB, or whether a SGO could report directly to FTC. While all three are options, it was again decided that the SG should be sponsored by WGFAST, and outside experts should be recruited.

The TGO discussed whether we wish to use optics to validate and improve the acoustic methods, or make additional measurements that are not feasible using acoustics? It was decided that a SGO should initially focus on validating and improving acoustic and net sampling methods, and recommend a list of other optical techniques to pursue in the future.

The group acknowledged that a large variety of optical instrumentation can improve or supplement our direct observation methods for the ecosystem approach to fisheries management. More specifically, the group recognized that optical techniques can be used to improve target identification, and characterize fish behaviour, and estimate measurement uncertainty (accuracy and precision) in acoustical and net sampling.

Recommendation: Ultimately, the Topic Group on Optics recommended that the FTC and WGFAST sponsor a Study Group on Fisheries Optical Technologies with Eirik Tenningen (Norway) as Chair. The SG will review the state-of-the-art in optical imaging and analysis technologies with the following terms of reference:

i) Produce a literature review of optical technology for: 1) target identification (e.g. species and sizes, benthic and pelagic habitat); 2) behavioural characterization (e.g. orientation, reaction, small-scale dynamics); 3) measurement uncertainty (related to optics, nets, and acoustics and scale differences between methods; e.g. catchability, selectability, and bycatch reduction or species identification; and measurement strategy); and 4) automated data processing and visualization, and data management.

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

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

iv) Consider a new Working Group on Fisheries Optics, Science and Technology;

v) Consider an ICES Symposium on this subject; and

vi) Produce an ICES Cooperative Research Report.

10.3 FTC Review of ICES Consultative Committee Meeting

François Gerlotto (France), FTC Chair, reviewed the activities of the ICES Consultative Committee meeting which occurred during 14–18 March, 2006. The main discussions at this meeting related to scientific committees within ICES. The lack of communication amongst the expert groups was identified as a problem. It was suggested that in large part, this may be due to the organization of expert groups within scientific committees. The primary proposal from the consultative meeting is to reduce the number of scientific committees, but the manner in which this would be accomplished is a subject of discussion.

The FTC leadership wishes to maintain the WGFAST-WGFTFB Joint Session (JS), every two years. The Chair(s) of the JS should be selected by the WG Chairs, and the terms of reference should be determined by the JS Chair(s). To improve interest and participation in the JS, the WGFAST recommends a focus on catchability, which is a common concern for WGFAST and WGFTFB.

There was a call for opinions on the subject of authorship of cooperative reports from the expert group. Input was also solicited on an ICES position paper on which technologies will be most useful for ICES in the future.

10.4 A Tribute to Herman 'Hank' Medwin

Andrzej Orlowski (Poland) prepared and presented the following tribute to Herman Medwin:

Herman Medwin, known as Hank, died in January in Pebble Beach at age 86. For all marine acousticians, his passing marks the end of an important époque. Everybody working in this field kept Hank's books available on their shelf. Even in my case, when the book had limited availability on the east side of the 'iron curtain', I often referenced Medwin and Clay's "Acoustical Oceanography," not in English…but in Russian. This is to say that Medwin's knowledge and its scientific importance transcended the political divisions of our world.

Hank was born in Springfield, Massachusetts in 1920. His first acoustic achievements were not associated with the ocean. During his schooling period, he was recognized as the best city violinist. In 1941, he earned a B.S. degree at Worcester Polytechnic Institute, and found his main interest in the field of Sound and Vibration. During the Second World War, Hank served in the US Air Force as a meteorologist, stationed in the United Kingdom. At this time, he married Eileen…who was serving in the British Army.

After the War, Hank was definitively interested in furthering his studies, and joined an elite group of acousticians at the University of California. He was awarded a M.S. degree in Applied Physics in 1948, and a PhD in the field of fluid dynamics, in 1954. His thesis was on acoustic streaming.

