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Report of the Working Group on Fisheries Acoustics, Science and Technology (WGFAST)

23–27 April 2012

Brest, France

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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

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Executive summary

The Working Group on Fisheries Acoustics Science and Technology (WGFAST) met at the Ifremer Centre, Brest, France, from 24–27 April 2012. Nils Olav Handegard (Norway) served as Chair. There were 69 participants from 19 countries who contributed to the five terms of reference with 31 presentations of new and exciting research in subjects related to fisheries acoustics.

Highlights

The major themes addressed during the meeting included:

- Ecosystem approach to fisheries management: metrics, indices and indicators.
- Design, implementation and review of observing systems integrating acoustic and complementary technologies.
- Acoustic properties of marine organisms.
- Behaviour affecting measurement uncertainty and for studying ecological processes.
- Emerging technologies, methodologies, and protocols in single and multispecies surveys and end-to-end ecosystem models.

A separate session was held for each theme, where the participants first presented the latest results of their work, followed by a discussion which addressed future challenges within each theme. These discussions formed the basis for next year's ToRs. The abstracts and discussion-summaries are given in the report.

The first theme addressed the development of ecosystem metrics and indicators from acoustic measurements. As in previous years, the topics included indicators/metrics for ecosystem-based management, re-analysis of existing time-series for non-target species/groups and the need to incorporate uncertainty in the metrics. A review paper has been published in Marine Ecology Progress Series (MEPS) summarizing much of the effort and work within this theme. In addition, numerous studies presented the use of acoustics in combination with other oceanographic observations and modelling results, representing another approach to apply fisheries acoustic methods. This theme session has become broader than the ecosystem metrics, indices and indicators, and this theme session will be broadened to explicitly address the themes described above in the ToR for 2013.

Acoustics have been integrated into observatories on a variety of platforms, including ships, buoys, moorings, bottom mounted, gliders and AUV's. The challenge to interpret these data without ground-truth samples such as catches and net sampling was a prominent theme of discussion. There was also discussion of calibration, noise removal, vessel motion, changes in absorption and sound speed, and development of data quality metrics to guide post-processing. WGFAST is also in the process of developing metadata standards for acoustic data that will provide appropriate and consistent documentation of acoustic data (see report of metadata topic group). To facilitate contributions that define how acoustics from observatories will be used in the context of management, this theme will be merged with the ecosystem and indicator session in the ToR for 2013.

The primary themes covered in the acoustic properties of marine organisms session included establishment of target strength (TS) relationships for additional species,

meta-analyses of TS relationships, broadband technology, lowered acoustic instrumentation and the need to consider multi-angle dependence of TS, which is timely given the increased use of non-vertically transmitting acoustic instruments such as sonars. It was noted that TS measurements are not deterministic, and sources of uncertainty (including variability of behaviour) should be addressed more broadly.

Behaviour remains a central area of activity for WGFAST, and the work can be divided into 1) behaviour as a source of variability of acoustic observations, and 2) the study of behaviour using acoustic methods. The primary themes included fish avoidance of research vessels, efficacy of noise-reduced research vessels in reducing fish reactions, effects of behaviour on acoustic properties of animals, the use of multibeam sonars to measure behaviour, and effects of exposure to sound produced by instruments used in fisheries acoustics.

One theme session was devoted to methodology development, which is a core activity for WGFAST. The topics covered new acoustic technology (e.g. broadband), increased understanding of instrument performance (e.g. calibration, sound absorption), use of alternative platforms other than ships (ROV, trawl, glider, observatories), integration of acoustics with other instruments (especially optics), and improved data processing and storage. It was noted that linking advances in technology to assessments and management advice is important: this issue will be explored at session F at the 2012 ICES annual science conference.

1 Opening of the meeting

Nils Olav Handegard, WGFAST chair opened the meeting, and welcomed the membership to Brest. He thanked the hosts Laurent Berger and Ann Lebourges-Dhaussy for their hospitality and noted the long-standing contributions of Ifremer to marine science. Antoine Dosdat, Director of the Brest Ifremer facility welcomed the membership of WGFAST to Brest. He described Ifremer's structure and noted that it is a hub for marine science and its longstanding work in fisheries acoustics. He noted that increasing demand for observational data to support the ecosystem approach to fisheries management will bring new demands on the working group. He predicted that in coming years, the working group will be challenged to broaden its activities beyond acoustic surveys of commercially important species to include monitoring of non-commercially important species, implementation of ocean observatories¸ and description of seabed characteristics. Ann Lebourges-Dhaussy presented an address from the Institut de recherché pour le developpement (IRD). She described the structure of IRD, reviewed the institution's long-standing activities in fisheries acoustics, and highlighted the importance of WGFAST to its activities. Nils Olav presented the meeting agenda, and emphasized the importance of informal discussion for the work of WGFAST.

2 Adoption of the agenda

The Working Group on Fisheries Acoustics, Science and Technology (WGFAST) chaired by Nils Olav Handegard, Norway, will meet in Brest, France from 8–11 May 2012:

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

   i) Ecosystem approach to fisheries management: metrics, indices and indicators. Provide methods and standards for creating and validating indicators and metrics derived from acoustic and complementary methods. Contributions addressing how acoustic metrics can be used to inform models and metrics addressing the effects of marine spatial planning, including marine protected areas are encouraged. Evaluate and compare a range of suitable metrics in empirical situations and by simulation, and data archaeology establishing long time-series of acoustic data are believed to be a key to make progress. (presentation session, Verena M. Trenkel)

   ii) Design, implementation and review of observing systems. Integrating acoustic and complementary technologies to meet national and international goals for ecosystem based marine management. (presentation session, Yvan Simard/John Horne)

   iii) Acoustic properties of marine organisms. Update on models and measures of target strength for classifying and enumerating living marine resources and associated variability of validating results. The use of multibeam sonars emphasize the need for addressing the

dependence of beam inclinations from several inclinations as opposed to the traditional vertical approach and needs to be addressed (Presentation session, Egil Ona).

iv) Behaviour. Characterization of animal behaviour in order to 1) describe measurement uncertainty when using acoustic and complementary survey technologies and 2) measure the behaviour or marine organisms for ecological studies. There is a particular need to quantify behavioural disturbance in response to acute and chronic stimuli, including anthropogenic noise effects on marine animals (addressing GES descriptor 11) in order to characterize impact on ecosystem processes. (Presentation session, Alex De Robertis)

v) Emerging technologies, methodologies, and protocols in single and multispecies surveys and end-to-end ecosystem models, including error structures and error budget modelling. (Presentation session, Richard O'Driscoll)

b) Based on our use of active sound in the ocean there is a need to review and document its footprint and place this in context with other natural and anthropogenic sources and the relative impact on marine biota. We will present a paper in the "Behaviour" session where the time, volume and levels will be addressed (Rudy Kloser);

c) Review the reports and receive updates from:

i) Study Group on Calibration of Acoustic Equipment (SGCal; David Demer).

ii) Topic Group on metadata standards (Tim Ryan).

iii) Engagement with SPRFMO (Francois Gerlotto).

iv) Observatories publication topic group (John Horne)

WGFAST will report by 30 June 2012 (via SSGESST) for the attention of SCICOM and ACOM.

3 Ecosystem approach to fisheries management: metrics, indices and indicators

3.1 Contributions to the session

Exploring the information content of multifrequency acoustic indices

Verena Trenkel and Laurent Berger

The information content of recently developed ecosystem indicators based on multifrequency data were further explored. The first index is the proportion of voxels in a given area whose multifrequency response is in agreement with dominance by different scatter groups, such as swimbladder fish, fluid like zooplankton and gas bearing organisms such larval fish and phytoplankton, and fish without swimbladder fish. These proportions are compared to data representing more directly the same scatter groups, such as NASC information for swimbladder fish derived from the same acoustic dataset by expert echotrace classification. Further the indices are compared among themselves to investigate relationships between swimbladder and fluid like organisms or gas bearing organisms. The second index summarizes the variability of multifrequency response types within a given area. Again it is compared to the first set of indices and other data. Conclusions are drawn regarding the insights gained on ecosystem structure that might be relevant to ecosystem based management.

Routine acoustic data as new tools for a 3D vision of the abiotic and biotic components of marine ecosystem and their interactions

Arnaud Bertrand, Michael Ballón , Ramiro Castillo, Alexis Chaigneau, Ronan Fablet, Daniel Grados, Mariano Gutiérrez, Jérémie Habasque, Erwan Josse, Zayda Quiroz, Gildas Roudaut, Gary Vargas

Here we show how routine acoustic data, primarily collected for stock assessment, allows for a 3D vision of the abiotic and biotic components of marine ecosystem and to study their interactions. The study area is the Humboldt Current system off Peru which is the most productive in terms of fish and encompasses a shallow oxygen minimum zone (OMZ). High-resolution estimation of the spatio-temporal variability of the oxycline, which delimits the top of the OMZ, can be achieved using the vertical distribution of epipelagic organisms as observed using acoustics. Physical forcing at meso and submeso scales is increasingly suspected to play a fundamental role in the functioning of marine ecosystems. The method allows for the resolution of a large range of meso and submesoscale structures such as eddies, filaments and internal waves. This information is used to estimate the habitable volume for the epipelagic fish. The volume can be filled by acoustic information on fish, macrozooplankton and other scatters. We used this unique dataset to show how the depth of the upper OMZ, a proxy of underlying physical processes, shapes macrozooplankton and fish distribution. These data, which can be obtained from any vessel geared with echosounders (an example of application from fishing vessel data is provided), is a novel way of studying the impact of physical processes on biogeochemical and ecological processes marine life and extracting valid information about the pelagic habitat and its spatial structure, a crucial aspect of Ecosystem-based Fisheries Management in the current context of climate change.

Acoustic-based characterization of the multiscale dynamics of ecosystem components in the northern Humboldt Current system

Daniel Grados, Ronan Fablet, Michael Ballon, Ramiro Castillo, Zaida Quiroz, Gildas Roudaut, Gary Vargas and Arnaud Bertrand

Upwelling ecosystems are particularly heterogeneous and present an intense mesoscale and sub-mesoscale activity that is expected to drive biogeochemistry-to-organisms distribution and interactions. Acoustic methods developed in the northern Humboldt Current system off Peru provide high resolution (one observation per second along survey tracks) estimates of the abiotic and biotic components of marine ecosystems, in particular the depth of the upper oxygen minimum zone (OMZ), and the biomasses of macrozooplankton and fish. Here we use the variability of the depth of the oxycline as a proxy of the physical forcing and study its impact on the distribution patterns of macrozooplankton and fish. Using wavelet methods we identify and characterize (height, width and depth) submesoscale-to-mesoscale downwelling and upwelling physical structures. Results show that the deformation (height*width) is stronger for downwelling processes. We also show that macrozooplankton hot spots are associated with downwelling (i.e. convergent) structures indicating strong bottom–up structuring processes at a continuum of spatial scales.

