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Executive summary

The Working Group on Fisheries Acoustic Science and Technology (WGFAST) met at the Hubbs Sea World Research Institute of Marine Sciences, San Diego, USA from the 27 to 30 April 2010. Rudy Kloser (Australia) was Chair and Tim Ryan (Australia) was Rapporteur. There were 68 participants from 12 countries who contributed to the five Terms of Reference with 48 presentations of new and exciting research.

Highlights:

It was an honour to dedicate this meeting to the late Dr Van Holliday who contributed greatly to the science of WGFAST and the ICES community in general. Van was awarded the Prix d'Excellence award in 2008 in recognition of extraordinary contributions, fulfilling the ICES vision of scientific discovery, leadership, and applications that have had major influence on policy for sustained use and conservation of marine ecosystems. In recognition of Van's contribution to marine science he was awarded the NOAA environment award by Ursha Vananasi at the meeting gratefully received by his wife and daughter.

In response to the 2009–2013 ICES strategic plan the working group dedicated a session to discuss how acoustic and complementary methods could contribute to fisheries and ecosystem based indicators (Verena Trenkel, France). The overview of the use of acoustics for ecosystem based management (EBM) showed that acoustics are currently mainly providing single species biomass indices for stock assessment models. Further, they are also used for gaining insights into local ecosystem functioning, in particular predator–prey spatial relationships. The review of suitable indicators for EBM derived from acoustic and complementary methods revealed the scope for further developments, in particular for metrics and indicators spanning species and trophic levels. To further our contribution to this topic we have suggested the following science plan: 1.) Joint session at ASC 2011 on indicators for EBM: How and what can acoustics provide? 2.) Next meeting ToR to provide methods and standards for creating and validating indicators and metrics derived from acoustic and complementary methods. Evaluate and compare a range of suitable metrics in empirical situations and by simulation.

The meeting reported on the high spatial and temporal resolution of active acoustics that offers unique capabilities for studies of the behaviour of aquatic animals. This capability represents a major opportunity for advancing our understanding of animal behaviour in marine systems. There were several reports of new developments in measurements of fish aggregation characteristics using advanced multibeam echosounders as well as ecological studies using the morphology of schools to infer behaviour. As an example these studies led to a better understanding of the species abundance which is used in the sustainable management of fish stocks. To this end our study group on "Causes and Consequences of Fish Reaction to Fisheries Research Vessels" (conveners J. K. Parrish and F. Gerlotto) are in the final editing of the cooperative research report (150 pages) to be completed by December this year. This report discusses the findings of new research on variable fish behaviour to noise reduced research vessels.

As a final highlight the use of acoustics is extending well beyond commercially targeted species to observing and quantifying other trophic groups from jelly fish to myctophids. This use of acoustics is expanding rapidly and observing systems are being put in place to monitor these trophic groups and develop appropriate metrics.

This is an exciting area of present and future research and will continue to be tackled by WGFAST at the next meeting.

Recommendations

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

1 Terms of Reference

In response to the ICES Resolution of the 93nd Statutory Meeting, the Working Group on Fisheries Acoustics Science and Technology (WGFAST) chaired by Rudy Kloser, Australia; and Rapporteur: Tim Ryan, Australia, met in San Diego, USA from the 27 to 30 April 2010 with ToR:

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.

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

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

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

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

3. Target strength and species identification modelling and measurement with particular emphasis on validation (optical and nets) and multifrequency and wideband measurements; (Presentation session)

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

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

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

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

c) Review the reports of the:

7) Study Group on Calibration of Acoustic Instruments in Fisheries Science (SGCal; DD); and

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

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

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

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

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

WGFAST will report by 30th June 2010 for the attention of the SCICOM steering committee Ecosystem Surveys Science and Technology.

2 Opening the meeting

2.1 Opening and welcome to FAST

Rudy Kloser opened the meeting and dedicated it to Dale Vance Holliday who sadly passed away in February 2010. He thanked Van Holliday's wife Beth and daughter (both from San Diego) for attending the opening of the meeting. Ursha Varanasi, Director and Acting Director of NOOA's South West and North West Fisheries Science Centres welcomed participants to the WGFAST meeting and David Demer (host) thanked the Hubbs Sea Worlds Institute and the director Don Kant for kindly providing the facility for the WGFAST and study group meetings. David Demer (abstract below) and Bill Karp both gave heartfelt and moving tributes to Van Holliday. To mark Dr Holliday's unsurpassed contribution to the field of acoustics Ursha Varanasi presented Van's wife Beth with the NOAA Environmental Hero award.

Tribute to D.V. Holliday

David A. Demer *Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA.*

A tribute to the life and science of D. Van Holliday: Pioneer of resonance, Doppler, and multiple-frequency acoustical oceanography; a visionary, mentor, and friend.

Dale Vance Holliday (29 May 1941 – 4 February 2010), provided the ICES community with vision, cutting-edge science, and leadership in the field of Fisheries Acoustics for more than four decades. Trained in applied physics at the University of Texas at Austin (B.S., 1961; and M.A., 1965) and the University of California at San Diego (PhD., 1972), his knowledge and contributions bridged many disciplines, from nuclear physics to biological oceanography, and made him a stand-out engineer, scientist, manager, and mentor. In 1972, Van offered the following guidance which remains entirely relevant to this day:

"One of the most urgent needs for improvement in the management of fisheries, both old and new, is in our capability to make timely, synoptic, species-specific stock assessments over wide geographic areas. Constraints of both time and cost dictate a remote sensing approach to the required survey capability as opposed to direct sampling. Severe restrictions on the propagation of electromagnetic energy in seawater, e.g. radar and light, leave underwater acoustics as the only recourse in conducting more than a surface examination of marine fish resources."

Van acted on his own advice and, in the 1970s and 1980s, pioneered most of the techniques which are now being broadly applied in surveys, with the resulting information providing solid scientific foundation to management policy. He was a pioneer of resonance, Doppler, and multiple-frequency acoustical oceanography. He was also a leader and innovator in advanced technologies, principally low- and high-frequency sonars, and passive acoustics for identifying and enumerating fish, plankton, and

marine mammals in diverse aquatic environments. Furthermore, during the last thirty years, he actively contributed to the endeavours of the ICES and particularly the WGFAST, and mentored numerous young scientists.

In 2008, ICES honoured Van as its first recipient of the Prix d' Excellence award for "extraordinary contributions, fulfilling the ICES vision of scientific discovery, leadership, and applications that have had major influence on policy for sustained use and conservation of marine ecosystem." In 2009, he published the paper "High-frequency acoustics and bio-optics in ecosystems research," in the ICES Journal of Marine Science. With his focus on critical processes that link the physical, chemical, and biological components of a marine ecosystem, he said, "Using acoustics and optics allows us to study the distribution of marine life and learn about ecosystem-relevant processes."

Van rightfully received numerous awards for his contributions and recognitions for his science and technology. However, those who knew Van will remember him most for his unselfish tendency to stop what he was doing to assist and guide his numerous friends and colleagues. Van was always ready, willing, and able to lend his hand.

2.2 Participants and agenda

A list of the 68 participants from 12 countries appears in Annex 1, agenda appears in Annex 2.

3 Study group updates

3.1 Francois Gerlotto, Update on SGFARV – Study Group on Fish Avoidance of Research Vessels

The Study Group met in San Diego USA, 26–27 April, 2010 to: produce and analyse the final version of a CRR titled "Causes and Consequences of Fish Reaction to Fisheries Research Vessels" (conveners J. K. Parrish and F. Gerlotto). The final draft was presented and approved by the SGFARV. In its final version (and before final editing) the CRR is formed of an introduction, 8 chapters, a bibliographical list and annexes, representing around 150 pages. The organization of the CRR is as follows:

Chapter 1. *Vessel induced fish behaviour: the reactions of fish to anthropogenic sounds*
Chapter 2. *Platform emissions*
Chapter 3. *The fish physiology related to signals (visual and acoustic)*
Chapter 4. *Towards a conceptual model of fish avoidance*
Chapter 5. *The fish behaviour*
Chapter 6. *Effects of fish avoidance on measurements and assessments of fish*
Chapter 7. *Designing experimental to evaluate fish reaction*
Chapter 8. *Results, recommendations (platform – assessment – behaviour)*
Litterature review
Annexes

Term of Reference a-i (*Many ICES nations have or are procuring quiet fisheries research vessels, at great additional costs relative to conventional vessels. To study the benefits of these new vessels, it is first necessary to understand the physical stimuli produced by vessels that could elicit avoidance reactions.) is addressed in chapters 1 and 2.*

Term of Reference a-ii *(Several countries are conducting or have recently completed significant studies in this area and the subject would benefit from a review of progress and an evaluation of the results obtained) is addressed in chapters 1, 2, 5, 7.*

Term of Reference a-iii *(Monitoring of physical stimuli produced by vessel is necessary to determine when and why some fish avoid some survey vessels) is addressed in chapters 2, 3, 4)*

Term of Reference a-iv *(Characterizing fish avoidance behaviour is challenging and a review of effective methods will aid researchers) is addressed in chapters 4, 5, 6).*

Term of Reference a-v *(New methods and experiments will be needed to better characterize fish avoidance reactions to survey vessels) is addressed in chapters 7 and 8.*

Term of Reference a-vi *(The SG should disseminate findings via an ICES CRR) is addressed through the production of the CRR manuscript.*

Decisions were taken on the schedules for the submission of the manuscript. It was agreed that the CRR should go through a peer review procedure, and the manuscript will be transmitted to chairs of WGFAST and SSGESST for evaluation before to be given to ICES for publication. This will be done in June, 2010.

A final report on the SGFARV activities will be given during the ASC in Nantes, September 2010, and the SGFARV will end its activities. Eight scientists were present at the SGFARV final meeting.

3.2 David Demer: Update on SGCal – Study Group on Calibration of Acoustic Instruments in Fisheries Science

The ICES Study Group on Calibration of Acoustic Instruments in Fisheries Science (SGCal) convened its first meeting at the Hubbs SeaWorld Research Institute, West Room, in San Diego, California, USA, on 26 and 27 April, 2010. David Demer (USA) was Chair, and Neal Williamson (USA) was Rapporteur. Thirty scientists from ten nations participated. The agenda spanned a day and a half, and, according to the terms of reference included presentations on calibration-related developments and was focused on outlining a new Cooperative Research Report on the calibration of acoustic instruments. The following is a summary of the CRR outline, including names of **lead** and **contributing authors,** which was adopted:

1. SUMMARY **(Demer)**
2. LIST OF TERMS, SYMBOLS, AND UNITS **(Demer, Jech, Macaulay, Chu)**
3. INTRODUCTION **(Jech, Bethke, Demer, Weber, Fässler, Le Bouffant)**
    1. Acoustic theory **(Demer, Le Bouffant)**
    2. Signal processing theory **(Bethke, Le Bouffant)**
    3. Equipment
        1. Echosounders **(Weber, Lurton)**
        2. Transducer platforms **(Fässler)**
    4. Calibration methods **(Jech, LeBouffant)**
4. STANDARD SPHERE CALIBRATION **(Macaulay, Demer, Ryan, Scalabrin, Bethke, MacLennan)**
5. CALIBRATION UNCERTAINTY **(Chu, Demer)**
6. CALIBRATION PROTOCOLS **(Williamson, Parker-Stetter, Gauthier, Domokos, Le Bouffant, Demer, Korneliussen, Chu, Stienessen, Bernasconi, Melvin, Ryan)**

7. FUTURE WORK **(Chu, Melvin, Weber, Jech, Boswell, Ryan, Macaulay, Perrot, Lurton)**

A list of calibration-related references was compiled and copies of most were distributed to members of the group.

The following timeline was adopted:

1 February 2011 – Draft chapters to section leads

1 March 2011 – Draft chapters to SGCal participants to review

April 2011 – Review chapters and collectively advise refinements

April 2012 – Review draft CRR

Sept 2012 – Submit final SGCal report and CRR

The next meeting will again be held in conjunction with WGFAST in Reykjavík, Iceland, from 7–8 May 2011.

3.3 Update on Working Group on Redfish Surveys (WGRS; formerly the Planning Groups for Redfish Surveys (PGRS)) Michael Jech

Mike Jech gave an update on his participation in the Working Group on Redfish Surveys (WGRS) and formerly the Planning Group for Redfish Surveys (PGRS). A workshop (Workshop on the Determination of Acoustic Target Strength of Redfish) WKTAR will be held in Tromsø, Norway on 1 to 3 June and attempt to develop an agreed upon target strength regression equation from current and historical data.

3.4 SCICOM Update Bill Karp

Bill Karp addressed the meeting about SCICOM related matters, presenting the ICES Science Plan and highlighted where the WGFAST group fits within that structure. In particular Bill updated the meeting on the following reports; the SCICOM update report from the 17–18 February; the SSGESST WebEx report and the SSGEST workplan and Terms of Reference for 2009–2010.