Hank dedicated his entire professional life to research and education in acoustics as applied to marine science. Importantly, he conducted highly meritorious research on very basic, but previously unknown acoustic phenomena in the marine environment (e.g. tiny bubbles, and mechanisms of surface and seabed scattering). Possibly more importantly, he adeptly passed his knowledge directly to students, peers, and naval officers in the U.S. and allied countries. As Fisheries Acousticians, we all know that Hank's outstanding endeavours in both research and teaching have opened the windows to marine ecosystem investigations. In recent years, Hank's interests turned to a new scientific field called "Acoustical Oceanography" – after the title of his book with Clarence Clay. Distinct from underwater acoustics, acoustical oceanography focuses on using sound to study the marine ecosystem and the living organisms that make the ocean their home. Medwin encouraged the use of sound to understand how marine processes lead to the observed distributions of physical, chemical and biological parameters in aquatic ecosystems. He strongly advocated development of acoustical methods to unravel the mysteries of the sea.

He was a very active member of scientific societies, especially of the Acoustical Society of America, from which he received the Silver Medal in Acoustical Oceanography. His last book: Sounds in the Sea: From Ocean Acoustics to Acoustical Oceanography, was published last year by Cambridge Univ. Press.

In spring 2004, I had my last contact with Hank. He was preparing his Keynote Speech for the European Conference on Underwater Acoustics in Delft, The Netherlands. We exchanged remarks on topics that would be addressed in his speech. Just before the conference, however, he had to withdraw his participation to be with his beloved Eileen, who was quite ill.

A few months ago, Hank passed away in his sleep, in Monterey, California. Imagine, if you will, our esteemed colleague and friend, with his friendly smile, climbing "The stairway to heaven". After all, this was a favourite piece played by his "Medwin String Quartet".

Andrzej distributed a paper for all to sign, for Eileen Medwin, with our condolences. The WGFAST Chair thanked Andrzej for paying tribute to Hank Medwin, and for all of his significant efforts aimed at maintaining a strong humanistic element within WGFAST.

10.5 Future Meetings

The 2008 meeting of the WGFAST will be held in Bergen, Norway, in conjunction with the Fisheries Acoustics Symposium. Offers to host the 2009 and 2010 meetings have been made by Peru and the U.S.A., respectively

11 Closure of meeting

The new RV "D.V. Holliday" was announced by David Demer (USA). This 32 foot multi-instrumented coastal survey vessel was custom built in USA for optical-acoustical surveys of rockfish in the Southern California Bight. D. Van Holliday (USA), a long-term and ultra-significant contributor to WGFAST, pioneered broad bandwidth acoustical methods for mapping and sizing rockfish, more than 35 years ago. Key features of the vessel include hydraulically deployed multi-beam sonar and multi-frequency echosounder transducers, and provisions for deploying a variety of other technologies (e.g. AUVs, ROVs, CTDs, towed-bodies and nets. As such, the RV "D.V. Holliday" is designed to efficiently sample nearshore ecosystems, and carry-on Van's legacy of using state-of-the-art optical and acoustical technologies. Pictures of Van aboard his namesake vessel were shown.

The Chair of WGFAST expressed his gratitude to the hosts at CSIRO, particularly Rudy Kloser (Australia), Denise McMullen (Australia), Nick Mortimer (Australia) and Tim Ryan (Australia). In addition, he thanked the sponsors of the meeting including SonarData, particularly Ian Higginbottom (Australia) and Tim Pauly (Australia); as well as Simrad, especially Lars Andersen (Norway) and Jeff Condiotty (USA). He thanked John Horne (USA) for his efforts in maintaining the WGFAST website. He thanked all the participants and invited speakers for their contributions to the working group. He led a round of applause for Alex De Robertis (USA) for his exemplary contributions as Rapporteur.

The meeting was closed by François Gerlotto (France), FTC Chair, who expressed appreciation on the part of the membership WGFAST for the role that David Demer (USA) has played during his 3 year tenure as Chair, particularly for his contributions in maintaining the scientific work of the working group at a high level.

The meeting was then closed.

Many thanks to Jessica Lipsky (USA) and Claire Welling (Denmark) for expertly compiling, formatting, and editing this report. Additionally, thanks go to Alex de Robertis (USA), Robert Keiser (Canada), and Ian McQuinn (Canada), for their tenacity and attention to detail in helping to edit the penultimate draft.