Use of acoustic data from fishing vessels to provide additional information on spawning aggregations of blue whiting (*Micromesistius poutassou*)

Sven Gastauer, Sascha M.M. Fässler, Dirk Burggraaf, and Thomas Brunel

Since 2004, the International Blue Whiting Spawning stock Survey (IBWSS), consisting of participants from five countries, has provided annual abundance and biomass estimates of blue whiting west of the British Isles. The design of the survey has traditionally been aimed at reducing the effects of double counting of the northward migrating spawning aggregation. Consideration is also given to the start and end times of the survey window to assure a synoptic coverage while taking into account vessel availability in the different countries and temporal occurrence of spawning aggregations. The main problem affecting the outcome of the survey relates to adverse weather conditions encountered in the Northeast Atlantic at the time of the survey (March/April). This was evident in 2010 when large areas within the core spawning area could not be covered, as bad weather caused one of the vessels to seek shelter while another one was delayed. This year, echosounders of two Dutch freezer-trawlers involved in the blue whiting fishery were calibrated. Their data were recorded during the entire fishing trip for subsequent analyses. Having acoustic data from fishing vessels available additionally to the survey will provide useful information on temporal changes in distribution and densities of major aggregations. Preliminary results are presented and compared to the survey time-series.

Bags-of-Features for fish school cluster characterization in pelagic ecosystems: application to the discrimination of juvenile and adult anchovy clusters off Peru

Ronan Fablet, Paul Gay, Salvador Peraltilla, Cecilia Peña, Ramiro Castillo, Arnaud Bertrand

speraltilla@imarpe.gob.pe

IMARPE, Perú

Fisheries acoustics data presents a great potential for the characterization of pelagic ecosystems, and especially the spatial distribution of pelagic fish. Whereas previous

work has mainly focused on the detection, characterization and recognition of individual fish schools, we here addressed the characterization and discrimination of fish school clusters. The proposed scheme relied on the application to acoustic echograms of the Bags-of-Features approach. The latter is widely exploited for pattern recognition issues and relies on extraction and categorization of objects in images; the image descriptor being formed by the count of objects in each object category. This approach is particularly suited to fisheries acoustic data where fish schools appear as a natural and meaningful object concept. We applied this approach to the discrimination of juvenile and adult anchovy clusters off Peru. Echogram-level discrimination performance raised between 88% and 92% of correct classification for different survey datasets. Significant improvement (about 10% of correct classification) was reported compared to previously proposed school-based echogram-level characteristics. The proposed school cluster classification model was applied to the mapping of juvenile and adult anchovy population from routine acoustic survey data

Tools for improved interpretation of acoustic marks: What's the catch?

Stéphane Gauthier and George Cronkite

The interpretation of acoustic marks has traditionally relied on catch composition from targeted trawls. This approach has several limitations, as it often assumes equal catchability and availability among aquatic organisms. In cases of catches with mixed species, it is often difficult (if not impossible) to determine if these species were naturally found in mixed aggregations or if they were spatially segregated but captured within the same trawl. To address these issues, we have combined a net camera, underwater lights, and a pressure-temperature sensor on a midwater trawl used for acoustic target identification. These instruments were secured a few sections in front of the codend, with the camera pointed towards the rear of the net. By synchronizing all instruments we could determine when and at what depth particular marks were captured, identify smaller animals that went through the net but were not retained by the codend, and quantify behavioural responses of animals within the net, including residency time. Results using this instrument configuration highlighted the shortcomings of traditional trawl interpretation. Using an array of different interpretive scenarios (e.g. using trawl catch solely or in combination with video) we demonstrate the potential bias this can have on estimating fish biomass. Development, application, and future directions for such combinations of instruments will be discussed.

Spatio-Seasonal abundance of Krill (*Euphausia pacifica*) Using a 2 frequency difference method

Jung-Hwa CHOI, Kyounghoon LEE, Seong-Wook PARK, Dong-Woo LEE

There is a variety of zooplankton and nekton in sound-scattering layer distributed in the ocean and the pelagic fish school sometimes mixed with them, so it is difficult to estimate the density of the specific target organism because it cannot give information to discriminate it from a lot of mixed scatterers using a only single frequency. Recently, the multifrequency analysis used to apply the species identification among fish and zooplankton in the sound-scattering layer using 2 frequency difference methods which is analysed by volume backscattering strength on the basis of its hydroacoustic backscattering strength characteristics at each frequency. In this study, a multifrequency, which consists of portable scientific echosounder was used to analyse the krill (*Euphausia pacifica*) density estimation by the extracted layer of krill using 2 frequency difference method applied by acoustical theoretical model, and it was verified biological composition using a FMT(1m×1m) as well as the spatial and tem-

poral distribution in the survey area. In survey area for March through July in 2010, the krill was typically distributed at the water column from surface to 150m depth, in June, it was distributed close to the coast and continental shelf waters, and its mean density (75.8g /m2) was higher than any other month. This survey area has various size distribution of krill so that it gives feeding biological indicators to fisheries resource assessment, and it needs to improve accuracy of assessment due to overestimated by other zooplankton's similar acoustic scattering characteristics in the sound-scattering layer.

3.2 Summary of session

The primary themes covered in the session included the following:

- Indicators and application to management
- Multifrequency species identification and verification
- Acoustics to define the environment
- Analysis of commercial Fishing data

WGFAST is actively involved in developing ecosystem indicators from acoustic information. A review paper describing how acoustics can contribute to the ecosystem approach to fisheries management based on discussions initiated at the working group has been published in Marine Ecology Progress Series[1]. There is substantial effort in the area of ecosystem indicators to summarize and interpret multifrequency acoustic measurements, with a trend towards increased statistical rigor in analysis of these indicators. Pitfalls in the biological interpretation of acoustic data including the impacts of non-linearity in scattering strength introduced by acoustic resonance were discussed. The incorporation of these indices and metrics into ecosystem management remains an important goal.

Species identification remains a major challenge in using acoustic data in ecological applications. Multifrequency analysis, particularly dual-frequency analysis is increasingly becoming routine, and techniques for identification of several groups (e.g. fish and zooplankton) were presented. It is still unclear how useful analyses of integrated backscatter are for ecological studies, and taxonomic inferences from acoustic data need to be verified. It is clear that 'what you catch with a net is not necessarily what is there': in this context net selectivity is a key issue that needs to be considered, and a common area of interest with FTFB. Cameras are increasingly being used in a variety of applications to improve acoustic species identification and investigate trawl selectivity.

It is increasingly clear that acoustics can be used to define the physical environment. Acoustic measurements have the potential to improve understanding of changes in ecosystems, and in some instances may be useful as a proxy for physical conditions. For example, the vertical distribution of scatterers has been used to image the location of the base of the oxycline in Peru. These measurements, along with the oxygen tolerance of species can be used to determine the volume of the available habitat for species.

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[1] Trenkel, Verena M., Patrick H. Ressler, Mike Jech, Marianna Giannoulaki, and Chris Taylor. "REVIEW Underwater Acoustics for Ecosystem-based Management: State of the Science and Proposals for Ecosystem Indicators." *Marine Ecology Progress Series* 442 (December 5, 2011): 285–301.

There is substantial interest in the use of acoustic measurements made opportunistically (e.g. during fishing operations, ferries, and on surveys) to complement and improve the design of acoustic surveys, as this can extend the temporal and spatial coverage of acoustic observations. There was discussion of the challenges of calibration and operation of acoustic instruments on fishing vessels to ensure high data quality, and how data from fishing operations can be analysed due to the sampling biases introduced by fishing strategy. A topic of interest for WGFAST is how to integrate data collected from fishing vessels: a large amount of data are collected while fishing, but the data generally do not follow a predetermined survey design. However, it may be possible to apply similar analysis techniques to those applied to catch per unit of effort data, which are subject to similar limitations.

4 Design, implementation and review of observing systems integrating acoustic and complementary technologies

4.1 Contributions to the session

Use of Active Acoustics in Ocean Observatories

John K Horne

The use of remote sensing technologies, including active acoustics, to monitor physical and biological properties of the ocean continues to increase throughout the world. Aggregations of autonomous or cabled instruments on platforms at the surface or on bottom represent one class of ocean observatories. Limited acoustic instrumentation may also be tailored to local conditions or dedicated to specific applications such as renewable energy site monitoring. A second class of observing systems combine instruments and platforms to routinely and continuously collect measurements on current and future states of water bodies ranging from ocean basins to coastal ecosystems. The construction and operation of observatories and observing systems continues internationally but there is no central repository that tracks installation and use of active acoustic instruments. At this time it is not clear how many observatories exist, how many include active acoustic systems, what systems are being proposed or used, how the data are stored, and what data are publicly accessible. Given the diverse array of science applications and locations, it is not surprising that standard protocols for adding and integrating active acoustics in ocean observing systems do not exist. This talk will attempt to summarize the use of active acoustic instrumentation in past, current, and future observing systems throughout the world.

Reducing error in open-ocean acoustic measurements

Tim Ryan, Ryan Downie, Rudy Kloser and Gordon Keith

Acoustic transect data at ocean basin-scale are now routinely made available as part of Australia's Integrated Marine Observing System (IMOS). The data are sourced from echosounder systems installed on research and commercial fishing vessels. The participating vessels operate in diverse locations and experience a wide range of weather and seawater environmental conditions while motion and acoustic performance of the vessels differs markedly. A fundamental objective is that the processed data can be compared across time and space and regardless of vessel origin. To that end it is essential that the sources of error both systematic and random are understood, where possible reduced, and communicated to both the expert and in-expert end-users of the data. The vessels are all calibrated, however this is but one source of

error. Intermittent noise, weather induced signal loss, seawater absorption and sound speed estimates and signal loss due to vessel motion are all potentially significant for our data. We present methods to reduce and correct for these errors in the context of open-ocean datasets, while working towards a method to estimate the true uncertainty of the measurements.

Acoustic detection of krill from an undersea glider

Sophie Fielding, Damien Guihen, Gwyn Griffiths, Liz Creed iRobot, Steve Curnow Imagenex, Eugene Murphy, Karen Heywood

The GENTOO project aims to investigate the potential for undersea gliders to make high resolution temporal and spatial biological and physical observations of ocean currents and krill distribution to the east of the Antarctic Peninsula. In January 2012 three iRobot Seagliders were deployed to measure temperature, salinity, dissolved oxygen, chlorophyll fluorescence, acoustic backscatter and depth-averaged current in the upper 1000 m along sections across the Antarctic continental shelf and slope into the Weddell Sea. At the same time a newly developed stand alone echosounder, Imagenex ES853 120 kHz, was integrated into a Seaglider to collect mean volume backscatter measurements of Antarctic krill. We outline the constraints of the glider as an active acoustic platform, present the first results of calibrating the echosounder using a tungsten carbide sphere, and discuss validation of target identification by mounting the echosounder onto a Rectangular Midwater Trawl (RMT8) and show data from two short deployments of the echosounder integrated into the glider.

