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ICES Fisheries Technology Committee

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Report of the Working Group on Fisheries Acoustic Science and Technology (WGFASST)

23 June 2008

Bergen, Norway



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Executive summary

The Working Group on Fisheries Acoustic Science and Technology (WGFAST) met at the Science Centre, VILVITE, Bergen, Norway on 23 June 2008. Rudy Kloser (Australia) was the Chair and Tim Ryan (Australia) was the Rapporteur. There were 40 participants from 13 countries.

Highlights:

The Symposium on the Ecosystem Approach with Fisheries Acoustics and Complementary Technologies (SEAFACETS) was held in Bergen Norway on 16–20 June 2008, with 400 people in attendance. There were 124 oral and 120 poster presentations split between five main themes: i) Ecosystem and Fisheries monitoring; ii) Remote classification and identification; iii) Target strength modelling and measurement; iv) Behaviour and assessments and v) Data quality and integration into ecosystem models.

The presentations given at the SEAFACETS symposium demonstrated that acoustic and complimentary technologies and methods can provide quantitative observations for a range of trophic, temporal and spatial scales: plankton to whales, 1 m fresh-water lakes to ocean basins and seconds to years. Behaviour of animals was a dominant theme throughout the symposium with our knowledge of behaviour being incorporated into observation strategies. The presentations provided new insights into ecosystem structure and function as well as quantitative inputs into ecosystem or fisheries assessment models. The symposium provided a time stamp of the state of knowledge in the field with the Working Group of Fisheries Acoustics, Science and Technology reviewing the research needs for the next few years and how we can impact on the environmental and fisheries management issues of the day.

Significant areas of ongoing research were proposed for 2009 being:

- i) Coastal, shelf and ocean observatories for fisheries and ecosystem monitoring. Role of acoustics for current applications, methods and technologies and future designs;
- ii) Fisheries and ecosystem acoustic indicators and the interface between observation outputs and model uptake including improved process understanding and assessment of indicator goodness of fit with ecological and fishery assessment models;
- iii) Target strength and species identification modelling and measurement with particular emphasis on validation (optical and nets) and multifrequency and wideband measurements;
- iv) Acoustic observations (passive and active) of spatial and temporal fish behaviour (e.g. spawning, migration) and how this knowledge is or could be incorporated into observation strategies, models and management advice;
- v) Anthropogenic sound impacts on fish: update of issues from member countries –research requirements and status of current knowledge and guidelines – potential for invited speaker.

Recommendations

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

1 Terms of Reference

In response to the ICES resolution of the 93rd Statutory Meeting the Working Group on Fisheries Acoustics Science and Technology (WGFAST) (Chair: Rudy Kloser, Australia; and Rapporteur: Tim Ryan, Australia) met in Bergen, Norway on 23 June 2008 to:

a) review the major outcomes of the ICES Fisheries Acoustic Symposium by the theme sessions of:

- i) Ecosystem and Fisheries monitoring;
- ii) Remote classification and identification;
- iii) Target strength modelling and measurement;
- iv) Behaviour and assessments;
- v) Data quality and integration into ecosystem models.

WGFAST theme leaders to review any new and innovative methods and technologies for consideration by the FAST working group in 2009.

b) review the reports of the:

- i) Planning Group on the HAC (PGHAC) common data exchange format;
- ii) Study Group on Fisheries Optical Technologies (SGFOT); and
- iii) Study Group on Avoidance Reactions to Vessels (SGARV).
- iv) Topic group on EK60 calibration.

WGFAST will report by 31 July 2008 for the attention of the Fisheries Technology Committee.

2 Opening the meeting

2.1 Opening and welcome to FAST by Rudy Kloser

Rudy Kloser opened the meeting and welcome participants. He thanked our hosts IMR and in particular Nils Handegard for his assistance. Conveners of the Symposium on the Ecosystems Approach to Fisheries Acoustics and Complementary Technologies (SEAFACTS) were also thanked, in particular Egil Ona and hosts at IMR for their hospitality.

2.2 Participants and agenda

A list of the 40 participants from 13 countries appears in Annex 1.

3 Review of the 2008 SEAFACTS symposium

3.1 SEAFACTS Overview

Rudy Kloser gave the following overview of the SEAFACTS symposium.

The Symposium on the Ecosystem Approach with Fisheries Acoustics and Complementary Technologies (SEAFACTS) was held in Bergen Norway between 16 and 20 June 2008, with 400 people in attendance. There were 124 oral and 100 poster presentations split between five main themes of:

- i) Ecosystem and Fisheries monitoring
- ii) Remote classification and identification
- iii) Target strength modelling and measurement
- iv) Behaviour and assessments
- v) Data quality and integration into ecosystem models

The presentations given at the SEAFACETS symposium demonstrated that acoustic and complementary technologies and methods can provide quantitative observations for a range of trophic, temporal and spatial scales: plankton to whales: 1 m fresh-water lakes to ocean basins and seconds to years. Behaviour of animals was a dominate theme throughout the symposium and how our knowledge of behaviour can be incorporated into observation strategies. The presentations provided new insights into ecosystem structure and function as well as quantitative inputs into ecosystem or fisheries assessment models. The symposium provided a time stamp of the state of knowledge in the field and the Fisheries Acoustics, Science and Technology (FAST) working group reviewed the focus for the next years and how we can impact on the environmental and fisheries management issues of the day. To review the symposium and provide guidance to future research directions for WGFAST the theme leaders provided a summary of the 5 sessions as outlined below.

3.2 Review of theme session i): Ecosystems and Fisheries Monitoring

O.R. Godø¹ and C. Wilson²

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Presentation Groupings

A total of 24 oral presentations were made in this session. The presentations covered a very broad spectrum of research topics. We grouped them into 3 broad categories that each contained several subcategories. The first category, Commercial Exploited Species Monitoring included nine presentations that were further subdivided into four subcategories: Abundance/Behaviour (2), Fish Size/Identification (3), Survey Strategy (1), and Dead/blind Zones investigations (3). The second category, Process Studies, included eight presentations subdivided into: Species Interactions (1), Bio-Physical Interactions (3), Passive Acoustics (1), and Diel Vertical Migrations (3). The third category, Ecosystem Coverage had seven presentations including: Oceanic (4), Freshwater (2), and Benthic Habitat (1) studies.

Significant Findings from New Research Topics

We recognized two new significant developments since the last Fisheries Acoustics Symposium in 2002, in our session. Ratilal presented results from the second experiment with an ocean acoustics waveguide remote sensing system (first presented in Nature in 2006). The system images an immense area of 100 km in diameter within 70 seconds and showed densities and movements of large herring aggregations over two weeks.

Another exciting new development was presented by Korneliussen who described a new generation of multibeam system (Simrad ME70, MS70) developed specifically for fisheries research. The MS70 has a horizontal swath area (60° horizontal by 45° vertical) composed of 500 beams. This is the first multibeam system with the

capability to ensonify an entire, large school very near the sea surface with a single ping. Analytical procedures were presented, based on recently collected krill data.

Significant Advances in Established Topics

There were several studies that integrated different remote sensing technologies (i.e. acoustical, optical) and direct sampling methods (e.g. nets) to address important research and monitoring issues. Examples include visual (i.e. geo-referenced snorklers) and acoustic surveys to define the coupling of littoral and pelagic fish habitats in a small lake (Gauthier). Comparisons of vessel data with two new autonomous acoustic systems (Totland), and vessel data with a sounder-equipped AUV (Scalabrin) quantified fish densities in the dead/blind zones. These near-boundary observations are critical to validate or replace current dead/blind zone compensation model estimates. A fresh-water study (Kubecka) evaluated density estimates based on acoustics or direct sampling (i.e. wheeled trawl or push trawl) in a very shallow lake (maximum depth 2 m). Lee used echosounders, as well as optical and acoustical (Didson) cameras to describe the vertical distributions patterns and swimming velocities of large jellyfish. The value of integrating or augmenting acoustic data from vessels of opportunity such as commercial vessels with research vessels was demonstrated by Kloser, who described ocean basin-scale patterns in pelagic mid-trophic level communities over several years. Finally, Olafsdottir combined acoustics and video information to assess juvenile cod in a particularly complex habitat composed of extensive kelp beds. In summary, substantial advances have been made in developing and expanding the suite of platforms and sensors to augment and validate acoustic observations.

Suggestions for Future Research

We suggest four broad areas where future research could facilitate our understanding of ecosystem processes and improve monitoring efforts. This will improve our ability to clearly and accurately document the structure and function of the ecosystem in the face of a changing environment, and support sustainable management under the ecosystem approach.

Ecosystem and fisheries monitoring demand objective quantification. The session had a good share of papers demonstrating the capability of acoustics to describe processes. During initial stages of the research, anecdotal descriptions of findings are useful, but it is important to quickly move towards quantification, which enables objective comparisons to be made with other studies.

