ICES WGFAST REPORT 2005

ICES FISHERIES TECHNOLOGY COMMITTEE

ICES CM 2005/B:05

Ref.

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

19-22 APRIL 2005

ROME, ITALY

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer
H.C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:
ICES. 2005. Report of the Working Group on Fisheries Acoustics Science and Technology (WGFAST), 19–22 April 2005, Rome, Italy. ICES CM 2005/B:05. 57 pp.

Contents

Executive Summary

The Working Group on Fisheries Acoustics Science and Technology (WGFAST) met at the Food and Agricultural Organisation of the United Nations in Rome, Italy, from 19–22 April 2005. David A. Demer, USA, was Chair, Alex De Robertis, USA, was Rapporteur and Jessica D. Lipsky, USA, was the Recorder. There were 83 participants from 16 countries.

a) The first topic was "Measuring underwater radiated noise from survey vessels and its effects on fish". Quiet vessels have distinct advantages over conventional vessels. It has been shown that herring did not respond to a vessel which complies with the *ICES Cooperative Research Report No. 209* specification for radiated noise. Reductions in high frequency vessel noise have also increased acoustic detection ranges for fish and zooplankton. However, it is clear that some species, under some circumstances, avoid even quiet survey vessels. Thus, a variety of stimuli produced by vessels such as light and particle motion, as well as radiated noise, may cause fish to react to a survey vessel. Noise reduced vessels provide new opportunities to investigate these stimuli. WGFAST recommends that research in this area should proceed swiftly and focus on: i) determining which species of fish react to conventional and quiet survey vessels and under what circumstances; ii) the stimuli for their behaviours; and iii) the design requirements for vessels surveying these species in sensitive situations. Additionally, for cases in which fish avoidance is inescapable, survey biases should be estimated. Development of economical and portable noise measurement systems is also encouraged.

b) The second topic was "Technologies for remote species identification (low-frequency, Doppler, multi-frequency, broad bandwidth, data integration, optical sensors)". Species identification can be one of the major sources of uncertainty in acoustic surveys of fish and zooplankton abundance, and it is vital to multi-species and ecosystem studies. Substantial progress was reported on a variety of methods for remote species identification. Such methods enable more automated and objective data processing, reduced uncertainty in acoustic estimates of fish biomass, economical ecosystem investigations and studies of predator-prey interactions, and may also facilitate a reduction of by-catch during commercial fishing operations. It was noted that further progress towards species identification will likely require a combination of acoustic and other measurements. Because net sampling is typically used to identify acoustic scatterers, gear selectivity can add substantial uncertainty to acoustic surveys. Thus, the WGFAST encourages research on random and systematic error in net sampling, and development of new methods for verifying acoustic scatterers. Particularly promising are underwater stereo video instrumentation and analysis methods.

c) The third topic was "Alternative technologies (small-craft, buoys, ROV, AUV, gliders, fishing vessels, multi-beam sonar, acoustic cameras), with special attention to shallow water and near boundary assessments (coastal, riverine, demersal and epipelagic species, and bottom typing)". Measurement platforms other than research vessels are being used to economically make measurements on ecologically important temporal and spatial scales. For example, acoustic instruments are being deployed on buoys, landers, autonomous underwater vehicles, remotely operated vehicles, and fishing vessels. Expanded use of these platforms is imperative for successful ecosystem-based fisheries management. Progress was also reported on development of multi-beam sonars, and analyses of their data for biomass estimation. Finally, productive collaborations between commercial manufacturers and the scientific community were reported and encouraged.

d) The fourth topic was "Target strength (modelling and measurements)". There is a growing body of evidence indicating that a first-order approximation of TS versus log-length is generally insufficient to accurately and precisely estimate fish TS. It was shown that factors such as fish orientation (tilt, roll, and yaw), age-dependent changes in morphology, and region-dependent relations between fish mass, length, and swimbladder volumes can eclipse the effect of fish length on

their TS. Exemplifying this point was another study showing a bimodal TS distribution from herring characterized with a unimodal length distribution.

e) WGFAST recommends that it next meets at CSIRO in Hobart, Tasmania, on 27, 28, 29, and 30 March, 2006 to examine works in the following research areas:

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

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

iii) Acoustical species ID techniques for multi-species assessments, ecosystem studies, by-catch reduction, and objective and automated data processing;

iv) Instrumentation, survey design, and data analysis techniques for studying aquatic ecosystems, with special attention to the estimation and use of measurement uncertainty in statistical analyses of multi-variate time series, and techniques for integrating multi-disciplinary data to elucidate functional relationships; and

v) Target strength (modelling and measurements).

f) WGFAST recommends that SGASC and SGTSEB both be extended for another year, retaining their current Chairs, to complete their respective CRRs; and SGAFV and SGASC also meet in Hobart on 25–26 March, and 31 March-2 April, respectively.

g) WGFAST recommends research on: 1) noise and other vessel related stimuli for fish behaviour; 2) video and still camera instrumentation and data processing; and 3) instrumentation and methods for remote species identification. These topics should be considered for one or more new Study Group at the 2006 meeting.

h) WGFAST and WGFTFB jointly recommend that a Task Force be formed, lead by David Somerton, USA, to: evaluate the state-of-the-art in optical imaging and analysis technologies and define the ICES community's requirements for additional optical technology.

i) WGFAST recommends a review of the ecosystem-based fisheries management strategies developed and employed over the past two decades by international communities such as CCAMLR. Accordingly, one or more keynote speakers from CCAMLR and or CSIRO will be invited to the 2006 WGFAST meeting.

j) WGFAST recommends that the ICES sponsored "2008 Symposium on Fisheries Acoustics and Technology for Aquatic Ecosystem Investigations," is held from in June 2008 at Grieg Hall, Bergen, Norway.

k) WGFAST Recommends the following theme sessions for the 2006 Annual Science Conference: i) Joint FTC-RMC Theme Session on "Quantifying, summarizing and integrating total uncertainty in fisheries resource surveys." Co-Conveners: David Demer, U.S.A.; and Stephen Smith, Canada; ii) Joint FTC/LRC Theme Session on "Spatio-temporal characteristics of fish populations and their environmental forcing functions as components of ecosystem-based assessments." Co-Conveners: François Gerlotto (France), and someone from LRC; and iii) Joint FTC/LRC Theme Session on "Technologies for monitoring fishing activities and observing catch." Co-Conveners: Bill Karp, USA, and Kjell Nedreaas, Norway.

1 Terms of Reference

In response to the ICES Resolution of the 90th Statutory Meeting, the Working Group on Fisheries Acoustics, Science and Technology (WGFAST) (Chair: David A. Demer, USA; Rapporteur: Alex De Robertis, USA; and Recorder: Jessica D. Lipsky, USA) met in Rome, Italy from 19–22 April 2005 to review:

l) Measuring underwater radiated noise from survey vessels and its effects on fish;

m) Technologies for remote species identification (low-frequency, Doppler, multi-frequency, broadband, data integration, optical sensors);

n) Alternative technologies (small-craft, buoys, ROV, AUV, gliders, fishing vessels, multi-beam sonar, acoustic cameras), with special attention to shallow water and near boundary assessments (coastal, riverine, demersal and epipelagic species, and bottom typing);

o) Target strength (modelling and measurements); and

p) Progress of the:

i) Study Group on Acoustic Seabed Classification (SGASC);

ii) Study Group on Acoustics from Fishing Vessels (SGAFV);

iii) Study Group on Baltic Herring Target Strength (SGTSEB); and

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

v) The Joint Session of the WGFAST and WGFTFB.

WGFAST will report to the Fisheries Technology Committee at the 2005 Annual Science Conference in Aberdeen, Scotland in September, 2005.

2 Meeting Agenda and appointment of Rapporteur

David A. Demer, Chair, opened the meeting and immediately gave the floor to Grimur Valdimarsson, Director, Fishery Industries Division, FAO, who welcomed the WGFAST to Rome and FAO. Wilfried Thiele, our FAO host, extended an additional welcome and provided relevant details of the facilities and social events. The Chair then appointed Alex De Robertis from the Alaska Fisheries Science Centre, Seattle, Washington, USA as Rapporteur, and announced that Jessica Lipsky, Southwest Fisheries Science Centre, La Jolla, California, USA, would assist him as Recorder.

The meeting was dedicated to three long-time participants of WGFAST that have greatly supported the goals of ICES through their service and scientific contributions. Van Holliday, USA was honoured in absentia. Despite his recent illness, and because of his devotion to ICES, Van submitted the largest contribution to the CRR on Acoustic Seabed Classification, in preparation, and provided his vision to the Chair for how WGFAST should support ICES' goal of ecosystem-based fisheries management. Ron Mitson, UK, and Noel Diner, France, announced their retirement from the WGFAST, and were heartily applauded by the WGFAST, with gratitude and admiration, for both their science and camaraderie. Notably, Ron Mitson was the lead on the CRR 209, which is driving the specification, acquisition, and use of quiet survey vessel around the world. For many years, Noel Diner has capably and meticulously explored uncertainties of acoustics measures, engineered reductions of these errors, and frequently opened doors to new areas of research.

The following agenda was then adopted:

Topic 1. Measuring underwater radiated noise from survey vessels and its effects on fish.

Topic 2. Technologies for remote species identification (low-frequency, Doppler, multi-frequency, broadband, data integration, optical sensors).

Topic 3. Alternative technologies (small-craft, buoys, ROV, AUV, gliders, fishing vessels, multi-beam sonar, acoustic cameras), with special attention to shallow water and near boundary assessments (coastal, riverine, demersal and epipelagic species, and bottom typing).

Topic 4. Target strength (modelling and measurements).

Review of the report of the Planning Group on HAC common data exchange format (PGHAC), by Laurent Berger, France.

Review of the report of the Study Group on Acoustics from Fishing Vessels (SGAFV), by Bill Karp, USA.

Review of the report of the Study Group on Acoustic Seabed Classification (SGASC), by John Anderson, Canada.

Review of the report of the Study Group on Baltic Herring Target Strength (SGTSEB), by Bo Lundgren, Denmark.

Discussion and recommendations

Closure of the meeting.

A list of the 83 participants from 16 countries appears in Annex 1.

3 Topic 1 "Measuring underwater radiated noise from survey vessels and its effects on fish"

3.1 R. L. Gentry[1] (presented by R. Mitson[2]). ICES Report on the effects of sonar on cetaceans and fish

[1]U.S. Department of Commerce, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland. Roger.gentry@noaa.gov. [2]Acoustec, 5 Gunton Avenue, Lowestoft, Suffolk NR32 5DA, UK. acoustic@acoustec.co.uk

In 2004 the European Commission asked ICES to, "undertake a scientific review and evaluation of all relevant information concerning the impact of sonar on cetaceans and fish, to identify gaps in our current understanding and to make recommendations for future research/investigations. The Commission would also be interested in advice about possible mitigation measures to reduce or minimise the impact of sonar on cetaceans and fish."

A 'final' report by the Ad-hoc ICES panel was transmitted to the European Commission on 9 February, 2005 but the panel agreed that the fish section of the report was incomplete. For example, many if not most of the key papers on noise exposure of fish had not been considered and the fish section was withdrawn. The panel volunteered to redraft the fish section and the ICES editor accepted this.

3.2 D.N. MacLennan. Biological effects of sonar transmissions

FRS Marine Laboratory, P.O. Box 101, Victoria Road, Aberdeen AB11 9DB, Scotland. maclennan22@aol.com

The "noise" radiated by research vessels includes any transmissions from acoustic instruments. It is important to know what effect (if any) these transmissions have on the insonified animals which, in this context, include aquatic mammals as well as fish. Current knowledge in this area is reviewed. Physical factors like source levels are easily measured and described. It is much more difficult to make factual statements about the biological effects. Nevertheless, various criteria have been developed which provide a framework for objective evaluation. Exposure limits are defined at different levels according to whether the interest is in the detectability of sonar transmissions, associated changes in behaviour or physiological effects like hearing-threshold shifts which can be temporary or permanent. This framework is conceptually complete, but its application depends on detailed knowledge of animal behaviour and sensory physiology which is often lacking.

3.3 R. Mitson. An outline of some Naval noise ranges

5 Gunton Avenue, Lowestoft, Suffolk NR32 5DA U.K. acoustec@acoustec.co.uk

Underwater noise measurements are difficult to make in an open sea situation unless the environmental conditions are very stable but, for long periods of time, such stability may not be present. Because of this, Naval forces around the world found it necessary to construct special facilities within sheltered areas where vessel noise signatures can be measured. Over the past three decades some fisheries research vessels have used these facilities to assess their radiated noise levels.

In addition to protection from sea-state due to wind and weather which can cause high and variable levels of ambient noise, there is a need for adequate depth of water and distance from other boundaries. Stability of temperature and salinity are also factors to be taken into account. The layout and characteristics of a number of ranges located in various parts of the world are considered. All such underwater noise measuring facilities aim to cover several frequency decades with a suitably wide dynamic range of noise pressures.

3.4 D. Wood. The measurement of underwater radiated vessel noise

Bureau Veritas Acoustic Technology, 36–38 The Avenue, Southampton, Hants, SO17 1XN U.K. dick.wood@uk.bureauveritas.com

The measurement of underwater radiated vessel noise is described. Techniques which range from very simple ‘dunk’ tests through mobile ranging facilities, to the formal ranging undertaken on noise critical vessels (including those for fisheries research) all require sufficiently standardised procedures to enable the valid comparison of signatures. Specifically, the noise range requirements, as set forward in Annexes (A, B and C) of NATO STANAG 1136, are discussed as this is invariably the standard referenced by the military ranges.

Measurement requirements, in terms of frequency bandwidth and frequency range are discussed along with some of the associated measurement complications. The Lloyds Mirror (Surface Reflection) effect is described along with some examples on the type of correction factor involved. Benefits of acquiring static signatures are considered along with the quantification of ‘start-up’ transients. Some limitations of the standard range noise measurement techniques (e.g., vessel in “free-running condition”) are discussed and recommendations set forward for supplementary tests which will advance the state of knowledge during the towing of trawls etc.

3.5 A. De Robertis. Use of onboard hydrophones to monitor research vessel self-noise

Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. Alex.DeRobertis@noaa.gov

Underwater radiated vessel noise can elicit fish avoidance reactions, which have the potential to bias survey estimates of stock size. In recent years, there has been substantial investment in the design of noise-quieted research vessels to minimize the potential effects of fish avoidance during survey operations. The acoustic signatures of underway research vessels are typically measured on acoustic ranges at naval facilities. Because these noise ranging methods are expensive, it will be difficult to regularly repeat these comprehensive evaluations to ensure that radiated noise does not increase as the vessel ages. One method that could aid in determining when comprehensive noise range measurements are needed is to use onboard self-noise hydrophones to detect changes in noise levels. Although measurements made from these hydrophones cannot be translated directly into far-field radiated noise measurements, they can be used to identify situations when additional noise ranging is warranted. The Alaska Fisheries Science Center has developed a data acquisition system to make measurements from hydrophones aboard the first noise-quieted NOAA Research Vessel, "*Oscar Dyson*". The system has been field tested, and protocols for self-noise measurements have been established. A calibration procedure is used to measure the frequency-dependent preamplifier gain. Initial use of this system concurrent with radiated noise ranging indicates that these self-noise measurements will be a useful diagnostic tool to evaluate propeller cavitation and diesel generator tones, which are the primary sources of radiated noise from the "*Oscar Dyson*". Hydrophone measurements will be collected on a regular basis in an effort to identify potential long-term changes in sound levels over the vessel's service life.

3.6 Y. Simard[1&2], N. Roy[1], and M. Nayel[2]. Measuring underwater radiated noise from vessels with autonomous hydrophone and coastal arrays

[1]*Maurice Lamontagne Institute, Fisheries and Oceans Canada, 850 route de la Mer, Mont-Joli, Québec, Canada G5H 3Z4.* [2]*Institut des Sciences de la Mer, Université du Québec à Rimouski, 310 Allée des Ursulines, Rimouski, Québec, Canada G5L 3A1. yvan_simard@uqar.qc.ca*

The acoustic environment and vessel noise of at the head of the Laurentian channel in the St. Lawrence estuary was monitored for 2 months in 2003 and 2004, using a combination of a large-aperture array of AURAL M1 autonomous hydrophones and a small-aperture coastal array deployed along a cape. Intense noise from various vessels is regularly recorded in this coastal environment that is located on a major continental seaway. The histogram of the background noise measured from the coast at a depth of ~130 m and a range of ~1.5 to 5 km from the shipping route has pressure spectral density (PSD) levels over the 10–1000 Hz band, varying from ~40 to 115 dB re 1 μPa^2 /Hz. The peak frequency is around 40–50 Hz, and the levels decrease by ~25 dB between 100 and 1000 Hz. The 2-month PSD envelope is spreading by about ±20 dB around the noise curve for heavy shipping traffic. The observational approach provides information to assess the small- to meso-scale time-space variability.