Investigation of bottomfish spatio-temporal distribution and biomass in the Hawaiian Archipelago

Réka Domokos

Local commercial fishers heavily target six species of snappers and one grouper that occupy areas with 100-400 m deep slopes in the Hawaiian archipelago. To date, fisheries dependent methods are being used for stock assessment and management purposes of these bottomfish. As part of an intercalibration study to evaluate three fisheries independent approaches to estimate biomass – active acoustics, moored near-bottom baited video recordings, and experimental fishing – this project is designed to assess the spatio-temporal distribution, movement patterns, and biomass of these economically important species using acoustic methods. Results of this study indicate that "bottomfish" occupy the water column between 30-320m depth and could be as far as 250 m away from the seabed, with most fish observed in areas of about 150m deep bathymetry. While loosely aggregated or individual fish were seen over the entire water column, tight aggregations were almost exclusively within 20m of the seabed. In general, fish tended to form schools which provided the vast majority of biomass in the area. Aggregations were typically looser but more numerous during daytime than during nights, with fish more mobile and dispersed during the crepuscular periods. Spatial distribution of these fish indicates the preference of 150m deep ledges near steep drop-offs to about 300m deep plateaus. While differences in distribution and biomass between surveys are significant, these fish exhibited the preference of a specific location within the survey area. Biomass estimated from acoustic data are significantly higher than cpue obtained from preliminary results of experimental fishing and video recordings.

Vertical distribution patterns of macrozooplankton in the Bay of Biscay, according to the hydrological conditions and fish distribution

Ainhoa Lezama-Ochoa, Xabier Irigoien, Alexis Chaigneau, Zayda Quiroz and Arnaud Bertrand

The influence of the environment on the vertical distribution of zooplankton has been widely studied during the last decades. However, many questions still remain unresolved. Here we study the vertical distribution of macrozooplankton in the Bay of Biscay, using a combination of multifrequency acoustic data, hydrological measures and satellite data. The most striking result was the observation by acoustics of a 'biocline' during the day that we defined as the limit between the surface layer almost empty of macrozooplankton and the richer deeper layers. The observed spatiotemporal changes on macrozooplankton vertical patterns according to environmental variables (photic depth, thermohaline vertical structure, stratification index, chlorophyll) indicated that there is no single limiting factor that explain the macrozooplankton distribution, but a set of them, which weight vary from region to region depending on habitat characteristics. Finally our results showed that fish vertical distribution cope the one of the macrozooplankton; being the only factor that could behave as both, a cause and/or a response to the vertical distribution of macrozooplankton. Fish was not a determinant parameter in the distribution pattern of macrozooplankton but the opposite could occur.

Comparisons between ADCP and calibrated acoustic sensors data, in the frame of two surveys in New Caledonia's Exclusive Economic Zone (EEZ). Preliminary results

C. Menkès[e], H. Smeti[a], A. Daroux[b], E. Josse[b], A. Lebourges-Dhaussy[b], M. Pagano[a], F. Marin[c'], F. Gallois[f], E. Kastenare[c], M.-H. Radenac[c], M. Rodier[a'], V. Allain[d]

[a] IRD, UMR 235, Mediterranean Institute of Oceanography (MIO), Marseille, France – [a'] MIO, Noumea, New Caledonia

[b] IRD, UMR 195, Laboratoire des Sciences de l'Environnement Marin (LEMAR), Plouzané, France

[c] IRD, UMR 065, Laboratoire d'études en géophysique et océanographie spatiales (LEGOS), Toulouse, France – [c'] LEGOS , Noumea, New Caledonia

[d] Secretariat of the Pacific Community (SPC), Noumea, New Caledonia

[e] IRD, UMR 182, Laboratoire d'océanographie et du climat : expérimentations et approches numériques (LOCEAN), Noumea, New Caledonia

[f] IRD, US 191 Instrumentation, Moyens Analytiques, Observatoires en Géophysique et Océanographie (IMAGO), Noumea, New Caledonia

Distribution and abundance of Albacore Tuna prey (zooplankton and micronekton) are largely unknown in New Caledonia's EEZ. During two interdisciplinary oceanographic cruises off New Caledonia, we sampled the dynamical and biogeochemical ocean conditions including currents, nutrients, chlorophyll, zooplankton, micronekton and acoustic backscatter from a 153-KHz S-ADCP, a scientific multifrequency echosounder and a TAPS. The purpose of the present work is to get an estimate of the quality of the ADCP data and to span the conditions impacting this quality, the goal being the possibility to exploit historical data. Comparison between the ADCP backscatter and the echosounder data showed a correlation with an overall R around 0.8 for the 120 and 200 KHz frequencies. Day/night differences can be observed, the

processing threshold can have impacts also on the quality of the comparison. Correlation between 0-100m integrated zooplankton biomass and ADCP backscatter data gave an R of 0.64 with the raw amplitude (in counts) and 0.45 with the backscatter intensity (Sv in dB). Some significant correlations are also observed between the ADCP and the TAPS measurements at some frequencies, indicating not the detection of common organisms but a common spatial distribution of various types of organisms.

4.2 Summary of session

In recent years, there has been increased investment in and use of ocean observatories. Most of the efforts to date deal primarily with collection and analysis of acoustic data, and there is room to fully take advantage of studies integrating the range of measurements that are made in ocean observatories. There is a need to further define how acoustics will be used in the context of observatories.

Observatories provide infrastructure for ocean instrumentation including power, communication, platforms for instruments, and a network for data distribution, which allows for coordinated observations over long periods of time. Ocean observing systems, or clusters of observatories have been, or are being, deployed around the world. Acoustic instrumentation (ADCPs and echosounders) have been integrated into these observatories on a variety of platforms, ships, buoys, moorings, wavegliders, bottom mounted, and gliders and AUV's. Analysis of historical ADCP data are promising due to the large amount of data available, but the performance of the instruments needs to be better quantified. To date, there has been some concern about interference of fisheries echosounders with other instruments (e.g. acoustic modems, hydrophones), which has been resolved with careful planning. Species identification is challenge: one concern is that there is typically no ground-truthing suitable for species identification conducted in the context of formal ocean observatories. Data from these observing systems are served by data portals, and data documentation is essential.

WGFAST is in the process of developing metadata standards for acoustic data that will provide appropriate and consistent documentation of acoustic data (see report of metadata topic group). Ocean observatories require a shift in perspective on analysis of acoustic data as in the past, those collecting the data were the principal users of the data. There was discussion of calibration, noise removal, vessel motion, changes in absorption and sound speed, and development of data quality metrics to guide post-processing. There is an emerging demand for active acoustic data for abundance estimates from observatories, but outreach may necessary for users to adopt acoustic data from observatories. Existing instrumentation has been developed for shipboard surveys, and the requirements for observatories may be different. The oceanographic community is using alternate platforms, and there was discussion of how data from observatories will provide a temporal context for shipboard observations at lower cost.

A list of papers, presentations and other contributions on acoustics and observatories are have been assembled by the study group and provided in Annex 4.

5 Acoustic properties of marine organisms

5.1 Contributions to the session

Estimating gas-bubble size and density in the deep-scattering layer using frequency difference

Rudy J. Kloser, Tim Ryan, Mark Lewis and Lisa Gershwin

rudy.kloser@csiro.au

CSIRO Marine and Atmospheric Research, Box 1538, Hobart, Tas. 7001, Australia

Understanding the structure and function of deep-ocean ecosystems is a necessary requirement for its sustainable management. Estimating the biomass of gas-bladdered organisms in the deep ocean is a simple first step to understand its structure. A two frequency (38 kHz and 120 kHz) target strength probe was lowered to 1000 m to estimate gas-bladder size and density. In situ target strengths from 38 and 120 kHz and their dB difference was compared to that of a gas-bladder resonance scattering model. Predicted mean equivalent spherical radius gas-bladder size was highest at the surface, 0.9 mm, and decreased with depth to 0.6 mm. Density of night-time targets varied throughout the water column highest (0.027 m-3) in the 100 to 200 m range. Predictions of volume scatter from the density of gas-bladdered sizes at 38 kHz was 3.1 dB (factor of 2) lower than measured by the vessels acoustics. This may indicate that a significant fraction of targets are not being sampled with this method. Identification of the species and their size and weight responsible for the scattering is ongoing and will require use of optical and net verification of targets at depth.

Boarfish (*Capros aper*) target strength modelled from magnetic resonance imaging (MRI) scans of swimbladders

Sascha M. M. Fässler and Ciaran O'Donnell

sascha.fassler@wur.nl

IMARES, Netherlands

Boarfish abundance has increased dramatically in the Northeast Atlantic from the early 1970s after successive years of good recruitment attributed to an increase in water temperature during the spawning season. The population growth has seen this species develop from an incidental bycatch species in pelagic fisheries to a large-scale dedicated international pelagic fishery with landings in excess of 137'000 tonnes in 2010. In the Northeast Atlantic, large, high-density spawning aggregations form off the southwest coast of Ireland from June to August. In 2011, a first acoustic survey was carried out to determine the spatial distribution and abundance of the spawning aggregation. As no species-specific target strength (TS) currently exists for boarfish, a project was started to model the TS based on MRI scans of whole fish taken from the observed size range. 3D swimbladder dimensions of each fish sample were used as input to a KRM model. Preliminary results and estimated TS-L relationships based on model calculations are presented.

Calibration of a split-beam broadband echosounder and broadband spectra from selected targets

Gavin Macaulay, Egil Ona, Lars Andersen, Rolf Korneliussen, Lucio Calise, Rokas Kubilius

gavin.macaulay@imr.no

Institute of Marine Research, Bergen, Norway

Trials with a probe-mounted broadband split-beam echosounder have yielded calibrated, beam compensated measurements of the frequency spectra (70 to 400 kHz, with some gaps) of a variety of organisms. In some cases photographic images are available that identify the organism generating the echo. Ping-to-ping variability of the frequency spectra of organisms in their natural state are presented and discussed. Techniques for using this information to improve acoustic target identification are considered. A technique for the calibration of a prototype broadband split-beam echosounder using multiple spheres is described. The additional complexities beyond a traditional single-frequency echosounder calibration are discussed and preliminary estimates of in-field and consistently achievable calibration accuracies are presented.

Backscattering properties of *mytilus edulis trossulus* (Southern Baltic Sea)

Natalia Gorska, Ewa Kowalska

ewa.kowalska@ug.edu.pl

Institute of Oceanography, University of Gdańsk

Studies of benthic habitats are important from an environmental and economical point of view. Non-invasive, rapid and relatively cheap methods of the habitat classification are required. It is the reason of the development of the hydroacoustic classification techniques. The techniques are sensitive to seabed sediments type and backscattering properties of the benthic habitats and developed for individual marine conditions. Last few years the hydroacoustic classification algorithms are created for the southern Baltic Sea. To further develop and improve the algorithms, it is important to study the scattering characteristics of individual benthic organisms. It was the main motivation of the paper. The backscattering characteristics of individual and aggregated organisms *Mytilus edulis trossulus*, the typical southern Baltic benthic species, have been studied basing on the numerical modelling. As the input model data, the morphometry and biomass data of *Mytilus edulis trossulus*, gathered in the study area near the Rowy (southern Baltic Sea), were used. The comparison of the obtained modelling results with the hydroacoustic backscattering data, collected in the same area during the same period, was made.