4 Topic A: Fisheries and ecosystem acoustic indicators

4.1 Verena M. Trenkel[1], Laurent Berger[2] Diversity and foodweb indicators derived from acoustic data: Proposals and first tests

[1]*Ifremer, EMH, Rue de l'Ile d'Yeu, BP 21105, 44311 Nantes cedex 3, France. vtrenkel@ifremer.fr* [2] *Ifremer, NSE, BP70, 29280 Brest, France.*

The WGFAST topic group on 'Ecosystem approach to fisheries management: metrics, indices and indicators' reviewed existing ecosystem indicators derived from acoustic data. It noted that little use has been made of acoustics to derive indicators other than species based ones despite the fact that acoustics have huge potential, both in terms of simultaneously sampling across trophic levels as well as at a range of spatial and temporal scales. The topic group proposed a number of indicators that could be tested. The basic ingredients are multifrequency and energy groups which are used to calculate a range of diversity and spatial overlap indices. Here we will present first results obtained with data from the Bay of Biscay.

4.2 Patrick H. Ressler[1], Alex De Robertis[1], Joseph D. Warren[2], Joy N. Smith[2], and Stan Kotwicki[1]. Using an acoustic index of euphausiid abundance to understand trophic interactions in the Bering Sea ecosystem

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Automated classification of multifrequency backscatter and analysis of concurrent plankton net tow catches during established acoustic-trawl surveys of walleye pollock (*Theragra chalcogramma*) on the Bering Sea shelf have been used to create an acoustic index of euphausiid (*Thysanoessa* spp.) abundance. Comparison of this acoustic index of euphausiid abundance with Pollock abundance from existing surveys has yielded an important observation: euphausiid and pollock abundance appears to be negatively correlated in both space and time. Large parts of the surveyed area were characterized by negative covariance between pollock biomass and euphausiid backscatter between 2004 and 2008, and whereas the biomass of pollock declined by half over that period, acoustic backscatter from euphausiids increased by at least threefold. One possible explanation is that recent declines in pollock abundance have reduced the effective predation impact of pollock on euphausiids, a key prey of pollock. To properly evaluate whether a release from top–down control of euphausiid populations by pollock predation is plausible, the euphausiid backscatter index must be scaled from units of acoustic backscatter to biomass. We discuss the results of using net catches and a physics-based model of euphausiid target strength to convert measurements of acoustic backscatter from four acoustic surveys on the eastern Bering Sea shelf to spatially explicit estimates of euphausiid biomass.

4.3 Ainhoa Lezama[1], Michael Ballón[2], Daniel Grados[2], Guillermo Boyra[1] and Udane Martinez[1] and Arnaud Bertrand[3] "Ecosystem approach of the Bay of Biscay pelagic ecosystem, by the simultaneous acoustical characterization of the main communities"

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The Bay of Biscay (Northeast Atlantic) is characterized by a complex physical forcing (circulation is controlled by river plumes, wind-induced upwelling, and deep canyons with intense mesoscale activity). In this system a multiplicity of small pelagic species (mainly anchovy, sardine, sprat, mackerel, horse mackerel and blue whiting) are foraged by top predators, fishers included.

Large amount of acoustic data have been collected in the Bay of Biscay, however, these data have only been used, so far, for stock assessment of the main fish target species. Acoustic data contain information on communities other than fish, in particular macrozooplancton which play an important role in the ecosystem functioning. Furthermore, one of the key macrozooplankton components easily identified in acoustics, the euphausiids, are one of the "big unknowns" in this ecosystem. Indeed although large euphausiids aggregations are regularly observed, their patterns of abundance and distribution are unknown as well as their interaction with other communities.

Here we adapted/applied a method based on bi-frequency analysis previously developed in the Humboldt Current system, to extract simultaneous information on small pelagic fish, fluid-like organisms (mainly euphausiids and large copepods), and others zooplankton scatter field species. We propose a first acoustic estimation of macrozooplankton biomass and describe its patterns of distribution according to the other communities and oceanographic parameters. Such information allows for an integrate study of ecosystem functioning and is a step forward for comparing the productivity and ecology of the Bay of Biscay with other upwelling systems.

4.4 Aymen Charef[1], Seiji Ohshimo[2], Ichiro Aoki[1] Effects of environmental forcing on pelagic fish distribution patterns in the East China Sea

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The East China Sea represents one of the main spawning and nursery areas of small pelagic fish in the waters off Japanese coasts. An ecosystem based fisheries management of these resources became an emergent issue to face the increase of fishing activities in these waters and to maintain sustainable productive commercial fisheries. Acoustic data were processed and fish schools were detected and characterized to identify target fish species. Two-stage generalized additive models (GAMs) were undertaken to investigate the relationships between environmental factors and distribution patterns. First, fish school characteristics (abundance, density, depth, height and length) were examined in relation to bathymetry and water salinity and temperature at various depths.

In second stage, models including most efficient predictors were selected and used to predict the abundance distribution in the non-surveyed areas. The application of GAMs offered biological interpretations of presence/absence of fish species. Near the Japan Sea, smaller fish schools were observed in response to the change in bottom topography and the decrease of salinity and temperature. Spatial modelling was useful to create plausible distribution maps and to estimate abundance, while considering environmental factors.

Keywords: environmental forcing, generalized additive models, distribution model, East China Sea.

4.5 Sandra Parker-Stetter[1] and John Horne[1] Assessing pelagic fish density distribution in the US Beaufort Sea

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Changing sea ice conditions in the Arctic Ocean has increased the potential for commercial fishing, oil and gas development, and transcontinental shipping. These potential changes in ecosystem use, coupled with increased international concern for Arctic ecosystem health, have heightened the need for ecosystem based assessments. A 2008 study used acoustics and midwater trawling to quantify density distributions of pelagic fish in the Beaufort Sea (20–500 m bottom depths) and to evaluate relationships between fish distribution and habitat descriptors. Age-1+ Arctic cod (*Boreogadus saida*) were the dominant pelagic/semi-demersal fish species, with peak densities of 150,000 fish/ha at bottom depths of 100–350 m. Oceanographically, age-1+ Arctic cod were associated with cold, saline waters. Interestingly, the density distribution of

age- 1+ Arctic cod closely mirrored published foraging distributions for beluga whales (*Delphinapterus leucas*). Age-0 fish (Arctic cod, sculpin, and eel blenny), dominated the pelagic biomass at bottom depths of 20–75 m, with peak densities up to 160,000 fish/ha, but were also found in surface waters at bottom depths >75 m. The age-0 fish were associated with warm, fresher water throughout the study area. A necessary component of the study was the development of an Arctic cod target strength to length relationship. Our equation, which included both age-0 and age-1+ Arctic cod, differed from other existing relationships. Given the large, unexploited biomass of Arctic cod in the Beaufort Sea, and its potential importance to marine mammals, there is a pressing need for standardized assessment and analytic methodologies that may be applied throughout the Arctic Ocean.

4.6 Rudy J. Kloser[1], Beth Fulton[1], Patrick Lehodey[2]; Ongoing model evaluation and use of acoustic indicators for the ecosystem approach to fisheries

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The increased number of overfished resources with impacted habitats and ongoing overcapacity in the worlds fishing fleets is well reported. This situation has lead to the adoption of an ecosystem approach to fisheries (EAF) to aid the traditional single species management approach. The implementation of EAF will require better governance and greater demands on our knowledge of the marine ecosystem beyond that of the targeted species. To achieve this, more knowledge of multispecies assemblages their trophic interactions and biomasses as a minimum will be required to monitor performance of EAF. In practice observational sampling for EAF will depend on the overall management arrangements for the fishery but a guide to the most useful indicators can be aided by modelling. We present two ecosystem models of Australian areas that highlight the dominant functional groups which provide the greatest information and the basic indicators to monitor change and direction. The ability of acoustic data to provide both quantitative and qualitative indicators over a range of trophic levels and large spatial and temporal scales is appealing. Using the ecosystem model we test the ability of acoustic data to provide quantitative metrics incorporating measurement uncertainty. The performance of acoustic indicators is presented as work in progress along with the development of acoustic observation systems and the experimental regions where we are applying them.

4.7 Summary of Indicators session (V. Trenkel)

The overview of the use of acoustics for ecosystem based management (EBM) showed that acoustics are currently mainly providing single species biomass indices for stock assessment models. Further, they are also used for gaining insights into local ecosystem functioning, in particular predator–prey spatial relationships. Four presentations showed examples of this classical use, though not always in classical situations, such as biomass estimates for plankton instead of fish. The Beaufort Sea is currently not exploited by fisheries, so using acoustic survey methods provided a baseline for species distributions and showed that the area is a nursery for several species including cod and sculpin (4.5). The spatial distribution of small pelagics in the East China Sea was shown to be related to environmental factors (4.4). In the Bering Sea, a negative spatial correlation has been observed between simultaneous acoustically observed euphausids and walleye pollock populations (4.2). Comparison of standing stock biomass estimates between euphausids and walleye pollock and walleye pollock potential consumption estimates supported the hypothesis that these spatial patterns could be a result of predation. It is noted that the frequency differenc-

ing method yielded an estimate of plankton (fluid like) biomass in the Bay of Biscay, which was much higher than estimates obtained based on net samples (4.3).

The review of suitable indicators for EBM derived from acoustic and complementary methods revealed the scope for further developments, in particular for metrics and indicators spanning species and trophic levels. Some initial tests with combining acoustics information in Shannon acoustics diversity indices were presented (4.1). The application to the Bay of Biscay showed their sensitivity to community structure (species composition) and diurnal effects. As an alternative to empirical testing, indicators or metrics can be tested in a simulation setting (4.6). However, traditional ecosystem simulation models might not be the most suitable, as they do not integrate the physical observation process for acoustics data. The topic of how to test acoustics derived indicators by simulation was taken up in the discussion. It might be worth proposing guidelines for such simulation tests. Further, it was felt that to test new acoustic indicators/metrics it would be useful to test them for well understood systems, as this would allow us to interpret highly aggregated metrics in terms of underlying ecological changes. The issue of reference points will require thinking and future work, as currently no such values are available for any acoustic derived metrics, other than stock biomass estimates. However, all developments within the acoustic community will contribute to ecological understanding and quantification from pattern description to metrics to indicators, all useful for EBM.

Proposed TOR for 2010

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.

Provide methods and standards for creating and validating indicators and metrics derived from acoustic and complementary methods. Evaluate and compare a range of suitable metrics in empirical situations and by simulation.

Proposed join session at ASC 2011 on indicators for EBM: How and what can acoustics provide?

5 Topic B: Observing (system) technologies – metrics, data processing, automated methods, data quality and management

5.1 John K. Horne. Characterizing temporally indexed acoustic data

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Distributions of pelagic organisms vary in space, time, and may be associated with fluid movements. Spatial distribution descriptions are often confounded by time when animals move and when surveys are conducted using mobile platforms. Temporally indexed acoustic data are rarely used to assess pelagic fish and macrozooplankton populations, with the notable exception of fish abundance estimates at counting stations. The addition of active acoustics to current and future ocean observing systems increases the potential use of temporally indexed data and the need to review metrics used to characterize vertical distributions and fluxes of water column biomass. Prominent biological features within the water column include aggrega-

tions, layers with distinct or diffuse boundaries, vertical migration of whole or partial layers, and shifts in vertical water column occupancy. Given that biological features can vary over temporal scales ranging from instantaneous changes in location of individual animals to seasonal or multiyear distributional shifts through community compositions, metric values must also characterize distribution patterns as a function of temporal scale. Metrics traditionally used to describe spatial distribution patterns and variability will be compared and contrasted to those used to describe temporally indexed data. A final set of metrics to characterize temporal acoustic data will be recommended.

5.2 Tim Ryan[1], Rudy Kloser[1], Gordon Keith[1] and Caroline Sutton[1] Standardised procedures for bio-acoustic data collection from ships of opportunities, data processing and dissemination as part of an integrated marine observing system

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Ocean observing initiatives are a rapidly expanding area of scientific endeavour both nationally and internationally. In Australia, the Integrated Marine Observing System (IMOS) has been running for three years, using satellite and a range of in-situ instruments to observe the physical and biological properties around the coast and open-ocean. For the first time, a bio-acoustic data stream that collects calibrated water column backscatter data (Sv) from vessels of opportunity has been added to the suite of measurements. Key features of IMOS are its unified data storage and access framework, along with timely and free availability of data to the public. To achieve this, the IMOS requirements are necessarily stringent with a strong emphasis on metadata and open data formats. This presentation outlines the procedures we are using for acoustic data collection, processing and dissemination to ensure that our data fits within the IMOS framework. More generally we hope to stimulate a discussion on how the acoustics community can take a consistent and unified approach so that ocean-observed bio-acoustic measurements have a common meaning and are comparable regardless of when, where and by whom they are obtained.