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Annex 2: Agenda

ICES Working Group on Fisheries Acoustics Science and Technology 2006 Meeting Agenda
Meeting place: CSIRO, Hobart, Tasmania, Australia

Monday March 27th

0850 Opening
Hosts at CSIRO
Fred Stein, "Announce tour of the FRV Southern Surveyor"

Topic 1: Fish behaviour in response to noise and other vessel related stimuli

0920 John Simmonds. "Inter-calibration of EK500 systems on a noise quieted fisheries research vessel and a chartered commercial trawler used for herring surveys."

0940 Hector Peña. "Inter-calibration of three commercial vessels equipped with scientific echo sounders in the Norwegian Sea."

1000 Steve Eayrs. "The application of acoustic stimuli to reduce bycatch in Australia's tropical prawn-trawl fisheries."

1020 Break

1040 Topic Group Noise (Ian McQuinn): Review the procedures and practice of noise specification on active research vessels. The review should consider the archival of existing noise specifications and their acquisition parameters. Recommend future actions (e.g. Study Group, Charter, and Chairperson).

1200 Lunch

1330 Topic Group Optics (Rudy Kloser): Review the state-of-the-art in optical imaging and analysis technologies and define the ICES community's requirements for additional optical technology. Recommend future actions (e.g. Study Group, Charter, and Chairperson).

Topic 2: Survey techniques for demersal, epi-pelagic and shallow water species

1440 Miles Lawler. "Acoustic detection of scallop and sponge habitat"

1500 Break

1520 Andrzej Orlowski. "Acoustic classification of southern Baltic benthic habitat."

1540 John T. Anderson, R.C. Courtney, C. Lang, and G.D. Fader. "Acoustic seabed classification using sidescan and normal incidence systems at preferred and non-preferred fish habitat sites on the Scotian Shelf."

1600 Robert Kieser, W. Tesler, B. Buelens and M. Wilson. "Implementation of seabed classification procedure for echogram and fish species classification."

1620 Miles J. Parsons, R.D. McCauley, and M.C. Mackie. "The use of acoustics techniques to study fish aggregations."

1640 Gordon Keith, R.J. Kloser, and A. Williams. "Integrating and visualizing epi-benthic habitat survey data."

1700 Adjourn

Tuesday March 28th

0850 Announcements

Topic 3: Acoustical species ID techniques for multi-species assessments, ecosystem studies, bycatch reduction, and objective and automated data processing

0900 Rolf J. Korneliussen, E. Ona, I.K. Eliassen, Y. Heggelund, R. Patel, O.R. Godø, C. Giertsen, D. Patel, E.H. Nornes, T. Bekkvik, H.P. Knudsen, and G. Lien. "The Large Scale Survey System – LSSS, a new post-processing system for multi-frequency echo sounder data."

0920 Eirik Tenningen and A. Lisovskiy. "Analysing lidar data in the acoustic post-processing program LSSS."

0940 Nick Mortimer, R.J. Kloser, and T. Koslow. "Methodologies for characterisation of mesoplankton using multi-frequency acoustics and discrete *in situ* plankton samples."

1000 Jock Young, A. Hobday, T. Ryan, and R.J. Kloser. "Micronekton distribution off eastern Australia from nets and acoustics."

1020 Break

1040 Topic Groups 1 and 2: sub-group meetings; report writing.

1200 Lunch

1330 Tim E. Ryan and R.J. Kloser. "Application of a dual frequency acoustic probe to aid species identification during industry vessel surveys."

1350 John K. Horne, C.I.H. Anderson, and J. Boyle. "Objective classification of multi-frequency backscatter."

1410 Alex De Robertis and I. Higginbottom. "A technique for echosounder background noise removal and estimation of signal-to-noise ratio."

1430 Ian H. McQuinn, D. Carrier, A. Raymond, J.L. Beaulieu, and J.F. Gosselin. "Defining marine-mammal essential habitat in the Gulf of St. Lawrence using multi-frequency acoustic classification."

1450 Suzanna Neville, S. Mackinson, and J. Preston. "Remote species identification using image based classification."

1455 Toby Jarvis, N. Kelly, and E. van Wijk. "Multifrequency hydroacoustics at the Australian Antarctic Division."

1515 Break

1530 Richard L. O'Driscoll. "Report of the second meeting of the CCAMLR Subgroup on Acoustic Survey and Analysis Methods."

1550 Myounghee Kang. "Comparison of real and simulated school echoes for retrieval of characteristics of the distribution structure of fish schools."