3.7 I.H. McQuinn, Y. Samson, and D. Carrier. RUSTLER, a Referenced Underwater Source-Target Level Encoded Recorder

Hydroacoustic Laboratory, Institut Maurice Lamontagne, Department of Fisheries and Oceans, 850, route de la Mer, Mont-Joli, Québec, Canada G5H 3Z4. mcquinni@dfo-mpo.gc.ca

The ICES scientific community has been concerned with the adverse affects of research vessel noise on fish behaviour and research survey results for several decades. Institutes interested in the measurement of vessel noise signatures (VNS) require frequent access to accurate measurement instrumentation, given that a VNS may change over time. Unfortunately, gaining access to noise ranges (usually military) can be difficult if at all possible. With limited availability to sound ranges there is a need for more accessible systems for measuring VNS. RUSTLER (for Referenced Underwater Source-Target Level Encode Recorder) was designed according to recommendations in ICES CRR No. 209 to be an inexpensive, portable recording system, with the objective of measuring the sound levels of an identified source using a rapidly-deployed calibrated hydrophone with an internal reference tone. Sound levels are recorded in standard.wav format on one channel, with a second channel used to continuously record encoded GPS position information via RF modems from both the source vessel and the receive platform for range estimation. The reference tone ensures that the recorded sound levels are always calibrated, independent of system gain settings. RUSTLER and the Calibrated Ambient Noise and Sound Analysis (CANASA) software have been used to measure vessel noise signatures, ambient and background noise levels, received and source levels associated with shoreline construction and vessel traffic, seismic received levels in a Marine Protected Area, and a calibrated projector for the field validation of 2- and 3-D sound propagation models.

3.8 I.H. McQuinn[1], V. Lesage[1], D. Carrier[2], and B. Doidge[3]. Measuring hunting-canoe noise exposure within beluga whale habitat in the Little Whale and Nastapoka Estuaries, northern Canada

[1]*Hydroacoustic Laboratory, Institut Maurice Lamontagne, Department of Fisheries and Oceans, 850, route de la Mer, Mont-Joli, Quebec, Canada G5H 3Z4. mcquinni@dfo-mpo.gc.ca.* [2]*Physics Department, Sherbrooke University, Sherbrooke, Quebec, Canada J1K 2R1.* [3]*Nunavik Research Center, Makivik Corporation, Kuujjuaq, Quebec, Canada*

A controlled approach was used in this study where an outboard-motor hunting canoe was driven along pre-defined transects at a constant speed and at different tidal states (current conditions) to compare the underwater noise propagation around two estuaries in eastern Hudson Bay, Northern Canada. The Nastapoka and Little Whale River (LWR) estuaries differ in coastal and bottom topography, in physical and geographic characteristics and in recent attendance by belugas. Recordings were made from locations representing where beluga frequented while inhabiting the estuaries, travelling along shore or arriving from offshore waters. Canoe position relative to the recording station was logged continuously from GPS data using RF modem. Noise levels at varying distances from the estuaries were weighted against the audiogram of belugas to contrast noise perception distances at the two locations. Ambient noise was measured before each recording session. Results indicated that the canoe was perceived at farther distances from within the estuary at Nastapoka compared to LWR even though the ambient noise was higher at Nastapoka and that the distance of perception correspond with the slope of the sand bank.

3.9 F.R. Knudsen[1], P.S. Enger[2], H.E. Karlsen[2], and O. Sand[2]. Detection and reaction of fish to infrasound

[1]Simrad AS, Horten, Norway. frank.reier.knudsen@simrad.com. [2]University of Oslo, Oslo, Norway. olav.sand@bio.uio.no

During the last 15–20 years we have demonstrated that fish are sensitive to infrasound (<20 Hz), and that the otolith organs are the sensory system responsible. Particle acceleration, and not sound pressure, is the relevant sound parameter for low frequency detection in fish. We have also demonstrated that intense infrasound induces flight responses in many fish species and that infrasound sources able to generate large near-field particle acceleration can be employed to divert migrating fish in river systems. This paper reviews our studies of infrasound detection in fish and the use of intense infrasound as a fish deterrent. We see this as relevant input to the discussion on noise from survey vessels and effects on fish.

3.10 P. Walline and C. Wilson. Short-term effects of commercial fishing activity on the distributional pattern of walleye Pollock

NOAA, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle WA, USA. chris.wilson@noaa.gov, paul.walline@noaa.gov

A field experiment was conducted off Kodiak Island in the Gulf of Alaska during August 2001 and 2004 to evaluate the effects of commercial fishing on the availability of walleye Pollock as prey for endangered Steller sea lions. Motivation for the study centred on the concern that factors during commercial fishing operations such as radiated vessel noise, trawling operations, and removal of fish could potentially disrupt Pollock distributional patterns over time scales of days to weeks and space scales on the order of 10s of km. These disruptions in fish distribution could reduce sea lion foraging success.

The study site consisted of two submarine troughs that served as treatment and control sites with commercial fishing allowed in one trough and prohibited in the other. Repeated acoustic survey passes were conducted over a period of several weeks before and during the fishery. Walleye Pollock biomass, vertical distribution, large-scale distribution (geographical), and small-scale (school) spatial patterns (2001 only) were estimated for each pass in each trough. No differences in estimates between the pre-fishery and fishery period could be attributed to fishing in 2001. Analyses of the 2004 data are underway, and tentative findings suggest results similar to those in 2001.

Analyses were conducted with the 2004 data to determine whether the statistical power of the tests based on the current experimental design was sufficient to detect biologically meaningful effects. The presentation will focus on the 2004 results and value of the power analysis in determining the future direction of this work.

3.11 N.O. Handegard[1] and D. Trjøstheim[2]. When fish meet a trawling vessel: examining the behaviour of gadoids using a free floating buoy and acoustic split-beam tracking

[1]Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway. nilsolav@imr.no. [2]Department of Mathematics, University of Bergen, P.O. Box 7800, 5020 Bergen, Norway. dagt@mi.uib.no

The reactions of individual gadoids to (the old) "*G.O. Sars*" during bottom trawling were observed *in situ* in the Barents Sea. The fish were located at depths from 150 m to 300 m. A free-floating buoy and acoustic target tracking methods was used to obtain more than 20,000 tracks. These were analysed in terms of velocity changes in vertical, athwarthship, and alongship direction relative to the vessel, the warps, and the trawl. The reactions were compared to the gradual increase in noise level from the approaching vessel. The fish started diving about 15 minutes before vessel passing. This coincides with the time the trawl is on the bottom and stabilised, and not with the gradual increase in vessel noise. The strongest and sharpest response is related to the trawl warps, and not to the propeller, which is where the maximum vessel noise occurs. The vessel noise, in terms of a threshold value, is not the key stimulus in our case.

3.12 K.K. Olsen and R. Joergensen. Investigations of effects of simulated low frequency sonar signals on survival, development and behaviour of fish larvae and juveniles

Centre of Marine Resource Management, Norwegian College of Fishery Science, University of Tromsø. 9037 Tromsø, Norway. kol000@nfh.uit.no and roarj@nfh.uit.no

The new low frequency military sonars (0.5–6 kHz) have already created considerable concern and even restrictions in use, due to possible physiological damaging effects on marine mammals. In Norway a question has been raised, if such sonars may be harmful on fish and in fisheries. In 2004 a project was carried out by NCFS, investigating if damages or disturbing effect could be observed when exposing fish larvae and juveniles to simulated low frequency sonar signals. The results indicated few damaging effects, but the signals created strong disturbing effects on the behaviour of herring often with a dramatic “panic swimming”. Cod, on the contrary, did not react at all when exposed to such signals (1.5–6 kHz).

3.13 E. Ona, G. Pedersen, R. Patel, V. Hjellvik, N.O. Handegard, O.R. Godø, T. Torkelsen, A. Totland, I. Svellingen, and R. Pedersen. Fish do still avoid survey vessels

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

Several experiments were conducted in 2003 and 2004 in order to measure herring avoidance, and to compare the reaction to conventional vessels with noise-reduced vessels. This presentation will give an overview of the experiments conducted and the instruments developed to solve this task. At last, it will introduce several of the specific presentations of the measurements, as well as raising questions for discussions.

3.14 G. Pedersen, E. Ona, R. Patel, T. Torkelsen, and A. Totland. *In situ* measurements of research vessel noise

Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway. geir.pedersen@imr.no

A new experimental set up was created to measure noise from approaching vessels. The main feature of this set up is a hydrophone connected to an acoustic lander positioned near the sea floor. Data was stored in the lander for later analysis. This equipment was used during the herring vessel avoidance experiments in 2004. An overview of the methodology will be presented as well as the results from the 2004 experiments.

3.15 R. Patel, E. Ona, G. Pedersen, V. Hjellvik, N.O. Handegard, O.R. Godø, T. Torkelsen, A. Totland, I. Svellingen, and R. Pedersen. Measuring herring avoidance with a fixed ADCP

Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway. ruben.patel@imr.no

An upward looking bottom mounted ADCP was used to measure the swimming speeds of Herring during the approach of survey vessels. Two different vessels were used: "*Johan Hjort*" and "*G. O. Sars*". The vertical swimming induced by the vessels was compared.

3.16 N.O. Handegard, E. Ona, R. Patel, G. Pedersen, V. Hjellvik, O.R. Godø, T. Torkelsen, A. Totland, I. Svellingen, and R. Pedersen. Herring avoidance from a conventional and a noise- reduced vessel

Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway. nilsolav@imr.no.

Herring avoidance was measured using acoustic buoy (2003), and a bottom mounded Lander (2004), acoustically observing a shallow herring layer, either from above or below the layer using standard split beam echo sounders. A preliminary, selective, analysis of the collected data for the avoidance to research vessels "*Johan Hjort*" and "*G.O. Sars*" have been made and presented. The avoidance have been measured as the reduction in reflected energy from the layer before passage, relative to the energy recorded at time of transducer passage on both vessels.

3.17 V. Hjellvik, N.O. Handegard, E. Ona, R. Patel, G. Pedersen, O.R. Godø, T. Torkelsen, A. Totland, I. Svellingen, and R. Pedersen. Herring avoidance as compared in a two-vessel relay-running experiment

Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway. vidarh@imr.no

Herring avoidance and vessel measurement performance on herring was compared by running two research vessels in a selected triangle, passing the same point of the herring layer with about one hour difference. The acoustic data on all transects are compared in parallel. The experiment was conducted to compare the measured herring densities measured by an old research vessel with a new vessel. Details of the experiment will be presented, with a preliminary analysis of the collected data.

3.18 O.R. Godø, E. Ona, A. Jameson, G. Pedersen, R. Patel, V. Hjellvik, N.O. Handegard, T. Torkelsen, A. Totland, I. Svellingen, and R. Pedersen. Can bioluminescence be the clue?

Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway. olavrune@imr.no

Several experiments were conducted in 2003 and 2004 in order to measure herring avoidance, and to compare the reaction to conventional vessels with noise-reduced vessels. Measurements of strong bioluminescence in the entire water column in the survey area may indicate that vessel noise in not the only “signal” in this system. Examples of the measured luminescence will be presented and discussed.

3.19 J. Hotaling. NOAA FRV Program, providing major research tools to fisheries scientists

National Marine Fisheries Service, HQTR Route: F/ST, Silver Springs, MD, U.S.A., john.hotaling@noaa.gov

This paper reviews the mission needs of NOAA’s new Fisheries Research Vessel (FRV) and the various design considerations necessary to produce a research ship which will serve the multi-mission needs of the scientific community. The design considerations for meeting the radiated noise criteria of *ICES Cooperative Research Report 209* are reviewed, including quiet hull form, propeller design, diesel electric drive, equipment mounting and acoustic sensor placement. The results of the Navy Noise range at AUTEC, Bahamas and underwater video of hull performance are presented.

3.20 Discussion

For many years, it has been repeatedly confirmed that some species of fish, under some circumstances, react to and avoid survey vessels, possibly resulting in biased acoustic estimates of fish distribution and abundance. In response to this concern, WGFAST sponsored a study group to evaluate the role of research vessel noise on fish avoidance reactions. This study group reviewed the hearing capabilities of fish, the production of underwater radiated noise by survey vessels, and evidence for reactions of fish to underwater radiated noise. In 1995, this expert group published its recommendations in *ICES Cooperative Research Report No. 209* (CRR 209). The study group concluded that vessel avoidance was a significant concern for the reliability of acoustic surveys for fish abundance, and proposed a standard for underwater radiated noise produced by research vessels. Limits for low frequency (less than 5 kHz) and higher frequencies are recommended to minimize fish avoidance reactions and to maximize the performance of acoustic survey instruments, respectively.

Several vessels have been constructed within the ICES community to comply with the specifications in CRR 209. Quiet hull designs, diesel-electric propulsion, fixed-pitch propellers, and other specialized design features have resulted in substantial reductions in noise levels (generally 15 dB, or 95%), over a wide frequency range (10 Hz to 40 kHz), compared to conventional research vessels. Measurements of noise radiated by these vessels at naval noise ranges have indicated general compliance with the CRR 209 specification. Quantifying vessel noise remains an active area of research. Presented was a list of possible additions to the specifications and measurement procedures outlined in CRR 209, and several presentations were made on recent advances in economical and portable noise-ranging equipment and methods.

Although quiet vessels have only been in service for a few years, some studies are now available which demonstrate their distinct advantages over conventional vessels. For example, Fernandes *et al.* (2000) reported that herring did not respond to a survey vessel built to comply with the CRR 209 specification for radiated noise. The reduction in high frequency vessel noise has also lead to improvements in echosounder performance resulting in increased acoustic fish detection ranges on these vessels compared to conventional vessels; this represents a considerable improvement in the ability to survey deep water habitats as well as low-abundance stocks, or species with low target strengths (Mitson and Knudsen, 2003).

At the 2005 WGFAST meeting, scientists from the Institute for Marine Research (Norway) reported the results of a study comparing avoidance reactions of herring, at night, to both their conventional Research Vessel, “*Johan Hjort*”, and the new larger noise-reduced vessel, “*G.O. Sars*” (which meets the ICES standard for underwater radiated noise). The herring in this area were densely distributed in extensive layers, located deep in the water column during the day and shallow at night (often 30–50 m below the sea-surface). Observations from several stationary acoustic instruments indicated that herring in the shallow layer exhibited similar reactions to both vessels, possibly even worse for the larger, quieter vessel. These results corroborate the report of Vabø *et al*. (2002), that shallow and dense shoals of herring are known to be highly reactive to approaching vessels. Thus, some fish species, such as herring, may still react to quiet survey vessels under certain conditions, particularly when densely aggregated at shallow depths. Egil Ona, IMR, reported that during the day, when they are deep, herring do not avoid either "*Johan Hjort*" or "*G.O. Sars*".

In some situations, a variety of stimuli produced by vessels, such as light (bio-fluorescence) and particle motion, as well as radiated noise, may cause fish to react to a survey vessel. The WGFAST considers it important to understand all of the stimuli that cause fish to react to survey vessels. This information is required to further develop non-invasive techniques for scientific studies, and as a foundation for policies to minimize the impact of human activities on marine mammals, fish, and the marine environment. Noise reduced vessels provide new opportunities to reach these goals. WGFAST recommends that research in this area should proceed to: 1) determine which species of fish react to conventional and quiet survey vessels and under what circumstances; 2) determine all the stimuli for their behaviours; and 3) develop additional design requirements for vessels that are used to survey species in sensitive situations. Additionally, for cases in which fish avoidance is inescapable, develop methods to estimate and compensate for survey bias. Finally, the development of economical and portable noise measurement systems is encouraged.

References:

Fernandes, P.G., Brierley, A., Simmonds, E.J., Millard, N.W., McPhail, S.D., Armstrong, F., Stevenson, P., and Squires, M. 2000. Fish do not avoid survey vessels. *Nature* 404: 35–36.

Mitson, R.B., and Knudsen, H.P. 2003. Causes and effects of underwater noise on fish abundance estimation Aquatic Living Resources. 16: 255–263.

Mitson, R.B., Ed. 1995. Underwater noise of research vessels, review and recommendations. International Council for Exploration of the Sea, ICES Cooperative Research Report, 209.

Vabø, R., Olsen, K., and Huse, I. 2002. The effect of vessel avoidance of wintering Norwegian spring spawning herring. *Fisheries Research* 58: 59–77**.**

4 Topic 2 "Technologies for remote species identification"

4.1 P.G. Fernandes[1], R.J. Korneliussen[2], E. Ona[2], T. Knutsen[2], A. Lebourges-Dhaussy[3], J. Masse[4], N. Diner[4], S. Cachera[4], M. Iglesias[5], J. Gajate[6], R. Ponce[6] and S. Fassler[1]. The SIMFAMI project: using multifrequency fisheries echosounders to identify scattering categories

[1]FRS Aberdeen Scotland. [2]IMR, Bergen Norway. [3]IRD, Brest, France. [4]IFREMER, Nantes, France. [5]IEO, Palma de Mallorca, Spain. [6]IEO, Madrid, Spain.

The SIMFAMI (Species Identification Methods From Acoustic Multifrequency Information) project was a three year research project funded by the European Commission. The goal of the project was to enable the identification of fish species using scientific echosounders operating at frequencies typical of those used in fisheries research (e.g., 18, 38, 120 and 200 kHz). This contribution describes the SIMFAMI project and provides an overview of the major results.