5.3 Gary D. Melvin[1], Norman A. Cochrane[2] and Pat Fitzgerald[3]. Evaluation for single and multibeam sonar technology for water column target detection in an acoustically noisy environment

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Acoustic backscatter measurements were undertaken in two differing locales within the Bay of Fundy system to evaluate the limitations in employing echosounders and sonars, in the presence of strong tidal currents, to potentially monitor fish distributions and movement in the vicinity of in-stream tidal turbines. Acoustic monitoring throughout the water column at two deployment sites within Western Passage appeared practical – but likely impractical at the immediately adjacent, but more turbulent, location known as the "Old Sow". Acoustic monitoring at a Minas Passage site near Black Rock on the Parrsboro shore appeared sometimes impossible within the upper half of the water column and occasionally throughout the water column due to vertical advection of near-surface entrained bubbles and resultant intense backscatter of a non-biological origin. The bubbles appeared entrained by tide rips in the vicinity

of Black Rock and drifted westward in a narrow stream for at least several kilometres. No bubble-induced anomalous acoustic attenuation was detected in the water column at 120 kHz. Based on our observations there appear to be limitations on when and where the technology can be effectively used, especially at the more turbulent sites

5.4 Thomas C. Weber[1], David A. Demer[2], George R. Cutter[2], and Christopher D. Wilson[3]. Working from top to bottom with the ME70 multibeam echosounder

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The recently developed Simrad ME70 fisheries multibeam echosounder has been designed primarily for investigations of marine organisms in the water column, with some stark differences between typical bottom mapping multibeam sonars (greatly increased dynamic range, much lower sidelobes, far fewer beams, and shorter aperture lengths). Ideally, the same multibeam sonar would be used simultaneously for both water column and seabed investigations, because both types of data have demonstrated value in defining Essential Fish Habitat. Our approach to using the ME70 for both water column and seabed investigations is to generate bathymetry and backscatter from standard water column modes. To achieve high resolution on the seabed despite the ME70's relatively low beam count (<45), we have developed a hybrid multibeam/phase-differencing approach that generates several soundings per beam (away from nadir), resulting in 100's of independent soundings per beam. Further, because this system can be fully calibrated using standard target spheres, we can generate angle-dependent bottom backscattering strength curves that are useful for classifying the substrate. This talk will be focused on the ability of the ME70 to perform seabed characterization work, including comparisons of the predicted and empirically derived sounding uncertainty, and examinations of angle-dependent backscattering strength in known sites. Field work on board the NOAA FRV "Oscar Dyson" conducted in both the Bering Sea and the Gulf of Alaska will be highlighted.

5.5 Laurent Berger, Mathieu Doray, Verena Trenkel. From 2D to 3D abundance estimates, impact of fish distribution and observed volume

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The precision of acoustic measurements depends on the relative size and position of fish schools compared to the acoustic beam width at a given depth. With an improved resolution and a wider sampling volume, the Simrad ME70 multibeam echosounder is expected to improve the precision of acoustic-based fish stock estimates. Detailed school simulations using values for school densities and sizes observed in the Bay of Biscay were used to quantify the impact of resolution on the variability of backscatter measurements and to estimate the possible observation bias for schools which are small compared to the beam width. Simulations were also used to study the impact of the across ship track school distribution on single beam and multibeam echosounder measurements and to quantify the impact of sampling volume on the variability of backscatter measurements. In the Bay of Biscay, the number of encountered schools (sample size) is generally small for single beam observations; hence the increased sampling volume of the ME70 can lead to substantially increased sample

sizes. The simulation results are used for explaining observed differences between NASC for single beam and multi beam echosounders in the Bay of Biscay.

5.6 James H. Churnside[1] and Alexei F Sharov[2]. Aerial surveys of menhaden in Chesapeake Bay

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The performance of airborne lidar and video for surveys of menhaden in Chesapeake Bay is compared. Video has a lower statistical uncertainty in school detection [relative standard error (RSE) 0.04 vs. 0.07] because of the greater swathe width. Lidar has a greater probability of detecting a school (0.93 vs. 0.73) because of the greater depth penetration. It has a lower probability of a false identification (0.05 vs. 0.13) because it is less dependent on surface conditions and ambient illumination. Lidar also has less variability (RSE 0.34 vs. 0.73) in repeated coverage of the same area. The average depth penetration of the lidar was 12 m, while the average depth of detected schools was 3 m. The performance of both techniques decreased with increasing windspeed, although the effect was smaller for lidar. The school area inferred by the two techniques was nearly the same. An examination of the missed schools and false identifications in lidar and video suggests that a combination of the two reduces most of the uncertainties associated with the use of either technique alone.

5.7 Nils Olav Handegard[1],[2], Kevin Boswell[3], Simon LeBlanc[2] and Iain Couzin[2] Detecting schooling behaviour using multi beam sonar and optical flow tracking methods

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Acoustics offer a method to observe fish behaviour in situ. When the density increases conventional tracking methods yield poor results. In this communication we show how to use dual frequency identification sonar (Didson) to observe schooling dynamics of prey species attacked by predators. We show that optical flow tracking techniques provide a promising method to analyse such data. Examples of the methods' ability to detect rapid fluctuations and dynamics are shown, and methods and applications are discussed.

5.8 Reka Domokos. Acoustic investigation of bigeye tuna at Cross Seamount

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Cross seamount in the Hawaiian archipelago is known to aggregate juvenile and subadult bigeye tuna, a population which is heavily targeted by the local fishery. In this study, acoustic descriptors such as aggregation shape, depth, density, and target strength were identified that are consistent with those of bigeye of the expected size range but different from those of other fish found at Cross Seamount. Results from fish tracks collected during shipboard acoustic surveys and identified as most likely bigeye indicate that bigeye actively forages at the seamount and are at least partially drawn there by the presence of increased forage, micronekton. Bigeye tuna are tightly

associated with the 400 m deep plateau or slopes that are not deeper than about 500 m. Acoustic data indicate that bigeye exhibit aggregated deep diving behaviour over the plateau. Bigeye tuna appear at dawn at the upcurrent edge of the plateau to feed on specific micronekton layers which are migrating downward from the shallow scattering layer. At this time, bigeye occupy a very small area of the plateau, are highly mobile, and form very loose aggregations. During the morning hours, bigeye spread over a larger area of the plateau, still feeding. Aggregations at this time frequently span the entire depth range of the plateau (~20–400 m). During the afternoon and early evening, bigeye occupy the entire area of the plateau and tend to form thicker aggregations. At around sunset, thick aggregations of bigeye start dispersing with their acoustic detection being minimal during the night.

5.9 Samuel S. Urmy, John K. Horne, and David H. Barbee. Temporally indexed patterns of pelagic fauna in Monterey Bay

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DEIMOS (Deep-Water Echo Integrating Marine Observatory), a 38 kHz echosounder at the MARS cabled observatory node in Monterey Bay, California, has been sampling at 0.2 Hz from 875 m depth on the continental slope since February 2009. Monterey Bay is located in the eastern-boundary California Current, and invertebrates dominate its pelagic fauna. The distribution and density of scattering organisms vary over a range of time-scales, from seasonal changes related to upwelling through diel vertical migrations to predator–prey interactions. Multiple scattering layers have been present throughout the year, changing seasonally in depth and number. Fewer layers migrated in late summer and autumn than in late winter and spring, but average density increased, due to a thick, deep, non-migratory layer that appeared midsummer. Throughout the deployment, the deepest 100–300 m were sparsely populated with single targets (mean TS approximately –58 dB re 1 μPa at 1 m). We have used a set of time-indexed metrics, including measures of density, location, and structure, to parsimoniously describe these vertical distributions. Long-term, temporally indexed data at high resolution are rare in the aquatic environment. Acoustic observatories such as DEIMOS can help fill this gap by providing a synoptic, near-continuous view of the water column over extended periods.

5.10 Rich Pawlowicz[1], Bob McClure[2]. Inverted Echosounder for High-Resolution Water Column Profiling from the Neptune (Canada) Ocean Observatory

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Long-term investigation of physical oceanography and fisheries-related biological oceanography on the west coast of Vancouver Island, British Columbia, Canada is being carried out through a monthly time-series of euphausiid biomass (18 years) and CTD+oxygen+Chlorophyl profiling, (6 years) in Barkley Sound, a relatively open coastal embayment. In order to better understand these time series, and how they relate to variations in the local ecosystem, a 3 frequency (38, 123, 210 kHz) upward-looking scientific echosounder has been deployed at a depth of 109m at the entrance to Barkley Sound. Operating as part of the Folger node of the deep-ocean cabled NEPTUNE observatory, observations began Nov 2009 and will continue into the foreseeable future at a sampling rate of 1 Hz. The whole water column is sampled. The sounder is intended to study fish/zooplankton behaviour and biomass variations

on time-scales of daily to interannual. Acoustic data accumulates at a rate in excess of 1 Gb/day. Although storage and retrieval is robustly handled by the NEPTUNE DMAS (Data Management and Archiving System) the size of the dataset presents a number of challenges in viewing and interpreting the datastream. Monitoring will be accomplished using a small set of derived time-series, as well as an automated alarm series to identify periods where anomalous events that may require more detailed investigation may occur.

5.11 David A. Demer[1]*, George R. Cutter[1], Josiah S. Renfree[1], Thomas C. Weber[2], Sarah Stienessen[3] and Christopher D. Wilson[3] Characterization of pelagic scatterers using multibeam echosounder data: echo amplitude and phase, and their variabilities and frequency spectra

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A recently developed statistical-spectral approach to acoustic-target identification (SSID) incorporates information contained in the frequency-dependent signal amplitudes and their variances. In addition to identifying biological targets, the SSID has demonstrated utility for estimating fish aggregation densities, abundances, and behaviours, and detecting and classifying the seabed (e.g. accurate depth, within-beam slope, hardness and roughness, and the height of the unresolved boundary region, the so-called dead zone. Further, the related multifrequency, bi-planar, interferometric technique (MBI) allows much higher resolution measurements of the seabed and sub-beam measures of slope, hardness and roughness. Here we extend the utilities of the SSID and MBI methods, with explicit consideration of the single-frequency signal phases and their variances, and frequency-dependent split-aperture phases and their variances, for improved estimations of pelagic-target sizes, and their aggregation densities, behaviours, and shapes. Data from the Simrad ME70, split-aperture, multibeam echosounder allow these methods to be applied to data collected over a broad-bandwidth and range of incidence angles for more classification and observation possibilities.

5.12 George R. Cutter[1], David A. Demer[1]. Variable-aperture processing of multibeam echosounder data to better resolve fish locations and seabed detections

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Acoustic classifications of fish and estimations of their orientation distributions are possible using multifrequency or broadbandwidth measurements of their acoustic target strengths (TS) with knowledge of their scattering directivity pattern (SDP) and size distributions. To measure TS of in situ fish, singlefrequency interferometric methods provide information to detect resolvable single targets and estimate their location within the acoustic beam. This technique is compromised by multiple targets that are unresolvable because of their spacing, but this situation can be mitigated with the use of multifrequency interferometry. The ambiguity caused by coincident echoes can also be substantially reduced using single-frequency, multiple-aperture interferometry. This method uses phase differences from multiple sub-arrays of a single-frequency (200-kHz) multibeam echosounder to estimate robustly when echoes originate from a resolvable single target, and its position within the acoustic

beams. Results provide accurate measures of beam-compensated TS and, in cases of low density scatterers, estimates of their volume density. Multiple-aperture interferometry can significantly improve the utility of single-frequency multibeam echosounders for quantitative measures of fish and zooplankton, and seabed-range detections.

5.13 Observatories discussion (John Horne)

Twelve papers were presented in the Observatory session encompassing a variety of locations, platforms, and acoustic technologies. Applications of the current or proposed observing systems included entire ecosystems monitored by dedicated research vessels and ships of opportunity, proposed renewable energy sites, and single locations continuously monitoring the water column. The definition of observatories or observing systems continues to expand with an increased number of required biological applications, as well as the number and type of acoustic instruments used to monitor aquatic organisms. An explicit requirement when contributing acoustic data to observing systems is the standardization and recording of metadata. Metadata should include not only the conditions of data collection but the settings and calibration parameters needed to ensure data accuracy. The potential to use acoustic data from observing systems as descriptors, metrics, and indicators of biological variables when monitoring ecosystems or detecting ecosystem change was noted during presentations. The challenge of identifying and validating direct or derived metrics is a current issue to be resolved. From a technical perspective, the integration of acoustic instruments within the suite of observatory sensors and the calibration of equipment were two issues that have to be addressed within the operations of an observing system.

6 TOPIC C: Target strength and species identification modelling and measurement

6.1 Kyounghoon Lee, Won-Deuk Yoon, Chang-Doo Park, and Seong-Wook Park. In-Situ Target Strength and Density Estimates of Giant Jellyfish (*Nemopilema Nomurai*) and Moon Jellyfish (*Aurelia Aurita*)

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A giant jellyfish (*Nemopilema Nomurai*) and 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 giant jellyfish, which is presumed to be developing in the East China Sea, is big size and gives a fatal damage to Korean and Japanese coastal and offshore fisheries. 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. And then, their size distribution from in situ TS was compared with sampling data from a bottom-trawling survey accomplished during 2006–2009. 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 southwest coast area of Korea. 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 and offshore areas.

6.2 Marian Peña[1], Joan Miquel[1] and Magdalena Iglesias[1]. Acoustic observation of zooplankton species in Cabrera and Sóller areas (Balearic Sea), Spain

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Multi-frequency techniques are applied to data registered in two oligotrophic areas of the western Mediterranean (the Balearic and Algerian sub-basins) with different geomorphologic and hydrodynamic characteristics, within the IDEADOS project. One of the objectives of this project is to determine the viability of the application of acoustic methods on the characterization of the communities of the meso- and bathy-pelagic system and the deep habitats in those areas. Ground-truthing from pelagic fishing and plankton nets (Calvet, WP2, Multinet, IRKMT and 3WP2) is available, though partly processed yet. Day-night distribution, acoustic layers typologies and preliminary acoustic identification of zooplankton groups is discussed. Analysis of the relative frequency response measured over three frequencies, 18, 38 and 70 kHz, contrasted to data from pelagic hauls is used to preliminary characterize acoustic backscatter. Trophic migration of myctophid species was recorded: direction of migration, acoustic and biological properties are considered.