Ecosystem indicators are rapidly becoming an integral component of successful assessment and management strategies. They were not discussed during any presentations in our session. Development of multiple frequency indicators, for example, from data collected during routine acoustic surveys may potentially provide early signs of ecosystem changes. There is a need for both methods development and evaluation of long-term datasets to develop and assess the applicability of such indicators.

Understanding and quantifying ecosystem processes demand relevant spatio-temporal resolution of the observations. Ecosystem processes occur at numerous time and space scales, whereas marine research is often conducted from large, expensive research vessels over coarse sampling intervals (e.g. short cruise once/year). Efforts should be made to involve other sorts of sampling platforms so that sampling can be accomplished at more appropriate scales. The value of other platforms, including moored sensors, commercial vessels, AUVs, and customized autonomous acoustic

systems were demonstrated in several presentations; additional devices such as oceanographic gliders and drifters may also be useful.

Acoustic observations are currently underutilized in ecosystem-based modelling. Acousticians have limited insight into what observations at what quality are needed. Improved interactions between modellers and fisheries acousticians are needed to promote a mutual understanding of what data are required and what can be provided to best describe the structure and function of the ecosystem.

3.2.1 Discussion following presentation

Single species vs. ecosystem approach

Arnaud Bertrand: Noted that so far we have not exploited all the data we can. For example we routinely remove the plankton information rather than assessing this in a routine way and noted that plankton signal is not noise. We have the possibility to provide data on non-exploited species, and will need to promote this towards other communities.

Chris Wilson: Endorsed this view and stated that they are moving towards this approach at the Alaska Fisheries Science Centre.

Arnaud Bertrand: Sees this approach almost as a duty but must promote this view and provide this to other communities. If we don't do this we will be stuck with small-scale studies on specific species.

Olav Godo: Agreed with this in principle, but noted that we cannot do everything and that prioritization is required.

Jacques Masse: Noted that we collect many data types, we need also to follow this over time; one survey in one year is not sufficient. Need to build studies to monitor and measure many parameters throughout the year. Problems of having capability to collect multi-parameters (different people have different means). Masse noted that he is disturbed that even in 2008 people are doing studies on just one species.

Francois Gerlotto: Make a small warning on the idea of using everything. We make a survey design for a given objective. Different studies may need different survey designs (e.g. whale survey vs. anchovy survey may require completely different designs).

Masse: Response to Gerlotto: In 2000 started anchovy survey. He suggested to other scientists to come along, but survey design was fixed on primary objective. Many scientists said they could not live with a rigid survey design, but others got on board and adapted their approach to work with a survey design over which they had no control

Olav Godo: Thinks there is a future in looking at what if scenarios to see for example what difference would a 50% effort make to the survey outcomes, and what could be done with the other 50% effort and if that extra effort in other areas might actually be effective in reducing uncertainty.

Interactions between the acoustics and modelling communities

Van Holliday noted that while acousticians may have a poor understanding of what modellers need, modellers have an even poorer understanding on what can be provided and suggested a joint session is needed to address this.

Bill Karp followed this comment up, suggesting we need to find direction on this issue and asked if there should be a theme session or study group to progress this.

Rudy Kloser: Can deal with it in topic sessions but need an outreach to modellers, so could suggest a theme session from Annual Science Conference.

Discussion regarding stationary acoustics

Yvan Simard asked the presenters how they see integration of long time-series of stationary acoustics.

Olav Godo: In his experience he has been stunned by the amount of information in stationary acoustics.

Yvan Simard: Is there a possibility to extract ecosystems indicators from the time-series of stationary data?

Olav Godo: Can look at things such as vertical indicators from this data and we can establish models to give predictions.

Other comments

Egil Ona: Perhaps research vessels should be reserved for the ecosystem approach, fishing vessels for single stock. Noted that sampling gear is not appropriate for ecosystem approach. They have a study group for this and either this group must address this, or perhaps FAST should try to progress this equipment which was designed much over 50 years ago.

Rudy Kloser: Agreed need for complementary technologies to be addressed.

Olav Godo: Closed by noting the importance of this group will grow as we have opened up many possibilities with this ecosystem approach.

Recommendations

Rudy Kloser: Timely to integrate with the modelling and ecosystem integration people. Recommended a theme session at the annual science conference, link in with other modelling groups (ecological, fisheries, oceanographer modellers) for 2010. Also continue with observational strategies in 2009.

3.3 Review of theme session ii): Remote Classification

Rudy Kloser for Anne Lebourges-Dhaussy¹ and Rolf J Korneliussen²

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There were 18 talks with prime authors from 11 countries in this session. The talks spanned wide, but could broadly be grouped into classification techniques (9 talks), species identification (5 talks) and other (behavior, zooplankton, benthos). The presentations spanned over passive recordings, single-frequency, dual-frequency, multifrequency, multibeam techniques and method development. Most presentations were based on methods developed and presented previously, but showed significant evolution as presented here.

Broad bandwidth use has shown its interest in two presentations for individual fish characterization: wideband multiview reducing the ambiguity between length and orientation in Roberts and Jaffe, with best classification seen at the largest (tilt) angles; in Renfree *et al.* the reduced TTS calculated on a broad bandwidth has significant differences among the 4 species considered. Demer and Renfree showed effectiveness of the use of statistical spectral approach to separate demersal fish from the seafloor,

measuring seafloor range, slope and roughness and quantifying the dead zone height.

Multifrequency is nowadays in common use, and is at time combined to processing methods, as regression trees (Fernandes) that showed promising results for species ID purposes. This is a variant of decision trees that were also used in the SIMFAMI project (but not invented in that project). Historical dual frequency (38/120 kHz) Peruvian data (Ballon *et al.*), combined with oxygen data, have allowed a classification between “fish”, “blue-noise”, “muñida” and “fluid-like”, this latter being well correlated with biological samples and fluorescence. MF is associated (Tesler *et al.*) with image analysis techniques (grey level co-occurrence matrices) and fractal dimensions, coming from seabed classification, leading on test data to 90% and 75% good classification of plankton mixed with two and three species respectively. Resonances at 18 kHz happen differently between blue whiting and mesopelagic fish during vertical migrations (Godø *et al.*) and help at separating two fish species.

In Berger and Poncet, MF is combined with **3D** visualization by means of the ME70 stabilized data that demonstrates clear improvement provided on schools shapes estimation, compared to single beam. Buelens *et al.*, comparing single and multibeam, introduced the concept of nodes in connection with kernel methods, and used the method to separate schools from bottom-scatter detected by side-lobes of the sonar.

On **echotraces**, comparing a global approach and a school-based inference approach to estimate species composition by means of **feature extractions**, Fablet *et al.* observe better results from the global approach. Cabreira *et al.* used different types of **artificial neural networks** (ANN) to identify fish species. The “self organizing map” proved to be the ANN-type that performed best with an average classification rate of 98% provided geographical location is one of the descriptors, and remain at 82% when geographical location was not used.

In lateral-aspect, **time-based echo metrics** and in particular echo width, is effective to discriminate migrating Chinook salmon from sockeye (Nealson *et al.*) as soon as pulse duration is > 0.2 ms. In **passive acoustics**, sound generated by rockfish were used to monitor populations (Širović *et al.*).

Technologies combination (video, acoustic, trawl) appears to be the only way to well assess species mixing in such difficult areas to sample as deep-water seamounts are (Macaulay and Kloser). A home-designed plankton sampler combined with TAPS has been designed by Mortimer *et al.* to make a fine work on TAPS data understanding and validation, in the context of very low zooplankton levels off Western Australia, showing higher correlations at the two highest frequencies.

In relation with blue whale feeding, McGarry *et al.* insist on the need to partition each contribution in the context of very abundant organisms (krill) but mixed with strong rare scatterers (siphonophores with pneumatophore).

Algae and seabed have also been evoked. Gavrilov and Zubov determine an increasing frequency response of brown algae observed at 50, 70 and 120 kHz and, in case of no underwater currents, the 70 kHz is the more related to the algae density. The relative efficiency of 50 and 200 kHz to succeed in seabed classification in presence of dense vegetation cover is studied by Freitas *et al.* using the QTCView system, cluster analysis and GIS approach and infer the inefficiency of the 200 kHz by lack of penetration capacity.

Recommendations: The value of using multifrequency acoustic is now generally acknowledged. However, complementary information can be very useful to go

further in classification, as the knowledge of environment conditions that has to be integrated, or of course information coming from complementary technologies. Classification tools applied to 3D schools-parameters is expected to become more commonly used, and will help a lot in differentiation of species. Wideband comes back with interesting application on fish/seabed differentiation.

3.3.1 Discussion following the presentation

Role of wideband acoustics

David Demer: Suggest mention should be made as to why wideband has not taken off. Problem of getting equivalent beam widths across frequencies is the main issue. Two issues: i) data collection with an equivalent beam width over the range and ii) a large detection range.