Notable outcomes include: guidelines for the collection of multifrequency data; an online database and summary document containing the relevant information for most of the pelagic commercial finfish species of the north east Atlantic; a database of echotrace descriptors for the fish species considered; algorithms to perform inversions using most of the plankton model types currently available; simple algorithms to remove plankton and (resonant) bubbles from echograms; algorithms to identify fish without swimbladders (such as Atlantic mackerel); and algorithms to identify schooling physostomes (such as herring) in waters deeper than about 80 m. The algorithms are supported by empirical or theoretical scattering models of the various groups. It is clear, at this stage, that these echosounder frequencies do not always provide sufficient information to resolve individual species, but in many circumstances, groups with similar physiology can be identified to some degree and more information is available than had hitherto thought possible.

4.2 N. Diner. Multifrequency analysis: attempt of fish shoal species identification after SIMFAMI-04 cruise on board "*Thalassa*"

IFREMER Centre de Brest, B.P. 70, 29280 Plouzané Cedex, France. noel.diner@ifremer.fr

In May-June 2004, a cruise was conducted, in the Bay of Biscay, on board IFREMER Research Vessel "*Thalassa*" with on board all participants of the European SIMFAMI project. This was the first cruise with "*Thalassa*" fitted with 5 "split beam" frequencies (18, 38, 70, 120 and 200 kHz), gathered in a same hull blister. Different species of pelagic fishes were detected on depth from 30 to 200 m and shoal identification was done by pelagic trawling.

Unfortunately, few pure catches were obtained, and in most places, detection was composed of 3 to 5 different species.

A new approach of multifrequency analysis was attempted, based on a combination of 4 frequencies (38, 70, 120 and 200 kHz). A "4-Frq" parameter was extracted from all shoals detected in water layers sampled by the trawl. Based on a histogram classification according to the "4-Frq" parameter values, it was possible to operate a detailed analysis of data from 10 hauls, giving main catches concerning 8 species with and without swimbladder (sardine, sprat, anchovy, horse-mackerel, mackerel, jack mackerel and "*Capros Aper*"). A final classification, with classes of 3/5 dB amplitude, seems possible on these data, leading to four classes:

a) mackerel
b) horse-mackerel, jack-mackerel and *Capros aper*.
c) clupeids # 20 cm
d) small clupeids < 15 cm

4.3 J.M. Jech. Using objective classification methods to evaluate uncertainty in fisheries acoustics surveys

NOAA Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543 USA. michael.jech@noaa.gov

Routine acoustical surveys for estimating Atlantic herring (*Clupea harengus*) population abundance have been conducted on Georges Bank during the autumn spawning season from 1998 to present. Acoustical data were collected with a Simrad EK500 scientific echo sounder operating 12- or 18-, 38-, and 120-kHz, and split-beam transducers. Biological measurements and verification of acoustical scatterers were obtained with a pelagic trawl. An objective method, S_v Presence-Absence, was applied using virtual variables in SonarData's Echoview to these multi-frequency data to classify Atlantic herring. Classification by the objective method was compared to human-scrutinized data to evaluate the efficacy for automated classification. This method was successful at classifying all scrutinized herring regions. Within scrutinized herring regions, s_A as determined by the S_v Presence-Absence method was 7–10% lower than scrutinized s_A. This method also classified S_v that was not scrutinized as 'herring' (i.e., false positives). Overall survey s_A values, and hence abundance estimates, were dependent on the level of potential false positives that were classified. The level of false-positive classification was much greater in 2000 than was observed in 2001–2004, suggesting a fundamental change in acoustic backscatter patterns during autumn over the past five years on Georges Bank. Implications of using objective classification methods on population estimates and applying these methods to investigate uncertainty are discussed.

4.4 C. Goss. Multiple frequency identification of components of the pelagic ecosystem using catch information

British Antarctic Survey, High Cross, Madingley Road, Cambridge, U.K. CB3 0ET. cg@bas.ac.uk

A significant proportion of the pelagic backscattering around the sub-Antarctic Island of South Georgia cannot be positively identified because of the difficulties of target fishing all the different size classes of the pelagic ecosystem. However, these classes, from the finest zooplankton to fish and squid, have been comprehensively described from samples obtained by a wide variety of nets and from higher predator gut analysis; most of the sampling that provided this wealth of information was carried out without appropriate acoustic surveys. The knowledge obtained from these samples is so extensive that it can be used to make lists of potential candidates for a range of unidentified echoes observed during acoustic surveys, aided by detailed, multi-frequency descriptions of echoes at specific locations. Some of these candidates can be included or excluded by comparing known features from species databases, e.g., abundance and spatial distribution, with the characteristics of an echo type, arriving at an identification by a process of elimination. Examples are given of fish and zooplankton species tentatively identified in this way. This is not proposed as a substitute for targeted fishing during acoustic surveys, but as a supplement to guide future fishing effort.

4.5 E. Josse[1], G. Moreno[2], P. Brehmer[3], and L. Nottestad[4]. Multifrequency approach to study tuna aggregations and their biotic environment around drifting FADs

[1]IRD, Centre de Bretagne, BP 70, 29280 Plouzané, France. Erwan.Josse@ird.fr. [2]AZTI Fundazioa, Txatxarramendi ugartea, z/g, 48395 Sukarrieta, Spain. gmoreno@suk.azti.es. [3]CRHMT/IRD, Ave Jean Monnet, BP 171, 34203, Sète cedex, France. brehmer@ird.fr. [4]IMR, Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway. leif.nottestad@imr.no

Drifting FADs (Fish Aggregating Devices) are extensively used in tuna purse seine fisheries; more than fifty per cent of tuna catches in the world are taken around drifting FADs. Although this usage of FADs by tuna fisheries has been well known by the scientific community for years, very few studies have characterized these aggregations. Acoustics represent a powerful tool to study the composition and behaviour of those fish aggregations. During FADIO program (Fish Aggregating Devices as Instrumented Observatories of pelagic ecosystems, a research project funded by the European Community) cruises, acoustic data were collected in the western Indian Ocean on fish aggregations around drifting FADs, and on local sound scattering layers (SSL). The tuna aggregations and the prey environment were studied using a Simrad EK60 echosounder with three frequencies: 38, 70 and 120 kHz. Advances in multifrequencies analysis allow echo-classification and an accurate characterization of the biotic environment, which shows the potential of multifrequency treatments analyses to study such aggregations in open sea pelagic environments. Results show that tuna aggregations around those FADs can be very dynamic over short time periods, in terms of school structure and density. Relationships with local prey environments (SSL) are discussed.

4.6 O. Diachok[1], C. Scalabrin[2], P. Smith[3], and S. Wales[4]. Bioacoustic absorption spectroscopy: results of BAS II

[1]University of Washington, Applied Physics Laboratory, Seattle, WA, USA and Poseidon Sound, Oakton, VA, USA. OrestDia@aol.com. [2]IFREMER, Brest, France. Carla.Scalabrin@ifremer.fr. [3]Southwest Fisheries Science Center, La Jolla CA, USA. Paul.Smith@noaa.gov. [4]Naval Research Laboratory, Washington, DC, USA. wales@nrl.navy.mil

Inversion of bio-acoustic parameters of year classes (number density, layer depth and layer thickness) from acoustic absorption measurements is feasible at night, when the majority of the fish are dispersed, and the effects of fish in schools may be neglected. The most recent experiment, BAS II, was designed to measure the effects of fish on sound absorption (bio-alpha) and sd/i, where sd is the standard deviation and i is the mean intensity. This experiment employed a source, which transmitted a sequence of 64 five sec long, CW tones between 300 Hz and 10 kHz; and a 16 element vertical array, which spanned most of the water column. The range was fixed at 3.7 km. A fisheries echo sounder provided layer depths; trawls provided fish species-length distributions. At night peaks in bio-alpha and sd/i were observed at the resonance frequencies of 15 cm long sardines and 10 and 6 cm long anchovies. sd/i peaks attributed to (night) schools occurred at frequencies which were lower than (equal to) the resonance frequencies of individual sardines (anchovies), and at depths which were deeper than (equal to) peak bio-alpha depths of sardines (anchovies). Peak depths of sd/i, which were derived from echo sounder and bio-alpha data agree, which suggests that sd/i is maximum at depths where the temporal variability of number density is maximum, i.e., at depths where schools are formed and dispersed. The implications of these results for practical applications will be considered. This research was supported by the Office of Naval Research.

4.7 D. Somerston. NMFS Workshop on the Analysis of Underwater Video

Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, Washington. David.Somerton@noaa.gov

This talk summarizes the Workshop on the Analysis of Underwater Video which was held 4–6 August 2004 to assess the usage of underwater video throughout all of the NMFS laboratories for stock assessment or habitat evaluation. Twenty distinct programs were identified, 16 of which attended the workshop and presented the objectives of their research and the role played by underwater video. A wide variety of methods were used to collect underwater video (divers, ROV, towed sleds, mini-subs, buoys, drop cameras, and direct attachment to pinnipeds). Typically, the video analysis required the time consuming process of direct viewing and evaluation, although several programs utilized either custom or commercially available software to increase speed. A variety of cutting edge technologies were presented by university researchers, including: stereo video, video mosaics, video databases, infra-red video, acoustic cameras, pattern recognition and automatic video analysis. The participants were in agreement that the biggest obstacle to routine use of video for stock assessment and habitat evaluation is the time required to for analysis and that better designed software, especially with pattern recognition and shape measurement capabilities, was urgently needed.

4.8 A. Lebourges-Dhaussy[1] and L. Berger[2]. The inversion algorithm for the zooplankton classification and its integration into the Movies+ software

[1]Institut de Recherche pour le Développement, Centre IRD de Bretagne, BP 70 - 29280 Plouzané, France. Anne.Lebourges.Dhaussy@ird.fr. [2]IFREMER, BP70, 29280 Plouzané, France. Laurent.Berger@ifremer.fr

In the frame of the European program SIMFAMI, IRD has focused its activities on the fish/plankton discrimination and the zooplankton classification. For the latter, the basic is to use multifrequency information, an inversion algorithm and a set of published plankton types models, to estimate the composition of the population that has produced the measured backscattering strengths. The whole processing needed until now several steps, performed through various tools: an echointegration by layers within a classical acoustic data processing software, then through Matlab routines, creation of the inversion input files from the result files of the integration, running of the inversion, and using graphic routines for the visualization of the results. A great improvement has been performed at IFREMER on the Movies+ software to integrate all this processing as a new tool of the software through a user friendly interface. As so the inversion becomes available to the users, and testing settings and parameters becomes much easier and faster, allowing more possibilities for a processing validation purpose. In addition, the processing time is low and the tool may in some conditions be run in real time. The current architecture of this new procedure in Movies+ is designed in order to be easily able to host new models in the future and if possible fish models.

4.9 C. Coll[1], J. Josse[1], Delphine Benoît[1], A. Lebourges-Dhaussy[1], E. Josse[1], L.T. de Morais[2], M. Simier[2], and R. Laë[1]. How to recognize the fish in the trees? Methodological reflections for the fish population assessment in an artificial reservoir

[1]Institut de Recherche pour le Développement, Centre IRD de Bretagne, BP 70 - 29280 Plouzané, France. Erwan.Josse@ird.fr. [2]Institut de Recherche pour le Développement, CRHMT, Avenue Jean Monnet, 34203 Sète, France. tito@ird.fr

Estimate the impact of the fishery pressure on a fish population is an important current goal for the research programs. The present work takes place in such a frame, applied to lacustrine environment. The experiments were performed in two contrasted Malian lakes, from the exploitation point of view. Facing the difficulty to get historical series, an estimate of the temporal evolution is appraised through the comparison of these two lakes which are at different fishery levels. The acoustic prospecting ran into difficulties which are specific to some continental waters areas, where various types of vegetation are present. In these cases, fish like usually remaining hidden into these areas. After some experience, it becomes possible to classify visually a large part of the echotraces; nevertheless it remains a part of subjectivity and the processing is fastidious. Statistical methods have therefore been tested in order to find keys to automate the processing. But even in the best case, the use of these keys depends a lot on the fish behaviour, which is very different from one lake to the other, with schooling fish in the more exploited reservoir, and dispersed fish in the other.

4.10 Discussion

Species identification is one of the major sources of uncertainty in acoustic surveys of fish and zooplankton abundance, and it is vital to ecosystem studies. Substantial progress was reported on a variety of methods for remote species identification that exploit frequency dependent acoustic backscattering, metrics of school characteristics (e.g., size, length, and echo intensity), and combinations thereof. Continuing development of methods for remote species classification or discrimination may soon enable more automated and objective data processing, reduce uncertainty in acoustic estimates of fish biomass, enable economical ecosystem investigations and studies of predator-prey interactions, and may also facilitate a reduction of by-catch during commercial fishing operations. It was noted that further progress towards species identification will likely require a combination of multi-frequency and broad bandwidth acoustic measures as well as a reduction in observation range to allow the use of higher frequencies and ping rates. That is a combination of acoustic techniques similar to that used by dolphins and bats. In addition, information from other observations such as time of day and season, water depth and temperature, and animal behaviour will be useful to tune acoustic species detection procedures to given situations.

Although progress in this area is substantial and accelerating, the utility of available techniques is generally situation-dependent, and must be evaluated for specific environments and species assemblages. That is, there is currently no universal method for remote species classification. As much as possible, the effectiveness of species identification methods should be evaluated in terms of their contribution to the total systematic and random error of acoustic surveys of fish abundance. One such analysis was presented for herring surveys on Georges Bank.

A major obstacle to quantifying errors associated with species identification techniques is the generally poor characterization of uncertainties related to selectivity of sampling gears. Consequently, uncertainties associated with net sampling to identify acoustic scatterers can add substantial uncertainty to acoustic surveys. Thus, the WGFAST encourages research on random and systematic error in net sampling, and development of new methods for verifying acoustic scatterers. Particularly promising are significant recent advances in underwater video instrumentation and analysis methods. Of these, stereo imaging and analysis appear to be the most promising tools.

5 Topic 3 “Alternative technologies, with special attention to shallow water and near boundary assessments”

5.1 M. Patterson[2], D. Needham[2], A. Jenkins[2], and D.A. Demer[2]. Nearshore studies of the Antarctic ecosystem, by AUV

[2]Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, Virginia, USA, 23062–1346. mrp@vims.edu. [2]Southwest Fisheries Science Center, 8604 La Jolla Shores Dr, La Jolla, California, USA, 92037. david.demer@noaa.gov

The Southwest Fisheries Science Centre, in partnership with the Virginia Institute of Marine Science, has used a Fetch I AUV from Sias-Patterson, Inc. to explore the near-shore region of Livingston Island, Antarctica. This area serves as the main feeding ground for the seasonally resident fur seal and penguin populations at Cape Shirreff. These animals feed primarily on Antarctic krill, which aggregates in large swarms and layers in the waters just offshore of the island. Shallow and highly variable bathymetry makes this area unsuitable for study from large ships. The Fetch I autonomous underwater vehicle was deployed from a 19’ zodiac. The 1.96 m long, 73 kg, seal-shaped AUV was equipped with a 600 kHz side-scan sonar, colour video camera, CTD with oxygen sensor, and GPS. The AUV was used to conduct feasibility studies in the nearshore region of Cape Shirreff including use of: 1) side-scan sonar to survey epi-pelagic krill swarms; 2) colour video to identify the acoustic targets; and 3) a CTD with DO to relate fine-scale physical oceanographic conditions to krill dispersion and abundance.

5.2 A.S. Brierley[1], R.A Saunders[1], D.G. Bone[2], and P. Enderlein[2]. Use of moored acoustic instruments to measure short-term variability in abundance of Antarctic krill

[1]Gatty Marine Laboratory, University of St Andrews, Fife, KY16 8LB, Scotland, UK. asb4@st-and.ac.uk, ras19@st-and.ac.uk. [2]British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, UK. pend@bas.ac.uk, dgbo@bas.ac.uk

Upward-looking ADCPs and single-beam echosounders were deployed on moorings at South Georgia to measure short-term variation in abundance of Antarctic krill. A new method was developed in which water flow past the moorings, as determined by the ADCPs, was used to scale echosounder observations of krill to provide robust quantitative abundance estimates. Flow past the stationary mooring was treated in an analogous manner to the motion along-track of a research vessel through a nominally stationary body of water during a conventional acoustic survey. The mooring data thus provides an Eulerian view of variation in krill abundance. This is ecologically instructive for South Georgia where krill are passive drifters on dynamic ocean currents and where temporal fluctuations in krill abundance have major consequences for krill-dependent predators. Echoes from krill were identified on the basis of the theoretical difference in echo intensity at the operating frequencies of the ADCPs (300 kHz) and echosounders (125 kHz), and were scaled to krill density using TS appropriate for the size of krill in the region: krill size was determined regularly from diet samples of predators foraging in the vicinity of the moorings. Moorings were positioned on transects surveyed periodically by a research vessel. Validity of the mooring approach to krill sampling was assessed by comparison of mooring and vessel observations.