6.3 Eckhard Bethke[1] and Benjamin Planque[2]. Estimation of TS-Values by counting the Targets and measuring the s_A–Values

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The basic idea is simple. For conditions where only a certain species and size of fish were caught one can often count the individual fish on the echogram. At the same time we know the measured s_A- value of the fish. Starting from the basic equations of hydroacoustics we can vary now the TS-value in a way that the number of fish counted, explain the s_A-value. A calibrated sounder is a basic requirement of this measurements. However, the intention at the end is not the use of this method for objective measurements of TS-values of fish but to calibrate echosounders of commercial fishing vessels. This method can be used in both directions, for the measurements of the parameters of the TS-equation and also for the calibration of echosounders if the targets are known. The finally goal is to provide measured data for scientific analysis which gained from fishing vessels using the catch data.

6.4 Ana Lara-Lopez[1], Peter Davison[1], and J. Anthony Koslow[1]. Methodological challenges to estimating abundance of mid-trophic organisms using multi-frequency acoustics and net sampling in contrasting hydrographic regimes off Southern California

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Concurrent acoustic and trawl data were collected in the California Current near Point Conception to compare the abundance of mid-trophic level animals present in contrasting water masses. Acoustic data were taken with a calibrated EK-60 equipped with 4 frequencies (38, 70, 120 and 200 kHz). A 5m2 Matsuda-Oozeki- Hu Trawl (MOHT) was used to collect midwater animals. Acoustic data were recorded to up to

750 m depth at a ping rate of 0.5 s-1 and pulse length of 0.512ms. Species identification and length measurements were obtained from trawl samples to model target strength (TS) as a function of frequency. Frequency spectrum shapes of the modelled target strength (TS) were categorized into "acoustic groups". Non-negative least squares inverse methods were applied to the observed multifrequency TS using the acoustic groups defined from forward modelling. Organisms were categorized into "acoustic groups" according to their frequency spectrum using modelled TS. The resulting abundance estimates of each acoustic group are compared to the trawl catch across the front. Challenges to the data interpretation include high species diversity, ontogenetic changes in swimbladder composition, net avoidance, and the inability to observe animals in the surface "dead zone" of 10 m. Several approaches will be presented to meet these challenges.

6.5 Gavin J. Macaulay, Olav Rune Godø. Diel variation in frequency response of gadoids in the Barents Sea. Is fish tilt-angle and swimbladder inflation the reason?

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Multi-frequency acoustic recordings of cod and haddock in the Barents Sea show a marked diel variation in amplitude. One hypothesis is that this is due to a diel change in the fish tilt angle distribution and swimbladder inflation level. Cod swimbladders were approximated by a prolate spheroid and the target strength (TS) at 18, 38, 70, 120, and 200 kHz estimated from a prolate-spheroid modal-series scattering model at low ka and the Kirchhoff-approximation at high ka for a representative fish length distribution and wide range of fish tilt-angle distributions and swimbladder inflation levels. As the mean swimbladder tiltangle moved away from horizontal the mean and spread of the TS values reduced, particularly at higher frequencies. Changes in the standard deviation of the swimbladder tilt-angle caused only minor changes to the mean and spread of the TS. Changes in swimbladder inflation level could have large changes on TS but this was strongly dependent on the depth ranges that the fish moves between. Barents Sea survey and simulated area backscattering coefficients (sa) were then normalized to those at 38 kHz and compared and broad-scale changes in fish tiltangle distribution and swimbladder inflation level investigated

6.6 Dezhang Chu, Rebecca Thomas, and Lawrence C. Hufnagle. Can we tell Pacific hake (*Merluccius productus*) from Humboldt squid (*Dosidicus gigas*) acoustically?

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In recent years, a massive northward invasion of Humboldt squid (*Dosidicus gigas*) into the waters off almost the entire West Coast of North America. This has brought a significant change in ecosystem dynamics in the California Current System (CCS). During the 2009 US-Canada joint Pacific hake acoustic trawl survey, Humboldt squid were often found to be mixed with hake layers in large numbers. This presented a serious complication to the acoustic identification of Pacific hake. In this presentation, preliminary investigations of spectral and statistical analyses of backscatter from Humboldt squid and hake will be presented. The analysis will be primarily based on multifrequency echograms collected during the 2009 hake survey. Discussions on the unexpected frequency dependence of the Humboldt squid target strength will also be

provided. This is a feasibility study and we believe that the results from this research can improve our capability of distinguishing between Humboldt squid and hake in future.

6.7 J. Michael Jech[1], T. K. Stanton[2], D. Chu[3], and J. D. Irish[4]. Broadband methods for resonance classification and high-resolution imagery of fish with swimbladders using a modified commercial broadband echosounder

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A commercially available broadband acoustic system (Edgetech, Inc.), originally designed for seabed applications, is being used to study fish with swimbladders. The towed system contains broadband acoustic channels collectively spanning the frequency range 1.7–100 kHz, with some gaps. Using a pulse-compression technique, the range resolutions of the echoes range from 3 to 20 cm depending on frequency band, allowing high-resolution imaging of patches and resolving fish near the seabed, as well as in the water column. The swimbladder resonance frequency can be used to estimate the volume of the swimbladder (inferring the size of fish), and signals at the lower frequencies do not depend strongly on the orientation of the fish, thus minimizing effects of behaviour on abundance estimates. At-sea studies of Atlantic herring (*Clupea harengus*) demonstrate the potential for routine measurements of fish size and density, with significant improvements in accuracy over traditional high-frequency narrowband echosounders. The system is also being used to detect patches of scatterers, presumably zooplankton, at the higher frequencies. New and innovative techniques for quantitative use of broadband systems, such as broadband calibration and relating target strength and volume-scattering strength to biological quantities, have been developed. Details are given in the paper: http://icesjms.oxfordjournals.org/content/vol67/issue2/index.dtl

6.8 Joseph D. Warren[1], Joy N. Smith[1], and Patrick H. Ressler[2]. Measurements of physical properties of Bering Sea zooplankton and their use to improve estimates of euphausiid Target Strength

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Assessment of walleye pollock (*Theragra chalcogramma*) stocks in the Bering Sea is conducted regularly using a combination of trawlnet sampling and multiple frequency acoustic echosounder surveys. Physics-based acoustic scattering models can be used to estimate both the amount and frequency response of the acoustic energy scattered by the zooplankton that are also detected during these surveys, but these models require knowledge of several acoustically important characteristics of the animals. Bering Sea krill (*Thysanoessa* spp.) and other zooplankton were collected from near-surface waters during summer of 2008. Animals were maintained in shipboard aquaria and a variety of morphological (size, shape) and acoustical (animal density and sound speed) properties were measured. CTD casts provided information about environmental conditions where the animals were collected. We investigated how these parameters varied among individual krill and over large geographic

distances (100s km) as well as how the acoustic scattering from individual (and groups of) krill would vary with these parameters. Significant differences in the acoustic scattering characteristics of krill were found for several of these parameters. Our results suggest that krill Target Strength (TS) varies geographically and that acoustic surveys may need to collect additional information about zooplankton in order to have accurate estimates of zooplankton numerical density or biomass.

6.9 Jules S. Jaffe[1], Paul L. D. Roberts[1]. Estimating fish orientation from broadband, limited-angle, multiview, acoustic reflections

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We have recently determined that multiview, broadband (635–935 kHz), nearly monostatic, acoustic reflections recorded from lateral views of juvenile fish can be used to infer animal orientation. Calibrated acoustic data were recorded from live fish in a laboratory while orientation was measured simultaneously via optical images. Using eight animals, two-dimensional datasets of target strength as a function of frequency and orientation were obtained. Fish length, lateral thickness, and dorsoventral thickness ranged from 24 to 48 mm, 3 to 7 mm and 10 to 20 mm, respectively. Preliminary estimates of orientation were computed from the direction of the gradient of the local autocorrelation function in the target strength image. These local estimates were then median-filtered over the full system bandwidth (but still limited angle) to improve accuracy. Angular estimates were then corrected for systematic bias via a simple, one-dimensional model that approximated the animals' reflection by that of a bar target. Taken over all orientations, the average absolute error in orientation estimation is 5.6o to 17o, dependent on the dataset. Results indicate, for most sets of views, reasonable estimates of lateral orientation can be obtained from broadband, multiview data over a set of limited angular reflections.

6.10 Summary of Session C (Mike Jech)

Ten presentations were given during the session on target strength with subjects ranging from jellyfish and zooplankton to mesopelagics and mid-trophic levels to top predators. A common theme among the presentations was the application of inverse methods to classifying and enumerating marine organisms. This represents an evolution from measuring target strength (the forward problem) to modelling and using target strength in classification methods and algorithms and estimating density and abundance (the inverse problem). There was the recognition that environmental and biological variability needs to be incorporated in classification routines and reporting of results. Included in this was how spatial complexity of the environment may influence material properties such as density and sound speed of organisms and how behavioural attributes such as spatial orientation and activity of individuals (i.e. swimming) and vertical migration, and anatomy and morphology of the animals affect classification and enumeration proficiency. A recurring discussion subject was the commonly observed mismatch between acoustic measures and trawl and net samples. This issue could be addressed by using acoustics and nets as complementary data rather than arbitrarily selecting one as the standard.

Suggested Draft TORs

Models and measures of target strength for classifying and enumerating living marine resources and associated variability of validating results (Presentation session)

Use of acoustic and fishing technologies as complementary data to address the variability of validating biomass estimates (Joint WGFTFB/WGFAST presentation session)

7 Topic D Behaviour/Surveys

7.1 J. Michael Jech[1] and Francine Stroman[2]. Shapes and sizes of Atlantic herring spawning queues on Georges Bank: 1999–2008

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Atlantic herring (*Clupea harengus*) in the offshore regions of the Gulf of Maine migrate each fall from their feeding grounds to the northern portion of Georges Bank to spawn. The NEFSC herring acoustic survey has taken advantage of this behaviour by conducting an annual systematic survey of the congregated fish since 1999. This survey consists of collecting multifrequency (18, 38, and 120 kHz split-beam echosounder) acoustic data and midwater trawl hauls on the FRV "DELAWARE II" along parallel transects. Acoustic data are classified using objective computer algorithms, visual scrutiny, and species composition from trawl catch data. Abundance estimates from these acoustic surveys suggest a change in herring abundance, which could be due to behavioural changes over the past ten years. To address this, herring acoustic backscatter are being analysed to describe their aggregation/schooling behaviour (e.g. shapes, sizes, location in the water column, density, and spatial and temporal distribution). School detection parameters were selected and algorithms were applied using Myriax's Echoview® software with the goal of analysing historical data for trends in spawning and queuing behaviour. The potential effects on monitoring surveys will be discussed.

7.2 Alex De Robertis[1], Christopher D. Wilson[1], and Neal J. Williamson[1]. Do silent ships see more fish? Quantifying fish reactions to a noise-reduced and a conventional research vessel in Alaska

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Fish avoidance of an approaching vessel is a major source of uncertainty in fish abundance surveys. Vessel noise is considered the primary stimulus for vessel avoidance, and standards for noise emission by research vessels have been established to minimize vessel avoidance. Although several noise-reduced vessels are in service, the effectiveness of noise reduction on vessel avoidance remains unclear.

Here, we summarize a series of vessel-comparison experiments to assess fish avoidance, which were conducted with the NOAA ships Oscar Dyson, a noise reduced vessel and Miller Freeman, a conventional research vessel. Experiments were conducted in 2006–2008 during five acoustic-trawl surveys of walleye pollock (*Theragra chalcogramma*) over a broad range of fish depths (~50–700 m), environmental conditions (e.g. winter, summer; day, night) and situations (e.g. non-spawning vs. spawning). The vessel comparison revealed significant differences: acoustic abundance estimates were substantially higher (up to 44%) from the noise-reduced vessel in some situations. The vessel discrepancy at each location tended to decrease with depth, which is consistent with a response to a stimulus propagating from the vessel. However, the results among the different sites could not be explained by fish depth alone. In one (of four) sites, there was a much stronger avoidance reaction at night than during the day. Observations from a buoy-mounted echosounder confirmed

that the discrepancies are attributable to decreased fish reactions to the noise-reduced vessel. These results illustrate that biases may be introduced into a fish stock abundance time-series by switching vessels, particularly when initiating use of a noise-reduced vessel.