1610 Matthew Wilson. "Recent developments and future plans for automated acoustic data processing in SonarData Echoview."

Topic 4: Instrumentation, survey design, and data analysis techniques for studying aquatic ecosystems

1630 Bill Karp. "Status of the Study Group on Acoustics on Fishing Vessels."

1640 Lars N. Andersen, S. Berg, O.B. Gammelsæter, and E.B. Lunde. "Status for the new scientific multibeam systems MS/ME70."

1710 John Dalen, H.P. Knudsen, E. Ona, R. Korneliussen, R. Patel, M. Dahl, L.N. Andersen, and S. Berg. "The new MS70 multi-beam sonar; some preliminary data from the first sea trials."

Wednesday March 29th

0850 Announcements

Invited Speakers – Ecosystem-Based Fisheries Management

0900 Denzil G.M. Miller. "CCAMLR: Strategies and international efforts in ecosystem-based fisheries management."

0920 David C. Ramm. "CCAMLR data and their use in ecosystem-based fisheries management."

0940 Andrew Constable. "Yield modelling for ecosystem-based management of Antarctic krill and fish."

1000 CCAMLR Panel Discussion (Denzil G.M. Miller, David C. Ramm and Andrew Constable)

1020 Break

1040 Beth Fulton. "Ecosystem-based fisheries management in theory and practice in Australia."

1110 Rudy J. Kloser and B. Fulton. "Model evaluation of acoustic monitoring requirements for the ecosystem approach to fisheries."

Keynote Speaker

1130 Nicholas C. Makris, P. Ratilal, D.T. Symonds, S. Jagannathan, S. Lee, and R.W. Nero. "Fish population and behaviour revealed by instantaneous continental shelf-scale imaging."

1200 Discussion about instantaneous continental shelf-scale imaging.

1230 Adjourn

Thursday March 30th

0850 Announcements

Topic 4: Instrumentation, survey design, and data analysis techniques for studying aquatic ecosystems

0900 Patrick H. Ressler and G.W. Fleischer. "Recent acoustic and video observations used in the development of a commercial vessel-based survey methodology for widow rockfish (Sebastes entomelas)."

0920 Carlos Robinson and J.G. Guitierrez, "Pacific sardine behaviour as inferred by acoustics related to tidal fronts in Baja California, Mexico."

Topic 5: Target strength: modelling and measurements

0940 Egil Ona, I. Svellingen, R. Skeide, R. Pedersen and A. Totland. "The TS-probe, a new tool for improved *in situ* target strength measurements of fish and zooplankton."

1000 Adam Dunford. "Target strength measurements of southern blue whiting."

1020 Break

1040 Rudy J. Kloser and G.J. Macaulay. "Can multi-frequency *in-situ* target strength measurements be used to infer species and their length in the Australian blue grenadier fishery (Macruronus novaezelandiae)?"

1100 Gavin J. Macaulay and R.J. Kloser. "Acoustic models of orange roughy (Hoplostethus atlanticus)."

1120 John K. Horne, K. Sawada, K. Abe, D. Barbee, and Y. Takao. "Swimbladders under pressure: anatomical and acoustic responses by walleye pollock."

1140 J. Michael Jech, R. Gamble, R.H. Towler, & J.K. Horne. "Towards a standardised data format of digital anatomy and morphometry for acoustic scattering models."

1200 Lunch

1330 Guy Fleischer, K. Cooke, P. Ressler, and R. Kieser. "Examination of *in-situ* target strength of Pacific hake (Merluccius productus)"

1350 David A. Demer, S.G. Conti, B. Maurer, and L. Asato. "Rockfish sound scattering spectra."

1410 John Horne presents: Natalia Gorska. "Modal based deformed cylinder modelling of Baltic herring backscatter."

1420 Status of the Study Group on Baltic Herring TS (John Horne)

	Status of the Study Group on Acoustic Seabed Classification (John Anderson)
	Status of the Planning Group on HAC (Laurent Berger)
	Report of the TG on noise specification on active research vessels (Ian McQuinn)
	Report of the TG on optical imaging and analysis technologies (Rudy Kloser)
1500	Break
1520	Andrzej Orlowski. “A tribute to Hank Medwin”
1540	Francois Gerlotto. “FTC Announcements and discussion”
1600	Announce new WGFAST Chair
	Summarize Recommendations
	All other business
1700	Closure of the meeting