TSbase: a meta-analysis of fish Target-Strength vs. length equations

Mathieu Doray, Pierre Petitgas

mathieu.doray@ifremer.fr

Ifremer, France

Knowledge of the acoustic response of single fish (or Target Strength: TS) is of prime importance for acoustic target classification and abundance estimation. TS-length equations have been established since decades for numerous species and size range using several experimental and/or modelling techniques. They are usually expressed as: TS = alog10(L) + b, where L is the fish length in cm. The a coefficient is commonly

set to 20, leading to the alternative equation: TS = 20log10(L) + b20 (L in cm). An exhaustive set of published TS-length equations was collected and gathered into a database called 'TSbase'. We have conducted a meta-analysis on this dataset to investigate two questions: i) can we find global statistical patterns in TS-length equation coefficients?, and ii) would this global pattern provide useful guidance when assessing and choosing TS-length coefficients for European small pelagic fish stock acoustic assessment? . It is then suggested to provide a public access to the database to help enriching its content.

Optically-verified in situ target strength estimates of southern blue whiting (*Micromesistius australis*)

Richard L. O'Driscoll, Johannes Oeffner, Adam J. Dunford

richard.odriscoll@niwa.co.nz

NIWA, New Zealand

Estimates of the acoustic target strength (TS) of southern blue whiting (*Micromesistius australis*) at 38 kHz were obtained using an autonomous acoustic optical system (AOS) mounted on a demersal trawl. Data were collected from aggregations of spawning adult (mean fork length, FL, 34.4 cm) and immature (mean FL 24.6 cm) southern blue whiting south of New Zealand. Mean TS was estimated from 162 tracks containing 695 echoes from targets identified from video as southern blue whiting (21 immature fish tracks and 141 adult tracks). The mean TS was -37.9 dB with a 95% confidence interval (CI) of –39.7 to –36.6 dB for immature fish and -34.6 dB (95% CI -35.4 to -34.0 dB) for adults. A logarithmic fit through the mean TS values for immature and adult southern blue whiting produced a new optically verified TS-fork length relationship of TS = 22.06log10FL – 68.54. This new relationship gives TS values within 1 dB of those estimated using the relationship recently adopted by ICES for blue whiting (*Micromesistius poutassou*) of TS = 20log10TL – 65.2 (where TL is total length) obtained from in situ measurements, but much higher values than those estimated from the previous relationship for southern blue whiting of TS = 38log10FL – 97, which was based on swimbladder modelling.

Density Estimates Comparison of Density Estimation acquired from between Scientific echosounder and Acoustic camera systems for Moon Jellyfish (*Aurelia aurita*)

Kyounghoon LEE, Won-Duek YOON, Chang-Hoon HAN, Seong-Wook PARK

A moon jellyfish (*Aurelia aurita*) have recently become one of major issues in the Northeast Asia region due to their fatal damage to fishing industry and power plants near to coastal areas. Therefore it becomes important to quantify the jellyfish's density variation in the survey area in order to prevent jellyfish's blooming from various damages in main season. A moon jellyfish, which is estimated to be developing in inshore sea, gives a fatal damage to Korean and Japanese coastal fisheries and the power plants. It needs to estimate its abundance in the survey when it blooms to prevent from a fatal damage. By the acoustic method, It can be extracted echo signals from the echogram using an echo counting method and be also verified its echo signals mixed by other scatterers using a 2 frequency difference method. A moon jellyfish, which is developed in the coastal area, is relatively small size and has intensive patchiness, so an echo integration method would be more useful and effective than an echo counting method. To extract their echo signals, the 2 frequency characteristics were collected and analysed by 38 and 120kHz on the basis of sizing estimates using

an acoustic camera, and it was also estimated the density in southwestern coastal area of Korea, and it was compared the density estimated values acquired from 2 systems. Results can be utilized to forecast and reduce the damages caused by jellyfish and it can be also effectively used to estimate jellyfish's abundance in coastal areas using the scientific echosounder and the acoustic camera systems.

In-situ measurements of the individual acoustic backscatter of European anchovy (*Engraulis encrasicolus*) and sardine (*Sardina Pilchardus*), with concurrent optical identification

Mathieu Doray, Laurent Berger, Jean Yves Coail, Jean Philippe Vacherot, Gérard Bavouzet, Pierre Petitgas

Knowledge of the acoustic response of single fish (or Target Strength: TS) is of prime importance for acoustic target classification and abundance estimation. TS is a stochastic variable which largely varies in the wild, in response to changes in physical (tilt angle, depth) or biological (physiology) single fish attributes. The first requirement to make sound TS measurement is to accurately identify the species comprising fish targets. Fish target identification is usually carried out by fishing. The comparison between fishing and acoustic data may be biased by the large differences in sampling volume and selectivity between acoustic and fishing devices. Optical systems can improve target identification, by providing images of the fish simultaneously insonified by the echosounder. We used Ifremer's towed body 'EROC', fitted with an optical-acoustic system, to conduct in-situ TS measurements of Biscay anchovy and sardine, with concurrent optical identification. The towed body was equipped with a Simrad EK60 200 kHz split-beam echosounder and a low-light black and white still camera. Combined optical-acoustic observations were made at various depth (10-100 m) during daytime, with or without concurrent pelagic trawling, to devise the most efficient way of measuring TS of optically identified small pelagic fish.

5.2 Summary of session

The primary themes covered in the presentation session included the following:

- Acoustic properties of additional species are being considered
- Meta-analyses of TS relationships will be informative
- Developments in broadband technology are underway
- There is increasing use of subsurface acoustic instruments both in nets and lowered probes for TS measurement and optical verification
- There is a need to consider angle dependence of TS, and measure animal orientation.

Characterization of the acoustic properties of organisms is a central concern for interpretation of acoustic backscatter. As more species are considered to support needs for ecosystem information, and new acoustic instruments are introduced, the demands for information on acoustic properties of organisms is expected to increase. The major activities reported in this area include development of TS models, use of lowered echosounders for *in situ* measurements, and developments in broadband echosounders.

Modelling and measurement of target strength (TS) remains a central activity of WGFAST. A variety of TS measurements and models for a wide range of fish and invertebrates were presented. There is a need to understand angle-dependent backscatter of fish: model results are essential to these efforts. This will allow better inter-

pretation acoustic measurements by incorporating the effects of changes in orientation and the non-vertical pointing angles that are increasingly used in fisheries sonars. Initial model comparisons suggest that the TS of fish with swimbladders that are less elongated will be less sensitive to orientation (i.e. less directive) than those that are more elongated. Medical magnetic resonance imaging technology allows for detailed reconstruction of morphology for use in scattering models. There is a need for better information on fish orientation in situ, as this is a key parameter that is often assumed in models.

A meta-analysis of TS to length relationships from the literature was presented. It was proposed to develop and maintain an online database on TS relationships, which can be used to compare TS across species and test assumptions made when using TS relationships, for example when 'borrowing' TS measurements from related species or other areas. It was agreed that Mathieu Doray and Chris Taylor would look into the possibility of public hosting of TS information in FishBase. It was suggested that there needs to be some level of quality control based on the underlying data to improve inferences made from the data.

For organisms that are resonant (commonly fish larvae, siphonophores, and many mesopelagic fish at the frequencies generally used in fisheries acoustics) the TS and the frequency response will vary substantially with depth. The depth-dependence of the frequency response can potentially be used to estimate animal swimbladder size for resonant organisms. Animal density can be enumerated directly by echo counting of targets from lowered systems, which may reduce uncertainties due to the wide variations of TS of resonant targets.

There is increasing use of subsurface platforms to bring echosounders closer to the fish of interest. This brings the targets in the range of optical instruments, allows for echo counting, TS measurements at high animal densities, and enables the use of high frequencies at depth as short-range measurements that are possible when the transducer is lowered to the targets. Trawl-mounted systems have been used to herd fish in to the view of acoustic instruments so that TS measurements of optically measured fish. These measurements constitute a promising new method, demonstrating that the TS of individual fish is highly variable, with > 20 dB observed for fish tracked over short periods of time. However, the fish orientation likely differs in the trawl likely differs from that of natural fish. Avoidance of lowered systems and behavioural reactions to towed systems and net-mounted systems may bias TS measurement, and is a concern that needs to be addressed in further studies.

Broadband systems are under development that will allow for increased frequency resolution and via pulse compression, and increases in range resolution which will allow for TS measurements at higher animal densities. Calibration of these instruments is more involved as the results are frequency-dependent, but great progress in calibration has been reported, and calibration is expected to be similar to narrowband split-beam calibrations from the user's point of view.

In discussion it was noted that TS measurements are highly variable both within and among individuals, and the mechanisms causing this variability need to be better understood. Since TS is affected by behaviour (e.g. tilt angle, body flexion and swimbladder inflation), TS measurements can likely be used to measure behaviour. It was recognized that TS is not deterministic, and it was proposed that the sources of uncertainty (including variability of behaviour) are often not considered explicitly.

6 Characterization of animal behaviour

6.1 Contributions to the session

Feeding herring do not react to seismic shooting

Héctor Peña, Nils Olav Handegard and Egil Ona

Using a fisheries omnidirectional sonar, the swimming behaviour of herring schools were observed during seismic shooting. The juvenile herring schools were feeding off Vesterålen, northern Norway, in a summer migration towards the Barents Sea. A drifting research vessel collected continuous sonar data while the seismic vessel was shooting along a predefined track line. Numerous small surface schools were scrutinized, and results were analysed together with data from a drifting buoy equipped with 3 hydrophones. Results show the schools were swimming slowly against the predominant northeast currents, but with a net displacement together with the current. No significant changes in the swimming direction, speed and area of the herring schools were observed when the seismic vessel was approaching.

Report of the study group on fish avoidance to research vessels

J. Parrish and F. Gerlotto

Presentation of the final report of the study group on fish avoidance to research vessels. http://www.ices.dk/reports/SSGESST/2012/SGFARV12.pdf

Fish avoidance of research vessel and the efficacy of noise reduced vessels: A review

Alex De Robertis Nils Olav Handegard

There have been an increasing number of reports indicating that fish may avoid approaching vessels, and vessel reactions have been documented to introduce a substantial bias on acoustic estimates of abundance. Although it is unclear how widespread such reactions are, this has led to concern that vessel avoidance will bias fisheries stock assessment surveys. Vessels radiate substantial noise at the frequencies where fish hearing is most sensitive, and vessel noise is considered the primary stimulus for vessel avoidance. International standards for noise emission by research vessels have been established in an effort to minimize vessel avoidance, and have led to the construction of several noise-reduced vessels. The limited comparisons of acoustic abundance measurements made from noise-reduced and conventional vessels are contradictory and demonstrate that sound pressure levels alone are insufficient as the only explanatory variable. Further research is needed to determine better the actual stimuli causing reactions, and the factors that affect whether fish experiencing these stimuli will react before further recommendations to reduce vessel avoidance can be made. In the interim, measurement of vessel avoidance during surveys and timing of surveys when fish are in a less reactive state may serve to reduce errors introduced by vessel avoidance.