Yvan Simard: There is a problem of not sampling the same volume in narrowband acoustics. Should tools be developed to address this? Same beam at different frequencies with a single transducer. This would simplify the deployment of acoustic systems.

Egil Ona: Reminder, that the person who was awarded "best presenter" at SEAFASST used wideband. Suggest there is a place where it could help for catch technology and school detection.

Dezhang Chu: Suggests having a constant beam width, you can design your array and by controlling transmission of the elements can have the same beam width over a range of frequencies.

Egil Ona: Comment on multifreq. High signal to noise ratio systems which are expensive but potential to have one sounder to fire across all frequencies, so still sees benefit of narrowband systems which have high signal to noise.

Van Holliday: Have not used complex pulse codes, and these could be looked at.

Rudy Kloser: Suggested a review status in this area at the next study group (perhaps Van Holliday to lead).

Study group on classification and ecosystem indicators

Rudy Kloser: Are we at stage on needing study group on classification?

Francois Gerolotto: We have to go from classification to indicators. So far the only indicators are abundance and species distribution and may not be the important information. If there is to be a study group it should go from remote classification to ask what data can be given to useable information to an ecosystem approach.

Rudy Kloser: Suggest a study group to look at ecological indicators, rather than remote classification per se.

John Simmonds: Wideband transducer has a number of ways forward. Can produce one beam width over a range of frequencies but can only achieve an octave range which is a limitation.

Rudy Kloser: Suggest we synthesize existing methods with a study group on area of remote identification with ability to put out indicators.

John Simmonds: Lot of good work from Petitgas using indicators to infer change. Indicators alone are meaningless if they don't infer change.

3.4 Review of theme session iii): Target Strength

Stéphane Gauthier¹ (Rapporteur) for Theme Leaders: George Rose²; Kohji Iida³.

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Background

It was generally accepted that target strength remains one of largest contributors, if not the largest contributor, to both bias and imprecision in acoustic measures, and that under any concept of ecosystem-based fisheries management, these discrepancies will be more difficult to deal with. The reason for this is that the standard length-based models do not account for observed variations and trends in fish behaviour and will defy standardization by survey design either for a single species being assessed under different environmental-seasonal-physiological conditions, or comparisons among species. Under the outdated single survey paradigm, clever survey design could often compensate for much of this variability although biases negate among species comparisons, for example in predator-prey models where absolute measures may be necessary. It was therefore clear from many studies presented at the SEAFACTS symposium that target strength is an area that will require renewed research emphasis to enable acoustics to play an increasingly important role in fisheries, as was thought to be appropriate for many reasons.

New Developments

- 1) Broadband methods
- 2) Camera (optical) methods
- 3) Hard parts analysis for swimbladderless species

Enhanced Developments

- 1) 3D modelling
- 2) *In situ* experimentation
- 3) Multi-frequency comparisons
- 4) Target tracking as aid to quantifying behaviour

The presentations were summarized as follows:

Overview of the Target Strength session

The unifying theme for the session was TS variability. Dr Horne gave an excellent glimpse into this topic with his invited lecture. He stressed the effects of anatomy, ontogeny, physiology, behaviour and orientation as important sources of variability in target strength estimates. As an example, he presented detailed responses of physoclist's swimbladders under pressure based on pressurized tank experiments.

Notwithstanding the latter, rough classification indicates that there were:

- 7 presentations on TS modelling
- 7 presentations based on *ex-situ* TS experiments
- 7 presentations based on *in-situ* TS measurements

TS modelling

- Use of hybrid models (choice of model based on ka)
- Detailed 3D imaging for TS modelling
- Use of models to assess potential sources of variability in Baltic herring TS
- Use of Bayesian model to assess variability in Baltic herring TS
- Measurements of sound speed and density contrasts, as well as body orientation to use in models of krill TS
- Krill backscatter angle response measured by multibeam
- Multiple scattering models of fish aggregations based on 3D reconstruction of fish in tanks

Ex-situ TS experiments and testing of new technologies

- Measurements of different fish body parts
- Backscatter and density measurements of cod using multibeam sonar
- Use of a microcosm to assess scattering of swimming krill
- Scattering of fish schools using hemisphere coordinates (hydrophone experiment)
- Investigating detection and measurement capability of the Didson sonar
- Use of broadband (dolphin-like) signals to measure fish TS spectra
- TS measurements of jellyfish

In-situ TS measurements

- Side aspect TS of Atlantic herring
- Sandeel TS measured *in-situ* using a cage dropped on top of their habitat
- TS measurements of saury and anchovy combined with stereo optics
- Uncertainty of Baltic herring TS
- TS distribution within scattering layers
- Variations in Atlantic cod TS and the effects of diel vertical migration
- Combining acoustics and optics for the TS measurements of deep-sea fish

Research Recommendations

- 1) Comprehensive and Robust Target Strength models: there is a compelling need for more comprehensive models that take account of variability associated with fish and plankton behaviour. In particular, variations associated with diel and other vertical migrations and changing tilt angles require useful quantification for many species. There are also seasonal variations. Models can be formulated based on theory but must be challenged and verified by *in situ* data.
- 2) Use of optical devices underwater to observe fish behaviour and confirm species: where possible optical devices on various platforms are recommended for increased study to enhance knowledge of fish behaviour. Advances in small ROV and other technologies now enables much easier application of such an approach- successful and unobtrusive observation is likely only with optimized equipment and a learned understanding of the behaviour of the species being targeted.

3.4.1 Discussion following the presentation

Egil Ona: It is timely that estimates of abundance have uncertainty associated with target strength.

Egil Ona: TS is complicated, it shouldn't be noted as extremely complicated, and that it should be possible to be within 1 dB in many cases for some commercially important fish species.

Egil Ona: Noted that fish TS should be quite stable at lower frequencies 18 kHz. Can look across different day/night results when comparing across 18-120 kHz.

Egil Ona: Models don't give comparable results. He would like to see a paper that compares the methods.

John Horn: We held a workshop to address exactly this issue in Jan 2008, and found results were more variable than expected. By summer there should be synthesis of these outcomes which will be reported at the next FAST. There will be three papers coming from this workshop.

Dezhang Chu: Most TS models are high frequency. A problem with low-frequency is marine mammal issues.

Rudy Kloser: Looking at how we use our knowledge to design better methodologies.

David Demer: Amplify Rose's point about models being challenged by real world measures. Will modelling workshop compare results with ex situ data?

John Horn: Model data workshop did comparisons with ex situ measures.

3.5 Review of theme session iv): Animal Behaviour

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Animal behaviour remains an area of major interest and activity in the field of fisheries acoustics. Improved understanding in of animal behaviour is a key goal in development of the ecosystem approach to fisheries management, as behaviour mediates how animals interact with each other and the environment. In addition, behaviour affects the process of measurement using acoustic techniques, and improved understanding of behaviour will result in increased confidence in acoustic measurements. The understanding of behaviour in aquatic systems has been limited by the difficulty of direct observation. However, substantial advances in the use of acoustic techniques for the study of animal behaviour were reported during the presentations made in the animal behaviour session as well as in the ensuing discussions. The primary topic areas during the session included development and use of multibeam techniques for studies of behaviour (4.1, 4.2, 4.3, 4.5, 4.10, 4.13), behavioural studies involving a combination of tools or parameters (4.12, 4.15, 4.18, 4.19), the use of target strength to infer behaviour (4.14, 4.17), acoustic tracking (4.9, 4.15, 4.16), application of time-series observations (4.4, 4.8, 4.11), and investigations of behavioural reactions to stimuli associated with vessels (4.6, 4.7, 4.10).

Technological advances have greatly improved the ability to image aquatic organisms in a way that allows for behaviour to be inferred. Several new tools for 3-

dimensional acoustic imaging suitable for acoustic measurements as well as new techniques for producing 4-dimensional (i.e. 3 dimensions and time) representations of the observations were presented. While optimizing the instrumentation and processing methods remain an active area of research, these new techniques are now allowing for much more detailed observation of behaviour. For example, observations of krill schools have revealed that their school shape is not spherical as would be expected for optimal predator avoidance, and a new hypothesis that oxygen demand has strong effects on school structure was proposed. In addition, 3-dimensional observations of small fish schools suggest more connectivity and interaction among schools than was previously thought based on single-beam observations.

It is clear that substantial progress in understanding animal behaviour will come from combining acoustics with other techniques and observations. Studies of anchovy school characteristics inferred from echosounders were analysed in the context of oceanographic measurements, and indicated that some features of schooling behaviour are strongly controlled by local conditions such as temperature and oxygen content. Seabed characteristics were used in combination with fish abundance estimates to quantify habitat preferences. In addition, a controlled experimental design manipulating a fishery, and geostatistical methods were combined with acoustic measurements of fish distribution in order to assess the impact of commercial fishing on the distribution of prey of endangered sea lions.