7.3 P. Brehmer[1], F. Gerlotto[2], J. Guillard[3], P. Arzelies[4], Y. Guennégan[5], Erwan Josse[1]. The fish avoidance reaction to an approaching vessel: not just a simple noise level threshold determinism

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The fish avoidance to an approaching vessel is an important issue in ecological studies, and for assessing fish populations in school structures. Using the data collected simultaneously by both sonar and echosounding in a lake, we have identified boat-induced behavioural changes in small pelagic fish schools. Using high resolution sonar data, we showed that the fish schools detected under the boat have a significantly larger volume than those alongside the boat. This finding is explained according to behavioural response due to the theoretical characteristics of the boat diagram sound pressure, and the existence of a strong thermocline. Then we compared two descriptors, the height of the fish school and the backscatter energy. We found significant differences, which reveal vertical fish school compression occurring simultaneously with the horizontal and sidelong escape behaviour. On the other hand we show that this avoidance reaction does not depend solely on the level of noise generated by the platform (usually a research vessel). An experiment carried out using a speedboat and a research vessel was carried out to compare the echosounder data obtained using the speedboat, which complied with the ICES reduced-noise standard, to that obtained using the research vessel. The results show that there was no difference between both platforms for the TS distributions, that the difference between the numbers of schools observed was very slight, and that the area and perimeter of the schools were similar. However, the shoals detected by the noisier vessel were deeper in the water, and unexpectedly had a significantly higher energy level. These findings suggest that noise-reduced vessels trigger a different avoidance reaction in pelagic fish. We assume that the noisier vessel triggered a smaller avoidance reaction at a longer range; whereas the quieter speedboat triggered a greater avoidance reaction at a shorter range. The noise-reduction standard is not sufficient to eliminate avoidance behaviour in pelagic fish in shallow water. We also have to take into consideration the level of ambient noise, which could impair perception of the platform by the fish, and the probability that the acoustic stimuli could be less important than visual perception under some local conditions. Lastly, we recommend that the vessels routinely used for pelagic stock assessment surveys should not be changed. This is in order to maintain a standardized time-series, which would be disrupted by switching to a new, noise-reduced fisheries research vessel.

7.4 Mathieu Doray[1], Laurent Berger[2], Pierre Petitgas[1], Verena M. Trenkel[1]. In-depth characterization of Biscay surface pelagic fish communities with ME70 multibeam echosounder

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In the Bay of Biscay, small pelagic fish communities are generally comprised of several species occupying neighbouring ecological niches at mid-trophic level. They play an important functional role in the pelagic ecosystems as forage species, ensuring energy transfer towards higher trophic levels. For ecosystem based management, better knowledge of this fish assemblage is needed to assess their resilience and anticipate their evolution in the face of fishing and/or climate related global change. The ME70 multibeam echosounder provides data of unique range and resolution for the description of the three-dimensional (3D: vertical x athwart x alongship) morphology of small pelagics shoals. It provides a 15-fold greater sampling volume than monobeam echosounders, in particular near the sea surface. Here we assess the improvement conferred by the use of ME70 3D acoustic data, in terms of abundance estimation and morphological description of surface fish shoals. The sensitivity of results to the threshold values are explored.

7.5 Sarah Stienessen[1], Christopher Wilson[1], and Thomas C. Weber[2] Associations between juvenile walleye pollock aggregations and the environment in the north Pacific

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The spatial distribution of walleye pollock, *Theragra chalcogramma*, is affected by environmental processes that function across a range of spatial and temporal scales. Although various studies have examined this relationship over large geographic areas, little is known about how biophysical processes influence the localized spatial patterns of walleye pollock. This study describes the three-dimensional size and shape patterns for three age-classes of juvenile walleye pollock aggregations in the eastern Bering Sea in relation to biophysical processes. Aggregation metrics were estimated from acoustic data collected with calibrated Simrad ME70 multibeam sonar during the NOAA acoustic-trawl survey conducted in the eastern Bering Sea during June-July 2009. Physical oceanographic measurements (e.g. ambient light levels, temperature) were also collected. Preliminary results indicate that as juvenile walleye pollock mature from 1 to 3-year olds, they form more elongated aggregations deeper in the water column, and they exhibit more variation in aggregation structure. Whether the variability of age-specific aggregation structure is associated with several biophysical processes will be addressed. The work provides a better understanding of juvenile walleye pollock responses and emergent patterns to their environment, and is fundamental to understanding the larger-scale ecological processes that influence this species in the north Pacific.

7.6 Jonsson Patrik*, Börjesson Patrik, Svensson Anders, Jacobsson Peter Larson, Niklas, Sköld, Mattias Using acoustics to monitor demersal fish in a coastal protected area

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A small and diminishing cod population located in a Swedish west coast fjord is protected by means of zonal regulations of fisheries and no-take zones. We present the set up and design of an acoustic monitoring program. Changes in biomass and number of larger fish (Ts > -32 dB) are estimated using a 120 kHz split-beam echosounder. Estimates are calculated using single echo detections and in situ fish size distributions. Fish traps and handlines are used to confirm the presence of mature cod. Despite the limitations of acoustic monitoring of demersal fish, acoustics proves to be cost efficient compared to other non-lethal methods.

7.7 Discussion sessions on Behaviour (Alex De Robertis)

The presentation session and subsequent discussions emphasized that behaviour is a common thread that runs through much of the work done by the membership of WGFAST. This was evident from the frequent discussions of animal behaviour in the other presentation sessions. The major themes of presentations and subsequent discussions in the session were 1) impacts of behaviour on acoustic measurements, and 2) studies of fish aggregation structure. It was evident during the session that increased understanding of behaviour is required as changes in behaviour impacts precision and accuracy of inferences from acoustic methods. For example, fish react to vessels, which will bias abundance measurements. For example, it was emphasized that behaviour can have major impacts on target strength, which introduces substantial uncertainty in the interpretation of acoustic backscatter measurements. The consensus was that continued work is required to characterize the impact of behaviour on these sources of uncertainty. It is clear that predicting behaviour is a major challenge, and that development of techniques to measure and characterize the impacts of behaviour and its impacts on acoustic inferences is required.

It was also recognized that the high spatial and temporal resolution offered by active acoustics offers unique capabilities for studies of the behaviour of aquatic animals. This capability offers a major opportunity for advancing our understanding of behaviour in marine systems. There were several reports of new developments in measurements of fish aggregation characteristics using advanced multibeam echosounders as well as ecological studies using the morphology of schools to infer behaviour. There was consensus that great opportunity exists for measurement of behaviour, for example vertical distribution of organisms, or timing of arrival to a spawning site could be acoustically inferred using acoustics. The uncertainty in these metrics has the potential to be substantially lower than those of abundance estimates. Coupled with a mechanistic understanding of the ecology of a species of interest, this could be used to generate robust indicators to characterize ecosystem processes.

Suggested Draft TORs

Characterization of animal behaviour in order to describe measurement uncertainty and improve the accuracy and precision of acoustic and complementary technologies (Presentation session)

Extraction of behavioural metrics from acoustic measurements. (Presentation session)

From observation to prediction of behaviour: linking acoustic measurements with behavioural models. (Presentation session)

8 Fishing Vessel surveys and SPRFMO update summary paragraph by Francois Gerlotto

8.1 François Gerlotto[1], Mariano Gutierrez[2] , Jorge Castillo[3]. The importance of acoustic data from fishing vessels for the analysis and management of the Chilean Jack Mackerel fishery in the South Pacific Ocean

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Large fisheries such as the Chilean Jack Mackerel (CJM) *Trachurus murphyi* fishery in the South East Pacific Ocean are among the most difficult to manage, due to their dimensions: the CJM covers a wide area in the Pacific Ocean, from 35ºS to 45ºS and 70ºW to 178ºE (New Zealand) in the open ocean, as well as inside the Peruvian and Chilean EEZs (4ºS – 45ºS). A large part of the stock is present outside the EEZs and several countries (Chile, Peru, Russia, China, New Zealand, EU, etc.) are exploiting it. Since the 70s (EUREKA surveys, Peru) and 80s (RASTRILLO surveys, Chile), vessels from the fishing fleet have been used for large synoptic acoustic surveys, and on specific experiment using acoustic data collected by the fishers during their routine operations on the fishing grounds. The use of acoustic data from fishing vessel presents several major advantages (see ICES CRR NO. 287 August 2007: Collection of acoustic data from fishing vessels, W. Karp Editor). They present also some drawbacks, mostly due to the difficulty in calibrating the acoustic devices and the huge amount of data to process and analyse. We describe the past experiences in Peru and Chile, and we suggest the development of a common methodology to be applied on the whole fleet by using a set of instrumented fishing vessels, through cooperation and participation of the different countries exploiting the CJM. The South Pacific Region Fishery Management Organization (SPRFMO) has established an informal study group to consider the use of acoustic data from fishing vessels.

8.2 Mariano Gutierrez[1], Emilio Mendez[2]. Acoustic monitoring of ecosystem functioning off Peru based on industry vessels echosounders

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The Northern Humboldt Ecosystem off Peru is highly variable though specially in the border front between coastal and oceanic water masses. The daily oceanic changes affects the fishing operations though provides an opportunity for continuously observing certain features of ecosystem functioning, such as depth of thermoclyne, zooplankton availability and internal waves using digital echosounders and processing methods. A relevant aspect is the observation of changes in the biological diversity after every fishing operation. There is a number of species rarely observed during scientific surveys though often caught during fishing seasons, and then there are no special regulations and studies on those living resources. Furthermore the possible use of industry vessels as platforms of opportunity might provide high resolution data on spatial extent and habitat characteristics to understand population dynamics of fish species. If stock abundance is mediated by spatially explicit processes it seems essential that management tools are designed to account for this.

8.3 Sigurður Þór Jónsson[1], Þorsteinn Sigurðsson[1], Páll Reynisson[1], Birkir Bárðarson[1]. MRI and industry vessel co-operative acoustics in Iceland

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First steps in MRI and industry co-operative acoustic surveys in Icelandic waters will be described. Vessels belonging to the pelagic fisheries fleet, now 7 were calibrated on standard 38 kHz ES or EK60 echosounders on a voluntary basis in 2008–2010. Commercial vessels acoustics were included in the capelin stock estimates in 2009 and 2010 and estimates of summer-spawning herring stock in 2009. The commercial vessels have either had a scientist on board or followed cruise tracks laid out by the institute, with remote control of the acoustic instrumentation and interpretation of downloaded data by scientists ashore. Industry participants have been remunerated with increased quota shares. A rough sketch of how MRI would like to see this cooperation developing in order to take advantage of the possibilities it presents is put up for discussion.

8.4 Discussion session on fishing vessel acoustics (Francois Gerlotto)

Although the presentations concerned only two areas (South Pacific and Iceland), it was acknowledged that the question of "fishing vessel acoustics" was taking a growing importance in the world and that the results of the session are of interest to most of the industrial fisheries. Incidentally it was noted that there were no major conceptual difference between the use of fishing vessels and ships of opportunity.

The SPRFMO scientific working group (subgroup "Chilean Jack Mackerel") presented its works to WGFAST with a request to achieve common research in this particular field. The groups agreed to have a common topic group during the next WGFAST meeting in Iceland in 2011.

One conclusion of the meeting was that the technique tools used aboard modern fishing ships are very close to scientific equipment and that there is no real material problems for using ships of opportunity and fishing vessels as a source of acoustic data. The two main questions concern (i) the additional cost of this activity, mostly in terms of equipment and cost of personal for data management; (ii) the definition and types of data (metrics, indicators) to be selected from the fishery vessels' huge quantity of information potentially accessible. It was in particular discussed on what is the best strategy, either record and store all the raw data from the fishing fleet, or do a preselection of the useful data and record only the information from these data. No agreement was obtained on this point, which should be one of the terms of reference of the future topic group.

9 Topic E – Review of long time-series survey programs

9.1 Marie-Hélène Radenac[1], Patricia E. Plimpton[2], Anne Lebourges-Dhaussy[3], Ludivine Commien[1], Michael J. McPhaden[2]. Impact of environmental forcing on the acoustic backscattering strength in the equatorial Pacific: diurnal, lunar, intraseasonal, and interannual variability

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We analyse several records of mean volume backscattering strength (Sv) derived from 150 kHz Acoustic Doppler Current Profilers (ADCPs) moored along the equator in upwelling mesotrophic conditions and in the warm pool oligotrophic ecosystem of the Pacific Ocean. The available long time-series allow gathering non-intrusive information about zooplankton and micronekton at the same spatial and temporal scales as physical observations. A high Sv layer spreads out from the surface to the middle of the thermocline between dusk and dawn in the mesotrophic regime. Biological and physical influences modify this classical diel cycle. When oligotrophic waters surround the 170°W and 140°W moorings during El Niño years, a subsurface night-time Sv maximum that does not exist in mesotrophic conditions is observed. Night-time, the base of the high Sv layer and the subsurface maximum closely track the thermocline depth from intra-seasonal to interannual time-scales. A recurring deepening of the high Sv layer is observed at a frequency close to the lunar cycle frequency. At 165°E, high day-to-day variations prevail and evoke the influence of moderately mesotrophic waters that would be advected from the western warm pool during westerly wind events. A review of the literature suggests that Sv variations result from changes in biomass and species assemblages among which myctophids, euphausiids, cephalopods, and shrimps would be the most likely scatterers.