Multibeam TS measurements reveals fish behaviour

Laurent Berger, Naig Le Bouffant and Mathieu Doray

laurent.berger@ifremer.fr

Ifremer, France

Scattered herrings have been surveyed at night in shallow water in the English Chanel with ME70 multibeam echosounder and EK60 vertical multifrequency echosounders. ME70 has been used in both traditional swathe mode and in "I" mode, with all beams steered in the same direction at different angles. If the TS vs. beam angle response is relatively flat, due to averaging of fish scattering directivity over various fish orientations, small variations reveal dominant orientations of fish avoiding the vessel. These micro-variations are consistent with the predictions of a scattering model. Frequency dependence of swimbladdered fish is also compared to modelling outputs. Calibration accuracy is eventually discussed based on the same dataset.

Simulations of multibeam sonar echos from schooling individual fish in a quiet environment

Arne Johannes Holmin, Nils Olav Handegard, Rolf J. Korneliussen and Dag Tjøstheim

The development of multibeam sonars capable of observing entire fish schools in one ping (e.g. Simrad MS70), has introduced new possibilities for studying the morphology and dynamics of marine aggregations. To aid the interpretation of such data, a model is developed and demonstrated for simulating sonar observations of fish schools with specified shapes and comprised of individuals having specified target strengths and behaviours. The model emulates the performances of actual instruments (e.g. Simrad EK60, ME70, and MS70) and generates synthetic echograms of fish schools which can be compared with real sonar observations. The model enables acoustic observations of large in situ fish schools to be evaluated in terms of individual and aggregated fish behaviours. It also facilitates analyses of the sensitivity of fish biomass estimates to different target strength models and their parameterizations. To demonstrate how this tool may facilitate objective interpretations of acoustically estimated fish biomass and behaviour, simulated echograms of fish with different spatial and orientation distributions are compared with real echograms of herring collected with a multibeam sonar (MS70) aboard the research vessel ``G.O. Sars''. Results highlight the important effects of fish-backscatter directivity, particularly when sensing with small acoustic wavelengths relative to the fish length. Results also show that directivity is both a potential obstacle to estimating fish biomass accurately and a potential source of information about fish behaviour.

Fish school analysis by means of the quantitative 4D-sonar MS70

Rolf J Korneliussen, Arne Holmin, Yngve Heggelund

Ecosystem investigations require simultaneous observations of marine organisms and their interactions, which imply observations of the complete water volume around a ship. The traditional narrow observation-volume covered by single-beam echosounders may be expanded by multibeam echosounders and multibeam sonars. The Simrad MS70 multibeam sonar mounted onboard RV "G.O. Sars" covers 3 spatial dimensions in each ping with port oriented beams. MS70 covers 60o (horizontally) x 45o (vertically) by means of 25 x 20 beams in each ping at a radial resolution of 40 cm, and is able to maintain a ping-rate of 1 ping per second. Thus, calibrated measures of schools are available at a high resolution in 4D (3D space + time). Methods for analysing such 4D data from fish or krill schools will be demonstrated, and also how to efficiently process the large amounts of data within limited available time at sea, and also development of methods to analyse, grid and visualize 4D data (3D +

time). Special attention is given to calculation of morphological properties of the schools by comparing output from the post-processing system with synthetic data.

Bathymetry and backscatter derived from ME70 fishery mode. Impact of along angle

Naig Le Bouffant, Laurent Berger

A classical distinction is made between bathymetric and fishery echosounders depending on whether they are designed to provide seabed or water column analysis. There is however a great advantage to collect consistent information on both aspects during the same survey with a unique echosounder. Regarding fishery echosounders this could allow to provide fish habitat analysis together with water column imaging, and enrich bathymetric databases with opportunity data collected during fishery surveys. A simple way to derive bathymetric and backscatter results from ME70 fishery mode is thus presented. All acoustic samples presenting significant amplitude level are geographically positioned through their slant range and split-beam angles. Bottom samples selection is then performed considering their spatial coherence. The particular impact of the integration of the split-beam along angle information on bathymetry and backscatter imagery is presented.

6.2 Summary of Session

The primary themes covered in the presentation session included the following:

- Fish avoidance of research vessels
- Efficacy of noise-reduced research vessels in reducing fish reactions
- Effects of behaviour on acoustic properties of animals
- Use of multibeam sonars to measure behaviour
- Effects of exposure to sound produced by instruments used in fisheries acoustics

Behaviour remains a central area of activity for WGFAST. The work can be divided into two major arenas. The first is understanding animal behaviour as a source of variability of acoustic observations which is necessary to make accurate measurements (e.g. of abundance) that are fundamental to fisheries management. The second is that study of behaviour is also an opportunity to make new insights as animals use behaviour to alter how they experience the environment. There is much to be gained from an improved understanding of behaviour, and it is increasingly important to be able to predict how animals will react in response to anthropogenic and natural variability of the environment.

The reactions of fish to approaching research vessels and the effects of these behaviours on acoustic measurements was a central area of discussion. The work resulting from the study group of research vessels was summarized discussed in depth (see also Section 6.3). The goal of this study group was to evaluate the bias due to vessel avoidance, what kind of noise is important, how can the fish detect the signal from approaching vessels, and how can we improve the design of research vessels. The study group has shown that the stimuli produced by vessels are complex, and the reactions exhibited by fish are variable. The body of published research has demonstrated that although fish avoidance is difficult to predict, it is an important potential source of survey bias. The limited comparisons of acoustic abundance measurements made from noise-reduced and conventional vessels are contradictory and demon-

strate that sound pressure levels alone are insufficient as the only variable explaining fish reactions to vessels.

In discussion, there was a consensus that fish avoidance of vessels should be measured and considered in survey design, and correction factors applied in analysis if appropriate. It was made clear that the stimuli controlling fish reactions to research vessels remain poorly understood, and fish reactions to vessels remain unclear. Further studies of fish reactions to vessels are thus a priority. It was broadly recognized that is important to measure avoidance of all survey vessels, including noise-quieted vessels under a variety of survey conditions. Fish avoidance is a potential source of survey bias, which should be measured and considered in survey design, and correction factors applied in analysis if appropriate.

The use of multibeam sonar is now an important area of activity for WGFAST, and multibeam sonars are being used to visualize and infer behaviour. This is an active area of research and examples of new processing techniques to visualize schools from these instruments as well as methods to simultaneously collect bathymetric and midwater measurements were presented. These methods are being applied in studies of fish behaviour (including measurements of reactions to research vessels as recommended by SGFARV). However, it is clear that one must take the acoustic properties of animals into account to avoid misinterpretations. Examples were given from a simulation showing that behaviour can have large impacts on sonar measurements for example by changes in orientation in a polarized fish school. Several presentations involved the use of scattering models to interpret multibeam sonar measurements as a function of angle and frequency. It was recognized that this is a useful approach likely to yield new insights in the near future, but acknowledged that the uncertainty in these predictions needs to be understood in order to draw robust inferences from these models.

The issue of anthropogenic noise, particularly the effects of sound emitted by the instruments used in fisheries acoustics on fish, invertebrates, and marine mammals is an area of increasing interest for the working group. Several members reported that they have been involved in discussions related to the possible impacts of acoustic devices used in fisheries acoustics. The consensus is that there is a need to characterize the instruments used in fisheries acoustics in terms of source level, pulse duration, and beam directivity to provide a foundation for calculating acoustic exposures from these instruments. One of the most likely outcomes of exposure to anthropogenic noise, particularly low-level exposures which will have a large area of influence, is changes in behaviour. However, how animals respond to anthropogenic sounds is very poorly understood and the major source of uncertainty when considering the consequences of acoustic exposures. The expertise in WGFAST in measuring behaviour will be very useful when applied to studies of how organisms change their behaviour when exposed to man-made sounds. For example, one of the studies reported at the meeting reported on measurements of fish reactions to airguns used in seismic surveys with a multibeam sonar.

6.3 Activities and results of the study group on fish avoidance to research vessels (SGFARV)

The ICES Working Group on Fisheries Acoustics, Science and Technology (WGFAST) proposed establishment of the Study Group on Fish Avoidance to Research Vessels (SGFARV) in 2007, in response to growing concern that specific recommendations of

an earlier ICES Study Group, on Research Vessel Noise (CRR 209, Mitson 1995). The following terms of reference were considered:

a) elucidate and expand the list of the possible physical stimuli produced by research vessels (platform related stimuli - PRS) that could elicit avoidance reactions in survey-targeted species; b) produce a literature review to improve our understanding of fish hearing and their reaction to sound stimuli; c) generate a list of recommended items to be monitored and measured on research vessels, wider than just noise related; d) produce a review of methods for measuring avoidance to aid in the design and development of new methods to independently monitor fish reaction to PRS.

Although one of the objectives of the study group was to produce a cooperative research report, this process was cancelled by the SSGESST chair, Bill Karp at the beginning of 2012 because the report was several years behind schedule and he was unable to receive any assurance regarding a completion date. The SGFARV chairs subsequently encouraged the individual contributors to publish their contributions in the primary literature, and material from several chapters was submitted to journals. The decision to cancel the CRR was discussed by the WGFAST members, and the consensus was that the working group asks the SSGESST Chair to reconsider the cancellation decision if the SG chairs could 1) provide a final CRR manuscript before by May 25 and 2) address any potential copyright issues arising from chapters currently being considered for publication in other venues.

The editors submitted a final CRR manuscript prior to the deadline, but the copyright considerations could not be resolved. As stated by Bill Karp, Chair of SSGESST*: "Unfortunately the finalized CRR has not been to satisfy the second condition. That is, some chapters have been submitted for journal publication and have either been accepted or are very likely to be published soon. Some of these submissions took place after the original decision to cancel the CRR had been made. Copyright conditions now preclude us from publishing all the original material in the CRR rendering it much less coherent, to the point of inability to fulfil the original terms of agreement."*

Although the manuscript was not published as a CRR, the material developed by the working group can be found as the 2012 SGFARV Report [2].