The acoustic target strength of animals has long been known to be affected by animal behaviour. This variability in the target strength from individuals has been exploited to make behavioural inferences from field observations. A new method was reported to estimate fish tail beat frequency and swimming speed from the temporal variability in repeat observations of fish observed from the side. The method is robust and can be used at high densities, which will allow for new observations of the behaviour of individual fish within a school. In another contribution, fish target tracking revealed that hoki have strong changes in swimming activity and TS over a diel cycle. It was recognized in discussion that variability in target strength should be exploited to infer about behaviour.

Advances in the use of acoustics for tracking of animals were reported. Developments enhancing the signal-to-noise ratio of tags used for acoustic tracking were reported. The use of passive acoustics to position vocalizing river dolphins was developed and demonstrated to be an effective survey technique by comparing it to sighting surveys. In a promising combination of technologies used for tracking, fish were tagged with a transponder, released, and subsequently re-detected with a multibeam echosounder, which was used to image the tagged fish. This manipulation allowed for observation of how a known fish interacts with other organisms and the environment.

New techniques for repeated observations of organisms or groups of organisms have advanced our understanding of the behaviour of marine organisms. Moored echosounders were reported to be useful in this capacity. For example, an echosounder moored at the surface and a bottom moored hydrophone were used to describe the mating behaviour and vocalizations of cod during the spawning. Use of cabled, bottom-mounted observatories in fjords was demonstrated to be an effective way to make detailed observation of deep-water organisms over seasonal cycles. New signal-processing techniques were applied to ocean acoustic waveguide observations were used to elucidate the dynamics of schools of fish at very large

scales. Substantial new knowledge regarding animal behaviour is likely to come from further development and use of techniques to rapidly image animals at scale from individuals to populations.

Lastly, significant progress was reported on behavioural reactions of fish to stimuli produced by ships and acoustic instruments. This topic is of interest as responses to vessels will bias measurements of abundance and behaviour and are a major source of uncertainty in acoustic measurements. A field experiment revealed that although fish respond to a passing vessel, they do not respond to low or mid-frequency sonar signals. However, they do respond to replays of killer whale signals, which are similar to the sonar signals. This indicates that fish reactions to sound are highly dependent on the information content encoded in this signals. Advances were reported in the use of multibeam sonars to estimate the impacts of fish avoidance on echosounder estimates of abundance. This type of approach is promising in that it may ultimately allow the effects of fish reactions to be quantified continuously during acoustic surveys. In addition, a comparison of a noise-reduced and a non-noise reduced research vessel indicated that under some circumstances, use of a noise-reduced vessel can increase survey estimates of walleye pollock. Previous comparisons with these and other vessels have revealed increased avoidance to the noise-reduced vessel, which highlights the need for improved understanding of how behaviour mediates how and if fish react when they detect stimuli from a measurement platform. Vessel-induced reactions of fish are likely to be an active area of research in the future as considerable uncertainty is introduced in acoustic measurements by these behaviours. Reduction of this uncertainty will increase the accuracy and precision of fisheries acoustics thus allowing for improved management of fisheries and the ecosystem.

Recommendations

- Broaden our perspective from standing stocks to include rates and timing of ecosystem processes
- To complement acoustic surveys with multibeam and moored acoustic measurements
- Extract behavioural information from variability in acoustic measurements
- 'Ask the right questions' – to develop reliable indicators and have a better understanding of behaviour and ecology

3.5.1 Discussion following presentation

François Gerlotto: Reinforced the need to “ask the right question” as per the last point in the recommendations from Alex’s presentations. We have questions from people who fund surveys, from people who read papers, and from ourselves. Questions have been simple because tools were simple, but now with better tools can revisit basics to rethink what questions should be asked.

Van Holliday: Re complementing acoustic surveys (point 2). Suggest that should not underestimate the difficulty due to advection, and will need arrays of moorings to quantify vertical and horizontal advection. Yet to see a system that allowed the data to be uniquely interpreted without additional data (e.g. physical oceanography, currents).

Rudy Kloser: Temporal and spatial scales must be understood.

Egil Ona: Animals change their behaviour according to background noise, yet we don’t measure changing sea conditions (e.g. wind, sea, rain).

David Demer: Need to be aware of correct space and time scales. For example on a vessel often ignore the time it takes to traverse a space on a vessel. Can see advection as an opportunity rather than a problem (e.g. as shown by Andrew Brierley in his invited speaker presentation). Therefore making use of variability can be a useful direction.

François Gerlotto: Passive acoustics can give a lot of information. E.g. Indian ocean hydrophones moorings or can be received through acoustic tags put on fish. Timely to call for experts to look at this.

Recommendation that passive acoustics be added to the list of topics for the 2009 FAST meeting.

3.6 Review of theme session v): Data quality and integration

Yvan Simard¹ and Verena .M. Trenkel²

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SEAFACTS summary of session on *data quality and integration* (20 talks)

1. Main areas of topics covered by talks

Data quality

- calibration: 2; survey design: 2; behavior effects: (DVM) 1 ; analysis: (fractal metric) 1; sonar: 1; non-linear process: 1;

Integration

- in formal statistical modelling and hypothesis testing : 7; using 4D visualization: 1; deep ocean survey: 1; monitoring from stationary systems to feed drift model: 1; FAD: 1;

2. Interesting new results

- ecosystem structure (and functioning) is revealed by acoustic data, and significant monitoring metrics can be extracted to track it over a large spectrum of scales, from meters and seconds to basin and decadal scales (e.g. schooling structures / Massé *et al.*, Petitgas *et al.*)
- stationary monitoring systems can reveal ecosystem processes to include in models and to track changes in real time

3. Advances on older topics

- SBES and MBES calibration; krill abundance series using new TS; krill DVM and catchability; non-linear effects at high frequencies; FAD dynamics;

4. Suggestions for future directions

- **real time acoustic systems** to look at the structure of the ecosystem, and its behaviour over a continuum of scales from individual fish behaviour (4D swimming activity) to global changes in ecosystem richness (plankton) and fish school structures, in response to some forcing (biological or environmental)
- **try to reproduce the observed distributions and structure at different scales** from 3D dynamic modelling of drifters (zooplankton and micronekton) in relation with environmental characteristics

- **document the behavioural effects on TS**, notably the diel pattern, and formally incorporate that into biomass assessments
- **improve multidimensional visualization**

Other suggestions:

- should FAST launch a passive acoustic study group on fish?
- enhance the visibility of acoustic contribution on ecosystem approach
 - **symposium Acoustic and Oceanography?**
 - **launch an international programme e.g. Echography of planet ocean ecosystem**

3.6.1 Discussion following presentation

Olav Godo: Mainstream of marine science has a strong emphasis on the development of technology. Maybe it is timely to integrate with activities of observatory systems.

Rudy Kloser: What is best way to facilitate this?

Yvan Simard: European and Canadian systems will have active and passive acoustic systems. Older oceanographic nodes don't have acoustics, but they should have. ADCP backscatter information could also be used.

Bob McLure: Comment there are two cable connected observatories operating 3-freq system (University of Victoria, Memorial University) that might be good to talk to.

Rudy Kloser: Is Observatories a good topic at the next FAST with a view to bringing out the possibilities?

Arnaud Bertrand: There is a need to improve collaboration with theoretical ecological modellers.

Rudy Kloser: There is a thread here of interacting more closely with modellers and oceanographers. Invite suggestions on how to facilitate via the Annual Science Conference.

John Horne: Two comments. 1. Ocean observatories. There has been resistance in the US to active acoustics because of capital expense and interference with other instruments. 2. Asks Yvan Simard what part of the passive acoustics he was referring to.

Yvan Simard: Noise made by fish.

John Horne: There is a whole community of people looking at sound production and sound interaction with fish that could be invited to participate with this group. Ranges from physiological to ecological sources of sound production.

Rudy Kloser: Way forward will be to get invited speakers on this topic. Requests Yvan Simard and John Horne to identify speakers.

Yvan Simard: Workshop last year in Denmark on ocean noise which could be a starting point.

Rudy Koser: Need to consider regulatory environment.

Bill Karp: SGFAR discussed on anthropogenic. Potential for ICES to be asked to give advice with respect to anthropogenic noise, therefore some focus in this area may become important.

Rudy Kloser: Timely to have invited speakers coming to the meetings.

Van Holliday: With respect to a symposium on acoustic oceanography. Has had offers from the Executive Director of the Acoustical Society of America to arrange a co-sponsored symposium (1–2 days) on this topic in conjunction with a regular meeting of the Acoustical Society of America, Has resisted this as he believes ICES symposium is the appropriate place for most of our new work with a fisheries emphasis to be reported, but suggests if there is interest in a joint meeting about half way in time between our ICES symposia, that it could be arranged. The timing is very important so that it would not detract from our exceptionally successful ICES symposia.