9.2 Stéphane Gauthier. Preliminary overview of split-beam acoustic data collected as part of a large-scale Antarctic whale survey

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In this presentation I will report on the collection of acoustic data as part of the joint Australian-New Zealand Antarctic Whale Expedition (AWE) conducted from 2 February to 15 March 2010. This voyage was the first dedicated non-lethal whale research expedition conducted under the Australian-led International Whaling Commission initiative of the multinational Southern Ocean Research Partnership (SORP). The AWE voyage was a pilot study for the use of small boats (used to deploy satellite tags and retrieve whale skin biopsies) operated from an ice-capable ship (RV "Tangaroa"). The survey occurred roughly between 150ºW to 150ºE with the general strategy of locating and working with aggregations of whales. Acoustic data using Tangaroa's hull-mounted Simrad split-beam EK60 echosounders were recorded at five frequencies (18, 38, 70, 120 and 200 kHz) continuously throughout the expedition. Along with large-scale patterns of prey (krill) distribution along the general survey track, search patterns for whales in specific areas, particularly along the shelf edge and around the Balleny Islands, will enable more detailed assessment of prey-field mesoscale variability. In addition, fine-scale synoptic surveys were conducted over aggregations of krill in humpback whale feeding areas on five occasions. These

consisted of a series of equally spaced parallel transects, ranging from 4 to 12 Nautical miles in length.

9.3 Juan P. Zwolinski[1], Robert L. Emmet[2], and David A. Demer[1]. Predicting habitat for optimizing acoustic and egg sampling of Pacific sardine

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Prior to the period of very low abundances that culminated in the fishery collapse in the 1950s, Pacific sardine extended over the entire west coast of North America and experienced seasonal latitudinal movements. During the following decades of low abundance, sardine were believed to be restricted to the southern extension of their distribution, and only in the 1990s, when sardine abundance increased significantly, the original behaviour of spawning in the Southern California Bight in spring followed by a northwards movement during summer was re-initiated. With it, and under thorough scrutiny of the management agencies, the sardine fishery off Oregon, Washington and British Columbia resumed. Up to very recently, the Daily Egg Production Method was the only direct estimate of abundance used for tuning the catch-at-age models used for assessment. The need for complementing the DEPM estimates with other fishery-independent estimates of sardine abundance have been stated by the Pacific Fishery Management Council, and resulted in the SWFSC mounting a scheme for acoustic-trawl survey with emphasis on the estimation of sardine abundance. Combined DEPM and acoustic surveys were performed off the US west coast in spring 2006 and spring and summer of 2008, revealing the need for improvements to the survey design to lessen the amount of time spent in areas of no abundance. Presented here is a statistical model based on a 12-year time-series of sardine egg surveys and remotely sensed oceanographic conditions. Significant relationships were identified between egg encounters and sea surface temperature (SST), chlorophyll-a, and gradient of sea-surface altitude. A non-linear model of these environmental variables predicts the habitat of spring-spawning sardine. The model accurately predicts the boundaries of the spawning stock during spring-spawning season. Notably, it also predicts the habitat for the sardine, not necessarily spawning, during their summer northward progression. Specifically, the model predictions of sardine habitat accurately matched the annual emergence of sardine off the mouth of the Columbia River, approximately 1000 km north of the main spawning area. Furthermore, the annual cycle of sardine habitat off the US west coast explained the seasonality of the sardine fishery off Oregon, Washington, and south of Vancouver Island throughout the last decade. The model output can be used to choose the optimal time of the year to conduct sardine surveys and can provide quasi- real-time information on which to base the survey tracks.

9.4 Rebecca E. Thomas[1], Dezhang Chu[1], Ken Cooke[2], Chris Grandin[2], Steve de Blois[1]. A preliminary biomass estimate of Humboldt squid (*Dosidicus gigas*) off the West Coast of North America

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The population of Humboldt squid (*Dosidicus gigas*) has seen an explosion in the Eastern North Pacific over the last several years. The species has gone from being rarely seen in the waters off OR, WA, and BC to becoming a major predator in the marine foodweb in this area. This population explosion has the potential to cause large impacts in major fish stocks. The 2009 US – Canada joint Pacific hake acoustic trawl survey also noted large amounts of Humboldt squid over much of the survey area. This paper presents a preliminary biomass estimate of Humboldt squid in the survey area, and discusses elements of uncertainty in the estimate.

9.5 Réka Domokos. Characterisation of the physical environment at Cross Seamount and its effects on micronekton

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In this study the author investigates the effects of Cross Seamount on the physical environment and the consequences of these effects on micronekton, thought to be the food source for economically important top predators. Mean currents impinging on the seamount topography result in a predominantly anticyclonic flow around the flanks and doming isopycnals over the plateau, consistent with the formation of trapped Taylor cones, while occasional depression of isopycnals over the plateau in combination with uplifting at the flanks indicate the presence of secondary circulation due to anticyclonic currents. Dominant semi-diurnal tides and frequent anticyclonic eddies result in a more prominent Taylor cone formation over the seamount. Bioacoustics data show that micronekton biomass is significantly higher and composed of relatively smaller organisms at the plateau and flanks of the seamount than in the nearby environment, with effects not extending to further than ~5 km away from the plateau's edge. Micronekton migrates between the shallow and the deep scattering layer at the downstream and upstream edge of the plateau, actively swimming against the currents. Differences in composition and active association with the seamount indicate the presence of resident species. Stronger anticyclonic circulation due to tidal flow and eddies result in a further increase in micronekton biomass. The increased micronekton biomass is presumably a response to increased presence of their forage, zooplankton, which are most likely swept into and trapped within the seamount environment by the anticyclonic flow.

9.6 Kasatkina S.M. Why the trawl catchability characteristics have to be considered in the acoustic surveys

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Presented by Rudy Kloser on behalf of SvetlanaKasatkina, who was unable to attend at the last minute.

The catchability characteristics of gears used for biological sampling in the acoustic surveys, are, as a rule, unknown and are not considered in the data processing. The author discusses the differential trawl catchability - the most important characteristic of the gear affecting the length and species composition of the haul – as the source of uncertainty of the acoustic survey results. The impact of the gear differential catchability (including codend selectivity) on the survey's results is traced through the fish length and species catch structure, acoustically derived fish biomass and

abundance indices by age groups. The problems from application of different gears aboard the vessels participating in the international acoustic surveys are analysed by the example of the international acoustic surveys in the Baltic Sea. Differential catchability of commercial trawls in relation to the jack mackerel was analysed in the context of goal of acoustic data collection aboard fishing vessels operating in the SPRFMO area. It is demonstrated that different catchability characteristics of commercial trawls can provide significant differences between acoustically derived indices based on the same acoustic data from fishing vessels. In conclusion the proposals on application of fishing vessel acoustic data accompanied by operational statistics of fishing fleet to support fishery management are discussed.

9.7 Discussion on long-term time-series (Anne Lebourges-Dhaussy)

Six presentations were given during this session. An important contribution (Radenac *et al*.) reported the use of long time-series ADCP's Sv data to observe the impact of environmental forcing on the backscattering in the Equatorial Pacific and its potential for ecosystem models validation. Two presentations described experiments for characterizing the trophic environment (micronekton, macrozooplancton) of predators: bigeye tuna around Cross Seamount in Hawaii (Domokos), whales in Antarctic (Gauthier). Domokos used three frequencies and the dB difference methodology. Gauthier used five frequencies and combined tags of whales and passive acoustics to study also whales' schemes of predation strategy. Three presentations pointed out new methodologies that resulted from experience working with time-series surveys. Kasatkina highlighted the uncertainties in the use of trawling results in survey results without taking into account the catchability and the selectivity of the trawls, and in particular using fishing vessels information. Zwolinski presented the ecosystem modelling and prediction of sardine habitat when combining 12 years of surveys on sardine eggs, remote sensing of oceanographic conditions and acoustic surveys, in order to optimize the survey strategy of a very large area. Thomas presented results of estimating Squid biomass given the similarities between the frequency responses of the Humboldt Squid and of the Pacific Hake. Humboldt Squid have had a marked increased in numbers on the USA west coast during that past few years, causing difficulties for Pacific Hake biomass assessment in particular.

The discussion reinforced the absolute need to pursue and improve the acquisition of long-time-series within the current context of global change and study of its impact onto ecosystems. This topic has clear links with the "Observatories" topic. For that purpose, all sources of data should be considered – e.g. ADCP data which is not perfect, is mono-frequency, but provides information on the very poorly documented and poorly known mid-trophic level, with large amounts of data. But also classical sources of data should be considered with "new eyes" in order to extract unusual information from usual data. For example; two frequency echosounders may provide information on the ocean oxy-cline; passive acoustics' moorings to study seismic noise may give information on marine mammals.

TOR for next year:

- The acquisition of long time-series in the context of studying the impact of the climate change on ecosystems is fundamental and must be pursued;
- With links with the Observatories Topic, the potential interest of using the backscattering Sv data provided by ADCPs should be considered, as their use will continue and expand. We should be looking at calibration methods.

- A review paper to summarize ADCP work would be very helpful to communicate issues to the wider community. WGFAST will recommend that the SGCal group add calibration of ADCP's to their list of considered instruments.

10 F1 – Fisheries Optics and sound impacts

Summary of Acoustical Society of America's bio-acoustic session in April 2010 (N. Handegard)

A summary from the Acoustical Society meeting was given. The themes were broadly separated into noise observations and prediction of the acoustic environment, masking effects, barotraumas, and behaviour. The acoustic environment contributions focused both on modelling and passive listeners, including construction sites and wind farms, and the concerns for marine mammals were discussed. The effect of noise masking is a concern for mammals, and several presentations reported on experiments where whether changes in frequency and amplitude occurred during various noise exposure. Small increase in amplitude and minimum frequency to short-term anthropogenic noise (shipping) were reported. Experiments to try to disrupt echolocation were tested in order to avoid mammals to be caught in nets, but they concluded that the effect was pure masking. There were several presentations on barotraumas, and setup for lab experiments for investigating pile driving impacts were presented. A classification template to classify barotraumas, a review of hair cell generation and a report on sea horse hearing thresholds were presented. A model predicting the stimulation of hearing cells was found to be in good agreement with current knowledge of hearing sensitivity. A study reported no behavioural response to low frequency military sonar. In summary the ASA community has moved from observing SPL to investigating potential impact on behaviour, similar to the relation between vessel avoidance and noise levels.

Noise print summary paper

There was a discussion about the acoustical footprint of fisheries acoustics tools, and there were concerns on how the community could best communicate this to others. The consensus seemed to be that a good description of echosounders and sonars was required, with special attention to beam angles and volume of ensonification. A draft paper will be prepared for presentation at the next meeting (R. Kloser and N. Handegard).

IMBER MAAS working group

An application to IMBER and EurOcenas has been submitted to fund the 2nd CLIOTOP Workshop on Mid trophic automated acoustic sampler (MAAS). The objective is to bring together the modelling community and the acoustic community to make progress on ocean observatory systems on the mid trophic levels.

Optical and image based technologies in the ecosystem approach to fisheries management

The meeting supported the application for a 2011 session at the ASC with E. Tenningen as co-chair "Optical and image based technologies for ecosystem approach to fisheries management". Also supported the input from other groups and in particular J. Hare from the ICES GOOS working group to expand its scope to include bio-optics.

11 Topic H: Automated and multibeam software updates

11.1 Laurent Berger. MOVIES3D a new fishery acoustics toolbox for operational use and exploratory research

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To fully exploit the ME70 multibeam echosounder, Ifremer has rebuilt its software suite MOVIES and makes now available the new MOVIES3D software.

MOVIES3D allows real-time 3D visualization and processing for improving for example the trawl sampling decision process and enables combined processing of single beam multifrequency and multibeam data for improved abundance estimation and ecological studies. All modules of MOVIES3D can be interfaced with Matlab for parameter sensitivity analyses and data batch processing of an entire survey.

The software will be presented through illustrations of 3D visualization of data collected in the Bay of Biscay for various species and different schooling behaviours. The potential for automatically processing large datasets will be illustrated with a sensitivity analysis of the impact of the threshold value used for automated echo-integration and school extraction.

11.2 Ian Higginbottom, Toby Jarvis, and Myounghee Kang. ME70 data processing in Echoview: current features, future plans

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Echoview support for the ME70 will follow a proven model of combining a high level of user input to feature selection and design; integration with key existing instruments and methods; and a user interface that allows flexible analyses to meet wide ranging needs of researchers. The proven Echoview model of continuous development over the long term will be adapted to the ME70.

Existing features include full support for analysis of individual ME70 beams using all methods available to the EK60 and other split-beam sounders; analysis of 3D school data including morphological and energetic parameters; scripted automation of analyses; 4D visualization of echogram data; export of results and geo-referenced samples for post Echoview analysis (such as integration with 4D environmental data in Eonfusion). Methods such as SSID approaches to extraction of bathymetric data are partially implemented and can be developed on demand. In 2010 and 2011 Echoview will be significantly updated with features such as a multi-threaded architecture and a re-designed analysis-engine to ensure that core of the software is ready to support researchers over the next ten years as new possibilities for data analysis are inspired by the ME70.