5.3 R. Patel, E. Ona, G. Pedersen, A. Steinsland, R. Johannesen, O.R. Godø, T. Torkelsen, A. Totland, I. Svellingen, and R. Pedersen. Kamikaze calibration of bottom-mounted split beam transducers

Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway. ruben.patel@imr.no

Two stationary bottom mounted transducers at 400 m and 500 m depth was calibrated using a survey vessel and a Remote Operated underwater Vehicle (ROV). A calibration sphere was attached to the ROV and piloted down to the transducer. The ROV hovered over the transducer and steered so that the sphere covered all the transducer quadrants.

5.4 D. Chu[1], L.C. Hufnagle, Jr.[2], and J.M Jech[3]. Quantitative acoustic measurements with multibeam sonars

[1]Applied Ocean Physics and Engineering Department, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543. dchu@whoi.edu. [2]Northwest Fisheries Science Center, NOAA-NMFS, Seattle, Washington 98112–2097. lawrence.c.hufnagle@noaa.gov. [3]Northeast Fisheries Science Center, NOAA-NMFS, Woods Hole, Massachusetts 02543. michael.jech@noaa.gov

Multibeam sonars are able to sample a much large water volume than conventional single beam or split-beam sonars over equivalent time periods, and are becoming increasingly important in fisheries acoustics. One of the essential components of quantitative applications of multibeam sonars to fisheries acoustical surveys is calibration. Protocols for calibrating multibeam sonar by the standard-target method have been recommended [Foote *et al.*, JASA 2005 (in press)]. In this current work, calibration of a generic multibeam echo sounder emphasizing the theoretical principles rather than the procedures is presented. A Graphic User Interface (GUI) based Matlab program developed for processing the multibeam echosounder data is presented. This program can provide quantitative target strength (TS) for resolvable echoes and volume backscattering strength (Sv) estimates. Examples and results from applying the GUI based program to raw data collected with the Simrad SM2000/90 kHz multibeam echo sounder are presented. Issues relating to the unique characteristics of multibeam sonars, biases resulting from uncertainties in sonar system and environmental parameters, and outstanding questions associated with the system calibration are analyzed and discussed.

5.5 J.H. Churnside[1], J.J. Wilson[1], A. Slotte[2], and E. Tenningen[2]. LIDAR target strength measurements of Atlantic mackerel

[1]NOAA Environmental Technology Laboratory, 325 Broadway, Boulder, CO, 80305, USA. james.h.churnside@noaa.gov, james.j.wilson@noaa.gov. [2]Institute of Marine Research, P.O. Box 1870, Nordnes, 5817 Bergen, Norway. eirik.tenningen@imr.no, aril.slotte@imr.no

We measured the LIDAR target strength of Atlantic mackerel in a net pen using a pulsed laser and a calibrated video recorder. The average values were -36.84 dB in the plane co-polarized with the laser and -38.24 dB in the orthogonal polarization. The depolarization of the scattered light was much greater than observed in previous measurements of Pacific sardines, suggesting that depolarization might be an important clue to species identification in LIDAR returns. This is important because multi-frequency and broadband LIDAR are not practical approaches. Several difficulties were encountered during the measurements, including camera nonlinearity, background light, and differences in the measurement distance. The nonlinearity was measured and a correction applied to the data. The level of background light in the green was estimated using the amount of blue light, since there was no blue laser light. The results were not sensitive to changes in background light colour over the range of colours encountered during the experiment. Differences in measurement distance were minimized by using only data from closer ranges, where the differences were less. Recommendations for improvements in procedure are suggested to provide more accurate LIDAR target strengths for this and other species.

5.6 J. Szczucka. Migratory fish behaviour measured by the autonomous hydroacoustic system

Institute of Oceanology, Polish Academy of Sciences, Powstancow Warszawy 55, 81–712 Sopot, Poland. szczucka@iopan.gda.pl

A 6-day series of inverted echosounding in the Baltic Sea is presented. The working frequency of 130 kHz determines the potential scatterers as millimetre size zooplankton and fish. Biological samples have not been taken, but the only possible Baltic fish taxa are sprats and herrings, and with the lower probability cods. On the background of the ordinary diel vertical migration some abnormal migratory behaviour can be observed. In windy time the vertical migration is seriously limited. During the strong wind the animals do not migrate so close to the surface as during the still weather. The parameterisation of echosignal allows us to find that during the windy nights the depth of the gravity centre of the echo signal envelope deepens to 30–40 m comparing to 10 m in calm conditions. The backscattering strength averaged over the whole water column (excluding the upper 5 metres) is several dB lower during storm than in calm conditions. Probable reasons for this are considered.

5.7 I. Higginbottom. 4D data visualization of Echoview illustrated with data from the new Furuno FSV30R scanning sonar

SonarData Pty Ltd, P.O. Box 1387, Hobart, Tasmania, 7001, Australia. ian@sonardata.com.

SonarData have extended the 3D visualisation environment in Echoview by adding time controls to create a new 4D visualisation tool. Objects such as echograms, fish schools and surfaces that are located in 4 dimensions can be visualised in both space and time. This feature will be illustrated using a range of data examples from the new Furuno FSV30R scanning sonar. Echoview supports 6 data modes from the FSV30R, vertical, slant and horizontal mode for “cruise scanning”, vertical and horizontal modes for “instrument scanning” and a target tracking mode. These modes will be demonstrated in the 4D environment using simulated and real survey data.

5.8 J.M. Jech. Report of a workshop to evaluate the Simrad EK60 and comparisons to the Simrad EK500

NOAA Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA, USA. michael.jech@noaa.gov

The Simrad EK500 has been a standard echo sounder used internationally for scientific fisheries surveys. The Simrad EK60 is its successor. To verify measurements and ensure validity of long-term data series, evaluation of the EK60 and comparisons between the EK500 and EK60 are required. A workshop was convened in 2004 by NOAA Fisheries to bring together academia, government, and industry to review prior and on-going comparisons and measurements, and to develop procedures for characterizing and comparing measurements and analyses by these echo sounders and post-processing software systems. While the EK60 is a significant advancement in scientific echo sounding, primary concerns of system performance and stability were emphasized during the workshop. Concerns included increased target strength variability, inexplicable large gain steps, and critical shortcomings in documentation. These concerns, recommendations, and on-going improvements to the EK60 will be discussed. Workshop attendees were in unanimous agreement that the EK60 user community should work cooperatively with Simrad and other third-party software developers to advance echo sounder system performance, signal processing, and data analyses with the goal of improving the accuracy and precision of acoustically derived fisheries estimates. The meeting and subsequent communication has proved to be a good venue for enhancing existing good rapport with Simrad and progress in resolving these issues has been made.

5.9 L.N. Andersen. Status and plans for the ER60/EK60

Simrad, P.O. Box 111, N-3191 Horten, Norway. lars.nonboe.andersen@simrad.com

The status for the current EK60 scientific echo sounder system will be presented to follow up the report of a workshop to evaluate the Simrad EK60 and the Simrad EK500.

The current status for the new Scientific Multibeam Systems project which will develop a Scientific Multibeam Echosounder in collaboration with IFREMER, France, and a Scientific Multibeam Sonar in collaboration with IMR, Norway, will be presented.

5.10 D.A. Demer[1], J. Butler[1], L. Asato[1], D. Pinkard[1], S. Sessions[1], D. Murfin[1], S. Mau[1], and K. Franke[2]. Non-lethal surveys for rockfish

[1]Southwest Fisheries Science Center, 8604 La Jolla Shores Dr, La Jolla, California, USA, 92037. david.demer@noaa.gov. [2]M/V Outer Limits Inc.,11464 Eastridge Place, San Diego, California, USA, 92131. kfranke3@san.rr.com

Marine sportfishing 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. The stocks of lingcod and six rockfish species, including four that are important to California anglers and commercial fishermen (bocaccio, canary rockfish, widow rockfish and cowcod), are estimated at or below 25% of their pristine levels. To assess the habitat and stocks of selected rockfish species in two marine conservation areas, the Southwest Fisheries Science Centre is developing a non-lethal surveying technique to use in cooperation with the sportfishing fleet. 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, the survey challenges are many. To overcome these obstacles, a combination of survey equipment is required. The challenge is first to identify the essential habitat for these rockfish, thus reducing the necessary survey area. This can be done with a combination of multi-beam sonar, sidescan sonar, multi-frequency echo sounders, and underwater video deployed from an ROV. It is also necessary to characterize the frequency dependence of sound scatter from the rockfish and coexisting species. This can be done by a combination of modelling, and both *in-situ* and *ex-situ* measurements. Finally, multi-frequency echo sounders, and underwater cameras can be used to acoustically survey the rockfish in their essential habitat and visually confirm the observations, respectively.

5.11 R. Kieser. A model for echo integration of non uniform fish densities

Department of Fisheries and Oceans, 3190 Hammond Bay Road, Canada. kieserr@pac.dfo-mpo.gc.ca

Echo integration (EI) is a well recognised method to measure the backscatter intensity and estimate fish density. Conventional EI is appropriate for high and low fish densities as long as the target distribution is uniform across the beam. This is generally the case in mobile applications that use a downward looking transducer. Uniform target distribution across the beam however cannot be assumed for riverine applications with a stationary side looking system. Observed distributions are often very non uniform especially when migrating fish are surface or bottom oriented. The development of a model for echo integration of non uniform fish densities and simulation results are described.

5.12 Discussion

Discussed were data collection from novel platforms, methods for processing and visualization of data from multibeam sonars, and new developments in echosounders and LIDAR. There has been increasing use of measurement platforms other than research vessels including acoustic instruments deployed on buoys, landers, autonomous underwater vehicles, remotely operated vehicles, and fishing vessels, as well as LIDAR on airplanes. These measurement platforms allow for measurements with increased temporal and spatial coverage or resolution that are not possible with traditional survey platforms, and economically enable the study of many ecological processes at more relevant scales. Additionally, many of these platforms are relatively non-invasive, and are appropriate for investigation of fish reactions to survey vessels.

Progress was also reported on development of multi-beam sonars for biomass estimation. A multi-beam calibration procedure has been developed and plans are underway for the procedure to be incorporated into commercial software. Methods were proposed and discussed for the suppression of the relatively high transducer side-lobes and cross talk that can interfere with multi-beam sonar observations. These and other hurdles must be overcome for reliable quantitative use of multi-beam systems. It was noted that one of the primary challenges when working with multi-beam systems is processing the huge data sets that they produce. New software was presented for facilitating both 3- and 4-dimensional visualization of these data.

Finally, productive collaborations between commercial manufacturers and the scientific community were reported. For example, a recent NOAA workshop compared the Simrad EK500 and replacement EK60 echosounders and suggested several improvements to the newer model. A gain instability that occurred very infrequently was one of the issues. After extensive testing by scientists and Simrad, and a painstaking investigation by the manufacturer, the source of the intermittent problem was identified and eliminated. After this issue was addressed, the EK60 and EK500 data were in acceptable agreement. Intersessionally, hardware and software manufacturers queried the scientific community for their current and future needs; this interaction enables efficient development of instrumentation and methods most useful to the ICES research community. The WGFAST encourages continuing dialogue and collaboration between scientists and manufacturers.

6 FAST/FTFB Joint Session

6.1 Topic 1: Advances in survey strategy, design, and gear

6.1.1 D. Somerton. The effects of vessel motion on the bottom-contact of the footrope and bridles of a survey trawl

Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, USA. David.Somerton@noaa.gov

Vessel motion, due to surface waves, is transmitted down the towing warps, producing vertical oscillations of the footrope and bridles of a bottom trawl. For bottom trawl surveys, such oscillations likely reduce bottom contact and thereby reduce trawl catchability, especially for crabs, flatfish and other benthic species. Establishing a maximum permissible sea state was considered to be an important survey standardization measure in the NOAA Protocols for Groundfish Bottom Trawl Surveys, but until recently no research was available to indicate how such a maximum could be objectively defined. This paper considers the results of an experiment in which a heave sensor was installed on a chartered commercial fishing vessel to measure the vertical motion at the trawl block and 11 bottom contact sensors were attached at various positions along the bridles and footrope of a standard survey trawl to measure distance off-bottom. Luckily, during the experiment, a storm event occurred in which the sea state increased to the level normally considered the maximum for safe working conditions on the deck. The vessel heave and bottom contact data from this experiment are analyzed with the objective of determining, by some optimality criterion, the maximum vessel motion that should be allowed for a survey tow based on its impact on catchability rather than safety.

6.1.2 N. Bez. Combining acoustic and trawl data: “outcomes” of the CATEFA project.

Institut de Recherche pour le Développement, BP 171, 34203 Sète, France. nicolas.bez@ifremer.fr

The principle objective of this project was to develop and apply appropriate combination methodologies for the use of both acoustic and trawl data from bottom trawl surveys.

Data sets were selected to encompass several existing situations. The project had four main objectives:

- To determine the relationships between the acoustic and trawl data.
- To develop mathematical models, to calculate combined stock abundance indices.
- To test the performance of these new indices within the stock assessment process.
- To provide and test improved survey designs.

When work began, it quickly became apparent that useful relationships between the simultaneously collected bottom trawl and acoustic data were difficult, although not impossible to find. I will review the main outcomes of the project and raise the key benefits and weaknesses of the four different methodologies used in the project i.e., Geostatistics, Generalised Additive/Linear Modelling, Fuzzy Logic Modelling and Artificial Neural Networks. Possible reasons for the weaknesses and strengths of the outcomes will be discussed (sampling areas, beam footprint/tow opening, etc).

6.1.3 Discussion

Discussion focused on methods to improve bottom trawl surveys, and the use of combined bottom trawl and acoustic methods for surveys of demersal fish. One potential source of variability is the effect of vessel motion on bottom trawl performance. Potential artefacts introduced by vessel motion include reducing herding by the bridles, and reduced headrope bottom contact, which is known to degrade capture efficiency of some species. It was suggested that it was possible to make the trawl more robust in rough weather by using auto trawl systems or increasing the amount of warp to the trawl to reduce trawl motion. It was agreed that the primary issue for trawl standardization is not wave height, but vessel motion, and that further studies should measure vessel motion.

There was also discussion of techniques to combine bottom trawl and acoustic measurements for demersal surveys. Agreement of acoustic and trawl measurements are often poor, but tend to be most comparable in cases where surveys are conducted in deeper water, like the Barents Sea. It was suggested that at larger depths, the footprint of the acoustic beam is comparable with door spread footprint, which may make measurements more comparable.

6.2 Topic 2: Techniques for validating multi-frequency acoustical species methods, with attention to appropriate time, space and scale

6.2.1 A. Bertrand[1], F. Gerlotto[1], M. Gutiérrez[2], S. Bertrand[1], G. Swartzman[3], and S. Peraltilla[2]. Echo-traces typology for Peruvian anchovy: an impossible task?

[1]IRD - Centre de Recherche Halieutique Méditerranéenne et Tropicale, avenue Jean Monnet – 34203 Sète Cedex, France. arnaud.bertrand@ird.fr, francois.gerlotto@ird.fr, sophie.bertrand@ird.fr. [2]Instituto del mar del Perú (IMARPE) - Gamarra y General Valle s/n

Chucuito, La Punta Callao, Perú., mgutierrez@imarpe.gob.pe, speralt@imarpe.gob.pe. [3]*University of Washington, School of Fisheries, Box 355640, Seattle, WA 98195, USA. gordie@apl.washington.edu.*

Echo-trace classification has been routinely used since the 1990s to improve species recognition and study functional relationships between fish and their environment. However, 2D echo-sounder data gives a biased vision of the 3D structures and the reality of the typology, in their ability to distinguish schools by their typology was seldom statistically validated. During a workshop held in Sète we attempted a validation in the case of the Peruvian anchovy (*Engraulis ringens*) using data from an acoustic survey performed in 2002. Data were processed using Movies to extract fish echo-traces, which were visually classified into four echo-types. Whatever the statistical method used (PCA, classification and regression trees, clustering) we could not validate the empirical typology and obtained a continuum in the echo-trace characteristics, preventing a split of echo-traces into distinct groups. At least two hypotheses can explain such a result. First that characterising “complex” echo-traces such as scattered fish or mixed structures with simple geometric indexes is problematic. The second hypothesis relies on Peruvian anchovy particularities. When this fish becomes abundant it “fills space”, i.e., it occupies space through a continuum of spatial structures. This hypothesis was confirmed by a specific behavioural ecology cruise performed in November 2004. Using an integrated approach (echo-sounder, multibeam sonar, CTD probes, phyto and zooplankton sampling, stomach content analysis, birds and mammal observations) we could assess small scale interaction between fish and their environment *sensu lato*. Fish structure dynamics was incredibly high, with a single aggregation passing from a classic “school” to a fine layer or an “amorphous” structure in few seconds. This dynamic was related to the high predation pressure by sea lions but also the presence of thermal fronts and zooplankton patches across the diel cycle. It is therefore important to study in more detail the 2D - 3D relationships by routinely coupling echo-sounder and multibeam sonar analysis.