Rudy Kloser: Noted Arnaud Bertrand's interest in acoustics and oceanography, suggested that interested people could get together.

David MacLennan: Noted difficulty in having another symposium because of clashes with other meetings. Suggest a theme session at the ASC could at least be a starting point that runs like a mini-symposia. This could involve invited speakers, and could have cooperative research report.

Rudy Kloser: Noted the right people as key drivers for it to be a good session.

Arnaud Bertrand: Suggest third possibility, is to try a review paper in a high impact journal to show acoustics approach to ecosystems management (e.g. Science and Nature) as a way of reaching a wider community. Could be less work and have a high impact.

Rudy Kloser: Agrees and suggests that it is important to publish in a high impact publications.

Van Holliday: I agree there is a place for a theme session. However, I only see three people here that usually go to the Acoustical Society meetings. Stressed that there is a different scientific community in the Acoustical Society and that they don't normally come and participate in ICES meetings. Since we do not always have the appropriate expertise within the ICES family to apply to our more difficult technical problems, should we attempt to expose some other scientific societies to our considerable strengths and more challenging problems, effectively building some bridges between our communities? Perhaps this could be an effective way of recruiting people with which to fill some of our technical gaps?

Bill Karp: Within the ICES community there is a broader interest so can reach across other science committees to organize a review of the science.

Egil Ona: Good idea to take it through the ICES community. Propose do this within ICES and also try to reach people within the Acoustical Society through presentations. Can pursue this on multiple fronts.

Rudy Kloser: Agreed that through ICES ASC (mini symposium, invited speak with review paper), Acoustical Society, Nature article via a workshop to produce a paper.

Arnaud Bertrand, Yvan Simard and Egil Ona agreed to participate in this process.

4 Study Group updates

4.1 Planning Group on the HAC Data Exchange Format (PGHAC)

Rudy Kloser for Laurent Berger¹

¹ Laurent BERGER, laurent.berger@ifremer.fr, IFREMER, Bp 70, 29280 Plouzane, France

Work in correspondence to achieve the following terms of reference for PGHAC 2008:

a) coordinate the further development of the HAC standard data exchange format;

No new developments

b) provide information on the changes in the format and its evolution;

Update of CRR 278 with MBES and trawl geometry tuples available

c) share information between manufacturers and users on the way acoustic data are processed and stored;

Biosonics HAC output available June 2008 –validation by PGHAC late 2008

KAIJO-SONICS HAC output for next generation of product (development planned by the end of this year)

Discussion following presentation

David Demer: Is the community finding HAC useful from a user perspective are the manufacturers comfortable with the effort required to implement?

Rudy Kloser: Agree that a user check would be useful to do periodically.

Denzhang Chu: Acceptance by the manufacturer is important.

David Demer: Suggest that this question goes back to PGHAC

Rudy Kloser: Will ask Laurent to canvass users and manufacturers on how they are finding HAC

Gary Melvin: Not using HAC in everyday processing, but very useful for archiving datasets from multiple systems.

Recommendation: PGHAC committee through the chair Laurent Berger to report at next FAST meeting how the manufacturers, developers and users see the advantages and disadvantages of HAC and future goals.

4.2 Study Group on Fisheries Optical Technologies (SGFOT)

Rudy Kloser for Eirik Tenningen¹

¹ Eirik Tennigen. eirik.tenningen@imr.no, Institute of Marine Research, Nordnesgaten 50, PO Box 1870 Nordnes, 5817 Bergen, Norway

The Study Group on Fisheries Optical Technologies (SGFOT) held its second meeting at the Institute of Marine Research in Bergen, Norway from 14–15 June 2008. Eirik Tenningen (Norway) was Chair and Terje Torkelsen (Norway) was Rapporteur. There were 14 participants from Canada, Denmark, Germany, New Zealand, Norway, Sweden and USA.

We reviewed the Cooperative Research Report outline. Responsible authors for each chapter were appointed and editors will be Jim Churnside (USA) and Eirik Tenningen (Norway). The chapter headings are:

- Introduction
- Optical Technologies
- Integration
- Data Processing
- Applications
- Recommendations
- Glossary

- Suppliers
- References

A time schedule for the cooperative research report writing was agreed. This gives deadlines for when the authors should send their contributions to the chapter coordinators and for when the chapter drafts should be available for the editors. An internal review process will also be carried out.

SGFOT will report by 31 July 2008 for the attention of the Fisheries Technology Committee. Terms of Reference for 2009 are given below.

Terms of Reference 2009

The Study Group on Fisheries Optical Technologies [SGFOT] (Chair: E. Tenningen, Norway) will meet in Ancona, Italy from 16–17 or 23–24 May 2009* to:

- Review and finalize the draft Cooperative Research Report on optical technology as agreed at the 2008 SGFOT meeting;
- Finalise recommendations for future work within optical technology to service the ecosystem approach for fisheries management.

Timetable for Cooperative Research Report

31.07.2008	The group will report to the FTC
01.12.2008	The responsible authors of each section send their section drafts to the chapter coordinators
01.02.2009	The chapter coordinators send their chapter drafts to the editors
15.04.2009	The report draft is distributed among the members for review
May 2009	SGFOT meeting in Ancona, Italy
Dec 2009	The Cooperative Research Report is finished

Details of the study group progress were presented and will be documented in the study groups report to the FTC on 31 July. Based on this presentation discussion of the chapter details and overall study group recommendations are documented below.

***The 2009 SGFOT meeting dates will be decided in dialogue with the Ancona hosts and chairs of FTC, WGFAST and WGFTFB**

Discussion from floor

Rudy Kloser: Suggest SGFOT meet before Ancona meeting (16-17th) so that they can report to the meeting. Noted the timelines are tight and that the study groups are voluntary so reiterated his appreciation of the efforts by the participants.

Van Holliday: Suggests that group does not have the expertise to cope with the bulk optical measures that are available (e.g. multispectral, multiangle absorption and scattering, flow cytometry, etc.). He sees value in producing the report which is largely on imaging optics but they will need an extension or another study group will need to look at the broader range of measures. Such a group will need to find the right people to volunteer.

Rudy Kloser: Terms of reference reflected this and that recommendations will be to look at broader range of measures.

Bill Karp: Note that it is a generic problem with the study groups is that we draw from the FAST community to form subgroups that won't always have the depth and breadth of expertise.

David Demer: With respect to suggestion that should a new study group be formed for optics. Suggest we need to bring optics into this group and not split this expertise into a separate group. Emphasis should be on bringing in expertise rather than dividing it.

Rudy Kloser: Agree we should be mindful of splitting groups noting the general synergy between the use of optics and acoustics creating more meetings with associated travel and meeting overload.

4.3 Study Group on Fish Avoidance of Research Vessels (SGFARV)

Francois Gerlotto¹

¹Francois Gerlotto, francois.gerlotto@ird.fr, CRH Avenue Jean Monnet, 34203 Sete, France

The SGFARV group of 15 participants met in Bergen on Saturday 21 June – Sunday 22 June

Recommendations for 2008

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

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

The Cooperative Research Report: “Causes and consequences of fish reactions to fisheries research vessels”

Report outline

- 1) State of the art on the effect of noise reduced vessels on detection of fish (observation and assessment)
- 2) The platform
- 3) The fish physiology
- 4) The fish behaviour
- 5) Effects of fish reactions on measurements and assessments of fish
- 6) designing experimental to evaluate fish reactions
- 7) Results, recommendations
- 8) Annexes

Terms of reference for 2009

The Study Group will work by correspondence on fish reactions to fisheries research vessels/platforms and meet in Ancona, Italy, in May 2009 to:

- i) produce a review and develop recommendations for the ICES community on methods for the study of physical stimuli produced by fisheries research vessels (platform related stimuli - PRS) and evaluation of reactions by survey-targeted fish;
- ii) update the literature review on fish reactions and vessel produced stimuli;
- iii) design explicit experiments to further examine the causes of fish reactions to PRS;
- iv) review progress of the SG according to the time table below
- v) review the draft of an *ICES Cooperative Research Report* on fish response to anthropogenic sounds that will be prepared during the year to be submitted to ICES in 2010.

Timetable for Cooperative Research Report

- 23 June, 2008: report to WGFAST with presentation of the structure of the CRR
- September 2008: report to FTC with precise content of all the chapters (and contributor lists), plus the existing material
- December 2008 (work by e-mail): existing material (literature etc.) in hands of leaders; feedback from the leaders (use of share point)
- May 2009: first draft at the study group meeting (Ancona, Italy), report to WGFAST
- April 2010: final draft to be presented to WGFAST and final submission at ASC for publication end of 2010

Discussion following presentation

Rudy Kloser: Should meeting be before FAST?

Francois Gerolotto: Preferably.