11.3 Rolf J. Korneliussen. A closer look at schools

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Ecosystem investigations require simultaneous observations of marine organisms and their interactions, which imply that some organisms are observed at times when they are not optimal for quantitative measurements. Thus, the narrow measurement volume covered by vertical single-beam echosounders has to be expanded by simultaneous data from quantitative multibeam sonar and multibeam echosounder. Improved coverage of volumes close to the surface for measurements of schools was

considered as the most significant acoustic measurements lacking in Norwegian waters, even compared to improved volumetric coverage close to the bottom. A request for a quantitative sonar that in each ping could completely cover schools in 3 spatial dimensions at a preferred ping-rate in excess of one per second resulted in the Simrad MS70. One challenge of using MS70 data during routine surveys is 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). MS70 produce data from 500 beams compared to the typically 25 beams from its sibling-instrument Simrad ME70. In May 2010, IMR starts using PROMUS, PROcessing system for advanced MUltibeam Sonar, during operational surveys. PROMUS is integrated with LSSS in a similar way as trawl and CTD information, and appear as an integrated module in LSSS. Some tools used to analyse and visualize the acoustic data will be demonstrated. The scrutinized data are stored in a database capable of handling multidimensional data, and those data are later used to estimate fish stock abundance

11.4 Maurice Doucet[1], and Lindsay Gee[1]. Advanced Mid-Water Tools for 4D Marine Data Fusion and Analysis

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Mapping and charting of the seabed underwent a revolution approximately 20 years ago with the introduction of multibeam sonars -- sonars that provided complete, high-resolution coverage of the seabed. The initial focus was the production of a bathymetric model; more recently innovations in processing software have led to approaches to characterize seabed type and for mapping seabed habitat in support of fisheries research. In recent years, a new generation of sonars has been developed that have the ability to map the water column along with the seabed. This ability will potentially allow multibeam sonars to address a number of critical ocean problems including the direct mapping of fish and marine mammals, the location of midwater targets and a wide range of physical oceanographic processes.

Currently, the users of these sonars have a limited view of the midwater data in real-time and limited capacity to store it, replay it, or run further analysis. The data also needs to be integrated with other sensor assets such as bathymetry, backscatter, sub-bottom, seabed characterizations and other assets so that a "complete" picture of the marine environment under analysis can be realized.

Software tools developed for this type of data integration should support a wide range of sonars with a unified format for the wide variety of midwater sonar types. This presentation describes the results of an effort to create a software tool that meets these needs, and the use to date with Kongsberg EM3002, EM302, EM122, EK60, EK500, ME70, and Reson 7125 sonar data.

11.5 Toby Jarvis*, Ian Higginbottom, Francis Chui, Bernd Wechner. An illustration of automation (scripting) in Echoview for marine and freshwater hydroacoustic data-processing applications

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Echoview's comprehensive range of tools for hydroacoustic data processing can be automated via COM scripting. The benefits of scripting are to reduce dataprocessing time, minimize human error and increase the objectivity and repeatability of analyses. This is becoming increasingly important in marine and freshwater applications as

hydroacoustic datasets become more extensive, particularly in view of the now widely adopted ecosystem approach to the management of aquatic environments. To illustrate the broader applicability and power of scripting, an ongoing fish monitoring project is presented for which a scripted data flow has been developed by the Echoview team. Day/night surveys are performed at least twice a month in the upstream forebay of a hydroelectric dam with echosounder data collected from four fixed locations, each with seven different pointing directions over time. The data are therefore extensive, and different processing templates are required for each transducer and orientation to enable bottom and dam-structure removal. The script has been designed to: create Echoview files from a predefined template; pick lines; create and export single-target detections; initiate the manipulation of the single-target data in an external program (C#); reimport the modified targets into Echoview; filter the targets and detect fish tracks; export the tracks and concatenate the results for a particular sounder into a single file. These concatenated files can be read into Eonfusion or other appropriate application for immediate visualization and analysis.

11.6 Discussion and review (David Demer)

Topic H included five presentations on software for processing multibeam data, particularly from the Simrad ME70, and automated acoustic data processing.

Laurent Berger (Ifremer) announced new features of MOVIES3D, Ifremer's EK60 and ME70 data visualization and processing software for use in both surveys and research. The software combines multifrequency and multibeam data, allowing real-time three-dimensional (3D) visualization, and target identification using frequency-response information for improved trawl sampling efficiency. MOVIES3D now includes a Matlab interface for exploring parameter sensitivity and batch processing. MOVIES3D is modular in design and allows both real time and replay visualization and analysis. It allows exploration of the effects of pitch and roll on EK60 data. It allows visualization and comparison of the volumes sampled by the EK60s and ME70. The software facilitates school identification and observations of animal avoidance behaviours and trophic interactions. Example images of a gas plume were shown. A Matlab package named SONARSCOPE has also been developed by Ifremer for additional data exploration.

Ian Higginbottom (Myriax), Toby Jarvis (Myriax), and Myounghee Kang (Myriax) presented new features of their Echoview software for ME70 data processing, highlighting both current features and future plans. The software includes features to process the data from the individual beams of the ME70 as it does for the EK60. Such analyses include 3D school metrics, four-dimensional (4D) echogram visualizations, georeferencing of samples, and integration with Myriax's Eonfusion software. The software is poised to implement the Statistical-Spectral method for target IDentifcation (SSID; Demer *et al.,* 2009). It includes a data flow map and allows echograms to be easily synchronized for efficient data exploration and analysis. Fully georeferenced 3D images and detected surfaces can be exported to Matlab or Eonfusion. Echoview's new Formula Operator has been extended to include statistical and logical operators and allows data manipulations of 3D sample spaces (i.e. ping and beam). Echoview is now ten years mature and was developed on the philosophy that it takes three components to be successful: Echoview software; research and development; and survey scientists to decide what is needed to produce useful products. Development has progressed synergistically with input from users.

Rolf Korneliussen (LSSS) explained the new PROcessing system for advanced MUltibeam Sonar (PROMUS) module of the Large Scale Survey System (LSSS) and how it

allows 4D analysis of multifrequency data from the MS70. The MS70 allows fish schools to be synoptically imaged near the sea-surface. It has been used to quantify avoidance behaviours of herring and mackerel. PROMUS allows 3D and 4D georeferenced imaging of MS70 data in post-processing. It improves data processing speed, allows flexible setup, includes JAVA portability, provides connectivity for data archive; and facilitates abundance estimations. Data compression utilities allow the original data volume to be reduced by 90%.

Maurice Doucet (IVS3D) and Lindsay Gee (IVS3D) presented their company's advanced midwater tools for 4D fusion and analysis of marine data. IVS3D has partnered with the Center for Coastal and Ocean Mapping at the University of New Hampshire to create GEOZUI, an integrated visualization tool. The software allows imaging of multibeam data as a midwater fan, and single-beam data as a curtain. An example showed whale tracks overlaid on acoustic data imagery. GEOZUI accepts various data formats including, but not limited to .raw, .all, .seg, .xtf, and .83b, and has a data conversion wizard. It accepts data from many sounders including, but not limited to the Simrad EM3002, EM710, ME70, EK60, EK500, and Reson 7125. It creates data files in a generic water column format. It allows data to be visualized in beam, stacked, and map views, and features composite sliders (minimum, maximum, and range of variables), and beam selector tools. The workflow allows import of data, visualization, identification of features, and export of data to Matlab and Fledermaus. It runs on Linux, Mac, and PC platforms. It is simple, fast, manages large data files, has export capability, and allows data-analysis plug-ins developed in other packages such as Matlab.

Toby Jarvis (Myriax), Ian Higginbottom (Myriax), Francis Chui (Myriax), and Bernd Wechner (Myriax) explained automated data processing using scripting in Echoview. The scripts were used to automate the monitoring and tracking of fish using data from four Biosonics split-beam echosounders on rotational mounts, each allowing nine pointing directions, at Box Canyon dam in the state of Washington, USA. To emphasize the utility of the automated-processing feature, ten years of historical data were processed, including daytime and night-time observations with 52 echosounder-observation directions. Echoview templates were setup with visual data flows. 'Com' scripting was used to control the Echoview data processing. The com-object hierarchy includes: loading of data; application of template; exportation of target strength data, manipulation of data external to Echoview, re-import of data; and detection of fish tracks in Echoview. Myriax offers training on their scripting features via: Echoview support; website Help; online tutorials; and customized training courses. Scripts can be programmed in Visual Basic and Matlab and examples scripts are available.

12 WGFAST meeting business and planning

12.1 Passing of Kjell Olsen

It is with regret that we update on the passing of Kjell Olson, Chair WGFAST 1984–1989 who passed away in August 2009. Below is a small extract of a tribute written by Egil Ona:

Internationally, Kjell Olsen was a respected, challenging and stimulating colleague, always ready to bring the established knowledge within marine science a step further with new ideas. He was the Norwegian Delegate to the International Council of the Exploration of the Sea (ICES) in 1987—2000, Chair of the Fish Capture Committee 1990–1992, and an initiator of

the Fisheries Acoustics, Science and Technology (FAST) Working Group, of which he was Chair from 1984 to 1989.

Kjell Olsen was very proud of his origin and roots in Havøysund (or "Hawaiisund" as he used to call it), where he came from a family with strong fishing interests which produced several leaders in Norwegian fishery science, industry and politics. He was actively interested in technological developments within the fisheries, as well as their effects on the coastal communities in Norway. His fishery connections and experience were also reflected in his scientific work, where often non-traditional and innovative experimental methods were successfully applied.

We all have permanent reminders and good stories in our memories from our research activities and social contacts with Kjell, in particular from the SEAFACTS symposium in Bergen last year when he stimulated intense discussion on key scientific issues of the day. His guiding spirit will be sadly missed in our future work.

We send our sincere condolences and deepest sympathies to his wife Lisbet and his three daughters. We share in their loss.

12.2 WGNEACS-SSGESST request

WGFAST discussed a request from Leonie Dransfeld for input to a response from their deep-water survey working group WGNEACS to a NEAFC request as below.

In 2008, NEAFC adopted recommendation XVI on bottom fishing activities in the NEAFC regulatory areas, which includes procedures for fishing activities in new bottom fishing areas. In areas not previously impacted by bottom fishing gear, fishing should be considered exploratory and shall be conducted in accordance with an Exploratory Bottom Fisheries Protocol. Proposed bottom fishing activities shall be subject to an impact assessment that would determine whether there are significant adverse impacts on vulnerable marine ecosystems (VMEs). Prior to the agreement of an NEAFC Exploratory Bottom Fisheries Protocol, an interim protocol, published in Annex 1 of recommendations XVI is to be followed. This protocol is as follows:

Until the Commission adopts a new protocol in accordance with Article 4, paragraph 1 of this Recommendation, exploratory bottom fisheries may commence only when the following information has been provided to the Secretary by the relevant Contracting Party:

a) A harvesting plan which outlines target species, dates and areas. Area and effort restrictions shall be considered to ensure fisheries occur on a gradual basis in a limited geographical area.

b) A mitigation plan including measures to prevent significant adverse impact to vulnerable marine ecosystems that may be encountered during the fishery.

c) A catch monitoring plan that includes recording/reporting of all species caught. The recording/reporting of catch shall be sufficiently detailed to conduct an assessment of activity, if required.

d) A data collection plan to facilitate the identification of vulnerable marine ecosystems/species in the area fished.

No one at the meeting volunteered and the Chair suggested that ideally someone from the ICES region who has an interest in this topic should engage and respond. Until a person is found the following general data collection issues were raised.

- Logging the vessels acoustic echosounder,
- Placing cameras/acoustics on nets,

- Detailed records of shot location and bycatch both fish and benthos.

12.3 2011 and 2012 meeting plans

WGFAST has received an invite from Mr Sigurjónsson to Reykjavik Iceland for the 2011 joint meeting between WGFTFB and WGFAST tentative dates are from the 9–13 May 2011.

WGFAST received an invite from France (A. Lebourges-Dhaussy and L. Berger) to hold the 2012 meeting in Brest.

12.4 Acoustic Symposium

Meeting discussed provisional planning for the ICES sponsored Acoustic Symposium with 2014 as a provisional date and to inform the ICES JMS and ICES SCICOM committee details for advanced planning. Technology is moving quickly and that a 6 year time frame between symposia is appropriate and we will need someone to step forward to lead the process. Important that there is a principle chair and host as this requires funding. There are documents from the last 3 symposiums that give budget and logistic details.

12.5 Meeting Recommendations

The meeting discussion on the Terms of Reference for the next WGFAST meeting resulted in the following recommendations:

12.5.1 Terms of Reference for the 2011 WGFAST meeting

The Working Group on Fisheries Acoustics, Science and Technology [WGFAST] (Chair: Nils Olav Handegard, Norway) proposes to meet in Reykjavík, Iceland from Tuesday 10 May to Friday the 13 May 2011 with a joint meeting with WGFTFB on Monday the 9 May:

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.

1. Ecosystem approach to fisheries management: metrics, indices and indicators.

    a. Provide methods and standards for creating and validating indicators and metrics derived from acoustic and complementary methods. Evaluate and compare a range of suitable metrics in empirical situations and by simulation. (presentation session Verena M. Trenkel)

2. 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 Rudy Kloser)

    a. Special call for review of use of ADCP technologies (presentation session Anne Lebourges-Dhaussy)

3. Update on models and measures of target strength for classifying and enumerating living marine resources and associated variability of validating results (Presentation session - To be determined).