6.2.2 Discussion

Echo-trace classification has been used extensively for species identification, and behavioural studies of fish and zooplankton. It was reported that although it is fairly easy to conduct an empirical classification by eye, it is difficult to do this in an automated way. It was felt that further advances in echo classification may be made by integrating other sources of information such as frequency-dependent scattering responses and environmental information in classification analyses.

6.3 Topic 3: Methods for integrating multi-disciplinary data to elucidate forcing functions of fish abundance and behaviour

6.3.1 F. Gerlotto[1], S. Bertrand[1], N. Bez[1], and M. Gutiérrez[2]. Methods for analyzing dynamics of pelagic fish school morphology and structure as observed by multibeam sonar: the case of anchovy under predation in Peru

[1]*IRD, Centre de Recherches Halieutiques Méditerranéennes et Tropicales, Avenue Jean-Monnet, 34203 Sète, France. francois.gerlotto@ird.fr. sophie.bertrand@ird.fr, nicolas.bez@ifremer.fr.* [2]*Instituto del mar del Perú (IMARPE) - Gamarra y General Valle s/n Chucuito, La Punta Callao, Perú. mgutierrez@imarpe.gob.pe.*

Fish school is the first organisation level where individuals become able to react to environmental patterns. As such a school adapts permanently its shape (morphology) and internal structure according to local changes. This high variability in space and time has impacts on fishing and acoustic survey results. Multibeam sonar gives relevant information in space and time allowing such research, but analysis methods are needed for extracting patterns from this dynamics. We studied in Peru the case of anchovy schools, under phases of free organisation with well identified and stable schools and phases of strong predation by sea lions. These schools were in an extreme level of agitation, and theirs changes in external morphology and internal structure occurred in a few seconds. We present results from two analysis methods, in order to study two phenomena. *School edge characteristics*. They are the place where building and collapse of schools should be observed. The fractal dimension of school perimeters is used as indicator of changes in time of the school morphology. *Internal structure variations*. Multibeam sonar images can record agitation waves which can be considered as communication among individuals inside schools. These waves induce a very fast change in the internal school structure. Variograms calculated on a series of 2-D successive school images recorded each 3.5 seconds allow a description of these changes in time and space. Communication within a school can be faster than 7 m/s over a distance of 100 m.

6.3.2 S. Bertrand[1], M. Gutiérrez[2], G. Swartzman[3], and E. Díaz[2]. Methods for integrating data from fisheries and acoustic surveys in a spatial predator-prey approach to fisheries

[1]IRD - Centre de Recherche Halieutique Méditerranéenne et Tropicale, avenue Jean Monnet – 34203 Sète Cedex, France. sophie.bertrand@ird.fr. [2]Instituto del mar del Perú (IMARPE) - Gamarra y General Valle s/n Chucuito, La Punta Callao, Perú. mgutierrez@imarpe.gob.pe, ediaz@imarpe.gob.pe. [3]University of Washington, School of Fisheries, Box 355640, Seattle, WA 98195, USA. gordie@apl.washington.edu

Behavioural relationships between fish and fishers are a key issue for fish population dynamics studies, especially for ecosystem based management of fisheries. A predator-prey framework can be chosen for studying these interactions as we demonstrated in another work where we compared fishers' spatial behaviour to natural predators'. Predator-prey relationships are known to consist of a variety of interactions across scales. To analyze these interactions we need to define meaningful indicators which take into account interaction processes over a continuum of scales. For the Peruvian anchovy fishery observers at sea and satellite Vessel Monitoring System provided complementary information on fisher's behaviour. Several CPUE indexes were analyzed and one "multi-scales" index of sinuosity of spatial behaviour of vessels was developed. Regular scientific acoustic surveys performed by IMARPE provided accurate data on anchovy distribution over a wide range of scales. We used 3 indexes based on acoustic data to characterize fish distribution over a continuum of scales: 1) an index of spatial concentration, 2) the fractal dimension of the anchovy distribution and 3) a clustering index based on the point processes Ripley's K function. These indexes were shown to be relevant as they gave evidence of connections between fish and fishers spatial behaviours over a wide range of spatial scales.

6.3.3 G. Boyra, P. Alvarez, U. Cotano, and A. Uriarte. Acoustic campaigns for anchovy juveniles in the Bay of Biscay

Marine Research Division, AZTI Foundation, Herrera Kaia, Portualdea z/g, 20110 Pasaia, Spain. gboyra@pas.azti.es

The project JUVENA aims to estimate the abundance of juvenile anchovies and their growth condition at the end of the summer in a sampled portion of the Bay of Biscay bounded at 5º W and 46º N. The long term objective of the project is to assess the recruitment to the fishery the following year. The annual surveys include 38 and 120 kHz echosounders for mapping fish dispersion and abundance; purse seine hauls for biological sampling and species identification; and continuous sea-surface temperature and salinity measurements plus CTD casts for characterization of the physical oceanographic habitat. Presented are results from the first two annual surveys in 2003 and 2004, and a comparison to the results of the 1998 and 1999 surveys of project JUVESU (FAIR CT 97–3374). Also discussed are some difficulties to achieving of the program objectives that were detected during the two first two JUVENA surveys.

6.3.4 A. Orlowski. Examples of integrating acoustic and environmental data for fish behaviour studies in the Baltic

Sea Fisheries Institute, ul. Kollataja 1, 81–332 Gdynia, Poland. orlov@mir.gdynia.pl

Calibrated acoustic data, collected during systematic surveys for each elementary distance unit (ESDU) in standardized depth intervals were compared to values of selected environmental parameters, estimated parallel. The comparisons were made for different spatial and time structure. The presentation illustrates how different standards of comparisons can improve recognition of inter-correlation among the time and spatial gradients among fish distribution and environment characteristics. Selected examples collected for the Baltic Sea are shown and discussed. They show dependence of vertical and horizontal fish (herring, sprat, cod) distribution on temperature, salinity, oxygen level, and seabed type in relation to seasonal and diel periods. Particular attention was given to dependence of local fish biomass density on temperature structure of the Baltic.

6.3.5 Discussion

Underscored was the importance of environmental conditions influencing fish distribution, behaviour, and the activity of fishing fleets. For example, as environmental conditions influence fish dispersion, the appropriate timing of surveys requires knowledge this abiotic-biotic relationship. Improved understanding of environmental effects on fish distribution will therefore facilitate improved survey designs and reduce the uncertainty in the resulting biomass estimates. Information from sources such as fishing fleets, and retrospective analyses can be used for this purpose. More generally useful is the 4-D characterization of aquatic ecosystems via the integration of acoustic and environmental data; one such analysis was presented in 6.3.4.

Also discussed were advances in techniques for studying fish behaviour. New methods were presented for the use of sonars to observe behaviours of fish schools. Comparisons of the variance structure of sonar images before, during, and after school reactions to predation events allowed quantification of changes in behaviour. Analysis of the fractal dimension of the school edge was suggested as a method to study behavioural changes at school boundaries, which is where school reactions are most likely to occur. These methods may be appropriate to evaluate the speed at which reactions propagate through a school. Preliminary measurements indicate that reactions of anchovy to sea lions propagate within schools at speeds of 10–20 knots.

New methods were discussed for relating fish spatial distribution and behaviour to that of the fishing fleet. Integration of measures of fish abundance and fishing vessel behaviour allowed description of fishing behaviour based on spatial scale, fish biomass, and patchiness. The scale of vessel sinuosity is related to the scale of fish patchiness, and it was thus suggested that analysis of fishing vessel tracks may provide an indicator of fish aggregation and distribution.

6.4 Topic 4: Review and discuss the report of Annual Meeting of Assessment Working Group Chairs (AMAWGC) of the Advisory Committee for Fisheries Management (ACFM) and the Working Group for Regional Ecosystem Description (WGRED) of the Advi-

sory Committee on Ecosystems (ACE); and the role of WGFTFB/WGFAST/FTC in the implementation of fisheries/ecosystem advice by ACFM and ACE

6.4.1 N. Graham. Recent changes within ICES and the role FTC in the advisory process

ICES is undergoing a transition to an ecosystem approach to fisheries management. The process is currently at an early stage. The focus of management is regional rather than a single stock, and requires a view of fish management and removal in a wider ecosystem context. This requirement has led to an increased number of requests for management advice to the working group, and it has encouraged WGFTFB members to contribute to management tools such as mesh regulations and by-catch mitigation.

FTC has been active in integrating WGFTFB into the ICES advisory process, as a number of areas require expert advice from WGFTFB. Formal and informal discussions on approaches and methods are needed for working groups to implement this new approach and meet the needs of managers. There is a need for better communication between the working groups and assessment working groups, and FTFB needs to be better represented in stock assessment working groups. Two working groups are particularly relevant to this goal: survey gears (SGSTS), which will seek more information on catchability and changes in gear, and unaccounted mortality (SGUFM), which will meet from 2005 onwards, and aims to develop and produce indices that can be used in assessments.

6.4.2 D. Reid. Report on the WGRED

WGRED is a newly established working group established to work on regional ecosystem description in support of the ecosystem approach to fisheries management. The aims of the working group are to consolidate an overall template for integrated ecosystem-scale information for ICES eco-regions in the North Atlantic, based on scientific information. Primary topics include seabed topography and substrates, oceanography, plankton biology, benthic organisms, fish, birds and mammals, and major environmental and fishery influences on ecosystem dynamics. The potential contributions of members of FTC to WGRED should emphasise fish abundance estimation. Major themes included quantification of catch, by-catch, discard rates, and effects of changes in fishing gear. This will require an increased understanding of survey gear selectivity, integration of survey methods, and integration of fishing vessels as survey tools.

6.4.3 D.A. Demer. Report on the WGFAST

The activities of WGFAST were reviewed, particularly those related to measurement and analysis technologies for ecosystem-based fisheries management. Recommended is a review of the multi-national ecosystem monitoring program in FAO area 48 (Scotia Sea), and the substantial progress made towards definition and implementation of ecosystem-based fisheries management strategies over the last two decades by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). A principal requirement of ecosystem-based fisheries management is the need for statistical characterization of *change* in marine systems. The first step to observing change in a system is the quantification of systematic and random components of error in measurements of the ecosystem.

6.4.4 P. Fréon[1] and A. Lebourges-Dhaussy[2]. The EUR-OCEANS European Network and possible links with FAST and FTFB

[1]Institut de Recherche pour le Développement, CRH, Avenue Jean Monet, 34203 Sète, France. pfreon@ird.fr. [2]Institut de Recherche pour le Développement, Centre IRD de Bretagne, BP 70 - 29280 Plouzané, France. Anne.Lebourges.Dhaussy@ifremer.fr

The overall objective of European Network of Excellence EUR-OCEANS (2005–2008) is to achieve lasting integration of European research organisations on *global change and pelagic marine ecosystems*. Particular attention is given to development of models for assessing and forecasting the impacts of climate and anthropogenic forcing on food-web dynamics (structure, functioning, diversity and stability) of pelagic ecosystems on continental shelves.

EUR-OCEANS is organised around a Joint Programme of Activities (JPA) that comprises: (1) Integrating activities on networking, data, and model integration); (2) Jointly executed research, organised around four broad modelling tasks (together with observations and experiments) on pelagic ecosystems end-to-end, biogeochemistry, ecosystem approach to marine resources and within-system integration; (3) Activities to spread excellence, including training of researchers, and spreading excellence to socio-economic users and to the European public; (4) Management Activities.

The network present composition is: 69 Member Organisations from 25 states (including 7 Third countries) and 160 PIs that serve as focal points. Close cooperation with the USA, Australia, Canada, Japan, and Namibia is expected. The total budget is 40 M€ (30 M€ from Members and 10 M€ from the EU).

FAST and FTFB can contribute to and benefit from EUR-OCEANS in the following activities: 1) integrated view of marine ecosystems by the combined use of up-to-date survey methodologies on plankton-acoustic, fish-acoustic and trawl sampling; 2) improved understanding of pelagic ecosystem dynamics, from plankton to fish; 3) model parameterisation; 4) technical solution/innovation for an ecosystem approach to fisheries through fishing technology that are more selective and more respectful of the environment.

6.4.5 R. Kloser and R. Coggan. Acoustic Seabed Classification- Applications in fisheries science and ecosystem studies. Report of Theme Session T. ICES ASC September 2004 - Vigo, Spain

[1]CSIRO Marine and Atmospheric Research, rudy.kloser@csiro.au.

There is now a growing interest in developing marine habitat classifications that are biologically relevant (e.g., marine bioregionalisation, assessing essential fisheries habitat, marine protected areas and environmental monitoring). The degree to which the hydro-acoustics remote sensing survey approach can be applied to these needs is under constant review within several ICES working groups under three committees (Living Resources (LRC), Marine Habitat (MHC) and Fisheries Technology (FTC)) addressing the following ICES objectives within the strategic plan:

- • Test the validity of the proposed EUNIS classification by producing habitat maps based on physical and biological field samples [MHC].
- • Develop relationships between habitat characteristics and biological assemblages [LRC/MHC].
- • Establish a framework to evaluate acoustic seabed classification technology and applications in bottom mapping [FTC/MHC].

The presentations at the session covered a large range of applications as indicated by the use of basic bathymetry collected by fishing vessels to assist in developing deepwater habitat characterisation for Patagonian Toothfish in South Georgia in the southern ocean to mapping intertidal seagrass beds in Spain. A notable contribution addressed the management needs of habitat mapping at different spatial scales to manage a deep-water demersal fish (pink ling). It provided an example of the mapping needs at different spatial scales to specifically address different management goals (Williams *et al*. 2004). The paper provided a clear example where due to the highly targeted nature of fishing effort the sustainable management of the resource required spatial controls. Effective use of spatial controls in the fishery required a detailed assessment of the habitat at a variety of scales.

An overview of the session will be presented.

6.5 Discussion. Considering FTC's working and action plans, how should the WGFAST/WGFTFB Joint Session proceed?

The primary focus of discussion was the ICES pursuit of an ecosystem approach to fisheries management and how WGFAST and WFTFB can best support this endeavour. Additionally discussed was the need for improved communication between stock assessment and the expertise in FTC.

Norman Graham, WGFTFB chair, reported that ICES is undergoing a transition to an ecosystem approach to fisheries management. The process is currently at an early stage, and the focus of management is regional rather than a single stock, and requires a view of fish management and removal in a wider ecosystem context. He noted that this requirement has led to an increased number of working group requests related to management advice, and encouraged WGFTFB members to contribute to management tools such as mesh regulations and bycatch mitigation.

FTC has been active in integrating WGFTFB into the ICES advisory process, as a number of areas require expert advice from WGFTFB. The Chair reported formal and informal discussions on approaches and methods needed for working groups to implement this new approach and meet the needs of managers. He identified a need for better communication between the working groups and assessment working groups, and discussed the need for FTFB to be better represented in stock assessment working groups. Two working groups were identified as particularly relevant to this goal: survey gears (SGSTS), which will seek more information on catchability and changes in gear, and unaccounted mortality (SGUFM), which will meet from 2005 onwards, and aims to develop and produce indices that can be used in assessments.

David Reid reported on WGRED, a newly established working group established to work on regional ecosystem description in support of the ecosystem approach to fisheries management. The aims of the working group are to consolidate an overall template for integrated ecosystem-scale information for ICES ecoregions in the North Atlantic, based on scientific information. Primary topics include seabed topography and substrates, oceanography, plankton biology, benthic organisms, fish, birds and mammals, and major environmental and fishery influences on ecosystem dynamics. The potential contributions of members of FTC to WGRED were discussed with an emphasis on fish abundance estimation. Major themes included quantification of catch, bycatch, and discard rates, effects of changes in fishing gear. This will require increased understanding of survey gear selectivity, and integration of survey methodologies, integration of fishing vessels as survey tools.

David Demer, WGFAST Chair, reviewed the activities of WGFAST, emphasizing importance of characterizing uncertainty in measurements of the ecosystem, and reviewed last year's meeting. He reported substantial process in measurement techniques, and progress is being made in integrating these measurements to understand to ecosystem functions. Major topics for the working group include avoidance of survey vessels, alternative platforms for data collection, methods for remote species identification, and integrating acoustic measurements into ecosystem assessments, and he recommended reviewing the efforts of other groups in this area.

There were repeated calls for wider dialogue and interaction between technologists in FTC and ecosystem modellers. A presentation of the EU Eur-Oceans European Network, and possible links with FAST and FTFB were explored. This project will integrate many data sources into ecosystem models, and is relevant to the transition towards ecosystem approach to fisheries management. Additionally, a review of a session at the annual science meeting revealed significant progress in the application of seabed classification and it's application in fisheries science and ecosystem studies.

Discussion of how the WGFAST/WGFTB joint session should proceed followed. It was recognized that analysis of optical data is an emerging challenge where the expertise of both groups overlap. The proposal of developing a joint workshop or joint study group on instrumentation and efficient analysis techniques for optical studies of fish behaviour, species identification, and habitat mapping was well received and supported as a link between the groups. There was substantial discussion on how to attract interest from those involved in ecosystem studies and habitat assessment outside of FTC.

WGFAST and WGFTFB jointly recommend that a Task Force be formed, lead by David Somerton, USA, to evaluate the state-of-the-art in optical imaging and analysis technologies, define the ICES community's requirements for additional optical technology, and draft the terms of reference for a potential Study Group.