[2] http://ices.dk/workinggroups/ViewWorkingGroup.aspx?ID=223

7 Emerging technologies, methodologies, and protocols

7.1 Contributions to the session

Standardized in-tank calibration protocol for multibeam sonar in imaging and echosounder modes

Yannick Perrot, Patrice Brehmer, Gildas Roudaut, Erwan Josse

The increased use of mobile multibeam sonars in aquatic ecology and fisheries, including some quantitative applications, will make it necessary to improve and facilitate their in-tank calibration protocols. A calibration protocol for routine use in tanks is described to optimize the duration of the protocol and the efficiency of measurement. For the imaging and echosounding operating modes, the estimated and measured Simrad SM20 performances and calibration factors, which make it possible to extract target strength and volume backscattering strength for quantitative applications, are compared and discussed. The significant correlations between the estimated and measured SM20 performances demonstrate the effectiveness of the protocol, with the exception of the measured equatorial aperture of the sonar head array elemental directivity, which was lower than predicted. Moreover, the measured equatorial aperture of the sonar head array transmit directivity was insufficient, in terms of echo-level continuity, to provide a consistent sonar image over 120°, which made it impossible to carry out efficient calibration for beam angles of less than ± 40° when transmission was provided by the sonar head array. The causes and the consequences of these problems are discussed. Finally, technical developments are described to improve calibration accuracy and reduce the total time required.

Echobase-EchoR: an open software suite for acoustic survey data storage and indicator computation.

Mathieu Doray, Laurent Berger, Tony Chemit

We have designed an open software suite for storing fisheries acoustic data and computing acoustic indicators for survey-based ecosystem monitoring. It comprises a postgreSQL database designed to store acoustic, navigation and fishing data from ecosystemic surveys (Echobase) and a suite of R codes (EchoR) for computing fish population indicators based on Echobase data. Echobase provide a web-browser interface for importing, editing and querying data, large storage capacities, and an easy integration into Geographical Information Systems or dynamic websites. The Echobase acoustic metadata format follows the WGFAST Topic Group on metadata standards recommendations. EchoR allows for flexible data import in text format, extended data correction and checking, 'expert' or unsupervised data processing procedures and diagnostic/output plots. It provides biomass and abundance per elementary sampling distance units, post-stratification region, age, length, echotype and species, as well as estimation errors. EchoR actually allows for the easy comparison of biomass estimates derived from different stock assessment methodologies.

The acoustic absorption coefficient at 333 kHz

Egil Ona, Gavin Macaulay, Rolf Korneliussen, Dezhang Chu

The absorption of sound by seawater is a known and accounted for effect when processing fisheries acoustics data. Recently observed differences between observed and expected frequency response spectra from some species at 333 kHz may be due to the

use of an inaccurate absorption coefficient. The difference between the F&S and F&G relationships at 333 kHz is 4 dB/km. A trial experiment to test the accuracy of the Fisher and Simmonds relationship at 333 kHz is described. It is also important to respect the valid ranges of the input parameters to the absorption equations. For example, the F&S relationship is only valid for salinities of up to 41 ppt, but recent acoustic surveys in the Persian Gulf regularly experienced salinities of 47 ppt and this indicates that the range of validity may need to be expanded and the accuracy of the current equations at the limits assessed.

Probing the ocean; a new promising combined observation method

Egil Ona, Ronald Pedersen

Horizontally observing multifrequency split-beam transducers, stereo camera and CTD were simultaneously used on a probe, slowly descending from surface to the bottom, measuring the volume density of fish and zooplankton in a Norwegian fjord system. Standard methods for post-processing the data were used to characterize the different layers in the fjord and their inhabitants. The potential behavioural effect of the probe itself was evaluated from the density and target strength recordings as a function of distance from the probe. Interesting layers of pearlside (Maurolicus muelleri, euphausiids (*Meganyctiphanes norvegica*) and mychtophids (*Bentosema glaciale*) were revisited in the retrieval phase and the animals were re-photographed in more detail in this phase of the cast. CTD data were also used to interpret the vertical structure of the registration. Together with vessel survey data and trawl date, a better high resolution snap shot of the density structure is obtained with this new and fairly simple tool.

Variability in abundance estimates from acoustic surveys: Atlantic herring in the Gulf of Maine

Michael J. Jech

Estimates of Atlantic herring (*Clupea harengus*) abundance and biomass in the Gulf of Maine were derived from an acoustic (Simrad EK500 and EK60, 12 or 18, 38, and 120 kHz) survey that began in 1999 and has continued to present. Acoustic data were also collected during these years, but as part of the annual bottom-trawl survey. Estimates derived from the acoustic survey appear to show three regimes of abundance: 1999-2001, 2002–2003, and 2004-present, where the estimates are consistent within each regime, but considerably different among regimes. Estimates derived from the acoustic data collected during the bottom-trawl survey do not show similar trends. Potential explanations (e.g. survey design, survey timing, echosounder calibration and electronics, multifrequency analyses) for these intra- and inter-survey differences are addressed. So far no convincing evidence has been found to explain the differences; therefore ideas will be solicited and discussed.

Acoustic abundance estimates of juvenile anchovy (*Engraulis encrasicholus*) in the of Bay of Biscay as an indicator for next year recruitment

G. Boyra, U. Martínez, U. Cotano, M. Santos, X. Irigoien and A. Uriarte

A series of autumn acoustic surveys for mapping and estimating the abundance of juvenile anchovy in the Bay of Biscay (JUVENA) was launched in 2003 with the long term objective of providing an early indication of the strength of recruitment to the fishery the following year. The survey was carried out annually in an adaptive manner, and covered from the coast to the off-the-shelf grounds. Fishing was based on

purse seining up to 2005, and then this was combined with pelagic trawls from 2006 onwards. After eight years of the survey, a coherent picture has formed of the spatial pattern of the juvenile anchovy distribution. Juveniles show a vertical and horizontal distribution pattern that depends on size. The younger individuals are found isolated from other species in more superficial waters off-the-shelf, mainly within the mid-southern region of the bay. The largest juveniles are usually found a bit deeper and closer to the shore, and are more abundant in the mid-northern areas in the company of adult anchovy and other pelagic species. We used the survey to assess a wide range of juvenile abundances, and obtained a significant positive relationship between these abundances and the 1 year old recruits to the population the following year. This result shows the potential of the juvenile index to provide early recruitment predictions that may help improving the management advice for the fishery of this short-lived species.

7.2 Summary of session

The primary themes covered in the presentation session included the following:

- New acoustic technology (e.g. broadband)
- Increased understanding of instrument performance (e.g. calibration, sound absorption)
- Use of alternative platforms other than ships (ROV, trawl, glider, observatories)
- Integration of acoustics with other instruments (especially optics)
- Improved data processing and storage
- Problems of interpretation for assessment.

Methodology development remains a major area of interest in WGFAST. Many of the presentations in other sessions were also relevant to this session. There is an increasing trend of integrating acoustics with other measurements, particularly optical instruments. This will improve understanding of fish abundance, behaviour and acoustic properties. There have been substantial advances in improved data storage and processing, and metadata, which is an area that needs progress. It is important to link advances in technology to assessments and management advice: this issue will be explored at session F at the 2012 ICES annual science conference.

Advances in tank calibration of multibeam instruments were reported, including direct measurements of equivalent beam angle, and discrepancies between the nominal and observed equivalent beam angles for the most steered beams. Advances in lowered instruments were reported incorporating horizontally pointing acoustics at multiple frequencies, CTD and optical sensors. This has the potential to be used during routine surveys and will not require additional ship time to deploy at CTD stations. The system has a fibre optic cable and the data are monitored in real time. This will require increased understanding of Target Strength at lateral incidence, which can likely be gained from the data collected with lowered instruments. It is unclear how animals react to the lowered probe, particularly given the use of artificial lighting at the relatively short ranges needed for optical imaging.

An integrated computer system developed at Ifremer for storage (Echo-base) and analysis (Echo-R) of acoustic and biological data used in acoustic surveys, using open source statistical software was introduced. This open source software, which will be available to interested parties allows for extensive data diagnostics, and spatial stratification of results, and estimates of survey precision. The software is freely available

to interested parties at http://maven-site.forge.codelutin.com/echobase/ a training course for beta testers will be held in November 2012.

Absorption coefficients at high frequency (>300 kHz) were reported to be less certain that previously understood, and there are discrepancies in predictions using different methods. This has impacts on high-frequency instruments that are increasingly being used. Anomalous observations of depth-dependent frequency response at 333 kHz are consistent with inaccuracies in absorption coefficient. A series of measurements with a calibration sphere suggest that absorption is higher than previously suggested. New measurements and model predictions on absorption at high frequencies are needed.

Several aspects of interpretation and refinements to acoustic surveys were discussed. There was discussion of surveys in which large changes in herring biomass have been observed. There were not consistent with stock assessments and other measures of the population, and the potential reasons for this discrepancy were explored using a series of diagnostics, but no clear answer was detected. It was mentioned that similar experiences had been observed in other fisheries including Hoki in New Zealand. In other areas, it was demonstrated that acoustic estimates of juvenile abundance of anchovy, which can provide a good estimate of recruitment, which can be used to improve fisheries advice.

8 Reports and updates from associated groups and organizations

8.1 Study Group on Calibration of Acoustic Equipment

The study group will deliver its final report to ICES before the 2013 annual science conference.

8.2 Topic Group on metadata standards

Nine participants of the Topic Group on Acoustic Metadata (TG-AcMeta) met at Ifremer on 23 April 2012. The objective of the group is to develop a metadata convention to describe processed water column acoustic volume backscatter measurements obtained from active acoustic systems. Significant progress was made towards stabilizing the document following e-mail correspondence during the year. There was good agreement on the overall structure and direction of the metadata convention. Outstanding issues have been noted and will be resolved via e-mail correspondence. It is recommended that the Topic Group continues in 2012 with the key objective of reviewing and referencing the document. This work will proceed in discussion with the WGFAST Chair to explore the most appropriate mechanism for review of the document. This may include review by the ICES data group and review by experts from established initiatives (e.g. GOOS).

8.3 Study Group on Fisheries Optical Technologies (SGFOT)

The final report by the Study Group on Fisheries Optical Technologies (SGFOT) was published as ICES CRR #312 in April 2012. The report had input from 12 authors and three co-editors describing ocean optics, optical technologies, integration and calibration of optical technologies, and applications of optical technologies to fisheries. The SGFOT does not recommend establishing a separate Working Group on optical technologies as the continued development in optical techniques will benefit fisheries applications without direction from the fishery community. The SGFOT does recommend greater involvement of the optics community in WGFAST, and suggests enhanced collaborative efforts such as integrating remotely located camera systems (e.g. towed, AUV, ROV) with acoustic surveys, and developing adaptive surveys using underwater and air-borne (e.g. lidar) optics with acoustic methodologies.

8.4 Engagement with SPRFMO

Rudy Kloser reported on engagement of WGFAST with the South Pacific Regional Fisheries Management Organization (SPRFMO). Two members of WGFAST participated in a meeting in Vanuatu in September 2011. There is interest in standardizing acoustic methods for abundance estimation across several nations in SPRFMO. The work of WGFAST is very relevant to this organization, and several members of WGFAST have engaged with SPRFMO in the area of acoustics. To help and facilitate acoustics in this organization, an acoustic group modelled on WGFAST has been proposed. This body will provide advice to SPRFMO science groups interested in using acoustics, primarily in the areas of assessment applications, ecological applications, and data management. The intent is that this group will be closely linked to WGFAST and ICES.