Annex 3: Terms of Reference for WGFAST, SGFARV, SGFOT, and Joint Session of WGFTFB/WGFAST

The **Working Group on Fisheries Acoustics Science and Technology** [WGFAST] (Chair: Rudy Kloser*, Australia) will meet in Dublin, Ireland from XX to XXX April, 2007 to:

a) examine works in the following areas:

i) Fish behaviour in response to vessel- and other platform-related stimuli;

ii) Survey techniques for epi-benthic, epi-pelagic, and shallow water species;

iii) Species identification techniques (e.g. acoustic, optical and nets) for multi-species assessments, bycatch reduction, and automated data processing;

iv) Target strength modelling and measurement; and

b) review the reports of the:

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

vi) Study Group on Fisheries Optical Technologies (SGFOT); and

vii) Study Group on Avoidance Reactions to Vessels (SGARV).

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

Supporting Information

PRIORITY:	Fisheries acoustics is a vital area of fish stock management and ecosystem research
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Term of Reference a-i) Several ICES member countries have built noise-reduced fisheries research vessels in the last few years. The noise characteristics sought for these new vessels were those recommended by WGFAST in the *ICES Cooperative Research Report No. 209*. While quiet vessels have many advantages, there is some indication that some fish species may react to quiet vessels in some situations. Therefore, it is prudent to explore fish behaviour in response to noise and other vessel related stimuli. This broad topic includes other observation platforms, tools to measure vessel noise patterns, a review of fish hearing and fish reaction to ultrasound and infrasound, light, particle motion, and other stimuli. A.N. #s: 1.10, 1.13.1, 1.13.4, 5.4 Term of Reference a-ii) Increasingly, many ICES member countries are challenged to survey epi-benthic, epi-pelagic and shallow water species. Many new platforms, instruments, and techniques are being developed and employed. Several members invest considerable research effort in this area. This will be the opportunity to exchange results, consolidate findings and identify further research needs. A.N. #s: 1.10, 1.13.4, 1.14, 1.12 Term of Reference a-iii) Acoustical species ID techniques. The recent change to incorporate the ecosystem approach in fisheries management requires collecting data on several components of the ecosystem, multiple species and trophic levels. Acoustics is a unique non-selective and non-intrusive tool that can provide multi-species assessments. This topic is to review the present uses of acoustics for multi-species assessments, ecosystem studies, bycatch reduction, and objective and automated data processing. The incorporation of automated techniques for data gathering and processing, from various acquisition platforms, as well as methods for validation are part of this topic. A.N. #s: 1.12.5, 1.14, 1.13.5 Term of Reference a-iv) The acoustic target strength (TS) is an important metric in fisheries and plankton acoustics to inform on fish characteristics and to convert the acoustic energy in biomass units. This keystone variable can be used in several ways in the biomass estimation process. New information from TS modelling and *in situ* measurements plead in favour of exploring new avenues to characterise TS as a stochastic variable and comparing the relative advantage of using it as a probabilistic versus deterministic estimator. This topic is to initiate a discussion on this issue. A.N #s: 1.12.5, 1.13.4 Term of Reference b) PGHAC, SGTSEB, SGASC and SGAFV meet before WGFAST in the same location and make their reports available to the WGFAST at its annual meeting according to their terms of reference. A.N. #s: 1.12.5

RESOURCE REQUIREMENTS:	No new resources will be required for consideration of this topic at WGFAST annual meeting. Having overlaps with the other meetings of the Working, Planning and Study Groups of the Fisheries Technology Committee increases efficiency and reduces travel costs; undertake additional activities in the framework of this group is negligible.
PARTICIPANTS:	Approximately 75 members and guests are expected to attend the meeting.
SECRETARIAT FACILITIES:	None.
FINANCIAL:	No financial implications.
LINKAGES TO ADVISORY COMMITTEES:	There are no direct linkages to the advisory committees but the work is of relevance to ACFM.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	The work in this group is closely aligned with complementary work in the FTFB Working Group. The work is of direct relevance to PGHAC, SGTSEB, SGASC, and SGAFV, PGSPUN, PGRS, PGHERS, WGBIFS and PGAAM.
LINKAGES TO OTHER ORGANIZATIONS:	-
SECRETARIAT MARGINAL COST SHARE:	ICES: 100%