Bill Karp: Should be no overlap. But noted other study groups want to meet before the meeting so will need to discuss with organizers.

Rudy Kloser: Will communicate with organizers.

Bill Karp: Should see if people would be willing to meet on the previous week (Thursday/Friday before).

Rudy Kloser: Will take an iterative approach with organizers and participants.

4.4 TGACE – Acoustic calibration topic group

Toby Jarvis¹ and Geir Pedersen²

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A number of documents have been submitted to the topic group and are available on the topic group Sharepoint site which can be accessed via the following link. <http://groupnet.ices.dk/EG/EG2007/wgfast2008/ctg/default.aspx>.

Terms of reference

- 1) To review the current calibration procedure of the Simrad EK60 echosounder as described in the equipment’s manual, and make recommendations for improvements to the derivation of on-axis sensitivity (SA correction). This review will be submitted as a working document to WGFAST 2008.
- 2) To identify other issues associated with the calibration of active sonar equipment. These will be presented to WGFAST in 2008.
- 3) To draft terms of reference for a Calibration Study Group, starting in 2008, with the ultimate objective of updating the last cooperative research report on this issue (Foote *et al.*, 1984). The study group would conduct a literature review of issues that need to be addressed when calibrating acoustic equipment for water column and seabed research and address some of the wider issues, such as the calibration of multibeam sonars. The topic group will also consider how long the Study Group should meet for and identify an appropriate Chair.

Outline of topic group report is as follows:

Draft report

1	Introduction	3
2	Definitions	4
2.1	Single target properties	4
2.2	Target ensemble properties	4
2.3	Transducer properties	4
2.4	Acoustic field characterization	5
2.5	Echo processing	5
2.5.1	Single target echo detection	5
2.5.2	Range compensation	5
3	Fisheries research uses of acoustic data	6
3.1	Echo counting	6
3.2	Echo integration	6
3.3	Importance of calibration	6
4	Standard-target calibration principles	7
5	Standard-target calibration protocols	8
5.1	Current Simrad EK60 protocol	8
5.1.1	Single Targets - Target strength	9
5.1.2	Multiple targets - Volume backscattering strength	10
6	Calibration targets	12
7	Critical issues	13
7.1	Environmental requirements (SNR, reverberation, operating range)	13
7.2	Energy and range estimation	13
7.3	Beampattern modeling and parameter estimation	13
7.3.1	Beampattern approximation function	13
7.3.2	Calibration parameter estimation	13
7.4	Equivalent Beam Angle (EBA)	14
7.5	Angle sensitivity estimation	14
7.6	Effects of hydrography	14
7.6.1	Changes in parameters due to change in sound speed	15
7.7	Bandwidth	15
7.8	Finite amplitude effects	15
7.9	Adoption of calibration results to survey site	15
7.10	Long term deployment	16
7.11	Potential effects of mounting	16
7.12	Signal quantization	16
8	Accuracy and precision	17
9	Conclusions and recommendations	18
A	Details regarding volume backscattering calibration	19
10	Acknowledgements	21

ToR 1: Review of Simrad procedures →

ToR 2: Identify other issues →

ToR 3: Draft ToR for Study Group...

Discussion following presentation

With respect to item 1: EK60 calibration

Rudy Kloser: Suggest review to be ready for ASC in September with draft ready for circulation 1 month before.

Gier: Should be possible.

Egil Ona: Software is available to do a more scientific calibration that puts uncertainty on parameters

With respect to item 2: Other systems

Rudy Kloser: Suggested to close off Item 1 and then present Item 2 at the FAST in 2009 as a lead in to setting up terms of reference to the calibration study group.

Toby Jarvis: Feels that Item 2 is simply a list of issues that have been more or less completed.

David Demer: Thought that Item 2 is outside the terms of reference and would like to add some items to the list of Item 2.

Rudy Kloser: Should aim to close to the topic group and lead in to study group.

Rudy Kloser: Suggest that new study groups are started before the end of 2009 once existing groups are complete, so that FAST does not get too split.

Toby Jarvis: Suggest that timing should be driven by identified urgency and this might be identified by the topic group.

Bill Karp: Suggest timing could be influenced by how long group is likely to run, and this could be 2, 3 (traditional) or 4 years.

Francois Gerlotto: Two types of group – acoustic orientated and ecological orientated, so there may not always be clashes depending on the nature of the study group.

Rudy Kloser: When should study group start?

Egil Ona: If study group starts in 2010 then it should cover more than EK60.

Geir Pedersen: Feel that need to do a comprehensive job on the EK60 and close that off before moving towards other sounders.

Rudy Kloser: Need to move to other sounders but not so quickly so that the science is not done correctly.

Rudy Kloser: Suggest delaying the terms of reference until the next meeting. The overhead of being the chair of a study group is noted in terms of need to find funding, time and effort, and people should be sure that they could dedicate the necessary time. Rudy said David Demer had offered to chair the group.

David Demer: Long term research interest in this area and so offered to chair the group.

Egil Ona: Take care not to appoint study group or topic group leaders that don't have funding and support of their institute. Maybe should see backing from institute in place first.

Rudy Kloser: Suggest Toby, Geir and Demer get together to work out some terms of reference to present to the 2009 FAST meeting. Meeting agreed with this course of action.

5 WGFAST meeting 2009

The 2009 WGFAST meeting will be in Ancona Italy. 18–22 May, 2009, with working groups beforehand. The combined WGFAST/WGFTB meeting links with a fishing industry meeting afterwards. Host: Antonello Sala.

David Demer the South West Fisheries Science Centre (USA) has invited the FAST group to meet in California in 2010.

Discussion regarding timing of WGFAST meetings

Bill Karp: Noted growing pressure for non-advisory groups to meet in the second part of the year.

Rudy Kloser: Point taken and noted the window between April-May and the need for flexibility between two groups (WGFAST/WGFTFB) and that this decision also affects the host and deciding when they can host it. Need also to judge timing in relation to ASC.

Jacques Massé: Suggest that perhaps every two years to change the season (e.g. February one year, June next year). For example it has been impossible for Masse to attend for the last four years because of clashes.

Van Holiday: Could we poll community to see how widespread problem of timing is.

Eigl Ona: Noted IMR needs to buy carbon offsets. Raised the issue of needing to minimize the distance between meetings.

Rudy Kloser: Can't ignore carbon footprint.

Rudy Kloser: Will discuss timing further at the ASC.

Rudy Kloser: Asked David Demer what time he had in mind for 2010.

David Demer: What are the timing restrictions?

Rudy Kloser: Way forward is to send out a note to wider working groups regarding timing.

Bill Karp: Noted it is not a restriction, but an encouragement from ICES for non-advisory groups to meet in the second part of the year.

David MacLennan: Third week of September will always be the ASC. The point is that FAST has to be sufficiently before the ASC to allow reporting to take place in time for presentation to the ASC.

Rudy Kloser: Discuss with WGFTFB at the ASC to look at other possible times.

Rudy Kloser: Noted it was difficult to determine if there was an issue with timing of the 2009 as there were conflicting response as to whether there was a timing issue.

5.1 WGFAST/WGFTFB 2009 joint session

WGFAST recommends that WGFAST and WGFTFB meet jointly in Italy, in April 2009. The Terms of Reference are to be mutually decided by the Working Group Chairs and a designated joint session Chair.

Following the Fish Trawl and Fish Behaviour Working Group meeting in April, Paul Winger proposed a 2009 FTFB/FAST joint session topic that was discussed by WGFAST and endorsed with some modifications assisted by Julia Parish and Emma Jones as outlined below.

Title: Why marine animals do what they do? Exploring behaviour in response to natural and human-associated pressures

Conveners: Paul Winger (Canada), Julia Parrish (USA), and Emma Jones (New Zealand)

Recommendation:

The WGFTFB and WGFAST recommend a one-day joint session between the ICES-FAO WGFTFB and WGFAST that explores the decisions (i.e. behavioural trade-off's) made by marine organisms in response to both natural and human-associated pressures, including but not limited to predator-prey interactions, and vessel and gear interactions.

Justification

The second ICES Symposium on fish behaviour, entitled "*Fish Behaviour in Exploited Ecosystems*" was recently held in Bergen, June 2003. Scientific research was presented across 5 key theme sessions, culminating in 27 peer-reviewed papers (Fernö *et al.* 2004) with *Discussion Sessions* recorded by Bjordal and Gerlotto (2004), Huse (2004), Glass and Gunn (2004), Walsh *et al.* (2004), and Thiele and Fernö (2004).

One of the dominant conclusions from several of the theme sessions was the need to challenge our traditional approaches to the study of fish behaviour. No one would argue that the field hasn't grown rapidly, or that our observational techniques haven't improved remarkably. They have. But what is clear, is that there continues to be too much observation and description of animal behaviour without an attempt to understand *why fish do what they do* (Bjordal and Gerlotto 2004; Glass and Gunn 2004; Walsh *et al.* 2004).