7 Topic 4 "Target strength"

7.1 J.K. Horne. Acoustic ontogeny of teleost fish: Donaldson trout (*Oncorhynchus mykiss*)

School of Aquatic and Fishery Sciences, University of Washington, Box 355020 Seattle, WA 98195–020, USA. jhorne@u.washington.edu

Changes in shape and size of swimbladder and body determine backscatter intensities from fish. Acoustic sizes to fish length conversions typically use length frequencies from net catches. How does ontogeny of individual fish influence the intensity and variability of acoustic backscatter? A group of 35 Donaldson trout (rainbow-steelhead hybrid) were tagged with passive integrated transponder (i.e., PIT) tags and radiographed at roughly biweekly intervals during an eight month grow-out period (October 2001 through May 2002). Twenty-four of the 35 fish that were initially tagged survived the 16 rounds of radiographs. Fish growth was linear in length and quadratic in weight. Dorsal swimbladder area increased exponentially with fish length. Allometric growth ratio (i.e., k) values of swimbladder length linearly increased with fish body length. Average swimbladder volumes occupied 3–6% of fish body volume and increased exponentially with fish length. Maximum mean target strength shifted from approximately 80^{o} to 86^{o} through the experimental period indicating a mean shift in swimbladder angle. Mean predicted acoustic backscatter increased at both 38 kHz and 120 kHz as average fish length increased. Target strengths at 38 kHz significantly exceeded those at 120 kHz at fish lengths less than approximately 150 mm. Mean target strengths at 120 kHz exceeded those at 38 kHz at lengths greater than approximately 280 mm and were more variable. Choice of fish length and model length range influences predicted backscatter intensities.

7.2 L. Calise[1&2], T. Knutsen[2], and W. Melle[2]. Direct acoustics measurements of free-swimming krill. Are we going in the right direction?

[1]Department of Physics and Technology, University of Bergen, Allégt. 55, N-5007 Bergen, Norway. calise@ift.uib.no. [2]Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway. tor.knutsen@imr.no, webjorn.melle@imr.no

During the last ten years a large effort has been undertaken to improve zooplankton theoretical scattering models in general on krill shaped animals/compositions. However, few direct acoustics measurements on free swimming individuals, both *in situ* or from experimental tanks have been performed and/or data published. These measurements might be of variable quality because of the difficulties to discriminate multispecies and multitargets scattering *in situ* or due to significant constraints in animal behaviour in small experimental tanks or enclosures.

To address the challenges outlined a novel experimental set up for direct multifrequency acoustic measurements of free-swimming northern krill (*Meganyctiphanes norvegica*) in a larger but limited volume under highly monitored condition (so called mesocosm) is described. The effectiveness of the Simrad EK60 scientific echosounder pulsating at six frequencies; 38, 70, 120, 200, 364 and 710 kHz, with transducers mounted on a floating rig is evaluated and criticized. All transducers were new composite type, except for the 38 and 710 kHz, and 7° split beam transducers, except for 5° single beam at 710 kHz.

Measurements from a set of experimental exercises, including the response of krill to a manipulated artificial light regime, the vertical migration activity, as well as on individual tethered animals are described. Aspects of swimming behaviour through as well as trends in the Relative Frequency Responses are also discussed. The implications for developing a more accurate algorithm for multifrequency analysis of echosurvey data and its importance to the abundance estimation of northern krill are indicated.

7.3 G. Pedersen and E. Ona. Target strength measurements of Norwegian spring spawning herring using an acoustic buoy

Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway. geir.pedersen@imr.no

In situ target strength measurements of wintering spring spawning herring in Vestfjorden in northern Norway were conducted using the Bergen Acoustic Buoy. This is a free-floating buoy equipped with a Simrad EK60 split-beam echo sounder operating at 38 kHz. The buoy was released from the RV "*G.O. Sars*" and drifted without any interference from the research vessel, thus eliminating any influence of vessel noise. Continuous acoustic measurements of the undisturbed layers of herring were performed over two days. The main goal of this work is to verify previous experiments by using an acoustic buoy that measures target strength of herring in an undisturbed state.

7.4 M.J. Henderson[1], J.K. Horne[1&2], and R.H. Towler[2]. Influences of fish orientation on target strength: it's not just tilt

[1]School of Aquatic and Fishery Sciences, University of Washington, P.O. Box 355020, Seattle, Washington 98195 USA. mhender@u.washington.edu, jhorne@u.washington.edu. [2]NOAA Fisheries, Alaska Fisheries Science Center, 7600 Sand Point Way NE Bldg. 4, Seattle, Washington 98115 USA. john.horne@noaa.gov, rick.towler@noaa.gov

Fish orientation, usually defined as tilt and possibly roll, is always listed as a major influence on fish target strength (TS). Effects of swimming direction (yaw) in combination with beam position on TS have rarely been examined. We combined 38 kHz target tracking data with backscatter model predictions to estimate the influence of yaw and distance-off-axis on Pacific hake (*Merluccius productus*) TS. Length frequency data from trawl catches and tilt angles from target tracking were convolved with predicted backscatter to simulate TS frequency distributions. Tilt and yaw distribution functions were also manipulated independently to assess their influence on TS. Regression analysis of the *in situ* data showed that tilt, distance-off-axis, and the interaction of yaw and distance-off-axis significantly ($p<0.05$) influenced TS. At any yaw and constant tilt angles, modelling experiments showed that TS differences increased with increasing distance off axis. For a 44.4 cm fish at 0º tilt and 10 meters off axis, changes in yaw resulted in as much as a 10 dB difference in TS. Surprisingly, when these TS values are averaged over all yaws there was no significant difference (ANOVA, p».05) in TS for any tilt as distance-off-axis increases. While individual target strengths are influenced by yaw, dispersion yaw angles within a beam can average out this effect.

7.5 A. Pedersen, P. Lunde, and M. Vestrheim. Consequences of non-linear sound propagation on target strength measurements – preliminary studies

[1]Christian Michelsen Research AS, P.O.Box 6031 Postterminalen, N-5892 Bergen, Norway. Audun.Pedersen@cmr.no, Per.Lunde@cmr.no. [2]University of Bergen, Department of Physics and Technology, Allégaten 55, N-5007 Bergen, Norway. Magne.Vestrheim@ift.uib.no

In fisheries research echo sounders, the excess attenuation caused by non-linear sound propagation has been disregarded until recent years. When high output powers are used, this effect may be significant in target strength measurements. "Non-linear" loss depends on frequency, output power, range, angle off axis, and several parameters of the propagation medium. The "Bergen code" simulation tool, which solves the KZK equation by means of finite difference methods, is being employed to explore the possibility of calculating the non-linear loss and correcting echo sounder data. Measurements are made in fresh water and sea water for verification. Some preliminary results from these investigations, and possible consequences for target strength measurements, are presented.

7.6 L. Calise[1&2], R. Pedersen[2], A. Johansen[3], and F.R. Knudsen[3]. Pulse transmission time delay correction for short-range data acquired with EK60

[1]Department of Physics and Technology, University of Bergen, Allégt. 55, N-5007 Bergen, Norway. calise@ift.uib.no. [2]Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway. ronald.pedersen@imr.no. [3]SIMRAD A/S P.O. Box 111, N-3190 Horten, Norway. are.johansen@simrad.com, frank.reirer.knudsen@simrad.com

The previous generation of Simrad Scientific echosounder EK500 became a world-wide standard fisheries research tool, and the new EK60 is about to establish the same status. This new system generation has many new features to improve both the multifrequency echo sounder data acquisition and analysis as well TS measurement. Seven simultaneously transmitting frequencies, comparable sampling volumes with choice of 5 different pulse durations for each frequency, new calibration software, raw data recording and replaying, are some of the most significant new features. In particular, the strength and range assignment of a target in EK60 is improved by higher sampling rate, depending on the pulse duration, and the use of the "echo centre of gravity" method.

The new target recognition method improves the accuracy of the TS data but doesn't already correct the delay time error due to the bandwidth limitation of the transmitting and receiving process such as the not ideal rectangular transmitting pulse shape and band-pass filter of the receiver. The error could become serious overall in the TS measurements at short-ranges when the distance to the scatterer must be determinate accurately and a correct 40Log TVG applied. Preliminary results from tank measurements for a wide set of EK60 configurations are presented and discussed. Time delay errors recognized at the available pulse durations for the frequencies 38, 70, 120, 200, 364 and 710 kHz and related standard and new composite transducers are indicated. The necessity to incorporate a time delay in the range compensation function of the EK60 is discussed.

7.7 N. Gorska[1] and D. Chu[2]. Influence of echo interference on the acoustic abundance estimation of densely aggregated fish and zooplankton

[1]Institute of Oceanology of Polish Academy of Sciences, ul. Powstancow, Warszawy 55, PL-81–712 Sopot, Poland. gorska@iopan.gda.pl. [2]Woods Hole Oceanographic Institution, Woods Hole, MA 0254 USA. dchu@whoi.edu

The main motivation of the paper was to understand the conditions under which the echo interference may affect the abundance and/or biomass estimation in fisheries and zooplankton acoustics significantly. Understanding of the echo interference in acoustic backscattering by randomly distributed and densely aggregated targets were improved on the basis of the presented analysis. Our approach included the analytical study and the Monte Carlo simulations of acoustic backscattering subject to three-dimensional distributions of marine targets involving the realistic signals from commercial echosounders. Echo interference was analyzed over a wide range of frequencies, for different pulse shapes and directivity patterns of the acoustic systems, and for various spatial distributions of the targets of different densities. The influence of the difference in target strength of fish or zooplankton was also considered. It is found that for the targets that are uniformly distributed within the sampling volume, the impact of echo interference on the observed volume backscattering strength (Sv) strongly depends on the product of the acoustic frequency and pulse duration, target abundance in sampling volume, and the degree of tapering of the transmitted pulses. The numerical example of abundance estimation of marine organisms is presented. It is demonstrated that even for very large densities of krill aggregations, the influence from echo interference can be compensated with a moderate tapering of the transmitted pulse.

7.8 N. Diner, L. Berger, and V. Mazauric. Single-beam simulation by OASIS soft: an essential way in interpreting shoal echo-traces

IFREMER Centre de Brest, B.P. 70, 29280 Plouzané Cedex, France. noel.diner@ifremer.fr, laurent.berger@ifremer.fr, valerie.mazauric@ifremer.fr

The OASIS software (presented at WGFAST in Gdynia), has been updated for simulation of single beam vertical echo-sounders operating at different frequencies. Very realistic echo-traces can be logged into files in HAC format, allowing data processing with fishery echo-sounder software like MOVIES. For multi-frequency purposes, transducers can be modelised at different locations with variable directivities, and generated files are calculated simultaneously. A series of simulations has been conducted on shoals with different densities and dimensions at various depths. Targets were placed outside and on vessel route, and vessel movements (roll and pitch) are also included. Processing implemented on these data provide interesting information concerning for example variability in shoal energetic parameters. This kind of study seems to be essential for the interpretation of shoal echo-traces in a multifrequency approach.

7.9 R. Kloser[1] and G. Macaulay[2]. Target strength and species identification in the Australian blue grenadier fishery (*Macruronus novaezelandiae*)

[1]CSIRO Marine and Atmospheric Research rudy.kloser@csiro.au; [2]NIWA, g.macaulay@niwa.co.nz

An industry based acoustic method is currently being developed to monitor the spawning population of blue grenadier **(***Macruronus novaezelandiae).* Critical to the application and interpretation of the collected acoustic data is an accurate estimate of target strength and species identification. Species identification is being achieved using both industry vessel trawling, school behaviour and multi-frequency methods. Initial target strength estimates have been based on *in situ* and modelling methods with *in situ* values varying by more than 10 dB for an 80 cm mean total length fish. Resolving this large range of *in situ* target strength estimates requires an investigation of the historic data, models of fish backscatter based on swimbladder volume and new *in situ* data collections. The large range in *in situ* TS data may be due to fish orientation, depth, composition and target identification with the appropriate length or weight. We outline our initial investigations and the steps to either resolve the large *in situ* TS range or propose a strategy to interpret the industry acoustic data acknowledging that there may be uncertainty.

7.10 Discussion

Discussed were a diversity of developments related to the study of target strength (TS) modelling and measurements. Presentations ranged from theoretical studies, experiments in controlled situations, and direct field measurements.

One area of discussion was the influence of fish growth and orientation on TS. Age-dependent changes in fish TS were explored using models solved with measures from repeated radiographs of individual fish. Age-dependent changes in morphology increased variability in fish TS when it is modelled at lengths other than the sizes on which morphological parameters are based. Consideration of the allometric growth of relevant body parts may allow more accurate extrapolation of TS models. The importance of change in fish orientation was also highlighted. Although it is widely recognized that tilt is a major influence on TS, it was pointed out that other components of orientation such as roll and yaw can influence TS. Moreover, it was shown that there may be substantial differences in body weight at length for fish from different regions, which may result in different swim bladder volumes for a given length. This underscores the importance of caution when using the conventional TS-length relations over a wide range of fish lengths, as other factors such as weight may be dominant.

A series of simulations were used to explore aspects of echosounder performance. The influence of distortion of sound due to non-linear propagation on TS measurements was considered. Non-linear effects increase with power levels, frequency, and decreasing pressure at the transducer face. They influence the beam pattern and range dependent losses. During a sphere calibration, these effects will be compensated for the range and location in the beam where the target sphere is places. Corrections are required elsewhere. The understanding of non-linear effects, simulations and measurements will serve to minimise and if necessary provide corrections of echosounder measurements. Numerical simulations of echo interference from multiple targets were presented. Effects can be substantial for a nearly square transmit pulse, but are mitigated by the rounded pulse that is typically transmitted into the water. Furthermore, the pulse transmission delay for the EK60 echosounder delay was measured in a calibration facility. It was observed that composite transducers may minimize range delay. Range delay corrections will be most important for calibration and TS measurements at short ranges. The echosounder manufacturer intends to use these measurements as a basis to correct for range delay effects in software.

The relationship between echo trace observations and the true shape of schools was explored using new techniques, which incorporate the directivities of echosounders, and school characteristics to generate simulated data. Analysis of this simulated data allows for sensitivity analysis and improved understanding of the bias and errors in echo trace classification and multifrequency methods.

To investigate if and how the presence of a research vessel affects TS, a buoy-mounted echosounder was used to make TS measurements of undisturbed herring. Results were consistent with previous in-situ TS measurements from a survey vessel. A bimodal TS distribution was observed, as is common in herring, but the cause was debated. Possible explanations included the artefacts of side-lobes, the directivity pattern of herring backscatter coupled with their distribution of orientation, inaccurate species identification, and multiple scatterers being misinterpreted as individuals.

8 Review of the Reports of the Study and Planning Groups

8.1 Study Group on Acoustic Seabed Classification (SGASC)

The Study Group on Acoustic Seabed Classification (SGASC) met at the FAO from 23–24 April 2005. John Anderson (Canada) was Chair of the meeting, and William Michaels (USA) was Rapporteur. There were 21 participants from seven countries and representatives from four industry groups. Members of the study group had worked by correspondence during the previous year drafting chapters for a proposed ICES Cooperative Research Report (CRR). These chapters were structured as first and second order chapters, where the first order chapters (Chapters 1–5, ICES Fisheries Technology Committee, ICES CM 2004/B:03, Ref. ACE, E) were written initially to provide a background for writing the remaining chapters. During this period further revisions of the proposed CRR chapter structure occurred via correspondence. The draft versions of the chapters were presented and critically reviewed during the 2005 meeting of the study group. The first order chapters were considered to be complete in draft form while the second order chapters were well developed but still needed further work. The study group will continue to work by correspondence during the coming year to fully develop written versions of each chapter for the CRR.

The study group recommended that work continue via correspondence during the coming year. The study group recommended that a final meeting be held following the WGFAST 2006 meeting in Hobart, Tasmania. It was recommended that the final SGASC meeting be limited to participating authors to mitigate completion of the CRR. Anderson emphasized the high level of interest by members of WGMHM and it was recommended that Anderson maintain contact with Roger Cogan (UK). In particular, feedback from WGMHM would be requested pertaining to application of ASC products for marine habitat mapping issues now and in the future. The SGASC meeting in 2006 will provide an opportunity for authors to incorporate expected feedback from WGMHM in the final preparation and organization of the CRR.

The aim of this CRR is to review the state-of-the-art in Acoustic Seabed Classification (ASC). The report will provide an overview of the major issues and applications in this field and a comprehensive review of the technologies and techniques used to investigate these issues. Acoustic technology and classification science are rapidly evolving to meet the needs of nations to manage and conserve coastal resources. Consequently, this report must be seen as representing a snap-shot of the discipline at this point in time. The SGASC anticipates that new developments will occur regularly and that this subject must be revisited in the future. This CRR will describe our current understanding and will provide guidelines for the coordination of developments in this field.