A **Study Group on Fish Avoidance of Research Vessels** [SGFARV], (Chair: François Gerlotto* France) will be established and will meet in Dublin, Ireland in April, 2007 to:

a) The Study Group will explore when and why fish avoid research vessels:

- i) Elucidate and expand the list of the possible physical stimuli produced by research vessels (platform related stimuli - PRS) that could elicit avoidance reactions in survey-targeted species;
- ii) Produce a literature review to improve our understanding of fish hearing and their reaction to stimuli;
- iii) Generate a list of required items to be monitored and measured on research vessels, wider than just noise related;
- iv) Produce a review of methods for measuring avoidance to aid in the design and development of new methods to independently monitor fish reaction to PRS;
- v) Design explicit experiments to further examine the causes of fish reactions to PRS; and
- vi) Produce an ICES Cooperative Research Report.

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

Supporting Information

PRIORITY:	The current activities of this Group will lead ICES into issues related to fish behaviour in relation to conventional and quiet fisheries research vessels, and the resulting uncertainty in survey and stock assessment results. Consequently, these activities are considered to have a very high priority.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Action Plan No: 1. Term of Reference i) Many ICES nations have or are procuring quiet fisheries research vessels, at great additional costs relative to conventional vessels. To study the benefits of these new vessels, it is first necessary to understand the physical stimuli produced by vessels that could elicit avoidance reactions. Term of Reference ii) Several countries are conducting or have recently completed significant studies in this area and the subject would benefit from a review of progress and an evaluation of the results obtained. Term of Reference iii) Monitoring of physical stimiuli produced by vessel is necessary to determine when and why some fish avoid some survey vessels. Term of Reference iv) Characterizing fish avoidance behaviour is challenging and a review of effective methods will aid researchers. Term of Reference v) New methods and experiments will be needed to better characterize fish avoidance reactions to survey vessels. Term of Reference vi) The SG should disseminate findings via an ICES CRR.
RESOURCE REQUIREMENTS:	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
PARTICIPANTS:	The Group is normally attended by some 20–25 members and guests.
SECRETARIAT FACILITIES:	None.
FINANCIAL:	No financial implications.

LINKAGES TO ADVISORY COMMITTEES:	There are no obvious direct linkages with the advisory committees.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	There is a very close working relationship with all the groups of the Fisheries Technology Committee.
LINKAGES TO OTHER ORGANIZATIONS:	None.
SECRETARIAT MARGINAL COST SHARE:	None.

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

- a) produce a literature review of optical technology for:
  - i) target identification (e.g. species and sizes, benthic and pelagic habitat);
  - ii) behavioural characterization (e.g. orientation, reaction, small-scale dynamics);
  - iii) measurement uncertainty (related to optics, nets, and acoustics and scale differences between methods; e.g. catchability, selectability, and bycatch reduction or species identification; and measurement strategy); and
  - iv) automated data processing and visualization, and data management.
- b) summarize other optical methods (current and emerging technologies) for ecosystem-based fisheries management that can be investigated further (e.g. update and expand the SCOR Technical Panel's summary);
- c) recommend linkages within and outside ICES (e.g. ICES ASC theme sessions; other ICES Expert Groups; and SCOR Technical Panel (e.g. survey design,
- d) consider a new Working Group on Fisheries Optics, Science and Technology;
- e) consider an ICES Symposium on this subject; and
- f) produce an ICES Cooperative Research Report.

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

Supporting Information

PRIORITY:	The current activities of this Group will lead ICES into improved techniques for surveying marine living resources and methods for improving existing survey strategies. Consequently, these activities are considered to have a very high priority.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Action Plan No: 1. Term of Reference a and b) Several countries are conducting or have recently completed significant studies in this area and the subject would benefit from a review of progress and an evaluation of the results obtained. A review of more recent work will determine the best approaches and strategies for future development. Term of Reference c) WGFAST must solicit information and participation from other groups to define, exploit, and extend the state-of-the-art in optical technologies for surveying fisheries resources. Term of Reference d) The ToR of WGFAST already include optical technologies, and WGFAST membership includes some expertise in optical technologies for surveying fisheries resources. This SG may, however, determine that the subject is large and valuable enough that a new WG is warranted, one that includes substantially different membership than WGFAST. Term of Reference e) Optical technologies for surveying fisheries resources, improving other techniques for surveying fisheries resources, and or characterizing fish behaviour are increasing in their accessibility, popularity, and value to fisheries management. An ICES Symposium may be a good strategy for expediting communications among researchers, and development of optical equipment and associated data analysis techniques. Term of Reference f) The SG should disseminate findings via an ICES CRR.
RESOURCE REQUIREMENTS:	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.