This joint session presents a forum for discussion on new approaches and interpretation of animal behaviour. We invite presentations and posters that emphasize the functional explanations behind behavioural expression, including behavioural responses to ecological factors - such as predator-prey interaction - as well as anthropogenic factors - such as vessel-induced behaviour or behaviour in relation to fishing gear. We wish to explore the costs and benefits associated with decision-making and how predictable behavioural responses can be under changing environmental, ecological, or anthropogenic conditions. For example, what are the behavioural trade-offs that fish make in response to an attractive odour plume when simultaneously engaged in spawning, or by contrast, what is the optimal avoidance distance to an approaching trawler when fish are actively engaged in feeding?

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5.2 Potential Topics discussed for 2009 WGFAST

- i) Recommendations from session theme leaders.
- ii) Long time-series acoustic survey and assessment model Q: review and synthesis.
- iii) Review of ecological inputs into fisheries management.
- iv) Anthropogenic sound impacts on fish: update of issues from member countries –research requirements and status of current knowledge –guest speaker suggested.
- v) Calibration of acoustic instruments lead into a study group.
- vi) Observatories – coastal – shelf – oceanic what role can acoustics play current methods and future designs.
- vii) Species identification – review of best practice including validation methods wideband systems.
- viii) Platform requirements (e.g. research vessels – noise and bubble zone entrapment).
- ix) Near boundaries synthesis.

Discussion

Rudy Kloser: Suggest we put recommendations from theme session leaders and put these in the FAST report for comment from participants.

Anthropogenic sound impacts? Invited speaker – Magnus.

Bill Karp: With respect to the first point – time-series acoustic surveys. Suggest it be generalized, Bill Karp to give feedback.

Francoise Gerolotto: Suggest for third point – Anthropogenic sound impacts. Shouldn't the words 'passive acoustics' be included?

Rudy Kloser: Will send out for updates for national guidelines for use of active acoustics, noting that some countries are putting out recommendations for use of active acoustics.

David MacLennan: With respect to the third point. Asks if anyone knows of an ICES study group on anthropogenic effects on mammals, if they did continue the part 2 which was the study on fish. Suggest this is a good starting point for this third topic.

Yvan Simard: Report is close to being finished.

6 ICES ASC Themes 2009-2010 (in review)

The WGFAST proposes the following three Theme Sessions for the 2009 and 2010 Annual Science Conference:

- a) Theme session on "Optical and image based technologies for use in the ecosystem approach to fisheries management".
- b) Theme session on "Monitoring requirements and methods for pelagic organisms at local and basin scales for input into ecosystem based fisheries management and climate impact models. With a particular focus on the acoustic indicators required for species such as zooplankton and micronekton".
- c) Theme session on "Surveying the water column with multibeam sonars".

Eirik Tenningen and Bill Michaels were not present but Rudy Kloser will ask chairs to provide terms of reference.

Discussion regarding ASC theme sessions

Francois Gerlotto: Is the intent to use optical and image based technology for and EAF framework?

Rudy Kloser: Yes

Rudy Kloser: Asked for a show of hands for ASC participants: only a very few put up their hands.

Rudy Kloser: If there is a theme session would that encourage people to go?

Consensus was that a theme session would encourage more people to go

Observation and monitoring requirements.

Francois Gerlotto with respect to Theme 2 Observation and Monitoring Requirements: Need is to obtain indicators. From where can we take indicators for EAF (acoustics, optics, VMS, birds)? Look for methods that can provide indicators to assist EAF. So could combine themes 1 and 2 into the one session.

Bill Karp: Could hold theme sessions (optics (1) and observations (2)) in different years to separate them.

Olav Godo: Could have an unfocused session if not careful.

Rudy Kloser: Could complement each other. Does having two sessions increase participation rate?

Van Holliday: What are chances of being given space for two sessions?

Bill Karp: We would probably be asked to merge sessions if they are too similar.

Jacques Masse: Thinks being wider in scope is not a problem.

Olav Godo: The key is to find the links between topics.

Francois Gerlotto: Session 2 as presented is technical. If indicators are not the question of this theme session, then this session is purely technical and should therefore not be limited to acoustics and could include optics. He suggested one session on what indicators are needed and another (technical) session on how to find the data.

Rudy Kloser: Suggest Rudy Kloser and Francois Gerlotto get together to discuss how to approach this if two sessions are to be merged into one.

Bill Karp: Noted: Limit to number of conveners to theme session to three. Can allow a theme session to submit between 5–12 papers to be published, which will add value to theme sessions.

Discussion regarding ICES ASC 2009/2010 (3) Observations with multibeam sonars

David MacLennan: Tagged issue of definition and measurement of sampling volume. Suggest that there is some consideration of this, particularly when comparing between two different systems.

Rudy Kloser: Could be a consideration for FAST 2009 – investigation of sampling area and volume.

David Demer: Multibeam allows measurement of systems close to seafloor and seabed and therefore shouldn't limit the recommendation to just water column. – suggest take out '**within the water column**' from the topic title.

Francois Gerlotto: Would like to see word **behaviour** included in the topic title.

Egil Ona: Feeling is that we have increased resolution but then say directivity is not important. Low frequency sonars more stable than high frequency wrt directivity.

Simmonds: Supports Egil's view. Petitgas paper in Venuzuela showed you could count schools, but driving source of variance was density of schools in fish schools. So accurate counting of schools may not decrease uncertainty.

7 Other business

7.1 South American acoustic community

The South American acoustic community are interested in forming a Latin American WG (GALA) of Fisheries Acoustics and to link this body to the ICES FAST WG acting as the host. A letter was submitted for WGFASST to consider and this was discussed at the meeting. The main elements of the discussion were centred on the need for a formal – informal arrangement and how we manage the size of FAST and in particular the joint meetings with FTFB. There was strong support for WGFASST to invite via the chair the South American community to the next meeting and to formalize this if necessary for future meetings.

WGFASST recommends that the chair invites the South American Acoustic Group to the next meeting to participate and to update on activities.

Coordinator of GALA Adrian Madirolas – members, Jorge Castillo, Edwin Niklitscheck, Salvador Peraltilla, Ruben Pinochet and Hugo Robotham.

7.2 ICES Acoustic Symposium 2013

Advanced notice that it will be necessary to start planning in 2010 for an acoustic symposium in 2013.

7.3 FAST chair election process.

Rudy Kloser outlined that his term as chair ends December 2009 and suggested a process to elect a new chair for 2010 to 2012 that was similar to previous methods.

Francoise Gerlotto outlined that in his experience a two stage election process has worked well where chairman or some group were canvassing select scientists and then an election was held.

John Simmonds: Good to get a feel for who will be in a position to take on the role and sees selection of chair as a good mechanism to get the group to go in a certain direction.

Rudy Kloser proposed that after both canvassing and a general call for expression of interest for the FAST chair a selection panel of the past and present FAST chairs (including FTC chair) would select the next FAST chair from the candidates available.

Recommendation to adopt this procedure for the selection of the FAST chair for 2010 to 2012.

7.4 Update from fresh water acoustics symposium and acoustic sampling procedures - Jan Kubecka

Jan Kubecka updated the meeting that looked at the standardization of methods of sampling fish with acoustics (Jon Hateley, Ian Winfield, Jan Kubecka and others). If interested in reading the document, e-mail Jan at kubecka@hbu.cas.cz. Document is copyrighted so it cannot be distributed via web page.

Discussion following presentation

David Demer: In spite of the physics not being that different between marine and fresh, there are two different communities. Suggest it would be good to exchange documents between communities so that every one knows what each other is doing.

Jan Kubecka: No official way to distribute.

Rudy Kloser: Is it possible to get someone to the next WGFAST meeting to give more details?

Jan Kubecka: They will try to get someone to present.

7.5 Mid-trophic ocean acoustic sampling initiative

Nils Olav Handegard gave an update of the CLIOTOP MAAS initiative to design a mid-trophic ocean acoustic sampler. A meeting was scheduled for Tuesday, 24 June at 12:00 hrs at IMR to discuss this topic in more detail. Erwan Josse gave an update on observatory activities at IFREMER. Rudy Kloser gave an update on the use of vessels of opportunities and combinations of stationary acoustics and longliners. David Demer gave a presentation on the development of low energy echosounders and a comparison experiment with the low cost/power Simrad ES10 and a conventional echo sonder. Nils Olav Handegard gave an orientation of the use of bottom mounted stationary echosounder data to validate eco system models. Developing low cost/power echosounders and a tighter collaboration with model developers were identified as the main bottlenecks.