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

SGAFV held its second annual meeting at the United Nations Food and Agriculture Organization (FAO) Headquarters in Rome, Italy, prior to the 2005 meetings of ICES FTC working groups, WGFAST and WGFTFB. The meeting was Chaired by Dr W. Karp (USA). Dr Guy Fleischer and Ms. Jessica Lipsky (USA) acted as Co-Rapporteurs. The Chair opened the meeting by thanking FAO 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 discussions from the 2004 meeting of the study group,
- Review recent developments in the field,
- Review and update draft report outline and content,
- Reach agreement on work to be completed before the next meeting of the Study Group,
- Recommend changes in the Terms of Reference if appropriate, and
- Identify major agenda items for the 2006 meeting of SGAFV.

The SGAFV Terms of Reference (ToRs) are:

- Review and evaluate recent and current research which involves collection of scientific acoustic data from commercial vessels (ToR a),
- 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 (ToR b), and
- Prepare background material, guidelines, methods and protocols for possible publication in the Cooperative Research Report series (ToR c).

The SG proceeded to address ToR a. The chair first provided an overview of presentations made on this subject during the 2003 meeting of WGFAST in Bergen Norway and the 2004 meeting of SGAFV. This was followed by 4 presentations by SG attendees:

- Richard O'Driscoll and Gavin Macaulay (New Zealand) - Using fish processing time to carry out acoustic surveys of hoki from commercial fishing vessels,
- Hector Peña *et al*. (Norway) – Using commercial fishing vessels to conduct acoustic surveys of capelin in the Barents Sea,
- Edwin Niklitschek (Chile) – Industry surveys of orange roughy off Chile, and
- Arnaud Bertrand (France) – Qualitative use of echograms beyond target organisms as support to the ecosystem approach.

Reviews of key sections of the final SGAFV report were then conducted. The discussion for each section was led by the lead section authors.

- Introduction (Martin Dorn, USA),
- Fishing vessel radiated noise concerns – (Ron Mitson, UK and John Dalen, Norway),
- Instrumentation and remote operation – (Richard O'Driscoll, New Zealand),

- Biological sampling – (Bill Karp, USA),
- Issues regarding cooperative research with industry – (Hector Peña, Norway),
- Study requirements – (Rudy Kloser, Australia), and
- Analysis, processing, and data management – (work on this chapter will be initiated following the meeting; lead author will be Gary Melvin, Canada).

SG members then agreed that:

- Senior authors will provide updated drafts of each chapter to the chair by 1 August 2005,
- The chair will collate and review all chapters for consistency and redistribute to the group of lead authors by October 2005 for final review, and
- A comprehensive updated draft will be distributed by the end of calendar year 2005.

After this discussion, SGAFV again reviewed the ToRs and recommended one minor change.

During its 2006 meeting, SGAFV will:

- Discuss recent developments in the field,
- Review the draft final report and resolve any areas of concern, and
- Reach agreement on a schedule and responsibilities for completion of the final report and submission to the ICES Secretariat for publication as a Cooperative Research Report.

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

The Study Group on Target Strength Estimation in the Baltic has worked in correspondence during 2004 and 2005. Additionally, there have been some informal meetings between the Chair and some of the members during the WGFAST meeting in Gdynia, Poland and the ICES ASC, in Vigo, Spain.

The SGTSEB aims to establish a TS-relation that explicitly accounts for the influences of fish length, water pressure (depth), and acoustic frequency. Until further knowledge has been obtained, account for the effects of fish tilt and condition, and geographic area on TS will be grouped into a constant term. The model will be based on available data from surveys in the area.

Activities 2004 – 2005:

- Tomas Didrikas and Thomas Axenroth at Stockholm University, Sweden, have sent a letter to scientists at the various institutions around the Baltic asking for available acoustic and ancillary fisheries data. They received datasets from Lithuania, Latvia, Russia, Germany, Sweden and Poland.
- Tomas Didrikas has converted the datasets from Lithuania, Latvia, Russia, Germany, Sweden, Poland to a common format analyze them according to a method described in a paper the ICES Journal of Marine Science in 2004.

Tomas Didrikas suggested two new TS-relations for Baltic herring based on calculations with data received from Latvia, Lithuania and Sweden:

$TS = 20*\log10L – 66.3$, and

$TS = 20*\log10L – 67.8$,

which are significantly higher than the previously used values of:

TS = 20*log10L – 71.2.

The work is summarized in a working paper delivered to the WGFAST meeting 2005. Terms accounting for the effects of water depth, acoustic frequency, fish tilt and condition, and geographic area are yet to be added.

Unsolved issues:

The Bo Lundgren, Chair of SGTSEB, has had increased workload associated with cruises in 2004 (planning, participation and reporting). Thus:

- not all of the datasets, mentioned above, were converted into a common format;
- a Danish dataset from March has only recently been made available in the common format; and
- a set of X-ray images of herring and sprat from two locations, delivered by Sweden, have also only been partly processed to obtain swimbladder shapes.

Terms of Reference 2006:

The Study Group of Target Strength Estimation in the Baltic Sea [SGTSEB] (Chair: B. Lundgren, Denmark) will work by correspondence in 2005 and 2006 to:

a) make a draft report available by 31 July 2006 for the attention of the Fisheries Technology Committee and the Baltic Committee; and

b) prepare a final report for possible publication in the ICES Cooperative Research Report series.

Activities planned for 2005–2006:

- Solve data compatibility problems and analyse the Danish dataset;
- Analyse the x-ray images of herring and sprat for swimbladder-contouring;
- Add terms to the TS model explicitly accounting for the effects of water depth, and acoustic frequency, and a constant term accounting for the combined effects of fish tilt and condition, and geographic area;
- update the literature search; and
- update and finalize the report.

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

The ICES Planning Group on the Common data exchange format (PGHAC) worked in correspondence since last PGHAC meeting as agreed 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 new collated HAC specification manual

e) review the development of tuples for multi-beam echosounders

The following main results have been achieved according to the terms of reference:

- **Item b) and d):**
  - the description of the “ICES HAC standard data exchange format version 1.6” document has been completed and reviewed
  - many changes have been made for clarifications and to ease implementation

- this final version will be published as an ICES Cooperative Research Report in the next months

- **Item a) and d):**

i) Small modifications have been made to multibeam tuples proposed in PGHAC04 according to the added flexibility offered during the development of the systems;

ii) These tuples will be soon stabilized and detailed in next PGHAC report (PGHAC06);

iii) These tuples will be dedicated to the new calibrated Simrad multibeam systems, and support of other existing multi-beams should be considered.

- **Item c:**
  - SIMRAD:
    - i) ER60 is exporting data into HAC files since version 2.1.0 (October 2004);
    - ii) This output has been tested by IFREMER and DFO;
    - iii) Remaining points are requested to Simrad and will be implemented in a next version of ER60.
  - MARPORT is studying the feasibility to output the data of their wireless net-sonde under development in HAC format.
  - BIOSONICS will output HAC format for their dtx systems at users request.

Despite the implementation problems encountered within SIMFAMI project, the HAC format has proven to be efficient for exchanging acoustic data.

With the production of a document and the experience gained in SIMFAMI, it will be much easier in the future.

The community has put a big effort in this format; it is now documented and handles all the data needed for proper interpretation with a file structure that avoids redundancy.

9 Recommendations

9.1 Terms of reference for 2006 WGFAST meeting

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

Recommendation: WGFAST recommends that the Working Group on Fisheries Acoustics Science and Technology (Chair: David A. Demer, USA) meets at CSIRO in Hobart, Tasmania, 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 epi-benthic, epi-pelagic and shallow water species;

iii) Acoustical species ID techniques for multi-species assessments, ecosystem studies, by-catch reduction, and objective and automated data processing;

iv) Instrumentation, survey design, and data analysis techniques for studying aquatic ecosystems, with special attention to the estimation and use of measurement uncertainty in statistical analyses of multi-variate time series, and techniques for integrating multi-disciplinary data to elucidate functional relationships; and

v) Target strength (modelling and measurements)

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).

Recommendation: WGFAST recommends a review of the ecosystem-based fisheries management strategies developed and employed over past decades by international communities such as CCAMLR. Accordingly, one or more keynote speakers from CCAMLR and or CSIRO will be invited for the 2006 meeting of the Working Group on Fisheries Acoustics Science and Technology.

Recommendation: WGFAST recommends that SGASC and SGTSEB both be extended for another year, retaining their current Chairmen, to complete their respective Cooperative Research Reports; and SGAFV and SGASC also meet in Hobart, on 25–26 March, and 31 March to 2 April, respectively.

9.2 Terms of reference for 2006 WGFAST-WGFTFB Joint Session

WGFAST and WGFTFB will not meet jointly in 2006.

9.3 Theme Sessions for the 2006 Annual Science Conference

In its continuing effort to contribute to the ICES Annual Science Conferences, WGFAST proposes the following three theme sessions for the 2006 Annual Science Conference (the first two were originally slated for the 2005 ASC, in Aberdeen).

Recommendation: Joint FTC-RMC Theme Session on "Quantifying, summarizing and integrating total uncertainty in fisheries resource surveys." Co-Conveners: David Demer, U.S.A.; and Stephen Smith, Canada. Fisheries management requires risk assessments and methods for quantitatively evaluating changes in a fish stocks or ecological systems. To evaluated risk and change, fisheries managers and scientists must be armed with a quantitative understanding of survey uncertainty that includes all the components of measurement and sampling error, both random and systematic. These errors must be incorporated into ecosystem analyses, and explicitly accounted for in stock assessment models and management advice.

In particular papers are invited on:

- Methods for quantifying and summarizing the systematic and random error in survey measurements and sampling;
- Techniques for summarizing these components of error into estimates of total survey error;
- Bayesian and other techniques for incorporating systematic and random survey error in stock assessment models;
- Detecting changes in a measurement data series which includes systematic and random error;
- Applications of statistical process control theory to fisheries management; and
- Strategies for managing fish stocks in the presence of measurement and sampling uncertainty.

Recommendation: Joint FTC/RMC Theme Session on "Technologies for monitoring fishing activities and observing catch." Co-Conveners: Bill Karp, USA, and Kjell Nedreaas, Norway. Independent collection of data at-sea is necessary to support a range of fishery-dependent information requirements associated with science, management, and compliance monitoring objectives. Traditionally, this type of information has been collected by trained fisheries observers but costs associated with deployment of observers are high, and some types of monitoring can now be carried out using electronic technologies and even when observers are on board vessels. Furthermore, observer efficiency may be improved through technological innovation, and some types of data are better collected by automated, self-contained electronic systems. Following collection of data by observers or electronic instruments, innovative application of database and communications technologies can be used to address data quality and timeliness needs, including provision of near real-time information for in-season accounting against quotas and information that can be made available to the fleet to help reduce by-catch. This theme session will focus on successful implementation of technologies in support of specific science, management, and compliance monitoring objectives, and evaluation of technological approaches that hold promise for addressing these types of objectives in the future. While we encourage all relevant contributions, those that address the following topics will be particularly welcome:

- Case studies and examples of electronic monitoring which integrate technologies to address specific objectives or demonstrate innovative applications of individual technologies
- Innovative approaches which hold future promise for addressing monitoring information needs, particularly those that bring new technologies to the attention of the community
- Systems for acquiring, integrating, managing and disseminating monitoring data
- Examples of monitoring innovation introduced by the fishing industry or through industry/government collaboration
- Addressing real-time information needs for in-season management, by-catch reduction, and other objectives
- Technologies that can be used by observers to improve data quality or the quantity and range of data collected
- Impediments to innovation - confidentiality, verification, reluctance (by industry or government), etc.
- Applications of technology for collecting ancillary scientific (physical, chemical, biological) information during fishing operations

Recommendation: Joint FTC/LRC Theme Session on "Spatio-temporal characteristics of fish populations and their environmental forcing functions as components of ecosystem-based assessments." Co-Conveners: François Gerlotto (France), and a representative from LRC. As the spatial structure of fish aggregations (school to population) and its dynamics can indicate adaptation to environmental conditions, characterization of this structure may provide information about stock status more efficiently and precisely than conventional indicators of catch and abundance. Contributions will be solicited on techniques for measuring and characterizing the distributions of fish aggregations, and relationships between their time-varying spatial structure and the associated environmental conditions, including exploitation activities.

9.4 2008 ICES Acoustics Symposium

Discussions on the "2008 ICES Acoustics Symposium on Fisheries Acoustics and Technology for Aquatic Ecosystem Investigations" resulted in the following recommendation.

Recommendation: WGFAST recommends that: an acoustics symposium is held at Grieg Hall, in Bergen, Norway in June 2008. Co-conveners are Egil Ona, Norway; Rudy Kloser, Australia; and David Demer, the United States of America. The scope and objectives of the Symposium were refined.

Scope: Ecosystem-based approaches to fisheries management require consideration of numerous biotic and abiotic factors of the aquatic environment using a variety of sampling equipment and analysis techniques. Data must be efficiently collected and integrated to enhance our understanding of relevant ecological processes and thus facilitate more effective management advice. Acoustical methods remain the primary remote-sensing tools for space-time-observations in the aquatic environment, but they continue to evolve with innovative implementations and augmentation with other mature and new technologies.

This Symposium is the premier forum for information exchange among fisheries acousticians, physicists, engineers, biologists, and ecologists. Provided is an invaluable opportunity for the international community to take stock of this rapidly evolving field, and thereby progress our knowledge of aquatic ecology, and its utility for improved fisheries management.

This will be the sixth Symposium on Fisheries acoustics and technology for aquatic ecosystem investigations sponsored by ICES. The others were held in Bergen, Norway in 1973 and 1982; in Seattle, USA in 1987; in Aberdeen, Scotland in 1995; and in Montpellier, France in 2002.

The 2008 Symposium will review and discuss the recent developments in methods and technologies applied to the characterization of marine and freshwater ecosystems for improving the effectiveness of fisheries management. Particular emphasis will be on technologies for measuring numerous aspects of the aquatic environment, and merging these data sets to elucidate functional ecological relationships. The contemporary challenges and future directions of these studies will be discussed. Papers reporting ongoing research, as well as those identifying areas for development are invited on the following themes:

Ecosystem monitoring:

- Observational strategies to meet ecosystem-based management needs;
- Platforms and technologies for observing ecological processes on important temporal- and spatial-scales. Some examples are instrumented small-craft, buoys, remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), gliders, and ocean observation systems;
- Instrumentation for continuous shipboard sampling of biological components of the sea-surface and the water column. Some examples include vertically oscillating towed-bodies, high-speed cast deployment systems, and egg pumps;
- Methods for observations of animals residing near a boundary. Examples are benthic, demersal, bentho-pelagic, epi-pelagic, and neritic species in fresh and saltwater environments; and
- Passive acoustical observations and assessments. Study of signals of aquatic animals to identify their presence, dispersion, species or biological states.

Remote classification and identification:

- Acoustical methods for multi-species assessments, by-catch reduction, and investigations of aquatic ecology. Examples are the use of low-frequency, multi-frequency, and broad bandwidth signals exploiting back, forward and total scatter, absorption, Doppler, and data integration;
- Acoustical and optical methods for studying phytoplankton, zooplankton, and micronekton; and

- Acoustical and optical methods for characterizing pelagic, demersal and benthic habitats;

Target strength:

- Modelling of target strength of fish, micronekton, and plankton;
- Measurement of target strength of fish, micronekton, and plankton; and
- New concepts and methods for target-strength measurement and the use of these data in ecosystem-based fisheries management. Particular attention will be paid to studies of target strength as a stochastic variable dependent upon morphological, behavioural, environmental, and observational factors.

Behaviour and assessments:

- Vessel-related stimuli for fish behaviour. Examples are the effects of sound, light, and motion on fish as related to observations of fish dispersion, abundance and behaviour. Also considered will be the use of artificial stimuli to control fish behaviour;
- Tagging and tracking technologies for studying aquatic animal behaviour and its impact on assessments; and
- Multi-dimensional measurements and data analysis techniques such as multibeam sonar methods and data analyses on 3-D and 4-D space and time scales. Of particular interest is the effect of fish behaviour on assessments;

Data quality and integration into ecosystem models:

- Estimation of uncertainty in net, acoustical and optical measurements of aquatic ecology. Particular consideration will be made for methods accounting for both random and systematic components in the sampling and measurement error. Some examples are the influences of survey design, stock boundary definition, net catchability and selectivity, echosounder calibration, acoustical species identification, and target strength estimation on the accuracy and precision of the survey results, and methods accounting for covariance of the individual error sources, such as Monte Carlo simulation and multi-frequency biomass estimation;
- Statistical evaluation of change and functional dependences in time-series data. Examples are multi-variate analyses using generalized additive models, stepwise regressions, Bayesian statistics, and statistical process control theory for elucidating ecologically significant functional relationships. Application of statistical tools appropriate for the often dependent data sets that characterise time series in ecological studies; and
- Predictive modelling of aquatic ecology. Particular consideration will be paid to techniques that support ecosystem-based fisheries management strategy such as an ecological basis for spatio-temporal management units.

10 Miscellaneous

For the 2007 Meeting of the WGFAST, offers have been extended by the Instituto de Fomento Pesquero (IFOP) in Valparaiso, Chile; and by François Gerlotto for Lima, Peru.