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

    a. Characterization of animal behaviour in order to characterize ecosystem processes and/or describe measurement uncertainty when using acoustic and complementary survey technologies. (Presentation session, Alex De Robertis)

5. Emerging technologies, methodologies and protocols for single and multispecies surveys. (presentation session)

b) Based on our use of active sound in the ocean there is a need to review and document its footprint and place this in context with other natural and anthropogenic sources and the relative impact on marine biota. Review progress to document footprint of fisheries acoustic devices and characteristics and recent symposia (Rudy Kloser, Nils Olav Handegard).

c) Review the reports and receive updates from:

6. Study Group on Calibration of Acoustic Instruments in Fisheries Science (SGCal; David Demer).
7. Final report of Study Group on Avoidance Reactions to Vessels (SGARV; Francois Gerlotto).
8. Final report of Study Group on Fisheries Optical Technologies (SGFOT; Eirik Tenningen).
9. Protocols of biological data from trawling for acoustic surveys (Dezang Chu).
10. Workshop on the Determination of Acoustic Target Strength of Redfish (WKTAR), (Mike Jech).
11. The IMBER MAAS program (Nils Olav Handegard)
12. Engagement with SPRFMO (Francois Gerlotto).
13. Observatories publication topic group (John Horne)
14. Development of a wikii page and acoustic forum

WGFAST will report by 30 June 2011 for the attention of the SCICOM steering committee Ecosystem Surveys Science and Technology.

12.5.2 Study, Planning and Topic Groups

Recommendation: WGFAST recommends that SGCal, David Demer (USA), Chair, work towards an ICES Cooperative Research Report and meet in Reykjavík, Iceland from the 7–8 May 2011. The result of their meeting to be reported to the WGFAST on 10 May 2011.

Recommendation: WGFAST recommends the formation of a topic group (Tim Ryan AUS) that will bring together a group of participants who are working with ships of opportunity to develop standardized metadata protocols to suit ocean observing system requirements for data acquisition, processing, quality control and data dissemination to report to the WGFAST in Reykjavik, Iceland 10 May 2011.

12.5.3 Theme Sessions for the ICES 2011 Annual Science Conference

Recommendation: In its continuing effort to contribute to the ICES Annual Science Conferences, WGFAST proposes the following Theme Session for the 2011 Annual Science Conferences:

SGFOT and WGFAST recommend a theme session on "Optical and image based technologies for ecosystem approach to fisheries management" be proposed for the 2011 ASC. Co-chairs: Eirik Tenningen (Norway) and To Be Determined.

WGFAST in collaboration with other assessment and survey based expert groups recommend a theme session in 2011 on the ecosystem-based fisheries management information needs from surveys: metrics, indices and indicators. How and what can acoustics provide?

Co-chairs – Verena Trenkel (France) and To Be Determined.

12.5.4 ICES geostatistics courses

WGFAST proposes that an ICES facilitated course on the use and application of Geostatistics would be well supported by its members and represents a cross cutting methodology that may appeal to a range of ICES working groups and members.

12.5.5 Joint session WGFAST/WGFTFB 2011

WGFAST recommends a joint WGFAST/WGFTFB session that includes a topic exploring how multiple technologies and methods either –improve or complicate our understanding of what is actually out there, both numerically, as well as ecologically and behaviourally. Questions include: can we decrease uncertainty with multiple techniques; is it cost-effective; does the promise of multiple technologies allow us to increase our knowledge to go beyond "simple" abundance estimates towards more accurate prediction of what those counted organisms will do, where they will go, and how they will react to natural and anthropogenic forces. Julia Parish and or Alex De Robertis to facilitate a joint session with WGFTFB. The joint session is tentatively scheduled for Monday the 9 May and may extend for 1–1.5 days depending on contributions.

12.6 Closure of meeting

Rudy Kloser closed the meeting at 16:00 hrs on Friday 30 April and thanked the participants for their active discussions and science presentations and Tim Ryan as Rapporteur. This is the last year as chair of WGFAST and he welcomed Nils Handegard as the new chair for 2011–2013. Rudy thanked our host David Demer and his team for ensuring that the meeting and social events ran smoothly. David Demer thanked his team, principally Steve Sessions and Roszella Sanford. He also thanked Jeff Condiotty, Simrad, and Ian Higginbottom, Myriax, for assisting with the social events; and Don Kent, Hubbs-Seaworld Research Institute, for providing the meeting venue. WGFAST participants expressed their sincere gratitude to Rudy Kloser for his adept chairmanship from 2007–2010.

Annex 1. List of participants

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Annex 2: Agenda

WGFAST 2010 HSWRI Demotte Centre

Monday 26th April

ToR		Time
	Registration	7:30
SGFARV	Francois Geriotto	8:30
	HSWRI Shedd Auditorium	17:30
SGCal	David Demer	8:30
	HSWRI West Room	17:30

Tuesday 27th April

ToR		Time
	Registration	7:30
SGFARV	Francois Geriotto	8:30
	HSWRI East Room	11:30
SGCal	David Demer	8:30
	HSWRI West Room	11:30
WGFAST	Registration	11:00
	House keeping	12:50
	WGFAST Opening	13:00
	Tribute to Van Holliday	13:10
G1	Study Group update SGFAR	13:40
G2	Study Group update Cal	14:00
G3	Red Fish TS update	14:20
	FAST planning	14:30
	SciCom update	14:50
	Afternoon break	15:30
A	Indicators	
	Introduction Trenkel	16:00
A1	Trenkel	16:15
A2	Ressler	16:30
A3	Lezama	16:45
A4	Charef	17:00
A5	Parker-Stetter	17:15
	Close	17:30
	Social	18:00
	Baja Room, Marina Village	21:00

Wednesday 28th April

ToR	Author	Time
	Registration	7:30
	House keeping	8:20
A	Indicators	
A6	Kloser	8:30
	Discussion	8:40
	Discussion	
	Discussion	
B1	Horne	10:00
B2	Ryan	10:15
	Morning break	10:30
B	Observatories	
B3	Melvin	11:00
B4	Weber	11:15
B5	Berger	11:30
B6	Churnside	11:45
B7	Handegard	12:00
B8	Domokos	12:15
	Lunch	12:30
B	Observatories	
B9	Urmy	14:00
B10	Pawlowicz_McClure	14:15
B11	Cutter	14:30
B12	Godo	14:45
B	Discussion	15:00
B	Discussion	15:15
	Afternoon break	15:30
	Software for automated methods and Multi beam	
H1	Berger-Movies	16:00
H2	Higginbottom-Echoview ME 70	16:15
H3	Kornelliussen-LSSS	16:30
H4	Doucet-Fiedermaus	16:45
H5	Jarvis-Echoview Automated processin	17:00
	Close	17:15

Thursday 29th April

ToR	Author	Time
	House keeping	8:20
B	Observatories Discussion	8:30
c	Target Strength	
C1	Lee	9:00
C2	Pena	9:15
C3	Bethke	9:30
C4	Lara-Lopez	9:45
C5	Macaulay	10:00
C6	Chu	10:15
	Morning break	10:30
	Target Strength	
C7	Jech	11:00
C8	Warren	11:15
C9	Jaffe	11:30
C10	Demer	11:45
	Discussion	12:00
	Discussion	12:15
	Lunch	12:30
D	Behaviour/Surveys	
D1	Jech	14:00
D2	De Robertis	14:15
D3	Brehmer	14:30
D4	Doray	14:45
D5	Stienessen	15:00
D6	Patrik	15:15
	POSTERS	
	Afternoon break	15:30
	Jonsson-behaviour	
	Behaviour/Surveys	
	Discussion	16:00
D7	Geriotto	16:15
D8	Gutierrez	16:30
D9	Jonsson	16:45
	Discussion	17:00
	Close	17:30
	Dinner	19:00
	Casa Guadalajara, Old Town	22:00

Friday 30th April

ToR	Author	Time
	House keeping	8:20
	Behaviour/Surveys Discussion	8:30
E	Behaviour/Surveys	
E1	Radenac	9:00
E2	Gauthier	9:15
E3	Zwolinski	9:30
E4	Kasatkina	9:45
E5	Thomas	10:00
E6	Domokos	10:15
	Morning break	10:30
	Behaviour/Surveys	
E7	Kasatkina	11:00
	Discussion	11:15
	Discussion	11:30
F1	Sound update	11:45
	Discussion	12:00
F2	Optics	12:15
	Lunch	12:30
	FAST REPORT	
	Terms of Reference 2011	14:00
	Symposium topics 2011/12 (optics)	14:20
	International engagement	14:40
	Planning next meeting	15:00
	FAST REPORT	15:20
	Other Business	15:40
	Afternoon break	16:00
	Close	16:00

Annex 3: WGFAST Terms of Reference for the next meeting

The Working Group on Fisheries Acoustics, Science and Technology (WGFAST) chaired by Nils Olav Handegard*, Norway proposes to meet in Reykjavík, Iceland from 10–13 May 2011 to:

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

1) Ecosystem approach to fisheries management: metrics, indices and indicators.

   a. Provide methods and standards for creating and validating indicators and metrics derived from acoustic and complementary methods. Evaluate and compare a range of suitable metrics in empirical situations and by simulation. (presentation session Verena M. Trenkel)

2) 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 Rudy Kloser)

3) Special call for review of use of ADCP technologies (presentation session Anne Lebourges-Dhaussy)

4) Update on models and measures of target strength for classifying and enumerating living marine resources and associated variability of validating results (Presentation session - To be determined).

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

   a. Characterization of animal behaviour in order to characterize ecosystem processes and/or describe measurement uncertainty when using acoustic and complementary survey technologies. (Presentation session, Alex De Robertis)

6) Emerging technologies, methodologies and protocols for single and multispecies surveys. (presentation session)

b) Based on our use of active sound in the ocean there is a need to review and document its footprint and place this in context with other natural and anthropogenic sources and the relative impact on marine biota. Review progress to document footprint of fisheries acoustic devices and characteristics and recent symposia (Rudy Kloser, Nils Olav Handegard).

c) Review the reports and receive updates from:

7) Study Group on Calibration of Acoustic Instruments in Fisheries Science (SGCal; David Demer).

8) Final report of Study Group on Fish Avoidance of Research Vessels (SGFARV; Francois Gerlotto).

9) Final report of Study Group on Fisheries Optical Technologies (SGFOT; Eirik Tenningen).

10) Protocols of biological data from trawling for acoustic surveys (Dezang Chu).

11) Workshop on the Determination of Acoustic Target Strength of Redfish (WKTAR), (Mike Jech).

12) The IMBER MAAS program (Nils Olav Handegard)

13) Engagement with SPRFMO (Francois Gerlotto).

14) Observatories publication topic group (John Horne)

15) Development of a wikii page and acoustic forum

WGFAST will report by 30 June 2011 (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 and relation to action plan:	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 plan to meet with WGFTFB and hold a joint meeting to ensure that complementary technologies and approaches are combined to tackle the issue of fish behaviour and its impact on the implementation of an ecosystem approach to marine management. WGFAST will report by 30 June 2011 for the attention of the SCICOM Steering Committee on 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 WGFTFB group. The work is of direct relevance to SGFARV, WGNAPES, WGRS, WGIPS, and WGBIFS
Linkages to other organizations	

Annex 4: Recommendations

RECOMMENDATION	FOR FOLLOW UP BY:
1. The Working Group on Fisheries Acoustics, Science and Technology [WGFAST] (Chair: Nils Olav Handegard, Norway) proposes to meet in Reykjavík, Iceland from Tuesday 10 May to Friday the 13 May 2011 with a joint meeting with WGFTFB on Monday the 9 May:	
2. WGFAST recommends that SGCal, David Demer (USA), Chair, work towards an ICES Cooperative Research Report and meet in Reykjavík, Iceland from the 7–8 May 2011. The result of their meeting to be reported to the WGFAST on 10 May 2011.	SGCal
3. In its continuing effort to contribute to the ICES Annual Science Conferences, WGFAST proposes the following Theme Session for the 2011 Annual Science Conferences: SGFOT and WGFAST recommend a theme session on "Optical and image based technologies for ecosystem approach to fisheries management" be proposed for the 2011 ASC. Co-chairs: Eirik Tenningen (Norway) and To Be Determined.	WGFAST, SSGESST
4. WGFAST in collaboration with other assessment and survey based expert groups recommend a theme session in 2011 on the ecosystem-based fisheries management information needs from surveys: metrics, indices and indicators. How and what can acoustics provide? Co-chairs – Verena Trenkel (France) and To Be Determined.	WGFAST, SSGESST
5. WGFAST proposes that an ICES facilitated course on the use and application of Geo-statistics would be well supported by its members and represents a cross cutting methodology that may appeal to a range of ICES working groups and members.	ICES
6. WGFAST recommends a Joint WGFAST/WGFTFB session that includes a topic exploring how multiple technologies and methods either –improve or complicate our understanding of what is actually out there, both numerically, as well as ecologically and behaviourally. Questions include: can we decrease uncertainty with multiple techniques; is it cost-effective; does the promise of multiple technologies allow us to increase our knowledge to go beyond "simple" abundance estimates towards more accurate prediction of what those counted organisms will do, where they will go, and how they will react to natural and anthropogenic forces. Julia Parish and or Alex De Robertis to facilitate a joint session with WGFTFB. The joint session is tentatively scheduled for Monday the 9 May and may extend for 1–1.5 days depending on contributions.	WGFAST/WGFTFB