8.5 Update on the HAC common data exchange format (Laurent Berger)

The Furuno FCV-30 is now HAC compliant as it outputs the basic tuples for data analysis (Generic sounder and channel tuples, Ping Sv tuples, Position), navigation platform positioning and attitude have been added by the sounder manufacturer for further analysis. A detailed specification of the HAC output from Furuno FCV-30 is available at Furuno.

Simrad EK60 version 2.4 allows the user to select the size of HAC files in the software interface. The single target tuples have also been modified since version 2.2 to export range of the target instead of depth and to avoid the output of empty single target tuples.

Annex 1: List of participants

Last name	First name	E-mail address	Affiliation
Algrøy	Tonny	tonny.algroy@simrad.com	Simrad, Kongsberg Maritime AS
Andersen	Lars Nonboe	lars.nonboe.andersen@simrad.com	Simrad, Kongsberg Maritime AS
Behagle	Nolwenn	cortexx13@hotmail.com	
Berger	Laurent	laurent.berger@ifremer.fr	Ifremer
Bertrand	Arnaud	arnaud.bertrand@ird.fr	IRD
Bethke	Eckhard	eckhard.bethke@vti.bund.de	Institute of Sea Fisheries (vTI)
Boswell	Kevin	kevin.boswell@fiu.edu	Florida International University
Boyra	Guillermo	gboyra@azti.es	AZTI Tecnalia
Boyra	Guillermo	gboyra@yahoo.com	AZTI Tecnalia
Brierley	Andrew	asb4@st-and.ac.uk	University of St Andrews
Choi	Jung-Hwa	choijh@nfrdi.go.kr	NFRDI
Condiotty	Jeff	jeff.condiotty@simrad.com	Kongsberg
Copland	Phil	coplandp@marlab.ac.uk	Marine Laboratory, Aberdeen
Cox	Martin	martin.cox@aad.gov.au	Australian Antarctic Division
Daroux	Aurélie	aurelie.daroux@hotmail.fr	IRD
de Nicasio	Ángela	denicasio@hotmail.com	ulpgc
De Robertis	Alex	alex.derobertis@noaa.gov	Alaska Fisheries Science Center
Domokos	Réka	reka.domokos@noaa.gov	PIFSC, NOAA
Doray	Mathieu	mathieu.doray@ifremer.fr	Ifremer
du Buisson	Louis	louis@silversoft.co.za	IRD and University of Cape Town
Eliassen	Inge	inge.eliassen@cmr.no	CMR
Fässler	Sascha	sascha.fassler@wur.nl	IMARES
Fielding	Sophie	sof@bas.ac.uk	British Antarctic Survey
Gastauer	Sven	sven.gastauer@wur.nl	IMARES
Gauthier	Stephane	stephane.gauthier@dfo-mpo.gc.ca	Institute of Ocean Sciences, Fisheries and Oceans Canada
Gerlotto	Francois	francois.gerlotto@gmail.com	
Gorska	Natalia	oceng@univ.gda.pl	University of Gda?sk
Grados	Daniel	danny.grados@gmail.com	IRD
Guillard	Jean	jean.guillard@thonon.inra.fr	INRA, UMR CARRTEL
Habasque	Jeremie	jeremie.habasque@ird.fr	IRD
Handegard	Nils Olav	nilsolav@imr.no	Institute of Marine Research
Holmin	Arne	arne.holmin@math.uib.n	University of Bergen

Last name	First name	E-mail address	Affiliation
	Johannes	o	
Horne	John	jhorne@uw.edu	University of Washington
Iglesias	Magdalena	magdalena.iglesias@ba.ieo.es	Instituto Español de Oceanografía
Jarvis	Toby	sales@myriax.com	Myriax
Jech	Mike	michael.jech@noaa.gov	NOAA/NMFS/NEFSC
Jonsson	Sigurdur Thor	sigurdur@hafro.is	Marine Research Institute
Kloser	Rudy	rudy.kloser@csiro.au	CSIRO
Knudsen	frank reier	frank.reier.knudsen@simrad.com	Simrad
Korneliussen	Rolf	rolf@imr.no	Institute of Marine Research
Kowalska	Ewa	ewa.kowalska@ug.edu.pl	Institute of Oceanography, University of Gdańsk
Laczkowski	Tomasz	tomlacz@mir.gdynia.pl	National Marine Fisheries Research Institute
Larson	Niklas	niklas.larson@slu.se	IMR, Lysekil, Sweden
Le Bouffant	Naig	naig.le.bouffant@ifremer.fr	Ifremer
Leblond	Isabelle	isabelle.leblond@ensta-bretagne.fr	Ensta Bretagne
Lebourges-Dhaussy	Anne	anne.lebourges.dhaussy@ird.fr	IRD
Lee	Kyounghoon	khlee71@nfrdi.go.kr	National Fisheries Research & Development Institute
Lezama Ochoa	Ainhoa	ainhoa.lezama.ochoa@gmail.com	AZTI / IRD
Lilja	Juha	juha.lilja@rktl.fi	Finnish Game and Fisheries Research Institute
Macaulay	Gavin	gavin.macaulay@imr.no	IMR
McQuinn	Ian	ian.mcquinn@dfo-mpo.gc.ca	Maurice Lamontagne Insttute
Melvin	Gary	gary.melvin@dfo-mpo.gc.ca	Fisheries and Oceans
Millington	David	sales@echoview.com	Myriax
O'Donnell	Ciaran	ciaran.odonnell@marine.ie	Marine Institute
O'Driscoll	Richard	richard.odriscoll@niwa.co.nz	NIWA
Pedersen	Geir	geir.pedersen@cmr.no	Christian Michelsen Research AS
Peña	Marian	marian.pena@ba.ieo.es	IEO
Peraltilla Neyra	Salvador	speraltilla@imarpe.gob.pe	IMARPE
Perot	Yannick	yannick.perrot@ird.fr	IRD
Petitgas	Pierre	pierre.petitgas@ifremer.fr	Ifremer
remond	barbara	barbara.remond@ifremer.fr	ifremer
Ryan	Tim	tim.ryan@csiro.au	CSIRO

Last name	First name	E-mail address	Affiliation
Schaber	Matthias	matthias.schaber@vti.bund.de	vTI, Institute of Sea Fisheries
Schneider	Patrick	patrick@aquason.com	AQUASON / MYRIAX
Smeti	Houssem	houssem.smeti@gmail.com	IRD
Spegys	Marijus	marijus.spegys@gmail.com	Department of Fishery Research
Toliusist	Sarunas	sarunast@gmail.com	Department of Fishery Research
Trenkel	Verena	vtrenkel@ifremer.fr	Ifremer
Valérie	Samedy	valerie.samedy@irstea.fr	IRSTEA

Annex 2: Agenda

	Tuesday	Wednesday	Thursday	Friday
8:45	*Bus to Ifremer center*	*Bus to Ifremer center*	*Bus to Ifremer center*	*Bus to Ifremer center*
9:30	*Housekeeping*	*Housekeeping*	*Housekeeping*	*Housekeeping*
9:40	FAST opening	Domokos	Peña et al	Jech
10:00	FAST opening	Lezama-Ochoa et al	Gerlotto and Parrish	Boyra
10:20	Trenkel et al	Menkes et al	De Robertis and Handegard	Future direction of this ToR
10:40	Grados et al	Observatory publications - Horne	Vessel noise recommendations	FAST business and meeting closure
11:00	*Coffee*	*Coffee*	*Coffee*	*Coffee*
11:20	*Coffee*	*Coffee*	*Coffee*	*Coffee*
11:40	Bertrand et al	Future diurection of this ToR	Berger et al	FAST business and meeting closure
12:00	Gastauer et al	Kloser et al	Holmin et al	FAST business and meeting closure
12:20	Fablet et al	Macaulay et al	Korneliussen et al	FAST business and meeting closure
12:40	*Lunch*	*Lunch*	*Lunch*	*Lunch*
13:00	*Lunch*	*Lunch*	*Lunch*	*Lunch*
13:20	*Lunch*	*Lunch*	*Lunch*	*Lunch*
13:40	*Lunch*	*Lunch*	*Lunch*	*Lunch*
14:00	Gauthier and Cronkite	Fässler et al	Le Bouffant and Berger	
14:20	Choi et al	Gorska and Kowalska	Future direction of this ToR	
14:40	Future direction of this ToR	Doray and Petigas	Perrot et al	
15:00	Future direction of this ToR	O'Driscoll et al	Macaulay et al	
15:20	*Coffee*	*Coffee*	*Coffee*	
15:40	*Coffee*	*Coffee*	*Coffee*	
16:00	Horne	Lee et al	Doray et al	
16:20	Ryan	Doray et al	Ona and Macaulay	
16:40	Fielding	Future direction of this ToR	Ona and Pedersen	
17:00	SGCal; David Demer	Bus to Brest	SPRFMO - Gerlotto	
17:20	Metadata; Tim Ryan		Bus from Ifremer to Kergroadez	
17:40				
18:00	Ice breaking at IFREMER ce			
1: Ecosystem appr				
2: Design, impleme				
3: Acoustic properti				
4: Behaviour				
5: Emerging techno				
FAST Business				

Annex 3: Group photograph

Annex 4: Ocean Observatory Presentation and Paper Summary

2010 – 2011

Presentations (14 oral, 4 poster):

Barbee, D. H., J. K. Horne, S. S. Urmy, and R. B. Kreisberg 2011. Interfacing a scientific echosounder with a cabled ocean observatory. 161st Meeting of the Acoustical Society of America. Seattle, Washington.

Bayrakci, G., C. Scalabrin, I. Leblond, L. Géli and J. B. Tary 2012. Monitoring of gas emission in the Marmara Sea by the combined study of the Acoustic Bubble Detector and Ocean Bottom Seismometers. European Geosciences Union General Assembly. Vienna, Austria. 22–27 April. (Poster).

Dalen, J. 2011. Impacts of marine transport on the marine environment. Some sound sensory characteristics in fish: sound pressure vs. sound kinetic components. EMAR2/RES WS Ostende, Belgium. 19–20 April.

Handegard, N. O., G. Huse, O. Maury, and N. C. Stenseth 2011. Toward a global observation and modeling system for studying the ecology of the open ocean using acoustics. 161st Meeting of the Acoustical Society of America. Seattle, Washington.

Horne, J., S. Urmy, and D. Barbee. 2010. Using sonar to describe temporal patterns of oceanic organisms from the MARS observatory. OCEANS'10 MTS/IEEE Meeting. Seattle, Washington.

Horne, J. K., S. S. Urmy, and D. H. Barbee 2010. View from the bottom: Pelagic dynamics in Monterey Bay. Invited lecture. Monterey Bay Aquarium Research Institute. Moss Landing, California.