It was proposed that the 2008 meeting of the WGFAST be limited to a one-day business meeting, and that it be held in Bergen, Norway in concert with the “2008 Symposium on Fisheries Acoustics and Technology for Aquatic Ecosystem Investigations.”

11 Closure of meeting

On behalf of all members, the Chair thanked the local hosts at the Food and Agricultural Organisation of the United Nations, Rome, Italy; specifically Wilfried Thiele, Grimur Valdimarsson, Thomas Moth-Poulson, Christiane Lagrange, Mary Cullingan and the audio-visual and custodial staffs for their meticulous planning, generous hospitality, and comfortable and effective facilities.

John Horne, USA, was repeatedly thanked for his efforts to maintain the WGFAST web site.

The Chair led a round of applause for Alex De Robertis, USA, the Rapporteur, and Jessica Lipsky, USA, who assisted him as the Recorder.

The meeting was then closed.

Annex 1: List of participants

NAME	ADDRESS	PHONE/FAX	EMAIL
Lars Nonboe Andersen	Simrad, P.O. Box 111, 3191 Horten, Norway	+47 33034462	lars.nonboe.andersen@simrad.com
John Anderson	NW Atlantic Fisheries Centre, Dept. of Fisheris & Oceans, PO Box 5667, St. John's, Newfoundland, Canada A1C 5X1	+1 (709) 772–2116	AndersonJT@DFO-MPO.GC.CA
Laurent Berger	IFREMER, Centre de Brest, BP 70, F-29280 Plouzané, France	+33 2982247000	Laurent.Berger@ifremer.fr
Arnaud Bertrand	IRD-CRHMT, Avenue Jean Monnet, BP 171, 34203 Sète Cedex, France	+33 (4) 9957–3211	Arnuad.Bertrand@ird.fr
Sophie Bertrand	IRD-CRHMT, Avenue Jean Monnet, BP 171, 34203 Sète Cedex, France	+33 499573220	Sophie.Bertrand@ird.fr
Eckhard Bethke	Federal Research Centre for Fisheries, Institute for Fishery Technology and Fishery Economics, Palmaille 9, 22767 Hamburg, Germany	+49 (0)40 38905 203	eckhard.bethke@ifh.bfa-fisch.de
Nicolas Bez	IRD, Avenue Jean Monnet, BP 171, 34203 Sète Cedex, France	+33 (4) 9957–3204	nicolas.bez@ifremer.fr
Guillermo Boyra	AZTI Foundation, Herrera Kaia, Portualdea z/g, 20110 Pasaia, Spain	+34 943004800	gboyra@pas.azti.es
Andrew Brierley	Gatty Marine Laboratory, University of St. Andrews, Fife, KY16 8LB, Scotland	+44 1334463458	andrew.brierley@st-andrews.ac.uk
Lucio Calise	IMR, P.O. Box 1870 Nordnes, N-5817, Bergen, Norway		lucio.calise@imr.no
Dezhang Chu	Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA	+1 (508) 289–3318	dchu@whoi.edu
Jim Churnside	OAR/NOAA/ETL/ET2, 325 Broadway, Boulder, CO 80305, USA	+1 (303) 497–6744	James.H.Churnside@noaa.gov
Maurice Clarke	Marine Institute, GTP Parkmore, Galway, Ireland	00 353 91 780 381	Maurice.Clarke@Marine.ie
Jeff Condiotty	Simrad, Inc., Fisheries Research, 19210 33rd Ave West, Lynwood, WA 98036, USA	+1 (425) 778–8821	jeff.condiotty@simrad.com
John Dalen	IMR, P.O. Box 1870 Nordnes, N-5817, Bergen, Norway		john.dalen@imr.no
Alex De Robertis	NOAA/AFSC, 7600 Sand Point Way NE, Seattle, WA 98115, USA	+1 (206) 526–4789	Alex.DeRobertis@noaa.gov
David Demer	NOAA/SWFSC, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA	+1 (858) 546–5603	david.demer@noaa.gov
Skip Denny	Scientific Fishery Systems, Inc., 26268 Twelve Trees Ln. USA	+1 (360) 509–6727	skipscifish@earthlink.net
Orest Diachok	Poseidon Sound and APL/UW, 3272 Fox Mill Rd, Oakton, VA 22124, USA	+1 (703) 716–1241	OrestDia@aol.com
Noël Diner	IFREMER, Centre de Brest, BP 70, F-29280 Plouzané, France	+33 (2) 9822–4177	Noel.Diner@ifremer.fr
Ian Doonan	Marine Institute, GTP Parkmore, Galway, Ireland	00 353 91 773 900	ian.doonan@marine.ie
Martin Dorn	NOAA/AFSC, 7600 Sand Point Way NE, Seattle, WA 98115, USA	+1 (206) 526–6548	Martin.Dorn@noaa.gov

Kjell Eger	Simrad, P.O. Box 111, 3191 Horten, Norway	+47 33034483	kjell.eger@simrad.com
Paul Fernandes	Fisheries Research Services Marine Lab, PO Box 101, Victoria Road, Aberdeen AB11 9DB, Scotland	+44 1224295403	fernandespg@marlab.ac.uk
Guy Fleischer	NOAA/NWFSC, 2725 Montlake Blvd E., Seattle, WA, 98112, USA	+1 (206) 860–3289	Guy.Fleischer@noaa.gov
Pierre Fréon	IRD, Avenue Jean Monnet, BP 171, 34203 Sète Cedex, France	+33 (4) 9957–3202	Pierre.Freon@ird.fr
François Gerlotto	IRD, Avenue Jean Monnet, BP 171, 34203 Sète Cedex, France	+33 (4) 9957–3205	Francois.Gerlotto@ird.fr
Olav Rune Godø	IMR, P.O. Box 1870 Nordnes, N-5817, Bergen, Norway		
Natalia Gorska	Institute of Oceanology PAS, Powstancow Warszawy 55, 81–712 Sopot, Poland	+48 (58) 551–7281	gorska@iopan.gda.pl
Cathy Goss	British Antarctic Survey, Madingley Road, Cambridge CB3 0ET, England		cg@bas.ac.uk
Eberhard Götze	Federal Research Centre for Fisheries, Institute for Fishery Technology and Fishery Economics, Palmaille 9, 22767 Hamburg, Germany	+49 (0) 40 38905 202	eberhrad.goetze@ifh.bfa-fisch.de
Nils Olav Handegard	IMR, P.O. Box 1870 Nordnes, N-5817, Bergen, Norway	+47 55238500	nils.olav.handegard@imr.no
Ian Higginbottom	Sonardata, GPO Box 1387, Hobart, Tasmania 7001, Australina	+61 (3) 6231–5588	ian@sonardata.com
John Horne	University of Washington, School of Aquatic & Fisheries Sciences, Box 355020, Seattle, WA 98195–5020, USA	+1 (206) 526–4618	John.Horne@noaa.gov
John Hotaling	NOAA/NMFS/ S/T, Suite 12506 1315 East-West Highway, Silver Spring, MD 20910, USA	+1 (301) 713–2369	John.Hotaling@noaa.gov
Magalena Iglesias	Spanish Institute of Oceanography (IEO), Spain	+34 971401561	magdalena.iglesias@bo.ieo.es
Valery Ignashkin	PNIRO, 6 Knipovich Street, Murmansk, 183763, Russia	+(8152) 473582	ign@pinro.ru
Michael Jech	NOAA/NEFSC, 166 Water Street, Woods Hole, MA 02543–1026, USA	+1 (508) 495–2353	michael.jech@noaa.gov
Roar Joergensen	Centre of Marine Resource Management, Norwegian College of Fishery Science, University of Tromsø, 9037 Tromsø, Norway	+47 95220836	roar@nfh.uit.no
Bill Karp	NOAA/AFSC, 7600 Sand Point Way NE, Seattle, WA 98115, USA	+1 (206) 526–4194	bill.karp@noaa.gov
Svetlana Kasatkina	AtlantNIRO, 5,Dmitry Donskogo Street, 236000 Kaliningrad, Russia	+7 (0112) 225–769	ks@atlant.baltnet.ru
Robert Kieser	Department of Fisheries and Oceans, 3190 Hammond Bay Road, Nanaimo, BC, V9T 6N7, Canada	+1 (250) 756–7181	kieserr@pac.dfo-mpo.gc.ca
Rudy Kloser	CSIRO Marine Research, P.O. Box 1538, Hobart, Tasmania 7001, Australia	+61 (3) 6232–5222	rudy.kloser@csiro.au
Hans P. Knudsen	IMR, P.O. Box 1870 Nordnes, N-5817, Bergen, Norway		hans.knudsen@imr.no
Frank Reier Knudsen	Simrad, P.O. Box 111, 3191 Horten, Norway	+47 3303425	frank.reier.kundsen@simrad.com

Chris Lang	Dept. of Fisheries & Oceans, PO Box 5667, St. John's, Newfoundland, A1C 5X1, Canada	+1 (709) 772–4952	LangCh@dfo-mpo.gc.ca
Niklas Larson	National Board of Fisheries Institute of Marine Research, P.O. Box 4, SE 453 21 Lysekil, Sweden	+46 523 18773	niklas.larson@fiskeriverket.se
Anne Lebourges-Dhaussy	IRD, Centre de Brest, BP 70, F-29280 Plouzané, France	+33 (2) 9822–4505	Anne.Lebourges.Dhaussy@ird.fr
Jessica Lipsky	NOAA/SWFSC, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA	+1 (858) 546–5600	jessica.lipsky@noaa.gov
Bo Lundgren	Danish Institute for Fisheries Research, North Sea Centre, P.O. Box 101, 9850 Hirtshals, Denmark	+45 33963200	bl@difres.dk
David MacLennan	Fisheries Research Services Marine Lab, P.O. Box 101, Victoria Road, Aberdeen AB11 9DB, Scotland	+44 1224 295360	MacLennan22@aol.com
Suzanne Maxwell	Alaska Dept. of Fish and Game, 43961 K-Beach Road, Suite B, Soldotna, Alaska 99669, USA	+1 (907) 260–2914	suzanne_maxwell@fishgame.state.ak.us
Valerie Mazauric	IFREMER, Centre de Brest, BP 70, F-29280 Plouzané, France	+33 (2) 9822–4986	Valerie.Mazauric@ifremer.fr
Ian McQuinn	Fisheries & Oceans Canada, Institut Maurice-Lamontagne 850, route de la Mer, C.P. 1000, Mont-Joli, Québec G5H 3Z4, Canada		McQuinnI@dfo-mpo.gc.ca
Gary Melvin	New Zealand Seafood Council, New Zealand	+64 (4) 385–4005	melving@seafood.co.nz
Bill Michaels	NOAA/NEFSC, 166 Water Street, Woods Hole, MA 02543–1026, USA	+1 (508) 495–2259	william.michaels@noaa.gov
Ron Mitson	Acoustec, Swiss Cottage 5 Gunton Ave, Lowestoft, Suffolk NR32 5DA, England	+44 1502730274	acoustec@acoustec.co.uk
Gala Moreno	AZTI Foundation, Herrera Kaia, Portualdea z/g, 20110 Pasaia, Spain		gmoreno@suk.azti.es
Ciaran O'Donnell	Marine Institute, GTP Parkmore, Galway, Ireland	00 353 91 730 494	ciaran.odonnell@marine.ie
Richard O'Driscoll	NIWA, Private Bag, 14–901 Kilbirnie, Wellington, New Zealand	+64 (4) 386–0300	r.odriscoll@niwa.co.nz
Kjell Kr Olsen	Centre of Marine Resource Management, Norwegian College of Fishery Science, University of Tromsø, 9037 Tromsø, Norway		Kjell.Olsen@nfh.uit.no
Egil Ona	IMR, P.O. Box 1870 Nordnes, N-5817, Bergen, Norway		
Andrzej Orlowski	Sea Fisheries Institute, ul. Kollataja 1, PL-81–332 Gdynia, Poland	+48 586201728	orlov@mir.gdynia.pl
Graham Patchell	Sealord Group, Resource Manager, New Zealand	+64 (3) 545–9538	gjp@sealord.co.nz
Ruben Patel	IMR, P.O. Box 1870 Nordnes, N-5817, Bergen, Norway	+47 55238618	ruben@imr.no
Audun Pedersen	Christian Michelsen Research AS Industrial Instrumentation, P.O. Box 6031 Postterminalen, N-5892 Bergen, Norway	+47 55574297	Audun.Pedersen@cmr.no
Geir Pedersen	IMR, P.O. Box 1870 Nordnes, N-5817, Bergen, Norway		geir.pedersen@imr.no

Hector Peña	IMR, P.O. Box 1870 Nordnes, N-5817, Bergen, Norway	+47 55235375	hector.pena@imr.no
Severina Regina	AtlantNIRO, 5,Dmitry Donskogo Street, 236000 Kaliningrad, Russia		
David Reid	Fisheries Research Services Marine Lab, P.O. Box 101, Victoria Road, Aberdeen AB11 9DB, Scotland	+44 1224295363	reiddg@marlab.ac.uk
Shale Rosen	Gulf of Maine Research Institute, 300 Commercial St., Portland, ME 04101, USA	+1 (207) 228–1635	srosen@gmri.org
Vladimir Severin	AtlantNIRO, 5,Dmitry Donskogo Street, 236000 Kaliningrad, Russia	+7 (0112) 225485	sever@gazinter.net
Yvan Simard	University of Quebec at Rimoush & Fisheries and Oceans, 310 Allée des Ursulines Rimouski, Quebec G5L 3A1, Canada	+1 (418) 723–1986 X1563	yvan_simard@uqar.qc.ca
John Simmonds	Fisheries Research Services Marine Lab, P.O. Box 101, Victoria Road, Aberdeen AB11 9DB, Scotland	+44 1224 295366	J.Simmonds@marlab.ac.uk
Andrzej Stephanowski	Gdansk Technical University Dept. of Geoinformatics, ul. Gabriela Narutowicza 11/12, PL-80–952 Gdansk, Poland		astep@eti.pg.gda.pl
Joanna Szczucka	Institute of Oceanology PAS, Powstancow Warszawy 55, 81–712 Sopot, Poland	+48 (58) 551–7281	szczucka@iopan.gda.pl
Jaroslaw Tegowski	Institute of Oceanology PAS, Powstancow Warszawy 55, 81–712 Sopot, Poland	+48 (58) 551–7281	tegowski@iopan.gda.pl
Sarunas Toliusus	Fishery Research Laboratory, PO Box 108 Lt 91001, Klaipeda, Lithuania	+37046391122	ztl@is.lt
Atle Totland	IMR, P.O. Box 1870 Nordnes, N-5817, Bergen, Norway	+47 55238668	atle.totland@imr.no
Steve Walsh	Northwest Atlantic Fisheries Centre, Dept. of Fisheries & Oceans, PO Box 5667, St. John's, Newfoundland, A1C 5X1, Canada	+1 (709) 772–5478	walshs@dfo-mpo.gc.ca
Vidar Wespestad	Pacific Whiting Conservation Cooperative, 21231 8th Pl. W., Lynnwood,WA 98036, USA	+1 (425) 672–7603	vidar@worldnet.att.net
Chris Wilson	NOAA/AFSC, 7600 Sand Point Way NE, Seattle, WA 98115, USA	+1 (206) 526–6435	chris.wilson@noaa.gov
Dick Wood	Bureau Veritas Acoustic Technology, 36–38 The Avenue, Southampton, Hants SO17 1XN, England	+02380 381 469	dickwood@uk.bureauveritas.com

Annex 2: Draft 2005 Resolution (Category 2)

The **Working Group on Fisheries Acoustics Science and Technology** [WGFAST] (Chair: David A. Demer, USA) will meet in Hobart, Tasmania 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 epi-benthic, epi-pelagic and shallow water species;

iii) acoustical species ID techniques for multi-species assessments, ecosystem studies, by-catch reduction, and objective and automated data processing;

iv) instrumentation, survey design, and data analysis techniques for studying aquatic ecosystems, with special attention to the estimation and use of measurement uncertainty in statistical analyses of multi-variate time series, and techniques for integrating multi-disciplinary data to elucidate functional relationships; and

v) target strength (modelling and measurements); 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).

WGFAST will report by 31 June 2006 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:	Action Item 1.10, 1.13.1, 1.13.4, 5.4– a(i) Action Item 1.10, 1.13.4, 1.14, 1.12 – a(ii) Action Item 1.12.5, 1.14, 1.13.5– a(iii) Action item 1.12.5, 1.13.4 – a(iv) Action item 1.12.5 – b 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 Coop. Res. 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: 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: 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, by-catch 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: Term of Reference a-iv) Instrumentation, survey design, and data analysis techniques for studying aquatic ecosystems will be discussed, with special attention to the estimation and use of measurement uncertainty in statistical analyses of multi-variate time series, and techniques for integrating multi-disciplinary data to elucidate functional relationships. This topic is to provide the opportunity to get a continuous update on this research area. A.N. #s Term of Reference a-v) 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 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:	-
Linkages to other Organisations:	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

Secretariat Marginal Cost Share:	ICES 100%