8 FTC and FTFB Update

Bill Karp the FTC chair provided an overview of the role of FTC and its relationship with ICES expert groups (Working Groups, Study Groups, etc) and the ICES Consultative committee (ConC). He also summarized progress to date on development of recommendations for the new ICES Science Plan (2008–2013) and science structure. While he provided some insights regarding discussions within ConC and recommendations that might be developed, he cautioned those present that policy decisions regarding possible changes had yet to be made. The discussion of the new science plan centered on themes which would be identified in the new plan, and possible areas of emphasis. The discussion of the new science structure focused on possible changes within the existing science committees and their relationship with ConC and the EGs. Bill encouraged all FTC members and interested individuals to attend the annual FTC meeting during the ICES ASC. He expected to be able to discuss details of the new plan and structure at this meeting.

WGFTFB 2008

Presenters: Bill Karp and Dominic Rihan (WGFTFB chair) by telephone.

A summary of the WGFTFB meeting was presented and the detailed report is available at: <http://www.ices.dk/reports/FTC/2008/WGFTFB08.pdf>.

9 Closing of the meeting

Rudy Kloser closed the meeting, thanking participants for their attendance and contributions to the meeting, in particular our host Nils Handegard, IMR Norway, and rapporteur, Tim Ryan, CSIRO Australia.

Annex 1: List of participants

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Annex 2: Agenda

Monday, 23 June

0830 Registration/coffee

0900 FAST Opening

Welcome – acknowledgements -- ToR

0915 Review of SEAFACST and implications for FAST ToR 2009

0930 Ecology and Monitoring – Olav Godo and Chris Wilson

0950 Remote Classification –Rolf Korneliussen/ Anne Lebourges-Dhaussy

1010 Target Strength – George Rose/ Kohji Iida

1030 Morning Tea Break

1050 Animal Behaviour – K. Michalsen/ A De Robertis/ Jacques Masse

1110 Data Quality and Integration – Verena Trenkel/ Yvan Simard

1130 Key SEAFACST outcomes/comments

1200 Study Group updates:

SGFOT – Rudy Kloser for Eirik Tenningen

SGFAR – Francois Gerlotto

PGHAC – Rudy Kloser for Laurent Berger

Topic Group on EK60 calibration – Gier Pederson, Toby Jarvis

Update from fresh water acoustic symposium - Jan Kubecka

1230 Lunch

1330 Calibration topic group cont.

1400 FAST 2009 ToR 18–22 May, Ancona, Italy

1430 Other business

FTFB/FAST joint session

ICES ASC 2009, 2010 theme sessions

Research vessel committee – 209 report

South American participation

Japanese participation

1500 Afternoon Tea Break

1530 Fisheries Technology Committee update – Bill Karp

1730 Close

Annex 3: WGFAST terms of reference 2009

The **Working Group on Fisheries Acoustic Science and Technology [WGFAST]** (Chair: R. Kloser, Australia) proposes to meet in Ancona, Italy 18–22 May 2009 with a joint meeting proposed with the WGFTFB and FTC on 20 May to:

- a) advance our understanding of new and innovative methods and technologies in applying the ecosystem approach to fisheries management and follow up on recommendations developed during the 2008 ICES SEAFACFS conference by addressing:
 - i) Fisheries and ecosystem acoustic indicators and the interface between observation outputs and model uptake including improved process understanding and assessment of indicator goodness-of-fit with ecological and fishery assessment models;
 - ii) Coastal, shelf and ocean observatories for fisheries and ecosystem monitoring. Role of acoustics for current applications, methods and technologies and future designs;
 - iii) Target strength and species identification modelling and measurement with particular emphasis on validation (optical and nets) and multifrequency and wideband measurements;
 - iv) Acoustic observations (passive and active) of spatial and temporal fish behaviour (e.g. spawning, migration) and how this knowledge is or could be incorporated into models and management advice;
 - v) Anthropogenic sound impacts on fish: update of issues from member countries –research requirements and status of current knowledge and guidelines – potential for invited speaker.
- b) review the reports of the:
 - i) Planning Group on the HAC (PGHAC) common data exchange format;
 - ii) Study Group on Fisheries Optical Technologies (SGFOT);
 - iii) Study Group on Avoidance Reactions to Vessels (SGARV);
 - iv) Topic group on EK60 calibration.
- c) Advances in the approach and interpretation of animal behaviour. Joint session with WGFTFB and WGFAST on 20 May.

WGFAST will report by 31 July 2008 for the attention of the Fisheries Technology Committee.

Supporting Information

Priority:	To implement the ecosystem approach to fisheries management within ICES requires observations and monitoring of the targeted species their trophic interactions and the environment. Fisheries acoustics and complementary technologies provide a unique suit of methods to sample at a variety of trophic levels, spatial and temporal scales and research into their application and further development is vital.
Scientific justification and relation to action plan:	Term of Reference a) The ICES Symposium on the Ecosystem Approach to Fisheries with Acoustics and Complementary Technologies (SEAFACFS) was held in Bergen, Norway in June 2008. This symposium provided an important update of our understanding of new and innovative methods and technologies in applying

the ecosystem approach to fisheries management. The presentations provided new insights into ecosystem structure and function as well as quantitative inputs into ecosystem or fisheries assessment models. Based on this symposium the Fisheries Acoustics, Science and Technology (FAST) working group reviewed the five main themes and recommended a science plan that would advance the ICES implementation of the ecosystem approach. First, there is a need to review the fisheries and ecosystem indicators available from acoustics and complementary technologies and how these can be used in ecosystem and fisheries models. Second, given our knowledge on these indicators how can acoustic and complementary technologies be best used in coastal, shelf and open ocean observatories. Third, acoustic observations also provide new insights into biotic behaviour and an update of new technologies to observe this behaviour and how this knowledge can be incorporated into fisheries and ecosystem assessments was recommended. Fourthly, estimates of biomass using acoustics relies on accurate target strength and species identification knowledge, advances in modelling and measurement with particular emphasis on validation (optical and nets) and multifrequency and wideband measurements was recommended. Finally, our use of active acoustics and other anthropogenic sound in the marine environment must be understood in terms of its impact on other organisms both physically and behaviourally and it is timely to update on the state of the science in this area with potential for invited speakers.

Term of Reference b)

PGHAC, SGFOT, SGARV and TGC meet before WGFASST in the same location and make their reports available to the WGFASST at its annual meeting according to their terms of reference. A.N. #s: 1.12.5

Resource requirements:	No new resources will be required for consideration of this topic at WGFASST annual meeting. Having overlaps with the other meetings of the Working, Planning, Study and Topic Groups of the Fisheries Technology Committee 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 70-75 members and guests.
Secretariat facilities:	None.
Financial:	No financial implications.
Linkages to advisory committees:	There are no direct linkages to the advisory committees but the work is of relevance to ACFM..
Linkages to other committees or groups:	The work in this group is closely aligned with complementary work in the FTFB Working Group. The work is of direct relevance to PGHAC, SGTSEB, SGFOT, and SGARV, PGSPUN, PGRS, PGHERS, WGBIFS and PGAAM.
Linkages to other organizations:	
Secretariat marginal cost share:	ICES: 100%

Annex 4: Recommendations

RECOMMENDATION	ACTION
1. The Working Group on Fisheries Acoustics, Science and Technology [WGFAST] (Chair: Rudy Kloser, Australia) will meet in Ancona, Italy, 18–22 May 2009.	
2. WGFAST recommends that SGFOT, Eirik Tenningen (Norway), Chair, continue to work towards an ICES Cooperative Research Report and meet in Ancona Italy 16–17 May 2009. The result of their meeting to be reported to the WGFAST on Thursday, 21 May 2009.	
3. WGFAST recommends that SGARV, Francois Gerlotto (France), Chair, continue to work towards an ICES Cooperative Research Report and meet in Ancona Italy 16–17 May 2009. The result of their meeting to be reported to the WGFAST on Thursday, 21 May 2009.	
4. WGFAST recommends that the PGHAC, Laurent Berger (France), Chair, should continue its work via correspondence and report to the WGFAST on 21 May 2009 with special reference to a review of product developers and users.	
5. The WGFTFB and WGFAST recommend a one-day joint session between the ICES-FAO WGFTFB and WGFAST that explores the decisions (i.e. behavioural trade-off's) made by marine organisms in response to both natural and human-associated pressures, including but not limited to predator-prey interactions, and vessel and gear interactions. Conveners: Paul Winger (Canada), Julia Parrish (USA), and Emma Jones (New Zealand)	FTC, WGFTFB
6. The WGFAST proposes the following three Theme Sessions for the 2009 and 2010 Annual Science Conference: <ul style="list-style-type: none"> a) Theme session on “Optical and image based technologies for use in the ecosystem approach to fisheries management”. b) Theme session on “Monitoring requirements and methods for pelagic organisms at local and basin scales for input into ecosystem based fisheries management and climate impact models. With a particular focus on the acoustic indicators required for species such as zooplankton and micronekton”. c) Theme session on “Surveying the water column with multibeam sonars”. 	SGFOT, LRC