Horne, J. K., S. S. Urmy, and D. H. Barbee 2011, Calibrating an ocean observatory echosounder at depth. ICES Fisheries Acoustics Science and Technology Working Group annual meeting. Reykjavik, Iceland.

Leblond, I., C. Scalabrin, N. Lanteri, and L. Geli 2010. BOB: bubble observation module. ESONET. Marseille, France. Dec. (Poster).

McClure, R., B. Moore, and S. Veirs 2009. Continuous, real-time acoustic observation of Orca and salmon at Lime Kiln State Park. Puget Sound Georgia Basin Ecosystem Conference. Seattle, Washington 8–11 February (Poster).

McClure, R. 2012. Ocean Observatories: Echosounder applications. Southeast Acoustics Consortium. Miami, Florida.

Pawlowicz, R., and R. McClure 2010. Inverted echosounder for continuous high-resolution water column profiling from the NEPTUNE (Canada) ocean observatory. OCEANS 2010 MTS/IEEE. Seattle, Washington. 20–23 Sept.

Simard, Y. 2011. Use of active and passive acoustics for whale ecosystem studies in the St. Lawrence. Dept. of Oceanography, Dalhousie Univ. Halifax, Nova Scotia. 18 Feb.

Simard, Y., and N. Roy 2011. Multi-scale ecosystem processes tracked with ADCP current and acoustic backscatter time-series: applications, possibilities and limitations from several environments in Canadian waters. ICES Fisheries Acoustics, Science and Technology meeting. Reykjavik, Iceland, 9–13 May.

Urmy, S. S., and J. K. Horne 2011. Metrics to characterize vertical distributions of pelagic fauna in large acoustic datasets. 161st Meeting of the Acoustical Society of America. Seattle, Washington.

Urmy, S., J. K. Horne, and D. H. Barbee 2010. Temporally indexed patterns of pelagic fauna in Monterey Bay. ICES Fisheries Acoustics Science and Technology Working Group annual meeting. San Diego, California.

Urmy, S. S., J. K. Horne, and D. H. Barbee 2011, Pelagic bio-physical coupling in Monterey Bay. ICES Fisheries Acoustics Science and Technology Working Group annual meeting. Reykjavik, Iceland.

Veirs, S., B. Moore, R. McClure, R. Otis, J. Wood, and V. Veirs 2009. Hydroacoustic assessment of the prey field for killer whales in Haro Strait. Puget Sound Georgia Basin Ecosystem Conference. (Poster).

Zedel, L. 2010. Finding Fish in Acoustic Doppler Profiler Data from the VENUS Ocean Observatory. CMOS 44th Congress, Ottawa, Canada. June.

Papers (13 published, 1 in press):

Benoit, D., Y. Simard, J.A. Gagné, M. Geoffroy, and L. Fortier 2010. From polar night to midnight sun: photoperiod, seal predation, and the diel vertical migrations of polar cod (*Boreogadus saida*) under landfast ice in the Arctic Ocean. Polar Biology 33: 1505–1520.

Bertrand, A., M. Ballón, and A. Chaigneau 2010. Acoustic observation of living organisms reveals the upper limit of the oxygen minimum zone. PLoS ONE 5: e10330.

Doksæter, L., E. Olsen, L. Nøttestad, and A. Ferno 2008. Distribution and feeding ecology of dolphins along the Mid-Atlantic Ridge between Iceland and the Azores. Deep-Sea Research Part II-Topical Studies in Oceanography 55: 243–253.

Doksæter, L., O. R. Godø, N. O. Handegard, P. H. Kvadsheim, F. P. A. Lam, C. Donovan, and P. J. O. Miller 2009a. Behavioral responses of herring (*Clupea harengus*) to 1–2 and 6-7 kHz sonar signals and killer whale feeding sounds. Journal of the Acoustical Society of America 125: 554–564.

Doksæter, L., O. R. Godø, E. Olsen, L. Nøttestad, and R. Patel 2009b. Ecological studies of marine mammals using a seabed-mounted echosounder. ICES Journal of Marine Science 66: 1029–1036.

Dypvik, E., T. A. Klevjer, and S. Kaartvedt 2012. Inverse vertical migration and feeding of glacier lanternfish (*Benthosema glaciale*). Marine Biology. 159: 443–453.

Johansen, G. O., O. R. Godø, M. D. Skogen, and T. Torkelsen 2009. Using acoustic technology to improve the modelling of the transportation and distribution of juvenile gadoids in the Barents Sea. ICES Journal of Marine Science 66: 1048–105.

Kaartvedt, S., J. Titelman, A. Røstad, and T. A. Klevjer 2011. Beyond the average: Diverse individual migration patterns in a population of mesopelagic jellyfish. Limnology and Oceanography. 56: 2189–2199.

Klevjer, T. A., and S. Kaartvedt 2011. Krill (*Meganyctiphanes norvegica*) swim faster at night. Limnology and Oceanography. 56: 765–774.

Orlowski, A. 2012. Acoustic tracking dynamic phenomena in marine ecosystem. *In* S. C. Mukhopadhyay (ed.). Smart Sensing Technology for Agricultural & Environmental Monitoring. LNEE 146, Springer Verlag Berlin Heidelberg, pp. 269–284.

Staby, A., and D. L. Aksnes 2011. Follow the light – diurnal and seasonal variations in vertical distributions of the mesopelagic fish *Maurolicus muelleri*. Marine Ecology Progress Series. 422: 265–273.

Staby, A, A. Røstad, and S. Kaartvedt 2011. A full year study of diel vertical migration of the mesopelagic fish *Maurolicus muelleri* reveals novel and varied migration patterns. Marine Ecology Progress Series. 441: 241–255.

Urmy, S. S., J. K. Horne, and D. H. Barbee 2012. Measuring the vertical distributional variability of pelagic fauna in Monterey Bay. ICES Journal of Marine Science. 69: 184–196.

In Press

Godø, O. R., R. Korneliussen, T. Kutti, M. Ostrowski, E. Tenningen, and J. H. Fosså. The Hermes Lander project – the technology, the data and evaluation of concept and results, Fisken og havet, 3–2012 (in press).

Annex 5: WGFAST terms of reference for the next meeting

The **Working Group on Fisheries Acoustics Science and Technology** (WGFAST), chaired by Nils Olav Handegard, Norway, will meet in Pasaia, Spain, from 16–19 April 2013. The TG-AcMeta (topic group on metadata standard) will meet Monday 15 April and the SGCAL will meet Saturday 20 April 2013 at the same venue:

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

  i) Applications of acoustic methods to characterize ecosystem. This session concerns the application of acoustic methods, often developed within the WGFAST community, and the application of those techniques in ecosystem studies. This includes acoustically derived metrics, indices and indicators to support the ecosystem approach to fisheries management, and the use of acoustics in combination with other observation tools to assess, understand and quantify ecosystem patterns and processes. The focus should be on larger scale systems, and examples of using data from platforms other than research vessels are encouraged, e.g. observatories, gliders etc, in addition to re-analysing historical data. Guests outside the community are particularly welcomed (Chair: Arnaud Bertrand).

  ii) Acoustic properties of marine organisms. This is a core activity for WGFAST, as the scattering properties of marine organisms must be understood to make biologically relevant conclusions from acoustic measurements. This includes models and measurements of target strength (in particular for multiple inclination angles), and acoustic target classification, including the use of multiple frequencies techniques or broadband systems. (Chair: Mathieu Doray).

  iii) Behaviour. This section address both the use of acoustics to measure (fish) behaviour and the impact of acoustic stimuli on behaviour, including the measurement uncertainty caused by target behaviour. There has been an increase in the use of acoustics to observe behaviour in ecological studies, and this represents an opportunity to engage others to learn more about and apply the tools and techniques developed within the WGFAST (Chair: Francois Gerlotto).

  iv) Emerging technologies, methodologies, and protocols. The use of acoustics and complementary technologies for fish surveys has been and still is a core activity of WGFAST. This session welcomes contributions on acoustic based single and multi species surveys and how they relate to traditional assessment work, including error structures and error budget modelling. The session also includes updates on the application of new technology in relation to such surveys, and more purely technological advances, such as advances in calibration and post-processing techniques, and development of new acoustic and optical sensors. (Chair: Gary Melvin).

b) Based on our use of active sound in the ocean there is a need to review and document its footprint and place this in context with other natural and anthropogenic sources and the relative impact on marine biota. We will present a paper in the "Behaviour" session where the time, volume and levels will be addressed (coordinated by Rudy Kloser).

c) Review the reports and receive updates from:

i) Report from the Study Group on Calibration of Acoustic Equipment (SGCAL; David Demer).

ii) Report from the Topic Group on metadata standards (Tim Ryan).

iii) Engagement with SPRFMO (Francois Gerlotto).

d) It was decided at the meeting to start working towards a new study group on acoustic target classification. A core group comprised of Stephane Gauthier, Ann Lebourges-Dhaussy, Rolf Korneliussen, John Horne, Ian McQuinn, and coordinated by Rolf Korneliussen will start initial discussions and present terms of reference for such a group to be endorsed by WGFAST and sent to SCICOM for consideration (Rolf Korneliussen).

e) The next acoustic symposium is currently being developed, and the status of the planning process will be presented at the meeting (WGFAST chair, Nils Olav Handegard).

WGFAST will report by 30 June 2013 (via SSGESST) for the attention of SCICOM and ACOM.

Supporting Information

Priority	Fisheries acoustics and complementary technologies provide the necessary tools and methods to implement the ecosystem approach to fisheries management within ICES and research into their application and further development is vital.
Scientific justification	In response to the ICES strategic plan 2009 – 2013, WGFAST will document how acoustic and complementary methods will contribute to the goals of an ecosystem approach with benthic and pelagic observations to improve assessment and management of living marine resources, understanding mechanisms and processes of change and stability, and parameterize and evaluate models of ecosystem structure and function. WGFAST will report by 30 June 2013 for the attention of the SCICOM steering committee Ecosystem Surveys Science and Technology.
Resource requirements	No new resources will be required for consideration of this topic at WGFAST annual meeting. Having overlaps with the other meetings of the Working, Planning, Study and Topic Groups increases efficiency and reduces travel costs; undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 60-70 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	
Linkages to other committees or groups	The work in this group is closely aligned with complementary work in the FTFB Working Group. The work is of direct relevance to the survey planning groups within SSGESST.

Linkages to other organizations	The work of this group is closely aligned with similar work in FAO, the Acoustical Society of America, the South Pacific Regional Fisheries Managament Organization and the American Fisheries Society

Annex 6: Recommendations

Recommendation	Adressed to
1.Review the metadata standard for acosutic data from the acoustic meta data standard topic group.	ICES Data Centre, SSGESST
2.Review suggestion for the next acoustics symposium	SSGESST
3.Address catchability issues in trawl-surveys	WGFTFB