PARTICIPANTS:	The Group is normally attended by some 20–25 members and guests.
SECRETARIAT FACILITIES:	None.
FINANCIAL:	No financial implications.
LINKAGES TO ADVISORY COMMITTEES:	There are no obvious direct linkages with the advisory committees.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	There is a very close working relationship with all the groups of the Fisheries Technology Committee. It is also very relevant to the Working Group on Ecosystem Effects of Fisheries.
LINKAGES TO OTHER ORGANIZATIONS:	None.
SECRETARIAT MARGINAL COST SHARE:	None.

A **Joint Session of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour** [WGFTFB] and the **Working Group on Fisheries Acoustics Science and Technology** [WGFAST] (The Chair(s) will be selected by Rudy Kloser* (Australia), [WGFAST] and Dominic Rihan* Ireland, [WGFTFB]) will meet in Dublin, Ireland in April 2007 to examine works in:

a) optical technology for quantifying catchability and selectivity in trawl surveys; and

b) accounting for these components of uncertainty in survey results and stock assessments.

The Joint Session of WGFTFB and WGFAST will report by DATE for the attention of the Fisheries Technology Committee.

Supporting Information

PRIORITY:	The current activities of this Group will lead ICES into improved characterization of uncertainties associated with trawl surveys, incorporation of these biases and imprecisions into stock assessments, and implementation of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Action Plan No: 1. Term of Reference a) Optical technology is increasingly viable for quantifying catchability and selectivity in trawl surveys. Studies of fish behavior also benefit from optical technologies. Term of Reference b) The uncertainties in trawl surveys must be quantified and taken into account in survey results, stock assessments, and management strategies. Methods to do this are needed.
RESOURCE REQUIREMENTS:	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
PARTICIPANTS:	The Group is normally attended by some 60–100 members and guests.
SECRETARIAT FACILITIES:	None.
FINANCIAL:	No financial implications.
LINKAGES TO ADVISORY COMMITTEES:	There are no obvious direct linkages with the advisory committees.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	There is a very close working relationship with all the groups of the Fisheries Technology Committee.
LINKAGES TO OTHER ORGANIZATIONS:	None.
SECRETARIAT MARGINAL COST SHARE:	None.

Annex 4: Recommendations

RECOMMENDATION	ACTION
1. The WGFAST recommends that Rudy Kloser (Australia) is Chair of the ICES Working Group on Fisheries Acoustics Science and Technology from 2007 to 2009.	
2. The WGFAST recommends that WGFAST and WGFTFB meet jointly in Dublin, Ireland, in April 2007. The Joint Session Chair(s) should be selected by the WG Chairs and the terms of reference should focus on catchability and optical technology.	
3. The WGFAST recommends that the PGHAC should continue its work via correspondence.	
4. The WGFAST recommends that the SGTSEB conclude its work in 2007, and not publish a Cooperative Research Report. The results of the Study Group's investigations have been or will be disseminated through primary literature.	
5. The WGFAST recommends that the Study Groups on Acoustic Seabed Classification and Acoustics from Fishing Vessels conclude their work in 2006, each with publication of Cooperative Research Reports. Final drafts will be submitted to the ICES Publications Committee by 30 August 30, 2006.	
6. The WGFAST proposes the following three Theme Sessions for the 2007 or 2008 Annual Science Conferences: i) Theme session on the changes of the characteristics of Baltic herring (LR/FTC/BC); ii) Theme session on noise and other vessel related stimuli for fish behaviour (FTC); and iii) Theme session on fisheries optical technology for data to support ecosystem-based approaches to fisheries management (FTC-WGFTFB/WGFAST/MHC-WGMHM).	